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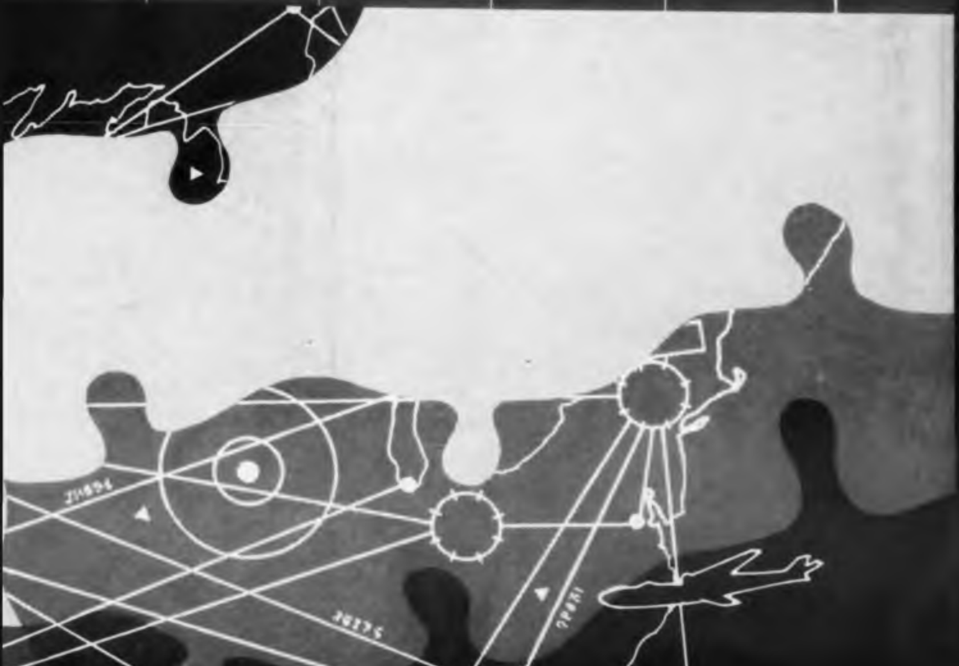
JUNE 7, 1961



SUPERSYSTEMS—a staff report...p 27

MicroWaves... p 129

ELECTRONIC DESIGN

COVER: The puzzle-pattern depicts the complex problem of integrating the various segments of a large air-traffic control system—one of the many supersystems discussed in the Special Staff Report commencing on p 27.

Selected Topics In This Issue

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ELECTRONIC DESIGN · ONE DAY SERVICE

USE BEFORE JULY 19th, 1961

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Sidelights of This Issue

Supersystems—Super Problems

Once upon a time a clever engineer had but to design a more successful product than his neighbor, and the world of electronics would beat a path to his door. Today a successful product isn't enough—at least not if it's earmarked for duty in a modern supersystem. By itself the design may be fine. But when *interacting* with other parts of the system, it may be a complete flop.

The problem is explored in a penetrating report by ELECTRONIC DESIGN's news staff, starting on p 27. Six supersystems are covered: satellite communications, antimissile defense, lunar exploration, air-traffic control, air tactical delivery (limited war) and business data-processing.

Birth of a Baby Satellite

It was late toward evening in Los Angeles, and Dr. Joseph M. Denney, manager of the Materials Dept. of Space Technology Laboratories, Inc., was becoming increasingly restless. What he had sketched seemed practical enough. Or was it? Finally he grabbed the sketch and walked into the neighboring office of Roy G. Downing, a member of the technical staff.

"Why couldn't you build a small, tetrahedral satellite, like in this drawing?" Dr. Denney asked.

"Well, I guess you could," Mr. Downing said after examining the sketch, "but you'd be out of your mind to want to."

What Dr. Denney had in mind was a 1-lb satellite that could be carried aloft by a large missile, go into an orbit of its own, if need be, measure only two parameters and telemeter the data to earth. Before the evening was spent, Mr. Downing became interested in the project, and the basic design was immediately completed.

For the full story, turn to p 12.

Iowa Engineer's Idea Pays $50

ED's Ideas for Design readers have given the second $50 Most Valuable Idea of Issue Award to John V. McMillin, project engineer with the Measurement Research Center, Iowa City, Iowa. Read about it on p 170, and ask yourself, "Why can't I be a winner, too?" Answer: You can.

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ELECTRONIC DESIGN Hayden Publishing Company, Inc.
850 Third Avenue, New York 22, N. Y.

ELECTRONIC DESIGN is published biweekly by Hayden Publishing Company, Inc., 830 Third Avenue, New York 22, N. Y. T. Richard Gascoigne, Chairman of the Board; James S. Mulholland, Jr., President; Edmund C. Grainger, Jr., Secretary. Printed at Hildreth Press, Bristol, Conn. Accepted as controlled circulation at Bristol, Conn. and at New York, N. Y. 38,202 copies this issue

Designers Study Exotic Communications Systems

Ultraviolet, Gamma-Ray, Deflected Sunlight and Other Systems Investigated to Escape Spectrum Squeeze and Gain Range

Alan Corneretto
News Editor

PRODDED by pressures of vanishing spectrum and growing requirements for space communication links, designers are reaching beyond conventional techniques for communication systems able to meet tomorrow's needs.

Under consideration are exotic systems that would use gamma-ray radiation, deflected sunlight, particle beams, ultraviolet and infrared radiation, blackbody radiators, X-rays, and optical frequencies. These were the most unusual of the systems discussed at the Fifth National Symposium on Global Communications (Globecom V) held in Chicago, May 22-24.

Most of the activity in radical systems is concentrated on those operating in the region above microwave. Narrow beamwidth and high antenna gains are chief advantages at these frequencies. None of these systems, however, was said to be close to practical development; only a few are considered promising.

L. R. Bittman, Martin Co., Baltimore, told a session at the meeting that "even if a practical exotic method were to be developed, it would almost certainly be restricted to operation in the visible-light region, since this is the only part of the [above 60 Gc] region possessing a transparent window in the earth's atmosphere."

"At present," he said, "the only promising means for communication in the earth's atmosphere is by means of deflected sunlight and the laser."

In reviewing communication systems for the exotic frequencies, he discussed particle systems in which an electron or ion accelerating gun designed for conventional beam modulation would be the transmitter and a scintillation detector would be the receiver.

Such a system appears promising at first, he said, because information would be borne on the beam rather than on the electromagnetic wave converted from the beam. High channel capacity could be expected. But the effects of magnetic fields on charged particles would limit use of such a system to outer space or bodies such as the moon. In addition, range would be limited to tens of thousands of miles. Using neutral rather than charged particles would be extremely difficult with practical power efficiency and would be complicated by the photoionizing effect of Lyman α radiation from the sun.

Coherent X-ray generators, suitable for modulation, were mentioned as a possibility by E. W. Keller, ITT Communication Systems, Inc., Paramaus, N.J., who read a paper jointly written by L. A. de Rosa. But devices able to produce enough quanta for long-range communication would have to be developed, he said. These would probably be coherent X-ray generators, however, and would be subject to severe cosmic-ray-noise background.

Gamma-Ray Communication Systems Would be Useful Only in Outer Space

Gamma radiation might provide cw communications to distances of 100,000 miles, and voice links to 1,000 miles, according to J. W. Eerkens, Aerospace Corp., Los Angeles. But this would be possible only in outer space because of atmospheric scattering. A likely source of radiation, Mr. Eerkens said, would be by-product gammas from a nuclear-reactor propulsion unit.

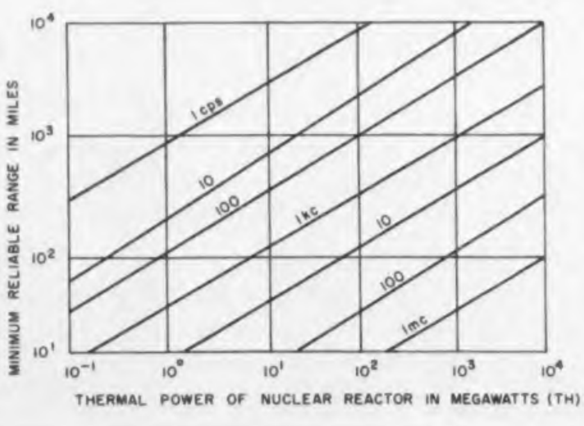
Chopped sources would have a low modulation bandwidth and limited transmission rate. Better approaches providing more coherency, were said to be conversion of gammas to photons in a scintillator for modulation by a Kerr cell, and exploitation of the Mossbauer effect through use of nuclear magnetic resonance circuitry and isotopes with suitable decay times. A scintillator could be used as a receiver.

In commenting on gamma-ray systems, Mr. Keller said that cosmic ray background would be severe and must be carefully analyzed.

Deflected sunlight as a special type of communications system was discussed by Mr. Bittman. The sun's light energy is noisy and incoherent but is free. However, though total radiation is high, amounting to 1.4 kw per sq meter at the earth's orbit, its energy per unit wavelength is very low. The most practical solution to the difficult problem of modulation appears to be an elaborate heliograph. He added that mirror-deflected sunlight might be practical and useful if limited range and channel capacity could be tolerated.

In discussing infrared systems, Mr. Bittman predicted that infrared masers might prove a use-

Gamma Radiation May Provide Space Communications



Range of a communications system using gamma-ray beams could extend beyond 10,000 miles under ideal conditions. Gammas would be by-products of a nuclear propulsion unit and would be detected by a scintillator. Figures in the graph are for a receiver surface of 1 sq meter, an emission area ratio of 0.01, and a minimum allowable signal-to-noise ratio of 10. System would have to operate beyond strong magnetic fields.

ful source of coherent radiation. Mr. Keller reported that present continuous optical masers using a gas discharge containing a helium-neon mixture have a typical power of 15 mw at 11,530 A in the near ir region. The most common type of infrared generation, thermal heating, will probably not prove useful, according to Mr. Bittman, because it produces incoherent radiation. Attempts to make such radiation monochromatic generally reduces power efficiency, while raising power density by raising temperature shifts the radiant peak. J. W. Ogland, Westinghouse Electric Corp., Baltimore, summed up the difficulty with infrared by saying that although it is suitable for optical beaming, with the resulting advantages, no point source of sufficiently high power density is known which can compete with sources emitting shorter wave lengths.

The ultraviolet region was considered more promising by several speakers. One type of uv generation discussed was that resulting from electrically exploded wire. The radiation produced by the exploding wire is essentially blackbody radiation with its peak power density in the uv region. Explosions of 1 msec, for digital use, were said to be possible at temperatures from 20,000 to 350,000 K. Power conversion efficiency, however, is low because of spectral distribution of the energy involved and because most of the energy appears in the kinetic energy of the exploded wire particles. Nevertheless this technique is considered possibly capable of achieving communications over astronomical distances.

Use of continuous optical maser techniques for achieving coherent uv signals was said to appear capable of producing signal-to-noise ratios more favorable than those of infrared maser systems and are under consideration.

A cathode-ray technique for generating a highly concentrated uv point source was described by Mr. Oglund.

Ultraviolet Com System Would Use A Cathode-Ray-Tube Point Source

At Westinghouse, he said, researchers are developing a point source of uv radiation using cathode-ray-tube technology. Their idea is to direct an electron beam on a rotating phosphor so that fresh phosphor would continuously be presented to the beam in such a way that the resulting spot would appear stationary from the outside of the device. Tests with a 5ZP16 tube operated at 30 kv with 25-μsec pulse trains at 60 pps have given an excitation power of 10 w into an 11-mil spot, he said. Assumed efficiency is 10 per cent, using an unoptimized phosphor; uv power, therefore, is about 1 w. This was said to be sufficient for a communication range of nearly 50 million miles at a 10-cps bandwidth and an antenna gain of 77 db. ■ ■

NEWS

Liquid Nitrogen to Cool Ultra-Low-Noise TWT's

Device, to Compete With Paramps, Reported at Microwave Symposium

CRYOGENICALLY cooled traveling-wave tubes that are expected to compete with parametric amplifiers as low-noise receivers are being developed by Watkins-Johnson of Palo Alto, Calif.

The company's president, Dean Watkins, speaking at the national symposium of the IRE's Professional Group on Microwave Theory and Techniques in Washington, D.C., told of plans to operate twt's in a bath of liquid nitrogen to reduce thermal noise in the tube helix.

This could result in a twt noise figure of only 1.6 db—1 db less than the best currently available twt's, Mr. Watkins declared.

Other significant accomplishments in microwave research disclosed at the PGMTT symposium included:

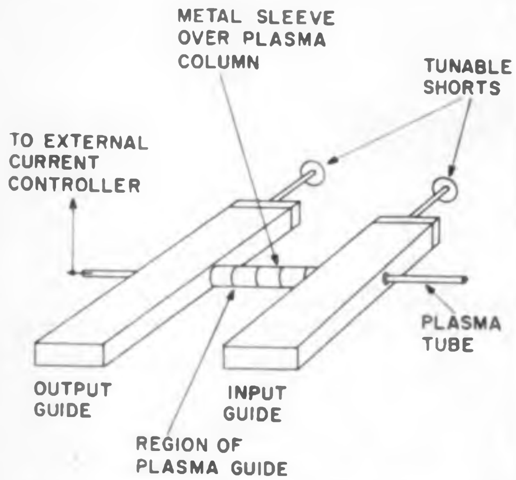
- A plasma guide selective coupler.
- Optical and quasi-optical components for the millimeter-wave range and beyond.
- A millimeter-wave Fabry-Perot maser.
- Wide-band, constant-frequency-output parametric amplifiers.
- Field-displacement ferrite devices.

Variable Microwave Coupler Employs Plasma Waveguide

The plasma coupler, developed by Space Technology Laboratories, employs a plasma column to couple two waveguides. The extent of coupling can be controlled by externally varying the density of the plasma. At plasma densities below a critical value, the guides are decoupled. As the density is raised, the coupling in increased until it eventually approaches a constant value. The device can thus be used as an electronically variable attenuator or waveguide switch.

An experimental mercury-vapor device operated at X-band had power-handling ability of 128 w. Isolation was 40 db, switching time 5 msec and insertion loss 8.5 db.

Fresnel zone plates have been used as microwave launchers in experiments at Electronic Communications Inc., Timonium, Md., the symposium was told. These plates, with focusing properties equivalent to lenses of f/1 aperture, were used to transmit millimeter waves up to 340 ft. It is thought that suitably designed zone plates



Plasma guide coupler developed by Space Technology Laboratories. By using a metal sleeve of proper size two modes of operation are sequentially achieved as plasma density is increased. These are the hollow-waveguide and rectangular-waveguide modes. The device can thus be designed so that it alternately couples, attenuates and couples as the plasma current is increased.

could eventually replace waveguides for signal transfer at millimeter-wavelengths.

Fabry-Perot Microwave Masers Are in Development at NBS

Maser effects in the millimeter-wave region have been observed in Fabry-Perot resonators at the National Bureau of Standards, Boulder, Colo. Such resonators could achieve a Q of up to 50,000 at 6.3 mm. Work is underway to develop ammonia and hydrogen cyanide Fabry-Perot masers at millimeter wavelengths, it was reported.

Development of wide-band, constant-frequency-output parametric amplifiers was reported both by the Stanford Research Institute, Palo Alto, Calif., and Airborne Instruments Laboratory, Melville, N.Y. The Stanford amplifier is an up-converter type. Output frequency is maintained constant over a wide range of input frequencies by varying the pump frequency.

The Airborne Instruments amplifier is a backward-wave type in which the idler frequency is maintained constant by varying the pump frequency. An electronically tunable octave-wide device operating below 1 Gc has been built along these lines.

Experimental field-displacement devices employing ferrites were reported by Sylvania Electric Products and Bell Telephone Laboratories. Sylvania has built a regulator and a variable attenuator having useful performance up to 7 Gc. Bell reported on an isolator operating at 57 Gc. At that frequency the forward loss of the isolator was about 1 db and reverse loss more than 60 db. Barium ferrite was employed. ■ ■

Improved Film Capacitors Are Heading for Market

Plastic, Ceramic and Cellulose Acetate Types Will Offer More Capacitance Per Unit Volume and Promise Greater Reliability

NEW TECHNIQUES are producing capacitors that offer designers more capacitance per unit volume than now available in certain price ranges and also promise greater reliability.

Some recent developments include:

- Deposition of ceramic dielectric films with sub-micron thicknesses for use in units having capacitances of up to 50 μf per sq in.
- Deposition of half-micron thick Teflon dielectric films with capacitances of about 0.7 μf per sq in.
- Production of metallized cellulose-acetate capacitors that are said to be up to 40 per cent smaller than present metalized-paper types.

The thin-film ceramic and Teflon dielectrics are being produced by gas-phase processes that appear to have important applications in electronic component production. The cellulose-acetate units are made by "peeling" techniques relatively common in production of metalized capacitors.

Two companies, Nuclear Research Associates, Inc., New York City, and Radiation Research Corp., Westbury, N.Y., are using gas-phase processes to deposit thin dielectric films. Radiation Research reports it polymerizes Teflon directly on metalized Mylar and is producing sample quantities of rolled dielectric suitable for capacitors. Nuclear Research is depositing a variety of dielectric films by a process it terms different from others. Films produced by these gas reactions are reported to have excellent adherence.

Vacuum system used in depositing sub-micron-thick dielectric films on various substrates at Nuclear Research Associates contains plasma that aids a gas-phase reaction. The dark plates in the Bell jar are electrodes, on which the deposit is forming. The reaction is being controlled here by Jerry Goldman, vice president and research director of the company.

Films Formed by Plasma Discharges Include Both Organics and Inorganics

In the gas technique, starting materials—with sufficient vapor pressure to undergo gas-phase reaction under proper conditions—are metered into a vacuum chamber. There a plasma is generated, either by electrode or electrode-less discharge. Depending on the starting materials and the proportions in which they are mixed, thin films of controlled dielectric constant are formed at low temperature by reaction of the gases with each other. The films are deposited on various substrates. The deposition can be made to tightly controlled depths and uniformities, both companies report.

So far this technique has been used for both organic and inorganic materials, mainly on dielectric films. Organic semiconductor films and bulk deposits have been formed by similar methods.

For capacitor materials, researchers have studied, among organics, Teflon, polystyrene, silicone and others. Among inorganics work has been done on titanates of lead, barium and zirconium, titanium dioxide and similar materials of widely varying compounds. The substrates used include Mylar, alumina, glass and Teflon.

In addition to being useful for dielectric and semiconducting films, the controlled-reaction technique is believed feasible for depositing conducting, insulating, photosensitive, lubricating and protective films. Nuclear Research says it has received expressions of interest in controlled-reaction-formed films of these various types from several electronic component users.

Controlled Reaction Technique is Suitable For Either Rolled or Flat Capacitors

The technique may be used either to make dielectric film suitable for rolled capacitors or to make thin-film, two-dimensional capacitors and other components. Capacitors would work in the low voltage range—from near zero to 100 v—and would combine small volume with high capacity at low cost.

At Nuclear Research controlled gas-phase reactions have been used to coat substrates with sub-micron-thick titanate film having dielectric constants of about 100. Because dielectric constant is a strong function of composition and because the company's technique is reported capable of synthesizing any material, dielectric constants can be varied over a wide range.

Breakdown voltages of up to about 200 v have been measured on single-layer devices, Nuclear Research says. It plans to produce commercial 2-D capacitors with multi-layer films that would have constants designed to customer's specifications. Multi-layer depositions would provide higher breakdown voltages or capacitances than would single layers of dielectric.

Experimental thin-film ceramic capacitors made by the company are reported to have shown capacitances of up to 50 μf per sq in. with breakdown voltages of about 10 v for single-layer films. The films were various titanates deposited on various substrates. Power factors ranged from about 10 per cent down to about 1 per cent. Resistivities ranged up to 1,000 meg-μf, the company says. Some of the films operated after being heated to more than 1,000 C, though with relatively low resistivity.

Resistivity for the ceramic thin-film dielectrics compares favorably with that of alumina and voltage breakdown limits compare well with those of plastic types, Nuclear Research reports.

Glow-Discharge Polymerizes Teflon Film On Metalized Mylar Substrate

Radiation Research is using a glow-discharge technique that it has patented to polymerize Teflon TFE fluorocarbon monomer directly on metalized Mylar to make a capacitor-grade dielectric. Its Glofilm dielectric is said to provide capacitance of about 1 μf per sq ft. The company says it expects to produce shortly capacitors that will have capacitances of from 0.01 to 10.0 μf at 50 and 100 working v dc. Capacitance density is expected to be 15 to 50 μf per cu in.

Power factors of less than 0.5 per cent at 1 kc are anticipated.

The company has also investigated deposition of polystyrene on Mylar and Teflon substrates. Quarter-mil-thick metalized Mylar substrates are used. The deposited film is 0.5 micron thick. The company reports that capacitors made with its dielectric will be 25 to 75 per cent smaller in volume than commercially available impregnated-paper types of either metalized or extended-foil construction. The dielectric sheets are said to be suitable for winding by standard equipment.

Sample rolls are available for 10 cents a foot in 1-in. rolls of 300 ft or more. Radiation Research is installing production machinery and is expected to mass-produce Glofilm at a user's cost of 10 to 20 cents per square foot or per μf in large-quantity orders. A vacuum chamber 14 ft by 20 ft will be used for deposition.

Both Radiation Research's plastic film and Nuclear Research's ceramic film are produced nominally pinhole free and capable of self-healing once in a capacitor. During manufacturing the reaction rate is greatest at thin spots in the film, because field-carrier density is greatest there; so the deposit is built up. If a thin spot or pinhole should be present in a finished capacitor, sparking would effectively seal it by vaporizing the electrode in the immediate area, as in any metalized-film capacitor. The resulting insignificant loss in capacitance is more desirable than the short circuits the pinholes would cause by permitting electrodes to touch one another.

Metalized Cellulose-Acetate Strips To Be Produced for Signal Corps

Western Electric Corp., at its Winston-Salem N.C., plant, is nearing production of general-purpose capacitors for the Army Signal Corps with metalized cellulose-acetate dielectric.

Originally developed at Bell Telephone Laboratories, these capacitors are made by coating a cellulose-acetate dielectric on a paper strip lacquered with a polystyrene and wax mixture. After a 0.003-mil thick metal film is added to the 0.13-mil cellulose acetate film, both are peeled off the paper and polystyrene.

The base is then discarded, leaving an unsupported strip of metalized cellulose acetate, which is rolled to form capacitors. These are lighter in weight and 20 to 40 per cent smaller than comparable metalized types.

Western Electric is making the prototypes of five sizes of the capacitors in 50-v ratings for operation at −55 to +85 C. The components range from 5.6 μf down to 0.1 μf in capacitance and are rated at about 15 μf per cu in. Their power factor is reported to be slightly less than 2 per cent. ■ ■

CIRCLE 9 ON READER-SERVICE CARD ➤

NEWS

PCM Telemetry Standards Given Priority by TSCC

Coordinating Group to Recommend Pcm Standards 1st, Conference Hears

DESIGNERS hoping for guidance in telemetry standardization can expect to get it first in pulse-code modulation systems. This was revealed by the Telemetry Standards Coordination Committee of the National Telemetering Conference. The coordinating group made its first full-scale report to the industry at the National Conference in Chicago.

Pcm was given first priority, according to A. E. Bentz, TSCC chairman, because it is the newest of the major systems, and standards recommended for it would have a good chance of achieving their purpose. Second priority has been assigned to pam/fm systems, the committee reported.

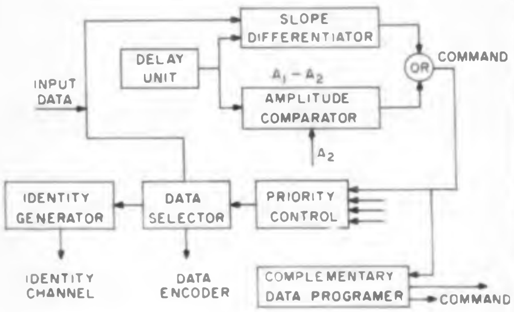
The TSCC group, which can only make recommendations, indicated that it is undecided on how detailed to make its suggestions. Committee members said they hoped that any standards eventually adopted would standardize effectively without freezing designs or inhibiting advance of the telemetering art.

However, one committee member reported that document 106-60 of the Inter-Range Instrumentation Group would probably be issued as a military standard as part of an effort to increase the influence of IRIG. The document contains telemetry standards. If any of the recommendations made by TSCC are adopted as standards they would probably be included in a revised version of 106-60, it was indicated.

Adaptive Telemetry Systems Studied To Reduce System Bandwith

The application of adaptive techniques for telemetering is being studied by several organizations, reported M. A. Lowy, Gulton Industries, Inc., Metuchen, N.J. In describing an approach being taken at Gulton to develop an adaptive system, Mr. Lowy said that bandwidth could be significantly reduced if an airborne telemetry system could be programed to send only portions of the data collected.

The approach is based on the idea that the most needed test data is that which is unexpected or which departs from design parameters. Mr. Lowy suggested a system in which data would be operated on or before coding and in which only selected data would be transmitted.



Portion of adaptive telemetry system discussed at National Telemetering Conference contains data selector between inputs and transmitter to minimize amount of data transmitted. Goal of system is to reduce telemetry bandwidth requirements, which are growing as role of telemetry gains in importance.

If data were to be chosen by a selector before encoding, Mr. Lowy said, any type of modulation could be used and maximum reductions in weight and volume would be possible.

Criteria that could be used to make decisions include rate of change and amplitude, time of occurrence and duration of an event, and comparison of two or more measurements. The adaptive system could be given a capability for sophisticated operations such as analysis of complex functions like shock and vibration.

Pcm/fm and Fm/fm Telemetry Systems Slated for First-Phase Dyna Soar Tests

First-phase tests of the Dyna Soar rocket-powered glider, which eventually will probe near-space at an altitude of 300,000 ft and speeds of up to 15,000 ft per sec, will be aided by two telemetry systems. Pcm/fm will be used to handle about 700 low-frequency, relatively high-accuracy measurements, and a special, 39-channel, fm/fm system will be used for about 40 high-frequency, relatively low-accuracy measurements. During first-stage tests, the vehicle will be launched from a mother craft at relatively low altitudes to measure handling characteristics at subsonic and transonic speeds.

Because the vehicle will be surrounded by an ion sheath during portions of its flight, reported W. M. Moore and W. D. Mace of the George Marshall Space Flight Center, Huntsville, Ala., rf transmission will be made at frequencies above 10 gc. Frequency translation will have to be used at this frequency, they reported, to give the fm/fm telemetry system a bandwidth of 290 kc, with one voice channel having a response of from 330 cps to 3 kc. ■ ■

1-Lb Satellite [illegible]gned for Space Missions

Tetrahedral Device W[illegible] Measure 2 Parameters Aloft And Transmit Informatio[illegible] to Earth Without Battery Power

Tetrahedron satellite that requires no batteries is opened by Dr. Joseph M. Denney of Space Technology Laboratories, the inventor. A small rocket could place several of the devices in orbit.

Thomas E. Mount
West Coast Editor

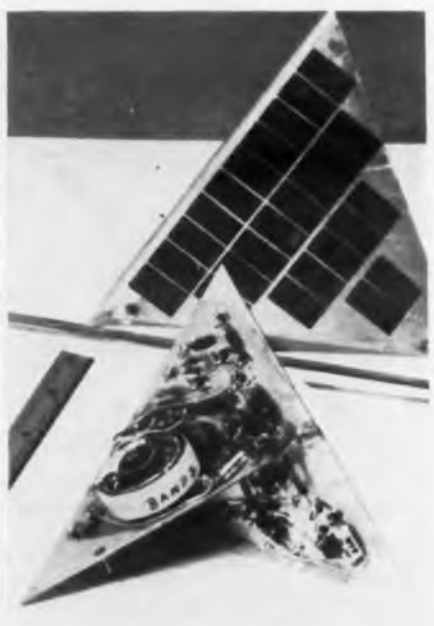
BABY tetrahedral satellites, weighing only 1 lb are designed to ride piggyback into space, measure two parameters and transmit the information to earth.

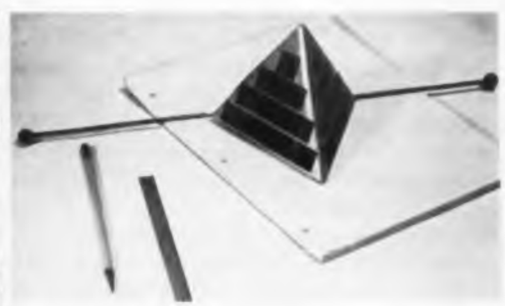
They need no batteries or regulators. They can collect their data while riding large, orbiting vehicles or can be fired into orbits of their own by small rockets.

The inventor of the tiny satellites, Dr. Joseph M. Denney, manager of the Materials Dept. of Space Technology Laboratories, Inc., Los Angeles, says the four-sided configuration is responsible for a simple, inexpensive design.

Twenty-five solar cells are mounted on each side of the prototype. "No matter how the tetrahedron tumbles," Dr. Denney said, "the power input to the solar cells is the same—there is a maximum ripple in their output of only about 15 per cent."

The area of the solar cells' intercepting solar flux increases in proportion to the decreasing angle of incidence: when a side is normal to the sun's radiation, the solar cells produce about the same electrical power as when the same side is





Extended antenna, as shown above, would transmit data from tetrahedron satellite to the earth. The configuration assures almost constant power input from the solar cells regardless of alignment of the axes. Dismantled satellite, left, shows biplanar construction of the internal package, and good shielding. Subcarrier oscillators are symmetrically placed on two of the wings. The large toroid on the third wing is an antenna loading coil.

at an angle to the sun, because one or two other sides then intercept solar flux also.

Thus an almost-constant source of power is furnished to instrumentation and telemetering equipment.

Two Ways to Solve Ripple Problems; Cooler Operation Than Usual Reported

Two techniques can be used to eliminate ripple problems, Dr. Denney said: "An fm transmitter can be designed, so the ripple only causes variation in the signal strength and can be ignored; or the transmitter can be designed to operate on the voltage level of the solar cells, which is almost constant regardless of the angle to the sun."

A bonus comes with the tetrahedral configuration, Dr. Denney reported. "Compared to normal satellites, the tetrahedron runs much cooler," he said. "With four sides, three emit infrared while only one absorbs. We have calculated that if we take the glass covers off the solar cells they will run at about room temperature. The packaging material is a good conductor like aluminum or magnesium—or if we are really interested in reducing weight, beryllium—so heat is readily transferred from side to side."

The prototype tetrahedral satellite is designed specifically to measure radiation damage. The two top solar cells on each side bias one of the voltage-controlled subcarrier oscillators. As the solar cells are damaged by radiation, the output current—and therefore the voltage modulation—change. The temperature of the solar cells is measured by thermocouples, that resistance-modulate another voltage-controlled oscillator. The two-channel transmitter is an fm unit putting out 50 mw.

According to Roy G. Downing, a member of the technical staff at Space Technology Laboratories, the solar cells provide a 1/2 w of power per side. This is more than enough for the instrumentation and transmission, he said.

"By taking advantage of all the area available on the tetrahedron, we could get a full watt—but it just isn't necessary," he added.

Many experiments require the measurement of only two parameters, and for these the baby satellites may be ideal. Experiments being proposed by the company in addition to the radiation-damage test include plasma measurements and measurements of the optical properties of surface coatings.

Magnetic-Field Measurements Possible; Three Major Program Uses Envisioned

Since the satellite is very small, it may be especially well-suited to magnetic field measurements. The sensitivity of magnetometers and the intensity of the parameters they are measuring require that the instrument be isolated as far from the satellite body as possible. The mass of the tetrahedron is so small that simply extending the magnetometer out on the end of an antenna may solve the isolation problem.

Three kinds of programs in which the tetrahedral satellite would be of major advantage were cited by Dr. Denney:

"First, if a particular large satellite is in the R&D phase, being designed for a specific mission—and you want to do other experiments that can't be fitted into the almost completed satellite—then the tetrahedron might ride piggyback on the mission. In this way the inclusion of new experiments wouldn't prejudice the completion of the major satellite.

"Second, if the experiment itself requires that it be isolated from any large bodies in space—like magnetic-field measurement, plasma experiments, sublimation measurements, or other test where you want to be sure the instrumentation is not shadowed by a large object—the tetrahedron would be very useful.

"Or, third, if you have many separate experiments to make but only a small rocket to put them into orbit, then the baby satellite is just about essential. ■ ■

NASA Gets Twin Gyro Stabilizer

Twin gyroscope controller for stabilizing satellites has been delivered to the National Aeronautics Space Administration for evaluation. This engineering model undergoing test at Chance Vought Electronics Div., Dallas, shows three twin-gyroscopic units, one for each axis of stabilization. The gyroscopes are in hermetically sealed drums. Cylinders protruding from the frames contain torquers. The uncased units visible in the foreground are amplifiers.

Ground-Air-Ground Tropo Link For FAA to Have 600-Mile Range

The Federal Aviation Agency is designing an experimental tropospheric-scatter system for communication between coastal air terminals and aircraft flying across oceans. The range of the system would be up to 600 miles. It would operate in the 118-to-136-mc vhf region.

The agency plans to install the ground-station equipment on the East Coast to test it in communications between air-traffic controllers and aircraft flying the North Atlantic.

Use of such a system would eliminate the relaying of messages through radio operators and, because of the forward-scatter techniques that would be used, would make communications more reliable than at present.

High-Gain, Low-Noise Equipment To Be Used in Air and on Ground

Some design goals outlined by the FAA are:

- Airborne-antenna gain—6 db minimum, receiving and transmitting. The antenna is to be a four-position array that would be switched by quadrants. Gain in the best direction would be 9 db. The antenna is to be mounted on the underside of the aircraft, which is considered the best location in trading off between gain and drag.
- Airborne-receiver gain—6 db. Median signal-to-noise ratio, based on a noise figure of 7 lb for the airborne receiver, is expected to be 10 lb. Received power is to be −150 db/w.
- Ground-receiver gain—33 db. Multibeam techniques involving a phased-array antenna are to be used in the ground equipment. A huge antenna is to be built to have a gain of 24 db.
- Ground-transmitter gain—36 db with 4 kw of power. This unit is to use a 4-kw linear amplifier specially designed to drive a 100-w linear amplifier already available.

Other design parameters are: for the air-ground path—basic transmission loss, 222 db, net transmission loss, 177 db; for the ground-air path—basic transmission loss, 222 db, net transmission loss, 186 db.

Procurement contracts have been written for some of the equipment. The agency expe'ts to have the system operating and some results available by early next year.

Because the main goal is positive two-way communication, the system is being designed to have reasonable circuit balance. The ground station, for instance, will not be vastly superior in performance to the airborne system, where transmitter power and antenna gain are limited.

It is hoped the system will have sufficient frequency flexibility to allow operation over the complete range from 118 to 136 mc.

Polaris Crews 'Navigate' Submarine, 'Fire' Missiles in Land Trainer

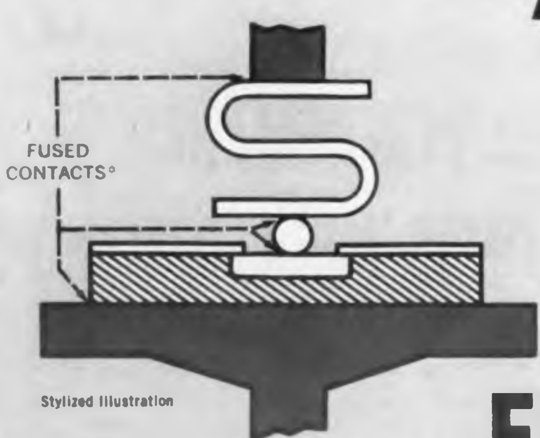
Navigational training system for Polaris submarine crews simulates three Ship's Inertial Navigation Systems (SINS), a Navigational Data Computer (NAVDAC), star-tracking periscopes and other navigational aids. Reflectone Electronics, Inc., Stamford, built the complex simulator for the Navy Submarine School, New London, Conn.

Data from all the submarine's navigational equipment are summarized in simulator's control panel, above. Selection of one of three SINS units is made by punching buttons at left. Charts at eye level show roll, pitch, latitude and longitude information. Reflectone Electronics had to use estimates of actual systems errors to make the simulation equipment perform realistically.

Commanding Officer's control panel is used to give commands for simulated Polaris missile firings. Navigational data from the ship's inertial navigation system are fed into the missile's guidance system up to the instant of firing.

Star sights through periscopes in land-based Navy trainer are used to correct small errors which develop in the inertial navigation system over long periods of underwater operation. Here an officer locates a simulated navigational star with a periscope accurate to within a few minutes of arc. When the star is located, crosshairs on a more precise periscope, accurate to seconds of arc, are centered on it. Error signals generated by the motion of the crosshairs make corrections to an assumed position previously fed into a navigation computer To compensate for ship motion during the sighting, the operator presses a mark button each time the crosshairs are exactly centered on the star.

RUGGED / RELIABLE / STABLE



FAIRCHILD SILICON FOR ALL SWITCHING AND

PLANAR PROCESS makes these diodes extremely stable. From the start of manufacturing, the surface is protected by an integral oxide coating. The junction is protected even as it is formed; the result is a diode of unsurpassed reliability.

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WASHINGTON REPORT

J. J. Christie
Washington Editor

UNIFIED STOCK PURCHASING

A plan for setting up a single manager type of supply agency for electronics has been submitted to the three military services for study. Comments and recommendations are due in about six weeks.

The proposal calls for the new group to handle the buying, cataloging, stocking and distribution of electronic replacement parts and small black-box items in common use by the three services. The agency would have its own working capital and warehouse facilities. In effect, it would serve as a "wholesaler" to the individual services, which would purchase their requirements with cash out of alloted funds.

It is also proposed that the agency do some straight purchasing of electronic gear for the three services over and above the across-the-board items it would buy for its own inventories. In this case it would only perform purchasing and cataloging, not warehousing and distribution. The purchasing would not involve major end items.

The unified supply agency would handle a substantial amount of the defense establishment's stock purchases but would still leave a major share of the buying in the hands of the services. The Pentagon estimates that the agency's purchasing authority would have applied to somewhat less than half the current electric-electronics inventory, valued at $4 billion.

A Tighter Rein on Stock Purchasing is foreshadowed by results of a General Accounting Office investigation of a sample batch of transactions covering procurement of 2,770 aeronautical replacement spare parts costing $106 million.

The GAO's findings, which flabbergasted a House Armed Services subcommittee, showed that parts orders were automatically placed with the original equipment manufacturers whether for manufacture or for purchase from suppliers. No attempts were made to deal with the prime's subs directly. Moreover, no serious efforts were made to make use of government-owned technical data or rights thereto for seeking competitive bids.

GAO officials testified that the government paid $66 million for 1,675 parts manufactured completely by subcontractors as compared to $44 million paid out by the primes. The Comptroller General noted that it was not within the scope of GAO's investigation to determine costs incurred by primes for inspection, packaging and other services or to evaluate the reasonableness of profits. Nonetheless, a host of the cost differentials cited were deemed prima facie evidence of unreasonable markups and grossly inefficient procurement practices. In one example, the Army paid $1.25 for an item which the Air Force bought for $0.27. In another, an order for armatures cost the Government $1,570,000 as compared to $740,000 paid by the prime contractor to his sub.

ANOTHER REFORM MOVEMENT

The new Administration at the Pentagon is ready to try its hand at correcting certain practices in procurement of original equipment that have become familiar targets of reform movements.

Renewed efforts will be directed toward achieving improvements in five areas:

- ***A more realistic approach to specifications.*** The objective here is to curb such wasteful tendencies as the overlooking of existing components that could do the job; the calling for higher performance characteristics than necessary; and the specification of features that cannot be justified on purely functional grounds.

- ***An end to change orders for marginal improvements.*** Cases recur where changes during production do not increase combat effectiveness commensurate with the added cost.

- ***Closer supervision of prime contractors.*** This is the old story of putting more pressure on primes to keep down costs in relation to their subcontracting and purchasing activities, particularly under cost-plus contracts.

- ***Discouragement of R&D allowances in procurement contracts.*** There is considerable doubt among top officials that R&D aimed at product refinements in the production phase is justified in most cases. The feeling is that provision for parallel R&D should be limited to products representing new developments that have considerable potential for more effective use.

- ***Stronger safeguards against serious cost underestimates.*** A tougher price redetermination attitude is considered necessary to prevent bidders on cost type of contracts from submitting unrealistic estimates for the obvious purpose of getting a contract award.

ELECTRONIC SHIP DESIGN

More efficient installation and maintenance of shipboard electronics systems eventually will result from the Navy's new program for coordinating electronic requirements with the initial design of ships.

Three industry teams are now under contract to develop integrated electronic system designs for a nuclear-powered attack submarine, a guided-missile escort vessel and guided-missile fregate. Each team includes several electronics companies and a shipbuilding firm, which will concern itself with structural design and installation problems. Heading the teams are Hazeltine, Collins Radio and General Dynamics' Electric Boat Div.

The three types of vessels selected for the program are to be built under the Navy's fiscal 1963 program. Provision undoubtedly will be made for housing a number of shipboard electronic systems in pre-wired compartments, which electronics manufacturers would fabricate for installation while the ship was being constructed. The Navy is strongly inclined toward the compartment concept because of the optimum accessibility offered for maintenance and repair.

Hughes Aircraft initiated a move in this direction by building a height-finding radar system around the compartment concept, and Lockheed Electronics is now working along the same line under another shipboard radar contract. As the ship's configuration changes, rearrangement of electronic cabinetry and new standards for racks and fittings will follow.

However, Bureau of Ships officials note that current design and feasibility studies will not result in any immediate basic design changes in shipboard electronic equipment and systems. Changes will be limited by the necessity of living with present systems for some time.

NEWS

Ultrasonics Keyed At Tool Show

Grinding Helped by Ultrasound; Many Controlled Machines Shown

IF ELECTRONIC equipment didn't actually "steal the show" at the Tool Exposition of the American Society of Tool and Manufacturing Engineers, it certainly played a prominent and dramatic role. Two types of equipment in particular received special attention at the Tool Show at New York City's Coliseum—ultrasonics and numerical control.

In the first field, a dramatic development was the entry of ultrasonics into the grinding field. Cavitron Corp. of Long Island City, N. Y., introduced an accessory for grinders which, reportedly, increases productivity by preventing "loading" of the grinding wheel. Loading, a buildup of metal between the abrasive particles on a wheel, inhibits cutting action; it dulls cutting action; and it can cause the wheel and work to heat, chatter, burn, or deform. It forces users to dress their grinding wheels often.

The Cavitron equipment, called Ever-Grind, reduces the frequency of dressing wheels; it allows the use of harder wheels with finer grits; and it makes each wheel last longer and grind better. The Ever-Grind, which can be mounted on any production grinder, agitates the normal coolant at a 20 kc rate, forming thousands of rapidly bursting bubbles per second. These

Rheem's numerical positioning control positions table, selects appropriate spindle, speed, and feed rate.

Thompson Ramo Wooldridge's three-axis contour control shown directing a Gorton rail mill.

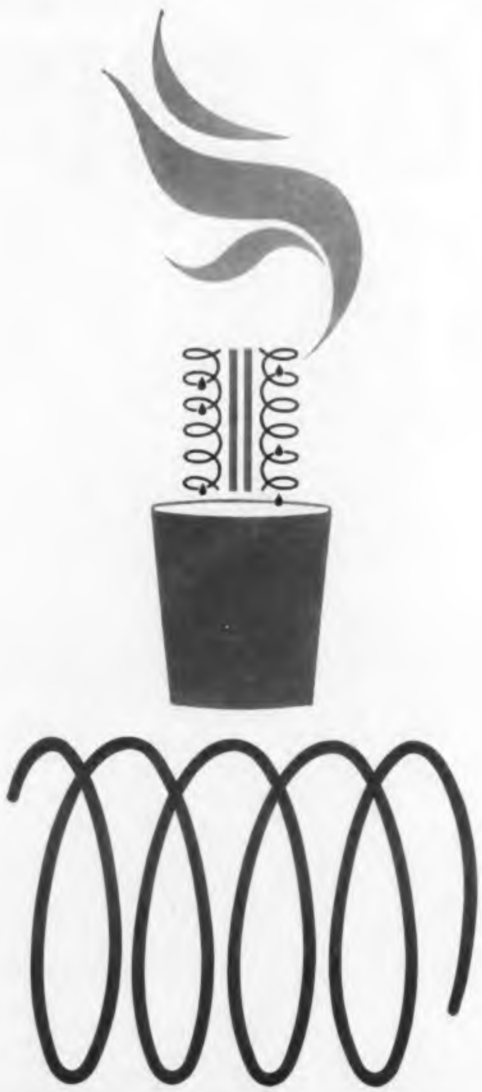
bubbles eliminate the "loading," presumably by dislodging the metal particles before they become fully lodged between the abrasive particles.

Numerical control was much in evidence at the Tool Show. Positioning units were shown by Lear's Electro-Mechanical Div. of Grand Rapids, Mich., by Ultra-Sonic Precision Co. of Mount Vernon, N. Y., by Moog Servocontrols of East Aurora, N. Y., and by Rheem Electronics of Los Angeles.

The Dage Div. of Thompson Ramo Wooldridge, Michigan City, Ind., showed a large contour control system for machine tools. It was said to be the first fully transistorized contour control in actual use.

ELECTRONIC DESIGN photos

Lear's low-cost numerical control is intended for small shop with short-run production.



NEWS

Experimental Metal Amplifiers Are Similar to Transistors

Metal Interface Amplifiers which resemble transistors in operation are under development at Philco Corp.'s Research Div., Blue Bell, Pa.

The devices consist of two metal films, separated by an insulating film, on a piece of germanium. Philco says that early models of the device have exhibited power gain at room temperature and have been used as the active element in an oscillating circuit.

Although work on the new devices is still in the early stages, researchers hope to achieve high frequency operation without the temperature dependence and susceptibility to radiation damage inherent in elements using semiconductor materials.

The devices consist of a gold layer on an aluminum oxide film, analagous to an emitter; a thin aluminum film, comparable to a transistor base; and an n-type germanium collector.

With a voltage across the terminals of the metal amplifiers, high energy electrons from the gold emitter escape across the potential barrier at the gold-aluminum oxide junction. Since the aluminum base layer (about 100 A thick) is much thinner than the mean free path of the electrons, most of the high energy electrons reach the base-emitter junction without losing energy. The electrons pass over another potential barrier at this junction, which keeps ordinary thermal electrons from crossing.

The thin metal base is said to offer less ohmic resistance than a semiconductor base. The electrons involved in the process have higher mobility than the charge carriers in semiconductor devices. These advantages must be balanced against the higher capacitance of the metal amplifiers.

The present devices are somewhat temperature dependent because of the germanium collector, but suitable metal substitutes may be found with further research.

NASA Selects RCA to Develop Relay Communication Satellite

The National Aeronautics and Space Administration has selected the Radio Corp. of America to construct the Relay experimental communication satellite. Purpose of the project is to test the feasibility of transoceanic telephone, telegraph, and TV communications using an active repeater satellite.

Contracts have been signed with the General British Post Office and the French Center for Telecommunications Studies to develop the European ground stations.

CIRCLE 248 ON READER-SERVICE CARD ➤

SILICON GENERAL PURPOSE DIODES **Package A** @ 25° C unless otherwise stated

Type	Minimum Breakdown Voltage @ 100μA	Minimum Forward Current in mA @ 1V	Maximum Inverse Current @ Specified DC Test Voltage @ 25° C (μA)	@ 150° C (mA)	Volts	Maximum Average Forward Current (mA)	Maximum Peak Recurrent Forward Current (mA)	Maximum Forward Surge Current 1 Sec (mA)	Maximum DC Inverse Voltage (Volts)
1N456	30	40	.025	.005	25	90	270	700	25
1N457†	70	20	.025	.005	60	75	225	600	60
1N458†	150	7	.025	.005	125	55	165	500	125
1N459†	200	3	.025	.005	175	40	120	400	175
1N461	30	15	.500	.030	25	60	180	550	25
1N462	70	5	.500	.030	60	50	150	500	60
1N463	200	1	.500	.030	175	30	100	400	175
1N464	150	3	.500	.030	125	40	120	400	125

† JAN Approved

SILICON COMPUTER DIODES **Package A** @ 25° C unless otherwise stated

Type	Minimum Breakdown Voltage @ 100μA	Minimum Forward Current @ Specified Voltage (mA)	Maximum Reverse Current (μA) @ 25° C	@ 100° C	Volts	Reverse Recovery: Reverse Resistance (R) (ohms)	Maximum Recovery Time (μsec)
1N625	30	4 @ 1.5	1.0	30	−20	400K	1.0
1N626	50	4 @ 1.5	1.0	30	−35	400K	1.0
1N627	100	4 @ 1.5	1.0	30	−75	400K	1.0
1N628	150	4 @ 1.5	1.0	30	−125	400K	1.0
1N629	200	4 @ 1.5	1.0	30	−175	400K	1.0
1N643‡	200	10 @ 1.0	0.025	5	−10	200K	0.3
1N643A	200	100 @ 1.0	0.025	5	−10	200K	0.3
1N658	120	100 @ 1.0	0.050	25	−50	80K	0.3
1N659	60	6 @ 1.0	5.0	25	−50	400K	0.3
1N662‡	100	10 @ 1.0	1.0	20	−10	100K	0.5
1N662A	100	100 @ 1.0	1.0	20	−10	100K	0.5
1N663‡	100	100 @ 1.0	5.0	50	−75	200K	0.5
1N663A	100	100 @ 1.0	0.1	15	−75	200K	0.3
1N837	100	150 @ 1.0	0.1	15	−75	400K	0.5
1N837A	100	150 @ 1.0	0.1	15	−80	400K	0.3
1N838	150	150 @ 1.0	0.1	15	−125	400K	0.5
1N839	200	150 @ 1.0	0.1	15	−175	400K	0.5
1N840	50	150 @ 1.0	0.1	15	−40	400K	0.3
1N844	100	200 @ 1.0	0.1	15	−80	400K	0.5
1N845	200	200 @ 1.0	0.1	15	−160	400K	0.5
HD6635	50	15 @ 1.5	1.0	30	−35	400K	1.0
HD6641	150	15 @ 1.5	1.0	100	−125	400K	1.0
HD6651	100	15 @ 1.5	1.0	30	−75	400K	1.0
HD6652	200	15 @ 1.5	1.0	30	−175	400K	1.0

* Measured in JAN 256 when switched from 30mA forward current to −35V. ** Measured in Modified IBM "Y" test when switched from 30mA forward current to −35V. *** Measured in JAN 256 when switched from 5mA forward current to −40V.
‡ Signal Corps Approved † At 150° C

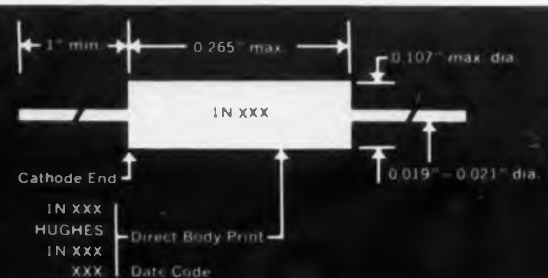
SILICON ULTRA FAST COMPUTER DIODES **Package A** @ 25° C unless otherwise stated

Type	Minimum Breakdown Voltage @ 100μA (V)	Minimum Forward Current @ 1V (mA)	Maximum Reverse Current @ 25° C (μA)	@ 100° C (μA)	Volts (V)	Reverse Recovery: Recovery Current (mA)	Recovery Time (mμsec)
HD5000	20	5	0.2	2.0	5	1	0.5
HD5001	20	5	1.0	10.0	5	1	0.5
HD5002	20	2	0.2	2.0	5	1	0.5
HD5003	20	2	1.0	10.0	5	1	0.5
HD5004	15	2	1.0	20.0	5	1	0.5

* Measured with the Lumitron scope and attachments, switching from 10mA forward to 6V reverse. The R_L = 100 ohms. Typical rectification efficiency ≥ 60%. Typical capacitance @ volts = 8μμf (measured on Boonton's Model 75A-58 capacitance bridge with applied signal voltage 50mV peak to peak).

Package A

PHYSICAL DIMENSIONS—
Note: Unless specified otherwise, 1N and HD types are direct body printed, however upon request:
1) Color bands can be used for 1N and HD types.
2) If special body markings or codings are required, allow additional .008" for outside body diameter.



SILICON HIGH CONDUCTANCE DIODES **Package A** @ 25 C unless otherwise stated

Type	Minimum Breakdown Voltage @ 100μA @ 25°C	Maximum Forward Voltage @ 100mA (Volts)	Maximum Inverse Current @ specified D.C. Test Voltage			Maximum Average Forward Current (mA)	Maximum Peak Recurrent Forward Current (mA)	Maximum Forward Surge Current 10 mSec (Amperes)	Maximum D.C. Inverse Voltage (Volts)
			@ 25°C	@ 150°C	Volts				
1N482	40	1.1	.25 μA	.030 mA	−30	100	400	1.0	36
1N482A	40	1.0	.025 μA	.015 mA	−30	200	650	2.0	36
1N482B	40	1.0	.025 μA	.005 mA	−30	200	650	2.0	36
1N483	80	1.1	.25 μA	.030 mA	−60	100	400	1.0	70
1N483A	80	1.0	.025 μA	.015 mA	−60	200	650	2.0	70
1N483B	80	1.0	.025 μA	.005 mA	−60	200	650	2.0	70
1N484	150	1.1	.25 μA	.030 mA	−125	100	400	1.0	130
1N484A	150	1.0	.025 μA	.015 mA	−125	200	650	2.0	130
1N484B	150	1.0	.025 μA	.005 mA	−125	200	650	2.0	130
1N485	200	1.1	.25 μA	.030 mA	−175	100	400	1.0	180
1N485A	200	1.0	.025 μA	.015 mA	−175	200	650	2.0	180
1N485B	200	1.0	.025 μA	.005 mA	−175	200	650	2.0	180
1N486	250	1.1	.25 μA	.050 mA	−225	100	400	1.0	225
1N486A	250	1.0	.05 μA	.025 mA	−225	200	650	2.0	225
1N487	330	1.1	.25 μA	.050 mA	−300	100	400	1.0	300
1N487A	330	1.0	.1 μA	.025 mA	−300	200	650	2.0	300
1N488	420	1.1	.25 μA	.050 mA	−380	100	400	1.0	380
1N488A	420	1.0	.1 μA	.025 mA	−380	200	650	2.0	380

GERMANIUM POINT CONTACT DIODES **Package A** @ 25 C unless otherwise stated

Type	Minimum PIV (V)	Minimum Forward Current @ +1V(mA)	Max. Reverse Current		Max. Ave. Forward Current (mA)	Maximum Forward Surge Current for 1 Sec. (mA)	Reverse Recovery			
			I_R (μA) at	V_R (V)			Max. T_{RR} (μSec)	to R (KΩ)	When Switched I_F (mA)/V_R	Circuit
1N34A	75	5	500	50	30	500				
1N38A	120	4	6	3	50	500				
1N54A	50	5	7	10	50	500				
1N55A	150	4	500	150	50	500				
1N55B	190	5	500	150	50	250				
1N58A	100	4	600	100	50	500				
1N66	60	5	50	10	50	500				
1N67A	80	4	5	5	30	300				
1N68A	130	3	625	100	30	350				
1N69A	75	5	500	50	40	400				
1N70A	125	3	300	50	30	350				
1N81A	50	3	10	10	30	350				
1N88	100	2.5	100	50	30	300				
1N89	100	3.5	100	50	30	250				
1N90	75	5	500	50	30	250				
1N95	75	10	500	50	30	250				
1N97	100	10	100	50	30	250				
1N99	100	10	50	50	30	300				
1N116	75	5	100	50	30	250				
1N117	75	10	100	50	30	250				
1N119	60	5	—see note 1—		25	500	0.5	50	30/35	IBM "Y"
1N120	—	5	—see note 2—		25	500	0.5	50	30/35	IBM "Y"
1N126	75	5	350	30	30	300				
1N126A†	75	5	850	50	30	350				
1N127	125	3	300	50	30	300				
1N127A†	125	3	300	50	30	300				
1N128†	50	3	10	10	30	300				
1N142	100	5	100	100	60	400				
1N191	60	5	—see note 1—		30	300	0.5	50	30/35	IBM "F"
1N192	70	5	—see note 2—		30	300	0.5	50	30/35	IBM "F"
1N198†	60	5	250	50 @75°C	30	300				
1N198A	100	5	250	50 @75°C	30	300				
1N198B	100	4	250	50 @75°C	30	300	0.3	100	2/6	JAN 256
1N268	30	6	25	10	30	300				
1N290	120	5	100	100	30	300				
1N294	70	5	800	50	50	500				
1N297	100	3.5	100	50	35	500				
1N298	85	30 @ +2V	250	40	50	500				
1N480	60	5	125	50 @ 60°C	35	—	0.5	50	30/35	JAN 256
1N636	60	2.5	10	10	30	300				

Notes 1. Dynamic back resistance at 55 C between −10V and −50V is 400K minimum
2. Dynamic back resistance at 55 C between −10V and −50V is 200K minimum

GERMANIUM ULTRA FAST SWITCHING DIODES **Package A** @ 25 C

Type	Min. PIV at I_R of 100μA (V)	Min. Forward Voltage Drop @ 100mA (V)	Max. Reverse Current @ Specified Reverse Voltage		Min. Rectification Efficiency (%)	Max. Capacitance @ 0 Bias & 100KC ($\mu\mu$fd)	Max. Reverse Recovery*		
			(μA)	(V)			T_{RR} (nsec)	to R (KΩ)	When Switched I_F (mA)/V_R
HD2963	7	0.65	10	5	65	4	6	2	10/−6
HD2967	4	0.75	40	2.5	65	4	6	1	3/−3

*Nanosecond Circuit. Sampling scope. R_L = 100Ω

GERMANIUM GOLD BONDED DIODES **Package A** @ 25 C unless otherwise stated

Type	Minimum PIV (V)	Minimum Forward Current @ +1V(mA)	Max. Reverse Current I_R (µA)	at V_R (V)	Max. Ave. Forward Current (mA)	Maximum Forward Surge Current for 1 Sec. (mA)	Reverse Recovery Max. T_{RR} (µSec)	to R (KΩ)	When Switched I_F (mA)/V_R	Circuit
1N96	70	20	500	50	30	250				
1N96A	75	40	500	50	30	400				
1N98	100	20	100	50	30	250				
1N98A	100	40	100	50	30	250				
1N100	100	20	50	50	30	300				
1N100A	100	40	50	50	30	250				
1N118	70	20	100	50	30	250				
1N118A	75	40	100	50	70	400				
1N133	6	3 @ 0.5	300	5	50	500				
1N139	40	20	1500	50	50	500				
1N140	70	40	300	50	85	750				
1N141	70	20	50	50	70	500				
1N143	100	40	100	100	85	750				
1N270†	100	200	100	50	60	500				
1N273	35	100	20	20	80	450				
1N276†*	60	40	100	50	40	400	0.3	80	5/40	JAN 256
1N277†**	100	100	75	10 @ 75°C	75	400	0.3	80	5/40	JAN 256
1N278	50	20	125	50 @ 75°C	35	175				
1N279	30	100	200	20	80	450				
1N281†	75	100	500	50	75	400				
1N283	20	200	20	10	60	500				
1N287	40	20	500	60	75	500				
1N288	70	40	350	50	75	750				
1N289	70	20	50	50	70	500				
1N291	100	40	100	100	85	400				
1N292	70	100	200	50	85	150				
1N634	115	50	115	100	60	300				
1N695		100	20	10		400	0.3	25	5/20	JAN 256
1N770	30	15 @ 0.5	15	10	40	300	0.35	15	5/10	IBM "Y"
1N835	30	100	200	30	75	350				

† JAN versions available. * JAN version specifies no reverse recovery and has a PIV of 100V. ** NonJAN version specifies no reverse recovery

PNP SILICON TRANSISTORS @ 25 C

Type Number	Case Style **	Dissipation (mW)	Breakdown Voltages (@ −100µA) BV_{CBO}	BV_{EBO}	BV_{CEO}	f_t (Mc) Min.	Typ.	Switching Times (Nanoseconds) t_d+t_r	t_s+t_f	h_{FE} ($I_C=-10mA$, $V_{CE}=-1V$) Min.	Max.	I_{CBO}* (µAdc) Max.	C_{ob} (pf) Max.	V_{CE} (SAT) (Vdc)	Operating Temperature °C
DOUBLE DIFFUSED MESA SWITCHING															
2N1254	D	275	−30	−5	−30	30	45	25	40	25	50	−0.2	10	−0.3	−65 to +175
2N1255	D	275	−30	−5	−30	50	60	25	60	40	80	−0.2	10	−0.3	−65 to +175
2N1256	D	275	−40	−5	−40	30	45	25	40	25	50	−0.2	10	−0.3	−65 to +175
2N1257	D	275	−40	−5	−40	50	60	25	60	40	80	−0.2	10	−0.3	−65 to +175
2N1258	D	275	−30	−5	−30	50	60	25	60	75	150	−0.2	10	−0.3	−65 to +175
2N1259	D	275	−50	−5	−50	40	50	25	60	25	100	−0.2	10	−0.3	−65 to +175
ALLOY JUNCTION GENERAL PURPOSE							$f_{\alpha b}$ (Mc) Typ ($V_{CB}=-5V$, $I_E=1mA$)			h_{fe} ($V_{CB}=-5V$, $I_E=2mA$)					
2N1228	D	400	−15	−15	−15		1.2			14	32	−0.1	95	−0.2	−65 to +160
2N1238	C	1W	−15	−15	−15		1.2			14	32	−0.1	95	−0.2	−65 to +160
2N1229	D	400	−15	−15	−15		1.2			28	65	−0.1	95	−0.2	−65 to +160
2N1239	C	1W	−15	−15	−15		1.2			28	65	−0.1	95	−0.2	−65 to +160
2N1230	D	400	−35	−35	−35		1.2			14	32	−0.1	95	−0.2	−65 to +160
2N1240	C	1W	−35	−35	−35		1.2			14	32	−0.1	95	−0.2	−65 to +160
2N1231	D	400	−35	−35	−35		1.2			28	65	−0.1	95	−0.2	−65 to +160
2N1241	C	1W	−35	−35	−35		1.2			28	65	−0.1	95	−0.2	−65 to +160
2N1232	D	400	−60	−60	−60		1.0			14	32	−0.1	95	−0.2	−65 to +160
2N1242	C	1W	−60	−60	−60		1.0			14	32	−0.1	95	−0.2	−65 to +160
2N1233	D	400	−60	−60	−60		1.0			28	65	−0.1	95	−0.2	−65 to +160
2N1243	C	1W	−60	−60	−60		1.0			28	65	−0.1	95	−0.2	−65 to +160
2N1234	D	400	−110	−110	−110		0.8			14	32	−0.1	95	−0.2	−65 to +160
2N1244	C	1W	−110	−110	−110		0.8			14	32	−0.1	95	−0.2	−65 to +160
ALLOY JUNCTION GENERAL PURPOSE										h_{FE} ($I_E=-1mA$, $V_{CE}=-5V$)					
2N327A	D	385	−50	−20	−40		1.2			9	22	−0.1			−65 to +160
2N328A	D	385	−50	−20	−35		1.2			18	44	−0.1			−65 to +160
2N329A	D	385	−50	−20	−35		1.2			36	88	−0.1			−65 to +160
DOUBLE DIFFUSED IF AMPLIFIER							($V_{CB}=-10V$, $I_E=10mA$)	Power Gain (db) ($V_{CE}=-10V$, $I_E=-2mA$)							
2N1196	D	350	−70	−4	−70		40	20 @ 4.3Mc				−0.25	4		−65 to +200
2N1197	D	350	−70	−4	−70		45	20 @ 12.5Mc				−0.25	4		−65 to +200

* @ 80% of Breakdown Voltage (Except 2N1196 & 7 which are measured @ $V_{CB}=-20Vdc$)

MESA MEDIUM POWER GENERAL PURPOSE

Type Number	Case Style **	Dissipation (mW)	Breakdown Voltages (V) BV_{CBO} (@ -100µA)	BV_{EBO} (@ -1mA)	LV_{CEO} (@ 10mA)	f_t min. (mc)	Switching Times (Nanoseconds) t_d+t_r	t_s+t_f	h_{FE}‡ min	max	I_{CBO} Max. @ 25°C	@ 150°C	Volts	Operating Temperature (°C)
2N1131	D	750	−50	−5	−35	50			20	45	1.0	100	−30	−65 to +175
2N1131A	D	750	−60	−5	−40†	50	45	35	20	45	0.5	50	−45	−65 to +175
2N1132	D	750	−50	−5	−35	60			30	90	1.0	100	−30	−65 to +175
2N1132A	D	750	−60	−5	−40†	60	45	35	30	90	0.5	50	−45	−65 to +175

** See Physical Dimensions

† LV_{CEO} @ 100mA pulsed. Storage Temperature −65 C to +300 C. ‡ Conditions: $V_{CE}=-10Vdc$, $I_C=-150mAdc$, 2% duty cycle, 1mSec pulse

SILICON RECTIFIER STUD PACKAGE **Package F** @ 25 C

Type	PIV	Maximum DC Current (Amps)
1N1124	200	3
1N1125	300	3
1N1126	400	3
1N1127	500	3
1N1128	600	3
1N1199	50	12
1N1200	100	12
1N1201	150	12
1N1202	200	12
1N1203	300	12
1N1204	400	12
1N1205	500	12
1N1206	600	12
1N1341	50	6
1N1342	100	6
1N1343	150	6
1N1344	200	6
1N1345	300	6
1N1346	400	6
1N1347	500	6
1N1348	600	6
1N1612	50	5
1N1613	100	5
1N1614	200	5
1N1615	400	5
1N1616	600	5
1N2246	50	10
1N2248	100	10
1N2250	200	10
1N2252	300	10
1N2254	400	10
1N2256	500	10
1N2258	600	10
1N2260	800	10
1N2262	1000	10

Package F

Package C

Package D

Package E

Cartridge Case Styles

RECTIFIER STUD PACKAGE

Package F Insulated Base

Type	PIV	Maximum DC Current (Amps)
1N2147	50	6
1N2148	100	6
1N2149	200	6
1N2150	300	6
1N2151	400	6
1N2152	500	6
1N2153	600	6
1N2565	50	6
1N2566	100	6
1N2567	200	6
1N2568	300	6
1N2569	400	6
1N2570	500	6
1N2571	600	6
1N2572	700	6
1N2573	800	6
1N2574	900	6
1N2575	1000	6
1N2576	50	12
1N2577	100	12
1N2578	200	12
1N2579	300	12
1N2580	400	12
1N2581	500	12
1N2582	600	12
1N2583	700	12
1N2584	800	12
1N2585	900	12
1N2586	1000	12

SILICON RECTIFIER CERAMIC PACKAGE **Package B** @ 25 C

Type	PIV	Maximum DC Current (mA)
1N645	225	400
1N646	300	400
1N647	400	400
1N648	500	400
1N649	600	400

SILICON RECTIFIER GLASS PACKAGE

Package A @ 25 C

Type	PIV	RMS (V)	Maximum Average Rectified Current (mA)	Maximum Surge Current 1 Cycle (Amp)
1N846	50	35	200	2
1N847	100	70	200	2
1N848	200	140	200	2
1N849	300	210	200	2
1N850	400	280	200	2
1N851	500	350	200	2
1N852	600	420	200	2
1N857	50	35	150	1.5
1N858	100	70	150	1.5
1N859	209	140	150	1.5
1N860	300	210	150	1.5
1N861	400	280	150	1.5
1N862	500	350	150	1.5
1N863	600	420	150	1.5
1N868	50	35	100	1.0
1N869	100	70	100	1.0
1N870	200	140	100	1.0
1N871	300	210	100	1.0
1N872	400	280	100	1.0
1N873	500	350	100	1.0
1N874	600	420	100	1.0
1N879	50	35	50	0.5
1N880	100	70	50	0.5
1N881	200	140	50	0.5
1N882	300	210	50	0.5
1N883	400	280	50	0.5
1N884	500	350	50	0.5
1N885	600	420	50	0.5

Maximum Average Rectified Reverse Current: 20μA
Storage Temperature: −65 C to +200 C

Package B

SILICON HIGH VOLTAGE CARTRIDGE RECTIFIERS @ 25 C

Type	Cartridge Sizes	Rated PIV (see note 1)	Rectified DC Output Current	Maximum DC Forward Voltage Drop @ 100mAdc
1N596	.375" dia. x ½"	600	150	3
1N597	.375" dia. x ½"	800	150	3
1N598	.375" dia. x ½"	1000	150	3
1N1406	.375" dia. x ½"	600	125	5
1N1407	.375" dia. x ½"	800	125	5
1N1408	.375" dia. x ½"	1000	125	5
1N1409	.375" dia. x ½"	1200	125	5
1N1410	.375" dia. x ½"	1500	125	6.25
1N1411	.375" dia. x 1"	1800	125	7.50
1N1412	.375" dia. x 1"	2000	125	6.25
1N1413	.375" dia. x 1"	2400	125	7.50
1N1730	.375"dia. x ½"	1000	200	5
1N1731	.375"dia. x ½"	1500	200	5
1N1732	.375" dia. x 1"	2000	200	9
1N1733	.375" dia. x 1"	3000	150	12
1N1734	½" dia. x 1"	5000	100	18
1N2382	½" dia. x 1"	4000	150	18
1N2383	½" dia. x 1½"	6000	100	27
1N2384	½" dia. x 1½"	8000	70	27
1N2385	½" dia. x 2"	10000	70	39
1N3052	½" dia. x 4"	12000	100	70
1N3053	½" dia. x 4"	14000	100	75
1N3054	½" dia. x 5"	16000	100	80
1N3055	½" dia. x 5"	18000	100	85
1N3056	½" dia. x 6"	20000	100	90
1N3057	½" dia. x 6"	22000	100	95
1N3058	½" dia. x 7"	24000	100	100
1N3059	½" dia. x 7"	26000	100	105
1N3060	½" dia. x 8"	28000	100	120
1N3061	½" dia. x 8"	30000	100	125

1. Continuous DC Rating Same as PIV. Operating Temperature Range −55 C to +150 C Ambient.
Maximum DC Reverse Current @ Rated PIV: 10μA.
Hughes will also supply custom assemblies for your requirements.

NPN SILICON TRANSISTORS **MESA HIGH SPEED SWITCHING**

Package E

Type Number	Case Style **	Dissipation (mW)	Breakdown Voltages (@ $-100\mu A$) BV_{CBO}	BV_{EBO}	BV_{CEO}	f_t (Mc) Min.	Typ.	Switching Times (Nanoseconds) t_{on}	t_s	t_{off}	h_{FE} ($I_C = -10mA$, $V_{CE} = -1V$) Min.	Max.	I_{CBO} (μAdc) Max.	C_{ob} (pf) Max.	$V_{CE(SAT)}$ (Vdc)	Junction Temperature (T_j) °C
2N706	E	1W*	−25	−3		200			60		20		−0.5	6	−0.6	−65 to +175
2N706A	E	1W*	−25	−5	−15	200		40	25	75	20	60	−0.5	5	−0.6	−65 to +175
2N753	E	1W*	−25	−5	−15	200		40	35	75	40	120	−0.5	5	−0.6	−65 to +175
2N707	E	1W*	−56	−4			400	— 80 typ (1) —			9		−5.0	10	−0.6	−65 to +175

(1) rb' C_c $\mu\mu$sec Storage Temperature: −65 C to +200 C * @ 25 C case

SILICON VOLTAGE REGULATOR DIODES **Package A, Package G** @ 25 C unless otherwise stated

Type	Zener Breakdown Voltage (Volts D.C.) (V_Z or E_Z) Min.	Nom.	Max.	D.C. Test Current (I_Z) (mA)	* Max. Dynamic Impedance (Z_D) (ohms)	@ mAdc
GLASS PACKAGE "A"						
1N702	2.0	2.6	3.2	5	60	10
1N702A	2.47	2.6	2.73	5	60	10
1N703	3.0	3.45	3.9	5	55	10
1N703A	3.28	3.45	3.62	5	55	10
1N704	3.7	4.1	4.5	5	45	10
1N704A	3.9	4.1	4.3	5	45	10
1N705	4.3	4.85	5.4	5	35	10
1N705A	4.6	4.85	5.1	5	35	10
1N706	5.2	5.8	6.4	5	20	10
1N706A	5.51	5.8	6.09	5	20	10
1N707	6.2	7.1	8.0	5	10	10
1N707A	6.75	7.1	7.45	5	10	10
1N708	5.04	5.6	6.16	25	3.6	25
1N708A	5.32	5.6	5.88	25	3.6	25
1N709	5.58	6.2	6.82	25	4.1	25
1N709A	5.89	6.2	6.51	25	4.1	25
1N710	6.12	6.8	7.48	25	4.7	25
1N710A	6.46	6.8	7.14	25	4.7	25
1N711	6.75	7.5	8.25	25	5.3	25
1N711A	7.12	7.5	7.88	25	5.3	25
1N712	7.38	8.2	9.02	25	6.0	25
1N712A	7.79	8.2	8.61	25	6.0	25
1N713	8.19	9.1	10.01	12	7.0	12
1N713A	8.64	9.1	9.56	12	7.0	12
1N714	9.0	10	11.0	12	8.0	12
1N714A	9.5	10	10.5	12	8.0	12
1N715	9.9	11	12.1	12	9.0	12
1N715A	10.45	11	11.55	12	9.0	12
1N716	10.8	12	13.2	12	10	12
1N716A	11.4	12	12.6	12	10	12
1N717	11.7	13	14.3	12	11	12
1N717A	12.35	13	13.65	12	11	12
1N718	13.5	15	16.5	12	13	12
1N718A	14.25	15	15.75	12	13	12
1N719	14.4	16	17.6	12	15	12
1N719A	15.2	16	16.8	12	15	12
1N720	16.2	18	19.8	12	17	12
1N720A	17.1	18	18.9	12	17	12
1N721	18.0	20	22.0	4	20	4
1N721A	19.0	20	21.0	4	20	4
1N722	19.8	22	24.2	4	24	4
1N722A	20.9	22	23.1	4	24	4
1N723	21.6	24	26.4	4	28	4
1N723A	22.8	24	25.2	4	28	4
1N724	24.3	27	29.7	4	35	4
1N724A	25.65	27	28.35	4	35	4

Type	Zener Breakdown Voltage (Volts D.C.) (V_Z or E_Z) Min.	Nom.	Max.	D.C. Test Current (I_Z) (mA)	* Max. Dynamic Impedance (Z_D) (ohms)	@ mAdc
1N725	27.0	30.0	33.0	4	42	4
1N725A	28.5	30.0	31.5	4	42	4
1N761	4.3	4.85	5.4	10	55	10
1N762	5.2	5.8	6.4	10	20	10
1N763	6.2	7.1	8.0	10	8	10
1N764	7.5	8.75	10.0	10	15	10
1N765	9.0	10.5	12.0	5	50	5
1N766	11.0	12.75	14.5	5	70	5
1N767	13.5	15.75	18.0	5	120	5
1N768	17.0	19.0	21.0	5	200	5
1N769	20.0	23.5	27.0	5	300	5
1N1929	5.1	5.65	6.2	5	8	10
1N1930	6.2	6.85	7.5	5	7	10
1N1931	7.5	8.3	9.1	5	15	10
1N1932	9.1	10.05	11.0	5	22	10
1N1933	11.0	12.0	13.0	1	30	5
1N1934	13.0	14.5	16.0	1	50	5
1N1935	16.0	18.0	20.0	1	70	5
1N1936	20.0	22.0	24.0	1	100	5
1N1937	24.0	27.0	30.0	1	200	3
SINGLE-ENDED PACKAGE "G"						
1N465	2.0		3.2	5	60	10
1N465A	2.47		2.73	5	60	10
1N466	3.0		3.9	5	55	10
1N466A	3.28		3.62	5	55	10
1N467	3.7		4.5	5	45	10
1N467A	3.89		4.31	5	45	10
1N468	4.3		5.4	5	35	10
1N468A	4.61		5.09	5	35	10
1N469	5.2		6.4	5	20	10
1N469A	5.51		6.09	5	20	10
1N470	6.2		8.0	5	10	10
1N470A	6.74		7.46	5	10	10
1N1313	7.5		10.0	0.2		
1N1313A	8.31		9.19	0.2		
1N1314	9.0		12.0	0.2		
1N1314A	9.97		11.03	0.2		
1N1315	11.0		14.5	0.2		
1N1315A	12.11		13.39	0.2		
1N1316	13.5		18.0	0.2		
1N1316A	14.96		16.54	0.2		
1N1317	17.0		21.0	0.2		
1N1317A	18.05		19.95	0.2		
1N1318	20.0		27.0	0.2		
1N1318A	22.32		24.68	0.2		
1N1319	25.0		32.0	0.2		
1N1319A	27.07		29.93	0.2		

* Dynamic impedance (Z_D) is measured at the dc test current noted with 60 cps ac current superimposed
RMS voltage of ac current ≤ 10% of dc test current

NOTES: 1. Operating Temperature Range −65 C to +175 C
2. Maximum Power Rating . . . 250mW; derate 1.5mW/ C above 50 C
3. Types 1N708 thru 1N725 have a voltage tolerance of ±10% nominal voltage listed
4. Suffix "A" denotes ±5% tolerance identified by dotted third color band on glass body or direct print on encapsulation

SILICON CAPACITORS **Package A** @ 25 C

Type	* Capacity ±20% @ −4Vdc (pf)	Maximum Voltage (Vdc)	Typical Capacity Range @ 0.1V to Max. Voltage (pf)	** Typical Q @ Max. Voltage @ 5mc	@ 50mc
1N950	35	130	6 to 88	360	39
1N951	50	80	12 to 120	330	36
1N952	70	60	20 to 170	270	30
1N953	100	25	46 to 240	200	23
1N954	35	25	14 to 88	175	20
1N955	50	25	22 to 120	175	20
1N956	70	25	32 to 170	175	20

Package A

Operating Temperature Range −65 C to +150 C
Maximum Leakage Current (From Bias Voltage Supply): 1μA @ 25 C, 50μA @ 150 C
Capacitance Variation over Rated Temperature Range: 300 Parts per Million / C Max
* Measured with Boonton model 75AS8 Capacitance Bridge
** Measured with Boonton Q model 260A

SILICON STABISTORS **Package A** @ 25°C

Type	Minimum Breakdown Voltage @ 100µA (Vdc)	Maximum Forward Voltage @ 100mA (Vdc)	Maximum Inverse Current @ Spec. DC Test Voltage		Maximum Average Forward Current (mA)	Maximum Peak Recurrent Forward Current (mA)	Maximum Forward Surge Current 1Sec. (Amps)	Maximum DC Inverse Voltage (V)
			@ 25°C (µA)	Volts (Vdc)				
1N929	25	20	0.1	−20	250	630	1.0	20
1N930	75	20	0.1	−50	250	630	1.0	50
1N931	125	20	0.1	−100	250	630	1.0	100
1N932	250	20	0.1	−200	250	630	1.0	200

Operating Temperature: −65°C to +175   Storage Temperature: −65°C to +200°C   Derating Factor 1.8mW/°C

CRYSTAL FILTERS

Types — Frequency	Bandwidth (Kc)	Shape Factor 60db/3db	Maximum Passband Ripple (db)	Maximum Insertion Loss (db)	Impedance In, Out (ohms)	Carrier Rejection (db)	Approximate Size (cubic inches)
10Mc Bandpass Filter	40 @ 3db	2.2:1	0.75	6	1.5K		2.5
100Kc Bandpass Filter	2 cps @ 6db	5:1 (30db/6db)		14	1 K		11.7
30Mc Bandpass Filter	108 @ 3db	2.1:1	±1	8	2.0K		3
1.75Mc Upper Sideband Filter	2.7 @ 3db	1.3:1 (Carrier Side)	±0.5	3	50	55	8.5
2Mc Upper Sideband Filter	7.0 @ 3db	1.3:1 (Carrier Side)	±0.5	6	6.8K	27.5	8
1.75Mc Lower Sideband Filter	2.7 @ 3db	1.3:1 (Carrier Side)	±0.5	3	50	55	8.5
1Mc Discriminator	±1.5		Linearity ±2% over 90% band	Efficiency DC out/AC in 0.7 min.	In = 50 Out = 1 meg.		3.7

All specifications determined at room temperature

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Full scale production facilities are now available for the Hughes developed CUP technique for casting silicon and germanium of the highest optical quality for infra-red optics as well as other possible uses.

Optical blanks with complex curvatures in silicon (up to 12½" diameter) and in germanium (up to 15" in diameter) can now be cast routinely.

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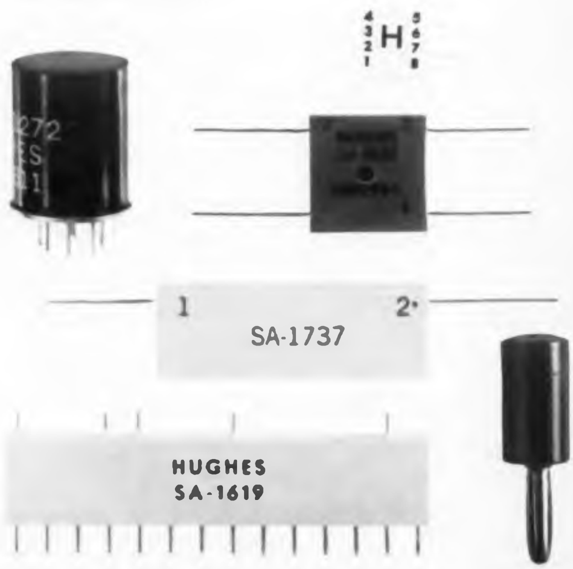
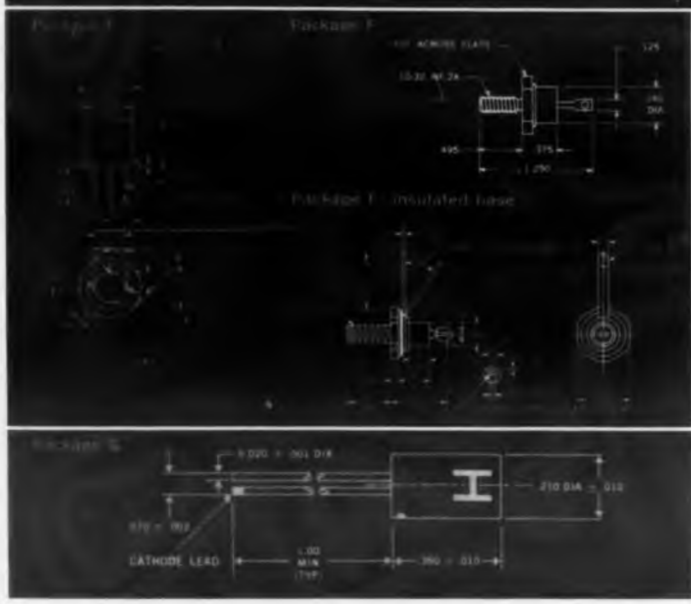


PACKAGE DIMENSIONS All dimensions maximum unless otherwise stated



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War on RFI "Improving," Defense Dept. Reports

The Dept. of Defense is claiming "some improvement" in combating radio frequency interference (RFI) through its Electromagnetic Compatibility Program.

The program is a joint effort by the Army, Navy and Air Force to obtain "spectrum signatures" for all electronic equipment for use in gaging mathematically the RFI in any environment where the equipment might be used.

Henry Randall, a Defense Dept. coordinator for the program, told the Seventh Regional IRE Conference in Phoenix, Ariz., that improvements in frequency management and the design of equipment and systems were being stressed equally by the military.

Computers to Help Determine Compatibility of Equipment

The frequency-management portion of the program includes the use of computer techniques to determine compatibility among the mass of military and commercial equipment in a given area. The computers make use of the spectrum signatures, which contain transmitter and receiver characteristics of the equipment.

Among other parts of the frequency-management program are these:

- Collection of a geographic configuration file.
- Establishment of a Joint Analysis Center.
- Improved frequency allocation procedures based on information derived from the analysis center.

Major R&D Goals Listed; Single Allocation Control Urged

In the R&D area, major items on the program include:

- Improved instrumentation for anti-RFI work.
- Establishment of new standard test techniques.
- Concentrated efforts towards RFI reduction in early stages of design.
- A comprehensive training program for all involved personnel, from design engineer to field technician, to educate them to the pitfalls of RFI and methods of correction.

Commenting on the grave need for interference reduction, Daniel Noble, executive vice president of Motorola, Inc., cited the need for a single body to control frequency allocation. At present the FCC is responsible for nonmilitary frequency assignments, while the Interdepartmental Radio Advisory Commission is concerned with military frequency needs. Proper spectrum management under a single body, Mr. Noble argued, would permit appropriate space assignments, integrated uses of the spectrum and spectrum conservation.

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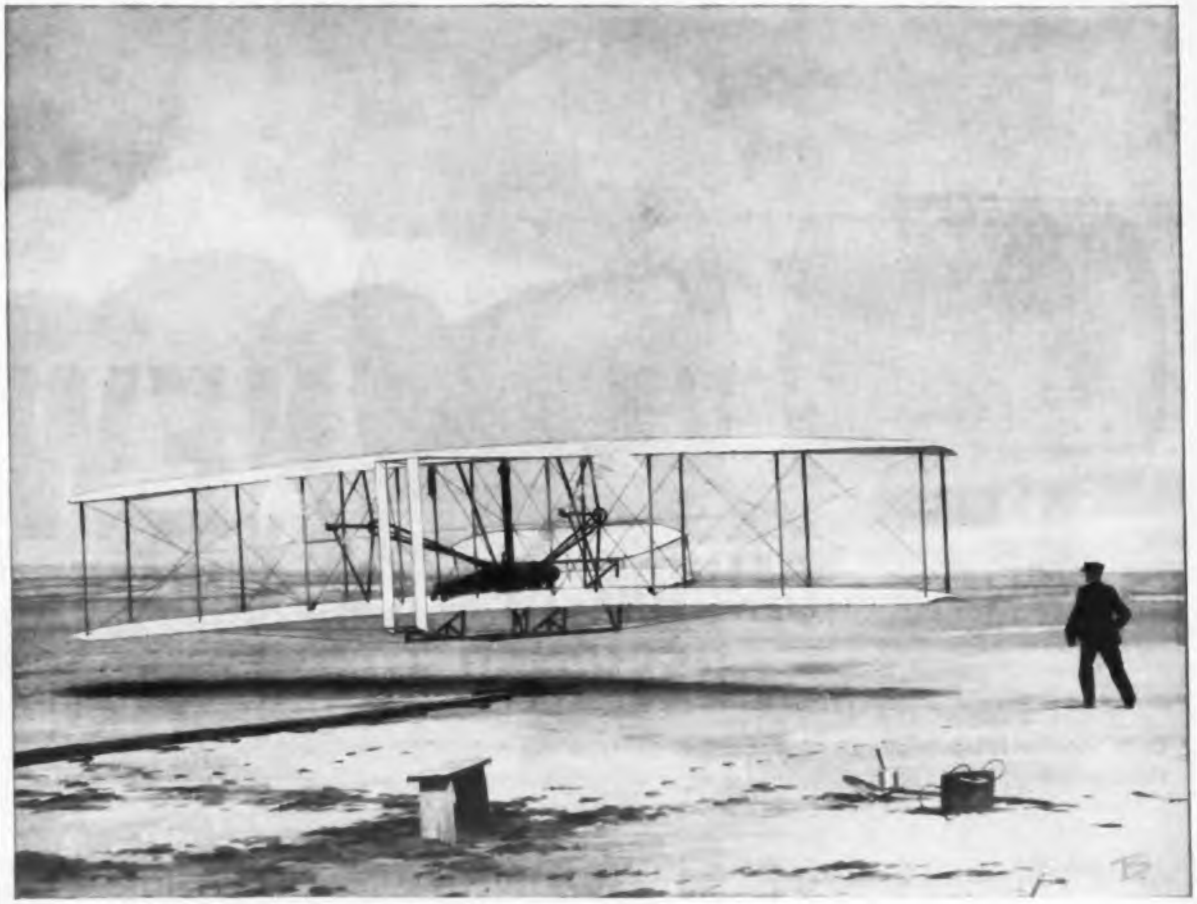

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SUPERSYSTEMS

Raise Super Engineering Problem:

WHAT to Design

A reorientation of thinking is needed by designers, based on the interrelationships of many different subsystems and individual equipments. In supersystems work a successful design is not enough. The sum of the parts must equal the whole.

ADVENT of the "supersystems" era is adding a new dimension to electronic design engineering. In designing for massive integrated networks it is no longer good enough for a circuit, a piece of equipment, or a subsystem to work. It must also mesh perfectly with all other components of the supersystem, and make the maximum possible contribution to the performance of the system's total function.

The systems engineer has problems far removed from the filling of black boxes. His problems are conceptual–political implications, cost minimization, reliability, state-of-the-art limitations–to cite a few. As systems grow steadily larger and more complicated the separation between systems and circuit designers becomes even wider.

Flaws in supersystems can often be traced to the lack of communication between the systems designers and the engineer who puts the circuits together. If the supersystems of the future are to accomplish objectives in an optimum manner, these lines of communication must be established.

If this is to be achieved, design engineers must become familiar with the total concepts behind the systems for which they are designing equipment. This report is a step in this direction.

Presented on these pages are the views of many of the top systems engineers and scientists now planning the supersystems of the future. Although the supersystems trend began in the military, it now extends into almost every branch of the industry. Therefore representative systems planned for the military, for business and industry, for space, and for public service are described in broad terms. Fundamental concepts, major limitations, and remaining problems are detailed for design engineer readers.

Contents

(This ELECTRONIC DESIGN Staff Report was written by **Thomas E. Mount,** West Coast Editor; **Robert Haavind,** Chief News Editor; and **Alan Corneretto,** News Editor.)

Systems Design Hinges on Trade-Offs; Reliability

TRADE-OFFS and reliability are "musts" in the design of modern electronic supersystems. Top systems managers, like Space Technology Laboratories, Hughes Aircraft Company, Convair, Lockheed, and Jet Propulsion Laboratories, reveal far less concern with technological breakthroughs or the design of components than with the need for conceptual design, systems analysis and integration.

"On the component level," says Jet Propulsion Laboratories' W. E. Giberson, "there are many ways of generating a desired function. The state of the art is continually improving—in fact, the expansion of the technical art has been far greater than the social and communications art."

Speaking of the construction of even so exotic a system as a spaceship, Mr. Giberson says:

"The main problems are not technical. They are conceptual. You can make a conceptual decision, proceed with the construction of a system and then find you have made a decision such that the whole system falls apart due to the interrelation of subsystems."

Many Disciplines Involved, And EEs Adapt Very Well

The problem of subsystem integration and interrelation is one that cuts across many disciplines. According to experienced systems builders, many systems managers fail in this area, ending up with a number of excellent subsystems and a complete system that doesn't work.

Systems managers point out that the systems engineer must keep the broad picture in mind. He must not only have a good technical background and wide interests but must also not become so enamored of any particular subsystem or technique that he subconsciously rejects other, perhaps more practical, techniques.

The concensus among systems managers is that "electronickers," as electronic designers are called in space and missile laboratories, make the best systems engineers.

"Obviously you need chemists, mechanical engineers, thermal designers and the like," said one space scientist, "but electronickers, because of their background in trade-offs, generally succeed where others might fail. They face a constant trade-off of gain margin versus phase margin, power dissipation versus high speed, for example. Structural people have some trade-off experience, too, of course, but the combinations and permutations are vastly fewer than those facing the electronicker every morning."

Over-Designing Must Be Shunned: The 'Most' Not Always Wanted

The trade-off and integration problem sometimes has results that baffle component manufacturers. One power-supply designer complained: "We broke our backs designing a power supply for the Ranger program. It's got everything. But they didn't buy it."

The systems manager explained that with a power system limited to the relatively low efficiency of solar cells and the area allotted to them, serial components like regulators were minimized. One central regulator was used, with several transformer regulators in parallel. If the load on one of the transformer regulators changed, a change in impedance would be reflected all the way back through the network. Under these conditions the power supply was vastly overdesigned.

"In the segment of industry that supplies components, they can't understand why we don't necessarily want the most accurate, highest efficiency components," says Dr. George Mueller, vice president of program planning and development at Space Technology Laboratories. "Like an improved sun sensor that requires more power—we have sun sensors that are fine right now. We often have to sacrifice accuracy for simplicity and reliability, too."

Three Keys to Success

Successful electronic systems call for expert use of trade-offs by designers. When considering trade-offs, the designer must ensure:

- **That the electronic design doesn't interfere with the thermal design of equipment.**
- **That the constraints, both physical and electrical, of the mission or performance of the system are satisfied.**
- **That all subsystems have electrical and mechanical interfaces that mesh neatly.**

Reliability Forcing Military To Order Redundant Systems

In the military tactical and space field particularly, the most-often mentioned problem is reliability. Trends in this area seem to be toward redundancy.

"The cost of getting a space vehicle to the moon is so fantastically high that we can't depend on a single system. We must have redundant, parallel systems," says David Conrad, manager of program control for lunar systems at Aeronutronics.

Another scientist observes: "Perhaps we will be able to obtain the kind of reliability inherent in animals. When animals have part of a function destroyed, parallel functions may take over. The advances in microminiaturization and the bioelectronics studies point the way to this solution to the problem."

Robert Wickersham, director of customer requirements at Space Technology Laboratories agrees: "There is a distinct trend to duplication of subsystems for space operations. You've got to cover yourself against failure in missions that take a year to accomplish. Remember, we're talking about component reliabilities in the order of 30 years' MTBF. We just don't have components of this quality."

Simplicity in Design Sought, Particularly in Space Work

Simple, reliable ways of accomplishing a given purpose are esteemed. An example was cited by John Small, a lunar systems engineer at Jet Pro-

Possibility of limited wars on rugged terrain is the conceptual background for design of this mobile, 60-channel multiplex terminal, adhering to standards set for the Air Force 480L global communications program. Printed circuitry and transistorization are used throughout. Parallel redundancy is applied to all active circuits and to carrier-supply amplifiers in transmission circuitry when the circuits and amplifiers are common to more than 12 channels. Lenkurt Electric Co., Inc., San Carlos, Calif., built the terminal for point-to-point radio, open-wire or cable uses.

pulsion Laboratories. "We wanted to take a couple of pictures of the moon from Pioneer III. The trouble was the vehicle was spinning at a high rate. Our problem was to de-spin the vehicle, so clear pictures could be taken. The natural reaction to this is to stick a couple of vernier rockets aboard to provide counter-spin forces. But one of our people suggested instead that we put a couple of weights aboard that could be released like a fly wheel, fly out and continue going.

"Moreover this was a system we could test on earth—a simple mechanization. It worked fine. This is an example of good systems engineering."

The most difficult area, of course, is in space. The systems problems are more fluid in this field than in any other, and the environment and physical constraints on the system are more severe. In designing a missile the systems engineer can write down the desired range, azimuth, etc., and so work backward. He has definite limitations within which to work. But in designing a space probe he must concern himself with the purpose of the project: instrumentation.

"Scientists want to measure everything in sight," says Mr. Giberson. "Systems designers know better. They can't. A reasonable compromise between the kinds of sensors and transducers they would like to have and the kind that are practical and feasible must be worked out. Also, the systems designer must calculate the range within which a physical phenomenon is likely to occur, so he can include instrumentation designed only for that range." ■ ■

Space Communications: A Two-Pronged Problem

An OPTIMUM wide-band satellite communications system requires careful integration of two technologies—space-vehicle and communications system design. The key portion of the system, the satellite package, must operate reliably for a number of years in a hostile environment, or else the entire concept is not economically justifiable. In addition a communications complex capable of squeezing the last few db's from a tiny orbiting repeater is necessary if quality overseas transmission is to be achieved.

Systems designers hoping to satisfy the often-conflicting requirements of this problem, working within the restraints imposed by the environment and the state of the art, must reach for a high point of refinement in fundamental concepts and trade-offs.

Frequency bands are limited on the high end by atmospheric attenuation, and on the low end by cosmic noise as well as allocations difficulties. Because of the heavy demand for spectrum, it will probably be necessary to share frequencies between ground and space services. This adds radio-frequency-interference problems to the designer's already heavy burden.

Modulation must be chosen to given an optimum signal-to-noise ratio, but at the same time it must be as economical as possible in bandwidth. Highly directive antennas are necessary to get maximum power to the relay and to avoid interference when ground stations are using more than one satellite overhead at the same time.

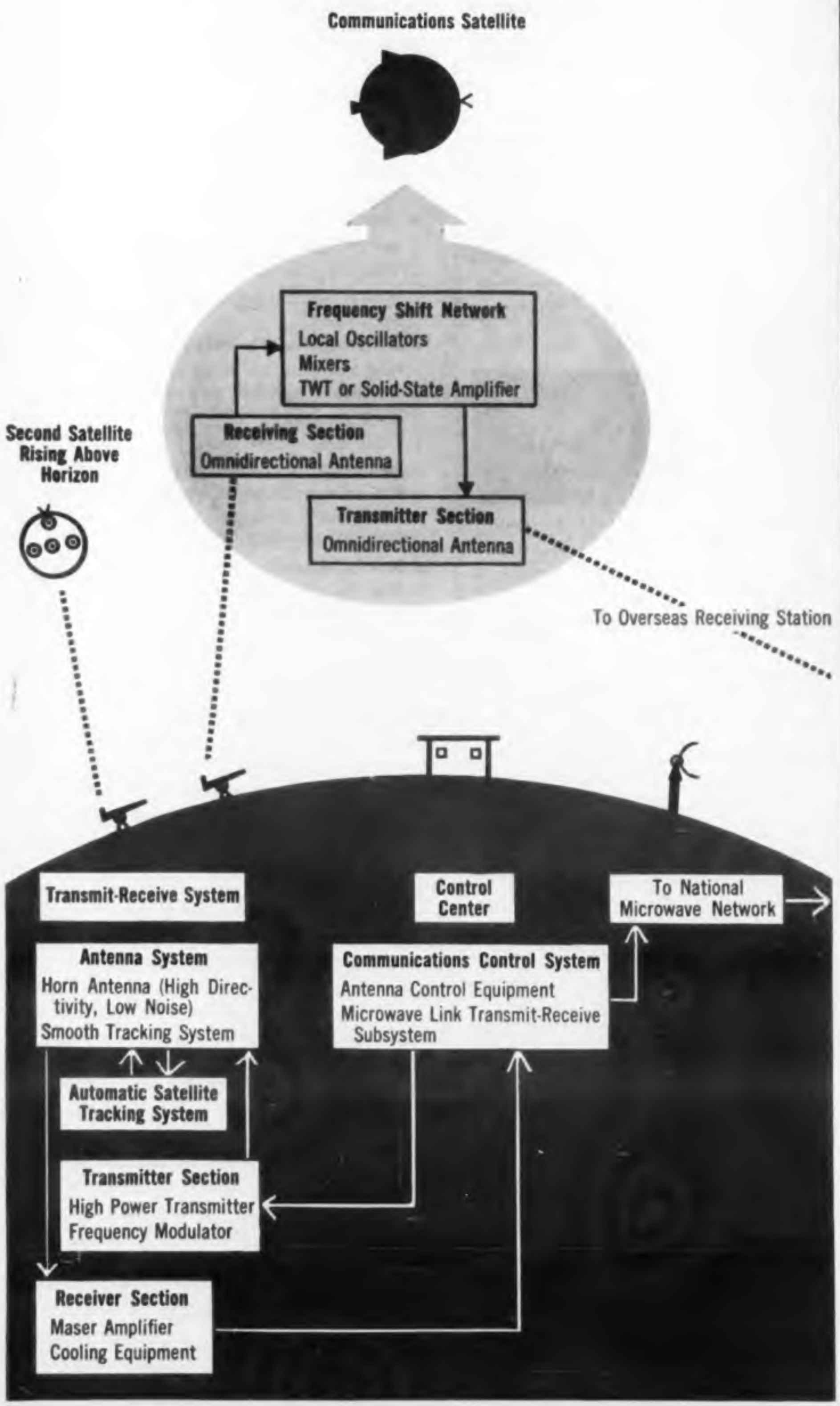
The requirements for the satellite to be used in Project Relay, tentatively set for launching in May, 1962, by the National Aeronautics and Space Administration, give an indication of many of the restraints imposed by the total system goal.

The weight of the satellite must be held to 85 lb, ±10 per cent. The shape must conform to the inner dimensions of the nose fairing of a Thor-Delta booster.

(text continued on p 32)

Planned satellite communications system to link the United States with Europe would use series of satellites in 5-6,000-mile orbits to relay telephone messages, TV programs, teletype and data.

Satellite Communications System



The following items must be tucked into this package:

- Wide-band receiver, frequency shifting network, and amplifier to boost signal power before retransmission.
- Power supply made up of batteries, solar cells, control circuits and monitoring devices. This may include devices to cut power to nonessential equipment while batteries are recharged.
- Telemetry and tracking receiving, transmitting and pcm encoding equipment.
- Radiation monitor and radiation effects instrumentation.
- Solar aspect detector.
- Temperature control system limiting average mounting surface temperatures to 40 to 70 F and localized temperatures on these surfaces to a 30- to 120-F range.
- Provision—such as a timer—for turning off the power supply irrevocably after a year.
- Wide-band transmitting and receiving antenna with essentially circular polarization.

Since the ultimate signal-to-noise ratio (S/N) is influenced by necessary trade-offs—between modulation method, bandwidth, power and picture quality—a figure was not directly specified for the Relay satellite. As a guide, however, a minimum allowable video S/N for conventional TV transmission was suggested by NASA, with 35 to 45 db desirable. An equivalent video bandwidth of 3 mc at the ground receiver (6 db down), with not more than 2-db attenuation at 2 mc, must be achieved. The effective bandwidth of audio signals received on the ground must be at least 8 kc, with S/N good enough to keep the noise level in the 40- to 8,000-cycle band at least 45 db below a level representing full modulation of the sound carrier.

The power package must operate within tolerances for 30 days with a reliability of 0.93 at 90 per cent confidence level under tests in a simulated space environment using expected duty cycles. A reliability of one year, including any necessary redundancy, is called for in the rest of the satellite equipment. For a sound commercial system, American Telephone & Telegraph Corp. feels that the satellites should have a 10-year life.

Adjustment and Maintenance Ease Is Important in Package Design

Ease of maintenance and adjustment is an important consideration in the design of the satel-

The Pros and Cons of Medium-Altitude, Active-Repeater Communications Satellite

Despite some disadvantages, the medium-altitude, active-repeater satellite has been chosen as the best approach at present to an intercontinental communications system. Other approaches, such as passive reflectors or synchronous-orbit repeaters, may become technically or economically feasible at some later time. The chief points for and against the medium altitude repeater follow.

Advantages:

- **Can be orbited by existing boosters.**
- **Does not require propulsion system to remain on station.**
- **Provides reasonable signal-to-noise ratios at ground receivers.**
- **Transmission delay nearly negligible.**

Disadvantages:

- **Many satellites needed for continuous operation, because a single satellite is visible only from stations on both sides of the ocean for a small part of an orbit.**
- **Extra ground transmitting and receiving systems needed for switching from one satellite to another.**
- **Radiation levels high at medium altitudes.**

lite package. No adjustments should be necessary after a subassembly is in place. Each subsystem should be designed so that components can be replaced directly by components of the same type without adjustment of any other units. If there is any possibility that adjustments will be required after the package is assembled, easy access must be provided. Provision must be made for manual turn-on of the satellite once it is installed in the launching vehicle, and no other adjustments should be needed before launching.

Radiation detection must be provided for the power components. Solar cells are known to deteriorate with bombardment by high-energy protons. Thick coatings, however, cut cell efficiency.

Some of the parameters for the ground stations are fixed for the Relay satellite system because of existing NASA facilities. An 85-ft parabolic antenna with 50 per cent efficiency and auto-track and programed tracking capabilities will be used. Tentatively the ground-receiver equivalent temperature from all sources is set at 150 K.

Because of the lack of worldwide TV standards, converters will be installed in the United States ground station to change the 525-line American raster to conform with European standards and vice versa.

The ground transmitter-receiver complex must be capable of handling all traffic including TV, multi-channel telegraphy and data. ■ ■

'Orbiting Arsenal' System Would Intercept Enemy ICBM's

TWO major approaches using satellites are under consideration in the United States today to counter any attack by enemy intercontinental ballistic missiles. In one approach satellite-borne missiles would be used to stop hostile ICBM's. In the second approach the satellites themselves would make the intercept.

Of these approaches to what has become known as BAMBI (Ballistic Anti-Missile Boost Intercept), the more difficult to achieve technically is Convair's "mother-satellite" system. In it a network of satellites, each carrying a supply of anti-missiles, would have:

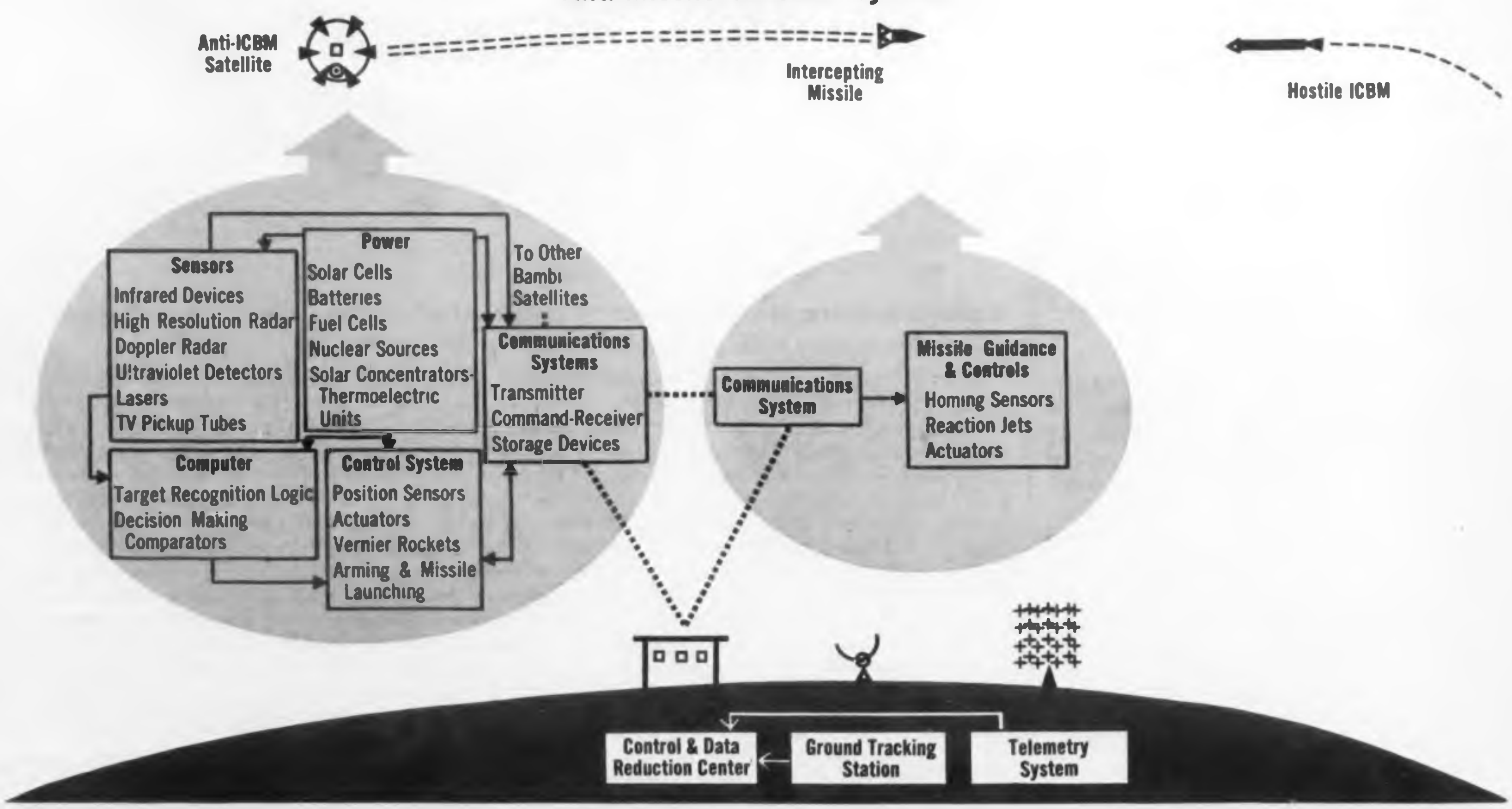
- Detection equipment capable of locating a ballistic missile in its initial boost stage.
- Decision-making equipment to enable the satellite to determine whether or not to shoot.
- Logic to compute an intercept point.
- Positioning and attitude devices to aim the anti-missiles.
- A means for guiding the anti-missiles to their targets.

The second approach consists of placing a large number of small satellites in orbit, each capable of detecting an ICBM and firing the entire satellite at it. The engineering problems here are similar to those in the mother-satellite system, but not quite so severe.

The problems in the mother-satellite concept are part political and part technical. In the political realm is the question of determining which targets of a potential enemy are peaceful and which are hostile. If permitted to fire at every target, a defending satellite might shoot down some country's astronaut or test missile. One possibility is to instruct the satellite to allow the first ICBM to come through and then shoot down every subsequent missile. The trouble here is that an enemy attack is not likely to start with one missile but many simultaneously.

This leads to another possible approach: instructing a satellite to ignore "onesies" and "two-

Anti-Missile Defense System



Orbiting satellites armed with intercepting missiles and loaded with sensors for detection and evaluation of missiles rising from the ground below represent one version of the BAMBI (Ballistic Anti-Missile Boost Intercept) concept. Telling hostile ICBM's from innocent test or astronaut launchings is a tough conceptual problem.

sies" and to start shooting only when a predetermined number of targets is in the sky at once. Of course, this leads to extreme technical difficulty—a communications link between satellites, so that total ICBM's can be recorded instantly.

The basic technical problems include cramming enough logic, programs and decision matrices into a small enough volume to be practical. The satellite must be able to track a target, determine its probable destination, communicate with other satellites that may be in a better position to fire, decide that the target is indeed an ICBM, and finally launch a guided missile to intercept it—all within the three minutes' boost time (with solid fuel) or five to eight minutes (with liquid fuel) for each ICBM.

Sensors to detect a ballistic missile in the boost stage are said to be more than adequate for the job. Infrared devices would most likely be used. The boost exhaust of a missile is extremely bright and can be made virtually unmistakable to an infrared detector.

Positional control of the satellite is also a problem, but with many adequate solutions.

Informed sources say it is likely that much of the telemetering, tracking and command functions could be combined in a package similar to that in Pioneer V, where tracking information and instrumentation data were put together in a 12-lb package.

It is clear that the computing aboard the mother satellite would be extensive. This would make computer microminiaturization necessary.

The power-source design for BAMBI is up for grabs; it is a serious problem. Certainly sun power is being considered favorably at present. Still, solar cells can only be so efficient (15 per cent maximum to date), and there is only so much area available for them. Solar concentrators—reflectors concentrating sunlight on thermoelectric generators—might be used.

In either of these alternatives batteries would be used. According to an informant at Space Technology Laboratories, batteries are still a major problem. "They just don't last long enough to accomplish a mission. In general, they leak."

Other sources of power, like nuclear devices or fuel cells, seem to systems designers futuristic. Designers are interested in the progress of such devices, but they do not anticipate using them in any systems now being considered.

Reliability of electronic and mechanical parts is, of course, still the biggest problem. BAMBI satellites would be required to circle the skies in hourly orbits for many years. To conserve power, it would be advisable to turn the satellites off while over friendly territory and turn them back on while over enemy territory. This would be hard on electronic equipment and would contribute to the reliability problem. ■ ■

Moon-Probe Projects Stir Wide Effort

LUNAR probes—systems that have captured the imagination of laymen and technical people alike—are the subject of almost as much concentrated engineering thought and effort as ballistic-missile defense. Hard-landing satellites are being readied for impact on the moon. It is hoped they will radio back information by means of unbroken, impact-proof electronics. Soft-landing satellites, like Surveyor, are in the design and construction stages at Jet Propulsion Laboratories (JPL) and Hughes Aircraft Co. They will puncture the surface of the moon with special drills to analyze the material. Prospector, a lunar probe that will carry a roving vehicle, is already being considered in design.

With present injection systems still only good enough to put a space vehicle in an approximate region of space, mid-course maneuvering will be necessary. Several approaches are possible:

- A strapdown inertial system with stellar supervision.
- A radio tracking and radio command system.
- An all-telescope system or a gimbaled inertial system in conjunction with a telescope.
- A digital computer and a precision clock.

Strapdown System Would End Need for Inertial Platform

The strapdown system differs from the gimbaled inertial system in that the acceleration sensors are strapped directly to the frame of the craft, eliminating the physical inertial platform. A gyroscope package keeps track of the angular position of the vehicle with reference to inertial space.

The difficulties involved here, according to space scientists, concern instrument fabrication, computer requirements and high gyroscopic torquing rates. The latter, though not required for mid-course guidance, are needed in the inertial and terminal systems.

Radio communication seems to be a good bet for lunar mid-course guidance, according to JPL's Daniel Schneiderman, though it would be inadequate for extended trips, such as a journey to Mars. At far distances from the earth, high power would be required, and angular resolution would be a limiting factor. Time lag would add to the inaccuracy.

In radio Doppler systems, says Hildrey Bement, a research specialist at the Autonetics Div. of North American Aviation, Inc., large antennas, long integration times and the use of such advanced components as maser amplifiers would be required to reduce velocity errors to even marginal proportions.

Doppler Approach Would Require Telescopes to Track Stars

For optical Doppler systems, the sun provides enough energy for highly accurate spectroscopic measurements. With even the brightest stars, however, special detection techniques—highly sensitive and with long time constants—would be needed.

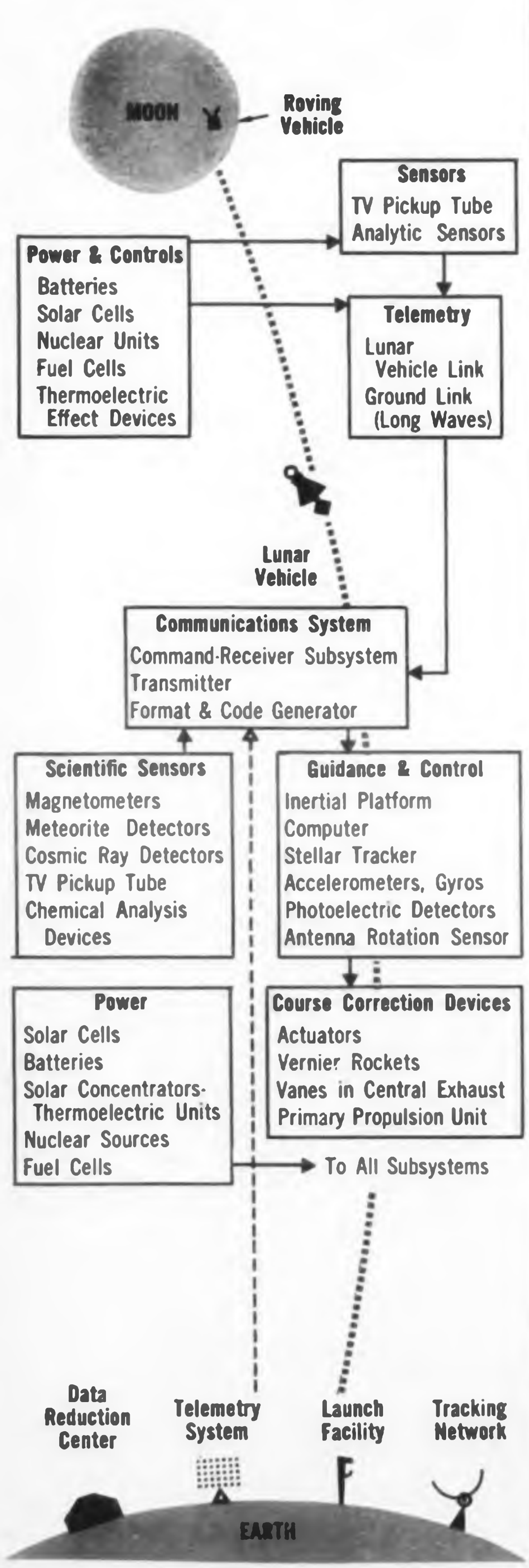
It might be possible to slave the entire spacecraft to an inertial reference through use of three telescopes, then use the vehicle itself as a stable reference. This system poses some immediate problems, however. During corrective thrust maneuvers, the telescopes might lose the stars they are tracking. The system might also be weighty and bulky, and not easy to integrate with the objectives of the initial and terminal systems.

A gimbaled inertial system using a telescope for monitoring the gyroscopes so their drift could be maintained within specified limits, might be acceptable; it would certainly provide the accuracy required. It might be, however, that the intensive trade-offs necessary in building a lunar probe would dictate the use of the simplest system possible. The favorite, for the time being, seems to be radio guidance.

In such a system the spacecraft would attitude-lock on the sun and the earth, both of whose spacial positions are known. The angle of the directional antenna facing the ground station

Possible configuration of lunar exploration system including roving vehicle that is released when the space vehicle reaches the moon's surface. Some of the scientific sensors shown aboard the lunar probe might not be needed if they were included in the rover.

Lunar Exploration System



on earth could be determined by a suitable transducer. With these three parameters, the attitude of the lunar probe could be determined very accurately—within a degree, says Mr. Schneiderman.

On command from the earth, the vehicle would disengage from the sun and earth referents and precess its gyroscopes to take up a desired attitude in space. After the vehicle had rotated, its electronic equipment would be powered by internal batteries since the vehicle's solar cells would also be disengaged from the sun. The vehicle would ignite its motors and correct its velocity direction and magnitude. It then would refer to the sun again.

Extremely Sophisticated Gyros Not Necessary for Mission

According to Dr. David Chandler, inertial navigation section chief at Autonetics, no extremely sophisticated gyroscopes—like cryogenic or electrostatic types—are required for a moon flight, since an angle-measuring device is needed anyway. The size and weight of the guidance package are not greatly important factors either, he added. Guidance systems are getting quite small and cutting their size in half would not make much difference.

So far as circuits and electronic techniques are concerned, the basic problems during a moon flight do not hinge on the sophisticated engineering of subsystems, space authorities say. They involve the reliability of the electronics, low-power requirements and temperature control. The anticipated environment would vary between -150 and $+100$ C. One side of the spaceship would be hot, the other cold.

The problem of communicating by radio to a spaceship behind the moon makes an on-board guidance system desirable, and the gimbaled inertial system may be chosen for sophisticated lunar probes, like Prospector.

During the terminal stage, landing problems will be paramount. Doppler radars will be required to measure velocity. Lateral velocities will have to be minimized; without their complete elimination, the vehicle's "legs" may have to be "crouched" in the direction of impact.

Altitude marker radars will determine the vehicle's distance from the surface and will take one of two forms, depending on whether the vehicle is solid-propellant powered or liquid fueled. With a solid propellant, the marker radar will signal the ignition of the rocket motor, which will burn for a predetermined period of time. Using liquid fuel, the marker radar can keep closer tabs on the motor's thrust, telling it continuously the amount of fuel it should be burning until impact at 10 ft per sec or less.

Communications, Power and Temperature Are Stabilization Critical Needs

Minimum requirements for a successful probe, once it had landed on the moon, would include communications with the earth, power for the communications equipment and research instrumentation, and temperature stabilization of the vehicle. The probe would have to withstand at least one cycle of lunar days and nights.

Instrumentation for on-surface activities breaks down into two categories: local and roving. The vehicle itself might sample the local ground, pat it to see how hard it is, fling harpoons and test local rocks. A vidicon would scan the area and relay a picture of the moon's surface to the earth.

Since not much could be seen in the immediate vicinity of the spaceship, it might be desirable to have a roving vehicle, itself equipped with a vidicon and other sensors. Here the problem of control would enter. If line-of-sight techniques were used, the "rover's" area of travel would be strictly limited if it were controlled from the spacecraft. Lower frequency communication would, of course, be possible. Another alternative is to control the rover directly from earth.

Transportation and Positioning Of Antennas Pose Problems

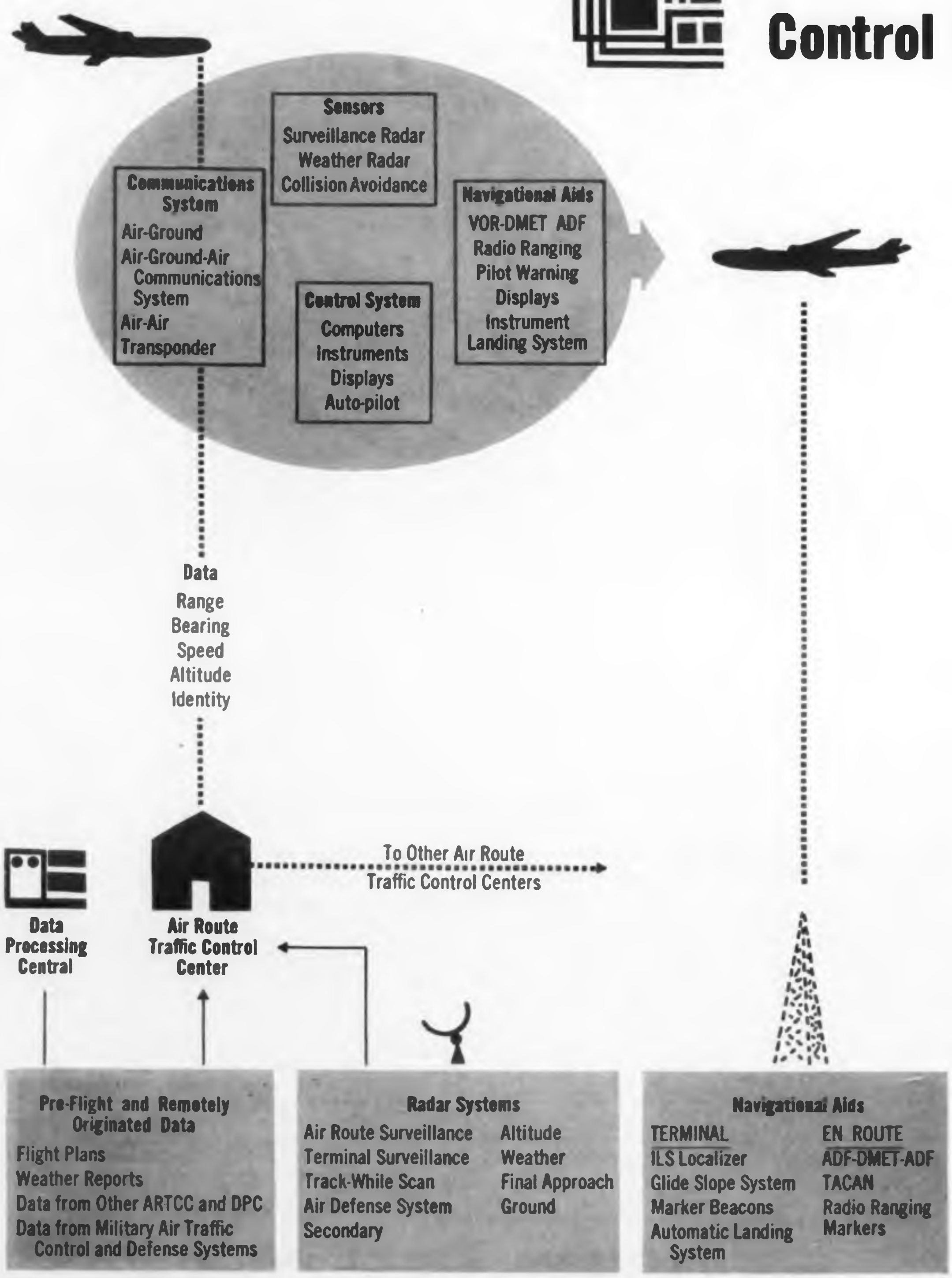
So far in space research the problem of antennas for communication has been bypassed. Directional antennas for high gain will be needed because of the low power available. Some means for transporting the antennas and setting them up must also be devised, according to David Conrad of Aeronutronics.

While not a great deal of communication power would be necessary (Pioneer III and IV only had a 1/4 w aboard, and Rangers III, IV and V only 25 mw) power for TV communication is a problem. The minimum desired is 1 frame per sec, or 20 kilobits of information.

To transmit at bandwidths necessary for these data rates, power on the order of a kilowatt would be required.

Power sources would use the greatest proportion of weight aboard a lunar probe. The more instrumentation aboard, the greater the power that would be needed to transmit information. Space engineering in the immediate future probably will be largely devoted to reducing the power consumption of equipment. ■ ■

Air Traffic Control System



Air-traffic control of the future will include many of the elements shown in this simplified system, based on many concepts now in development. The form that many subsystems, such as collision avoidance or altitude determination, may take is still to be decided. The Data Processing Central concept itself is now being re-evaluated because of planned integration of civilian atc and air defense systems.

Control of Airways Challenges

DESPITE intensified efforts in the last several years to develop a modern, adequate system of air-traffic control, more challenges face designers in this specialty than ever before. The reason: planners are re-evaluating the entire air-traffic control situation to decide how to get the best control for the least money and effort as planes get faster and flights more numerous.

For designers, the most significant issue under consideration is whether present civil air-traffic control should be integrated with the military's SAGE air-defense system. The most likely alternative is continued overhaul of the present civil system along lines laid down several years ago. This modernized system would be built around automatic data-processing centrals.

Federal Aviation Agency planners point out a third possibility that always exists: the agency is never so committed to a system or subsystem that it cannot adopt a safer and more efficient method if one is devised.

The problems facing designers in air-traffic control can be classified into two groups: improving information flow through the system, and developing equipment for individual jobs.

Much of the FAA's current modernization program is aimed at automating the flow of information. Such functions as processing flight strips, conflict-monitoring and control, and profiling and sequencing of aircraft in transistion and terminal areas are being automated in varying degrees.

Many of the subsystems that will do these jobs have been developed and are ready for evaluation. A special-purpose computer designed to process the new information flow is being tested with its peripheral equipment at the FAA's proving grounds at Atlantic City, N.J.

In addition to speeding information flow Government planners have a long list of potential equipment they would like for specific tasks. In general, better acquisition and presentation of data are needed.

More track-while-scan capabilities are needed for the air-traffic-control system. Controller's displays with identifications for aircraft are sought, and the displays must be brighter.

Better altitude information is sorely needed. One air height surveillance radar system under test, the ASHR-1, uses a gigantic antenna that receives multiple beams reflected from targets. In this system aircraft are illuminated by a remote radar transmitter.

Design Ingenuity

Altitude reporting via beacon-transponding systems is another approach under study by the FAA. If developed, the technique would fit in with the agency's secondary radar program.

A similar automatic data link is being developed for communication. An automatic ground-air-ground communication system, AGACS, is under test both as a particular system and as a concept. AGACS is a two-way, time-division digital data link, able to handle about 500 real-time messages in two minutes at 750 bits per sec.

Controllers using such a system would push a button to transmit a question to an aircraft. The message would be displayed in front of the pilot, who would transmit a precomposed reply or compose a new one and push a button to send it to the ground.

Related systems are also being studied. The FAA is exploring methods of achieving continuous, automatic position reports; display of vectoring and speed control information in the aircraft flight instruments, and use of high-data-rate equipment for automatic landing.

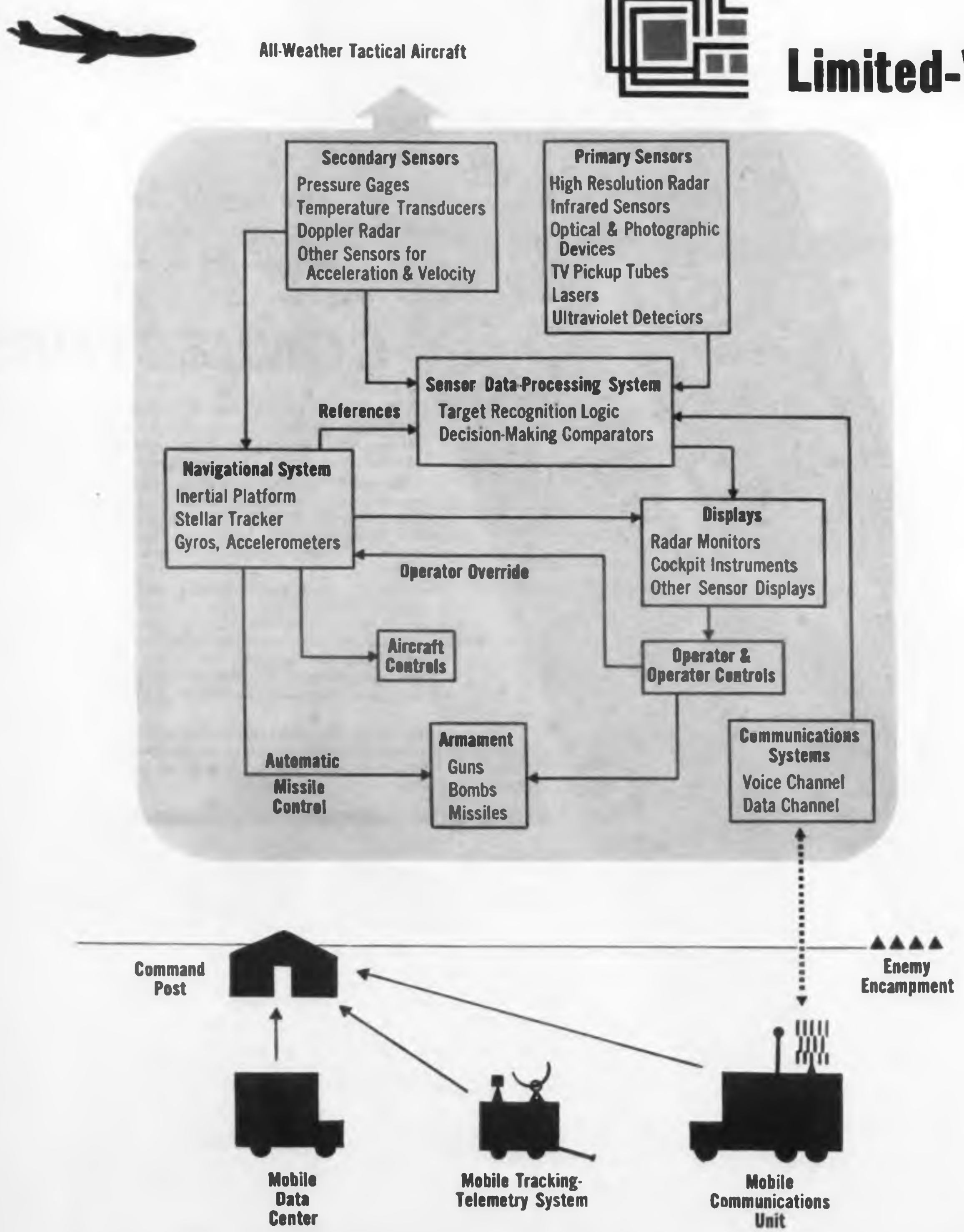
If the present air-traffic control system is integrated with SAGE, the military computers, dark-room displays and much other equipment would have to be modified. Bright displays would be installed and the relatively high-speed SAGE computers would have to be buffered with low-data-rate input-output equipment.

The SAGE system is based on Cartesian-coordinate area division, but the FAA system uses irregular geographical sectors. Whether there is integration or not, the civilian air-traffic system will probably be shifted to a grid system. This is because the FAA will probably switch to area control, in which commercial aircraft would be free to fly routes of their pilot's choosing rather than those in established airways. This shift, in turn, would be possible because the military system of positive control would be adopted by the FAA. In this system aircraft positions are known to controllers at all times. At present most civil aircraft report their positions only occasionally en route.

Finally air-traffic-control designers are being asked to provide collision-avoidance and pilot-warning systems; better altimeters and altitude reporting systems, and automatic-landing systems. An acceptable solution of these problems has so far proved elusive. ■ ■

Air Tactical Delivery System

Limited-War Concept Calls for



Air tactical delivery system for all-weather missions is one of the vital components of military units prepared for limited warfare situations. The basic system shown here is modeled after the Republic F-105D. Some of the subsystems shown, however, represent further advances now in R&D which have not been integrated into the Republic aircraft. Mobility is a key feature of ground subsystems supporting the tactical aircrafts.

THE limited-war concept that has gained prominence over the course of the cold war requires a specialized approach to design of equipment. For ground forces, ruggedized transportable data processing, tracking and telemetry, and communications equipment has been designed. Some of the most intensive activity for limited warfare supersystems, however, has been directed toward modernizing tactical aircraft.

Use of electronic sensors has led to the concept of the all-weather tactical fighter-bomber, such as Republic Aviation Corp.'s F-105D. To permit low-altitude flights over rough terrain, the aircraft includes automatic terrain-avoidance equipment. In design of this aircraft, and in continual modifications that are being made with advances in the state-of-the-art, a wide range of electronic subsystems are employed to give a pilot the maximum possible assistance in performing a mission.

Before the aircraft takes off on an assignment, a mission description is programed into the navigational subsystem. Reference instruments of all kinds may be used for navigation. The guidance system may be a combination of inertial, star-tracking, Doppler navigation and terrain recognition equipment. Sensors used to aid the guidance function include acceleration and velocity measurement units, radar altimeters, mapping radar, and optical and photoelectric devices.

Solid-state logic is used, but memory may be either electromechanical or solid state.

Designers Tend to Overspecify Computer Characteristics, Engineer Charges

Gordon Smith, group engineering leader, Autonetics Div. of North American Aviation, Inc., says designers often make a common mistake in specifying a computer for a guidance system.

"They so specify the computer characteristics —word capacity, iteration rates, and so forth— that the result is a computer design."

"But professional computer designers, knowing the requirements of the system, can often take short cuts. We can use special approximations if we know the system characteristics— and in effect design a small computer to do the job of a big one."

A trend in navigational instrumentation is the reduction of all inputs to digital form. Designers are looking for digital transducers and digital display devices.

Primary sensors aboard an all-weather weapons system aircraft include infrared detectors, optical systems, high-resolution radar, TV and ultraviolet devices. Further improvements in resresolution are being sought with the development of laser radars—such as Hughes Aircraft Co.'s Colidar.

Infrared sensors are stopped by heavy cloud cover, but on a clear night they can provide clear confirmatory evidence of targets picked up by other techniques—or may direct attention to camouflaged "hot spots."

Sensor, Pilot Computer Inputs Permit Recognition of Target

Information from these sensors is fed to a central computer. This computer is preprogramed with target information so that it can draw comparisons between the data it should be receiving from a target and the information it is actually receiving. In addition, the pilot will be able to punch in information if he sees landmarks or indications of enemy activity below.

Display subsystems play an important part in the design of tactical aircraft. They have been made as simple and foolproof as possible since the pilot of a modern aircraft has too many instruments to watch as it is. Current thinking is to design a single display that will present information from one or more sensors, as the pilot chooses, simultaneously or in rotation.

The pilot might, for example, superimpose infrared hot spots and Doppler radar targets on a TV display to emphasize the presence of targets. He should with a single control have the ability to vary the size of the arc he is looking at to obtain more detail. When he is satisfied there is a target on the display, he can move crosshairs over it, push a button to fire missiles or drop bombs.

All-weather guided missiles, which may be command-guided from the aircraft, are currently under serious consideration. With this semi-active type of missile, a missile radar will illuminate the target and transmit reflected information to the aircraft. This will be processed in the aircraft's versatile computer, and the pilot will be able to send instructions back to the missile. ■ ■

Worldwide Data Systems Are Foreseen for Business

LACK of total systems orientation has already led to serious problems in business data-processing. Early computer designers did not foresee the extent to which the business community would make use of their creations. Machines built by one company were not compatible with those built by another. Programing was a mysterious art predicated on the needs of the machine rather than the users of it. When the computer industry took shape, there was little thought of cooperative networks of processing equipment, linked by worldwide data communications facilities.

The lesson taught by this lack of systems perspective is being learned painfully. The wild chase after ever higher computation speed has slowed preceptibly as manufacturers refocus on input-output devices, real-time processing, and automatic programing aids. Steps are being taken to standardize basic machine languages—using understandable phraseology.

But the shift in emphasis is only beginning. Men with understanding of both machine problems and business requirements are moving into responsible positions in industry. The naivete of the businessman in the early phases of data-processing is fast disappearing, and design will have to be modified rapidly to serve tomorrow's market.

Oil Company Plans Extensive Facilities To Permit Worldwide Data Access

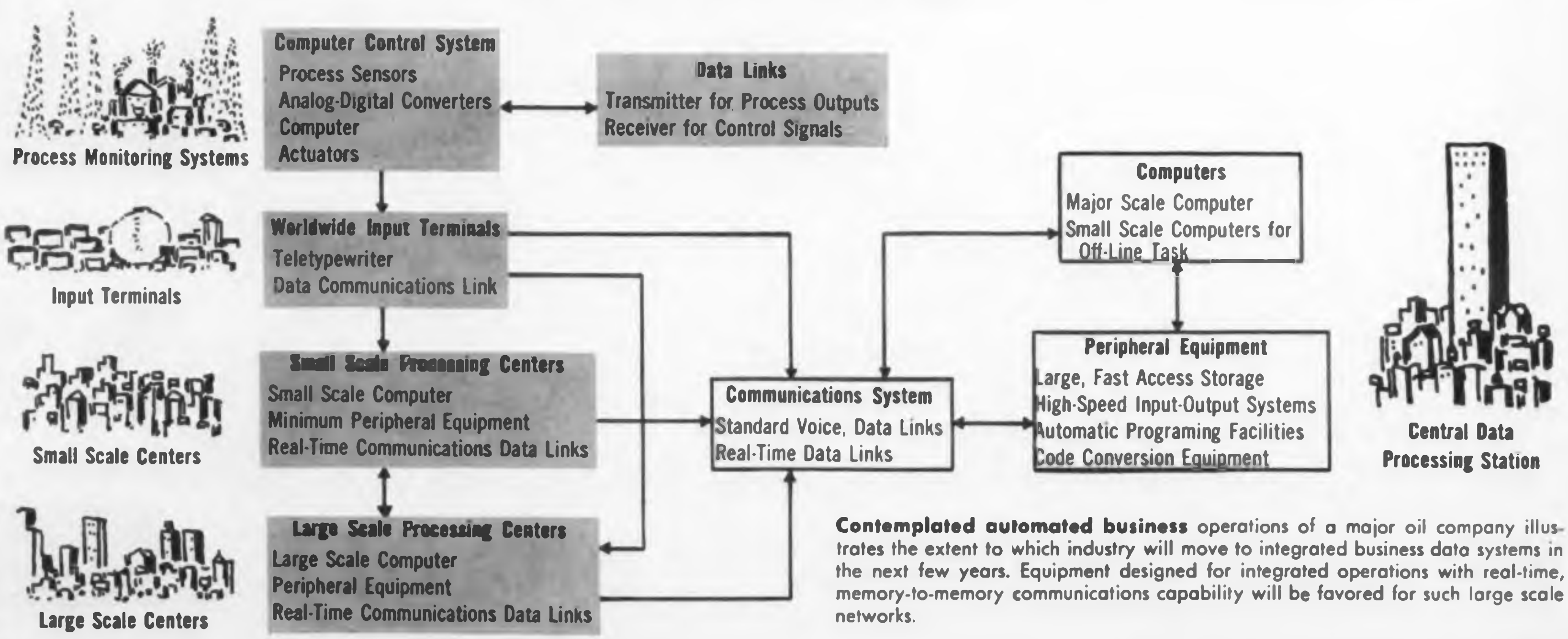
The plans of one of the country's top oil companies illustrate the necessity for this shift toward total systems orientation. The Socony Mobil Oil Co. plans to give any person in the company anywhere in the world immediate access to any pertinent company data.

The accompanying system diagram shows some of the facilities planned by the company in the next five years. The central station in New York City will require a system renting for about \$100,000 a month. Five large-scale centers will have computers renting in the \$10-\$25,000-a-month range. Some 50 smaller centers will have data-processing equipment renting for about \$3-\$7,000 a month.

In addition about 100 input terminals will be installed at refineries, sales offices, distribution points and other company centers. Data-access sets for executive offices are also planned.

A network of data-communications facilities will be used to tie this integrated system together. The company is already using both telephone lines and microwave links for data communications. Future links will tie various computers together memory-to-memory, so that

Business Data Processing System



Contemplated automated business operations of a major oil company illustrates the extent to which industry will move to integrated business data systems in the next few years. Equipment designed for integrated operations with real-time, memory-to-memory communications capability will be favored for such large scale networks.

real-time processing is accomplished. This will eliminate much of the present effort involved in collecting data from remote stations and manually entering it into a central processing system.

In planning the primary processing center around an IBM 7090 computer Socony Mobil is organizing the total system around a central large-capacity, disk-file memory subsystem. Two 1401 computers, now on order, will handle input and output functions and set up programs for processing in the 7090's very fast arithmetic circuits.

An additional IBM 1410 system is being considered for monitoring operations of the other machines and directing segments of a problem to the machine best suited for handling them. Data to and from various parts of the interlinked group of specialized machines will be sent into the central disk-file memory for storage until it is needed by other parts.

This concept will require design of disk files allowing independent access by various parts of the processing system complex. Different read-write arms will be assigned to particular machines, so that the 1401 might be writing information into one part of the file while the 7090 is taking data from another section of the same file.

Socony Mobil is presently thinking about a telephone approach to remote access to the computer. A query called in by telephone is entered into the machine, and when the answer is printed out, it is read back over the phone by a girl. The printed answer is then mailed to the questioner. The possibility of prerecording data, such as numbers and letters of the alphabet, and then having a reply automatically read back over the telephone is now being studied.

Another step being considered by the company is the control of all refinery operations from the central computing system in New York. Programs have been worked out for optimization of refinery outputs, and it is felt that this might be done most efficiently on a total company scale rather than optimizing processes at each refinery individually.

Compatibility, Real-Time Processing Among Needs For the Future

Many large companies are considering business automation on a similar scale. If the equip-

Main console, right, and several tape units of the $3 million IBM 7090 computer used as the hub of Socony Mobil's growing business-automation system. The company hopes to improve the integration of its facilities throughout the world with real-time data communications networks over the next few years.

ment of the future is to be suitable for meeting these needs, some of the following requirements must be met:

- Compatibility—The many machines in a business automation system should be capable of working smoothly with one another, without expensive conversion equipment at each interface.
- Real-time Capability—Transmission from one computer memory to another should take place automatically, on a planned priority basis, so that the central system has a continuously updated picture of the total company activity.
- Massive Storage—Inexpensive, rapid-access files containing great masses of data must be accessible to many machines and must be easily kept up to date.
- Programing—Simplified programing techniques are needed, so that massive operations research and other large-scale problems can be handled conveniently.
- Logic—The present approach to logic and arithmetic operations is based on single computers. New approaches may be more adaptable to large integrated business systems tied together by many communications links.
- Output—Easy-to-read and easy-to-store output must be provided by these complex systems. Present line printers do not meet this qualification. Microfilm may be helpful for some purposes, but fast data-retrieval systems are necessary to make this approach useful.

In business systems more than anywhere else cost factors assume vital importance. Businessmen want to turn to automation, and they are preparing to spend billions to do it, but the competition will be keen and only the most economical approaches will gain favor in the long run. ■■

NEWS

Japanese Audio Trade Is Stressing New Lines

Stereo and Multiband Sets Favored Over Transistor Radios and Color TV

Stuart Griffin
ELECTRONIC DESIGN Japan Correspondent

A SHIFT in consumer electronics production seems under way in Japan, if displays at the Fourth Tokyo International Trade Fair are any indication.

De-emphasized at the show were such former favorites as miniature transistor radios, color television, portable transistorized video and novelty products. The stress was on stereophonic equipment, fm combinations, multiband receivers and other advanced and costlier items. Small and large tape recorders were in profusion: tiny portables alongside standard-sized hi-fi models-for commercial, semicommercial and private use.

Many new items were on display, including refrigerators using thermoelectric elements, T-E room coolers and a radar cooking range.

Nippon Electric, which entered the industrial TV field last year, showed its new stereo TV, a modification of a system revealed by the Japan Broadcasting Corp. The Victor Co. of Japan displayed a color video tape recorder, capable of monitoring even while recording is in progress.

Sample Molectronic Devices; Speedy 'Color Computer'

In the field of electronics research, Mitsubishi Electric presented samples of successful trial-manufactured molectronics, such as preamplifiers; power amplifiers; tuning, phase and notch oscillators; saw-tooth wave generators, multivibrators and OR circuits. The same company also showed ribbon types of pnp and pnpn crystal cells and diode matrices.

One of the more important advances on view was a new "color computer" turned out by the Matsuda Research Laboratory of Tokyo Shibaura Electric Co., Ltd. The computer is said to be able to analyze colors and register their values in both figures and graphs in just two minutes. The instrument, credited to the cooperative research of three Toshiba technicians—Dr. Takashi Azuma, Leo Mori and Isamu Niikura—is termed a "combination of a spectrophotometer and an electronic computer."

Such a combination has already been built by the General Electric Co. of the United States.

Japanese businessman admires color analyzer produced by Tokyo Shibaura Electric Co., Ltd., at the recent Tokyo International Trade Fair.

The GE model, however, has an analog computer, and the Toshiba's is combined analog-digital.

Using the "normal method" of spectrophotometry, Toshiba says it keeps the error range well within 0.04 per cent. The final accuracy of the measurement and computation together is put within 0.1 per cent.

Pocket-Sized Lie Detector; 'Eyelid' for Auto Lights

Another eye-catcher on display was a new pocket-sized, all-transistorized lie detector, developed by Takei Kiki Co., Ltd., of Tokyo. The company says the unit is the first of its kind anywhere. Sold here as Model TK-611, it is 9 by 6 by 4 cm and weighs only 150 g. A single knob operates the detector. An inexpensive dry cell inside is reported operable for more than 100 consecutive hours.

For motorists, Takasago Denken Co., Ltd., of Tokyo was showing an automatic Eyelid control for auto headlights. Connected to the headlamp switch and installed inside the vehicle so it faces the windshield, Eyelid picks up oncoming headlights up to 100 yd away and automatically lowers the user's high-beam headlight position to "dim." After the other vehicle has passed, the device returns the lights to high beam. The invention incorporates an amplifier and a special photoconductor made of an alloy of calcium sulfide.

The "smallest neon tube ever developed in the world" was also shown. It was so described by its maker, Ushio Kogyo Co. of Kobe City. The tube measures 2 mm in diameter and 5 mm long. Among its applications are use as a pilot lamp for home electric appliances and as an integral part of electronic computers. The company envisions the mass production and export of 300,000 of the new tubes monthly once it has installed new manufacturing equipment. ■ ■

EDITORIAL

Conceptual Problems in Supersystem's Design

According to the nation's systems experts, our main systems design problems are not technical but conceptual. It is clear from the ELECTRONIC DESIGN report beginning on p 27 that we can build near perfect black boxes and subsystems but when all of the parts are connected the result is less than a working system.

In thinking about our conceptual limitations one is led to ponder the role played by the terms that we use to describe our systems thinking. Key words in systems discourse are interface, trade-off, reliability and redundancy.

Could it be that these very words are causing us to build inadequate mental models? Linguistic scientists and general semanticists tell us that this is quite probable.

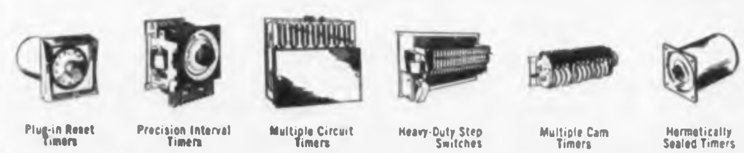
It is likely that the word "interface" which describes the problems at the boundary between two systems is often inferior to the word "interaction." The mental picture suggested by interaction does not have as its focal point the boundary but depicts all of the mutual or reciprocal action or influence (or lack of it) that takes place between systems.

The word "trade-off" is expressive and probably better than the word "compromise." But we do become concerned with the word "redundancy" and the way it has been bandied about. When it describes *one* way of achieving reliability it is expressive, but too often it has come to mean reliability or *the* way of achieving it. Better alternative concepts to redundancy are suggested by the word "self-adaptability" or the phrase "resourcefulness in overcoming failures".

The very term "reliability" has a limited philosophical connotation. With all of the emphasis on high-quality, long-life parts, it has come to mean absolute unchanging behavior. This viewpoint is valid when discussing parts. When discussing complex systems, it is unrealistic to expect rigid unchanging performance. Some new word such as "intelligent goal seeking" might be a better description of the characteristic we need. Such a term when applied to human organisms means effective use of resources in dealing with varying situations including the failure of one or more component parts. Systems problems might be viewed in this light.

We are not proposing that the alternative concepts expressed here are better symbols or models of situations than those now used but we are suggesting that any word has limitations because of its historic meaning and its indiscriminate use detracts from forming adequate new concepts.

James G. Lippke



Design Simple, Phase-Stable Limiters

With growing need for extracting large amounts of useful information from small signals in noisy environments, there has grown the need for sensitive amplifiers that can accept large signals. The gain-controlled amplifier or limiter offers an approach to solving the problem. But it can pose an additional problem of phase shift which the designer must guard against.

Irving Dlugatch
Space Technology Laboratories, Inc.
Los Angeles, Calif.

CONVENTIONAL techniques for controlling amplifier gain over wide dynamic ranges all suffer from one limitation or another. Some methods are satisfactory over large ranges but they involve considerable circuit complexity.

Conventional agc systems can control as much as 80 db of dynamic range but they cause large changes in interstage capacitance as controlled tubes are varied from cut-off to rated g_m. Several corrective measures have been used to reduce the phase shift of amplifiers subjected to agc. They include:

- Operating at low frequencies.
- Using low values of coupling resistance.
- Restricting the range of g_m variation.
- Using low-Q tuned circuits.
- Using fixed gain with voltage-controlled attenuation.

The gain-controlled amplifier is a special form of limiting amplifier. The latter suffers from the same limitations for the same reason. In addition, where an amplifier is operated beyond its linearity limits, it may distort the signal and produce large phase errors due to baseline shift.

The conventional diode limiter solves many of the problems in controlled amplifiers. Comparison of the shunt and series types shows a preponderance of advantages on the side of the series limiter where phase error is of prime importance. In analyzing the merits of the two types, one must make four assumptions.

- Diode forward resistance approaches zero.
- Diode reverse resistance approaches infinity.
- Frequency of operation is low enough so circuit shunt capacities can be ignored.
- Phase angles involved are small enough to be proportional to their tangents.

The phase error is limited to the change in phase of the output signal for a change in amplitude of the input to the limiter. This error is normally caused by the changes in diode resistance and capacitance and baseline shifts due to amplitude distortion.

Shunt Diode Limiter Gives Large Phase Errors

The shunt limiter is shown in Fig. 1 with its low-frequency equivalent circuits. C_1 and C_2 are the diode nonconducting capacities while C_{1a} is the capacity for one diode conducting. Diode forward resistance is represented by r_1. C_s is the circuit shunt capacity which is assumed constant.

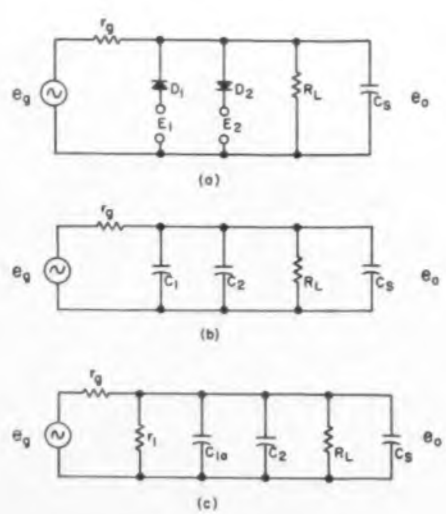


Fig. 1. The shunt diode limiter (a), its equivalent circuit when neither diode is conducting (b), and its equivalent circuit when D_1 is conducting (c).

When the signal peaks are less than the bias voltages, E_1 and E_2, diode resistances are assumed infinitely large. Then the transfer function for the circuit, (Fig. 1b) is

$$\frac{e_o}{e_g} = \frac{R_L}{\sqrt{[r_g R_L \omega (C_1 + C_2 + C_s)]^2 + (r_g + R_L)^2}}$$

When one of the diodes is conducting heavily its resistance is very much lower than that of the other. The conducting diode's capacity is increased because of the decreased diode junction voltage. The transfer function for this circuit, (Fig. 1c), is

$$\frac{e_o}{e_g} = \frac{r_1}{\sqrt{[r_g r_1 \omega (C_{1a} + C_2 + C_s)]^2 + (r_g + r_1)^2}}$$

If the circuit phase angles are small and C_s is very much larger than the diode capacitances, the phase angle comparison is approximated by

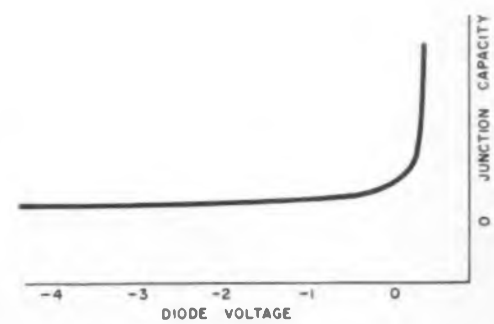


Fig. 2. Typical variation of diode-junction capacity with applied voltage.

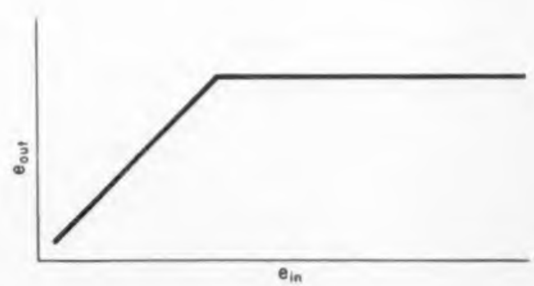


Fig. 3. Ideal limiter or agc characteristic.

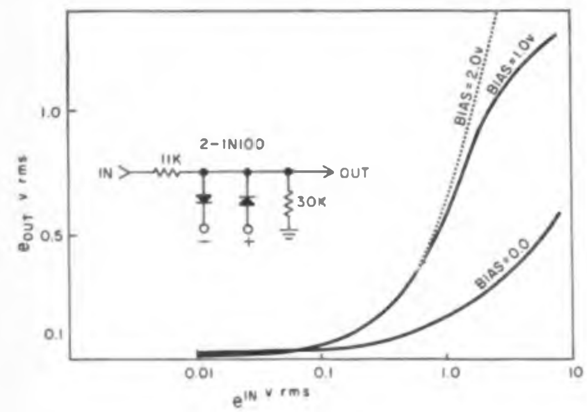


Fig. 4. Variations in the output of a conventional shunt limiter for three different values of bias. Note the baseline shift and the nonuniform clipping.

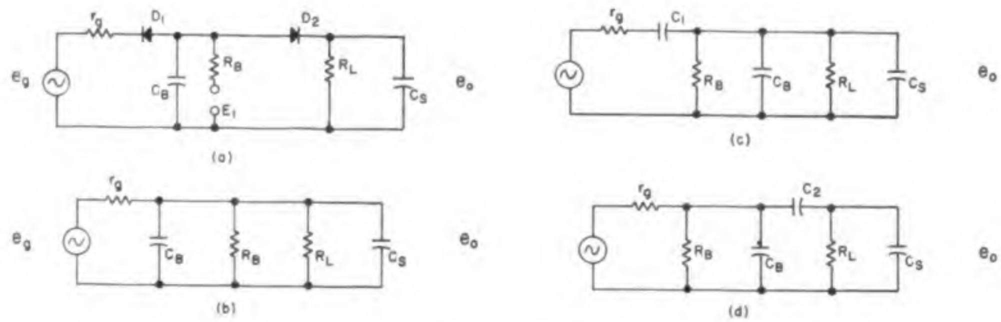


Fig. 5. The series diode limiter *(a)*, its equivalent circuit with both diodes conducting *(b)*, with only the second diode conducting *(c)*, and with only the first diode conducting *(d)*.

$$\phi_1 \approx \omega R_L (C_1 + C_2 + C_s) - \frac{1}{\omega r_g (C_1 + C_2 + C_s)}$$

when neither diode conducts, and

$$\phi_2 \approx \omega r_1 (C_{1a} + C_2 + C_s) - \frac{1}{\omega r_g (C_{1a} + C_2 + C_s)}$$

when D_1 is conducting. Then

$$\frac{\phi_1}{\phi_2} \approx \frac{R_L}{r_1}$$

The ratio indicated for the two phase angles can be used as a measure of the phase shift to be anticipated between the clipped and non-clipped outputs. It is obvious that r_1 will vary considerably with the amplitude of the current flowing through it and that it must have a value very much smaller than R_L to be effective. Therefore, very large phase shifts can be expected with signal amplitude changes. If clipping is slight and cascading is used with several stages of amplification, the error can be minimized to that due to Δr_1.

Diode Capacitance Must Not Be Neglected

Actually, the effect of the diode capacity cannot be ignored because its change with voltage is often as much as 40 db greater than that of the resistance and its absolute magnitude could be too large to be disregarded at the frequency of interest. The increase in capacity tends to offset the decrease in resistance in the calculation of the phase angle and its more rapid and earlier rise actually reduces still further the amount of clipping that is feasible without phase error. Fig. 2 shows a typical diode-capacitance characteristic. Finally, compensation by the addition of inductance can reduce the effect of changing capacitance but it can do nothing about the resistance change.

The transfer function for the shunt-clipped mode shows that the output amplitude is determined by the diode's capacitance and resistance while conducting. Both vary considerably over a small voltage increment. Further, neither resistance nor capacitance can be matched in two diodes for any large portion of their characteristics. That is, it is extremely difficult to obtain symmetrical clipping of the signal wave so large baseline shifts are to be expected.

An additional disadvantage of the shunt limiter accrues from the slope of the diode's *E-I* characteristic which lacks sharpness in the transition from cut-off to conduction and which lacks flatness in the conduction region. The curves in Figs. 3 and 4 illustrate this point. Fig. 3 shows the ideal limiter curve while Fig. 4 gives data plotted for a conventional shunt limiter. The data show that such a limiter is not efficient in stripping off amplitude variations. Its clipping is not uniform and its baseline shifts.

One must conclude that the shunt limiter is useful only if a small degree of clipping is permitted. This calls for cascading limiters and amplifiers to obtain control over a wide range of signal amplitude.

Series Diode Limiter Minimizes Phase Shift

The series type of diode limiter, Fig. 5a, is better. At low levels of input signal, both diodes conduct and, if forward resistances r_1 and r_2 are negligible, the equivalent circuit assumes the form of Fig. 5b. The diode capacity is assumed to have a reactance considerably higher than the diode conductance at ω. The transfer function is

$$\frac{e_o}{e_g} = \frac{R_L R_B}{\sqrt{[r_g R_L R_B \omega (C_B + C_s)]^2 + (r_g R_B + r_g R_L + R_L R_B)^2}}$$

When the polarity and amplitude of the signal are such that the first diode is cut off, we have the equivalent circuit of Fig. 5c.

It is desirable that ω be low enough so excessive attentuation is not introduced by the capacitive divider which becomes apparent. This effect is evidenced by a droop on the limiter characteristic as e_g is increased past the knee of the curve of Fig. 2, thus increasing the diode reactance. Under these conditions,

$$\frac{e_o}{e_g} = \frac{R_L R_B}{\sqrt{(r_g R_L + r_g R_B + R_L R_B)^2 + \left(\frac{\omega C_1}{R_L + R_B}\right)^2}}$$

For the conducting mode, the phase angle is

$$\phi_1 \approx \frac{\omega R_B R_L (C_B + C_s)}{R_B + R_L} - \frac{1}{\omega r_g (C_B + C_s)}$$

$$\approx \frac{\omega^2 R_B R_L r_g (C_B + C_s)^2 - (R_B + R_L)}{\omega r_g (R_B + R_L)\ (C_B + C_s)}$$

The value of $\omega(C_B + C_s)$ has been assumed to be high enough so ϕ_1 is essentially zero. Also, all the terms in the equation are constants so the phase angle is affected only by changes in component values due to environment.

(continued on p 54)

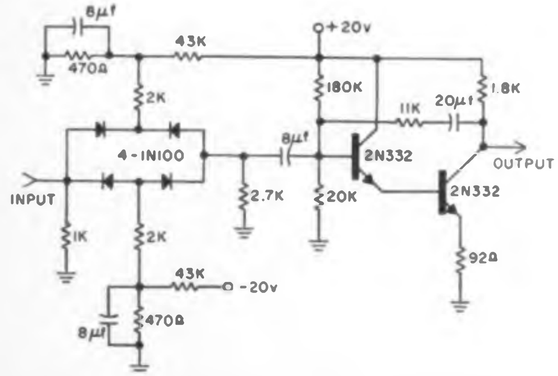


Fig. 6. Bridge version of series limiter (shown feeding a transistor amplifier), provides better performance than conventional series limiter.

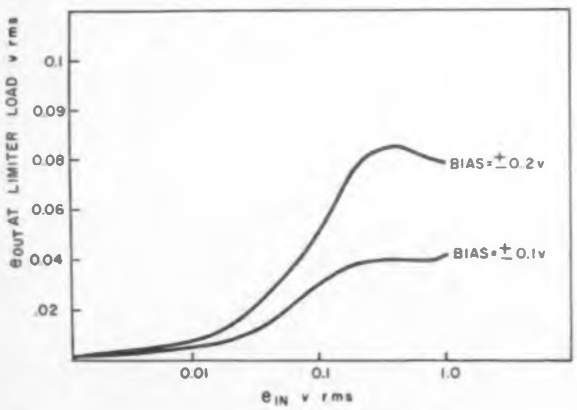


Fig. 7. Characteristics of bridge limiter of Fig. 6, measured at 500 kc, show marked improvement over shunt limiter characteristics of Fig. 4.

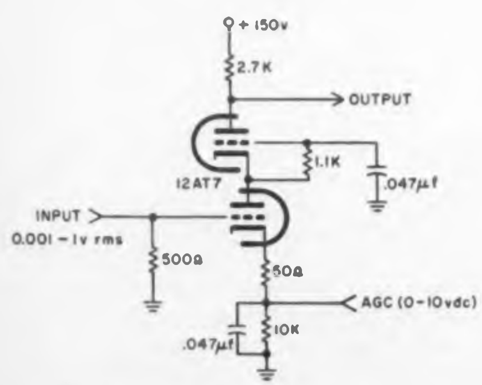


Fig. 8. A cascode amplifier with cathode degeneration and agc added.

For the nonconducting mode of the first diode.

$$\phi_2 = \frac{\omega R_B R_L (C_B + C_s)}{(R_B + R_L)} - \frac{(C_B + C_s)}{\omega r_g C_1 (C_B + C_s)}$$

$$\approx \frac{\omega^2 R_B R_L r_g C_1 (C_B + C_s)^2 - (R_B + R_L)(C_B + C_s)}{\omega r_g C_1 (C_B + C_s)(R_B + R_L)}$$

and

$$\frac{\phi_1}{\phi_2} \approx \frac{C_1}{C_B + C_s}$$

Series Limiter Can Provide High Clipping Symmetry

C_1, which determines the change in phase angle with the presence of clipping for this case, has a small, constant value because it is the value while the diode is cut off. It becomes, then, a matter of keeping the shunt circuit capacities low to make the ϕ_1/ϕ_2 ratio small. This circuit permits the use of compensating inductance to further reduce the phase error.

Insofar as the baseline shift is concerned, the clipped transfer function shows only the diode's cut-off capacitance as a variable. This is small and capacitance can be matched readily in production diodes. A high degree of clipping symmetry can be achieved.

Further, increasing signal drives the series diode further into cut-off, where incremental change in the resistance is small. This gives a flat characteristic, more nearly approaching the ideal. Since good phase stability can be accomplished with a minimum of amplification and without cascading, the series diode limiter appears to offer the optimum solution to the problem.

The transfer function for the second diode being cut off, when the polarity of the signal is reversed, is

$$\frac{e_o}{e_g} = \frac{R_B}{(R_B + r_g)\sqrt{1 + \frac{1}{\omega^2 R_L^2 C_2^2}}}$$

and

$$\phi = \frac{1}{R_L \omega C_2}$$

Comparing the amplitudes for the two polarities, we find the only variables in each function are the diode capacities. Variations in these, from diode to diode, are insignificant. This gives a further assurance of symmetrical clipping.

It should be noted that Δr_1 for varying signal amplitudes has a negligible effect on the phase angle (except at very high frequencies) due to the high value of diode conductance.

Series Bridge Limiter Gives Even Better Performance

To obtain larger outputs with a sharper knee in the limiter characteristic, a bridge version of the series limiter can be used. This consists of two series limiters connected in parallel. Such a circuit, used with a transistor amplifier, is shown in Fig. 6. It was designed for operation at 500 kc.

Low-capacity diodes with high front-to-back ratios are essential in the design of this circuit. The relationship betwen R_B, R_L, and r_g is fixed by the symmetrical-clipping requirements but the input and output impedances should be small if phase shift is to be kept down. From the typical diode-capacitance characteristic, it is noted that it is advantageous to have clipping occur at a low level to minimize ΔC. This suggests the use of low bias voltages. Optimum design for low phase error requires specific information, not readily available in diode literature. The information must be determined empirically.

Fig. 7 shows characteristics of the completed limiter for two values of bias. Comparison with the shunt-limiter characteristic in Fig. 4 shows a marked improvement. The phase shift for 60 db of input signal variation was not measurable.

Most Vacuum-Tube Limiters Require Diode Clipping

Triode or pentode vacuum tubes can be useful in limiter circuits. However, saturation effects cannot be avoided without resorting to diode clipping at their inputs. Saturation operation is

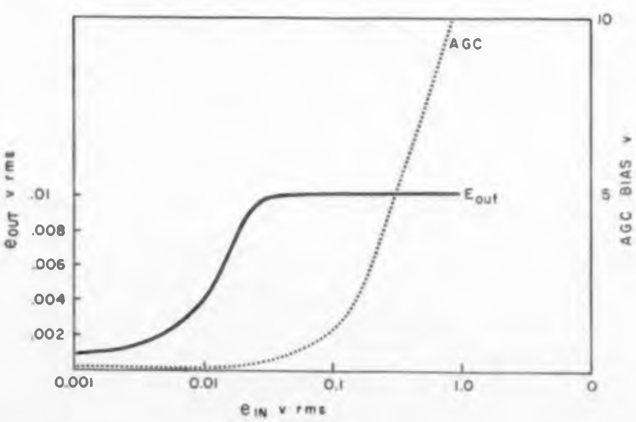


Fig. 9. Output of the modified cascode amplifier of Fig. 8, operating at 500 kc, shown with the variation in agc.

equivalent to operation with a shunt diode limiter and, therefore, subject to the same disadvantages.

Controlling the g_m of an amplifier stage or stages with agc usually avoids saturation but introduces the new problem of the Miller effect, which produces large changes in interstage capacitance.

Cascode Amplifier Offers Excellent Performance

The cascode amplifier can eliminate many of these disadvantages. In one set of tests, a cascode amplifier provided as much as 80 db of attenuation with no loss of flatness and no detectable distortion. In a neutralized version feed-through did not occur until 88 db of attenuation were attempted. Gain control was obtained by varying the cathode resistor.

Fig. 8 shows a cascode amplifier with agc and with a degenerative cathode resistor. Operating at 500 kc, it provides a phase shift of only 0.5 deg for an input-signal range of 60 db. Neutralization and resistive feedback, which would be essential at higher frequencies, could have been used at 500 kc to improve the performance even further. The output of this amplifier, plotted in Fig. 9, compares very favorably with the output of the ideal limiter, plotted in Fig. 3.

The cascode amplifier is particularly suited to limiter applications because of its reduced Miller effect, its low values of coupling impedance, its exceptionally low noise figure, its high gain (equivalent to that of a pentode), and its restricted variations.

In the particular cascode shown in Fig. 8, the cathode resistor reduces phase error even further. Neutralizing the input stage would minimize the effects of its grid-to-plate capacitance on its output admittance (which must be kept low to maintain phase stability).

The output admittance of the second stage is kept low by making the admittance presented to its input small compared with its g_m. The second tube must have low cathode-to-plate capacitance. It can be run with high grid bias and low plate voltage, and it should have high g_m.

The solutions offered here for maintaining constant delay in wide-dynamic-range receivers are recommended for frequencies under 5 mc since the author's testing did not go beyond this frequency. The methods proposed are by no means the only ones that the designer should consider. Excellent results have been achieved with more conventional but considerably more complex schemes. ■ ■

Fluid Flip-Flops: When Should You Use Them?

Easy to construct, the basic "DOFL" fluid counterpart of the electronic flip-flop has no moving parts. It is one of the first nonelectronic devices to approach the reliability and computing ability of transistor circuitry. This rundown on the design data which is emerging on this "new degree of freedom" in systems will help you decide if you should be considering these fluid devices to complement the electronics in your systems. It has resulted from **ELECTRONIC DESIGN** ***staff interviews with the following engineers at the U.S. Army's Diamond Ordnance Fuze Laboratories, Washington, D. C.: Dr. Ronald E. Bowles, Amiel Goodman* and Raymond W. Warren.***

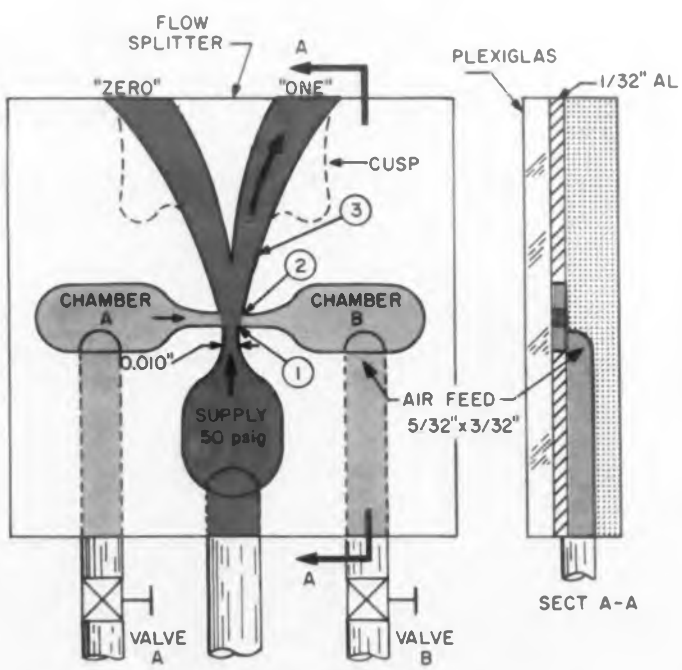


Fig. 1. Fluid flip-flops are simple to construct. This is the basic experimental unit used by DOFL. More sophisticated plastic injection molding and "Photoceram" etching processes are being investigated for mass-producing these units at nominal costs. (There is no reason why these units should eventually cost more than "ten-cent-store" items, researchers believe.)

FLUID-POWERED counterparts of electronic digital circuits appear attractive alternates for high-temperature applications where only moderate computing speeds are needed.

Though fluid-powered computing systems will probably never be able to operate at much over 100 kc clock rates, they have already demonstrated that they can operate without difficulty at temperatures far beyond those possible with electronic devices. Essentially their temperature limitation, assuming inert fluids such as nitrogen or water are used, is the temperature limit of the materials which form the fluid passageways. An upper limit of 7,000 F has been set for these de-

Operating Spectrum for Fluid Devices

	Minimum	Maximum
Temperature	—100 F	+7,000 F
Pressure	10^{-1} psi	10^{1} psi
Operating Frequency	0	100 kc
Form of Output	Display of Computation Results	Servo Action

* Now with Cook Electric Co., Chicago, Ill.

6DJ8—sharp cutoff double triode designed for VHF cascode amplifier service and high-gain pre-amp service. Features Gm of 12,500 μmhos, and low capacitance figures.

3/4/6EH7—semi-remote cutoff pentodes for IF amplifier service. -EH7 family features improved input characteristics for IF service in the 30 to 60MC range. Gm is 12,500 μmhos.

3/4/6EJ7—sharp cutoff versions of the -EH7. -EJ7 family features a Gm of 15,000 μmhos and a Gm:Ib ratio of 1500.

6ES8—semi-remote cutoff double triodes designed for cascode VHF amplifier applications. Features Gm of 12,500 μmhos, noise figure of 6.5db, excellent cutoff characteristics, high electrical stability, improved input loading resistance.

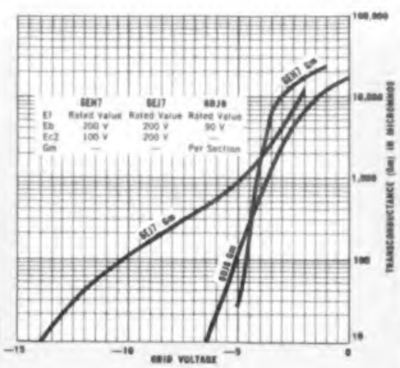
2/3/6FQ5A – semi-remote cutoff triode for VHF RF amplifier service at a B+ voltage of 135V. Features exceptionally low noise figure and high Gm:Ib of 1350. Partial shield between grid and plate contributes to low capacitance. Employs dual cathode leads for reduced input loading.

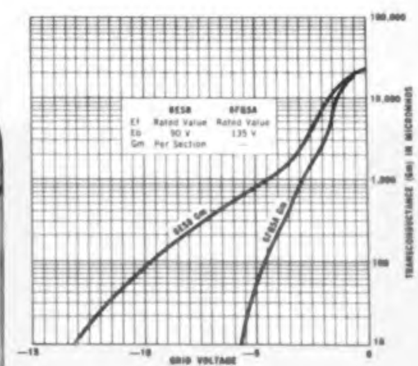
2/3/6GK5—gain-controlled triode designed for use as a VHF RF amplifier at a B+ of 135V. Also well suited for neutralized IF amplifier applications. Gm is 15,000 μmhos; Gm:Ib is 1300. Noise figure is 4.7db, obtained at 200MC (in optimized triode RF amplifier stage, noise matched).

6922—ruggedized sharp cutoff double triode (electrically similar to 6DJ8) featuring Gm of 15,000 μmhos. It is designed for use in cascode circuits, RF or IF amplifier, mixer or phase inverter stages or as a multivibrator and cathode follower in computers.

7308—ruggedized sharp cutoff double triode (electrically similar to 6DJ8) featuring shock and vibrational controls. Rated for Class A service.

7803—double triode (electrically similar to 6DJ8) designed for exceptional reliability in short continuous service under severe environmental conditions. In continuous Class C service at 175 MC, it provides 3.5 watts plate dissipation per section.





The highly refined Sylvania frame grid design lends itself readily to automated production techniques—providing unusually high operating uniformity and the economies of volume production. At Sylvania, sturdy lateral straps are automatically fabricated to rugged side rods, controlling strength and dimensions of the grid throughout life. Micas, therefore, are snugly fitted without detriment to grid dimensions. Mechanical strength is increased, noise and microphonics are appreciably decreased. Too, automated facilities achieve extremely high T. P. I. of exceptionally fine grid wire, tightly and precisely wound, accurately aligned. As a result, electrical stability, gain, Gm, and Gm:Ib ratios are significantly improved.

Too, because Sylvania Strap Frame Grid possesses a "flat" minor grid dimension it is fitted with a planar-design cathode. This remarkable combination provides exceptional uniformity of grid to cathode spacing with dramatic improvements in electron transit time, cutoff controls, uniformity of characteristics.

BIKINI CATHODE IMPROVES PERFORMANCE OF SYLVANIA 3/4/6EH7, 3/4/6EJ7, 6ES8

Sylvania-originated Bikini Cathode is a pre-cast film of emissive material bonded to the two major sides of a flat cathode sleeve. This remarkable design minimizes stray emission, assures uniform temperature and emission over the entire cathode surface, reduces possibility of grid-cathode shorts, improves tube longevity.

Examine the superior qualities of Sylvania Strap Frame Grid tube types for your design. Contact your Sylvania Sales Engineering Office, or for data on specific types, write Electronic Tubes Division, Sylvania Electric Products Inc., 1100 Main Street, Buffalo 9, N. Y.

AVAILABLE NOW FROM SYLVANIA!

PANELESCENT®

Sylvania AN-150, 1½" alpha-numeric, is diagrammed, right, to show the 14 segments that produce the complete English alphabet, 0-9 numerics and selected mathematical symbols.

READOUTS

• NUMERICS, ALPHA-NUMERICS / • X-Y GRID PANELS

...wide range of patterns, sizes, mountings / *...wide range of sizes, resolutions*

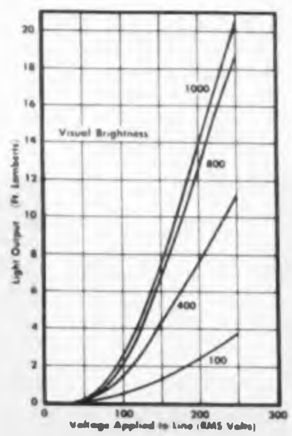
PANELESCENT electroluminescent (EL) devices open a vast new future for creative design of readout displays. Outstanding features include: compact, flat area source of light • long life • absence of catastrophic failures, enabling planned maintenance • low power requirements • wide angle viewing • simplified circuitry.

Sylvania advances in EL techniques now make practicable character heights from ⅜" for numerics and ⅝" for alpha-numerics to 12". Multiple numerics or alpha-numerics are available formed on one substrate for in-line display. Sylvania techniques of packaging can provide several "plug-in" designs, to conform with your individual design requirements, offering optimum combinations of economy, compactness and ruggedness.

Sylvania X-Y Grid panels—for position-plotting displays – utilize conductive strips placed at right angles to each other. When the strips are excited a point of light is produced at the intersection. This point of light is moved by selective excitation of the strips. Sylvania X-Y panels, using a green phosphor, provide contrast ratios in the order of 15:1. Panels with active areas of 2½" x 2½" are now available with resolutions of as high as 50 lines/inch. Larger panels are also available.

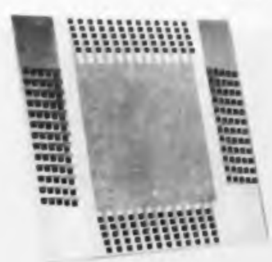
Contact your nearest Sylvania Sales Engineering Office for further information. They'll be pleased to discuss your individual readout requirement. Or, send for the descriptive brochure, "Sylvania Electroluminescent Display Devices." Write Electronic Tubes Division, Sylvania Electric Products Inc., Dept. EL, 1100 Main St., Buffalo 9, New York.

Sylvania NU-150, 1½" numeric, is diagrammed, right, in actual size to show the 9 segments that produce a display of 0-9 numerics. Numeric characters are also available with as few as 7 segments.



Curves illustrate variation of PANELESCENT lamp brightness with voltage at varying frequencies.

® Panelescent is a registered trade mark.



Sylvania X-Y Grid Panel, having a resolution of 50 lines/inch, is shown above.

First Pages of DOFL Handbook On Design of Fluid Devices Now Available

Since the early work on fluid devices was announced by the Army's DOFL Laboratories a year ago, DOFL's efforts have been directed towards formalizing its design know-how in fluid devices into a handbook for industry. The "Fluid Amplifier Handbook" will be available for purchase from the government when it is completed. Meanwhile DOFL is releasing loose-leaf installments as they become available to a special mailing list. Because of the demand (over 500 requests) DOFL has had to limit the private firms on the mailing list to those which are helping build up the handbook's information.

The handbook will have chapters on: components, interconnections and transmission lines; power supplies; production and test evaluation; computer system design; servo system design; signal to noise ratios; transducers, and design for extreme environments.

To purchase copies, write: U.S. Dept. of Commerce, Office of Technical Services, Washington 25, D.C.

vices. (See Table on page 56 for other limits).

The sketch, Fig. 1, shows the simplicity of design and construction of a fluid multivibrator. The sketch is approximately full size. For experimental purposes DOFL has been using units contained in 1 to 5 in. squares. However, it is felt that much smaller sizes will be eventually desirable, both for system compactness and for higher computing speeds. Regardless of the unit's over-all dimensions, the configuration of the passageways is as shown. (There are other types of fluid flip-flops, but this one appears to be the most attractive. For example, a Swiss researcher has developed a type using tiny pistons; it has the obvious disadvantage of moving parts.)

The critical dimensions are the flow passages formed by the walls in the vicinity of (1), (2) and (3) in the figure. These have been enlarged on the sketch for clarity. Actually, the passages from the main 50-psig supply and chambers *A* and *B* should be 0.010-in. wide.

Note, too, that there is a small setback between points (1) and (2) on either side of the control passageways from chambers *A* and *B*. That is, the width of the main (vertical) passageway increases abruptly by a small amount (about the ratio shown, but exact values should be determined experimentally). This setback has been found important for the control action. On the other hand, the cusps (shown as dotted lines) in

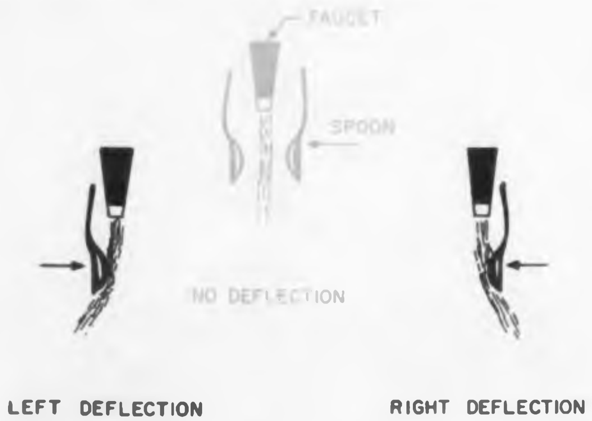


Fig. 2. It's easy to demonstrate the operating principle of fluid flip-flops. Just move the backside of a spoon into a fluid stream and observe how the flow deflects.

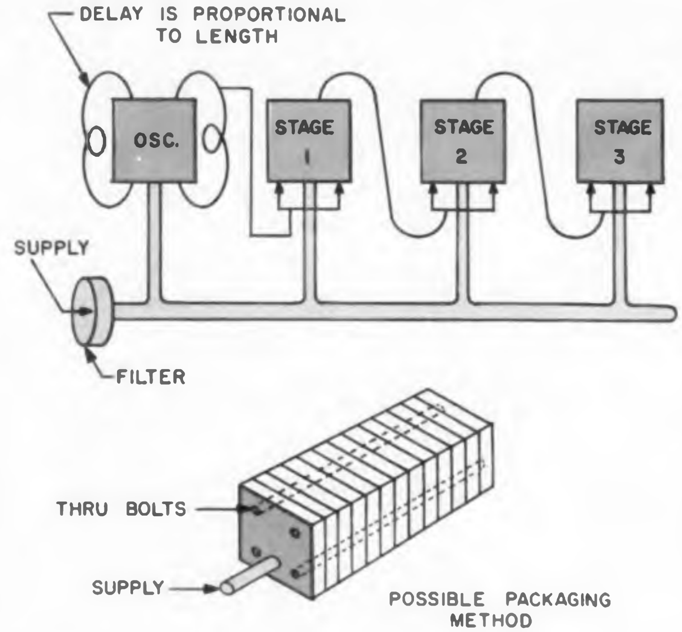


Fig. 3. Complete fluid computers can be built from fluid flip-flops. Experimental models are easiest built with flexible tubing interconnections (top) but ultimate systems may be more compact and rugged if bolted together into a "solid" unit (bottom). (Caution: the designer should investigate a certain refinement now under patent application by DOFL concerning interconnection design.)

the main exit sidewalls which were originally thought important, have since been abandoned.

As section *A-A* shows, the passages are cut out of a 1/32-in. aluminum sheet. This plate is then sandwiched between two other plates. It is convenient to make at least one of these outer plates out of a clear plastic such as Plexiglas (Acrylic) for experimental models so that the state of the internal flow passages can be observed. It is an easy thing, then to see if the tiny flow passages are obstructed by particles by bits of foreign matter. In addition, by use of colored dyes, the actual behavior of the fluid streams can be observed. The feed passages are scooped in the back plate in this design.

The exact shape and material for these devices are not too critical, provided the basic "wall hugging" phenomenon occurs in the vicinity of (1), (2) and (3). In fact, one DOFL researcher showed that a workable fluid multi could be cut out of vinyl floor tile. However, on some designs, it is important to hold air leakage between the layers to a minimum by close spacing of the clamping bolts (or careful application of contact-type adhesive) along the passageways. Acrylics "cold-flow" under bolt compression and are self gasketing; other materials may need rubber or Teflon gaskets.

Wall Hugging Is Operating Principle

The fluid multivibrator shown in Fig. 1 will act just like an electronic flip-flop. When the supply air (or other fluid) is turned on, the unit will go into one output state or the other. As the supply pressure builds up and flow starts through the nozzle past points (1), (2) and (3) on the passage wall, "entertainment asymmetry" causes "hugging" of one wall or the other. Thus the flow will be directed out the "zero" or "one" side of the flow-splitter at the flip-flop exit.

A simple experiment illustrating this wall-hugging tendency is the "faucet and spoon" demonstration shown in Fig. 2. Here, as the spoon is moved into contact with the stream, the flow attaches to the curved backside of the spoon and is deflected. A spoon moved in from the right deflects the faucet's stream to the right and a spoon from the left deflects the stream to the left.

In the same manner, the flow in the fluid multi goes to the "zero" and "one" sides of the flow splitter at the top of the unit, according to which side the flow attaches.

But to make a useful amplifying device, it is necessary to trigger the flow from attachment to one side to attachment to the other. This triggering is done with smaller control flows from chambers *A* and *B*. The arrows in Fig. 1 indicate that flow from chamber *A* has switched the flow away from *A*'s side to *B*'s side to go out the "one" exit.

Amplification occurs because the pressure level needed for switching is significantly below that used for the main supply. With the 50-psig supply shown, changes of pressures in *A* and *B* of only 1 or 2 psi are sufficient to switch the output.

Use of Basic Unit in Circuits and Systems

Fig. 3 shows schematically an oscillator and counter made up from the basic multivibrator flip flop. The oscillator frequency is set by the fluid delays in the length of lines feeding the outputs back to the inputs. The counter stages are similarly interconnected by lengths of tubing. A possible packaging method is also shown. The units would be through-bolted together using intermediate blocks which would contain the interconnecting passageways. In this manner, one "solid-state" computer could be built up from fluid units.

Shift registers and full adders have already been developed at DOFL. Valve matrices, flip-flop registers and conventional magnetic drums will be used for memories. The valve matrices for fixed permanent memories will be set valve-by-valve much like diode matrices are set by selectively burning out diodes. Once the valves are set, they will retain their information even if fluid power is lost. The flip-flop memories on the other hand will be used for scratch-pad computing memories. It is believed that once the flip-flop units are mass-produced they will become cheap enough to be used in this manner.

For very large memories, it may be necessary to revert to magnetic drum arrangements, transducing the fluid signals into electrical signals.

Photoceram Looks Good for Fabrication of Units

DOFL does not believe that anyone has begun to exhaust all of the many possible ways for fabricating these units. Obvious choices of materails are epoxy resins for short-run production and diallyl phthalates for mass production runs (using injection molding machinery).

For highly miniaturized, fairly high-temperature fluid multis, precision-etched Corning Photoceram appears quite promising. DOFL is using many of the same artwork and optical pattern transfer methods which it has developed in its electronic microminiaturization program.

Still other materials such as stainless steel and graphite may be necessary as the full 7,000-F potential is approached.

Uses for Fluid Devices
Cover, Sensing, Computing and Actuation

Fluid devices appear attractive for combined sensing, computing and actuation systems, particularly where a source of fluid power is already available. They are being investigated for missile systems where the fluid power is available in the form of ram air (while in the atmosphere) or the rocket propulsion system. They are being investigated for industrial systems which would work off "shop air" in the plant. The fact that they can only transmit signals at up to the speed of sound prohibits their use in spread-out industrial systems, however.

They are ideal for digital servo systems. They could take a count command from a master electronic computer, and directly operate either a digital or analog fluid actuator until a fluid feedback sensing system had uncounted the command. Part of the research in fluid systems is concerned with transducers which will enable the fluid devices to communicate with electronic systems.

But perhaps the best example of an application in which fluid devices would be superior to any current system would be the autopilot of a Mach-3 commercial airliner or an "X-15" type hypersonic aircraft. Here, it would be nice to keep the amount of electronics to the minimum to lessen the cooling load. (Already the X-15 flights have demonstrated that surface temperatures at these speeds can burn the paint off the vehicle). Fluid devices, powered by ram air scooped up in flight, could take the navigation signals from the basic electronic computer and do all the slower computing necessary for minor loop stability and control. They could directly sense many of the flight variables (airspeed and pressure altitude are "fluid" to begin with) and directly gate the reaction jet "puffs" for high-altitude control. They could also direct fluid control streams into the throat of the vehicle's main propulsion rocket to deflect the exhaust for steering.

Since fluid devices of the DOFL type are one of the few recent developments which can in any way compete with electronic approaches, and since often the fluid devices will complement as much as compete with electronic approaches, designers should keep abreast of developments in this new field. ■ ■

A Check List for Design Review

Part 2

Here is the concluding half of the check list whose first part appeared in the May 24 issue of* Electronic Design, *p 36.

The first part covered Electrical Design. Part 2 covers Mechanical Design, Human Engineering, and Value Engineering.

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TOO OFTEN, the electronic design engineer reviews his work only in light of the electronic design. He checks to see that the circuit works properly, that components are properly rated, and that the electronics specifications are met.

But too often, by the law of perversity of inanimate objects, failures come from precisely those parts he hasn't checked. This check list should help the designer to evaluate the obvious factors that determine how well his design will work, and also some of the less obvious features that determine how useful the design will be to the customer and how profitable it will be to his company.

Mechanical Design

General Design

1) Has use of cantilever mounting for parts and assemblies been minimized, and, where used, is the center of gravity near the mounting?
2) Has the chassis been properly designed?
3) What are the locations and load ratings of mounting points?
4) Where are the heaviest parts?
5) Are all large parts and assemblies securely mounted?
6) Has the center of gravity been considered in terms of the proper distribution of shock mounts?
7) In the case of terminal boards, are the critical components mounted at the edges rather than at the center, and are they properly supported?
8) In the case of lead-mounted parts, have component weight, lead weight, thermal expansion, supplementary support, bend rate, and other mounting considerations been evaluated?
9) Have clearances been provided with due consideration for vibration, shock, and noise stresses?
10) Can electrical instability be caused by vibration of mechanical parts?
11) Have shock and vibration tests been performed?
12) Has the cooling design been analyzed to provide a temperature contour?
13) Are heat-dissipating elements properly located with respect to heat-sensitive parts? Is there suitable flow of air?
14) Have component parts, subassemblies and assemblies been supported and clamped properly with adequate consideration for heat dissipation?
15) Is the unit of the lightest weight consistent with sturdiness, safety, and reliability?
16) Are all items visually and physically accessible when the unit is on the test stand?
17) Is the possibility of physical damage due to misuse of adjustments minimized?
18) Is the possibility of damage to the unit during handling and installation minimized?
19) Can the unit be removed and replaced within the required time limit?
20) Is the packaging scheme such as to avoid unrealistic spare-parts requirements?
21) Does each part of the unit designed as nonfield repairable meet the minimum reliability requirement for this classification?
22) Have suitable heat treatments been called out?
23) Has design been based on standard tooling wherever possible?
24) Have radii, fillets, curves, and straight lines been sufficient to give all possible freedom to manufacturing?
25) Have the most economical parts satisfactory for the application been specified in all cases?
26) Are all purchased components called out by MIL or AN (not vendor) numbers?
27) Are the components arranged and mounted for the most economical assembly and wiring?
28) Are all fasteners large enough?
29) Are guide pins, keys, and latches strong enough?
30) Is the basic structure strong enough?
31) Is the design such as to prevent excessive radiation into or out of the unit?
32) Are parts located to provide for logical wiring?
33) Are lubrication points minimized? Where required, are they accessible and clearly marked?
34) Is the predicted reliability within the unit requirement?
35) Have unit environmental tests, including tem-

perature measurement at key points, been completed?

36) Has there been compiled a separate list of recommendations for product improvement or redesign?

37) What alternate designs were considered?

38) Have the appropriate standards been consulted for materials, components, drafting, manufacturing, and workmanship?

39) What factors influenced the choice of this particular design?

40) Do firm specifications exist, including test specifications?

41) Have all specifications been met?

42) Does any specification require modification?

43) Can any unreasonable or unusually difficult requirements be relaxed?

Workmanship and Maintainability

1) Is soldering adequately specified? What provisions have been made to prevent cold joints and to ensure removal of flux?

2) Are proper screw lengths and locking provisions specified?

3) Are designs such as to prevent damage to components during installation?

4)Have guide pins been provided to facilitate installation of plug-in units?

5) Are plug-in units keyed (by some means other than the connector) to prevent accidental insertion in the wrong location?

6) Have tolerances of component-mounting provisions and mating holes been coordinated?

7) Have all holes been located far enough from bends to prevent distortion?

8) Are bend radii specified to be large enough, in accordance with appropriate standards?

9) In reference to wiring and cabling, have the following items been considered?

a. Does the design provide for properly leading cables around corners and sharp edges?

b. Are grommets provided where needed?

c. Is the design such as to minimize soldering-iron burns during both manuafacture and maintenance?

d. Is lacing properly and adequately specified?

e. Have harnesses been properly routed and has sufficient clamping been provided to prevent cables from hanging loose?

f. Has adequate space been allowed for harnesses and for breakouts to connectors, etc?

g. Are heavy wires brought to large enough terminals?

h. Are stranded wires properly secured close to solder joints to prevent flexing?

i. Is any cable (or wire) overly taut, with strain being placed on the connector, the cable (or wire), or the clamps?

j. Do any cables or wires lie across removable units or across fasteners of any type?

k. Are all connectors visible, and are they easily accessible to tools and hands?

l. Have cables (wires) and connectors been properly identified? Can wrong connections result from cable layout and connector type?

m. Do any cable (wire) runs permit contact between the cable (wire) and moving parts?

10) Are all items (parts and subassemblies) visually and physically accessible for assembly, wiring rework, and maintenance?

11) Are all test points accessible when the unit is properly installed?

12) Are all field adjustments accessible when the unit is properly installed?

13) Has sequential assembly been avoided which results in involved sequential disassembly to make repairs and adjustments?

14) Is the design such that no unrealistic requirements for special facilities for maintenance, storage, or shipment are imposed?

15) Is the design such that no unnecessary requirements for a special maintenance environment (e.g., ground power carts, cooling, special primary power, etc.) are imposed?

16) Does the design provide for adequate protection of maintenance and test personnel against accidental injury?

Materials and Processes

1) Have standard materials been specified in all possible cases?

2) Have the most economical materials and processes suitable for the applications been specified in all cases? (Material cost, fabrication cost and finishing cost should be considered.)

3) Have corrosion-resistant materials or finishes been provided?

4) Are there dissimilar metals in contact?

5) Are all materials satisfactory for the temperatures involved?

6) Is the possibility of flaking considered,

7) Has moisture protection been provided where necessary?

8) Are all materials fungus resistant or inert?

9) Are electrically conductive finishes provided where necessary?

10) Have machine finishes been reviewed for the most economical processes suitable for the requirements?

11) Have rivets or spot welds been specified where possible in preference to welding, furnace brazing, etc.?

12) Has each sheet-metal piece been examined to determine whether it has too many bends for economical fabrication?

Human Engineering

1) Are visual indicators mounted so the operator can see scales, indices, pointers, or numbers clearly? Are scale graduations, numerals, pointers, and scale progressions presented so that accurate reading is enhanced?

2) Do visual displays have adequate means for identifying an operative condition?

3) Have ambiguous information and complicated interpolations been eliminated from visual indicators to minimize reading errors?

4) Do controls work according to the expectation of the operator? (Naturalness of movement direction is derived from previous experience as well as certain handedness factors.)

5) Do functionally related controls and displays maintain functional or physical compatibility, such as direction-of-motion relationships or proximity to each other?

6) Are controls designed so the operator can get an adequate grip for turning, twisting, or pushing?

7) Does console design provide knee room, optimum writing-surface height, or optimum positions for controls and displays?

8) Do equipment design and arrangement allow space for several operators to work without interfering with each other?

9) Do arrangement and layouts stress the importance of balancing the workload, or do they force one hand to perform too many tasks while the other hand is idle?

10) Is the illumination designed with the specific task in mind, rather than with a general situation?

11) Have glare hazards been eliminated, such as brightly polished bezels, glossy enamel finishes, or highly reflective instrument covers?

12) Do fasteners for chassis and panels require special tools which hamper maintenance?

13) Do chassis door slides have means for holding the unit extended for servicing? Are the slides too loose, or do they bind?

14) Are handles provided, and are the chassis or units light enough to be moved without undue strain?

15) Is calibration indexing provided for maintenance adjustment and calibration controls? (Screwdriver adjustments are often too sensitive.)

16) Do the coding and symbols on equipments and in instructon manuals coincide? (Too few books tell what or how to check, what to expect, or how to correct. When covered, the information is not organized so that it may be found quickly.)

17) Is illumination provided for the maintenance technician?

Value Engineering

Specification Review

1) Have the customer's specifications been critically examined to see whether they ask for more than is needed?

2) Has the cost of any overdesign been defined for its effect on production as well as on the R&D program?

3) Has the cost effect of contrac[illegible] uired overdesign been discussed with the custo[illegible]

General

1) Does the design give the customer what he requires and no more,

2) Could costs be radically reduced by a reduction of performance, reliability, and/or maintainability to the minimum specified?

3) Could costs be radically reduced by a reduction of resistance to high temperature, shock, vibration or other environments to the minimum specified?

4) Have circumstances changed (changes in concept or specification, progress in the art, development of new components or processes) so that the design includes unnecessary or expensive circuitry, parts, or processes?

5) Have unnecessarily-high-cost items been included as a result of their availability when the breadboard or model was constructed?

6) Can any variable devices such as potentiometers included for breadboard or model-operational-adjustment be changed now to fixed component parts or semi-adjustable designs?

Production Costs

1) Are the quantities to be built on this order known? Are the estimated quantities to be built on future orders known? Have these factors been considered in the design decisions?

2) Will tooling costs be in line with present and anticipated production?

3) What is the estimated cost of the design in production?

Electronic Design

1) Does the design represent optimum electrical simplicity?

2) Is circuitry overly complex or conservative?

3) Have standard "preferred circuits" been reviewed to see how many can be used beneficially?

4) Has the field of commercially available packaged circuits, power supplies, etc. been reviewed against requirements?
5) Can circuitry be eliminated by having one circuit do the job of two or more?
6) When specifying special component parts, have potential vendors been consulted for alternatives or modifications that would hold costs down?
7) Have all high-cost components such as transistors, semiconductor diodes, magnetic and high-power devices, motors, gear trains and decoders been examined to determine whether lower-cost substitutions can be made,
8) Are the components the lowest cost meeting the design requirements?
9) Can any electrical tolerance be liberalized to allow specification of lower-cost parts?
10) Have nearly identical parts been made identical to gain the advantage of quantity buying or manufacture?
11) Has coax cable been specified when hookup wire or shielded cable will do the job?
12) Has silicon been specified for transistors or diodes when germanium will do the job?
13) Can metalized Mylar be substituted for tantalum or Cerafil capacitors?
14) Have automated techniques been used to the maximum?
15) Is Teflon wire specified where other insulation will suffice?

Mechanical Design

1) Does the design represent optimum mechanical simplicity?
2) Is every part absolutely necessary? Can any part be eliminated or combined with another part to reduce total number of parts and cost?
3) When specifying special parts, have potential vendors been consulted for alternatives or modifications that would hold costs down?
4) Are mechanical tolerances within the limits of normal shop practice?
5) Are the surface finishes the coarsest that will do the job?
6) Are the fabrication processes the lowest cost meeting the design requirements?
7) Have nearly identical parts been made identical to gain the advantage of quantity buying or manufacture?
8) Are the materials the lowest cost meeting the design requirements?
9) Does the combination of material and protective finish specified result in the lowest cost combination?
10) Has relative workability of materials been considered?
11) Have standard alloys, grades, and sizes of stock been specified whenever possible?
12) Can the design be altered in any respect to avoid the use of nonstandard tooling?
13) Has the 1/10 in. grid-drafting system for sheet-metal parts been used wherever applicable?
14) Can the design be modified to use the same tooling for right and left hand or similar parts?
15) Are drawings for fabrication of parts that are similar to parts already produced cross referenced so available tooling can be used?
16) Can the design be altered to avoid unnecesary handling and procesing resulting from such things as riveting and spot welding on the same subassembly part?
17) Have automated techniques been used to the maximum?
18) Are casting bosses of adequate size, considering the large tolerances in casting dimensions?
19) Can cores or complex parting lines be eliminated from any casting by moderate redesign?
20) Is impregnation of castings called out when it would aid processing? (Castings should be impregnated after machining if they are to be electroplated. This impregnation prevents absorption of plating acids or salts. Castings should also be impregnated if they are to hold liquids or gases under pressure.)
21) Have engineering and factory specialists been consulted for castings, forgings, weldments, heat treatment, and other specialties?
22) Have standard sizes, grades, and alloys of fasteners been specified whenever possible?
23) Are all manual welding operations specified absolutely necessary? Can furnace brazing be substituted?
24) Are the assembly processes the lowest cost meeting the design requirements?
25) Has adequate clearance between parts been provided to allow for easy assembly? (Parts have become smaller but hands have not.)
26) Are all parts designed for assembly at the earliest possible time? Assembly costs go up as the build-up of the system progresses.
27) Are markings adequate to guide the assembly processes?
28) Have the engineering and factory specialists been consulted on any unusual assembly problems?
29) Has datum-line rather than multiple-surface dimensioning been used on all drawings?
30) Can any four-place dimension be changed to three-place dimensions?
31) Can any three-place dimension be changed to two-place dimensions?
32) Can heat treating after forming sheet-metal parts be eliminated by change of design or material to avoid straightening problems?
33) Is all masking from finishing materials (such as plating solutions and paint) necessary?

Standardization

1) Has the design been coordinated with similar designs, circuits, parts, or components to get optimum benefit from standardization and past experience?
2) Are the standard circuits, standard components and standard hardware the lowest cost standards which will supply the minimum-required characteristics?
3) Can the use of each nonstandard part or circuit be adequately justified?
4) Can any new nonstandard part be replaced by a nonstandard part which has already been approved?
5) Do control drawings leave no question that a vendor standard part is being specified when such is intended?
6) Has standardization been carried too far so the cost of excess function is greater than the gains resulting from high quantity?

Maintainability Design

1) Is each assembly self-supporting in the desirable position or positions for easy maintenance?
2) Can assemblies be laid on a bench in any position without damaging components?

Testing

1) Are the test processes the lowest cost meeting the design requirements?
2) Can any test specification be eliminated or relaxed?
3) Have interacting controls been eliminated or the adjustments specified in such a manner that the lowest-cost factory-test personnel can easily align the circuit?
4) Is the system compatible with the requirements for checkout in the factory—if not as a complete system, then in large subsystem segments?
5) Have the test-process experts been consulted for alternatives that would keep their costs down?

Subcontract Items

1) Has the field of commercially available packaged units, subassemblies, and circuits been thoroughly reviewed to be sure there are no standard vendor items that will do the job?
2) Is desired cost control adequately emphasized in subcontract specifications?
3) Have specifications for subcontract items been reviewed against the check list to be sure they are not overspecified?
4) Have suggestions been invited from prospective suppliers regarding possible value improvement from loosening specification limitations? ■ ■

Phasors Simplify Differentiating And Integrating Equations Of Exponentially Damped Sinusoids

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DIFFERENTIATING and integrating equations representing damped sinusoids can be greatly simplified by use of phasors. The usual techniques of treating these equations, such as differentiating as a product of two functions or integrating by parts, rapidly become very clumsy, especially if it is necessary to find the second or third derivative or integral.

To show how phasors can be used to simplify the mathematical treatment, one can take a typical representation of a damped sinusoidal oscillation:

$$v = e^{at} \sin bt$$

Consider the meaning of this equation from a phasor viewpoint. It represents the projection in a horizontal direction of a rotating phasor of varying length e^{at}, which starts at zero phase angle at zero time. If a is positive, the phasor grows longer, and the amplitude of the projected sinusoid increases with increasing time. If a is negative, the phasor shrinks, and the amplitude of the projected sinusoid is damped asymptotically toward zero.

The derivative of v with respect to t may be represented by a phasor rotating at the same rate, b radians per second. One can draw a phasor of length a in the same direction as the phasor representing sin bt, and draw a phasor of length b leading the phasor sin bt by an angle of 90 deg, as shown in Fig. 1.

The resultant of these two phasors is of length $(a^2 + b^2)^{1/2}$. It leads sin bt by the angle θ where

$$\theta = \arctan \frac{b}{a}$$

This resultant represents the derivative. The derivative may be written:

$$\frac{dv}{dt} = \sqrt{a^2 + b^2}\, e^{at} \sin (bt + \theta)$$

Similarly the second derivative may be written:

$$\frac{d^2 v}{dt^2} = (\sqrt{a^2 + b^2})^2\, e^{at} \sin (bt + 2\theta)$$

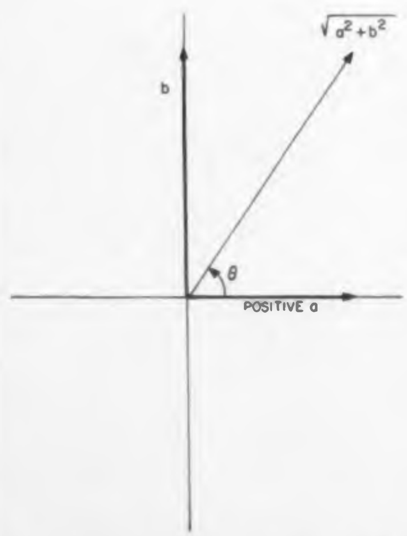


Fig. 1. Resultant of two phasors represents the derivative of $v = e^{at} \sin bt$.

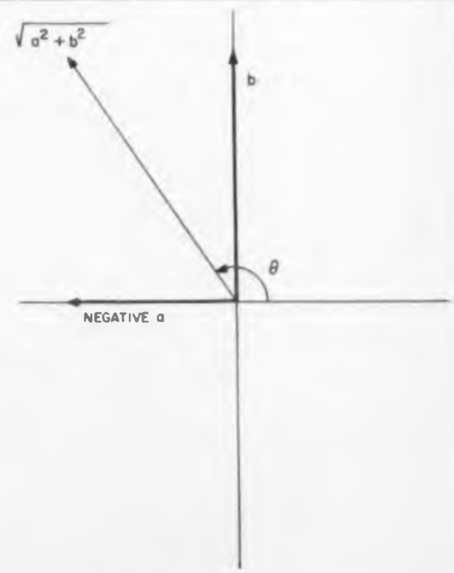


Fig. 2. The resultant here represents the derivative of $v = e^{-at} \sin bt$.

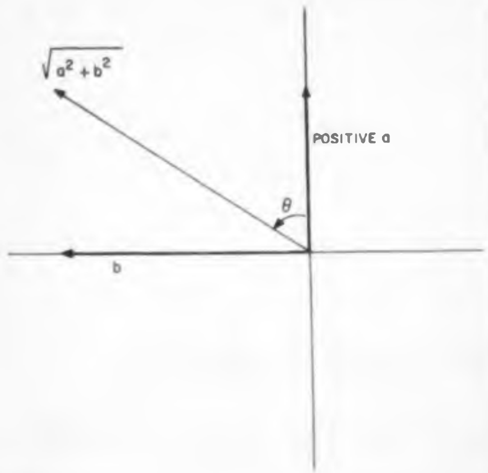


Fig. 3. Rotating the phasors through 90 deg allows cos *bt* to be substituted for sin *bt*.

and the third derivative:

$$\frac{d^3 v}{dt^3} = (\sqrt{a^2+b^2})^3 e^{at} \sin(bt+3\theta)$$

Integration is the reverse process.

$$\int v\,dt = \frac{e^{at}}{\sqrt{a^2+b^2}} \sin(bt-\theta) + C$$

where C is a constant of integration. Similarly

$$\iint v\,dt\,dt = \frac{e^{at}}{(\sqrt{a^2+b^2})^2} \sin(bt-2\theta) + C$$

and

$$\iiint v\,dt\,dt\,dt = \frac{e^{at}}{(\sqrt{a^2+b^2})^3} \sin(bt-3\theta) + C$$

If a is negative, which is the usual case in engineering problems, its phasor must be drawn in the opposite direction, as in Fig. 2. In this case θ is greater than 90 deg but less than 180 deg.

In these formulas, cosine may be substituted for sine. This rotates the a and b phasors through an additional 90 deg, as shown in Fig. 3. On the other hand, cos bt can be written as sin $(bt + 90°)$. The derivative of

$$e^{at} \cos bt = e^{at} \sin(bt + 90°)$$

may be written:

$$\frac{d(e^{at}\cos bt)}{dt} = \sqrt{a^2+b^2}\, e^{at} \cos(bt+\theta)$$

or as

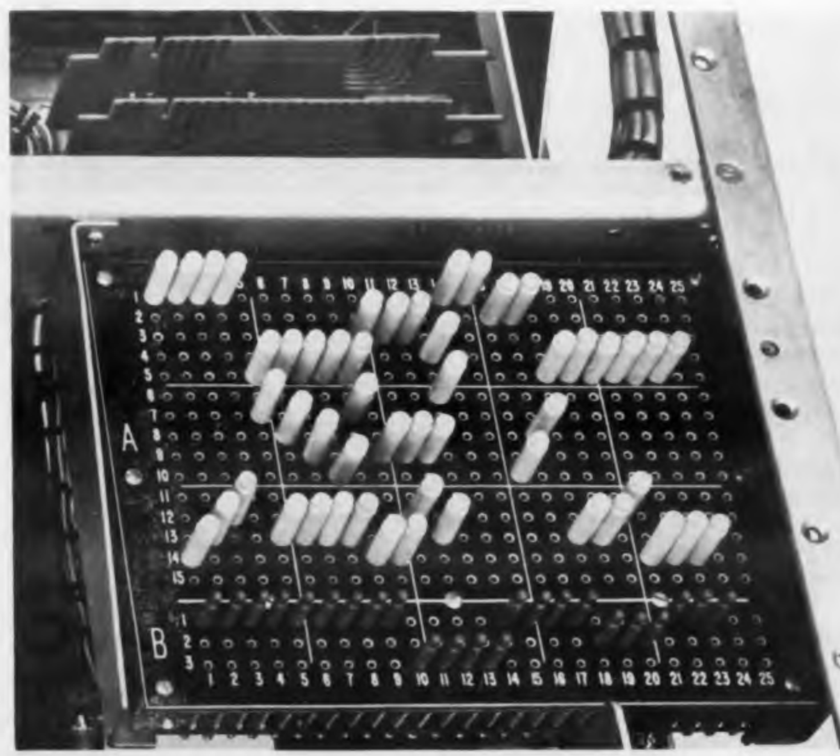
$$\frac{d(e^{at}\cos bt)}{dt} = \sqrt{a^2+b^2}\, e^{at} \sin(bt+90°+\theta).$$

■ ■

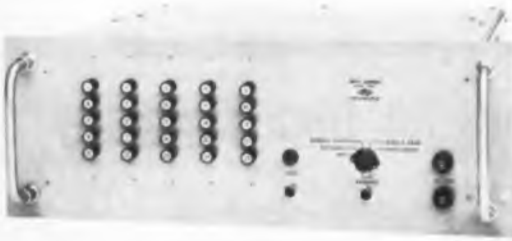
Selective 25-Channel Scanner Programs Output Device for Each Input

A NEW input scanner can scan as many as 25 input channels and can tell an output measuring device what function to measure and on which range. Pushbuttons on the scanner's front panel allow the user to select specific channels to be scanned while others are skipped.

A product of Dymec, a division of Hewlett-Packard Co., 395 Page Mill Road, Palo Alto, Calif., the YD-2901 scanner can be used in a step mode, advancing from one preselected input channel to the next on command from a pushbutton or external pulse or it can provide



Program pinboard in the Dymec Input Scanner. Diode pins in the *A* section of the pinboard give programing information on function to be measured and range to other devices in the system. Shorting pins in the *B* section insert one of three preselected measurement delays for each channel.



a single scan of selected channels. Or it can scan continuously.

A pinboard in the 2901 provides three types of programing. First, it can set a measuring device to measure the proper function (such as voltage, resistance, frequency, etc).

Second, it can set the appropriate range on the measuring instrument for each measurement channel. Third, it can select one of four measurement delays for each input channel. These delays, from 20 to 750 μsec, are useful when a circuit being measured requires time to reach equilibrium.

The 2901 generates channel-identification codes for both visual and electrical readout. For the visual readout, a lamp within the pushbutton for the channel being scanned is energized to full brightness. (Lamps are at half brightness for selected channels when they aren't being scanned.)

Electrical channel identification, in a choice of codes, including binary-coded-decimal, 10-line, and staircase, can be used with virtually any type recording device.

The scanner can accept input voltages ranging from 5 mv to 500 v peak and can accept frequencies as high as 100 kc. When used with up to three slave scanners, the DY-2901 can sample as many as 100 input signals, each coming in on a shielded pair of wires.

Priced at $1,950, the scanner is available on 10-week delivery.

For more information on this versatile scanner, turn to the Reader-Service Card and circle 251.

Attache-Cased Symbol Generator Rounds Characters for High Legibility

Compact enough to be tucked into a small corner of a conventional attache case, a transistorized character generator, the "Curviline," combines high legibility with fast writing rates. The generator, useful with any crt display, combines continuous straight and curved lines to form all digits, letters, and symbols. The combination of straight and curved lines eliminates the ambiguity between similar characters like *B* and *8*, *5* and S, *D* and *O*.

Manufactured by RMS Associates, Inc., 805 Mamaroneck Ave., Mamaroneck, N.Y., tne generator provides writing rates as high as 200,000 characters per sec (for special models), and 50,000 characters per sec for standard models. The high writing rates are obtained by forming all symbols from a few simple formats.

An external tilt control allows one to tilt each character. Even a single line of characters can include both conventional and italic symbols. Character size can be controlled externally too, so different-sized symbols can be mixed within a single display. Since the character generator uses continuous lines rather than a matrix of dots or scanned lines, the symbols can be made any height without impairing readability.

Input to the Curviline generator is merely a single line for each character. Grounding the correct line selects the desired character. There are three outputs: one for *X* deflection, one for *Y* deflection, and one for intensity.

The model C36000 Curviline, in a 4 x 6 x 7 in. case, fits snugly in a corner of an attache case that houses a similarly compact display demonstrator. Though

Conventional attache case . . .

houses compact character generator in one corner. It . . .

initially built simply to dramatize the operation of the character generator, the demonstrator, as a package, has been found valuable as a piece of field-test equipment.

In one application, it served as a portable source of programable alphanumerics in evaluating and testing a crt photographic system. The demonstrator is also useful for field checks on computer memories. A complete data-display system, the demonstrator includes the Curviline character generator, a 1 x 3 in. crt, an electronic commutator, programers, deflection amplifiers, power supplies, and a computer simulator.

The simulator, used to program any desired message, consists of five printed circuit cards, each serving as a crossbar switch, so any symbol can be displayed at any position.

The entire demonstrator, including a character generator operating at any specified rate between 400 and 15,000 characters per sec costs $13,900. It can be delivered in 60 days.

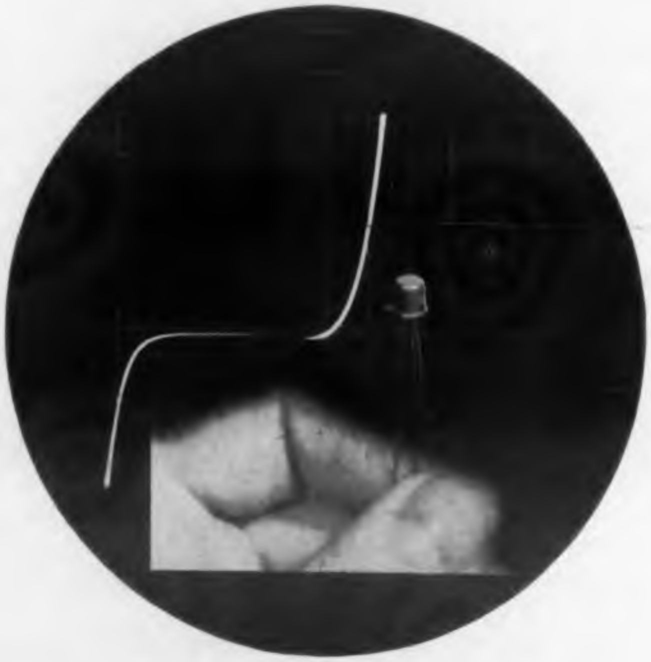
The compact Curviline is priced at $4,500 in prototype quantities. A larger model, the CL36000, packaged on a standard 5-1/4 in. relay-rack panel, cost $4,000. Production quantities of either model are priced appreciably lower. Prototype deliveries take from 30 to 60 days.

For more information on the character generator or on the complete data-display system, turn to the Reader-Service Card and circle 252.

gives highly legible characters like these.

NEW PRODUCTS

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



Germanium Backward Diode Available In Quantity 254

High forward conductance of diode type 1N3353 is useful in complementary digital and small-signal applications. Forward voltage is 90 mv max at 1 ma. Peak point current is 100 μa max, reverse breakdown voltage 480 mv min at 1 ma. Typical valley capacitance is 3.5 pf, series inductance 1 ph. Case size is TO-18. Designed for high-frequency, low-level applications, the device is suitable for gating and dc restorer uses. Philco Corp., Lansdale Div., Dept. ED, Lansdale, Pa.

Price: $4 ea in production quantities.

Rubidium Frequency Standard Has High Accuracy 255

Long-term stability of 2 parts in 10^{10} and short-term stability of 3 parts in 10^{11} for a 1-sec sampling is provided by model X-4700 rubidium vapor frequency standard. Absorption cell is manufactured to a customer-specified time scale. Standard output frequencies are 5.0, 1.0 and 0.1 mc with others available. The set draws 110 w, is designed for standby battery operation, weighs 130 lb, and occupies 4 cu ft.

Instrument Div., Varian Associates, Dept. ED, 611 Hansen Way, Palo Alto, Calif.

P&A: $21,650; 90 days.

Digital Voltmeter Has Tilting Readout 256

Accuracy to ±1 digit is provided by the series 4000 digital voltmeter. Range is 0.001 to 999.9 v dc. Four-digit measurement is displayed on a 3-position tilting readout. Polarity and ranging are automatic. Input impedance is 1,000 to 11 meg. Sensitivity is 0.1 mv.

Electro Instruments, Inc., Dept. ED, 8611 Balboa Ave., San Diego 11, Calif.

P&A: $1,395; immediate delivery.

Cathode-Ray Tube Is Small, Inexpensive — 257

Miniature cathode-ray tube NU129 is 1-5/16 in. in diameter and 4 in. long. The flat-face tube has electrostatic focus and deflection with an isolated cathode lead. It may be operated at up to 1 kv, and provides a bright display with spot size less than 0.010 in. Heater operates at 6.3 v. Available in most phosphors, the tube is useful in monitor and test positions.

National Union Electric Corp., Electronics Div., Dept. ED, Bloomington, Ill.

P&A: $17.50 ea. 100 to 999; 1 week.

Teflon Dielectric Film Is 1 Micron Thick — 258

Direct polymerization of Teflon on a metallized Mylar substrate under vacuum in a high-frequency glow discharge produces a micron-thin capacitor dielectric film. Capacitance is about 1 μf per sq ft. Called Glofilm, the material promises capacitors 25 to 75% smaller by volume than presently available.

Radiation Research Corp., Dept. ED, Westbury, L. I., N. Y.

P&A: $0.10 per ft in 1-in. rolls of 300 ft or more; 3 to 5 weeks.

CIRCLE 59 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Sonic Transducer 600

Is guaranteed. The Omnimite is a magnetostrictive transducer metallically bonded to a 1/4-in. thick stainless steel diaphragm. Used in a line of sonic cleaners, the device is guaranteed for the life of the cleaning unit.

The Bendix Corp., Pioneer-Central Div., Sonic Energy Products, Dept. ED, Davenport, Iowa.

Differential DC Amplifier 577

Serves a dual purpose. Model 94G is an isolation amplifier with unity gain and a high current amplifier capable of driving low-sensitivity, fluid-damped galvanometers.

Video Instruments Co., Inc., Dept. ED, 3002 Pennsylvania Ave., Santa Monica, Calif.

***Availability:** From stock.*

Trimmer Potentiometer 598

Humidity-proof, high-temperature trimmer potentiometer model 3000 measures 3/4 x 5/32 x 5/16 in. Resistances are 50 ohms to 20 K, power rating 0.5 w at 70 C.

Bourns, Inc., Dept. ED, 6135 Magnolia Ave., Riverside, Calif.

***P&A:** $6 in production quantities; immediate.*

Nylon Cable Clamp 575

For temporary or permanent assembly. Tab-Loc cable clamps require no tools for installation. Made of solid nylon, they are adjustable from 3/8 to 3/4-in. in diameter for bundles or single cables.

The Weckesser Co., Inc., Dept. EI-2, Dept. ED, 5701 Northwest Highway, Chicago 46, Ill.

Servo Amplifier 574

Has several input options. Model A248 servo amplifier is powered from 115 v, 60 cps and can drive a size 18 or equivalent motor. Options are two parallel summing inputs, two-speed cross-over network, twin T network, or modulator for dc input.

Westamp Inc., Dept. ED, 11277 Massachusetts Ave., Los Angeles 25, Calif.

***Availability:** 1 week.*

Insulated Terminals 596

Stand-off and feed-through terminals are made in seven configurations. Series 4000, 4100 and 4200 have white Teflon press-mount bodies with tinned brass terminals as standard. Colored Teflon and silver plate are available on special order.

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

NEW PRODUCTS

Delay Line 594

Continuously variable magnetostrictive delay line model VT2-25 has a range of 2 to 25 μsec. Input and output impedances are 500 ohms; maximum pulse rate is 500 kc. An input pulse of 1 μsec, 15-v peak, provides an output of 30 mv.

Columbia Technical Corp., Dept. ED, Woodside 77, N. Y.

***Availability:** 2 weeks.*

Carbon Potentiometer 570

Resists humidity. Rated at 0.25 w at 50 C, carbon potentiometer model 3011 has ranges from 20 K to 1 meg. Operating temperature range is −65 to +150 C; unit meets humidity tests per MIL-STD-202A, Method 106. Panel and printed-circuit mountings are available.

Bourns, Inc., Dept. ED, 6135 Magnolia Ave., Riverside, Calif.

***Price:** $5.20 to $4.33 ea.*

Tuning-Fork Oscillator 569

Accuracy of ±0.05% at 25 C and ±0.3% from −55 to +125 C is provided by the K3MP series of tuning-fork oscillators. Frequencies range from 240 to 2,400 cps. Supply voltage is 12 to 32 v dc; output is 2 v rms into a 5-K load, square waveform. Silicon transistor drive circuit is contained within the plug-in unit.

Fork Standards, Inc., Dept. ED, 1915 N. Harlem Ave., Chicago 35, Ill.

***P&A:** $49.50 ea; 1 week.*

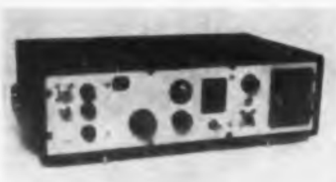
◄ CIRCLE 62 ON READER-SERVICE CARD

Accelerometer 571

In-place calibration is provided by model 2242M5 accelerometer. The device may be operated at temperatures up to 500 F. Voltage sensitivity is 12 ± 2 peak mv per peak g; range is 500 g sinusoidal. Amplitude linearity is $\pm 1\%$.

Endevco Corp., Dept. ED, 161 E. California Blvd., Pasadena, Calif.
Price: $525 to $483.50 ea.

WWV Receiver 573



Transistorized receiver model 925 provides the time standards, frequency standards and radio propagation notices of stations WWV and WWVH. Set tunes by manual switching and contains provisions for separating 600- and 440-cps tones.

General Mills, Inc., Dept. ED, 1620 Central Ave., Minneapolis 13, Minn.

Tachometer Indicator 576

Has solid-state circuitry. Model FR-85 provides digital indication in per cent of full rpm. A manual digital null-balance dial covers the range of 50.0% to 110.0% rpm and can be read to better than 0.1% rpm. Accuracy is 1/4%. Operating temperature range is −40 to 130 F.

Waugh Engineering Co., Dept. ED, 7842 Burnet Ave., Van Nuys, Calif.

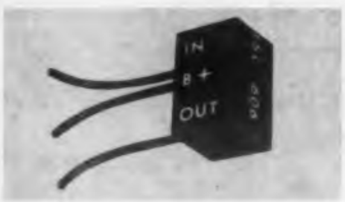
CIRCLE 63 ON READER-SERVICE CARD ➤

Delay Line 597

Step-variable delay line is built of M-derived lumped constant sections. Total delay is 100 μsec; rise time ratio is 25:1. Impedance is 200 to 1,000 ohms. Rotary switches provide increments from 1/10 to 1/100 of total delay.

Gray & Kuhn Div. of Burnell & Co., Dept. ED, 80 Swalm St., Westbury, N. Y.

Preamplifier 583



Noise range is 1.1 to 1.8 db. Preamplifier model ISL 606 is for use with infrared photoconductors and other low-level transducers. Operating temperature range is −40 to 100 C. It can be modified to permit a further reduction of noise by 0.5 db. Input impedance is 1.0 meg, with an optional value of 10 meg. Output resistance is 2 K. Power required is 10 v ac, 0.18 ma. Size is less than 1 cu in.

Infrared Industries, Inc., Dept. ED, Waltham, Mass.

Power Supply 581

For 55- to 400-cps systems. Power supply model RS205A operates over a current range of 0 to 50 ma, continuous duty. It has a voltage regulation of 0.05% load, 0.05% line, ripple and noise of 5 mv max peak to peak, and a recovery time of less than 25 μsec. Input voltage is 105 to 125 v ac. It is available in modular construction, rack mounting and rack mounting with 3-1/4-in. meters.

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

P&A: $55.50 to $115.00; from stock.

Linear Actuator 599

Push-pull force of 3 lb is developed over a 5/16-in stroke displacement by the BM-02 linear actuator. Time constant is 5 msec. The actuator requires about 30 w.

Block Associates, Dept. ED, 385 Putnam Ave., Cambridge, Mass.

Rectifier Assembly 580

Rated at 100 amp. Unit is used in battery chargers. It is a center-tap circuit consisting of two rectifiers mounted on a heat-dissipating copper fin. Double-diffused silicon rectifiers are hermetically sealed diodes. Piv is 200 v max. Inverse voltage is 35 v rms. Peak working voltage is 50 v. Rectifier dc output is 125 amp max. Designation is 2RUP-5-1242.

Trans-Sil Corp., Dept. ED, 55 Honeck St., Englewood, N.J.

Availability: 5 days.

Waveform Translator 572

High-speed, repetitive waveforms are transferred from oscilloscope to an X-Y plotter by waveform translator type 101. It is useful in reproducing magnetic hysteresis loops. Lissajous figures, etc. A manual sampling mode is provided. Translator can be operated without an intermediate oscilloscope.

F. L. Moseley Co., Dept. ED, 409 N. Fair Oaks Ave., Pasadena, Calif.

GENERAL INSTRUMENT SEMICONDUCTOR DIVISION

NEVER BEFORE POSSIBLE...ultra-fast silicon diodes that combine 2 nanosec speed,100 mA conductance, .025 μA leakage and 2 pf capacitance

The new General Instrument 'SP' series offers a combination of electrical characteristics never before possible in ultra-fast switching silicon diodes. The complete line, including the popular IN914, IN916 and IN903 series, are immediately available in production quantities. They all feature nanosecond switching speeds, coupled with either high conductance, low leakage current or low capacitance. Check the chart. Then call the General Instrument sales office or franchised distributor nearest you for complete specs. Or write today to General Instrument Semiconductor Division, 65 Gouverneur Street, Newark 4, New Jersey.

ACTUAL SIZE

TYPE	Breakdown ① Voltage (BV)	Maximum Reverse Current (μA) 25°C	150°C	Test Voltage ②	Forward Current (Min. mA @ 1V)	Reverse Recovery Max. (mμsec) ③	Capacitance at $V_R=0$ (pf) ④	Rectification ⑤ Efficiency
SP100	75	0.1	100	50	10	2	2	45%
SP101	30	.025	50	20	100	2	2	45%
SP106	125	.025	50	100	100	2	2	45%
IN914A	100	.025	50	20⑥	20	4	4	45%
IN916A	100	.025	50	20⑥	20	4	2	45%

① Breakdown Voltage at 100 μA. ② Voltage at which Reverse Current measurements were taken. ③ Switching $I_F = 10$ mA to $V_R = 6.0$ V $R_L = 100$ ohms recovery to 1 mA. ④ Measured at 1 megacycle. ⑤ Measured at 100 megacycles using MIL-STD-19500 test circuit. ⑥ Reverse leakage when measured at −75 Volts and 25°C shall not exceed 5 μA.

GENERAL INSTRUMENT CORPORATION

NEW PRODUCTS

Exposure Repeater 582

For producing photo-masks. Photographic exposure repeater permits positioning of patterns to an accuracy of 1 micron. It has a programing mechanism capable of performing various combinations of step-and-repeat operations for automatic exposures. It may also be used manually for specially spaced exposures.

David W. Mann Co., Dept. ED, Lincoln, Mass.

Gage Tester 593

Liquid quantity gage systems and probes can be tested and calibrated with the TF-20 servo-operated tester. The set measures probe capacitances of 0 to 5,000 pf with accuracy of ±0.15% of full scale.

Consolidated Airborne Systems, Inc., Dept. ED, 900 Third Ave., New Hyde Park, N. Y.

Pressure-Vacuum Control 578

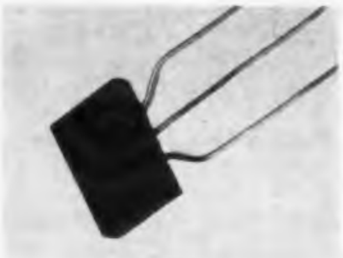
For many applications. Type H41 is for direct incorporation into equipment. Several adjustable ranges are available within limits of 30 in. of mercury vacuum and 500 psi, with

◄ CIRCLE 65 ON READER-SERVICE CARD

on-off differentials from 1.5 ± 1/2-in. of mercury to 10 ±3 psi. Switch action includes normally open, normally closed and double throw. Ratings are 10 and 20 amp at 115/230 v. Unit is suitable for temperatures up to 180 F. It can be used for sterilizers, centrifuges and welding equipment.

United Electric Controls Co., Dept. N, Dept. ED, 85 School St., Watertown 72, Mass.

Voltage Doubler **567**



Silicon rectifier voltage doubler circuit has maximum piv of 400 or 600. Leakage current and forward voltage drop are low; power rating is 1/2 amp at 100 C. The unit is encapsulated in a package 11/16 x 15/32 x 3/16 in.

Mallory Semiconductor Co., Dept. ED, Du Quoin, Ill.

Price: $0.85 ea, 1,000.

Encoder Translator **603**

Conversion time is less than 5 msec. The X116 shaft encoder translator is for use in inductosyn systems. It will convert four separate channels of digital data into visual decimal displays of the two input angles. Azimuth display can be in hours, minutes and tenths of seconds, or in degrees, minutes and seconds. Elevation data are presented in degrees, minutes and seconds.

Harvey-Wells Electronics, Inc., Dept. ED, 14 Huron Drive, Natick, Mass.

P&A: $11,300; 60 days.

CIRCLE 66 ON READER-SERVICE CARD ▶

NEW PRODUCTS

Differential Refractometers — 602

Refractive index difference between a flowing sample from a process stream and a reference standard liquid is measured by these differential refractometers. Models RE-A4, 5, and 6 have sensitivities of 0.0001, 0.00001, and 0.000002 respectively. The instruments will handle corrosive liquids at high temperatures and pressures.

Barnes Engineering Co., Dept. ED, 30 Commerce Road, Stamford, Conn.

Electronic Consoles — 601

Custom-built electronic consoles are made in any configuration and weight capacity. Welded, water-tight sheet steel units are designed to eliminate heating problems by use of ventilating panels.

Beach Manufacturing Co., Dept. ED, 2000 S. Santa Fe Ave., Compton, Calif.

Tape Recorder — 568

For analog data. Tape recording and reproducing system model 204 is linear within 0.2% of full scale. The four-channel unit has frequency response of 0 to 800 cps at 15 in. per sec. Input sensitivity is ±3 v or ±10 v. The recorder is useful in handling all types of analog data.

Mnemotron Corp., Dept. ED, 3 N. Main St., Spring Valley, N. Y.

CIRCLE 68 ON READER-SERVICE CARD ➤

New Hughes Tonotron Tube for the space age

Unretouched photo of simulated display on face of H-1038 *multi-mode* Tonotron tube.

Dark Trace Writing: For high-contrast, black-on-white, line or halftone displays with resolution over 125 lines per in.

Write-through: Superimpose non-stored data like cursors, target markers, artificial horizons, maps, on stored displays.

Now you can get clear, constant image displays of slow-scan TV transmissions from space vehicles, satellites, or earthbound subjects. The new Hughes *multi-mode* Tonotron* storage tube, the most unique display device on the market, makes this possible. In addition to the excellent capabilities previously available from Tonotron tubes—controllable persistence and high brightness—these new *multi-mode* tubes offer the ability to selectively erase target information, present moving cursors on stored displays, and produce high resolution light or dark trace halftone images.

The Hughes *multi-mode* Tonotron tube can solve *your* display problems too. Write or wire today for full information.

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

*Trademark, Hughes Aircraft Company

Creating a new world with Electronics

HUGHES

HUGHES AIRCRAFT COMPANY

VACUUM TUBE PRODUCTS DIVISION
2020 Short Street, Oceanside, Calif.

Selective Erasure: Retains full brightness of entire display with high resolution. Eliminates unwanted information.

CIRCLE 88 ON READER-SERVICE CARD

Temperature Controller 469

Range is −100 to 300 C. Temp-Trol, model N-300, is accurate to 0.5 C and has a rated load of 15 amp on both heating and cooling cycles. Included with the instrument is a fast-response time probe, in a sealed stainless steel housing suitable for use in contaminated atmospheres or corrosive liquids. Size is 8-1/2 x 10 x 7 in.

Omtronics Manufacturing, Inc., Dept. ED, P. O. Box 1419, Peony Park Station, Ohama 14, Neb.

P&A: $239.50; from stock.

Microminiature Relays 472

For 2 amp, 26.5 v dc. Suitable for a variety of low-level applications, type 30-22 has Spade terminal headers and is equipped with two L-shaped mounting brackets. Type 30-23 has a 90-deg potted printed-circuit header. Meets military specifications.

Phillips Control Co., Dept. ED, 59 W. Washington St., Joliet, Ill.

Accuracy Is Our Policy . . .

In the Jan. 4, 1961 issue of Electronic Design, an article on the Orbiting Astronomical Observatory stated that "Astronomers would like a gray scale of 1,000" for satellite-borne TV systems. The correct requirement is a dynamic range of about 10,000, with 100 discernible levels.

In the article "All Solid-State Proportional Control Temperature Servos Can be Simpler, Better," in the March 15 issue, an omission and a polarity reversal were made in Fig. 2 on p 56. The bottom of the Thermistor bridge (junction of R_1 and R_2) should be grounded to the lower (negative) power supply line. The polarity of the emitter and collector connections for transistor Q_3 should be reversed. The flow path for the collector should go through the heating coil to the upper power line. The flow path from the emitter should go to the lower power line.

NEW PRODUCTS

Fixed-Station Antennas 525

Covering 25 to 50 mc, Beacon fixed-station antennas are from 10 ft 8 in. to 12 ft long. Full half-wave length radiator is employed from 40 to 50 mc. From 25 to 40 mc, electrical half-wave is accomplished by heliwhip principle in top 2 ft of radiator.

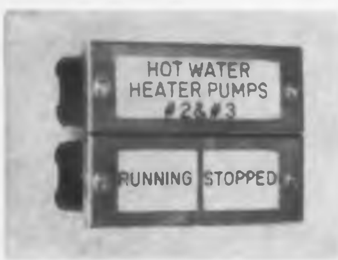
Mark Products Co., Dept. ED, 5439-41 Fargo Ave., Skokie, Ill.

Protective Film 530

Thickness is 1 to 8 microns. For protection against electrical deterioration, moisture and oxygen, Lectra-Shield film can be used on enclosed motors, insulators, seals and covers. It is a nonconductor and can be applied over previous coatings.

Corrosion Reaction Consultants, Dept. ED, 116 Chestnut St., Philadelphia 6, Pa.

Indicator Lamps 447



Voltage range is 6 to 120 v. Types ML and DRLV have filters, multicolored legend plates, neoprene gaskets and stainless steel finish. Legend plates can be furnished for engraving, printed and drawn insertions, or grease pencil.

H. R. Kirkland Co., Dept. ED, Morristown, N. J.

Calculator-Punch 526

Speed is 50 cards per min. The 604 model 2 calculator-punch is composed of the 521 punch and the 604 calculator. It stores up to 37 digits of information and accumulates factors of up to 13 digits. Programed by two control panels, it performs up to 20 program steps per card.

IBM Corp., Data Processing Div., Dept. ED, 112 E. Post Road, White Plains, N. Y.

Price: $330 per month rent.

Tape Punch 529

For 8-channel, 1-in. tape. Model TP-1 tape punch produces all decimal codes plus alphabetic codes S, T, U, W, X, Y and Z, as well as end line and tape feed codes. Keyboard has inclined surface and is connected to the punch with plug-in cable. Special keyboards can be furnished.

Carlton Controls Corp., Dept. ED, 15 Sagamore Road, Worcester 5, Mass.

Gain Meter 527

For uhf, vhf and microwave frequencies, model 625-A gain instrument measures loss, gain, noise figure and other transmission characteristics. Self-contained, it incorporates mixing, if-amplifying, attenuating, detecting and indicating elements as well as power and control circuits.

Kay Electric Co., Dept. E-4, Dept. ED, 14 Maple Ave., Pine Brook, N. J.

Electric Furnace 445

For wire annealing. Tap switches provide for variable output voltages. Typical specs are: first output, 35 to 52.5 v in 2.5-v steps at 570 amp; second output, 7.5 to 20 v in 2.5-v steps at 385 amp; input, 220 v, 60 cps, single phase. Ratings to 200 kva can be furnished.

Light Electric Corp., Dept. ED, 212 Lackawanna Ave., Newark 4, N. J.
Availability: made to order.

Magnetic-Tape Tester 528

Speed is 4 min for 2,400 ft of tape. Model Seven magnetic-tape tester indicates defects due to dropouts, time-displacement errors and noise pulses on a circular chart. Tape stops automatically at work stations for repair. Footage counter is provided.

General Kinetics Inc., Dept. ED, 2611 Shirlington Road, Arlington 6. Va.

◄ CIRCLE 70 ON READER-SERVICE CARD

NEW PRODUCTS

Mounting Terminals 471

For electronic components. Tri-El terminal is a formed stamping that mounts to a terminal board with a simple stacking tool. It provides one connection on the top of the board and two below. Military specifications for vibration stability are met. It is available ready for mounting or already mounted on standard or custom terminal boards. Stamped from brass or beryllium copper, the units are silver-plated, with gold, tin and other metals also available.

Pacific Coast Electronics Corp., Dept. ED, 2457 Chico Ave., South El Monte, Calif.

Cable Analyzer 495

Tests 75 circuits in 2 sec. Completely transistorized, the Mark 75 analyzer operates continuously on 110 to 125 v, 50 to 60 cps, or for a 4-hr period from self contained chargeable nickel-cadmium batteries. It checks leakage from any one conductor to all others and ground. It registers and remembers leakage, poor solder or crimp joints, open circuit or transposed wires in 4 leakage and 4 conductor resistance range limits. Weight is 18 lb.

Micro Balancing, Inc., Dept. ED, Herricks Road, New Hyde Park, N. Y.

Coaxial Heater Cable 466

For induction heaters. Coaxial cable for high frequency induction heaters can handle the output of a 50-kw heater. Heater output may be controlled by a hand-grip, foot pedal or automatic timer. Applications include brazing of tube joints, soldering, and annealing. Available in 20-ft lengths, this cable may be extended to 100 ft max length by coupling. It contains the circulating water cooling courses for the work coils.

L. C. Miller Co., Dept. ED, 717 Monterey Pass Road, Monterey Park, Calif.

Push-Button Switch 464

With snap action. Type 2SJ6-1D switch gives momentary-contact dpdt circuit control at loads of 5 amp, 125 to 250 v ac, 5 amp at 30 v dc resistive, or 3 amp at 30 v dc inductive. Over-all dimensions are 25/32 x 21/32 x 61/64 in. deep behind panel.

Maxson Electronics Corp., Unimax Div., Dept. ED, Ives Road, Wallingford, Conn.

Sealed Relays 493

Good for 100,000 operations at rated load of 2 amp noninductive at 28 v dc, 1 amp inductive at 28 v dc, model 240, 4 pdt, and model 260, a 6 pdt relay, are available with coils ranging from 20 ohms to 22,000 ohms. Power requirements are 3-1/2 w nominal, 0.9 w max operate, and 5 mw min release. Resistance is 50 milliohms max at rated current. Both models meet military specifications.

North Electric Co., Electronics Div., Dept. ED, Galion, Ohio.

P&A: 1-9, 240 is $15.30, 260 is $16.70; 6-8 weeks.

Strain Gage 496

Has polyester base. Type P-8 flat grid polyester base wire strain gage has grid dimensions of 5/16 by 5/64-in. It may be installed at room temperature in 20 min using an adhesive and operation is then possible to 400 F without elevated temperature cure. Polyester base is transparent and tests indicate good creep and hysteresis characteristics.

Metrix, Inc., Dept. ED, P. O. Box 683, Walnut Creek, Calif.

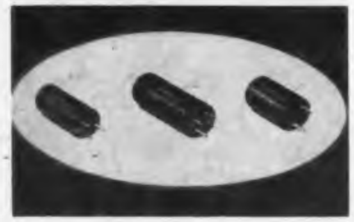
Semiconductor Tester 465

For all types. Model G-320 test set measures ac and dc parameters of transistors, diodes, and rectifiers. It can be used with all semiconductor devices, power as well as low-level types, and offers pnp and npn polarity. It measures dc current gain of 1 to 200 at base current levels of 25 μa, 250 μa, 2.5 ma, and 25 ma. Ac current gain is measured at 1,000 cps.

Molecular Electronics, Inc., Dept. ED, 87 Weyman Ave., New Rochelle, N. Y.

Price: $2,145.00.

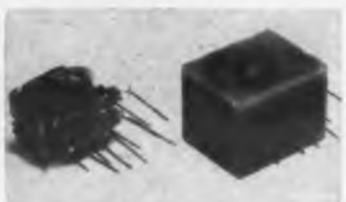
Electrolytic Capacitors 473



For printed wiring boards. Type 89D Verti-lytic aluminum electrolytic capacitors are designed for transistor-type circuits. They are available in a series of 142 standard ratings ranging from 3 to 50 v. Special multiple ratings which contain both dual- and triple-section capacitors are also made. Operating temperature range is −20 to 65 C. Standard tolerance is −10, +100% of rated capacitance.

Sprague Electric Co., Dept. ED, 347 Marshall St., North Adams, Mass.

Flip-Flop Module 437



Frequency is 200 kc. The DM is a digital circuit with an operating temperature range of −60 to +71 C. Two 5-input AND gates plus transient coupling allows the circuit to function as a shift register stage, counting stage, static storage or other logic and control stages. It meets MIL-E-5272D.

General Motors Corp., Delco Radio Div., Dept. ED, 700 E. Firmin, Kokomo, Ind.

Price: $37.90.

Differential DC Amplifier 468

Uses transistor circuitry. Output, input and chassis are isolated from each other. Type 101A differential dc amplifier has an output of ±10 v at ±10 ma. It will drive a capacitive load of up to 5 μf. Common mode rejection is 100,000,000:1 at dc; 1,000,000:1 at 60 cps. Uses include digital-processing systems and preamplification and isolation for strip chart recorders. Size is 2-7/8 x 6 x 14-5/8.

Neff Instrument Corp., Dept. ED, 1088 E. Hamilton Road, Duarte, Calif.

P&A: $625.00; 60 days or less.

Circuit Breaker 470

High-speed milliampere circuit breaker responds to 1 μsec transients, and opens the load within 10 μsec. The trip current range is adjustable to any value between 15 and 150 ma. An overload condition is indicated by a red light and a reset button is provided. Accuracy is ±10%. Power required is 120 v, 60 cps. Insertion loss is 4 milliohms to 4 ohms per ma over the operating range. Nominal resistance is 10 meg in the open position.

Orbitec Corp., Dept. ED, 512-30th St., Newport Beach, Calif.

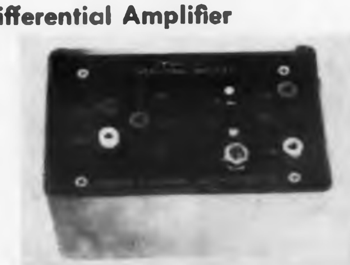
Price: $160.00 ea, 1-5.

Temperature Chamber 435

Control accuracy is ±0.5 F. Model 1060 completes a cycle of −100 to +500 F in 12 min. At −65 F, it consumes less than 3-1/2 lb of carbon dioxide per hr. Test volume is 10 x 7 x 7 in. Weight is 40 lb.

Delta Design, Inc., Dept. ED, 3163 Adams Ave., San Diego 16, Calif.

DC Differential Amplifier 467



Output is ±5 v at 10 ma. Model 203 dc differential amplifier is transistorized, operating from two internal 9-v batteries. It has an open loop gain of greater than 10,000, a common-mode rejection of greater than 10,000 at 60 cps, a unity gain bandwidth of approximately 500 kc, and a voltage drift of less than 1 mv per day under laboratory conditions.

Monroe Electronic Laboratories, Inc., Dept. ED, 21 Vernon St., Middleport, N. Y.

Price: $99.50 complete with batteries.

NEW PRODUCTS

Voltage-Sensing Relay 438

Impedance is 100 K. Designed for sensing ac or dc levels and operating relay contacts, the device has a differential between pull-in and drop-out of less than 1%. Switching accuracy is ±5%. Various contact arrangements and ratings can be supplied. Units are hermetically sealed.

Hi-G, Inc., Dept. ED, Bradley Field, Windsor Locks, Conn.

Capacitors 418

Range is 150 to 500 wvdc. Designed for space and airborne uses, the CK series of capacitors spans a temperature range of −55 to +150 C and has tolerances of ±5%, ±10% and ±20%. Six sizes, from 0.15 x 0.15 in. to 0.6 to 0.5 in., are available. Requirements of MIL-C-20 are exceeded.

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

Price: 60¢ up in sample quantities.

Sintered Titanium Alloy 421

Tensile strength is 119,000 psi. Ductility is 6% elongation; hardness is Rockwell C 23. Strengths up to 146,000 psi can be obtained by heat treatment. The material has excellent corrosion resistance and a low coefficient of thermal expansion. Type is CPT-64AV.

Clevite Corp., Mechanical Research Div., Dept. ED, 540 E. 105th St., Cleveland 8, Ohio.

Crystal Oscillator 436

Frequency is to 100 kc. The DFO-10 transistorized units are available in 10 kc to 3 mc in a package 1 x 1 x 3 in., and from 3 to 100 mc in 1 x 1 x 1-1/8 in. Frequency tolerance is ±0.03% to ±0.005%. Output voltages are 100 mv to 12 v. They meet MIL-E-5400 at 100 kc.

Delta-F, Inc., Dept. ED, 113 E. State St., Geneva, Ill.

P&A: $154 to $218; 30 to 45 days.

HF Power Tube 408

Life is 4,000 hr or more. Type 3B4WA 7-pin miniature tube is similar to the 3B4, but has been redesigned for longer service. It also resists impact shock to over 700 g.

CBS Electronics, Dept. ED, Danvers, Mass.

Silicon Rectifiers 494

Piv is from 50 to 600 v. Types 1N1199-A, 1N1200-A, and 1N202-A through 1N206-A are diffused-junction rectifiers for 12-amp service, also available as reverse-polarity types. Transient inverse-voltage ratings are from 100 to 800 v. Junction-to-case thermal resistance is 2 C per w. Leakage current is as low as 1 ma at 150 C. Forward voltage drop is 0.55 v max at 150 C. Operating temperature range is −65 to 200 C.

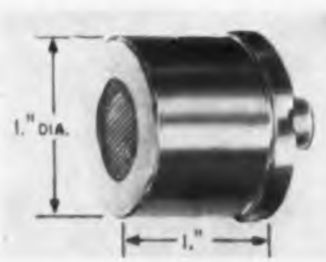
RCA, Semiconductor & Materials Div., Dept. ED, Somerville, N. J.

Switch Actuators 491

Used with timers. Switch actuators allow on or off action from 0 through 360 deg. Model A uses a silver contact rated at 1,500 w incandescent; life expectancy is 100 million operations at speeds between 1 and 60 rpm. Model B has a snap switch for speeds under 1 rpm or where a double-throw switch is required. Switch may be arranged to close and open on alternate revolutions.

Bayside Timers, Dept. ED, 43-69 162nd St., Flushing 58, N. Y.

Ultrasonic Transducer 431



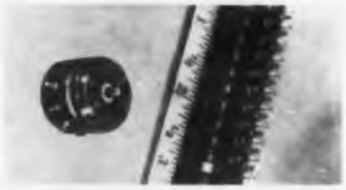
Frequency is 40 kc. Model TR-7 is for command signaling, short distance communication, proximity detectors and ultrasonic probes. As a transmitter, it delivers sound pressure at +25 db above 1 microbar at 1 ft with 25-mw excitation. Harmonics are attenuated by more than 40 db.

Massa Div. of Cohu Electronics, Inc., Dept. ED, Hingham, Mass.

P&A: $1.50 to $5; stock to 30 days.

NEW PRODUCTS

Ganged Potentiometers 433



Up to 24 pots occupy 2 in. Series 319 rotary precision units have resistance values of 100 ohms to 200 K over a temperature range of −55 to +150 C. Power rating is 2 w. Meeting all applicable Mil specs, they withstand severe shock and vibration.

Daystrom, Inc., Potentiometer Div., Dept. ED, Archbald, Pa.

Control Actuator 477

For missiles. Jet Vane actuator is used as a vernier control device. It contains control and telemetering data elements. Output torque is 2.5 oz-in. over the full travel with less than 3 w input. Shaft position control has a range of ±25 deg. Direct coupled dc torque motor provides the drive. It will operate at 500 miles altitude and for periods up to 10 min at 500 F. Size is 1.75-in. in diameter x 2-in. long. Weight is 0.5 lb.

The Aeroflex Corp., Aeroflex Laboratories Div., Dept. ED, 34-06 Skillman Ave., Long Island City 1, N. Y.

Shaft Encoders 426

Output is binary. The DADC series size 20 and 30 analog-digital encoders provide an output for tape storage or for input to digital computers. The output is also indicated on a dial mounted on the face of the housing. Single or double ended synchro mounting for clockwise or counter-clockwise rotation is available.

Guidance Controls Corp., Dept. ED, 110 Duffy Ave., Hicksville, L. I., N. Y.

Switch-Potentiometer 429

Rating is 0.2 w. Designated series 44, it can be furnished with resistances of 500 to 2.5 ohms. Resistance tolerance is ±20% up to 100,000 ohms and ±30% above. A carbon element is used. Insulation breakdown between metal surfaces is over 1,000 v. The switch is spst or dpst rated at 20 or 67.5 v.

Clarostat Manufacturing Co., Inc., Dept. ED, Dover, N. H.

RF Oscillators 463

For 10 kc to 400 mc. The 50 series is electronically tuned and offers a 5 to 1 tuning ratio for the 10 kc to 200 mc range, a 2 to 1 ratio for 160 to 320 mc, and a 1.5 to 1 ratio for 180 to 400 mc. Signal outputs are 0.5 v rms for 10 kc to 200 mc, and 0.25 v for 180 to 400 mc. Units require an extended power source of 150 v, 30 ma, and 6.3 v, 0.4 amp. Models are available with either transistor or vacuum tube circuitry and with single or multiple band tuning, also made to customer specifications.

Trak Electronics Co., Inc., Dept. ED, Wilton, Conn.

Multiple-Stroke Arrestor 432

Weight is less than 2 oz. Over-all length is 1-1/2 in. Major application is as a lightning arrestor on antennas. It can also be used for surge limiting. Capacitance is 3.5 μf, arc-over voltage is 500 to 5,000 v dc, adjustable. It will by-pass surges of 300 amp in 2 msec.

Dale Electronics, Inc., Dept. ED, Columbus, Neb.

NEW PRODUCTS

Cryogenic Thermometer 443

Range is 0.3 to 25 K. The Cryotherm operates from an ac bridge current supplied by a plug-in signal generator tuned to 155 cps. The probes measure mutual inductances as low as 2×10^{-4} µh. Measurements are made without any special compensation and are read directly on a calibrated scale.

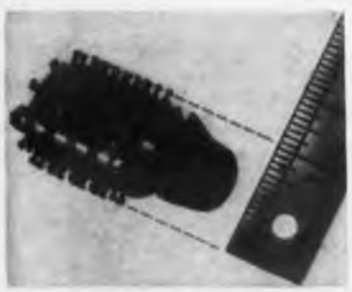
Malaker Laboratories, Inc., Dept. ED, Mountainside, N. J.

Terminal Bushings 485

Fluted and tubular bushings are made for use with silver solder, brazing or welding techniques. They are suitable for manufacture of large hermetically sealed units. Insulator bodies are made of 94% alumina. Metal hardware consists of nickel iron flanges and caps with fused silver finish. Terminal studs or lugs of cold rolled steel are nickel plated.

Frenchtown Porcelain Co., Dept. ED, Frenchtown, N. J.

Rotary Switches 448



Diameter is 1 in. Rotary switches are made for low-current use in test equipment and airborne applications. Series 7000 provides 12 switching contacts per deck with rotor contacts on the front and switching contacts on the rear of the same deck. Series 5000 has 12 contacts on the front and 12 contacts on the rear, a total of 24 per deck.

JBT Instruments, Inc., Dept. ED, 133 Hamilton St., New Haven 8, Conn.

Transient Suppressors 462

Solid-state suppressors. Series TR is designed to protect transistor circuitry from damage that may result from line transients or transients caused by the switching of inductive current loads. Nonpolarized, polarized and ac types are available. The units drain no current under normal conditions. Standard voltages range from 6 v to 115 v dc and ac rms. Temperature range is −65 to 125 C, with no power derating.

Relcoil Products Corp., Dept. ED, Spring St. and Route 75, Windsor Locks, Conn.

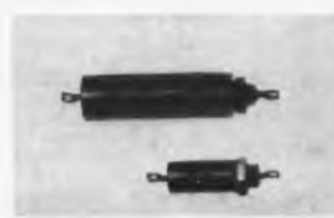
Availability: *3 to 4 weeks.*

Digital Module 521

Life is 5,000,000 operations. Model CC-501 digital module, consisting of 6 printed-circuit relays, is used as a binary-coded decimal-to-decimal converter. The code inputs are dc voltages from decade counters, shift registers or other modules. Unit operates visual displays, printers and other devices directly.

Control Equipment Corp., Dept. ED, 19 Kearney Road, Needham Heights 94, Mass.

Feed-Through Capacitors 434



Range is 0.01 to 5 mf. Capacitance tolerance is ±20%. Voltage ratings are 150 to 600 v dc and 60 to 250 v ac at 400 cps. Current rating is 5 to 20 amp. The units meet temperature and immersion requirements of MIL-STD 202B, method 102A, condition C and method 104A, condition C.

Dearborn Electronic Laboratories, Inc., Dept. ED, P. O. Box 3431, Orlando, Fla.

P&A: *$2 to $5.40; stock to 30 days.*

NEW PRODUCTS

Logic Module 427

Rate is 1 mc. Model 220 triple-inverter logic module requires pulses of 4-v amplitude and 4-μsec width. Three independent inverter stages may be connected in series, in parallel or in series-parallel. There is a gate and signal input for each stage.

Harvey-Wells Electronics, Inc., Dept. ED, 14 Huron Drive, Natick, Mass.

P&A: $40; from stock.

Carbon-Film Resistors 458

For high humidity use. Filmistor X-70 line of epoxy-coated carbon-film resistors is rated for full wattage operation at a temperature of 70 C instead of the conventional 40 C. Sizes range from 1/8 to 1/2 w; their standard resistance tolerance is ±1%. Resistance values range from 10 ohms to 3.16 meg. Other values are available on special order.

Sprague Electric Co., Dept. ED, 347 Marshall St., North Adams, Mass.

Key Punch 461

Reproduces tabulator cards. This auxiliary desk-top punch is used for reproducing damaged tabulator cards. It has 14 keys, one for each of the 12 vertical punching positions, plus space and release keys, a tab stop and quick release feature. Small, light in weight and entirely mechanical, it is completely portable.

Panels Wires Inc., Dept. ED, 213 E. Grand Ave., South San Francisco, Calif.

Price: $395.00

THIS IS THE CABLE THAT HELPS MAKE SURE YOU HAVE A SEAT!

At a major airline's electronic reservation center, a computer locates one seat in a million *in seconds* to confirm your reservation.

The Rome cable inside the computer connects the many control panels that take in the data from 135 reservation and ticket agents in the New York area, as well as from other cities along the Eastern Seaboard.

And what kind of cable is it? Custom made, of course, with 75 conductors; slim and trim for quick, easy connections; insulated and jacketed with Rome Synthinol (PVC) compound that can stand up to oils, acids, alkalies, grease, gasoline and flame.

Our experience in instrumentation cables for telemetering, data recording, circuit control testing and electronic computers is broad. So when you bring us your cable problem, Rome Cable Division has the know-how and facilities to deliver precisely what you need.

Bulletin RCD-400 will give you a good introduction. Write for it. Or address specific questions to Rome Cable Division of Alcoa, Dept 11-61, Rome, New York.

ALCOA
ROME CABLE
DIVISION

CIRCLE 86 ON READER-SERVICE CARD

Limit Stop 457

Variable from 0 to 42 turns. SR 3341 miniature limit stop has a torque rating of 40 oz-in. Shielded stainless steel ball bearings are provided at both shaft ends. An external adjustment controls the stop range without disassembling. Size is 2 in. long by less than 1 in. in diameter. Unit weighs under 2 oz.

Reeves Instrument Corp., Components Marketing Div., Dept. ED, Garden City, N.Y.

***P&A:** $50.00 to $75.00 for 1 to 100 from stock.*

Shaft Encoder 425

Circuitry is self-contained. The ADC 11-11 analog-digital encoder uses a 6- and a 5-bit disk to obtain an output of 2,048 counts. Accuracy is ±1/2 of the least significant digit. Resolution in 1 revolution is 1 part per 64; full count is obtained in 32 revolutions. Uses are in data processing, checkout and control.

Guidance Controls Corp., Dept. ED, 110 Duffy Ave., Hicksville, L. I., N. Y.

Power Supply 459

For heavy industrial use. Rated at 25 ma, 15,000 v dc model PU15-25 has a small remote control box with trip-free reset circuit, pilot lamp, and a high-efficiency conversion circuit to insure low input power requirements. It can be mounted on floor, wall or ceiling, and is used for electrostatic charging of materials, particle separation and similar applications. It requires 115 v, 60 cps.

Perchel Electronics, Inc., Dept. ED, R.F.D. No. 1, Patterson, N.Y.

***P&A:** $475.00 3 to 4 weeks.*

New Dykor®
Bi-Directional, High Speed

PERFORATED TAPE READERS and HANDLERS

PERFORATED TAPE READER... All solid-state photo-electric readers that give you *Performance*... stops before the next character at 1,000 characters per second; *Versatility*... handles 5 to 8-level tape, interchangeably; *Speed*... single or dual, up to 2,000 characters per second with complete dependability.

PERFORATED TAPE HANDLER... High speed... handles up to 500 feet of standard 5 to 8-level tape, in either direction, at speeds to 400 characters per second... rewinds at 150 inches per second... captive knob expansion hubs for ease of loading. Designed for use with uni-directional Model 3500 or bi-directional B3500 tape readers. For full technical information on these and other models, please write

DIGITRONICS
ALBERTSON, NEW YORK. PHONE HT 4-1000

WRITE FOR INFORMATION ABOUT DIAL-O-VERTER HIGH SPEED DATA TRANSMISSION AND CONVERSION EQUIPMENT

CIRCLE 87 ON READER-SERVICE CARD

NEW PRODUCTS

Character Generator 410

Speed is 20,000 characters per sec. The 980 electronic decoder converts digital code into alphanumeric symbols. Made to fit 19-in. rack assemblies, it takes up only 1 cu ft. The output can be displayed on cathode-ray tubes or printed out.

A. B. Dick Co., Dept. ED, 5700 W. Touhy Ave., Chicago 48, Ill.

P&A: $6,700; from stock.

Frequency Converter 409

Output is three-phase, 400 cps. Using a single-phase motor and a Nobrush alternator, the unit supplies three-phase, four-wire, 120 to 208 v from a 60-cps source. Dimensions, including terminal box, are 13-7/8 x 15-3/4 x 11-9/16 in. Weight is 147 lb.

Georator Corp., Dept. ED, Manassas, Va.

Pressure Switches 460

For airborne systems. Deltadyne pressure and differential pressure switches are suitable for system pressures or overpressures up to 250 psi. Actuation range is from 0.125 to 16 psi differential. Switch is either completely actuated or completely disconnected at all times. Supplied with aluminum housings. Stainless steel, brass and other metals available on special order. Weight is 0.45 lb.

Pall Corp., Dept. ED, 30 Sea Cliff Ave., Glen Cove, N.Y.

Servo Potentiometer 428

Range is 1 to 100 K. Accuracy is ±5% and standard linearity tolerance is ±2%. These servo-driven, multi-output units are designed for use in missile steering control systems. Power rating is 2 w, derated to zero at 165 C. Life is 5,000,000 operations.

Chicago Aerial Industrial, Inc., Kintronic Div., Dept. ED, 550 W. Northwest Highway, Barrington, Ill.

Counters 455

For diversified applications. Designated type C, various versions are available for the following applications: magnetic or electrical impulse counter, predetermining counter, time counter, hand counter, revolution counter, sheet counter for printing presses, revolution and ratchet counter, and a counter for the textile industry. All types turn the numbers on a mechanical wheel for each unit counted.

Rowan Controller Co., Dept. ED, Red Bank, N.J.

Sensitive Relays 456

Three basic series. T-682 series combines solid-state components with a magnetic relay. The device can control loads up to 20 amp resistive with 1 μa at 0.5 v required for actuation. T-683 series requires 1 ma at 1 v for actuation. Both series are available with a switch and operate on 115 v 60 cps. T-684 series offers an all solid-state relay with no moving parts. Controls up to 10 amp with 10 ma at 1 v required for actuation.

Precision Thermometer & Instrument Co., Dept. ED, 1434 Brandywine St., Philadelphia 30, Pa.

NEW PRODUCTS

Power Supply — 454

Rated from 0 to 40 v ac at 500 ma, model TVCR-040-0.5 has a 25 μsec response time. Features are adjustable, automatic regulation and limiting of both voltage and current, remote programing and sensing, transient-free output, short-circuit-proof design, full protection against turn-off and turn-off overshoots, series or parallel operation, and 500 μv ripple. Load regulation voltage is ±0.01%; current, ±0.02%.

Perkin Electronics Corp., Dept. ED, 345 Kansas St., El Segundo, Calif.

Price: $198.00.

Audio-Visual Annunciator — 452

Has no moving parts. Annunciator has a 2 x 3-in. indication area and operates on a closing or opening of remote contacts. Indication signals include steady and flashing light and buzzer. Designed to be used singly or in combination, all units may be operated by a common acknowledging push button and one common sounding device. Two models with different modes of operation are available.

Radiation Technology, Inc., Dept. ED, 657 Antone St., N.W., Atlanta 18, Ga.

Lighted Switches — 453

For direct panel mounting. Any combination of from 2 to 12 alternate or momentary action model 801P ganged Lit-Switches may be mounted on the same channel to fit individual customer requirements. They mount on 1-in. centers and are available single pole through 6 poles.

The Sloan Co., Color-Lite Div., Dept. ED, 7704 San Fernando Road, Sun Valley, Calif.

Electronic Counter 586

Digital readout to 999,999. Model 464 is a 1-mc, solid-state counter. Available is a choice of any commercial readout, recorder or printer, with a variety of inputs. Applications to control and check-out are also featured, with self-contained comparison logic to be used with externally stored limit values. Preset switch selector panels are available for local or remote limit selections.

Electronic Counters, Inc., Dept. ED, 155 Eileen Way, Syosset, N. Y.

IF Filter 585

For navigation equipment. It is an L-C type if filter that yields 1/2-db max bandwidth ripple with a 6:100-db bandwidth ratio less than 1:2. Units are temperature normalized and the frequency drift is 0.1% max over a range of −40 to 65 C. Input and output tanks can be peaked for optimum performance after installation.

Hathaway Instruments, Inc., Dept. ED, 5800 E. Jewell Ave., Denver 22, Colo.

Reticle Adaptor 595

Visual calibration of vibration equipment over a range of 30 to 200 cps is enabled by reticle adaptors. The Wedge provides measurement of 20 to 100 mils double amplitude. The Para-Line has a series of parallel lines spaced 0.0647 in. apart to measure ±10 g at 55 cps.

Columbia Research Laboratories, Dept. ED, MacDade Blvd. & Bullens Lane, Woodlyn, Pa.

P&A: $25 ea; stock.

NEW PRODUCTS

Photovoltaic Cells 519

Encased or encapsulated selenium photovoltaic cells are for high-output applications in adverse atmospheres. Encased models are: 857, tinned silver, 1-1/4 in. in diameter with glass front; 859, electro-tinned brass, 2 in. in diameter, filled with helium. Other models are: 9971, plastic encased, and 596, Bakelite.

Daystrom, Inc., Weston Instruments Div., Dept. ED, 614 Frelinghuysen Ave., Newark 12, N. J.

Power Supplies 514

Provide low-voltage outputs. Model PS 120 power supply, for transistorized circuits and strain gages, delivers 0 to 10 v dc at 0 to 1 amp with a regulation of 0.002% for 10% line voltage change. Model PS 150, for filament supply and computers, provides 6.3 v dc at 5 amp with a regulation of 0.05%.

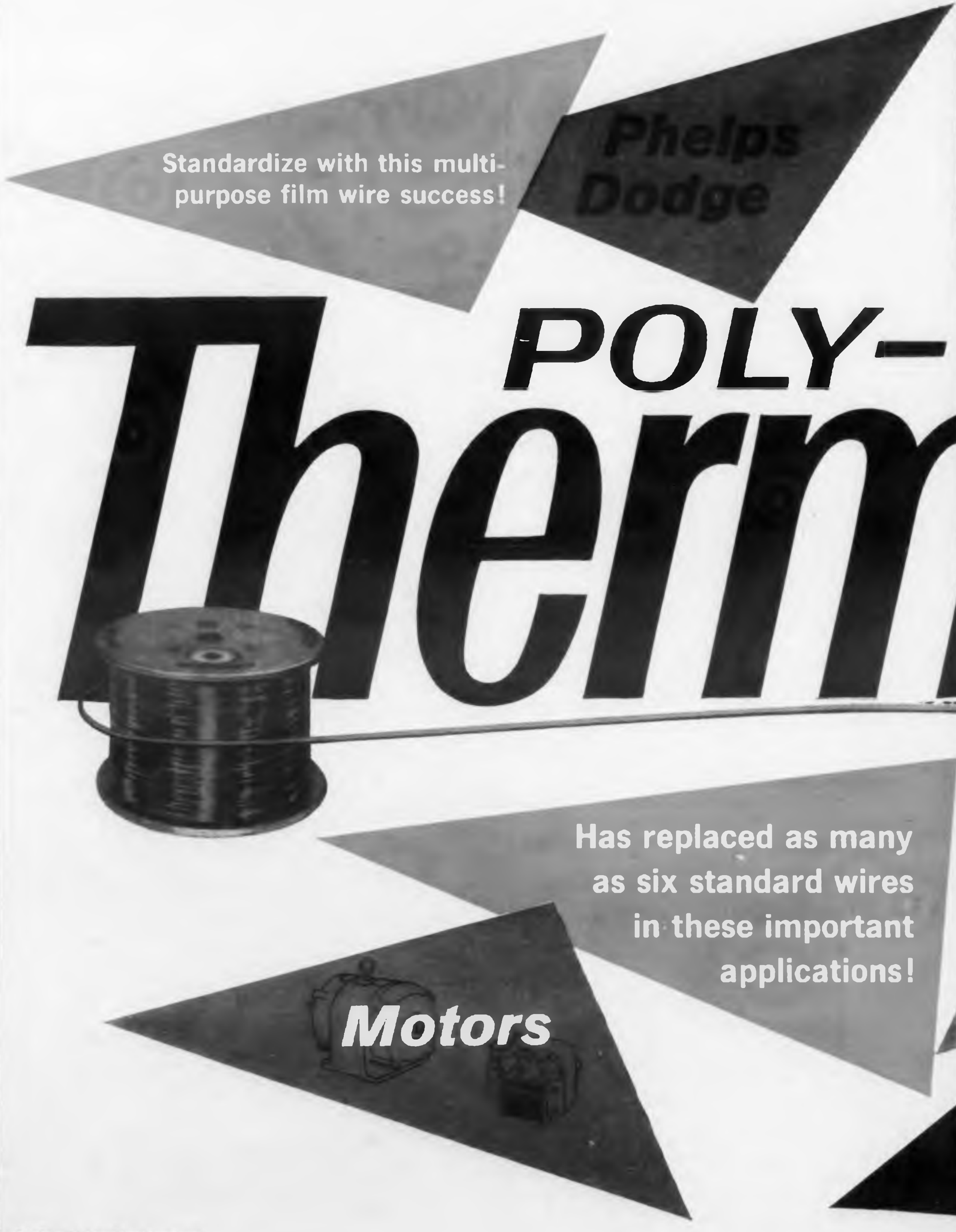
Dynex Industries, Inc., Dept. ED, 123 Eileen Way, Syosset, N. Y.

Availability: *8 weeks.*

Single-Turn Potentiometer 518

Ranges extend to 100 K. Model C-116 single-turn potentiometer is a 2.5-w, 1-1/16 in., wirewound, precision unit, encased in aluminum. Resistance element can be linear or nonlinear. Rotation is continuous or brush-limited. Noise level is low. There are 6 standard ranges.

DeJur-Amsco Corp., Dept. ED, 45-01 Northern Blvd., Long Island City 1, N. Y.



Glass Capacitors 520

Range extends to 60 kv dc. Glass capacitors, offered in 12 voltage ranges, are suitable for continuous operation from −60 to +125 C and operate 10,000 hr at 85 C. Triple dielectric construction consists of plastic film and high-density paper.

Corson Electric Manufacturing Corp., Dept. ED, 540 39th St., Union City, N. J.

Ceramic Closure 476

For diodes. Closure is suitable for thermal cycling between −65 and 150 C. It consists of a metalized ceramic shell with a band of metal fired onto the inner edge at each end. End caps are supplied with each shell. Ceramic is L5 steatite or 85 to 95% alumina. Sizes available are 3/8, 1/2, and 1-in. lengths with diameters to 1-in. OD. Special sizes are also available.

Metalizing Industries, Inc., Dept. ED, 338 Hudson St., Hackensack, N. J.

Potentiometer Adapter 513

Ratio adjustments to 25:1 are possible with model VA-100 adapter which changes a single-turn unit into a multi-turn type. Made to BuOrd OP1755 motor dimensions, it is 1-5/8 in. high with a 2-in. diam. Class 5 ABEC bearings are used. Backlash is 0.5 deg max.

Elm Instrument Corp., Dept. ED, 30 Chasner St., Hempstead, L. I., N. Y.

P&A: $118 to $148; from stock.

NEW PRODUCTS

Vapor-Cooled Tube 444

Dissipation is 50 kw. The ML-7479 three-electrode tube is designed for 50-kw industrial heating and for am broadcasting. At up to 30 mc, maximum ratings are 12.5 kv dc, plate voltage, and 90 kw, plate input. The cathode is a thoriated-tungsten filament with self-supporting design to eliminate stress.

Machlett Laboratories, Inc., Dept. ED, Springdale, Conn.
P&A: $850; 30 days.

Corrosion Meter 489

Compact, portable corrosion meter model CK-2 provides a simple means of making precise corrosion measurements. The meter has interchangeable probes and a drift-free, transistorized amplifier. Mercury battery power gives 1 year operation before replacement. Weight is 11 lb.

Crest Instruments, Dept. ED, Santa Fe Springs, Calif.

Liquid-Cooled Accelerometer 441

Operates at 2,200 F. Model 2206 is a shock and vibration transducer, suited for dynamic measurements in rocket motors, combustion chambers and turbines. It measures 7/8 x 0.53 in., including connectors and mounting stud; it weighs 1.6 g.

Endevco Corp., Dept. ED, 161 E. California Blvd., Pasadena, Calif.

◄ CIRCLE 95 ON READER-SERVICE CARD

Conical Washers 439

For mounting silicon rectifiers. One-piece Keps combine both washer and nut to provide take-up spring pressure. Offered in sizes 8-32 through 1/2-20, they are made of carbon steel, corrosion-resisting steel, aluminum, brass or other materials.

Illinois Tool Works, Shakeproof Div., Dept. ED, St. Charles Road, Elgin, Ill.

Availability: some types from stock.

Signal Amplifier 488

For 400-cycle carrier signals. Model TCA-100 signal amplifier is completely transistorized. Gain is 400 ±20% open loop. Output is greater than 25 v rms. A two-phase output signal allows connection to either balanced, full-wave or single-ended grounded loads. Output does not lose amplitude when the input is overloaded. A feedback terminal allows connection of external feedback networks. Unit requires ±50 v dc an 750 mw. Size is 3 x 1-1/2 x 1-1/2-in.

Epsco-West, Dept. ED, 240 E. Palais Road, Anaheim, Calif.

Glass Silicon Diodes 440

Range is 30 to 300 v. Types ASG3 through ASG30 mesa diffused-junction diodes measure 0.265 x 0.11 in. Coil rating is 1.25 amp at 70 C. Contact protectors eliminate arcing and erosion across relay contacts. Temperature range is −55 to +165 C.

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

P&A: $1.07 to $3.08; from stock.

CIRCLE 96 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Microminiature Accelerometer　442

Weight is 3.1 g. Model 2227 is 1/2 x 3/8 in. (hex), including a 6-32 stud. Voltage sensitivity with 180-pf external capacity is 5 mv peak per g peak, nominal; resonance frequency is 30 kc. Temperature range is −65 to +350 F. Design provides mechanical isolation from noise-producing cable stress.

Endevco Corp., Dept. ED, 161 E. California Blvd., Pasadena, Calif.

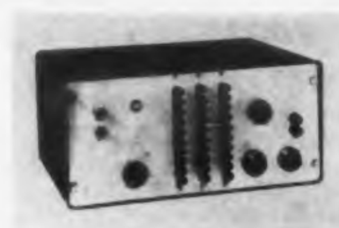
Plug-In Limit Switch　486

Operates 4 circuits with each direction of the lever. The 301LS8 contains two basic switches, each with a two-circuit double-break contact arrangement. It has a center neutral; switches can be adjusted to operate in sequences. Rating is 10 amp at 120, 240, or 480 v ac; 1/2 hp at 120 v ac; 1 hp at 240 v ac; 0.8 amp at 115 v dc; 0.4 amp at 230 v dc; and 0.1 amp at 550 v dc.

Minneapolis-Honeywell Regulator Co., Micro Switch Div., Dept. ED, Freeport, Ill.

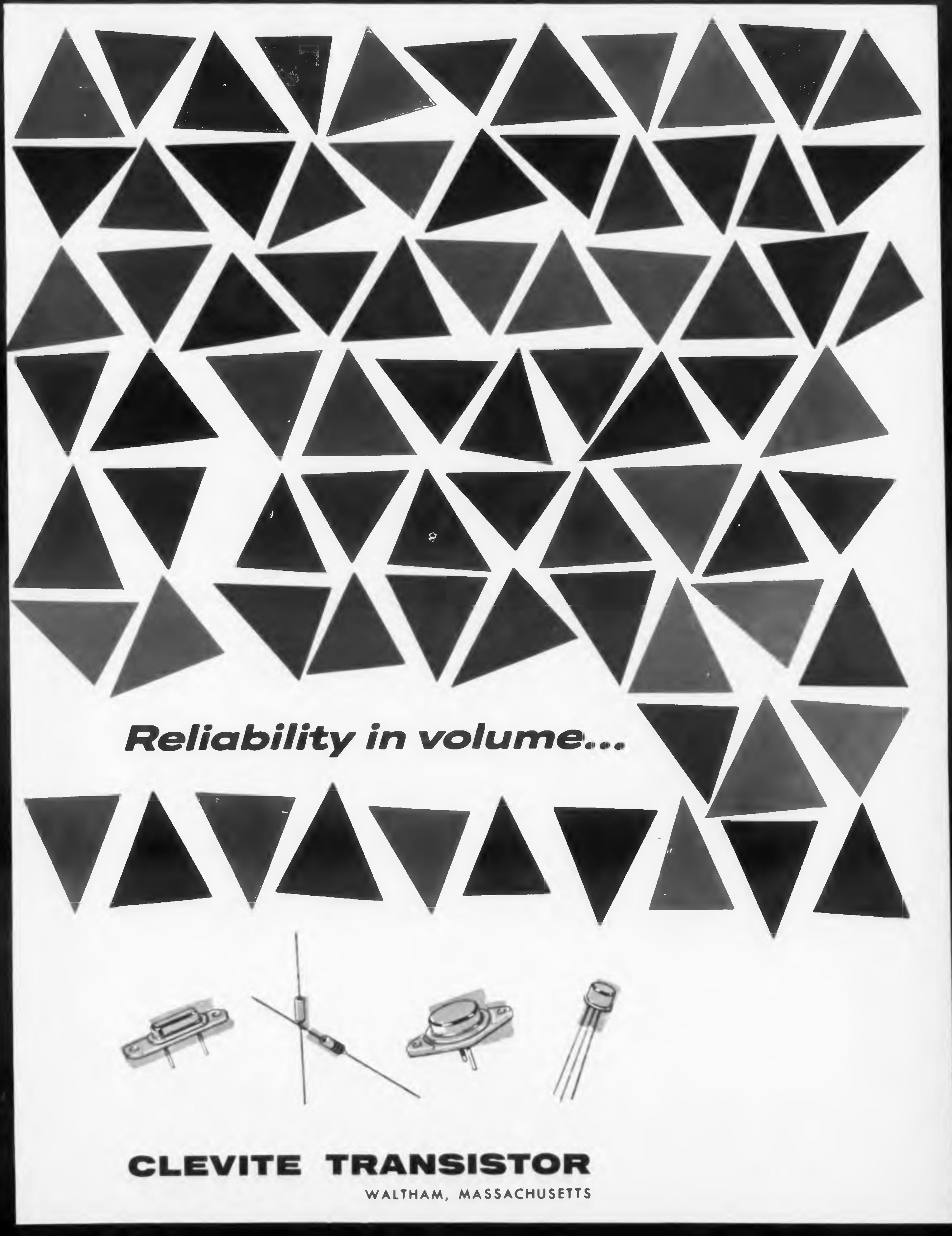
***Price:** $21.75.*

Stable-Amplitude Oscillator　446



Distortion is 0.01%. Amplitude stability is 0.01%. Model 446 produces a sine wave continuously adjustable from 1 cps to 100 kc. Frequency-calibration accuracy is within 1% from 1 cps to 10 kc. Hum bounce or line

◄ CIRCLE 97 ON READER-SERVICE CARD
CIRCLE 98 ON READER-SERVICE CARD ►


Reliability in volume...
CLEVITE TRANSISTOR
WALTHAM, MASSACHUSETTS

How to select power transistors

by RICHARD F. MOREY, JR.

Manager, Applications Engineering, Clevite Transistor Division of Clevite Corporation

A basic understanding of the interrelationship of transistor design parameters facilitates selection of the most advantageous unit for a given application.

Transistor characteristics depend upon each other. Consequently, a design change in the manufacture of a transistor directly affects a number of its electrical characteristics.

As a guide to users of power transistors, several of the important design elements and the electrical characteristics they influence have been summarized in chart form (fig. 1).

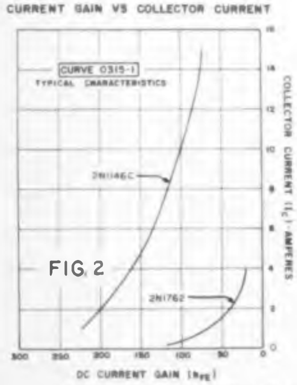
The curves (figs. 2-5), show typical characteristics for two power transistors of quite different design. Clevite's 2N1762, for example, is a 3 ampere unit having the following design parameters: Small junction area; high resistivity germanium; moderate germanium lifetime; average wafer thickness and no emitter doping.

In contrast, Clevite's 2N1146C is a 15 ampere power transistor which has several quite different parameters based upon a higher current and power requirement; large junction area several times the size of the 3 ampere unit; identical base width and resistivity but longer germanium lifetime and thicker wafer plus aluminum doping to increase emitter efficiency.

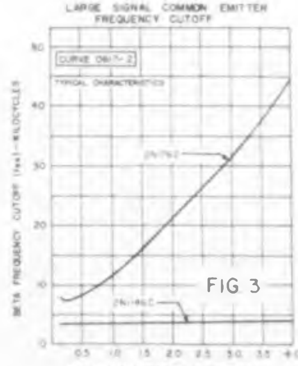
Working with the chart in figure 1 and the table, figure 6, we see that the comparative design elements of the two transistors result in the 15 ampere unit exhibiting:

— lower thermal resistance and higher leakage currents because of its large junction area.
— slightly lower collector to base voltage.
— higher gain because of the emitter doping and higher lifetime.
— very linear current gain out to high currents because of its large area and special emitter doping.
— lower collector to emitter breakdown voltages because of its higher gain and lower collector to base voltage.
— much lower saturation voltage and base input voltage because of its high gain and thicker wafer and larger area.
— low common emitter frequency response because of its high gain and large area.

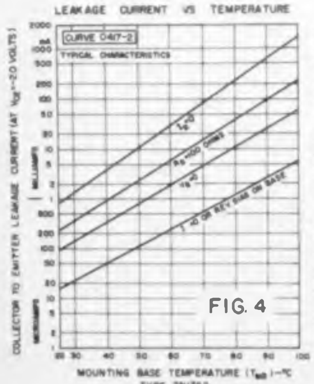
CURRENT GAIN VS COLLECTOR CURRENT



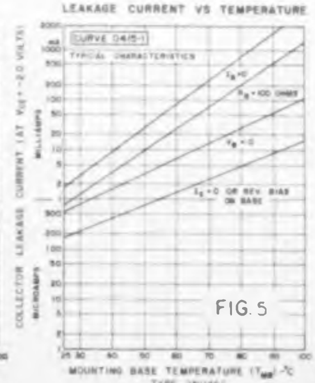
LARGE SIGNAL COMMON EMITTER FREQUENCY CUTOFF



LEAKAGE CURRENT VS TEMPERATURE



LEAKAGE CURRENT VS TEMPERATURE



Effect of Transistor Design on Characteristics

DESIGN PARAMETER	Addition of Emitter Doping	Increase in Wafer Thickness	Reduction in GE material lifetime	Increase in GE material resistivity	Reduction in Base Width	Increase in Junction Area
THERMAL RESISTANCE R_t	—	—	—	—	—	decrease
COLLECTOR LEAKAGE CURRENT I_{CBO}	—	decrease	increase	increase	—	increase
COLLECTOR BASE VOLTAGE V_{CB}	—	—	—	increase	—	decrease slightly
COLLECTOR EMITTER VOLTAGE V_{CE}	decrease	—	increase	increase	decrease	decrease slightly
D.C. CURRENT GAIN h_{FE}	increase	—	decrease	—	increase	—
LINEARITY OF h_{FE}	better	—	—	—	—	better
SATURATION VOLTAGE $V_{CE(SAT)}$	decrease	decrease	increase	increase	decrease	decrease
BETA CUTOFF FREQUENCY f_{ae}	decrease	—	increase	—	increase	decrease
PUNCH THROUGH VOLTAGE V_{PT}	—	—	—	decrease	decrease	—
SECONDARY BREAKDOWN CURRENT I_{sb}	increase	increase	—	decrease	—	increase

Figure 1.

Comparison of Characteristics — Two different designs

Characteristic	2N1762 Typical Value 3 Amp. Device	2N1146C Typical Value 15 Amp. Device	Units
Thermal Resistance	1.4	0.5	°C/watt
I_{CBO} at 100V at 85°C	3	15	mA
I_{CBO} at 100V at 25°C	1	4	mA
BV_{CBO}	130	120	Volts
$V_{CEO(sus)}$	70	50	Volts
Current Gain at I_C = 1 Amp.	60	220	
Current Gain at I_C = 5 Amps.	15	140	
Current Gain at I_C = 15 Amps.	—	75	
Saturation Voltage at 3 Amps.	0.3	0.2	Volts
Saturation Voltage at 15 Amps.	—	0.4	Volts
Saturation Resistance	100	26	Milliohms
Frequency Cutoff at 1 Amp.	18	4	kc.

Figure 6

In order for circuit designers and users of power transistors to obtain the best combination of electrical characteristics, the requirements for the application must be well known and be matched to the transistors available on the market. Therefore, an elementary knowledge of the existing relationships between transistor characteristics is a useful design tool. A tabular summary of characteristics for Clevite's complete line of power transistors is available. Ask for Bulletin 61-A.

frequency beat is less than 0.05%. Amplitude change with line voltage is 0.005%.

Krohn-Hite Corp., Dept. ED, 580 Massachusetts Ave., Cambridge 39, Mass.

P&A: $1,350; 8 weeks.

Tachometer-Generator 487

Two independent signals are supplied by model 2CM9ABC-Y9 tachometer-generator, designed for aircraft installation. One signal drives standard panel-mounted tachometer indicators. The second signal is an ac sine-wave voltage suitable for driving any frequency-measuring device.

General Electric Co., Instrument Dept., Dept. ED, West Lynn, Mass.

Circuit Boards 490

Meet military requirements. Printed circuit boards incorporate military preferred circuits. Boards are completely etched, requiring only drilling and component insertion for finished assembly.

Advanced Designs Inc., Dept. ED, Vienna, Va.

Price: $2, sample.

Rack Cabinets 532

Have welded construction. Cabinets are available in standard depths of 22 or 25-1/2-in. Standard openings in series A vertical cabinets are 22-3/4, 35, 43-3/4, 61-1/4, and 70 in. Openings in series B slope-front cabinets are 12-1/4, 17-1/2 and 21-in. on upper slope front, and 24-1/2-in. on bottom vertical front. Any vertical panel opening in a multiple of 1-3/4-in. or any depth is available on special order.

Electro-Rack, Inc., Dept. ED, 11501 Jefferson Blvd., Culver City, Calif.

Teflon Resin 536

For electrical insulation. Teflon TE-9500 FEP fluorocarbon resin dispersion or spray finish is suitable as a class H impregnant and surface coating for wire, cable and component insulation. It provides low permeability coatings, good heat sealability and high dielectric strength in thin films. It may be fused at temperatures of 575 to 625 F.

E. I. du Pont De Nemours & Co., Public Relations Dept., Dept. ED, Wilmington, Del.

CIRCLE 100 ON READER-SERVICE CARD ▶
◀ CIRCLE 98 ON READER-SERVICE CARD

NEW PRODUCTS

Bandpass Filters 555

Range from 15 to 25 kc. Fixed bandwidths are 1 to 15 cps. Series EM-3100 bandpass filters have input and output impedances of 20 to 500 ohms. Single-element filter cut-off rate is 6 db per bandwidth octave.

Raytheon Co., Industrial Components Div., Dept. ED, 55 Chapel St., Newton 58, Mass.

P&A: *$125 to $199 ea; immediate.*

Potentiometer-Clutch 542

In size 11. A magnetic clutch and a spring centering mechanism are coupled to a center-tapped potentiometer. Rotation is continuous in either direction; disengagement returns shaft to center ±15 min.

Orbit Instrument Corp., Dept. ED, 131 Eileen Way, Syosset, N. Y.

Pressure Transducer 550

Over-pressure capability is 10,000 psi or 10 times rated pressure applied for 3 min. Type 4-350 pressure transducer has a sensitivity of 50 mv, low residual unbalance and a combined figure of ±0.35% for linearity and hysteresis.

Consolidated Electrodynamics Corp., Dept. ED, 360 Sierra Madre Villa, Pasadena, Calif.

Digital Clock 549

For solar or sidereal time. Model 801 digital clock has these outputs: time as a 28-bit binary number, pulses at preselected times, 100-kc reference frequency accurate to 1 part in 10^7 per day, and WWV audio signals. Information can be read out as parallel binary bits by a computer or tape perforator.

General Mills, Inc., Dept. ED, 1620 Central Ave., Minneapolis 13, Minn.

Display Assembly 559

Six decimal digits, derived from four-bit code inputs, are displayed by model 2062. Nixie readout is used. Code input is up to 24 bits, with binary *1* represented by −6 to −12 v, binary *0* by 0 v. Gate input may be pulse or static at +10 v, duration 5 μsec min. Display assembly is housed in a rack-mounting case with 3-1/2 in. panel height.

Hermes Electronics Co., Dept. ED, 75 Cambridge Parkway, Cambridge 42, Mass.

P&A: $1,440; delivery from stock.

Multi-Gang Timers 553

Speeds are from 50 cycles per min. to one revolution per hour. Harco 4, 5 and 6-gang timers incorporate 115-v, 60-cps synchronous motors, spdt switches and adjustable cams which may operate in sequence or simultaneously. Applications include life testing, process control, pulsing, delayed timing and flashing.

Herback & Rademan, Inc., Dept. ED, 1204 Arch St., Philadelphia 7, Pa.

Availability: from stock.

CIRCLE 102 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Magnetic Clutch 478

Has 3 operating modes. Model MC-100 combines 2 clutches in a single housing. At one end a 0.125-in. diam shaft passes through the clutch within a 0.250-in. diam shaft. The other end has a 0.250-in. diam shaft. The 0.250-in. diam shafts may be coupled individually or simultaneously to the smaller shaft. Output torque is 26 to 70 oz-in. at 24 to 28 v dc. Power required is 3 w per coil. Size 11 unit measures 4.689 x 1.062-in. in diameter and weighs 8-1/2 oz. Sizes 5 to 18 are available.

Elm Instrument Corp., Dept. ED, 30 Chasner St., Hempstead, N. Y.

P&A: $128.00 to $160.00 for size 11; from stock.

Magnetic Counter 517

Enclosure is vapor sealed. Model CG-H magnetic counter is available in add or subtract types with a capacity of 9999 and a speed of 10 counts per sec. Life is 1,000,000 cycles. It is suitable for airborne applications and can be used in any altitude or position.

Abrams Instrument Corp., Dept. ED, Lansing, Mich.

Sensitive Relay 509

Rating is 10 amp, 300 v ac for transistorized sensitive relay with dpdt contacts. It has high-impedance input. Applications are in inspection, sorting and positioning machinery. It can be used with photocells, thermistors and liquid-level probes.

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

Building Block Scaler 523

Range is dc to 1.5 mc. The LB1001 scaler is designed for preset counting, compared counting, digital clock and beat frequency pulse dividing. Diode logic instead of NOR logic is used. Temperature range is 0 to +85 C. Silicon mesa transistors are used.

Frontier Electronics Co., Dept. ED, 4600 Memphis Ave., Cleveland 9, Ohio.

Magnetic Timer 510

Ranges are 0.1 to 38 sec. Types D and E magnetic timers have a repeat accuracy of ±1% of the maximum time range with a line-voltage variation of ±15%. Type D provides delay after opening of initiating switch; type E, after closure. Contacts are dpdt, rated at 5 amp at 115 v ac or 28 v dc.

Gemco Electric Co., Dept. ED, 25685 W. Eight Mile, Detroit 40, Mich.

Transistor Test Set 498

DC currents to 7 ma and potentials to 70 v are furnished. Model 210-A transistor test set measures h-parameters and leakage currents of small transistors and diodes. Accuracy is better than 5%. An internal oscillator and ac-millivolt meter provide dynamic tests at 1,500 cps.

Owen Laboratories, Inc., Dept. ED, 55 Beacon Place, Pasadena, Calif.

Price: $550.

NEW PRODUCTS

Ultrasonic Solder Pots 507

Ratings are 10, 50 and 100 w. Models G-10 and G-100 generators, SPT-10 and SPT-100 transducer and pot measure from 3/8 to 2 in. in diameter. Heating-element capacity is 20 or 35 w in 10-w unit, 50 or 75 w in 50-w unit, 100 or 200 w in 100-w type. Transducers have 80% efficiency and temperature range to 700 F.

Gulton Industries, Inc., Vibro-Ceramics Div., Dept. ED, 212 Durham Ave., Metuchen, N. J.
P&A: $249 up; 3 weeks.

Right-Angle Gearmotors 497

Ratings are 1/8 to 1/3 hp. A 1/4-hp gear-motor weighs 26 lb. The output shaft can be used at either side of the gear unit. The cast-iron gear case has integrally cast end shield. Enclosures are fan cooled. A total of 13 reduction ratios are offered as standard.

Reliance Electric & Engineering Co., Dept. ED, 24701 Euclid Ave., Cleveland 17, Ohio.

Analog-Digital Converter 508

Operation is electromechanical. Model 791-S converter is designed for low-speed conversion of linear data. Output is 11-bit binary, which can be increased to 19 bits. Accuracy is 1 part in 2,048. Uses are in digital computers, fire control systems, airborne navigation and machine-tool control.

General Precision, Inc., Librascope Div., Dept. ED, Glendale, Calif.

NEW PRODUCTS

Thermal Reference Junction 516

Provides 250 F reference. Type RJ-24 thermal reference junction provides: uniformity between junctions, 1 F; ripple ±1 F; regulation throughout environmental temperatures of −65 to +165 F, less than 3 F. Power consumption is 5 w, dimensions are 3-1/4 x 3-1/4 x 5-1/4 in., and weight is 4 lb. Capacity is 24 channels.

Astra Technical Instrument Corp., Dept. ED, 12930 Panama St., Los Angeles 66, Calif.

Resistance-Force Transducers 430

Range is 500 to 26,000 ohms. Force ratings are 0.5 to 5,000 lb. Called Micro-Ducers, they operate instruments, lamps, and miniature motors. No amplification is needed. Power required is a flashlight cell or 1.6 v dc, regulated. The largest size uses 5 ma.

Clark Electronic Laboratories, Dept. ED, Box 165, Palm Springs, Calif.

Power Supplies 512

Outputs are to 110 v dc. Three power supplies in this series provide: 3 to 20 v dc at 0 to 1.5 amp; 5 to 60 v dc at 0 to 1.5 amp; 10 to 110 v dc at 0 to 0.75 amp. Output impedance is 500 milliohms, regulation for input variation is 15 mv or 0.5%, ripple is less than 3 mv rms and temperature limit is 85 C. Input is 105 to 125 v at 60 cps.

Flite-Tronics, Inc., Dept. ED, 3312 Burton Ave., Burbank, Calif.

Accelerometer 511

Resonance frequency is 30 kc. Nominal sensitivity is 72 mv peak per g peak. Model 2217 accelerometer is especially suited for submarine low noise tests. It meets MIL-E-5272B. Weight is 1.1 oz.

Endevco Corp., Dept. ED, 161 E. California Blvd., Pasadena, Calif.

Interference-Free Lighting 492

Cold-cathode fluorescent lighting equipment is designed to completely suppress conducted and radiated rf interference. Surface, pendant, and recessed fixtures are made in 4-ft and 8-ft lengths and in continuous runs with two or four rows of lamps. Equipment exceeds requirements of MIL-1-16910A, and is free of rf interference from 14 kc to 1 Gc. Lamps are available in 13 standard colors.

National Cathode Corp., Dept. ED, 317 E. 34th St., New York 16, N. Y.

Price: $73 to $118 ea, 1 to 9.

DC Amplifier 413

Gain is 1,000 max. Model 10-111-3 amplifies low-level signals from thermocouples, strain gages and other devices. It produces an output of 0 to 5 mv for use in telemetering, instrumentation and recording systems. Frequency response is from 0 to 500 cps. Linearity is 0.1%. Dimensions are 1 x 3.5 x 5 in.

Magnetic Research Corp., Dept. ED, 3160 W. El Segundo Blvd., Hawthorne, Calif.

Power Supply 506

Output is 30 kv dc at 2.5 amp. Power supply is askarel-insulated and self-cooled. It is designed and built to meet individual specifications.

Hill Magnetic Products, Dept. ED, 1055 O'Brien Drive, Menlo Park, Calif.

NEW PRODUCTS

Wirewound Potentiometer 484

In 7/8-in. diameter, the 2440 series potentiometer is rated at 3 w. The wirewound units are linear over specified resistance ranges from 10 to 50,000 ohms. Resolution ranges from 229 to 900 turns. Turret-type terminals are gold-plated; servo or bushing mounts are used. With a temperature range from −55 to +125 C, the unit meets military specifications.

Amphenol-Borg Electronics Corp., Borg Equipment Div., Sales Dept., Dept. ED, 120 S. Main St., Janesville, Wis.

Transducer Adapter 482

Universal input conditioning unit for strain gages and transducers may be used with one, two or four-arm bridges, and will adapt to any input wiring technique including eight-arm bridges. Integral power supply may be adjusted between 1 and 15 v dc. Six modules mount in rack width; panel height is 8-3/4 in.

B & F Instruments, Inc., Dept. ED, 3644 N. Lawrence St., Philadelphia 40, Pa.

Counter-Timer 480

For laboratory or production use. Model 725A counter-timer counts periodic or random events and measures frequency, period and time intervals. Sensitivity is 50 mv. Range is 0 to 220,000 pps; 1 to 220,000 cps or 10 μsec to 10^7 sec (2,777 hr). Short term accuracy is 0.0001%. Readout is in 5 or 6 decades. Automatic decimal point and modular construction permit maximum flexibility and easy maintenance. Unit weighs 23 lb.

Erie Resistor Corp., Erie-Pacific Div., Dept. ED, 12932 S. Weber Way, Hawthorne, Calif.

Silicon Transistors 557

Double-diffused pnp silicon mesa transistors 2N1131 and 2N1132 operate in complementary symmetrical circuitry with 2N696 and 2N697 npn transistors. Power dissipation is 2 w; dc current gain is 20 to 45 and 30 to 90, 20-mc current gain 2.5 and 3.0 respectively.

Texas Instruments, Inc., Dept. ED, P. O. Box 5012, Dallas 22, Tex.

P&A: *$19.25 and $20.90 ea, 1 to 99; stock.*

PNP Germanium Transistors 554

For audio or if amplifiers. Types R-2 and R-3 pnp germanium transistors have a noise factor of 5 db max with beta ranges exceeding 300. They dissipate 30 mw at 25 C. Alpha cutoff frequency is 1 or 2 mc.

Zenith Radio Corp., The Rauland Corp., Dept. ED, 6001 W. Dickens Ave., Chicago 39, Ill.

Price: $1.90 up.

High-Vacuum Triodes 561

For pulse modulation. Air-cooled type WL 7750 triode has a duty factor of 0.008 at 30-kv dc plate voltage, and 8-kw plate dissipation. Water-cooled type WL 7748 has a duty factor of 0.02 max and 35-kw plate dissipation.

Westinghouse Electric Corp., Electronic Tube Div., Dept. ED, P. O. Box 284, Elmira, N. Y.

P&A: *7748, $560; 7750, $640; 90 to 120 days.*

Trimmer Potentiometers 544

Ranges are 250 ohms to 2.5 meg. Series 220 trimmer potentiometers measure 7/16 x 1/2 in. and are for use in communications, computers and instrumentation.

CTS Corp., Dept. ED, Elkhart, Ind.

P&A: *$0.90; 2 to 4 weeks.*

CIRCLE 115 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Readout for Annunciators — 505

Capacity is 60 messages. Series 90oooH readout operates on a rear-projection principle and provides 60 miniature lenses or positions. Over-all dimensions are 5-1/4 x 12 x 16-1/2 in.

Industrial Electronic Engineers, Inc., Dept. ED, 5528 Vineland Ave., North Hollywood, Calif.

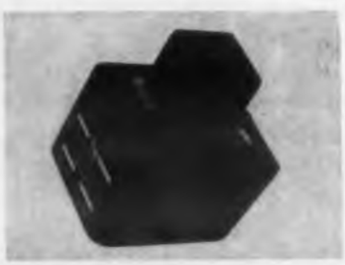
Limit Stop — 479

For varied use. Model ELS-100 can provide any angle of contact in turns, degrees or minutes or any combination thereof, up to 10 turns max. One common leg is used for all contacts. Contacts and slip rings are silver. Unit is supplied with contacts in the positions specified by the customer. Sizes 5 to 18 are available. Size 10 unit measures 1-3/4 x 1-in. in diameter. Uses include computer, servo and control systems, flight instrumentation.

Elm Instrument Corp., Dept. ED, 30 Chasner St., Hempstead, N. Y.

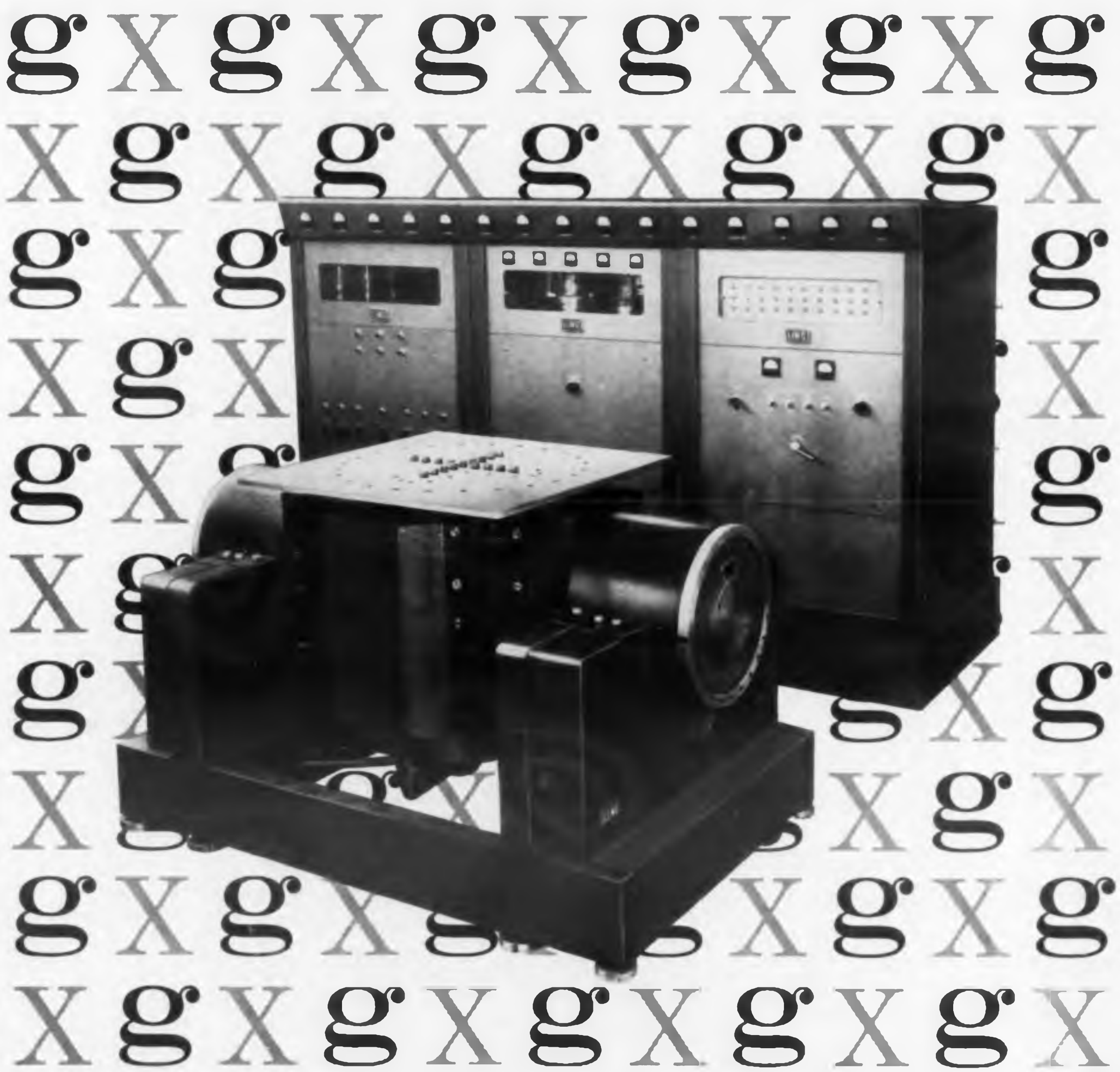
P&A: $103 to $129 for size 10; 10 days.

Electromechanical Switch — 504

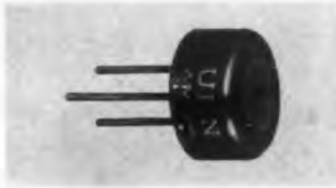


A 60-position shorting type switch, and an incremental saw-tooth function generator are contained in a 3,600-rpm electromechanical switch. Saw-tooth function is of 5-v amplitude divided by 30 discrete resistors. Accuracy is 1.5%. Outputs of both poles may be used in an external comparator network to determine coincidence of information signal with function amplitude.

Instrument Development Laboratories, Inc., Dept. ED, 67 Mechanic St., Attleboro, Mass.



Wirewound Potentiometer 474



For printed circuits. Model 3367 is a single turn wirewound potentiometer. Resistance range is 100 ohms to 20 K. Power rating is 0.5 w at 70 C. Resolution is as low as 0.12%. Resistance tolerance is ±5%; closer tolerances are available. Operating temperature range is from −55 to 105 C. It is available with printed circuit pins, or solder lugs with bushing mounts. Size is 1/2-in. in diameter x 0.210-in. high. Weight is 0.05 oz.

Bourns, Inc., Dept. ED, 6135 Magnolia Ave., Riverside, Calif.

Price: *$3.00 ea.*

Silicone Fluid 483

Nitrile-containing silicone fluids have high polarity and limited electrical conductivity. They are insoluble in aliphatic and aromatic hydrocarbons. The X-1100 series fluids have dielectric constants ranging from 3 to 20 at 60 cps.

General Electric Co., Silicone Products Dept., Dept. ED, Waterford, N. Y.

Pulse Measuring Set 475

For Dataphone signals. Model DRMS-1 measures polar data signals and indicates either peak distortion or changes in the steady-state level of distortion. It can be arranged for any of 999 different speeds from 362 to 2,625 bits per sec. Two jacks provide input impedances of 100 K and 10 K. Size is 4-1/2 x 12 x 5-1/2-in. deep. It is supplied with a panel cover and handle.

Atlantic Research Corp., Dept. ED, Alexandria, Va.

NEW PRODUCTS

Crystal 502

Range is 4.966 to 6.133 mc. The JKG6AS 5th overtone "Glasline" crystal is made for use in frequency standards exposed to severe environments. Under vibration of 10 to 200 cps at 10 g, frequency change is less than 1×10^{-8}. Unit stands 100-g shock when tested per MIL-STD-202A, method 202A.

James Knights Co., Dept. ED, Sandwich, Ill.

Silicon Rectifier 522

Rated at 1,500 piv, 37.5 ma per half-wave section, USAF type IN570 full-wave silicon rectifier meets MIL-E-1/1275. It is designed to replace type 6X4 tube where miniaturization and high reliability are required.

Columbus Electronics Corp., Dept. ED, 1000 Saw Mill River Road, Yonkers, N. Y.

Pulse Generator 481

For general applications. Type 404-B pulse generator has a rise and fall time of 13 nsec; jitter between trigger and pulse is less than 3 nsec. It is capable of putting 90 v into 93 ohms or 55 v into 50 ohms. Repetition rate range is from 250,000 pps to a single push-button actuated pulse of selected width and amplitude. Pulse width range is 0.05 to 105 μsec. Pulse width accuracy is 3%.

Allen B. Du Mont Laboratories, Div. of Fairchild Camera & Instrument Corp., Dept. ED, 750 Bloomfield Ave., Clifton, N. J.

P&A: $725.00; from stock.

EXCITATION!

115-VOLTS...400-CYCLES...FOR BOTH MOTOR AND GENERATOR

Now, a Size 8 servomotor-generator with both motor and generator wound for 115-volt, 400-cycle supplies. It's BECKMAN Model 9008-1106-0, ready now to help cut costs in your system ...aid in achieving greater reliability and economy.

Generator specs show an output of 0.30 volts per 1,000 rpm, phase shift is 0° ± 10°. The servomotor turns 6,000 rpm, no-load speed, its stall torque is 0.33 oz. in., and acceleration at stall is 70,700 rad/sec². Length of this motor-generator complete is 1.850" and maximum weight is 2.6 ounces.

For complete facts on BECKMAN Model 9008-1106-0, contact your nearest Helipot Sales Representative, or write directly to us.

Beckman® / Helipot®

POTS : MOTORS : METERS

Helipot Division of
Beckman Instruments, Inc.
Fullerton, California

CIRCLE 821 ON READER-SERVICE CARD

Size 5 Servomotor — 822

For minimum size and weight applications

Model 9005-1502-0 Servomotor is designed for applications calling for minimum size and weight. The Size 5 weighs 0.6 ounces, is 0.865" in length. Powered by 26-volt, 400-cycle reference voltage, the servomotor has a no-load-speed of 10,000 rpm. Torque-at-stall registers 0.1 oz.in., while rotor inertia is 0.18 gm.cm.², providing an acceleration-at-stall of 39,000 rad/sec². Stainless steel bearings, shaft and housing, and Teflon for insulation permits operation over an ambient temperature range of −55°C to +130°C. Maximum unit operating temperature is +200°C.

Beckman Instruments, Inc., Helipot Division Technical Information Service, 2500 Harbor Blvd., Fullerton, Calif.

Single-Turn A-C Potentiometer — 823

Reduces quadrature and loading effects

Model 5803, a 3" diameter single-turn A-C potentiometer, has high input impedance and low output impedance to substantially reduce quadrature and loading effects. New design minimizes the chance of catastrophic failure and provides stable linearity throughout the life of unit. Impedance range is 1,000 to 75,000 ohms, with frequency range of 400 to 1,000 cps. This is the first of a series of precision potentiometers for A-C excited circuits. Beckman Instruments, Inc., Helipot Division Technical Information Service, 2500 Harbor Blvd., Fullerton, Calif.

All-Metal Panel Meter Line — 824

Gasket sealing keeps movement trouble-free

These all-metal panel meters are gasket sealed to keep out dust, moisture and foreign particles. Steel movement enclosures protect against the effects of magnetic panel materials or stray RF. Pictured is 4" x 6" meter, with scale length of 4.7" for maximum visibility and reading ease. The 4" x 6" meter mounting configuration matches other meters of similar size. Standard meter finish is flat black with bezel available in any color.

Availability: 30 days.

Beckman Instruments, Inc., Helipot Division Technical Information Service, 2500 Harbor Blvd., Fullerton, Calif.

LAB ACCURACY IN A PANEL-MOUNTED METER?... it's yours with BECKMAN Expanded Scale Meters. Your knowledge of power supplies... whether in the lab or on the launching pad... is only as accurate as the instruments you read.

Precision built by Helipot Division, BECKMAN Expanded Scale Voltmeters always tell the truth. The critical voltage range – the one you want to know the most about – is expanded across the entire arc of a fully linear scale, thus eliminating unnecessary and unusable calibrations.

Resolution of a typical 110 – 120v AC meter is one-tenth volt: combine that resolution with ±0.3% accuracy, and you have an instrument that will perform like a highly specialized bench model... yet is fully ruggedized and sealed, ready for the most demanding application. And this meter doesn't care what shape the waveform is in. Be it square, zig-zag, or what-have-you... this meter always reads direct rms. Nothing average here – not even the sensing device!

BECKMAN Expanded Scale Meters come in a variety of shapes, sizes, and ranges... including AC and DC voltmeters, frequency meters and linear scale ammeters. Each is available in both commercial and military models... and delivery is superb: 30 days on standard models, 60 days on specials.

For the whole truth about your power supply, use BECKMAN Expanded Scale Meters. For the whole truth about BECKMAN Expanded Scale Meters... send for Data File.

Beckman® / Helipot®

POTS : MOTORS : METERS

Helipot Division of
Beckman Instruments, Inc.
Fullerton, California

CIRCLE 825 ON READER-SERVICE CARD

NEW PRODUCTS

Multi-Meter 552

Measures volts, ohms, milliamperes. Model 800 multi-meter provides: frequency compensation from 40 cps to 20 kc, overload protection, sensitivity of 20,000 ohms per v dc and 10,000 ohms per v ac. Mirrored scales are 6.95 in. at top arc.

Triplett Electrical Instrument Co., Dept. ED, Bluffton, Ohio.

Clamp Assembly 547

Meets military specifications. Type 6086 stainless-steel clamp assembly is built to BuOrd specifications 643019 and is finished in black oxide. Over-all dimensions are 5/16 x 13/32 in.

Vemaline Products Co., Dept. ED, Franklin Lakes, N. J.
P&A: $0.40; from stock.

Potentiometers 545

Wirewound and carbon types. Potentiometers for commercial applications meet steady-state humidity requirements of MIL-STD-202A. Model 3067, wirewound, is offered in ranges of 100 to 20 K and has a power rating of 0.5 w. Model 3068, carbon, has ranges of 20 K to 1 meg with 0.2-w power rating.

Bourns, Inc., Dept. ED, 6135 Magnolia Ave., Riverside, Calif.

◄ CIRCLE 117 ON READER-SERVICE CARD

Arc Melting Furnace 533

Power capacity is 400 amp. Model AF-92 arc melting furnace has a water-cooled nonconsumable tungsten arc tip. Electrode is pivoted on a universal joint and the process can be observed through a 360-deg glass band. With standard copper hearth plate. Six buttons 1-in. in diameter can be produced at one time. Chamber can hold a vacuum down to 10 microns or an inert gas atmosphere up to 15 psia.

MRC Manufacturing Corp., Dept. ED, 47 Buena Vista Ave., Yonkers, N. Y.
Price: $2,475.

DC Power Supplies 546

Provide up to 72 w. The ST power supplies have a line regulation of ±0.03%, load regulation of 0.05%, recovery time of less than 25 μsec and ripple of 1 mv rms. Five continuously variable models provide: 18 v at 0.5 amp, 18 v at 3.5 amp, 36 v at 1 amp, 36 v at 2 amp and 60 v at 1 amp.

PRL Electronics, Inc., Dept. ED, 232 Westcott Drive, Rahway, N. J.
P&A: $200 to $285; from stock.

Vertical Radiator 562

Capable of handling 150 kw, the TRYLON broadband vertical radiator is designed for omnidirectional and multifrequency service. Input impedance is constant, eliminating the need for impedance-matching equipment. It is designed for a 50- or 70- ohm coaxial line. The vswr is less than 2:1 up to high frequency.

Wind Turbine Co., Dept. ED, West Chester, Pa.

CIRCLE 118 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Differential DC Amplifier 531

Is completely transistorized. Model A-16 wide-band differential amplifier has a noise level of 5 μv rms from 0 to 50 kc and a drift of less than 2 μv for a 1-day period. Gain is 10 to 1,000. Input impedance is 100 meg shunted by 500 pf. Settling time is 200 μsec. Frequency response is ±1% to 1 kc, ±1 db to 10 kc, ±3 db to 20 kc. Output impedance is 40 milliohms.

Electro Instruments, Inc., Dept. ED, 8611 Balboa Ave., San Diego 11, Calif.

Heat Dissipators 564

For semiconductors. Models 6029, 6030, 6071 and 7030 provide 70 to 150 sq in. of radiating area. Made of aluminum, they are available in several finishes including unfinished aluminum, chromate conversion and black anodize. Dielectric resistance is 500 v min. No mica washers are needed for mounting. Thermal resistance is 0.5 C per w.

Vemaline Products Co., Dept. ED, Franklin Lakes, N. J.

Voltage Monitor 534

Range is 0 to 100 v dc. Model 86 monitors dc power supply output and restricts voltage excursions within 4 preselected bandwidths at any selected voltage. At 100 v bandwidth range is from ±1 to ±5 v. At voltages close to 0 the bandwidth range is from ±70 to ±350 mv. Bandwidth tolerance is ±20% of indicated values. Operating speeds range from 10 μsec to 20 msec, depending on mode of operation. Power required is 115 v at 50 to 60 cps.

Electronic Measurements Co. of Red Bank, Dept. ED, Red Bank, N. J.

Modular Plug 535

For 3 to 60 circuits. Modular plug and receptacle pairs are made to assure positive polarity. Additional polarization is possible by intermixing male and female terminals in plugs and receptacles. Uses include vending and office machines and other wiring harness devices. Units are mounted into panel hole by a snap-in method.

Molex Products Co., Dept. ED, 9515 Southview Ave., Brookfield, Ill.

Digital Converter 558

Nixie readout of six different binary codes is provided by binary-to-decimal converter model 262. Mounted on a circuit board, converter measures 9-7/8 x 2-7/8 x 9/16 in. No tubes or relays are used.

Hermes Electronics Co., Dept. ED, 75 Cambridge Parkway, Cambridge 42, Mass.

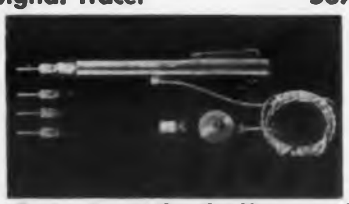
P&A: $95 to $85 ea; stock.

Mylar Film Tape 560

Stands temperatures to 150 C. Type 4272 Mylar film tape has a pressure-sensitive silicone adhesive to adhere to silicone-treated surfaces. Uses are in splicing silicone-treated interliners or carriers in processing operations. Elongation is 100%.

Permacel, Dept. ED, New Brunswick, N. J.

Signal Tracer 537



Is transistorized and self-contained. Low level microwave audio and modulated rf signals can be detected, amplified and reproduced through an earphone. Tracer may also be used as an oscilloscope or voltmeter preamplifier using an adapter plug with a terminal impedance of 600 ohms. It is supplied with 3 attenuator probes, earphone, cord, plug, ground clip and battery. Designation is Stethotracer.

Don Bosco Electronics, Inc., Dept. ED, 56 Route 10, Hanover, N. J.

CIRCLE 120 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Digital Rotary Pickup 524

Pulse amplitude is 1.5 v across 1-K load from 1/10 to 30,000 rpm. Called the Rota-Pic, the digital rotary pickup requires 10-v dc input. Input torque is 1 g-cm. Ranges of 100 to 1,800 pulses per revolution are available.

Digitool Corp., Dept. ED, 5300 Brownway Road, Houston 27, Tex.
Price: $185 to $240.

Decade Scaler 515

Has five decades. Model 100 decade scaler is designed for low-activity counting and for training use. It has a 2,500-v supply with time delay to protect the detector, and built-in elapsed timer.

ATOMasters-Buntaine Corp., Dept. ED, 111 W. Jewel Ave., St. Louis, Mo.

Transducer 451

For dual function. Microsen E-300 is an electrical-to-pneumatic transducer that provides both dc signal amplification and pneumatic conversion within an accuracy of 0.75%. Both functions are carried out within a single water-proof enclosure. It is suitable for remote, unattended processing operations that require centralized sensing and control.

Robertshaw-Fulton Controls Co., Dept. ED, 911 E. Broad St., Richmond 19, Va.

Cryostats 503

Cool photo-sensitive devices to –109 F. Coolant is carbon dioxide. Typical time to lower temperature from +72 to –70 F is 1 sec; to –109 F, 12 sec. Cryostats are available for various duty-cycles, including one-shot applications. Typical dimensions are 8-1/2 in. long and 1-1/8 in. in diameter.

Walter Kidde & Co., Inc., Dept. ED, 675 Main St., Belleville 9, N. J.

Flutter Meter 540

Measures flutter and wow. Flutter meter has built-in three-range filter, test oscillator, high-gain preamplifier and limiter. Filter ranges are 0.5 to 6 cps for wow, 5 to 250 cps for flutter, and combined flutter and wow of 0.5 to 250 cps. Oscillator provides a 3,000-cps signal.

Amplifier Corp. of America, Instrument Div., Dept. ED, 398 Broadway, New York 13, N. Y.

Interval Timers 541

Solid-state interval timers are externally adjustable from 5 msec to 120 sec, model 300, and 60 sec, model 400. Timers have positive or negative output at 2 amp and 500 ma. They require 24 to 32 v dc input. Reset time is 5 msec max. Life is 1 million operations minimum. Environmental requirements are met.

Electronic Products Corp., Dept. ED, 4642 Belair Road, Baltimore 6, Md.

Price: From $103.75 ea.

Data Converter 538

Pulse-to-step converter type ST-150 is used for positioning and indexing. It converts low-level signal pulses or square waves into the switching sequence needed to drive a synchronous motor at 200 or more steps per min. Signal input impedance is 1 K, with a voltage change of 1.5 v min.

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

Microminiature Coaxial Connectors 811

Microdot's microminiature connectors—including the world's smallest 50-ohm coax connectors—are available in over one million combinations. Plugs are available in straight or angle screw types and slide-on versions. Receptacles include printed circuit and bulkhead feed-thru types. Only highest quality materials are used. Conductors are of silver-plated copperweld or cadmium bronze, center contacts are of gold-plated coin silver. Housings are silver-plated brass to assure minimum electrolysis with aluminum panels. "Teflon," "Kel-F," polyethylene, and neoprene are used as dielectrics, jackets, bend relief caps, and pin protectors.

Microdot Inc., 220 Pasadena Avenue, South Pasadena, California

Coaxial Switch 812

SPDT miniaturized switch features a case volume of ½ cu. in. and weight of 1¼ oz. Design allows direct insertion into miniaturized circuit without cumbersome adapters. Toggle action is positive, rf characteristics are highly efficient. VSWR is less than 1.25 to 2.0 kmc. Insertion loss is 0.8 db at 2.0 kmc. Contact rating is ⅛ amp at 150 V. resistive. Operating is 50,000 operations, minimum. Special stripline manufacturing technique provides low loss, wide frequency band properties.

Microdot Inc., 220 Pasadena Avenue, South Pasadena, California

CIRCLE 813 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Elapsed-Time Indicator 543

Range is 99,999.9. Model 5700 elapsed-time indicator measures 2-3/16 in. high and 2-13/64 in. wide on panel surface. It operates on 24 v, 60 cps; 115 v, 60 cps; 230 v, 50 or 60 cps. Black numerals are displayed on white nylon.

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

Silicon Rectifier 548

Rating is 2,000 piv, 200 ma at 100 C. Type IN2361 top-hat silicon rectifier can be supplied to meet MIL-S-19500/187. Used with limiting resistors, it replaces up to 10 components. It is hermetically sealed.

Columbus Electronics Corp., Dept. ED, 1000 Saw Mill River Road, Yonkers, N.Y.

Accelerometer 565

Used for missiles, this nonpendulous linear accelerometer weighs less than 3 oz and measures 1-3/4 x 1-in. in diameter. It measures linear accelerations and output is an ac signal. Unit is hermetically sealed. Temperature range is from −65 to 250 F.

United States Time Corp., Dept. ED, Irvington, N.Y.

Silicon Rectifiers 539

Rated at 12 amp, stud silicon rectifiers 1N1199 through 1N1206 meet MIL E1/1108. Ratings range from 50 to 600 v. The devices are available in high-voltage assemblies as well as in standard and special configurations.

Bradley Semiconductor Corp., Dept. ED, 275 Welton St., New Haven, Conn.

P&A: $2.10 to $28.00 ea; stock.

◄ CIRCLE 124 ON READER-SERVICE CARD

Metal Film Resistors 499

Ratings are 1/4 and 1/2 w for types FE25 and FE50 ceramic enclosed metal film resistors. Resistance tolerances are ±1% to ±0.1%; ranges available are 100 ohms to 500 K and 100 ohms to 1 meg. Temperature coefficients are ±100 to ±15 ppm.

Mepco, Inc., Dept. ED, 37 Abbett Ave., Morristown, N.J.

Add-Subtract Counter 500

Torque is 0.25 oz-in. max at room temperature and speed is 350 rpm continuous or 600 rpm intermittent. Model 30-130 add-subtract counter can be driven to ±99.9 and is for use where plus and minus, right and left, or directional readouts are required. Numerals are 0.125 in. high.

Melland Gear & Instrument Co., Inc., Dept. ED, 88-06 Van Wyck Expressway, Jamaica 18, N.Y.

Impulse Counter 501

Speed is 1,500 counts per min. Type 2TCeF4PE impulse counter provides in-line readout to 9999 plus control function by means of spdt contact. Dimensions are 2 x 4 x 5 in. Housing is aluminum. Input is 110 or 220 v ac; counter coils are dc, rectifier-supplied.

Landis & Gyr, Inc., Dept. ED, 45 W. 45th St., New York 36, N.Y.

NEW PRODUCTS

Phenolic Rods 449

Paper base phenolic rod, Insurok T-308R, has high density, low moisture absorption, good electrical properties and is suitable for high speed machining. Uses include cam-actuated pins, machine screws and inside-threaded caps. Rod is available in 42-in. lengths with diameters from 0.093 to 0.509 in. Natural tan and black colors are supplied with standard and special finishes.

The Richardson Co., Dept. ED, Melrose Park, Ill.

Thermoelectric Material 450

Gadolinium selenide, a thermoelectric material with a high Z factor, is available in a powdered form for further processing by the customer into rods. Undoped material, as well as n-type and p-type material are available.

Semi-Elements Inc., Dept. ED, Saxonburg Blvd., Saxonburg, Pa.
Price: $5.50 per 100 g.

Motor Starter 563

For air-conditioning compressors. Starter is a size 6 controller and measures 90 x 36 x 28 in. deep. Contactors are rated for 600 amp at 600 v for either front or rear-connection.

Westinghouse Electric Corp., Dept. ED, P. O. Box 2099, Pittsburgh 30, Pa.

Switching Diode 566

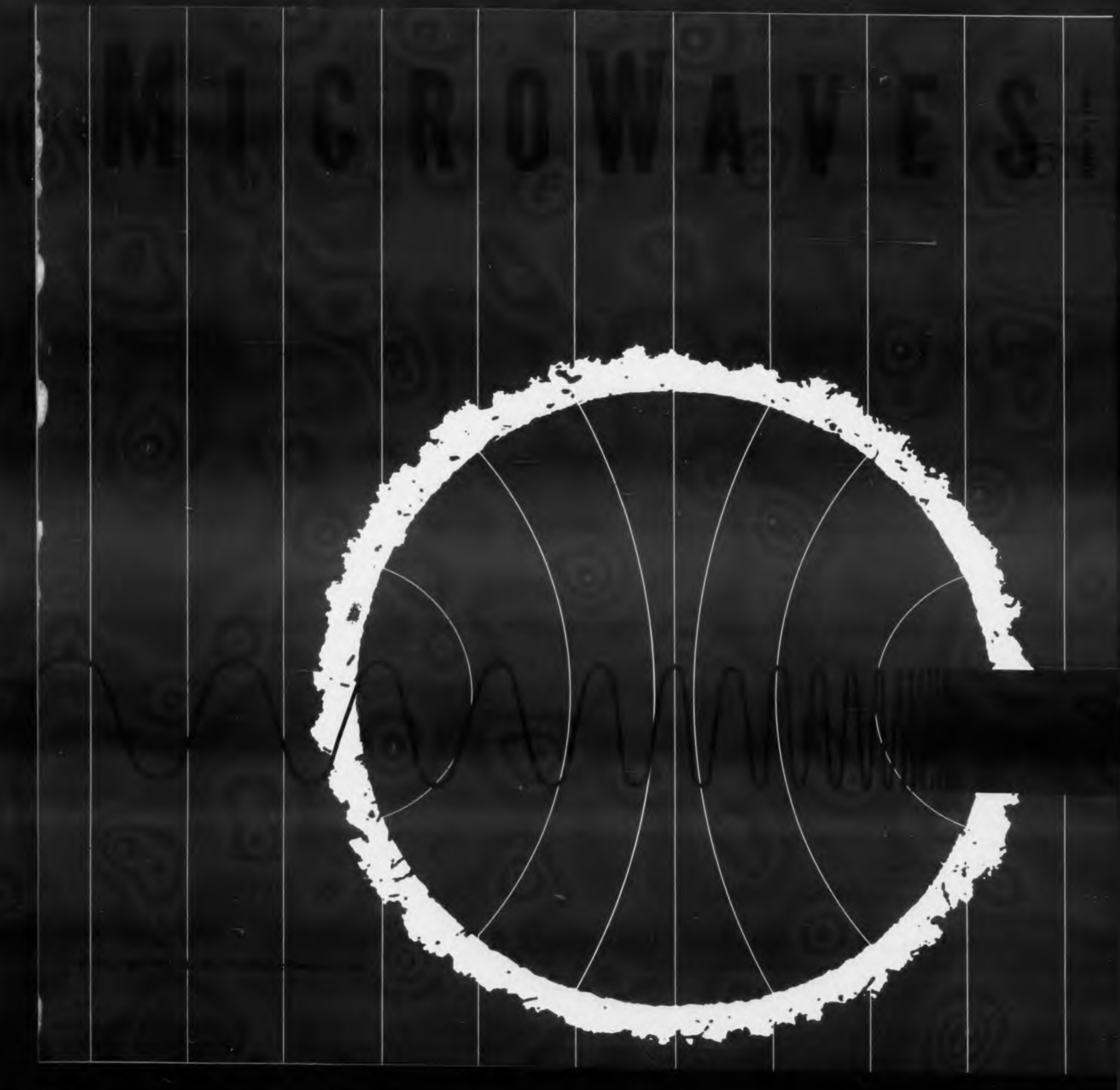
Has very low capacitance. Type UCI-362 glass diode has a shunt capacitance of 1 pf and is designed for switching in the nanosecond range. It is hermetically sealed and meets military requirements.

United Components, Inc., Dept. ED, 105 Lincoln Ave., Orange, N. J.

Amplifiers 587

For use in aircraft. Transistorized airborne amplifiers are used with high impedance transducers such as pressure gauges and high intensity microphones. Characterized by high input, low output impedances and broad frequency response, these amplifiers have excellent gain stability over a wide range of temperatures and power supply variations.

Gulton Industries, Inc., Gulton Instrumentation Div., Dept. ED, 212 Durham Ave., Metuchen, N. J.
P&A: $565.00 up; from stock.


MICROWAVES

MICROWAVES

Two Dopplers in Every Garage

If you think that listening to train whistles is a pointless diversion, consider the case of Christian Doppler, who by careful listening in 1842, wound up with an Effect for a namesake. Some 100 years later electronic designers began listening to microwaves with similar good purpose.

Now, since half the fun in traveling is knowing how fast you're going, Doppler radar will become increasingly useful as time goes by. Some day the world may have Dopplers on automobile bumpers to keep drivers from ramming into semi-trailers.

Until that day, however, there are sufficient new markets to ensure that Doppler remains a rapidly growing branch of the microwave industry.

The article opposite describes what's in store.

New Air, Land and Sea Uses Spur Doppler Demand

NEW applications promise a large increase in sales for Doppler equipment. The emergence of new classes of vehicles is fostering the design of complementary Doppler-based navigation systems. The airlines are on the verge of fleet-wide installation of Doppler navigation aids, thus creating a new, continuing market for this highly competitive branch of engineering.

At the same time the cutbacks in military orders for manned aircraft and consequent drop in Doppler sales have been reversed by a new demand for tactical "brush-war" airplanes—particularly the vertical takeoff and landing and short takeoff and landing types. Here again Doppler manufacturers anticipate a continually growing market. Foreign competition in Doppler is practically nonexistent, and the new, supersonic NATO air forces will likely rely on made-in-U.S.A. navigation equipment.

Other vehicles for which Doppler navigation systems are planned include:

- Lunar vehicles of the hard-landing, soft-landing, orbital and manned types.
- Space-rendezvous vehicles, such as the SAINT satellite inspection system and SLOMAR logistic supply vehicles.
- Tanks, missile carriers and other terrestrial vehicles.
- Ground-effect machines.
- Hydrofoil boats.

Dopplers for Lunar Vehicles Already on Drawing Boards

Lunar-vehicle Dopplers are already well along on the drawing boards. Ryan Electronics in San Diego, Calif., is designing a system for NASA's hard-landing Ranger. The Doppler will be strictly a vertical velocity indicator to control the firing of retrorockets. Consistent with Ryan's design philosophy, the Doppler will be a cw unit operating in K band. First tests of the Ranger are scheduled for early 1962.

Surveyor, a more sophisticated soft-landing lunar vehicle, will be equipped with a correspondingly more elaborate Doppler to sense lateral as well as vertical motion. This will permit upright landing of the vehicle, and eventually, navigation to a preselected point on the moon's surface. Most likely a series of radio beacons would first be planted on the moon for position reference.

Orbital and manned lunar vehicles, such as Apollo, would likewise employ Doppler navigation aids in the vicinity of the moon. Requirements for such systems would closely approach those for helicopter Dopplers, as the lunar vehicle might first have to hover to examine the proposed landing area and then touch down rather gently.

Requirements for a lunar Doppler might be as follows:

- Horizontal velocity—0 to 40,000 fps.
- Vertical velocity—0 to 10,000 fps.
- Range—100 miles.
- Range error—1 per cent.
- Velocity error—1/2 per cent.
- Transmitter power—20 to 30 w.
- Operating frequency—10 Gc.
- Power drain—200 w.
- Weight—40 lb.

Extreme Environments Pose Problems in Lunar Design

In addition a lunar Doppler must operate in extreme environments. Some difficulty is anticipated in propagation of the rf signal through the plume of the retrorocket. This might be overcome by intermittent firing of the rockets.

Little is actually known about the scattering coefficient of the moon's surface, but it is feared that its properties would be similar to those of a desert. This would give a reflection of only about 1 or 2 per cent.

Other operational difficulties anticipated for a lunar Doppler include the high changes in vertical velocity while decelerating. These would allow only very short smoothing times for the velocity-measuring system. Wide fluctuations in

Doppler will measure rate of descent of Surveyor lunar lander, shown in full-scale model above. The vehicle is required to land with minimum impact, since it contains delicate mechanisms to probe the surface of moon and perform chemical analyses.

the aspect ratio of the Doppler beams would also complicate velocity measurements.

Despite these problems several companies are actively bidding for the Surveyor Doppler. These include Ryan, General Precision Laboratories and Laboratory for Electronics. An award by Hughes Aircraft, prime contractor for the vehicle, is expected shortly.

Doppler for space rendezvous is beset with its own formidable design problems—particularly where intercept and inspection of presumably hostile vehicles are concerned. The small size of the target would seem to call for a beacon

What the airlines don't want in Doppler is typified by this ground maintenance scene of a fighter Doppler. Airlines want simple, reliable equipment that is easy to service and repair by plug-in replacement subassemblies. To an airline, time spent on the ground is money lost.

aboard the interceptor rather than a transmitter. Since a hostile satellite would not be so accommodatingly equipped, it could conceivably be illuminated by a powerful ground radar. The Doppler receiver would then have to distinguish the weak reflected signal from the much stronger illuminating signal at nearly the same frequency.

Above-K-Band Frequencies Appear Feasible in Space

Active Dopplers are possible, but frequencies much above K band appear necessary to form the very narrow multiple beams needed to determine velocity in three coordinates relative to a very small target. Atmospheric attenuation of such higher frequencies rules them out for conventional airborne Doppler, but they may well prove useful in space Dopplers.

Although no development contracts for rendezvous Doppler have been awarded, most companies in the Doppler field are sponsoring their own feasibility and system studies in anticipation of future military requirements.

Doppler for commercial airlines and executive craft, is however, an immediate and eagerly sought market. After more than five years of study and testing, the airlines have just about decided on fleet-wide installation of Doppler navigators in over-water airplanes.

The immediate market here totals about 200 craft, with each plane probably carrying two Dopplers. Ultimately Dopplers will also be used in over-land planes. The Federal Aviation Agency is studying the problem of how best to tie in Doppler with existing navigation aids. It is hoped that many new air routes will thus be opened to relieve congestion along existing airways. Executive aircraft, which are often flown outside the regular, marked airways, are being increasingly equipped with Doppler navigators. Perhaps 200 executive aircraft are now so equipped.

Rugged Competition Based On Auxiliary Factors

In attempting to sell the airlines, the established manufacturers of military Dopplers have met surprisingly strong competition from relative newcomers to the Doppler game, such as Bendix and Collins Radio.

The major factor in this contest is no longer performance. Over the years designers have debugged their systems to the point where all of the conventional Doppler modulation schemes are sufficiently accurate for the airlines. "We're getting accuracies down to 1 per cent of distance traveled, and figure we can live with this for now," a spokesman told Electronic Design.

Rather the contest is reduced to such factors as knowing and meeting the airline's requirements for packaging, installation, serviceability and ease of operation. These requirements, spelled out in Aeronautical Radio, Inc., specifications for all the airlines, differ significantly from those for military hardware. Thus Bendix and Collins Radio, who have been selling to airlines for many years, have an edge on some of the militarily oriented companies.

For example, in many military Dopplers electronic components are mounted directly onto the antenna. The airlines, however, demand simple, passive antennas that can be replaced and serviced with minimum time and cost. Complex antennas are also undesirable, as the airlines would prefer to use a single antenna for both of the Doppler systems to be carried by the airplane.

Some military Dopplers feature a steerable planar antenna, servoed to align it with the ground track of the airplane. While this arrangement has many advantages, the airlines believe that a fixed antenna may prove more reliable.

Compass and Over Water Errors Major Problems

Two major contributions to the error of any airborne Doppler are inaccurate compasses and over-water errors.

Compass variations result in azimuth errors of about twice the magnitude of distance-traveled errors. Since the gyromagnetic compasses commonly used on aircraft must be corrected for vehicle speed, any velocity errors are also reflected as compass errors. The FAA will soon award a contract for studying methods of reducing compass error.

One approach along these lines is a so-called North-seeking Doppler compass being developed by General Precision Laboratory for use aboard the Air Force RC-121 picket-radar plane. In this method Doppler-derived velocity measurements are used to correct the gyromagnetic compass.

Doppler-inertial systems, such as one used in the B-58 bomber, would also minimize compass errors. But cost of Doppler-inertial navigators is still prohibitive for commercial airplanes.

Over-water errors are particularly troublesome to correct. In relatively calm seas there is no Doppler return, and the navigation system must store present velocity information and carry on by dead reckoning until the signal is reacquired. It is estimated that the signal might be lost for a total of 5 min on a typical Atlantic crossing.

The return signal also varies as the aspect angle of the beam is changed. This may occur in very high sea states or when the aircraft maneuvers. General Precision Laboratories is reportedly developing a system that employs a steerable antenna for minimizing such errors, but design and performance details are still under wraps.

Army Seeks Doppler for Tanks And Other Land Vehicles

Doppler is also making a bid for navigation of terrestrial vehicles, such as tanks, ground-effect machines and hovercraft. In addition Ryan and General Precision are designing Doppler systems for use with hydrofoil boats.

Ryan reportedly has built and tested a breadboard of a tank navigation Doppler. The system is a multiple-beam cw unit based on the company's airplane Dopplers. Antennas would be mounted at the side or bottom of the vehicle. The Army Engineering, Research and Development Laboratories, Ft. Belvoir, Va., have expressed interest in such a system.

"We could move our tanks twice as fast if we had better navigation systems," an Army spokesman said in pointing to the interest in Doppler. Mobile missile carriers would also benefit from a Doppler navigator. The Army plans to continue development of land Doppler as funds become available.

Hovercraft Dopplers are being studied by Ryan and Laboratory for Electronics.

For terrestrial and marine vehicles, microwave Doppler may face competition from an ultrasonic system being developed by the Arma Div. of American Bosch Arma. The company has built two models, one for boats and the other for trucks, and reports that accuracies are comparable to those that might be expected with microwave Doppler.

Arma spokesmen cite smaller packaging, greater reliability and lower cost in support of ultrasonic Doppler for surface navigation. The Arma system operates from 40 to 160 kc.

Because of extreme attenuation by the air, the higher ultrasonic frequencies are chosen only when the transducer can be mounted very near the reflecting surface (such as the bottom of a tank). ■ ■

MicroWaves

Improved Method Cuts Errors In Swept-Frequency Microwave Tests

By calibrating out scalar, frequency-dependent errors, swept-frequency testing is raised to a new level of accuracy and convenience. In one production test application, author Minck reports that 26 point-by-point measurements of a wide-band directional coupler were replaced by a single, 10-sec measuring sweep. Rapid, "go" "no-go" test procedures for a variety of microwave measurements are described.

John Minck
Hewlett-Packard Co.
Palo Alto, Calif.

SWEPT-FREQUENCY techniques are extremely useful in testing high-frequency, broadband microwave equipment. Traditional point-by-point measurements are slow and may not always indicate narrow resonances. Swept-frequency tests clearly indicate such defects and assure specified performance over the entire operating range of the equipment.

Since the introduction of the reflectometer, many ingenious swept-frequency tests employing this set-up have been devised. A typical example is illustrated in Fig. 1.

This and similar methods are, however, subject to a variety of calibration errors. Initial calibration is generally performed with a 100 per cent reflection (such as a sliding short). However, subsequent tests with a low-return-loss unknown may place the reverse detector in a significantly different power region. In addition, range-to-range error of the ratiometer can contribute several percentage points to the over-all system error. Nonsimilarity of directional coupler characteristics and other scalar errors must also be considered.

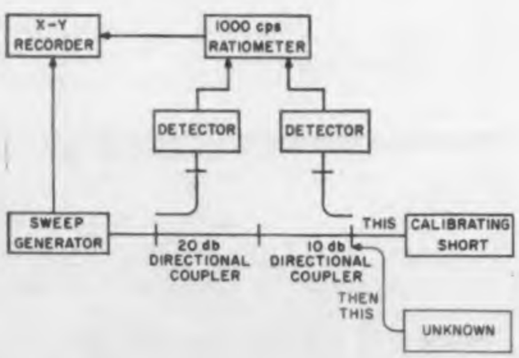


Fig. 1. Basic reflectometer set-up shown here must be calibrated at 100 per cent reflection. Accuracy is thus dependent on square-law response of the crystal detector and tracking of the coupler and ratiometer.

An improved reflectometer system which materially reduces calibration errors has been developed at Hewlett-Packard. This arrangement (see Fig. 2) enables continuous calibration over the entire frequency range by means of a broadband rotary vane attenuator in the secondary arm of the reverse coupler.

The attenuator, in effect, pre-inserts the return losses anticipated for actual tests. With the attenuator in the system, a frequency sweep of the reference load yields a calibration trace that includes the anticipated system errors. A series of such traces can then be compared with the performance trace of the instrument being tested on a "go" "no-go" basis.

Scalar errors caused by nonmatch of the coupling factors, variation of detectors with frequency and power, and errors in the ratiometer and X-Y recorder can thus be disregarded because of their inclusion in the calibration curves. Over-all accuracy of the system is still limited by the reverse coupler directivity vector—a shortcoming of any high-directivity reflectometer system.

This improved technique can be modified for a wide variety of basic measurements and has been adopted for production tests of most Hewlett-Packard microwave instruments. The use of this method in performing swr, directivity and attenuation measurements, crystal matching, and twt noise figure measurement will now be described.

Step-By-Step Procedure For Measuring SWR

Swr is measured by the following procedure:

- With reference to Fig. 2, connect the 100 per cent calibrating short to the reverse coupler.
- Set the expected value of return loss into the standard rotary vane attenuator. For instance, if the expected swr is 1.2, the standard attenuator should be set to 20.8 db.
- Set the ratiometer range and the X-Y recorder sensitivity so that the pen remains on scale for the full horizontal sweep.
- Sweep the frequency generator over the required range to obtain a plot of frequency vs swr.
- Reset the attenuator for a different swr value and plot additional calibration lines. A series of typical calibration lines is shown in Fig. 3. Two or three calibration lines should give enough information for "go" "no-go" tests.
- Replace the calibrating short with the unknown load.
- Remove all attenuation from the standard attenuator and trigger the final measurement sweep. The colored trace in Fig. 3 shows an instrument swr characteristic between 8.2 and 12.4 Gc.

Note that the swr of the instrument is known for any calibrated value over the full range of the frequency sweep. Any convenient frequency range can be used with this procedure. Where repeated tests of identical instruments are to be performed, the calibrating traces can be inscribed on a transparent overlay which is then used as a template.

Similar Method Used To Measure Directivity

A similar procedure is followed in measuring directivity of multi-hole precision waveguide

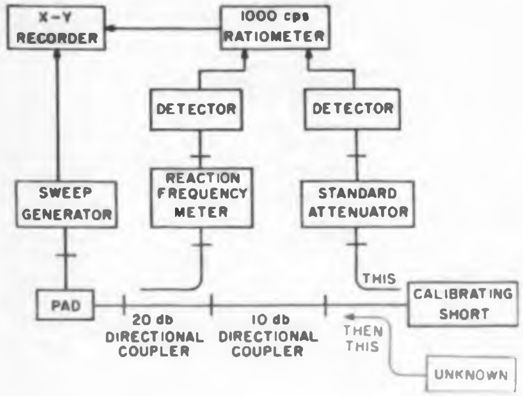


Fig. 2. Improved reflectometer includes a standard rotary vane attenuator in the secondary of the reverse coupler. Scalar errors are calibrated out using procedures described in this article. This modification results in significantly greater versatility and accuracy. The set-up illustrated here measures reflection coefficient.

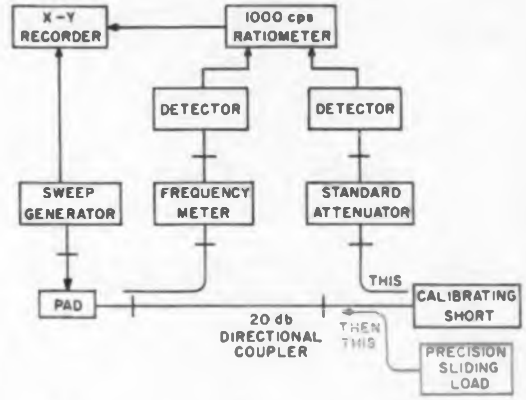


Fig. 4. Circuit for measuring directivity of coupler. The precision sliding load is adjusted back and forth during a slow frequency sweep to vary phase between the directivity and load vectors. This cancels effect of load reflections.

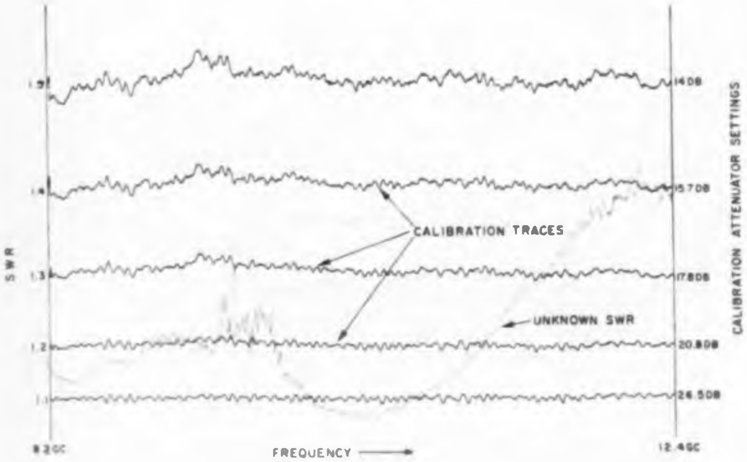


Fig. 3. Results of swr measurements using improved reflectometer. Calibration traces were made with the standard attenuator set to various expected values of return loss. Final measurement run, made with attenuator set to zero, is shown in color.

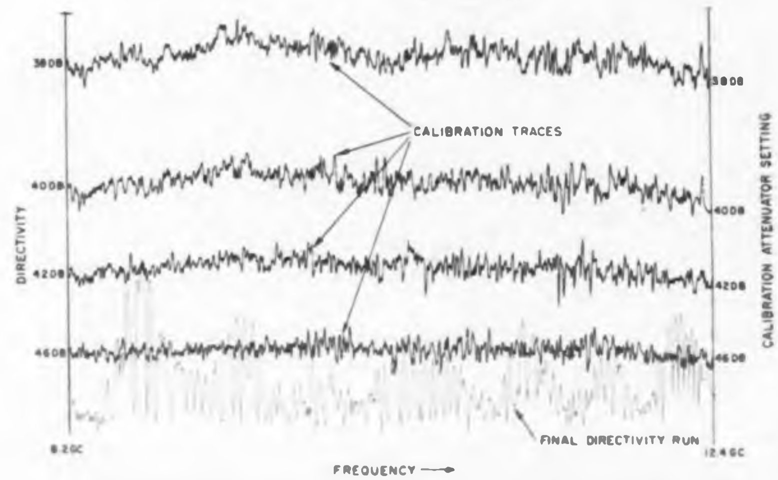


Fig. 5. Results of directivity measurements of a 40-db coupler. Test run is shown in color. The peaks and valleys in the curve are due to the phasing effect of varying load. Average value of the curve is a good approximation of the directivity.

couplers. Equipment is arranged as shown in Fig. 4.

Insert the calibrating short and plot calibration traces for several different return loss values of the rotary-vane attenuator (e.g., 40, 41 and 42 db). The full gain of the ratiometer can be used to provide additional dynamic range and system sensitivity. When calibration is complete, return the attenuator to zero db and replace the short with a precision sliding load.

Since a perfect load cannot be achieved, a tapered poly-iron load is used and its small reflection effect cancelled by repeatedly sliding the moving load back and forth during an extremely slow rf sweep. All possible phase combinations between the directivity and load vectors are thus experienced and the combined signal arriving at the reverse detector swings between the sum and difference of the vectors.

If the swing is small, the load reflection vector is small compared with the directivity vector. Under these conditions, the average value between swings is a good approximation for directivity. Test results for a 40-db coupler shown in Fig. 5 indicated that the unit is well within specifications.

To obtain the true value of coupler directivity, main line transmission loss must be added to the test results. In a 3-db coupler, 3 db would be added, while in a 10-db coupler, 0.46 db would be added. This testing of directivity leads to a convenient method of selecting couplers for applications which require exceedingly high directivity over discrete bandwidths.

The coupler of Fig. 5 exceeds 45 db of directivity over a rather large segment of the sweep. If used in a production test reflectometer restricted to that band, directivity ambiguities of reflection coefficient would be less than 0.005.

Attenuation Measurements Possible to 70 Db

A set-up for swept frequency attenuation measurements is illustrated in Fig. 6. Here, the reflected channel of the ratiometer becomes the transmission channel because the coupler-detector is placed in the forward direction. The transmission detector should be isolated by a coupler or pad to provide good matching over the entire test band.

Calibration traces are plotted with the precision standard attenuator set on and around the expected values of attenuation. The unknown is inserted in the line, and the standard attenuator returned to zero db. The final test sweep is then run with the unknown attenuator.

Again, this method removes the influence of all system scalar errors because the transmission detector operates in the same power regions both during calibration and actual testing. Characteristics of a flap attenuator set to 15 db are shown in Fig. 7.

The maximum attenuation which can be measured with this system depends on the power output of the sweep generator. Although 50 db appears to be a practical limit, the range can be

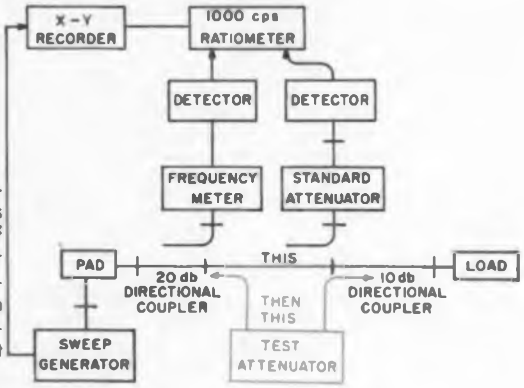


Fig. 6. Calibration of attenuator. Set-up provides a convenient method of checking attenuators for broadband flatness. Calibration traces are run with standard attenuator, after which test unit is inserted as shown.

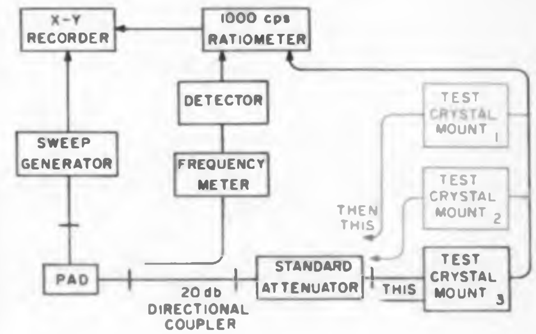


Fig. 8. Circuit for measuring frequency response of crystal mounts. The control crystal should be precalibrated with point-by-point measurements against a power meter.

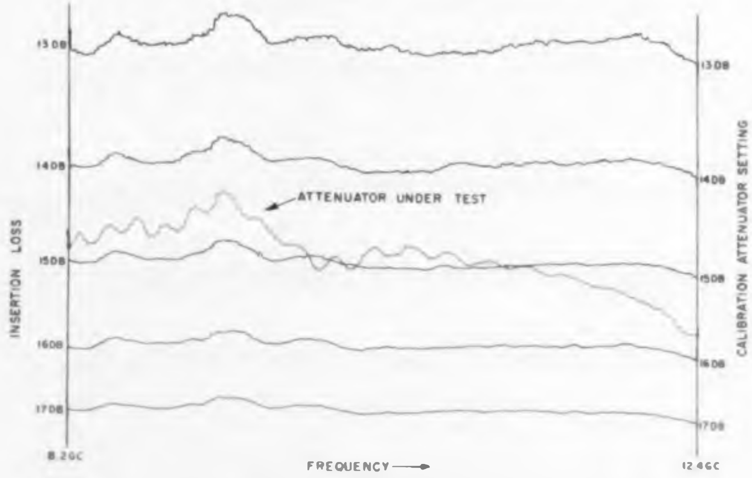


Fig. 7. Characteristic of flap attenuator set to 15 db. Ambiguity of the calibration traces in such a plot is approximately 0.3 to 0.5 db. Error can be reduced by running separate point-by-point calibration of the standard attenuator (usually a rotary vane type). The flap attenuator tested here has a specified accuracy of ±2 db

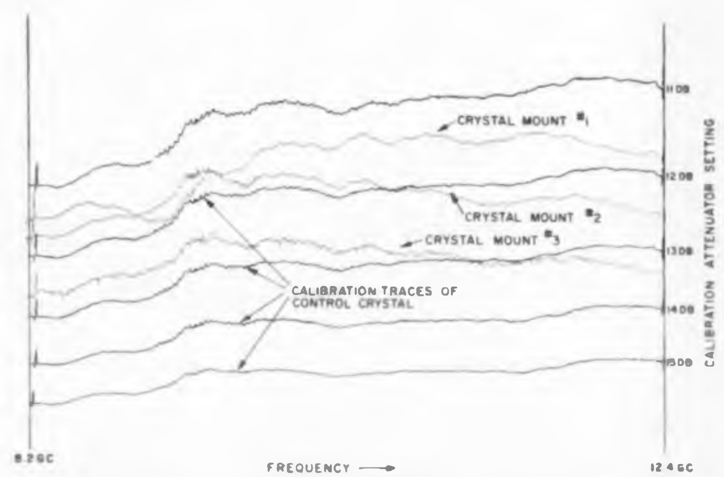


Fig. 9. Frequency response of three crystal mounts. A second run made at —30 dbm could be used together with these curves to select matched pairs for best frequency and square-law characteristics.

extended to 70 db by including a 1-w twt amplifier at the output of the sweep generator.

Simplified Method Speeds Crystal Matching

Crystal detector mounts can be matched with the set-up diagrammed in Fig. 8. The precision attenuator is adjusted in 1-db increments to give a series of calibration traces with a control crystal mount in the circuit. The attenuator is then set to the center attenuation value and a separate sweep is run for each of the crystal mounts being tested.

Results for a group of three mounts are illustrated in Fig. 9. A second calibration chart can be made at a lower detection power level to check square-law operation of the mounts. Crystals can be conveniently matched by plotting the high-power, low-power, and calibration runs on separate transparent sheets. By superimposing all three sheets over a light table one can quickly select crystal mounts for frequency response and square-law tracking within 1 db.

The control crystal is normally calibrated for frequency response point-by-point against a power meter.

Procedure For Checking Signal Generator SWR

Output swr of a signal generator can be checked by the set-up shown in Fig. 10.

The first calibration trace is made with the attenuator adjusted to 6 db. Several additional swept frequency traces are then made above and below the 6-db level for specified swr values. For values above 6 db, the attenuator should be set at 20 log 2 $(1-|\Gamma_g|)$; below 6 db, the attenuator is set at 20 log 2 $(1+|\Gamma_g|)$. A well-matched output load is specified in all instances. After calibration, the attenuator is reset to 6 db for actual tests.

The load is then replaced by a movable short which is repositioned for each of several frequency sweeps of the generator. The signal reflected from the short and re-reflected by the generator is sampled by the directional coupler and applied to the detector.

A sufficient number of runs should be made to assure a wide variety of reflected phases. Each sweep of the generator is a series of oscillation about the original 6-db trace. The envelope of all the test-sweep traces is the output swr of the generator. Fig. 11 shows the output swr of a typical X-band backward wave oscillator with a specified swr of 2.

Noise Figure of TWT Can Also Be Measured

Noise figure analyses of twt amplifiers and other broadband devices can be performed with a sweeping receiver and an automatic noise figure meter as shown in Fig. 12. The if amplifier shown has a bandwidth of 1 mc. Since the sweeping receiver has full image response, the noise figure meter responds to the average of two 1-mc windows spaced ±30 mc from the

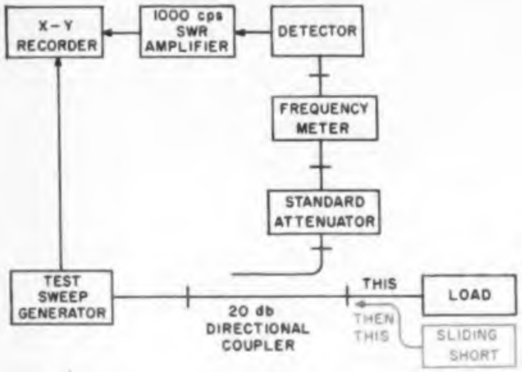


Fig. 10. Circuit for measuring output swr of a signal generator. Phase of reflected signal is varied by adjusting the sliding short.

Fig. 11. Results of signal generator swr. Envelope of the swept frequency runs (shown in color) is the swr. This method is much faster than point-by-point impedance plotting.

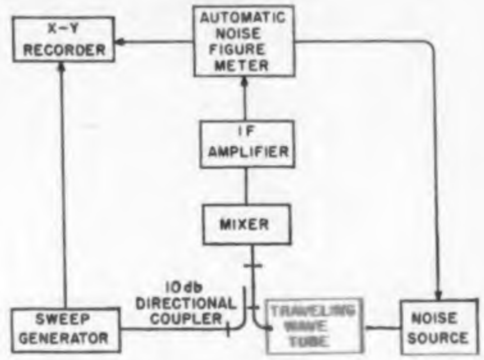


Fig. 12. Circuit for swept-frequency noise figure measurements. Twt amplifiers and other broadband devices can be readily checked with this set-up.

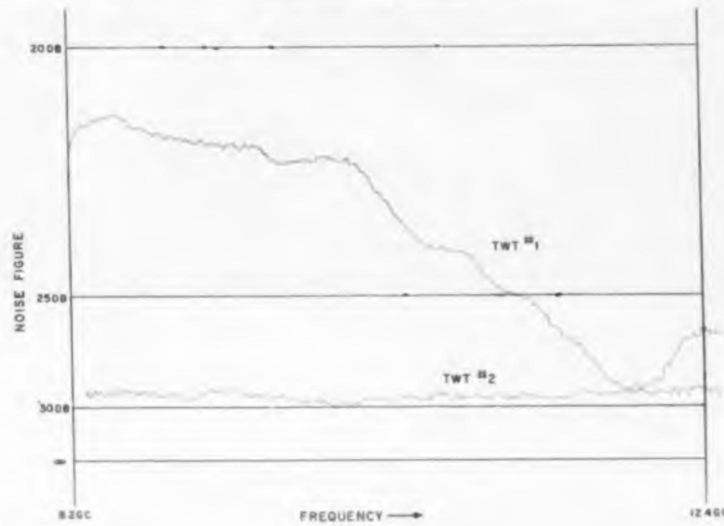


Fig. 13. Noise figure test results for two twt amplifiers. Noise figure of the receiver is negligible compared to the twt contribution. Such measurements permit electrode settings for best broadband noise figure.

local oscillator frequency. This is normally adequate for measurements where the swept frequency plot does not change rapidly.

The receiver itself should first be calibrated to establish that its noise contribution is negligible. In the typical twt measurements of Fig. 13, the receiver noise figure is less than 15 db across the band and does not significantly affect the twt contribution of 25—30 db.

Coax Measurements Are Possible But Accuracy Is Reduced

The measurements described here can also be made with coaxial reflectometer systems. Broadband coaxial pads of various values would provide the standard attenuation when calibrating the equipment. Several manufacturers supply such attenuators with discrete 1-db values.

Measurements in coaxial systems would, however, be less accurate than those in waveguides because random directivity errors are somewhat larger in coaxial couplers. Basic coupler directivity in coaxial systems cannot be as high as in waveguides. The same test procedures can, however, be successfully employed in coaxial systems.

Measurement Errors Are About 5 Per Cent

The errors inherent in these broadband measuring procedures are divided into vector errors and scalar errors. Vector errors are primarily due to imperfect directivity of the reverse couplers. Typical multi-hole precision couplers with directivities greater than 40 db give reflection coefficient errors of 0.01 in the final reading.

A second vector error is due to variation in the matching of the standard attenuator in the calibration and measurement steps of the test procedure.

For example, the standard attenuator of Fig. 2 looks one way into the secondary of a 10-db coupler and the other way into the crystal mount of the detector. This causes slight variations of transmitted power in going from the "Calibrate" to "Measure" condition. If the attenuator has an swr of 1.15, the ambiguous mismatch error is less than 0.4 db. This is equivalent to a 5 per cent error of the reflection coefficient value.

Inaccuracy of the standard attenuator is the major contribution to scalar error. Commercial rotary vane attenuators have specified accuracies of 2 per cent of the reading. For a return loss measurement of −20 db, such attenuator inaccuracies would result in a 5 per cent error of reflection coefficient.

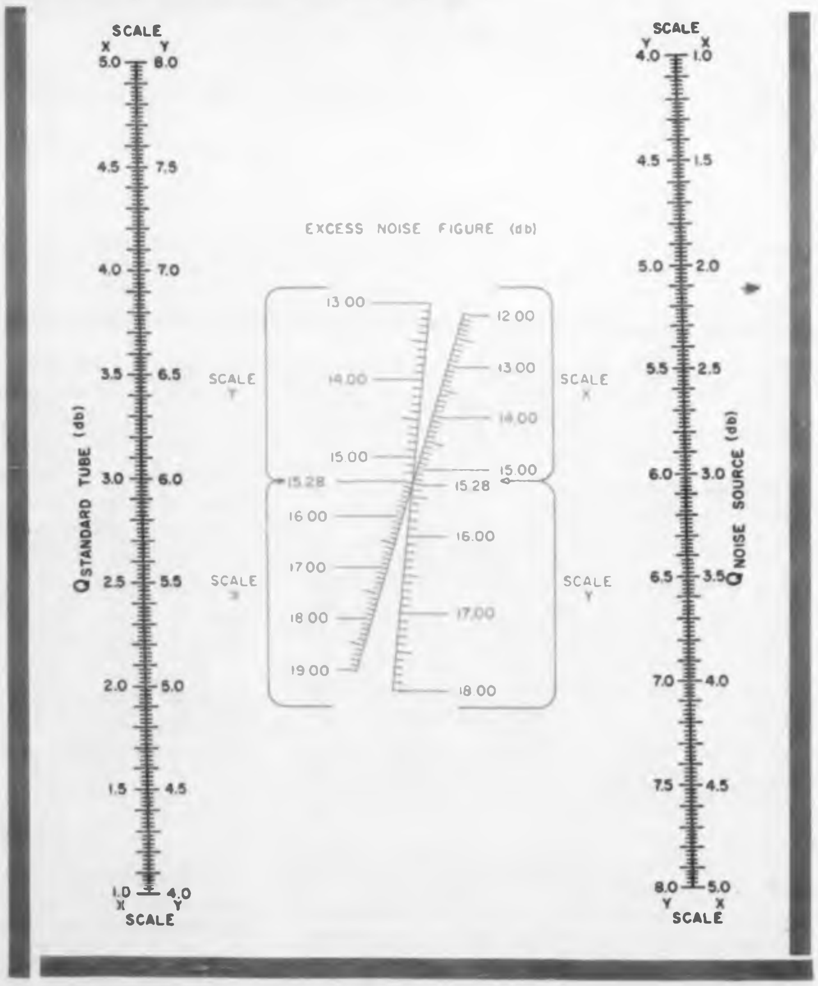
This error can be minimized through point-by-point calibration of the standard attenuator. All other scalar variations are calibrated out by the test procedure. ■ ■

Acknowledgment

The techniques described in this article have been refined to their high degree of accuracy and speed largely through the efforts of Keith Hunton of the Hewlett-Packard Microwave Engineering Dept. and Elmer Lorence of the Hewlett-Packard Microwave Test Dept.

Excess Noise Figure Nomograph

The slide-rule manipulation involved in determining the excess noise figure of gas discharge tubes is eliminated by use of this nomograph. Arnold Westlund, an engineer in Bomac's advanced development section, prepared the chart to speed calibration of noise sources produced by the company, where noise of more than 100 gas discharge tubes per month is checked out in this manner.



Arnold Westlund, Jr.
Bomac Laboratories Inc.
Beverly, Mass.

Excess noise (F) is calculated by the following formula:

$$F = \frac{\left(\frac{T_2}{T} - 1\right) - Q\left(\frac{T_1}{T_0} - 1\right)}{Q - 1} \qquad (1)$$

Where: $T_0 = 290$ K

$T_1 =$ Effective temperature of the discharge generator in the "off" condition.

$T_2 =$ Effective temperature of the discharge generator in the "on" condition. T_2 (argon) $= 10{,}050$ K.

$Q =$ Inserted if attenuation required to return the test receiver indicator with the noise source "on" to the position when the noise source is "off". This is expressed as a power ratio.

At room temperature, however,

$$\frac{T_1}{T_0} \approx 1 \text{ and the term } Q\left(\frac{T_1}{T_0} - 1\right) \rightarrow 0$$

Thus,

$$F_{(argon)} = \frac{\left(\frac{T_2}{T_o} - 1\right)}{Q - 1} \qquad (2)$$

Expressed in db, $F_{(argon)} = 15.28 - 10 \log_{10}(Q-1)$ (3)

The nomograph was constructed in accordance with Eq. 3.

To determine the excess noise figure by means of the nomograph:

- Obtain Q for the argon noise generator standard.
- In similar manner obtain Q for the unknown noise source.
- Determine whether both values of Q fall in the X or the Y range scale.
- Place a straight edge from the Q value for the standard tube reading side to Q on the same letter range scale (X or Y) of the noise source reading side.
- Read the excess noise figure of the unknown noise source directly at the intersection of the straight edge and the corresponding X or Y point on the center scale.

Two Examples Given For Use of Nomograph

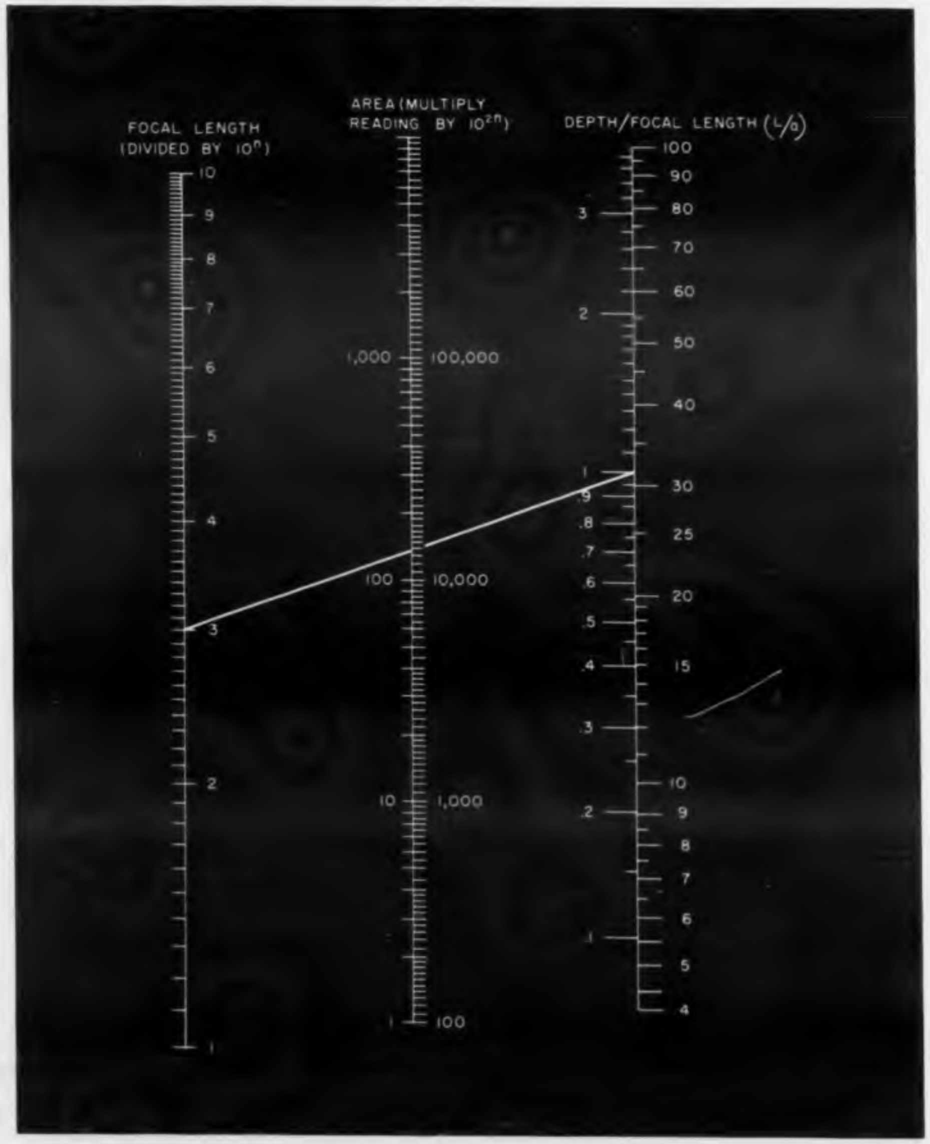
Example 1: Let $Q_{standard} = 7.50$ db and $Q_{source} = 6.00$ db. Since both values lie within the Y-range scale, plot 7.50 db on Y-scale of standard tube reading side and 6.00 db on Y-scale of noise source reading side. Read the excess noise figure of 13.37 db on Y-center scale by connecting these points with a straight line.

Example 2: Let $Q_{standard} = 4.00$ db and $Q_{source} = 4.50$ db. Since both values lie within the X-range scale, plot 4.00 db on X-scale of standard tube reading side and point 4.50 db on X-scale of noise source reading side. Read the excess noise figure of 16.08 db on the X-center scale by connecting the points with a straight line.

Always select the proper scale (X or Y) whose range will accommodate both $Q_{standard}$ and Q_{source}. The excess noise figure is then read from the corresponding center scale.

Since the nomograph scales are linear, they may be extended to take into account any unusual values of Q. ■ ■

Nomograph for Determining Surface Area of Paraboloidal Devices



Robert L. Peters
Consultant
San Francisco, Calif.

THIS NOMOGRAPH supplements a similar chart published in the March 15, 1961 edition of MicroWaves. The earlier nomograph is useful only for calculating the area of certain truncated paraboloids; this nomograph is general and applicable to complete paraboloids of any depth-to-focal length ratio. To use the nomograph, proceed as follows:

- Select the depth-to-focal length ratio on the appropriate side of the *L/a* scale.
- Select the focal length (divided by 10^n) on the left-hand scale. For example, a focal length of 300 equals 3×10^2 and would be plotted as "3" on the focal length scale.
- Connect these points and read the value from the side of the center line corresponding to the *L/a* selection.
- Multiply the center scale reading by 10^{2n} to obtain the area. Thus, a device with a focal length of 300 and an *L/a* ratio of 1 would have an area of 133 x 10^4 square units. ■ ■

MicroWaves

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Oscillates at 10 Gc. Model D-4168-D is a P-type germanium tunnel diode with peak currents of about 3.5 ma and peak-to-valley ratio of 5:1 min. Series resistance is 7 to 10 ohms, negative resistance 30 to 40 ohms. Capacity is 1 pf, valley voltage 400 mv. Height is 0.057 in. The device can be made with higher current-to-capacity ratios.

Sylvania Electric Products Inc., Semiconductor Div., Dept. ED, Woburn, Mass.
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Microwave & Power Tube Div., Raytheon Co., Dept ED, Foundry Ave., Waltham 54, Mass.
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Model	NFA & NFT		NFA/T & NFT/T		NFA/N & NFT/N		NFAM		
Input/output impedance, ohms	50, 75	50, 75	50, 75	50, 75	50	50	50 75, 93	75 50, 93	93 50, 75
Nominal attenuation (db)	1, 2, 3, 4, 6, 10, 12, 15, 20 / 2, 3, 6, 10, 20		1, 2, 3, 4, 6, 10, 12, 15, 20 / 2, 3, 6, 10, 20		1, 2, 3, 4, 6, 10, 12, 15, 20		minimum loss		
Frequency range (mcs)	DC-1000		DC-2000		DC-2500		DC-1000		
Maximum V.S.W.R.	1.2 at 1000 mcs		1.2 at 2000 mcs		1.2 at 2500 mcs		1.2 at 1000 mcs		
Connectors	Type BNC		Type TNC		Type N		Type BNC		

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frequency accuracy	Crystal, Standard models 0.005%
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band pass	1% to 5% up to 3 kmc Less than 1% above 3 kmc
spurious frequencies	Down 30-40 db
output impedance	50 ohms
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Bomac Laboratories, Inc., Dept. ED, Salem Road, Beverly, Mass.

Y-Circulator 402

Extends operation below 200 mc. Model 300 Y-Circulator is a compact microwave device that extends low-frequency operation below 200 mc with high power capability. When operated with an electro-magnet it can be made to act as a spdt switch. Specifications are: isolation, 40 db max; insertion loss, 0.5 db max; vswr, 1.1 max; peak power, 30 kw; average power, 100 w.

Electronic Communications, Inc., Dept. ED, 1830 York Road, Timonium, Md.

Directional Couplers 398

Coupling value is 6 db. Operating from 8.5 to 9.6 Gc, coupling variation is ±0.4 db. Directivity is 15 db min, vswr 1.20:1 max. Length is 5-1/4 in. A second model, for Ku band, has coupling variation within ±0.5 db, directivity of 12 db min, and vswr of 1.30:1 max. Length is 5 in. Both units are available with narrow or broad wall. Custom designs can be made with values from 5 to 10 db.

Waveline, Inc., Dept. ED, Caldwell, N. J.

Waveguide Adaptors 354

For coaxial cable. Available with TNC or TM connectors, three models of waveguide adaptors cover a range of 3.2 to 10.8 Gc with vswr of 1.12 max. Impedance is 50 ohms; standard flanges are X or C. Material is brass, with aluminum available on special order. All metal parts are silver-plated with rhodium flash.

General RF Fittings, Inc., Dept. ED, 702 Beacon St., Boston 15, Mass.

Duplexer 400

Covers 225 to 400 mc. Balanced wide-band duplexer T4248V5D has a peak power rating of 10 kw. Transmitter-receiver isolation is 40 db min. Duty cycle is 0.1, insertion loss 0.5 db max. Input vswr is 1.3:1 high-level, 1.5:1 low-level.

Tucor, Inc., Dept. ED, 59 Danbury Road, Route 7, Wilton, Conn.

***Availability:* 90 days.**

Parabolic Antenna — 356

For millimeter bands. Made for V, E and F bands, parabolic antenna is 3 in. in diameter. Beam width is 4 deg at 70 Gc. Antenna is rated at 22 db max side lobe, 32.9 db gain, 1 in. focal length. It is designed for systems and test applications.

Technical Research Group, Inc., Antenna & Microwave Dept., Dept. ED, 9 Union Square, Somerville, Mass.

Frequency Meter — 399

Is fully automatic. Operating from 3.0 to 50.0 Gc, series AFM meter is accurate to 0.1%. Indicator uses a dual-meter movement for direct and unambiguous reading of frequency.

Somerset Radiation Laboratory, Inc., Dept. ED, 192 Central Ave., Stirling, N. J.

P&A: $92 ea; 30 days.

Magnetron Test Set — 360

For testing beacon magnetrons. Test set BLP-002K includes matched coaxial line to waveguide transition, pulling device, folded cross guide directional coupler and frequency meter. The modulator is capable of producing 0.5 and 1.0 μsec pulses at a peak amplitude of 3.0 kv at 2.0 amp. It is for X- or C-band testing.

Bomac Laboratories, Inc., Dept. ED, Salem Road, Beverly, Mass.

No Down Time Is Normal...

Alfred Electronics Model 504 Microwave Amplifiers, in use at Hughes Aircraft Co., Culver City, California

with ALFRED Microwave Amplifiers

These Alfred TWT microwave amplifiers have seen continuous service at Hughes for over 9 months. There has been practically no down time even for replacement of TWT tubes. Used in the RF portion of a missile testing system, the Alfred units provide high gain, wide band, flat response and low spurious modulation from 8 to 12.4 kmc. Hughes engineers praise the functional layout of the Model 504, its simple operation and reliable performance.

In short, Hughes finds the Alfred 504 Microwave Amplifiers good, sound, straightforward reliable instruments. We think you will too.

KEY SPECIFICATIONS—ALFRED MICROWAVE AMPLIFIERS

	Model	Frequency Range KMc/s	Gain db (min.)	Power Output (min.)	Price
General Purpose Amplifiers for AM, Pulse and Phase Modulation	505	1 to 2	30	10 mw	$1550.00
	501	2 to 4	30	10 mw	1490.00
	503	4 to 8	30	10 mw	1550.00
	504	8 to 12.4	30	10 mw	1490.00
	549	10.5 to 16	30	10 mw	3190.00
Medium Power Amplifiers	5-6752	1 to 2	30	1 W	$1990.00
	512	2 to 4	30 20	1 W pulsed 100 mw CW	2050.00
	502	2 to 4	30	1 W	1550.00
	5-6868	2 to 4	30	10 W	2750.00
	506	{4 to 8} {4.5 to 7.5}	27	{.5 W} {1 W}	2290.00
	5-542	4 to 8	30	1 W	3190.00
	*528	7 to 11	30	5 W	3490.00
	509	8.2 to 11	27	.5 W	3190.00
	510	8 to 12.4	20	100 mw	2290.00
	*527	8 to 12.4	30	2 W	3490.00
	*526	12.4 to 18	25	1 W	4950.00
High Power Amplifiers	5-6826	2 to 4	30	1 Kw Pk .01 duty cycle	$6895.00
Low and Medium Noise Figure Amplifiers	Amplifiers with low and medium noise figures are available either as packaged units or unitized for remote operation of TW tube and solenoid. Standard units provide coverage from .5 to 12.4 KMc with noise figures from 7 db up.				

*New Instrument

MANY MODELS TO CHOOSE FROM

The 504 is just one model from the industry's most complete line of microwave amplifiers. For technical details and a demonstration arranged at your convenience, contact your nearby Alfred representative or write direct. Please address Dept. 36.

ALFRED ELECTRONICS

897 COMMERCIAL STREET
PALO ALTO, CALIFORNIA

CIRCLE 142 ON READER-SERVICE CARD

Carrier System 372

Handles 600 voice channels. Microwave carrier system MX-106 uses frequency division with ssb suppressed carrier techniques. Frequency allocations, sideband allotment, and carrier levels are compatible with standard equipment. An initially small system can be expanded. Circuits are printed on cards that plug into rack-mounted cages.

Microwave Sales, Collins Radio Co., Dept. ED, 1930 Hi-Line Drive, Dallas, Tex.

Coaxial Transitions 367

Have short insertion length. Series 6000-6001 coaxial-to-coaxial transitions mate type N male or female connectors to 7/8-in., 1-5/8-in., and 3-1/8-in. coaxial lines. The compact, lightweight devices have low vswr.

Bogart Manufacturing Corp., Dept. ED, 315 Siegel St., Brooklyn 6, N. Y.

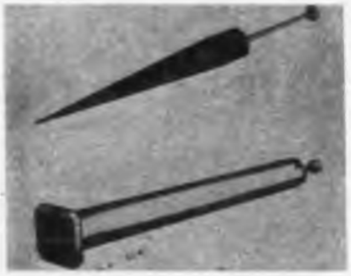
Slide-Screw Tuner 373

Covers 1 to 10 Gc. Coaxial slide-screw tuner model N311A will match vswr up to 10:1, of any phase, to 1.00:1. Insertion loss is less than 1 db when a mismatch of 3:1 is corrected. Length is 11-1/2 in., with carriage travel of 7-1/2 in.

FXR, Inc., Microwave Div., Dept. ED, 25-26 50th St., Woodside 77, N. Y.

P&A: $190; delivery from stock.

Waveguide Moving Loads 371



For residual reflection phase change. Model 55L5C circular waveguide moving loads consist of a section of circular waveguide in which is mounted a sliding, tapered, low reflection load. A plunger controls the position of the load which is variable at least one wavelength at the lowest waveguide frequency. This permits changing the phase of the residual reflection so it can be separated from the other reflections in the waveguide system. Specifications are: residual vswr, 1.04 to 1; operating bandwidth, 5.0 to 5.9 Gc.

Applied Microwave Electronics, Inc., Dept. ED, 114 W. 25th St., Baltimore 18, Md.
Price: $25 ea.

Multiplexing System 374

For long-haul use. Type 46A provides 600 voice channels on as many as seven tandem links totaling up to 4,000 miles in length. Total per-channel noise and crosstalk for a single link will not exceed 23 db during 99% of use time. Channel harmonic distortion is not greater than 1%.

Lenkurt Electric Co., Inc., Dept. 216, Dept. ED, San Carlos, Calif.

Continuous Impedance Plotter 366

Has expanded frequency coverage. Type 14 automatic impedance plotter gives complete frequency coverage from 0.1 to 1,700 mc. Used in conjunction with a suitable external oscillator it provides continuous impedance information displayed as a trace on a crt. If a permanent record is required a separate X-Y recorder can be added to the system without affecting crt display.

Alford Manufacturing Co., Dept. ED. 299 Atlantic Ave., Boston, Mass.

MICROWAVES *PRODUCTS*

Low Pass Filters 379

For harmonic suppression use. Model 15 FLCX coaxial low pass filters are for harmonic suppression use with high power transmitters. They are available in coaxial sizes from 5/8 to 9 in. Cut-off frequency can be designed anywhere in the classic coaxial frequency band. Specifications are: f_{co} 1.5 Gc; vswr, 1.25 to 1 max; power, 1-kw cw; insertion loss, 0.4 db.

Applied Microwave Electronics, Inc., Dept. ED, 114 W. 25th St., Baltimore 18, Md.

Price: *$585 ea.*

Tunnel Diode Amplifiers 358

Noise is 4.5 db. Amplifier NTA 615 is typical of a line of narrow-band units covering 375 to 1,400 mc. Gain is 17 db, noise figure 4.5 db. Frequency is 615 mc, bandwidth 30 mc. Saturation level is −37 dbm for 1 db compression. Replaceable battery has 5,000 hr life.

Micro State Electronics Corp., Dept. ED, 152 Floral Ave., Murray Hill, N. J.

Tracking Antenna 361

Portable microwave antenna mount has handwheels for manual tracking in azimuth and elevation. Parabolic antenna, for operation at 1,680 mc ±50 mc, has gain of 22 db over half-wavelength dipole. Mount is available with parabolic, helical beam and horn antennas.

Automation Dynamics Corp., Dept. ED, 255 County Road, Tenafly, N.J.

Directional Couplers 378

For strip transmission lines. The Tri-Plate variable directional couplers are for strip transmission line circuits with coupling as tight as 2 db. The series of nine models are in three overlapping frequency ranges, each covering one or more octaves between uhf and upper S-band. As a single unit the couplers provide equal 3-db outputs. Multiple units can be cascaded to provide adjustable power dividers with 4, 8, 16 or more adjustable outputs in any ratio or power.

Sanders Associates, Inc., Dept. ED, 95 Canal St., Nashua, N.H.

Collapsible Antenna 365

For 350 to 600 mc. A four-element array, model 521A measures 6 x 6 x 7 ft in operation and collapses to 4 ft x 4 ft x 20 in. The 95-lb array can be quickly erected. Gain is 17 to 20 db, power handling capability more than 1 kw. The array withstands icing and 100-mph winds.

Avien, Inc., Dept. ED, 58-15 Northern Blvd., Woodside 77, N. Y.

Variable Attenuator 368

Range is 30 db. Model X2217 variable attenuator will maintain more than 30 db of attenuation for a constant value of current as frequency varies from 10,250 to 10,500 mc. Unit may be switched from minimum to maximum attenuation in less than 20 μsec. Insertion loss is 1 db max, input vswr 1.15:1 max. Power handling capability is 2 w average from 30 to 65 C.

Cascade Research Div., Lewis and Kaufman Electronics Corp., 5245 San Fernando Road, Los Angeles 39, Calif.

Availability: 3 to 4 weeks.

Coaxial Attenuator 369

Handles 20-w cw input power. Model 693 fixed coaxial attenuator handles an input power of 20-w cw and 10-kw peak. It is matched at both terminals and the full rated power can be applied to either terminal. Specifications are: frequency range, dc to 2 Gc; attenuation range, 1 to 20 db; impedance, 50 ohms; connectors, type N; vswr, input, max, 1.15 to 1 Gc.

Weinschel Engineering, Dept. ED, 10503 Metropolitan Ave., Kensington, Md.

P&A: $200 to $250; from stock to 30 days.

Video Multicoupler 382

Solid state. The VF1327 multicoupler has all solid-state circuitry and provides six emitter follower outputs driven from a single input. Bandwidth is 40 mc and gain is 12 db. Isolation between channels is greater than 50 db at 10 mc.

LEL, Inc., Dept. ED, 75 Akron St., Copiague, N.Y.

Traveling-Wave Tubes 353

For L-band use. Two permanent-magnet, focused traveling-wave tubes are part of a series which cover the 1- to 12-Gc range. Type TW-4267 provides over 15-mw rf output power and 35 db gain from 1 to 2 Gc. It weighs 3.5 lb. Type 4268 operates over the same range with more than 1-w rf output power and 30 db gain. It weighs 4 lb. Both tubes have a max diam of 2-1/4 in.

Sylvania Electric Products, Inc., Dept. ED, 1100 Main St., Buffalo, N.Y.

P&A: $925 ea; immediate to 60 days.

CIRCLE 148 ON READER-SERVICE CARD ▶

ELECTRONIC DESIGN ENGINEERING DATA

Spectrum Analysis Error Nomogram

Alonzo J. Davis
Marshall Space Flight Center
Huntsville, Ala.

THE ACCOMPANYING nomogram provides an easy method of assessing the statistical error that comes from taking finite or short samples in the narrowband, power-spectrum analysis of random noise. Without this nomogram, computing the probable limits of error can be quite involved. This nomogram can prove highly useful to people in the process of designing noise-analysis equipment.

Application of the nomogram assumes analysis of a stationary Gaussian process (random noise) with a spectrum essentially flat (white) over the analysis bandwidth.

When a repetitious tape loop is made from such a spectrum, the spectrum is "Fourierized" into frequency components spaced $1/T$ cps apart, where T is the tape loop length or the sample time in seconds. The amplitude of each of these components is only statistically related to the spectrum amplitude.

The statistical distribution of the energy within the passband of the analyzing filter is a chi-square distribution with N degrees of freedom. The number of degrees of freedom is physically explained as twice the effective number of Fourier components contained within the filter passband.

The nomogram gives the chi-square probable statistical error limits for 50-per-cent confidence in amplitude percentage, as a function of bandwidth and sample time. The shape of the filter is taken into account in the filter constant K. Note that a rectangular filter has constant of unity. K can be computed for any filter shape by measuring the filter response and using the equation

$$K = \frac{[\Sigma F_n{}^2]^2 \, \Delta f}{B \, \Sigma F_n{}^4}$$

where B is the effective filter bandwidth, Δf is a small interval chosen for measuring filter response, and F_n is the normalized amplitude response measured at intervals Δf.

K is related to N by the equation

$$N = 2\ KBT$$

where T is the sample time. This is the equation upon which the nomogram is based, with the appropriate probable error numbered on scale E in lieu of N.

Instructions For Using Nomogram

Draw a line from the sample time in seconds on scale T to the effective bandwidth in cps on scale B. From the intersection of this line on the index scale I, draw a line to the filter constant on scale K. The intersection of this line on scale E is the probable error in percentage of rms amplitude. To obtain sigma, or the rms error, divide this result by 0.675.

Where the spectrum contains a noise resonance narrower than the filter bandwidth, it is necessary to enter the nomogram with B as the noise bandwidth and K as the corresponding shape function if they are known or if they can be approximated.

Use of the nomogram requires certain assumptions about the equipment used. The results apply to rms amplitude spectra. The sample time T is the loop time in the case of analysis of a continuous loop. It is assumed that the averaging time is longer than the loop period and that the analyzer sweep speed is slower than one bandwidth per sample averaging time.

Otherwise the effective sample time is shortened with consequent loss of accuracy. In cases where direct analysis is made with a sweep analyzer, without the use of tape loops, the sample time is approximately the inverse of sweep rate in bandwidths per second.

Examples of Nomogram Use In Typical Applications

Example 1. An analysis is to be made with a filter closely approaching rectangular shape ($K = 1$) having a bandwidth of 20 cps. A 5-sec tape loop is available. Join 5 sec on the T scale with 20 cps on the B scale. Join the intersection of this line on I to 1.0 on the K scale. The intersection of this line on E gives ± 4.8 per cent as the probable error. The error will lie between these limits in 50 per cent of similar samples.

Example 2. It is desired to make an analysis using a double-tuned synchronous filter with a bandwidth of 5 cps and a probable error within ± 10 per cent. What sample time is required?

Assume a filter constant of 2.0. Draw a line from $K = 2.0$ through the 10-per-cent point on E and intersecting I. A line from 5 cps on B through this intersection will strike T at 2.4 sec. Therefore a sample or tape loop of 2.4-sec duration will be required for this analysis.

Additional Scales Usable For Other Bandwidths and Times

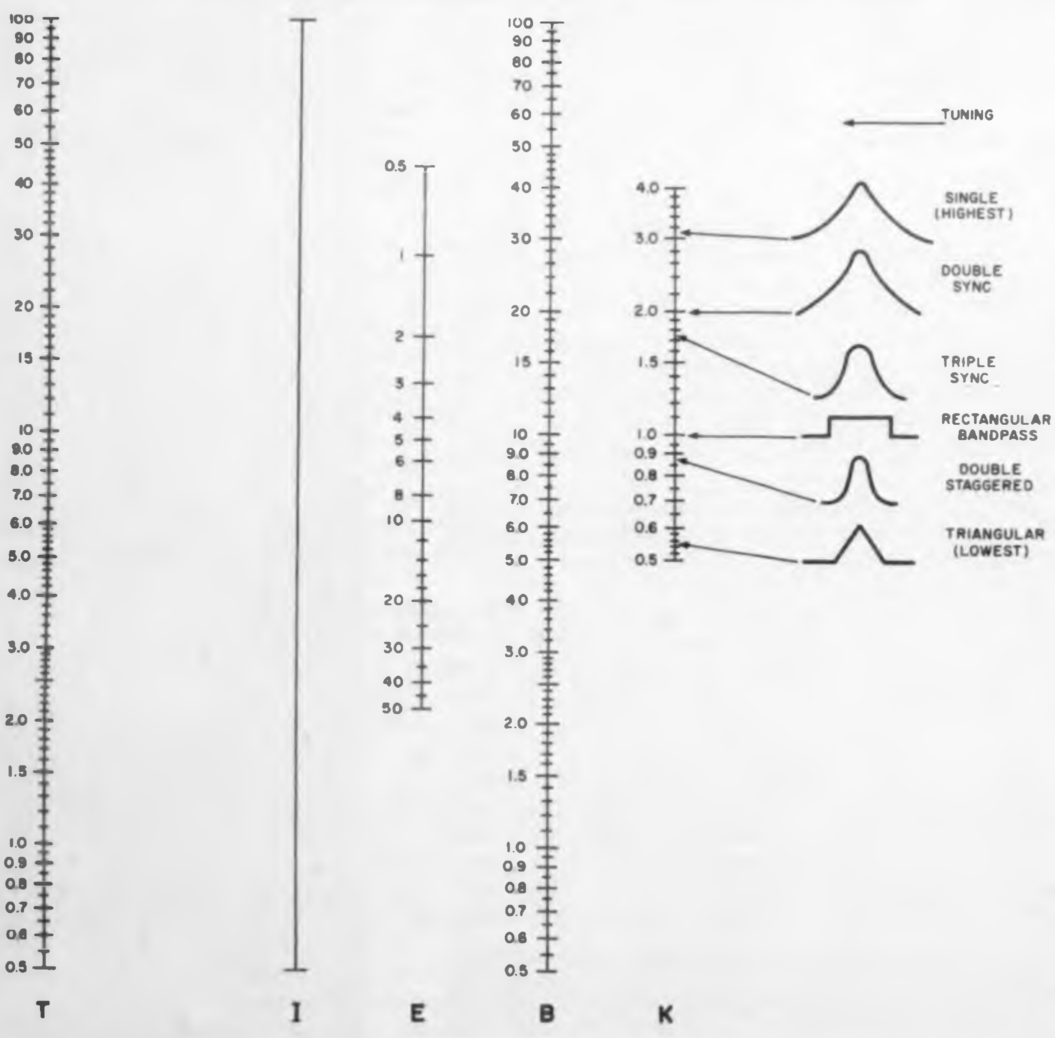
The nomogram may also be used for other bandwidths and sample times by multiplying B by a constant and dividing T by the same constant. For instance, if B is in kilocycles per second, then T is in milliseconds. If B is in megacycles per second, then T is in microseconds.

Further information on this subject may be found in Ref. 1 and 2. ■ ■

References

1. Blackman, R. B. and Tukey, J. W., "The Measurement of Power Spectra from the Point of View of Communications Engineering—Parts I and II," *The Bell System Technical Journal*, Jan. and Mar., 1958.
2. Pierson, W. J. Jr., "An Electronic Wave Spectrum Analyzer and Its Use in Engineering Problems," Beach Erosion Board Technical Memo. No. 56, Oct., 1954.

Probable Error-Limit Nomogram for Spectrum Analysis



SERVICES FOR DESIGNERS

Environmental Test Facilities Test Missile And Rocket Parts 261

Associated Testing Laboratories, Inc. performs environmental testing of missile, rocket and aircraft components. The firm also offers a full line of environmental equipment to concerns setting up their own testing programs.

Associated Testing Laboratories, Inc., Dept. ED, Wayne, N. J.

Firm Seeks Contracts In Reliability Testing 262

Paraton Corp., an independent research organization, is assembling a staff of technical consultants to perform services in the field of reliability for government and industry. The firm is seeking contracts in the following areas: reliability investigation, specification and standardization studies, testing, inspection and quality control.

Paratron Corp., Dept. ED, 125 Old Country Road, Carle Place, L. I., N.Y.

Materials Testing Facility Adds Two New Testing Services 263

The material testing facility of Delsen Corp. has added two new testing services. The firm now has the necessary equipment for measuring dielectric constants and dissipation factors at X-band frequencies. Also with the addition of equipment for determining thermal conductivity by the Cenco-Fitch method, the firm now provides a complete service for measuring the thermal properties of materials.

Delsen Corp., Dept. ED, 719 W. Broadway, Glendale 4, Calif.

RF-Transmission Systems Are Completely Custom-Built 264

Telerad Manufacturing Corp. is equipped to solve design, application, and manufacturing problems encountered in rf-transmission systems. A producer of complete systems and standard components, the firm can custom engineer complete transmission systems using components especially engineered to customer requirements.

Telerad Manufacturing Corp., Dept. ED, 1440 Broadway, New York 18, N.Y.

NEW LITERATURE

Computer Format Recorder 265

The solid-state S-2010 computer format recorder is described in an eight-page brochure. When used with a digital-output data gathering system, the instrument automatically processes continuous data onto gapped computer format magnetic tape. Features, a variety of available options, typical configurations and specifications are discussed. Epsco Systems Div., Epsco, Inc., 275 Massachusetts Ave., Cambridge 39, Mass.

Terminal Insulators 266

Bulletin No. 161 shows 62 different terminal insulators carried in stock. Complete dimensional data are given, as well as individual corona and flashover voltages. The 24-page bulletin includes a description of the insulator ceramic, forming techniques used, high-temperature metallizing and brazing techniques, and inspection. Coors Porcelain Co., 600 Ninth St., Golden, Colo.

Magnetic Shields 267

Engineering data and specifications, for Mu-Metal and Nicoloi magnetic shields for cathode-ray tubes and photomultiplier tubes are contained in this 15-page brochure. Specifications for bezels, knobs and dials are also included. James Millen Manufacturing Co., Inc., 150 Exchange Place, Malden, Mass.

Passive Repeaters 268

Passive Repeater Engineering Manual No. 161, pages, describes in detail the use of passive repeaters. It contains the technical data necessary to design passives into microwave systems. Specifications on the firm's line for systems from 2 to 12 Gc are included. Microflect Co., Inc., 3450 25th St., S.E., Salem, Ore.

Motor-Alternator Set 269

Bulletin GEA-7303, four pages, illustrates how the new brushless-design, 400-cps motor-generator set isolates 60-cps input power from output to prevent input line transients from affecting computer performance. Limits of voltage overshoot and dip during transient computor loads are described. General Electric Co., Schenectady 5, N.Y.

Winding Machines 270

Two-color catalog 61 HD, 12 pages, illustrates and gives full technical details on 14 heavy-duty transformer and coil winding machines and three heavy-duty tensions. Geo. Stevens Manufacturing Co., Inc., Pulaskie Road at Peterson, Chicago 46, Ill.

Temperature Controls 271

Complete details of three models of the 500 series of thermistor sensing temperature controllers and indicators are contained in this eight-page brochure. Complete electrical and mechanical specifications, available modifications and illustrated descriptions of major features of the units are included. Fenwal, Inc., Pleasant St., Ashland, Mass.

Translation Devices

A family of magnetic tape translation devices to provide computers with on-line input conversion of foreign tape formats and signals. A sizable group of computers has been analyzed to be coupled with several tape transports. *Write on company letterhead for Bulletin AE30548 to Auerbach Electronics Corp., Dept. ED, 1634 Arch St., Philadelphia 3, Pa.*

PNP Transistors 272

Three specification sheets describe pnp alloy junction transistors specially designed for high level chopper and electronic commutating applications. Sheets 2N1917 through 2N1922 give electrical data, ratings and applications. Graphs show emitter characteristics. Sperry Rand Corp., Sperry Semiconductor Div., Norwalk, Conn.

Counting Instruments 273

Catalog 608,462, six pages, is a condensed catalog and price list for electric, stroke, turn, revolution and coil winding counters. It fully describes and illustrates dustproof and hermetically sealed counters, actuating switches and photoelectric equipment. General Controls Co., Automation Controls Div., 8080 McCormick Blvd., Skokie, Ill.

Computer Elements 274

Bulletin C-50, 24 pages, describes computer elements which employ all-transistor design, printed circuitry and modular construction. They are for quickly assembling electronic counters, data-processing equipment, logic control systems, computer logic and digital systems. Ransom Research, 374 W. Eighth St., San Pedro, Calif.

Hydrogen Thyratrons 275

Bulletin PT-49, 20 pages, contains a comprehensive discussion of hydrogen thyratrons. General theory and application is included along with special reference to three different tubes for data and ratings. Schematics, charts and graphs detail the construction, operation, characteristics and applications of the tubes. General Electric Co., Power Tube Dept., Schenectady 5, N.Y.

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The circled numbers on a Reader Service card get special attention from ELECTRONIC DESIGN. We know that you're interested in certain products—that you want more information to help you evaluate them. And we know that you want this information in a hurry.

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So, when seeking more information about products you've seen in advertisements or in our New Products Section, simply circle the Reader Service numbers. It's the fast way. The easy way.

NEW LITERATURE

Microwave Filters 276

Present state of the art of microwave filter design is discussed in a 12-page paper. Various techniques for designing filters are described; advantages and limitations are considered. An extensive bibliography has been included for those interested in more detailed design procedures. PRD Electronics, Inc., 202 Tillary St., Brooklyn 1, N.Y.

Power Supplies 277

A line of solid-state power supplies and power conversion devices is described in an illustrated eight-page brochure. Included are sine wave inverters, regulated low-voltage power supplies, high-voltage supplies, modular supplies, and five power converters for special application. Power Sources, Inc., Burlington, Mass.

Tube Catalog

Descriptions and specifications of a variety of tubes are given in this 25-page catalog. Among them are cold-cathode trigger tubes, ignitrons, indicators, klystrons, noise diodes, photomultipliers, radiation counters, thyratrons, rectifiers, and traveling-wave tubes. *Write on company letterhead to Amperex Electronic Corp., Dept. ED, 230 Duffy Ave., Hicksville, L.I., N.Y.*

Constant-Voltage Transformers 278

A complete line of constant-voltage transformers is described in a 12-page bulletin, CVI-316A. Voltage variation is discussed; transformer application and selection guides are provided. Prices and specifications are listed. Sola Electric Co., 4633 W. 16th St., Chicago 50, Ill.

Analog Computer 279

Model 231R general-purpose analog computer is described in bulletin No. AC-6007, 20 pages. The basic system, building block design, and automatic features are treated. A digest of available readout equipment is included. Electronic Associates, Inc., Long Branch, N.J.

Drawing Instruments

A line of drawing and measuring instruments is described and illustrated in this 124-page catalog. Included are advanced drawing sets, designing aids, drafting materials, computing and measuring devices, magnifiers, and surveying instruments. *Write on company letterhead to Alvin & Company, Inc., Dept. ED, Windsor, Conn.*

Plastics Catalog 280

This 64-page catalog lists prices of plastic sheets, rods, tubes, films, blocks and flat tubings. Available sizes, weights, color ranges, textures, purchasing specifications, grades and prices are given. A two-page comparison table of chemical, electrical and mechanical properties of 14 plastics families is included. Cements, pigments and miscellaneous supplies are listed. Cadillac Plastic & Chemical Co., 15111 Second Ave., Detroit 3, Mich.

Tunnel Diodes 281

Bulletin No. 2106, four pages, gives characteristics and applications of tunnel diodes. Applications include amplifiers, oscillators, and high-speed switches. Methods of obtaining parameters are described and several basic circuit designs are given. Sperry Rand Corp., Sperry Semiconductor Div., Norwalk, Conn.

Adhesives Selector Chart 282

This adhesives selector chart gives the properties of key adhesives and hardeners, such as tensile shear strengths at different temperatures and in several fuels. The operating temperature range, coefficient of thermal expansion and other criteria are indicated. Hysol Corporation, Adhesives Dept., Olean, N.Y.

Reliability Program 283

"Reliability In Action," a 28-page booklet describes new concepts, techniques and thinking brought on by AGREE (Advisory Group on Reliability of Electronic Equipment) procedures. Hoffman Electronics Corp., 3761 S. Hill St., Los Angeles, Calif.

Analog Computers

Written as a manual for the PACE TR-10 transistorized computer, this 70-page handbook provides a comprehensive introduction to the capabilities and operation of general purpose analog computers. *Available at $1.75 per copy from Electronic Associates, Inc., Dept. ED, Long Branch, N.J.*

Power Units 284

A fully illustrated eight-page brochure describes and gives full specifications on a complete line of regulated transistorized power supplies, frequency changers and converters for use with infrared detectors, Geiger tubes, scintillation counters and for general laboratory and industrial use. Victory Electronics, Inc., 50 Bond St., Westbury, N.Y.

DESIGN DECISIONS

Featuring the clever and unusual in packaging appearance design and circuitry in electronic equipment.

Control-panel covers provide protection and portability.

The Case for Instruments

Simple brackets convert bench mounts to rack mounts. Tilt-slide system is easily attached to instruments that may require frequent access.

Grooved feet allow for easy, stable stacking. Sub-modules can be grouped together in modular adapters so they can be stacked with full-width instruments or mounted in racks.

Top and bottom covers, as well as side plates, snap off for easy access to components.

THE INSTRUMENT package has come into its own as a case deserving the designer's attention. Ugly instruments, the norm a few years ago, are getting harder and harder to find. Some observers, in fact, have gone to the extent of characterizing this year's IRE Show as one marked by a notable absence of ugly instruments. But good packaging can do more than merely enhance the appearance of an instrument.

A well-designed package can make an instrument easier to use and easier to maintain; it can help an instrument mate more readily with companion instruments; it can even cut production costs.

As a case in point, one can study the packages recently introduced by Hewlett-Packard Co. of Palo Alto, Calif. Pictured here, these modular packages offer versatility, attractiveness, and a number of less obvious features that contribute to their usefulness. For example:

- Control-panel covers are available for all full-width instruments and modular adapters. They provide easy portability and protect the instruments from weather and damage in field use. The covers are interchangeable between units of the same panel height.
- Instruments that do not require full-module width are made in standard submodules of one-half or one-third of the full-width module.
- Submodule instruments can be grouped in modular adapters and can be stacked with full-width instruments or modular adapters.
- Simple brackets, attached quickly in place of trim strips, convert any of the full-width instruments or modular adapters from bench-mounted to rack-mounted units. This gives the customer flexibility and saves the manufacturer tooling costs required for separate bench-mount and rack-mount cases. In addition it eliminates the need to guess at the number of bench- and rack-mount cases to be manufactured.
- A tilt-slide system is easily attached to all instruments where frequent access is desirable. The system uses pressure-actuated extension, retraction, and tilting—with no need for locking mechanisms.
- Each instrument has four grooved feet that interlock with the side rails of the instrument on which it is stacked. A fifth foot interlocks with a groove separating the instrument's front panel and top cover, providing proper alignment and good lateral stability.
- Top, bottom, and side covers can easily be snapped off the instruments to provide access to components.

These unusual packages were designed under the direction of Carl J. Clement, H-P's manager of industrial design. ■ ■

DESIGN DECISIONS

Washerless Transistor Mount Cuts Production Snags

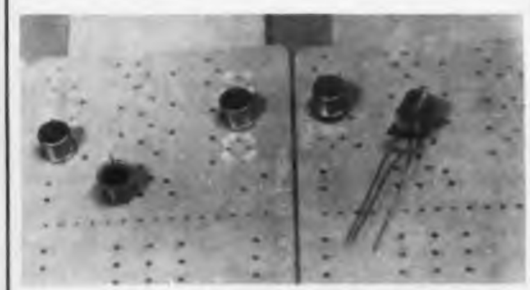
A beautifully simple production technique completely eliminates one problem often encountered in mounting transistors with spacers or washers. When printed-circuit cards are to be soldered automatically, it is common practice to separate transistors from the cards by spacers.

A spacer allows air to circulate between the transistor and the board and also prevents solder which may creep up through the mounting holes from shorting the transistor leads.

But in automatic assembly, where transistors with their washers are often chute-fed to an assembly point, washers sliding around can often jam the steady flow of transistors. Even where the washers are mounted on the transistor right at the assembly point, it involves an additional manual operation and thus an additional source of trouble.

At IBM Corp.'s General Products Division in Endicott, N.Y., the problem is completely eliminated at virtually no expense. Each transistor location on a card is automatically embossed with a series of small ridges. The same machine that countersinks the transistor mounting holes and imprints assembly numbers on the card also embosses the ridges.

The ridges serve just as effectively to separate a transistor from the board and, of course, they require no manual operation.



Embossed ridges on PC card at left serve as transistor mounts instead of washers shown at right.

Photocells from One Silicon Slab Read Any Colored Punched Tape

Nine photovoltaic diodes, cut from a single slab of silicon, can read any color paper tape in a new punched-tape reader. Because the cells have highly uniform characteristics, one can achieve very precise and uniform adjustment of all reading channels.

Most tape readers require complex design or special bias adjustments if they are to read tapes of different opacities. In the model 350 Tape Reader, manufactured by the Cedar Engineering Div. of Control Data Corp., 5806 W. 36th St., Minneapolis, the photocells provide nearly identical characteristics. Each photocell drives a transistor amplifier with a very sharp threshold bias.

During manufacture, each transistor amplifier has its threshold bias adjusted for operation under the worst conditions (usually with oiled, buff-colored tape). The equipment can then read any tape of higher opacity.

Another feature, a very narrow light beam, contributes to the capabilities of the tape-reading system. The light beam, about 20 mils wide, is directed into a 40-mil light guide. This narrow beam increases the system's immunity to diffused light that could pass through translucent tapes and cause a false reading.

Household Pressure Cooker Speeds Porosity Tests

A household pressure cooker came to the rescue when engineers at General Resistance, Inc. in the Bronx, N. Y. had to test electrical leakage and porosity of an epoxy encapsulent. The engineers found themselves under pressure when they needed to test the potting for some of their resistance networks and they found that all their humidity chambers were in use.

In desperation, they tried a four-quart, household, pressure cooker. They mounted the potted resistance network on a simple stand which kept the network out of the water. They put 8 oz of water in the pot and started cooking. They maintained 15-psi steam pressure for two hours. The steam intensity they developed provided the equivalent to a 5-day exposure to a 95 to 100 per cent relative humidity.

Pressure cooker doubles for humidity chamber in testing for electrical leakage and porosity of epoxy encapsulent.

DESIGN DECISIONS

Two Hinged Doors Give Access To Soldered Connections

Two hinged doors, at the rear of a new power supply, provide easy access to all soldered connections and to all small components. All the components except for the filter capacitors, chokes, and power transformer are mounted on one of the doors.

The high-dissipation elements are mounted on the finned, outer door to help dissipate heat from this completely convection-cooled supply. Using this cooling technique, Lambda Electronics Corp. of College Point, N.Y. has been able to rate a 20-amp supply for a 50-C ambient without the need for blowers.

The basic justification for a two-door design, according to Lambda engineers, is that a good, high-power supply is, of necessity, heavy. The two-door design, with all small components accessible, obviates the need for two men to handle the supply for checking. The doors can be opened by a half-turn on each of two screws. Though the supplies are designed for easy maintenance, Lambda expects little or no maintenance needed as the supplies are sold with a five-year guarantee.

Two hinged doors on convection-cooled power supply offer easy access to all soldered connections and small components.

Magnetic-Tape Strips Simplify Torque Measurements

Two strips of magnetic tape help simplify the measurement of rotational speed, torque, and horsepower. They work with a horsepower meter, developed by Sierra Research Corp., P.O. Box 22, Buffalo, N. Y., which requires no physical contact with rotating parts.

The strips of tape (or any magnetic oxide) are bonded around the circumstance of a power-carrying shaft and displaced laterally along the shaft. A reference frequency is recorded on the tapes while the shaft is rotating at no load.

Magnetic pickup heads read the recorded voltages to provide information on shaft speed, torque, and horsepower. The output from each head is amplified, clipped, and differentiated. The differentiated pulses trigger a flip-flop alternately. The duty cycle of the flip-flop can be adjusted to exactly 50 per cent by physically adjusting the distance between the heads.

Twisting the shaft varies the duty cycle in direct proportion to torque and integrating this output provides a voltage proportional to torque.

The output of the torque flip-flop triggers a one-shot multivibrator whose integrated output provides a voltage proportional to shaft speed.

The filtered torque signal and unfiltered rpm signals are mutiplied to provide a horsepower signal.

Transistor Test Sockets Feature Reversible Contacts

A line of transistor test sockets uses reversible contacts to double the life of the sockets. The sockets have guide holes that direct a transistor lead toward one half of the spring-clip contact.

After about 500,000 transistor insertions, the beryllium copper contacts tend to wear at the points of lead entry. With the sockets designed by Atlantic Electronics Corp. of Garland, Tex., one can simply remove the spring clips from the rear (without dismounting the test socket) and reverse them before reinserting them. This exposes new contact surfaces, and thus, doubles the useful life of the sockets.

Reversible contacts double the life of a transistor test socket. The socket has off-center guide holes to direct transistor leads to only half of each contact. Note, in right part of photo, how transistor leads mate with opposite halves of the two contacts.

DESIGN DECISIONS

Wiper Lifts Wire In Infinite-Resolution Pot

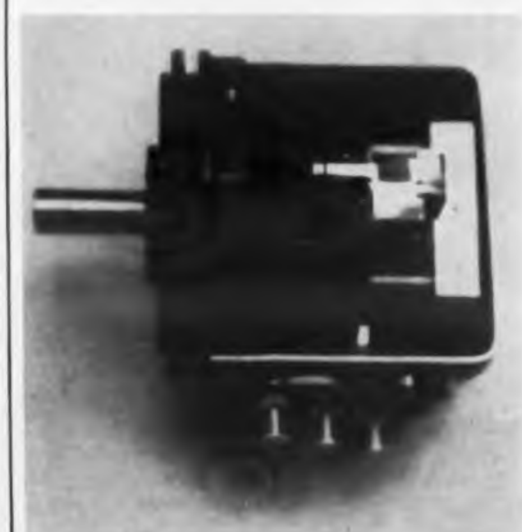
The wiper lifts the resistance wire in a new, infinite-resolution, wirewound potentiometer. As a result, the pot offers the infinite resolution of film-type potentiometers together with the high stability, low noise, and low contact resistance of wirewound units.

As it travels, the precious-metal wiper actually lifts the helical slide wire out of its groove, then lays it back into its original position, maintaining exact linearity. The wiper has a narrow groove in which the wire rides. The wire form is precision ground in the same machine that grinds the lead screw, so there is no tracking error as the slider moves along its helical path.

The new technique, developed for a line of potentiometers by Vogue Instrument Corp., of 2350 Linden Blvd., Brooklyn, N. Y., offers an additional advantage, not readily apparent. It allows Vogue to wind higher-resistance pots in smaller physical configurations.

This is because in conventional, helical, slide-wire pots, where the wiper rides on top of the wire, the wire diameter must be large enough to protrude from its groove (to keep the wiper off the wire form), and the separation between turns must be large enough to prevent the wiper from shorting adjacent turns. In the "life wire" technique, these needs are removed so smaller wire can be used and the turns can be spaced more closely.

Dual-ganged potentiometers can be made by



Wiper lifts resistance wire in potentiometer, offering infinite resolution with high stability, low noise, and low contact resistance. Wire being lifted has been emphasized in the photo, for clarity.

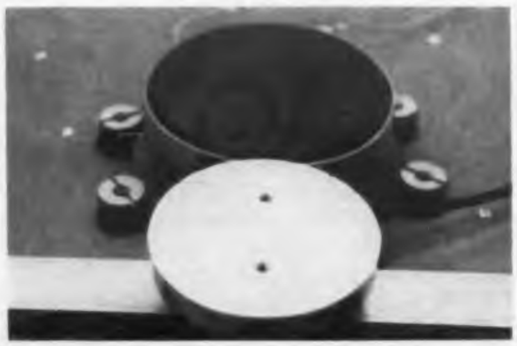
winding adjacent helices and displacing the wipers by 180 deg. As many as four, independent, 10-turn windings can be placed in the 1.8-in. diameter package.

Electrostatic Fixture Speeds Vibration Tests

An electrostatic fixture, rather than an electromagnetic or mechanical type, serves to hold the load on a new shaker. The fixture, manufactured by Electroforce Inc., of Fairfield, Conn. is used in vibration test fixtures made by Unholtz-Dickie Corp. of Hamden, Conn.

The electrostatic fixture (like a magnetic type) is designed for rapid production testing to vibration specifications. It provides for rapid changes of specimen position without time-consuming bolting operations.

But, unlike the magnetic type, the electrostatic fixture can be used with nonmagnetic materials. It can hold any metallic specimens and even ceramics, glasses, and plastics if the latter are flash plated.



Electrostatic fixture for vibration test fixture . . .

. . . **can be mounted quickly** without need for bolting specimen down.

IDEAS FOR DESIGN

Modified Multi Generates Output Gate With Each Trigger — 735

The circuit presented here shows how a monostable multi was modified t initiate an output pulse at each input trigger. An output gate is produced even if the input's repetition period is less than the natural period of the multi. Thus, an effectively continuous gate can be obtained.

For triggers with greater repetition periods the unit behaves as an ordinary monostable device.

The multi is designed so that if positive input pulses are used, Q_2 is initially in saturation. Since both Q_2 and Q_3 are on, the first pulse initially has no effect on the multivibrator's state.

However, after a short interval τ_d due to the delay line, this first pulse turns Q_1 on. Transistor Q_2 is then turned off and a negative gate is generated at the output. If a second positive pulse does not appear at the input the output gate will terminate at the end of the multi's natural period.

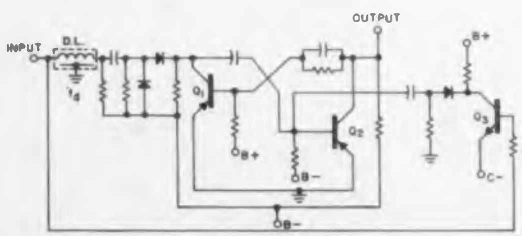
If a second positive pulse appears before the output gate terminates, Q_3 will be immediately turned on. This produces a negative pulse at the base of Q_2, forcing it back into saturation; the multi has been caused to flip before the end of its natural period. This occurs in less time than the delay line period τ_d.

After the delay time, τ_d, the pulse arrives at Q_1. It finds the multi completely recovered and ready to generate another negative gate at its own natural period.

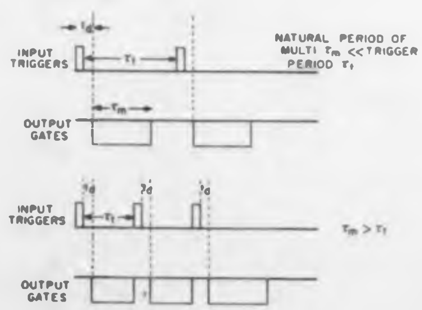
The virtually continuous output gate will continue as long as the period between trigger pulses is less than the natural period of the monostable multi.

Charles W. Haase, Electronic Engineer, Naval Research Laboratory, Washington, D.C.

If this Idea is valuable to you, give it a vote by circling Reader-Service number 735.

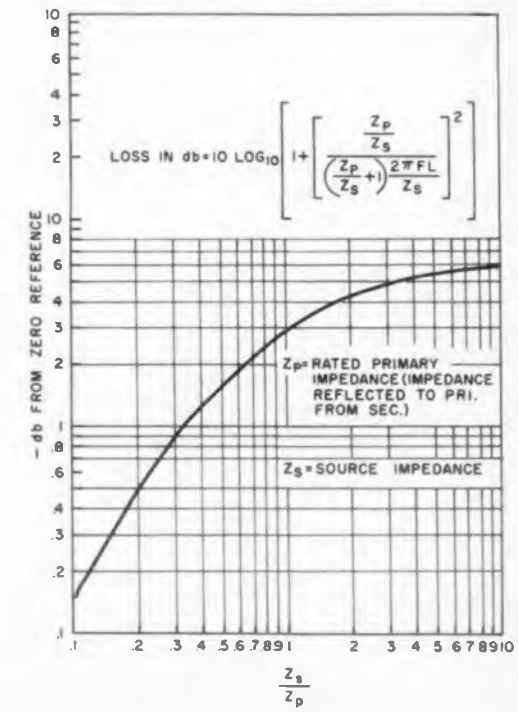


(a) Modified monostable multi initiates an output pulse at each input trigger.



(b) Output pulses are generated even though period of input triggers is less than natural period of multi.

Curve Helps Determine Unmatched Transformer Response — 736



Low end response under unmatched conditions of an audio transformer can be determined from this curve.

The low frequency response of an audio transformer under unmatched conditions can be readily determined from the curve below.

Most audio transformers are rated for frequency response under matched conditions. However they are very often used under unmatched conditions, in applications such as pentode outputs and bridging circuits.

The curve shown can be used by the circuit designer to determine the low-end response of a transformer in his particular circuit.

Points on the curve are compared with the −3-db point of a matched transformer $Z_S/Z_P = 1$. The curve is not valid for input transformers connected to open grids.

Troy Burgess, Engineer, Triad Transformer Corp., Venice, Calif.

If this Idea is valuable to you, give it a vote by circling Reader-Service number 736.

How You Can Participate

Rules For Awards

Here's how you can participate in Ideas for Design's Seventh Anniversary Awards: All engineer readers of ELECTRONIC DESIGN are eligible.

Entries must be accompanied by filled-out Official Entry Blank or facsimile. Ideas submitted must be original with the author, and must not have been previously published (publication in internal company magazines and literature excepted).

Ideas suitable for publication should deal with:

1. new circuits or circuit modifications
2. new design techniques
3. designs for new production methods
4. clever use of new materials or new components in design
5. design or drafting aids
6. new methods of packaging
7. design short cuts
8. cost saving tips

Awards:

1. Each Idea published will receive an honorarium of $20.
2. Ideas judged Most Valuable of Issue will receive $50.
3. The Idea judged to be Idea of the Year will receive the Grand Prize of $1,000 in cash.

The Idea of the Year will be selected from amongst those judged to be Most Valuable of Issue.

Most Valuable of Issue and Idea of the Year will be selected by the readers of ELECTRONIC DESIGN. Votes will be cast by circling keyed numbers on Reader-Service Cards. Payment will be made eight weeks after Ideas are published.

Exclusive publishing rights for all Ideas will remain with the Hayden Publishing Co.

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Straight Line Graph Yields Logs to Base 2 Quickly 738

Calculation of information amounts and rates often involve finding logarithms to the base 2. Since readily available tables are generally sketchy, to obtain $Y = \log_2 X$ one commonly uses the relation $Y = \log_{10} X \cdot \log_2 10$, finding Y by looking up the common log of X and multiplying it by 3.3219. It is accurate enough and a lot easier to find the logarithms graphically.

All that is necessary is to draw a line on a sheet of semi-log paper. Along the logarithmic axis of the paper, mark the range of X of interest. Along the linear axis mark off the corresponding range of Y. Draw the line by plotting two convenient points, such as ($X = 1$, $Y = 0$) and ($X = 8$, $Y = 3$). To find convenient points, just remember that $Y = \log_2 X$ is equivalent to $X = 2^Y$.

Jesse Roth, Proj. Engineer, Kearfott Div., General Precision Lab., Little Falls, N.J.

If this Idea is valuable to you, give it a vote by circling Reader-Service number 738.

Printed Wire "Plug-In" Cards Reduce Number of Card Types 739

The variety of printed circuit cards required in an electronic system can be reduced by using a "plug-in" wire card—a printed wiring card having projecting taper pins, Fig. 1. By inserting this printed wire between various points in a basic printed-circuit layout, the card can be rearranged into different circuit configurations.

An example of how these plug-in cards are used is shown by the basic printed circuit layout, Fig. 2, designed for the two amplifier circuits of Fig. 3. The only difference between the two circuits is the coupling arrangements between the tube plates and suppressor grids.

By inserting plug-in wire cards of the proper length between points *a* and *d* and points *b* and *c* on the basic wiring card, the circuit of Fig. 3a is completed. By removing these and inserting printed wires between points *c* and *a* and points *b* and *d*, the circuit of Fig. 3b is completed.

Where complex circuits are used, a good amount of thought must be given to the basic printed design of the circuit layout. The eyelets as shown in Fig. 2 can be evenly spaced to provide equal lengths of printed wires. It is also feasible to plug one printed wiring card into

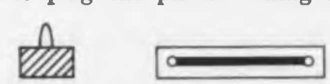


Fig. 1. Wire printed on a card can be plugged into printed-circuit card to alter circuit configuration.

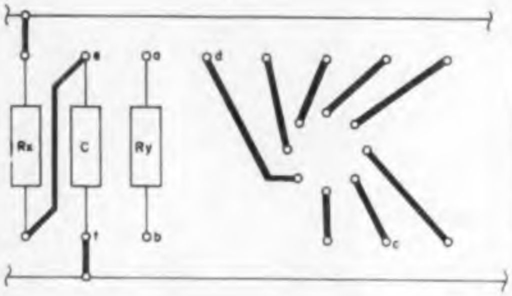
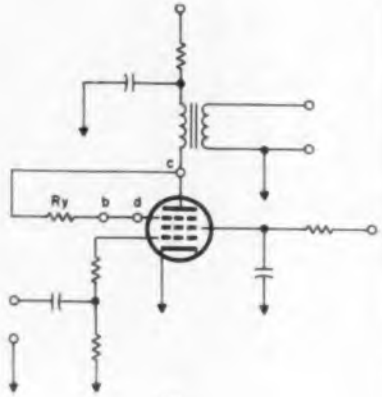
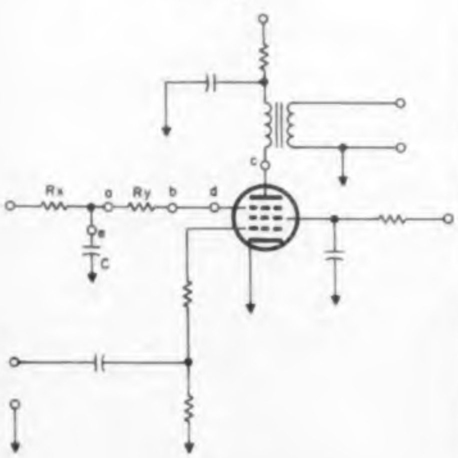


Fig. 2. Slightly different amplifier stages can be laid out on a single, basic printed-circuit card. Circuit configuration can be altered by inserting the proper printed wire plug-ins.



(a)



(b)

Fig. 3. Almost identical amplifier stages differ only in connections of plates and suppressor grids. Circuits are laid out as in Fig. 2.

another. This connection method does not require soldered joints. The taper of the pins is sufficient to provide the mechanical and electrical contact.

Ralph S. Gootner, International Business Machines Corp., Federal Systems Div., Kingston, N.Y.

If this Idea is valuable to you, give it a vote by circling Reader-Service number 739.

IDEAS FOR DESIGN

Staggered Columns Identify Printed Data Easily 743

A method of recording a maximum of data on an 11-column paper tape printer, or the like, while retaining separation and easy identification of data channels is illustrated below. By switching the data channels appropriately on alternate prints and by sharing certain columnar positions, a group of channels can be printed in an array that enables individual channels to be identified by relative position. The trend of each channel can also be readily followed.

In addition, a larger number of significant digits is available than might ordinarily be. In the example shown, 5 data channels are accommodated, with a total of 17 significant digits.

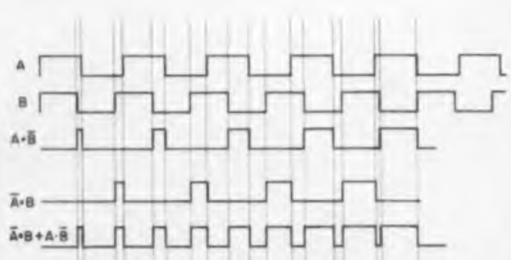
```
468 654 718
 5731 1231
469 649 679
 5742 1016
459 658 725
 5732 0991
399 650 800
 5786 0980
387 700 701
 5792 1098
357 681 779
 5700 1187
348 705 829
 5699 1232
```

K. C. Herrick, Project Engineer, Philco Corp., Western Development Laboratories, Palo Alto, Calif.

If this Idea is valuable to you, give it a vote by circling Reader-Service number 743.

Gated Square Waves Vary Pulse Width of Output Train 741

In some electronic systems, such as a pulse transmission, multiple-echo reception system, a linearly increasing pulse width is required for a given number of cycles.



Square waves *A* and *B*, gated as shown, produce an output pulse train whose width varies linearly with time.

A simple method for generating such a pulse train is shown in the figure.

Two square waves are gated whose difference in periods is equal to twice the desired incremental change in pulse width per cycle. The pulse width increases linearly per cycle and then decreases as the phase of the two frequencies shifts.

Leonard L. Kleinberg, Electronic Engineer, Lockheed Electronics Co., Metuchen, N.J.

If this Idea is valuable to you, give it a vote by circling Reader-Service number 741.

Ordinary Diode Protects VTVM From Overload 740

A vacuum tube voltmeter can be protected from the effects of overloads by putting an ordinary diode across its meter terminals.

Although the meter in a standard vtvm is commonly regarded as "burn-out proof," overload conditions can cause the meter current to be 3 to 4 times the full-scale value. Such an overload or surge could result in a bent pointer or even in an open armature coil.

The characteristic curve of a type 1N538 diode has its knee at approximately 0.55 v. Meters in vtvm's usually have a full-scale deflection of 0.18 v. Thus, a 1N538 diode connected directly across the meter terminals will have negligible effect on the meter accuracy. At the same time, it will provide good limiting action when the voltage applied to the meter appreciably exceeds the full-scale value.

In an actual circuit having a 200-μa meter (which required 195 mv for full-scale deflection), the meter current was limited to 250 μa even though the input voltage to the unit was increased to 30 times the full scale reading. Although other special diodes (such as Zeners) could be used, the cost of a common type such as the 1N538 makes it quite attractive for this application.

L. A. Stoll, Sr. Engineer, Electronics & Ordnance Div., AVCO Corp., Richmond, Ind.

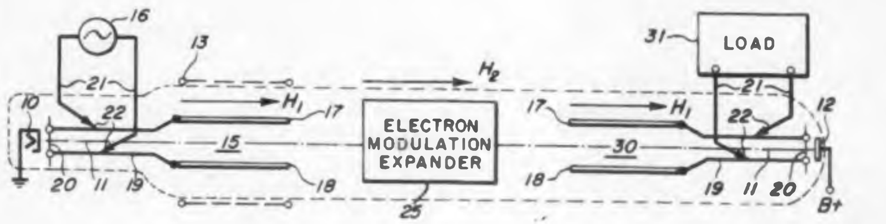
If this Idea is valuable to you, give it a vote by circling Reader-Service number 740.

Patent Pending On Filter Circuit

The Twin-T filter circuit shown as an Idea for Design, (*ED*, April 12, p 196), is the sole property of the Datrax Division of the W. W. Henry Co. and is not available for use by anyone else without risk of violating that company's property rights. A patent application is pending.

PATENTS

Benjamin Bernstein

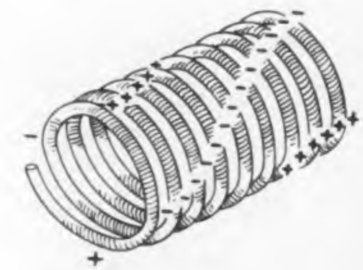


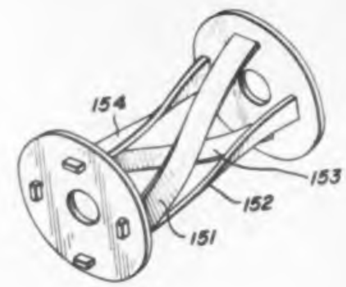
Parametric Amplifier Modulation Expander

Patent No. 2,959,740. R. Adler (Assigned to Zenith Radio Corp.)

The Adler transverse fast wave amplifier is more flexible when the expander is a helix instead of a quadruple array of deflection plates. This permits the pump frequency to be shifted to locate the idler frequency and allows the amplification of signals having either finite or infinite phase velocities.

In the conventional (Wade) arrangement, one of the two rotating fields has the correct phase when the pump is at twice signal frequency. The structure must be twisted if the pump-to-signal frequency ratio is changed. However, the helix electrically provides the necessary twist and, in addition, only the field which is synchronous with the wave on the beam is caused to propagate.



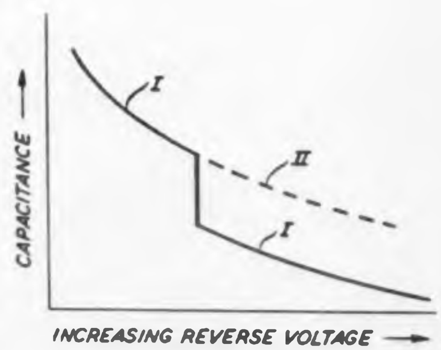


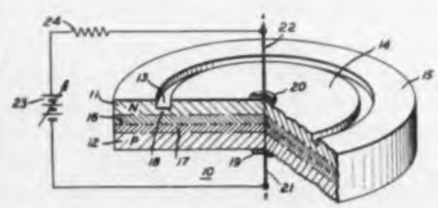
Semiconductor Capacitor

Patent No. 2,964,648. E. J. Doucette and C. J. Spector (Assigned to Bell Telephone Labs).

Capacitance of a pn junction is changed by varying the effective area of the depletion layer.

The pn junction is formed by joining p-type and n-type wafers. In addition, a circular slot is cut into the upper face of the n wafer. As the reverse bias is increased, the boundary of the depletion layer moves away from the junction. The capacitance is reduced and the layer ultimately intersects the boundaries of the slot. This pinches off the area of peripheral portion *15* and causes a large change in the effective capacitance.



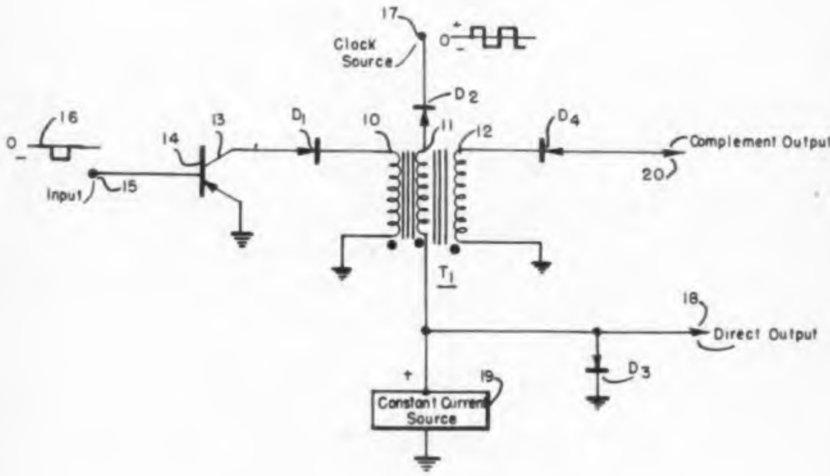


Logical Elements

Patent No. 2,972,060. R. D. Torrey (Assigned to Sperry Rand Corp.)

In a simple logic circuit, a control signal steers the output to a designated terminal.

With quiescent transistor *14* cut off, clock signals are applied to transformer winding *11*. Winding *12* provides a complement output. A negative control signal drives transistor *14* into hard conduction. This effectively reduces the impedance of winding *11* so that there is a direct output only when diode D_3 is unclamped from ground.



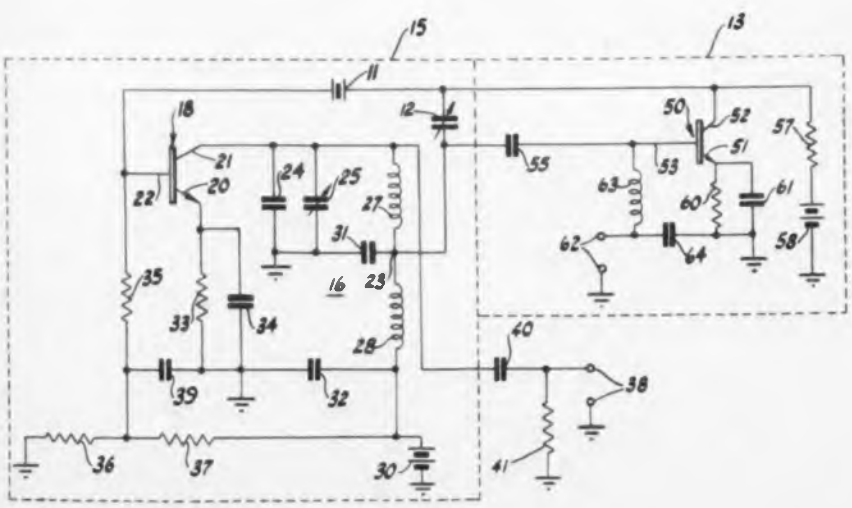
Variable Frequency Crystal-Controlled Oscillator Systems

Patent No. 2,972,120. R. J. Kircher and M. C. Wager (Assigned to Hughes Aircraft Co.)

Frequency of a crystal-controlled oscillator is varied by changing the effective reactance of a capacitor in series with the crystal. A transistor in shunt with the capacitor varies the reactance.

Hartley oscillator *15* has capacitor *12* in series with crystal *11* in its feedback circuit. The base-collector network of transistor *50* is in parallel with capacitor *12*. Initially, the frequency is set by the series capacitor.

Thereafter, frequency is linearly adjusted by a variable base-emitter bias applied to terminals 62.



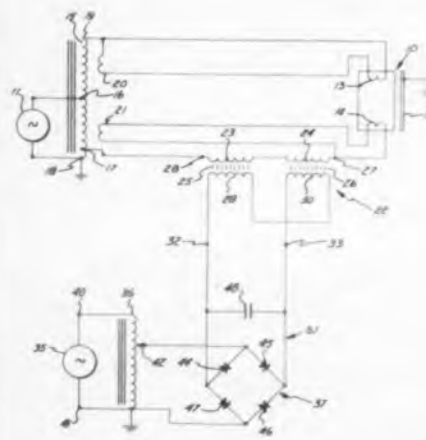
PATENTS

Dimming Circuits for Fluorescent Lamps

Patent No. 2,961,579. R. B. Roney and P. E. Massie (Assigned to Day-Ray Products, Inc.)

An inexpensive, flicker-free fluorescent light dimmer comprises an adjustable saturable reactor in series with the lamp and power source. The impedance of the reactor varies with the direct current through the coils of the saturable element.

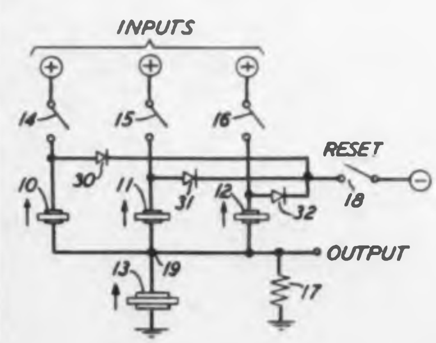
Auto transformer *36* and rectifier *37* set the impedance of windings *23* and *24* in series with lamp *10*. As the direct current through windings *29* and *30* increases, the level of magnetization of cores *25* and *26* increases, decreasing the impedance of gate windings *23* and *24*.



Translator

Patent No. 2,956,265. E. E. Schwenzfeger (Assigned to Bell Telephone Labs).

A logic AND circuit using ferroelectric crystals develops the required output even when the control signals are not applied simultaneously.



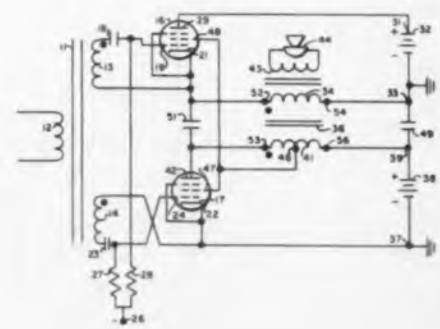
In a simplified version of the invention, crystals *10, 11* and *12* have equal electrode areas, while crystal *13* has twice the electrode area of any of the others. All crystals are initially negatively polarized. When input *14* is applied, *10* switches completely while *13* switches half way. When input *15* is applied, both *11* and *13* are switched. Now, when input *16* is connected, *12* switches and since *13* remains unchanged, the charge passes through resistor *17* to develop an output signal.

Audio Amplifier

Patent No. 2,947,947. S. Bernstein Bervery (Assigned to General Precision Inc.)

High power, low output impedance and low distortion are obtained by driving a Class AB power amplifier push-pull, and taking its output in parallel. Beam tetrode tubes operate effectively as low distortion triodes when the screen grids are driven by a second primary winding.

Tubes *16* and *17*, suitably biased by the negative voltage at terminals *26*, are driven push-pull by secondary windings *13* and *14*. The tubes drive winding *34* in parallel to supply load *44*. The screen electrodes are connected to tap *46* of the second primary winding *41* so that beam power tube output is obtained with a triode's low distortion.



Voltage-Comparing Circuit

Patent No. 2,956,177. R. A. Day (Assigned to Hughes Aircraft Co.)

A transistor circuit determines both the time the applied signal equals the reference level and the change of po-

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TYPE "S"—Slightly larger than the Type "M". Peak voltage rating 850 volts—plate spacing .013", other spacings available on special order. Mounting studs tapped 4-40 on 17/32" centers.
TYPE "J" AND "K" CAPACITORS
TYPE "J"—This heavy duty miniature has wider spacing (.025") than most small air variables, yet occupies little more space. Ideal for small space tank circuits in low power stages. DC-200 treated insulator—soldered plate construction. Peak voltage rating 1200 volts. Mounting brackets and 6-32 screws provided.
TYPE "K"—Widely used for military and commercial applications. DC-200 treated insulator—slotted stator contacts—extra-rigid soldered plate construction. Peak voltage rating 1000 volts. Plate spacing .015". Available in production quantities to meet MIL-C092A specifications—other capacities and variations available.
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This popular variable has extra-heavy steatite stator support insulators and soldered .023" thick brass plates. Metal parts heavily nickel-plated. Sturdy brass end frames—double bearing construction—silver-plated beryllium copper wiping contacts—peak voltage rating 1200 volts. Available in a number of plate spacings as well as special platings, shaft lengths and without mounting feet for panel mounting applications. Bearing threaded 3/8"-32.
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Ideal for applications requiring extreme stability and strength. Rotor bearings and stator support rods soldered directly to heavy 3/16" thick steatite. Split-sleeve bearing and silver-plated beryllium copper contact provide constant torque and smooth capacity variation. Plate spacing .030". Peak voltage rating 1500 volts. Available in a number of plate spacings, as well as special platings, shaft lengths and stator terminal locations. Bearings threaded 3/8"-32. Single section, dual, butterfly and differential types.
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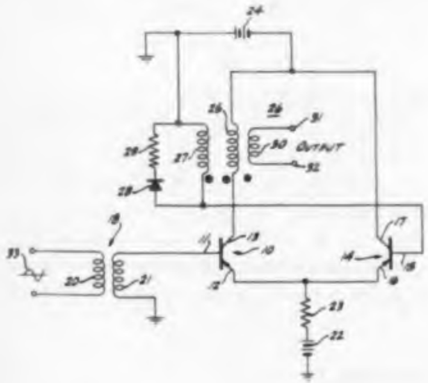
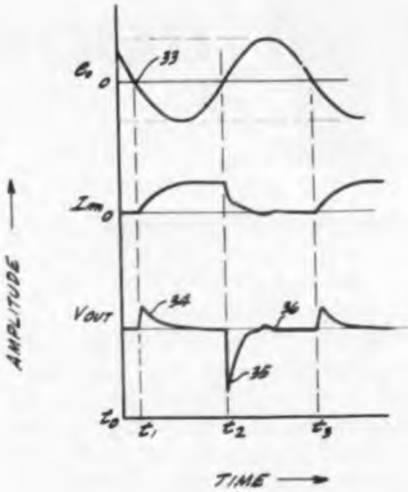
larity of the signal as the level is crossed.

With the input signal positive, transistor *14* is conducting and transistor *10* is cut off. At time t_1, the signal crosses the reference level. The circuit then switches





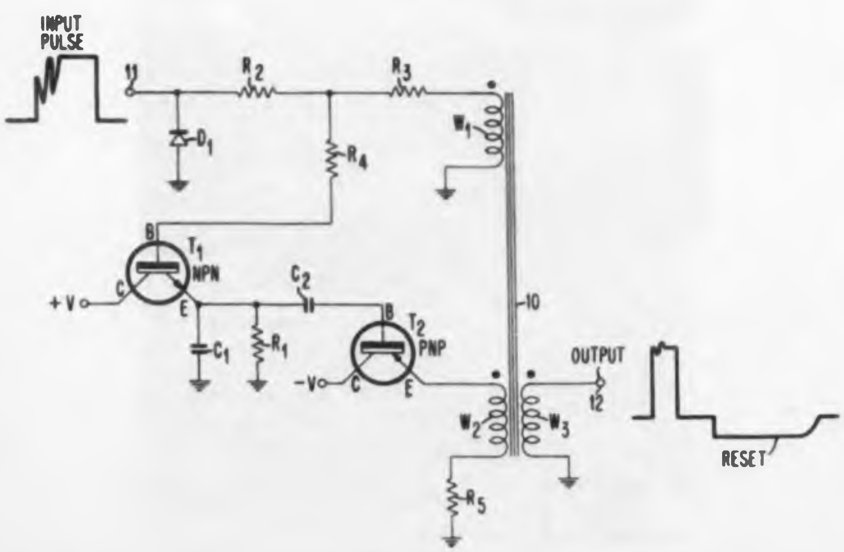
so that transistor *10* is now conducting and transistor *14* is cut off. However, winding *26* voltage couples to winding *27* to make diode *28* conducting. This loads the output and a small positive pip *34* appears there. When the signal crosses the reference at t_2, the circuit flops back and transistor *14* conducts hard to cut off transistor *10*. At this instant diode *28* is cut off and a large negative pip *35* is coupled to the output. If the polarity of diode *28* is reversed the positive pip *34* will be distinctly larger than the negative pip *35*.

Pulse Integrator Quantizer With Single Reset

Patent No. 2,951,949. H. C. Kuntzleman and J. G. Simek (Assigned to IBM Corp.).

Fast, nonringing pulses, suitable for counting purposes, are produced by the switching of a magnetic circuit.

The input pulse drives core *10* whose flux change is metered as an output until the core saturates; diode D_1 limits the polarity of the input pulse. Transistors T_1 and T_2 together with integrator R_1C_1 reset the core to the initial condition. Thus, the input pulse makes T_1 conducting to cut off T_2 and to change C_1. After the capacitor voltage has run down, T_2 again conducts to reset the core.



BOOKS

Coupled Mode and Parametric Electronics

William H. Louisell, John Wiley & Sons, Inc., 440 Park Ave. S., New York 16, N.Y., 268 pp, $11.50

Emphasized in this text are three specific aspects of microwave electronics. First, it serves as an introduction to the theory of coupled modes and shows how the use of this approach simplifies the study of coupled systems. It then presents a unified theory for traveling wave tubes, backward wave oscillators, and similar devices. Finally, it treats the theory of parametric amplifiers, oscillators, and frequency converters. The consideration of the theory of coupled modes from a general viewpoint permits its application in many fields.

The book has been written so that a first-year graduate student or a senior in electrical engineering who has had a course in Maxwell field theory should be able to follow it. Although largely mathematical in nature, the book contains no very difficult mathematics, and the more tedious sections have been relegated to the appendices.

Servicing TV Tuners

Jess E. Dines, Technical Book Div., Howard W. Sams & Co., Inc., 2201 E. 46 St., Indianapolis 6, Ind., 272 pp, $4.95.

This is the newest volume in the Jess E. Dines TV Servicing series. In addition to describing the mechanical and electrical characteristics of practically every type of TV tuner ever built, hundreds of schematic diagrams and photos are used to complement circuit discussions that go into detail on the purpose of every component. This book explains how tuners are classified in accordance with mechanical design (turret, switch, disk and continuous tuning) and rf circuit design (cascode, pentode, tetrode, neutrode, etc.). It also includes complete data on troubleshooting and alignment techniques. The book is intended for use by TV servicemen, students, engineers, and others who need a one-source reference volume on all phases of TV tuners.

The Surface Chemistry of Metals and Semiconductors

Harry C. Gatos, John Wiley & Sons, Inc., 440 Park Ave. S., New York 16, N.Y., 526 pp, $12.50.

Contained in this volume are the papers presented at the Joint Symposium of the Corrosion and Electronics Divisions of the Electrochemical Society on the Surface Chemistry of Metals and Semiconductors held in Columbus, Ohio, October 19-21, 1959. The Symposium was sponsored by the Office of Naval Research and the Electrochemical Society. It was conceived as a medium for an exchange of theory and technology between the fields of metal surfaces and semiconductor surfaces.

The material is grouped into five parts: I—Chemistry and Physics of Surfaces; II—Imperfections and Surface Behavior; III—Electrode Behavior of Metals and Semiconductors; IV—Surface Reactions in Liquid Media; and V—Surface Reactions in Gaseous Media.

Practical Auto Radio Service and Installation

Jack Greenfield, Gernsback Library, Inc., 154 W. 14 St., New York 11, N.Y., 160 pp, $2.95.

Discussed in this servicing guide are methods of installation and repair for the different types of auto radio sets, the equipment and components needed to set up an auto radio servicing shop, and how to remove and install rear seat speakers. Tuners, interference suppression, fm, and auto phonographs are discussed as well.

Important facts to know about laminated plastics

A few Taylor composite laminates (left to right): copper-clad section; sandwiched copper component; Taylorite vulcanized fibre-clad part; laminated tube, copper inserts.

Composite Laminates Open Up New Design Opportunities

While the great variety of commercially available laminated plastics satisfy most electrical and mechanical requirements, there are applications that can benefit from the combination of properties provided by composite laminates. Recent advances in bonding techniques have made it possible to bond virtually any compatible material with a laminate. These can be supplied as clad or as sandwiched materials. And they can be molded into many shapes to fit design requirements. Taylor is presently supplying to order the following composite laminates:

- **Copper and laminated plastics.** Clad for printed circuits and formed shapes. Sandwiched for special applications.
- **Taylorite® vulcanized fibre-clad laminates.** These combine the high strength of laminated plastics with the superior hot-arc-resistance of vulcanized fibre. They are being used in both high and low-voltage switchgear applications. Also in applications where the high impact strength of vulcanized fibre may be advantageous.
- **Rubber-clad laminates.** Almost any type of natural or synthetic rubber may be used as the cladding material. These laminates are widely used for condenser tops in wet condensers to protect the laminate against highly alkaline electrolytes. They also have application in any part where sealing or chemical resistance is needed.
- **Asbestos-clad laminates.** For applications where high heat- and arc-resistance are required.
- **Laminate-clad lead.** Lead sheets sandwiched between Grade XX paper-base laminates have been used for X-ray shields. The laminate provides strength and contributes to the high shielding properties of the lead.
- **Aluminum-clad laminates.** These have been used extensively for engraving stock. They also offer possibilities as printed-circuit material and as plate holders for X-ray machines.
- **Beryllium copper-clad laminates.** Beryllium copper is nonmagnetic and a good conductor—properties that give these laminates possibilities in many applications.
- **Stainless steel-clad laminates.** Applications where nonmagnetic properties are required. Also in certain corrosive environments where the resistance of stainless steel to attack is an asset.
- **Magnesium-clad laminates.** These laminates have been produced in 108-in.-long sheets for use as screens for X-ray operators. Weight was a factor.

Our design and production engineers are constantly developing new materials, new applications, and new procedures for fabricating laminated plastics. Our experience is yours for the asking. And if you have a problem requiring assistance or more information on composite laminates, write us. Also ask for your copy of Taylor's new guide to simplified selection of laminated plastics. Taylor Fibre Co., Norristown 48, Pa.

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BOOKS

Dictionary Of Automatic Control Terms

Robert J. Bibbero, Reinhold Publishing Corp., 430 Park Ave., New York 22, N.Y., 282 pp, $6.00.

An encyclopedic dictionary of automatic control terms, this volume provides a condensed discussion of each topic including applications and related subjects. The areas covered include control theory and basic concepts, computers and data processing, industrial machine and process control, aircraft and missile control and telemetering, and control components and design factors.

Finite-Difference Methods for Partial Differential Equations

George E. Forsythe and Wolfgang R. Wasow, John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 444 pp, $11.50.

Directed to the reader who is unfamiliar with the theory of partial differential equations, but who has studied advanced calculus and matrix theory, the book covers initial-value and boundary-value problems. Emphasis is given to topics of importance in the solution of these problems with computers.

Analog and Digital Computer Technology

Norman R. Scott, McGraw-Hill Book Co., Inc., 330 W. 42 St., New York 36, N.Y., 522 pp, $12.75

Said to be unique in its field, this book presents information about both the use and the design of the two principal types of electronic computer—the electronic differential analyzer and the stored-program digital computer. The principles of both analog and digital computers are treated for the electrical engineer studying at the senior or beginning graduate level.

Although the treatment is not highly theoretical, there is enough theory presented which the author hopes clearly presents computer technology both as it

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exists today and as it may develop in five to 10 years from now. Information is also included, on transistor NOR logic, magnetic core storage systems, and Quine's reduction logarithm for switching circuits. Chapter headings include Computer Representation of Nonlinear Functions, Computing Amplifiers, Solving Problems on the Digital Computer, Logic Circuits for Arithmetic and Control, and Electronic Circuits for Logic. Most of the chapters have sets of problems as well as extensive bibliographies.

Inertial Guidance

C. S. Draper, W. Wrigley, and J. Hovorka, Pergamon Press, Inc., 122 E. 55 St., New York 22, N.Y., pp 130, $6.50.

This text discusses the physical principles and engineering methods underlying the inertial navigation and control of airborne vehicles. Starting points are conventional navigation and Newtonian physics. The development proceeds from an examination of traditional navigation in terms of physics, through a discussion of past uses of inertia in navigation, to the interpretation of the operations of navigation in terms of control theory.

The writing is directed at graduate-level engineers. Problems discussed include the most recent methods of ballistic missile guidance, with the use of gyros in geometrical stabilization given a unique treatment. A bibliography (to 1960) is also included.

Digital Computer Fundamentals

Thomas C. Bartee, McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N. Y., 342 pp, $6.50.

An introduction to the digital computer for the engineer who is not a specialist in this field, this book begins with a description of the various functions of computers. Typical computer circuitry is explained, followed by an introduction to block diagram representation of circuits and the use of Boolean algebra to describe circuit functions. Space is given to the arithmetic element, memory, input-output devices and controls. Magnetic cores, punched cards and paper tape are also discussed.

BOOKS

Handbook of Laplace Transformations

Floyd E. Nixon, Prentice-Hall, Inc., Englewood Cliffs, N.J., 115 pp, $6.00.

A compilation of Laplace transforms, this volume also presents derivations of many Laplace transform theorems, with detailed examples of practical physical problems solved by the Laplace transform method. Included are discussions on effective root finding methods, Routh's criterion, and the use of determinants.

Statistical Theory of Communication

Y. W. Lee, John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 509 pp, $16.75.

Written for the communications specialist or graduate student, this account of the statistical theory of communication attempts to cover all the basic elements in this area. Intended as an introductory work, the book does not include information on nonlinear systems.

Statistical filtering and prediction theory, correlation theory, and generalized harmonic analysis are among the topics presented.

Thermoelectric Materials and Devices

Irving B. Cadoff and Edward Miller, Reinhold Publishing Corp., 430 Park Ave., New York 22, N.Y., 344 pp, $9.75.

Based on a series of lectures given at New York University, this text surveys recent progress made in the development of new materials for thermoelectric devices. It features contributions by twenty experts and ranges from basic theory to device design. The first section is devoted to the theory of thermoelectric processes and thermoelectric circuits. This is followed by a general evaluation of materials, both theoretical and experimental, for use as thermo-elements. A chapter on thermionic conversion has been included for comparison with the "solid state" conversion devices. Where appropriate, the authors have included brief reviews of background material. The concluding section concerns the principles of device design and describes some experimental and prototype units.

Elements of Maser Theory

Arthur A. Vuylsteke, D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, N.J., 362 pp, $9.50.

The theory of maser operation represents an application of the quantum theory, statistical mechanics and the interplay between the two. In this volume, both fundamentals and applications are discussed at length.

Organized into three main parts, the text first surveys the basic phenomena responsible for maser behavior, with a brief description of the Bohn quantum theory and statistical mechanics. Part 2 covers some of the theory of quantum and statistical mechanics and radiation theory. The main subject, masers, is discussed in Part 3 and is limited to a theoretical treatment of the most basic and currently well-understood features. The subject of infrared masers is, for example, not treated.

The Antenna

L. Thourel, John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 407 pp, $12.50.

Based on a course given at the Ecole Nationale de l'Aviation Civile, Paris, this text is essentially a manual for use in planning an antenna system to specific requirements. It is written for both engineers and technicians who need information on antenna types and techniques. Mathematical arguments have been kept to a minimum, although practical design formulas are presented.

Included in the book are sections on antennas for decimetric and centimetric waves; short-wave antennas particularly rhombics; end-fire, omnidirectional, wideband, and paraboloid antennas; electromagnetic lenses. A bibliography is given at the end of each chapter relating to theoretical works and those which treat, in detail, specific problems.

J. George Adashko

A Device for Observing Three-Dimensional Functions

A SPECIAL instrument has been designed which can display three-dimensional functions on a single oscilloscope. The device can be used whenever electrical signals, proportional to the coordinates of a three-dimensional object, are obtainable.

The electronic portion of the device, Fig. 1, has three inputs, proportional to the coordinates x, y and z of the three-dimensional vector, and two outputs.

From one output we obtain alternately, by using an electronic or electromechanical switch, P, voltages proportional to $y \pm kx$, where the constant factor k characterizes the depth of the image. These voltages are formed by a broadband amplifier y (of gain k), an inverter I, and a summer S. They are applied to the horizontal deflecting plates of the oscilloscope.

A voltage proportional to the coordinate z is fed from the second output to the vertical deflecting plates. Thus, the apparatus produces simultaneously both images of the two-dimensional projections on the screen of a single oscilloscope. These images can be viewed directly through a stereoscope.

Circuit Is Designed For Audio Frequencies

Fig. 2 shows the circuit diagram of the instrument, designed to operate at audio frequencies. One half of a 6N8 (equivalent of 6SN7) dual triode serves as the amplifier and inverter (tube *1*). The variable resistances R_1 and R_2 serve, respectively, to adjust the gain (depth of the image) and to equalize the output voltages. The anode and the cathode of tube *1* are connected to the contacts of the electromagnetic relay P, fed from a multivibrator (6N8 tubes 5 and 6). Resistance R_5 sets the multivibrator frequency. The summer is a negative-feedback amplifier 6Zh4 (equivalent of 6AC7) pentode, tube 3; the plate load is tube 2. The output voltage of the

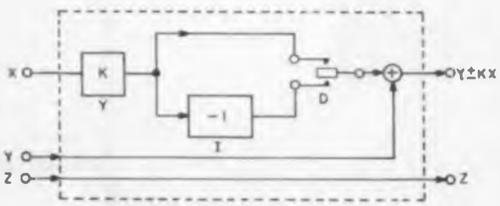

Fig. 1. Block diagram of electronic portion of instrument which can display three-dimensional functions on a single oscilloscope.

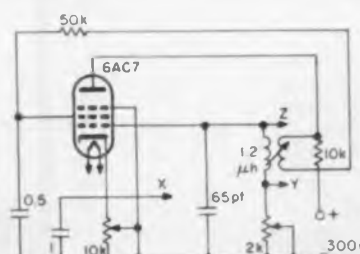

Fig. 3. Three-dimensional limit cycles are produced by oscillator having self bias in the cathode circuit.

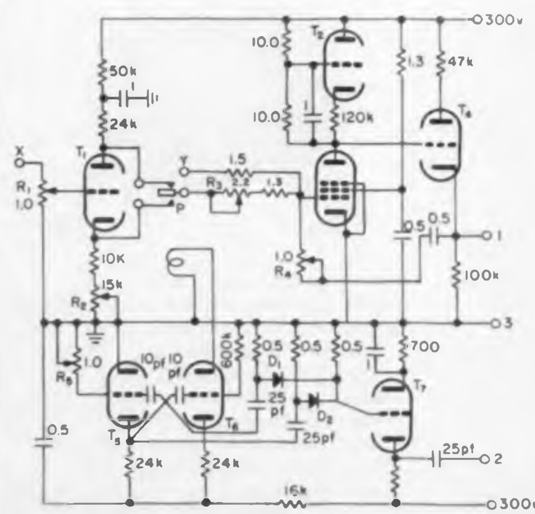

Fig. 2. Schematic diagram of the instrument.

Fig. 4. Photograph of two-dimensional projections of three-dimensional limit cycle.

summer is fed to the grid of a cathode follower, tube *4*. The tubes' output terminals are then connected to the horizontal deflecting plates of the oscilloscope.

The voltage proportional to the coordinate z is applied, multiplied by a suitable scale factor, to the vertical oscilloscope plates.

The distance between the images can be varied on the screen by adjusting resistance R_3.

Two passive differentiating networks are used to suppress the interference produced by the switching of the relay's armature. Pulses from these networks are fed through crystal diodes *1* and *2* to the grid of tube *7*. The output terminal *2* of this stage is connected to the center tap of the oscilloscope 'brightness' potentiometer.

The system is fed from a stabilized rectifier. Three-dimensional limit cycles were produced by an LC oscillator with self bias in the cathode circuit, Fig. 3. It is well known that such a system, representable by a third-order differential equation, is able to generate intermittent oscillations with self-modulation of the oscillation amplitude.

The points from which the voltages are proportional to the space coordinates are suitably marked on Fig. 3.

Fig. 4 is a photograph of the two-dimensional images of the projections of the three-dimensional limit cycle for intermittent oscillations.

Translated from N. I. Ashbel', G. G. Denisov, V. A. Dozorov, News of the Higher Institutions of Learning, *Radiophysics Series, Vol. III, No. 3, May-June 1960, pp 540-543.*

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A. A. Andronov, A. A. Vitt, and S. E. Khaykin, Theory of Oscillations. Fizmatgiz, M., 1959, p 902 (An English Translation of the first edition of this book was published by the Princeton University Press in 1949).

N. A. Fufayev, Memorial Volume to A. A. Andronov, Academy of Science Press, Moscow, 1955, p 334.

N. A. Zheleztsov, J. Tech. Phys. (USSR), 18, 496 (1948).

J. George Adashko

Circuits For Calculating the Functions $U_1{}^m\sqrt{U_2}$

IN ELECTRONIC computers, when, solving, for example, nonlinear equations, it is frequently necessary to calculate functions of the form $U_1 \sqrt[m]{U_2}$ and $U_1/\sqrt[m]{U_2}$. In particular the square and cube roots and their reciprocals must be calculated.[1] Analogous problems are encountered also in automatic control systems.[2]

These functions can be calculated by making use of the dependence of the electrostatic (barrier) capacitance of a pn junction on the voltage applied to it. This dependence, is given by the equation:[3]

$$C_b = \frac{k}{\sqrt[m]{U + U^*}} S, \tag{1}$$

where k is a constant, S is the area of the pn junction, U is the blocking voltage applied to the p-n junction, and U^* is a voltage close to the contact potential difference U_k between the p and n regions. For fused pn junctions $m = 2$; for grown pn junctions $m = 3$, and for pn junctions manufactured by diffusion, $2 \leq m \leq 3$. The electrostatic capacitance depends little on the temperature.[4,5]

Simple Circuit Helps Calculate Root Function

The simplest circuit for calculating the function $U_1 \sqrt[m]{U_2}$ is shown in Fig. 1. A sinusoidal voltage of amplitude U_1 is applied to the input. A voltage U_2, which in general varies with time,

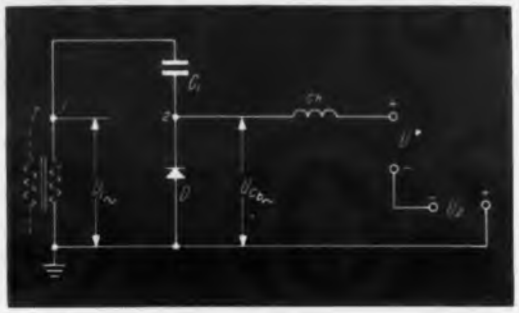

Fig. 1. Circuit for calculating the root function $U_1 \sqrt[m]{U_2}$.

is applied to diode D through the blocking choke Ch. The sign of U_2 depends upon the blocking direction of the diode. In addition a constant "unblocking" bias voltage U° is applied to the diode. The value of U_2 can range from U° (corresponding to the unblocking of the pn junction) to $U^\circ + U_{max}$ (where U_{max} is the maximum voltage on the pn junction, corresponding to the maximum permissible reverse-current increase).

When $C_1 << C_b$, the amplitude of the alternating voltage at point 2 is determined from the approximate equation:

$$U_{Cb\sim} = U_{1\sim} \frac{C_1}{C_b} = U_{1\sim} \frac{C_1}{\kappa S} \sqrt[m]{U_2}. \qquad (2)$$

In the case of a constant output-voltage amplitude ($U_1 =$ const), we obtain:

$$U_{Cb\sim} = a \sqrt[m]{U_2}, \qquad (3)$$

where a is a constant quantity. To avoid nonlinear distortion, the condition $U_{cb} << U_2$ must be satisfied.[3]

C_1 Must Exceed Parasitic Capacitance But Also Be Less Than C_b

Because capacitance C_1 must exceed the parasitic capacitances and also must be considerably less than the capacitance of the pn junction C_b, C_1 must be on the order of 10^3 pf or more. In an actual version of the circuit of Fig. 1, the author used a silicon pn junction, having a ca-

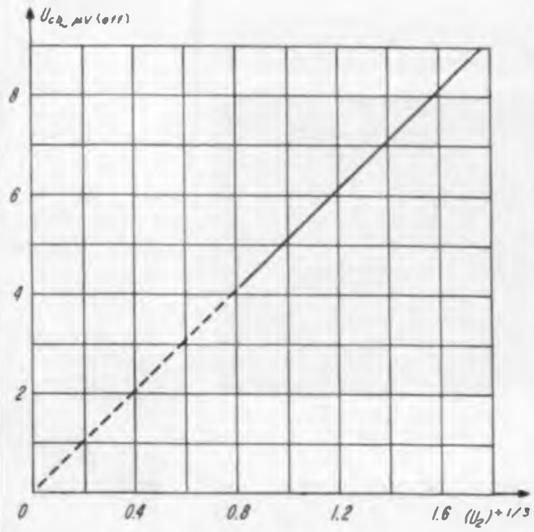

Fig. 2. Experimental dependence of $U_{cb}\sim$ on $(U_2)^{1/m}$ for $m = 3$.

pacitance of approximately 0.1 to 0.2 μf and a high Q in the low-frequency range.[4] The frequency of the voltage U_1 was chosen to be 5 kc. Fig. 2 shows an experimental dependence of U_{cb} on $(U_2)^{1/m}$ for $m = 3$. In accordance with Eq. 3, the experimental points fit, within the limits of measurement accuracy, on a straight line.

The circuit for calculating the function $U_1/\sqrt[m]{U_2}$ is shown in Fig. 3 An alternating voltage U_1 is applied to the input. A voltage U_2 is applied to the diode D through blocking choke Ch. This voltage, in general, varies in time. An unblocking bias $U°$ is also applied. The limits of application of U_2 are the same as in the first circuit. When $C_1 >> C_b$ the amplitude of the alternating voltage U_1 on the capacitance C_1 is given by the approximate equation:

$$U_{C1\sim} = U_{1\sim}\frac{C_b}{C_1} = U_{1\sim}\frac{\kappa S}{C_1\sqrt[m]{U_2}}, \qquad (4)$$

when U_{C1} is constant we get

$$U_{C1\sim} = \frac{b}{\sqrt[m]{U_2}}, \qquad (5)$$

where b is a constant.

Since $C_1 >> C_b$, almost the entire variable voltage U_1 is applied to the diode. Therefore to avoid nonlinear distortion, the condition $U_{1\sim} << U_2$ must be satisfied. It is also obvious

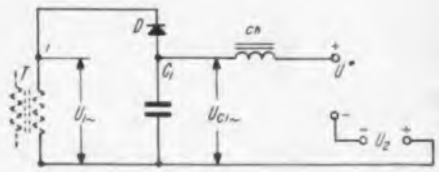

Fig. 3. Circuit for calculating the function $U_1/^m\sqrt{U_2}$.

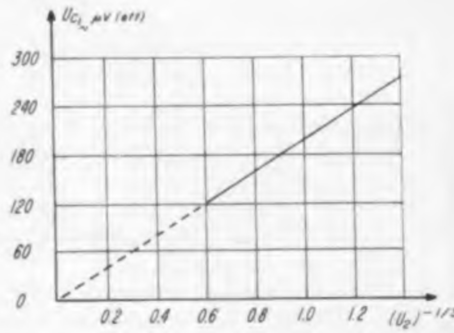

Fig. 4. Experimental dependence of $U_{cb}\sim$ on $(U_2)^{1/m}$ for $m = -3$.

the $U_{c1\sim} << U_{1\sim}$. Thus $U_{c1\sim}$ in this circuit is one order of magnitude smaller than the voltage $U_{cb\sim}$ used in the preceding circuit.

Fig. 4 shows the experimental dependence of $U_{c1\sim}$ on $(U_2)^{-1/m}$ when $m = 3$ (the nonlinear capacitance and the conversion frequency are the same as in the preceding circuit). According to Eq. 5, the experimental curves fit a straight line, within experimental accuracy.

We see from Eqs. 2-5 that the tolerances in the parameters k, $U°$ and S do not influence the character of the functional transformation but may require retrimming of the circuit when the diode is replaced.

Translated from "Circuits For Calculating the Function $U_1{}^m\sqrt{U_2}$*," L. S. Berman*, Radioteckhnika, *Vol. 15, Number 10, 1960, pp 70-72.*

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4. Berman, Landsman, and Subashiev, *Radiotekhnika*, Vol. 14, No 12, 1959, pp 69-70.
5. V. P. Demin, News of the Colleges, *Radio Engineering*, No 3, 356-361, 1956.

GERMAN ABSTRACTS

E. Brenner

Cross Modulation in Transistors

NONLINEAR characteristics of transistors cause cross-modulation in high-frequency amplifiers exactly as in vacuum tubes. Cross-modulation refers to the following phenomenon: When a generally weak signal is received, the modulation of another transmitter, operating at a different frequency, is detected. Since the cross-modulation disappears in the absence of the desired (weak) signal, highly selective if stages cannot eliminate the phenomenon.

There is a marked difference in behavior of alloy junction and drift transistors with respect to cross-modulation. At frequencies below about 1 mc it can be shown that this difference in behavior is due to the difference in base resistance. At higher frequencies the diffusion capacitance must be considered, but the base resistance remains important.

In alloy junction transistors the base resistance R_B is of the order of 100 ohms. In drift transistors the corresponding value is of the order of 10 ohms.

The cross-modulation characteristic in transistors, exactly as in vacuum tubes, can be described quantitatively by specifying the rms value of an interfering signal, V_e, with modulation index, m_e, that produces a cross-modulation index of 1 per cent. For transistors it can be shown that:

$$V_e = \frac{0.1\,(V_T + I_B R_B)^2}{m_e V_T \cdot \sqrt{|V_T - 2\,I_B R_B|}} \qquad (1)$$

where $V_T = kT/e$ (about 26 mv at 23 C). In Eq. 1, the value of R_B must include any significant output resistance of the source. The formula, Eq. 1, is plotted in Fig. 1. Of particular interest is the value of base current where V_e is infinitive; this value is the "pole" value:

$$I_{b0} = V_T / 2R_B$$

For drift transistors the pole value lies approximately one decade above the value of the alloy junction transistor. Experimental determination of the pole values is not carried out because of the large currents involved.

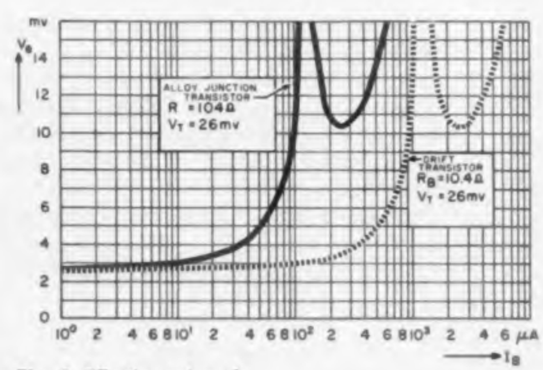

Fig. 1. Effective value of 100 per cent modulated interfering signal necessary to produce a cross-modulation index of 1 per cent as a function of base current.

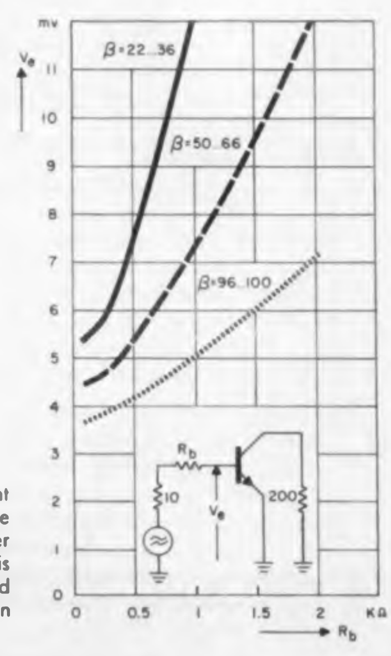

Fig. 2. Effective 100 per cent modulated interfering voltage V_e necessary to produce 1 per cent cross-modulation index is plotted as a function of added base resistance, at 1 kc, for an alloy junction transistor.

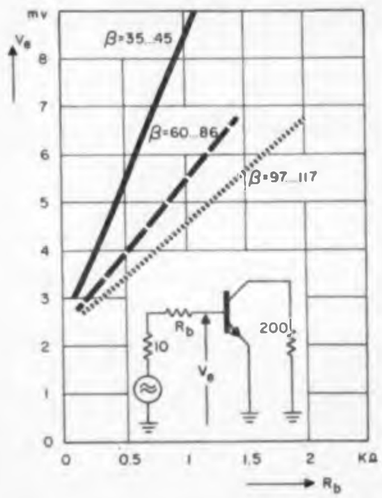

Fig. 3. Effective 100 per cent modulated interfering voltage V_e necessary to produce 1 per cent modulation index is plotted as a function of added base resistance, measured at 1 kc, for a drift transistor.

The discussion can be related to collector current by using the current gain factor, $\beta = I_E/I_B$. In Figs. 2 and 3 the value V_e (100 per cent modulated) necessary to produce 1 per cent cross-modulation index is shown as a function of base resistance with β as a parameter.

Abstracted from an article by H. Lotsch, Elektronische Rundschau, *Vol. 14, No. 12, Dec. 1960, pp 509-512.*

Constant Envelope-Delay Filters

ALTHOUGH envelope delay can often be achieved by using smooth delay lines, there are applications where lumped-element networks may be preferred. Suitable networks can be realized as reactance two-ports with envelope-delay characteristics that are within an equal ripple (Tchebycheff) approximation.

The network function to be synthesized is the operating voltage transfer function referred to a

1-ohm termination, Fig. 1. This function is defined as

$$H(s) = \frac{V_1/2}{V_2} \tag{1}$$

where s is the complex frequency variable, normalized with respect to a reference frequency. The corresponding normalized envelope delay τ is given by

$$\tau = \frac{d}{d\omega}\left[I_m\,(ln\ H)\right] \tag{2}$$

In the all-pass realization, the H-function has the form

$$H(s) = \frac{E(s)}{E(-s)} \tag{3}$$

where $E(s)$ is a Hurwitz polynomial of degree n. Defining the complex envelope delay function $t(s)$ as

$$t(s) = \frac{d}{ds}\left[ln\ H(s)\right] = \frac{H'(s)}{H(s)} \tag{4}$$

it can be shown that

$$t(s) = \sum_{k=1}^{n} \frac{1}{s - s_k} + \frac{-1}{s + s_k} \qquad Re\,[s_k] < 0 \tag{5}$$

where $s_1 \ldots s_n$ are the zeros of $H(s)$.

A Tchebycheff approximation for constant time delay can be constructed using a "Tchebycheff rational function." Such a function, Fig. 2, can be constructed as

$$R(s) = \left[\text{Even part of } \frac{Q(z)}{Q(-z)}\right]_{z^2 = (s^2+1)/s^2} \tag{6}$$

where $Q(z)$ is a Hurwitz polynomial.

Allowing an envelope-delay tolerance δ in the interval $|\omega| < 1$, Fig. 3, the R-function is introduced in the equation

$$R(s) = \frac{1}{\delta}\left[\tau_0 - t(s)\right] \tag{7}$$

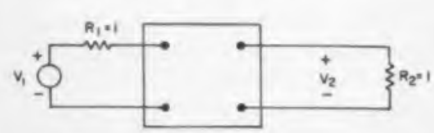

Fig. 1. Operating voltage transfer function of the network function to be synthesized is $V_1/2V_2$.

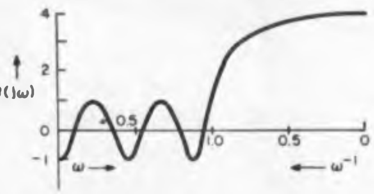

Fig. 2. The Tchebycheff rational function, $R(s)$, for $s = j\omega$, $n = 5$.

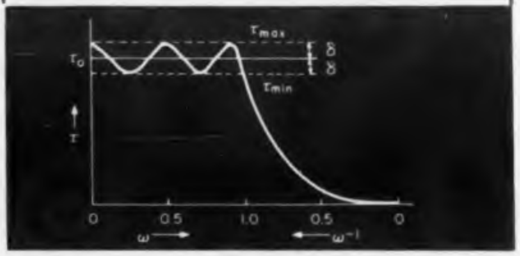

Fig. 3. Envelope delay characteristics corresponding to Eq. 7 and Fig. 2.

where τ_0 is the (normalized) desired delay.

The transformations linking the s and z planes

$$z^2 = (s^2 + 1)/s^2 \text{ and } s^{-2} = (z^2 - 1)$$

result in

$$\tau_0 = \frac{\delta}{2}\left[\prod_1^n \left[\frac{z_k + 1}{z_k - 1}\right] + \prod_1^n \left[\frac{z_k - 1}{z_k + 1}\right]\right] \qquad (8)$$

The singularities z_k (and therefore the corresponding s_k values) are obtained by solution of the equations

$$\frac{(z^2m - 1)^{3/2}}{z^2m} + \delta \prod_{\substack{k=1 \\ k \neq m}}^{n} \left(\frac{z_k + z_m}{z_k - z_m}\right) = 0 \qquad (9)$$

$$m = 1,2, \ldots n > 1$$

or for $n = 1$

$$(z_1^2 - 1)^{3/2}/z_1^2 + \delta = 0$$

where one chooses

$$Re\,[(z_m^2 - 1)^{1/2}] < 0$$

Although explicit solution is not possible for $n > 2$, convergent iteration procedures can be established for the use of digital computers.

The original paper includes a description of the iteration scheme, tables of singularity location for polynomials up to $n = 10$ and tolerances up to $\delta = 0.5$, numerical examples and detailed proofs.

Abstracted from an article by E. Ulbrich and H. Piloty, Archiv der Elektrischen Uebertragung, *Vol. 15, No. 10, Oct. 1960, pp 451-467.*

GERMAN ABSTRACTS

E. Brenner

Microwave Phase Shifters

THE CONSTRUCTION of circulators requires reciprocal as well as nonreciprocal phase shifters. One reciprocal phase shifter consists of a rectangular guide that is partially filled with dielectric, Fig. 1. For this arrangement the difference in propagation constant, $\Delta\gamma$ can be calculated approximately. A typical result is shown in Fig. 2. Measurements confirm the calculations for small dielectric "loading" ($d \ll a$).

To determine the frequency characteristics of the structure, the change in difference of propagation constant with frequency is calculated. Normalized, a meaningful function is:

$$\psi = \frac{\delta\,(\Delta\gamma)}{\delta\omega} \cdot \frac{\omega}{\Delta\gamma}$$

which is plotted in Fig. 3. For $d \ll a$ it can be shown approximately that:

$$\psi \approx \frac{2\,(\pi/a)^2 - \omega^2\,\mu_o\,\epsilon_o}{(\pi/a)^2 - \omega^2\,\mu_o\,\epsilon_o}$$

Although ψ approaches zero when the guide wavelength is $\sqrt{2}$ times the free space wavelength for $d/a = 0.01$, these values cannot be used in practice because 90-deg phase shifters would have to be several hundred wavelengths long.

To investigate nonreciprocal phase shifters the structure shown in Fig. 4 is used. A ferrite strip of height h and width b, biased by an external

Fig. 1. Rectangular guide of reciprocal phase shifter is partially filled with dielectric.

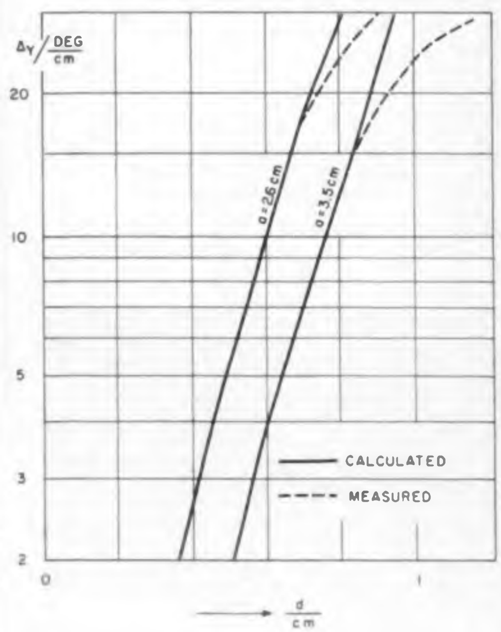

Fig. 2. Measured and calculated phase characteristics taken at 7.4 Gc

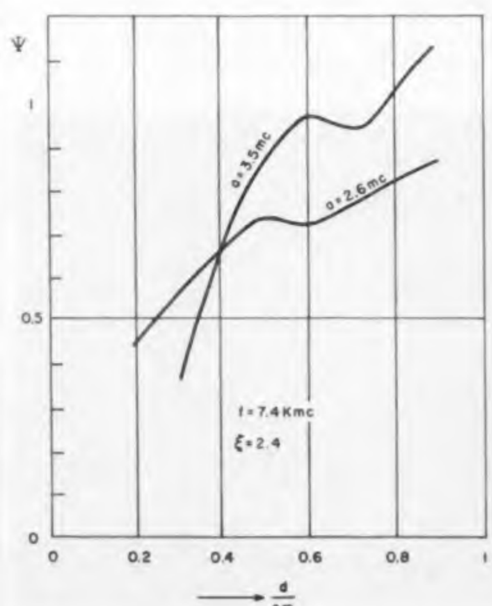

Fig. 3. The frequency function ψ plotted as a function of dielectric width *d*.

GERMAN ABSTRACTS

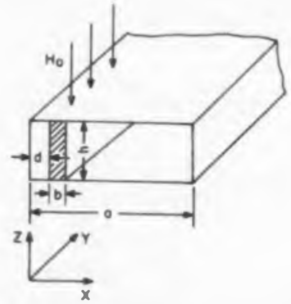

Fig. 4. Nonreciprocal phase shifter has ferrite slab placed in middle of rectangular guide.

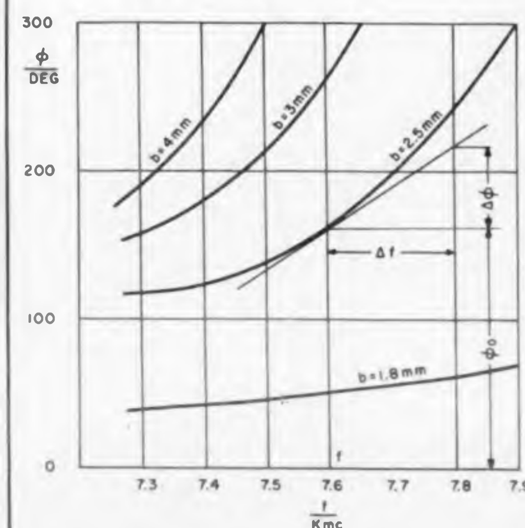

Fig. 5. Phase difference as a function of frequency with ferrite width as parameter. Length = 10 cm, h = 1.3 cm, field strength H_0 = 400 oersted.

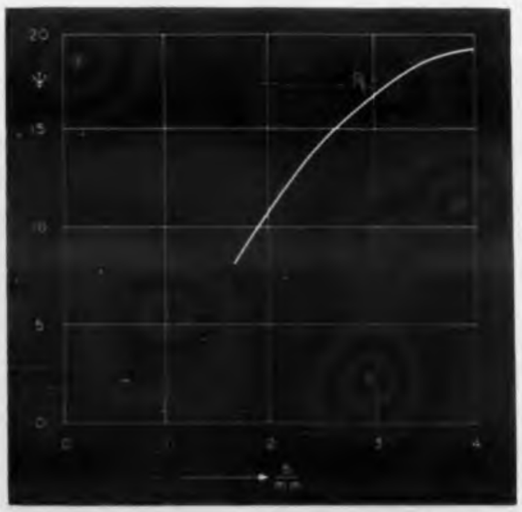

Fig. 6. The frequency function ψ as obtained from Fig. 5.

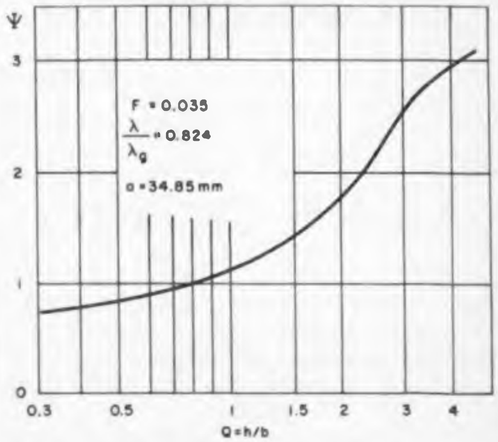

Fig. 7. Frequency function ψ plotted against height-to-width ratio of ferrite.

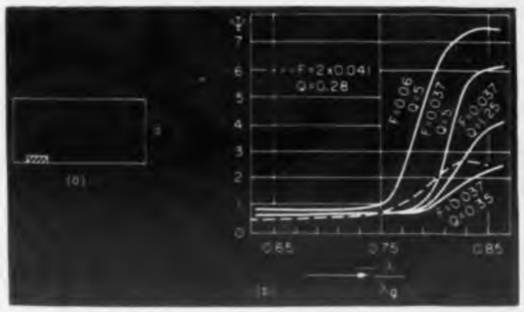

Fig. 8. Characteristics of sample ferrite phase shifters.

magnetic field H_o is placed in the guide. Of interest is the difference in propagation constants between the positive and negative y directions. Typical plotted results are shown in Fig. 5; the frequency dependence factor $\psi = \Delta\phi(f/\phi_o)\Delta f$ is plotted in Fig. 6.

The effect of geometrical variation is conveniently studied by using a constant area ferrite strip (bh = constant). It is useful here to define a "filling" factor, F, as the ratio of ferrite to total cross-sectional area. In Fig. 7 the frequency function ψ is plotted as a function of $\rho = h/b$. In obtaining this curve the magnetic field is not kept constant but is, for each measured point, adjusted to a value H_{max}. This is the value of H at the knee of a phase shift – H_o curve.

In designing ferrite phase shifters, large values of F are used to obtain large phase shifts for short lengths of guide. To obtain small phase error over the band, ψ must be small. Hence, the ratio h/b is generally chosen between 0.2 and 0.6. For matching, the guide width of the phase shifter is chosen so that λ/λ_g is between 0.63 and 0.8. For the geometry of Fig. 8, typical results are plotted in Fig. 8b.

Abstracted from an article by E. Pivit, Frequenz, *Vol. 14, No. 11, Nov. 1960, pp 369-378.*

GERMAN ABSTRACTS

E. Brenner

An RC Predictor

AN IDEALIZED chain of differentiators and scaling amplifiers, Fig. 1, can be used to predict an appropriately differential signal, $v(t)$, which can be represented by the Taylor series:

$$v(t+\Delta t) = \sum_{k=0}^{\infty} \frac{(\Delta t)^k}{k!}\left(\frac{d^k v}{dt^k}\right)_t \tag{1}$$

The frequency response function for the ideal system:

$$\frac{V_{out}}{V_{in}} = e^{j\omega\Delta t} \tag{2}$$

cannot be realized with a finite number of elements. However, when the signal is band-limited.

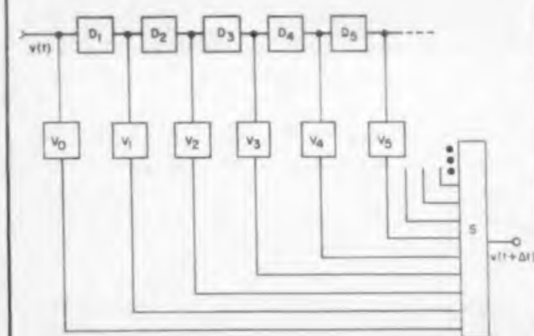

Fig. 1. Ideal predictor. The blocks marked *D* are differentiators; those marked *V* are amplifiers and S is a summer.

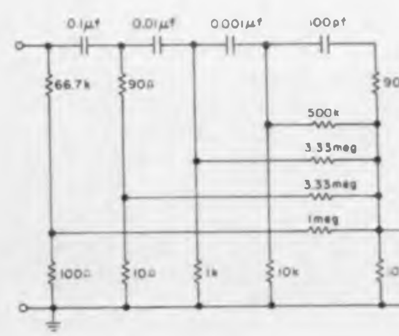

Fig. 2. Four-stage RC predictor.

so that zero (insignificant) spectral components exist above a frequency f_0, then the finite series:

$$\sum_{k=0}^{n} \frac{(j\omega\Delta t)^k}{k!}$$

represents a transfer function which can approximate the predictor properly.

In Fig. 2 a four-stage predictor is shown; decoupling between stages is achieved by choice of the impedance level. The predicting time Δt is 200 μsec. The network was incorporated in the test system of Fig. 3 to predict the waveform of filtered noise in the audio frequency range. Typical oscilloscope records are shown in Fig. 4.

Abstracted from an article by A. Schief Archiv der Elektrischen Uebertragung, *Vol. 15, No. 2, Feb. 1961, pp 91-93.*

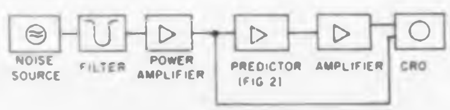

Fig. 3. Block diagram of test system.

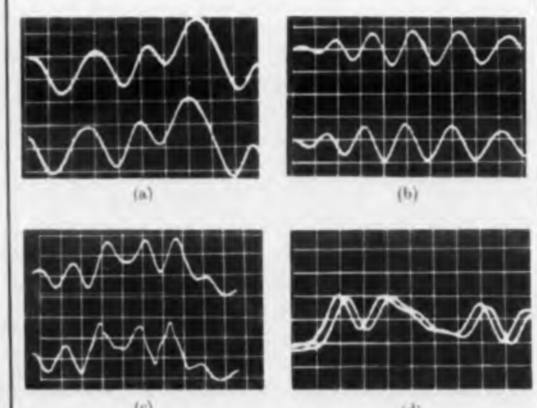

Fig. 4. (a) Noise in band 30 cps to 1 kc; Top: input, bottom: output. Prediction time 500 μsec/division left to right. (b) Similar to (a) but band selected is centered about 1 kc. (c) Similar to (a) but band selected is 30 cps to 1.4 kc. (d) Same as (a) but both input and output are superposed.

In-Transit Bouncing of Packages Studied By Air Force

JUST HOW roughly are packages handled in shipment? A recently completed Air Force study attempted to answer this question by measuring the maximum distance a variety of packages were dropped while in transit.

Study results led to a rule-of-thumb estimate that packages of the size used in the test would not be dropped more than 29 in. This conclusion was based on a recording of drops of a group of cleated and banded plywood containers, measuring 19-in. square, on 49 cross-country shipments by air, rail, and truck, from Wright-Patterson Air Forch Base, Ohio. The packages were shipped as far east as New York, as far west as California, and as far south as Texas.

Using the results of these shipments as a guide, the Air Force considers a test drop of 21 in. adequate for measuring the ability of packages of similar size and construction to withstand the rigors of actual shipping conditions.

Shock-Recording Instruments Concealed in Packages

To insure scientific accuracy, the Air Force used shock-sensitive recording instruments concealed inside ordinary-looking plywood containers. Personnel handling the test containers tossed them about as they would any other item. However, each bump, jolt, and drop was being registered by calibrated stylus on wax coated paper fed from a roll inside each container.

During the study, several test packages were inadvertently marked "Fragile, Handle With Care." The shock-recording instruments indicated that these packages were not necessarily handled more carefully, so this mismarking did not invalidate the study. But in fairness to the package handlers, the report emphasizes that the similar shock figures obtained for fragile as well as unmarked packages are based on packages making only 11 out of the 49 test trips. So it is still uncertain whether or not it pays to mark a package "fragile."

Comparative data collected from packages making air, rail and truck transit show no trend which would indicate one type of carrier handled packages more carefully than the others. It was noted however, that most incoming packages were handled more carefully than outgoing packages. Shocks recorded in instruments in incoming packages usually were smaller in magnitude than those recorded in outgoing packages.

Study Recommends Test-Drop-Heights for Packages

The major conclusion of the study is that accurate measurement of shock environment, and estimation of probable average and maximum safe test-drop-heights, is not only possible but feasible. Using commercially available shock-recording instruments costing less than $200, the Air Force established the recommended test-drop-heights for its shipping containers.

The report points out that only drop tests representative of the shipping environment are effective indicators that a shipment is properly packaged for safe transit. One reason the survey was conducted is the fact that drop-test heights are often arbitrarily set and are not representative of the shipping environment. Because of shortcomings of the shock-recording equipment and the limited scope of the study, the data gathered are not considered sufficient to assure the accuracy of all reported test-drop-heights. But the data do show the frequency and distribution of significant shocks incurred by a particular type of container during normal shipping. And, they point the way to the establishment of reliable test-drop-height standards.

Shock-probability graphs compiled from data obtained in the study indicate that there is less than one per cent chance of the average test package being dropped more than 29 in. at any one time during shipping. Only eight out of 1,000 drops were greater than 29 in. The report of the survey includes percentage figures of drop probability for other heights and discusses problems associated with shock damage prevention. The shock-recording instrument used is described and installation, calibration and recording techniques are explained. Data collected are analyzed and presented in graphs.

Digested from Measuring Field Handling and Transportation Conditions. K. W. Bull, Capt., USAF, and Dr. C. F. Kossack, Purdue University, for Wright Air Development Division, U. S. Air Force, Feb. 1960, 39 pages. (Order PB 161918 from OTS, U.S. Department of Commerce, Washington 25, D. C., price $1.)

REPORT BRIEFS

Semiconductor Delay Lines

The drift of minority carriers in an electric field in a semiconductor can be used for delaying a video signal. Equations are developed for the delays and rise times that may be expected. At room temperature, delays of tens of microseconds with rise times of the order of one microsecond can be obtained. At lower temperatures, the delays and rise times are both shorter. It is shown that the ratio of delay to rise time depends only on the temperature and on the potential difference through which the carriers drift. *Semiconductor Delay Lines, J. J. G. McCue, April 15, 1958, 8 pp, Microfilm $1.80, Photocopy $1.80. Order PB 150609 from Library of Congress, Washington 25, D.C.*

Pulse Compression

Described here is a method for suppressing the sidelobe level of a phase-coded pulse autocorrelation function to any desired level. The sidelobes are suppressed by mismatching the receiver. Consequently, the detection capability is reduced. The method is explained by an example in which a weighting network is designed to suppress the sidelobes of a particular phase-coded pulse autocorrelation function. A bound is placed upon the loss in detection caused by this weighting. *A Method Of Sidelobe Suppression In Phase-Coded Pulse Compression Systems, E. L. Key, E. N. Fowle, and R. D. Haggarty, Aug. 28, 1959, 8 pp, Microfilm $1.80, Photocopy $1.80. Order PB 150597 from Library of Congress, Washington 25, D.C.*

Pulse Compression

A pulse-compression method is presented which requires that the receiver be an exact matched filter to the transmitted signal. In addition, the transmitted waveform is made to have an approximately rectangular envelope. The method permits the receiver output or autocorrelation function, the time duration and envelope shape of the signal to be independently specified. The method depends upon the ability to specify the phase characteristic of a dispersive all-pass network. An approximate expression for the phase characteristic is derived in terms of the envelope shape desired and the signal energy density spectrum. *A Method Of Pulse Compression, E. L. Key, E. N. Fowle, and R. D. Haggarty, Lincoln Laboratory, Massachusetts Institute of Technology, Lexington, Mass., Aug. 13, 1959, 11 pp, Microfilm $2.40, Photocopy $3.30. Order PB 150595 from Library of Congress, Washington, D.C.*

Communication Channels

Briefly summarized is the progress made in miscellaneous studies of communication channels. The following topics are discussed: (1) a numerical method for approximating the capacity of a symmetrical binary channel with uniform digit spacing, exponentially decaying memory, and additive Gaussian noise, (2) the combination of discrete channels to form cascaded, sum, product, or other networks to achieve increased range, capacity, or reliability, (3) feedback systems for the reduction of multipath distortion, (4) a study of mathematical techniques applicable to the combination of fallible formal neurons as proposed by McCulloch. *Studies Of Communication Channels, Sze-Uou Chang, Robert D. Klein and others, Electronics Research Laboratory, Northwestern University, Evanston, Ill., May 17, 1960, 43 pp, Microfilm $3.30, Photocopy $7.80. Order PB 150645 from Library of Congress, Washington 25, D.C.*

Harmonic Distortion

A theoretical analysis, supported by experimental measurements, was made of amplifier and cathode-follower circuits to correlate nonlinear distortion with the various parameters in vacuum-tube circuits. The analysis shows that under certain operating conditions minimums may exist for the various harmonics in a vacuum tube circuit. These minimums do not ordinarily occur for different harmonics under identical operating conditions. Measurements were made using 6AK5 and 6C4 tubes at audio frequencies. However, the analysis is also valid for broadband amplifiers at higher frequencies. *Harmonic Distortion In Amplifiers, S. R. Swanson and W. G. Long, Jr., Naval Research Laboratory, Washington, D. C., June 17, 1952, 15 pp, Microfilm $2.40, Photocopy $3.30. Order PB 153576 from Library of Congress, Washington 25, D. C.*

Digital Computers

Written for those who do not have specialized knowledge of electronics or digital computing, this introduction to electronic digital computers contains a preliminary guide to computer programing. The report reviews current applications of digital computers, and cites some of the varied uses of computers in science, engineering, and business. Mathematical aspects of digital computing are discussed, and practical factors of computer programing are reviewed. *An Introduction To Digital Computers, B. F. Green, Jr., Lincoln Laboratory, Massachusetts Institute of Technology, August 1960, 46 pp, $1.25. Order PB 171100 from OTS, Washington 25, D. C.*

REPORT BRIEFS

Magnetic Amplifiers

Three types of self-saturating magnetic amplifier circuits are analyzed in a general form, useful for design purposes. Based on ferromagnetic domain walls theory, a general core function in terms of mmf, and flux ϕ is derived. *Ferromagnetic Core Functions In The Analysis And Design Of Self-Saturating Magnetic Amplifiers, H. C. Bourne and D. Nitzan, Dec. 1, 1959, 122 pp, Microfilm $6.30, Photocopy $19.80. Order PB 146750 from Library of Congress, Washington 25, D.C.*

Magnetic Modulators

A polyphase modulator is described whose output pulse-repetition rate is greater than the input ac frequency by an integral factor. Experimental results on four basic three-phase connections showed that all circuits can be made to operate in a stable and balanced manner, yielding three output pulses per cycle having equal amplitudes and interpulse spacing. The effects of phase interaction on required modulator size, stability, and ease of balance were investigated. *Three-Phase Magnetic Modulators, Edward J. Smith, July 7, 1960, 42 pp, Microfilm $3.30, Photocopy $7.80. Order PB 150875 from Library of Congress, Washington 25, D.C.*

Binary Communication

A new binary decision-feedback system is described which is very effective for high-reliability transmission when the channel is subject to fading, intermittent strong noise bursts, or other changing conditions. The results presented suggest that this problem can be solved by employing long codes with feedback, correcting only a very small number of errors, and utilizing a new technique which effectively prevents any type of disturbance in the feedback channel from harming system reliability. *Reliable Fail-Safe Binary Communication, J. J. Metzner and K. C. Morgan, New York University College of Engineering, New York, July 10, 1960, 76 pp, Microfilm $4.50, Photocopy $12.30. Order PB 152791 from Library of Congress, Washington 25, D. C.*

Strip Line Filters

An analysis of a strip line traveling-wave loop directional filter is performed to optimize the device as a band rejection filter. A method for choosing the optimum physical parameters is developed. Several illustrative examples are given to show that a considerable difference exists between the optimum band pass and optimum band rejection designs. *Optimization Of A Strip Line Traveling-Wave Loop Directional Filter As A Band Rejection Network, Robert D. Standley, Army Signal Research and Development Laboratory, Fort Monmouth, N. J., July 1, 1960, 23 pp, Microfilm $2.70, Photocopy $4.80. Order PB 153003 from Library of Congress, Washington 25, D. C.*

Dielectrics

The effects of simulated high altitude environment on the electrical properties of electrical insulating materials are reported. Tests were made for periods up to 96 hr in high vacuum, in the presence of ultraviolet and 50-kv X-ray radiation. Measurements of flash-over strength from 60 cps to 18 mc, dielectric constant and dissipation factor from 60 cps to 100 mc, and dc surface and volume resistivity were made on Alathon 4 BK 30, Alox (aluminum oxide), glass polyester laminate, and Formica FF-95 printed-wiring board. *Dielectrics For Outer Space, Louis J. Frisco, Dielectrics Laboratory, Johns Hopkins University, Baltimore, Md., May 31, 1960, 66 pp, Microfilm $3.90, Photocopy $10.80. Order PB 150806 from Library of Congress, Washington, D.C.*

High-Speed Electronics

The following high-speed electronic circuits are discussed: scanners, high-speed logic circuits, flip flops, flip-flop gating circuits, buffers, special gating boards, super cathode followers, high-speed clocks, low-to-high speed clocks, power supplies, power supply sequencer, and low- and high-speed board testers. *High-Speed Electronic Circuits, International Telemeter Corp., Los Angeles, Calif., Nov. 1957, 116 pp, Microfilm $6.00, Photocopy $18.30, Order PB 147803 from Library of Congress, Washington 25, D.C.*

Miniature Transducer

Design, operating theory, and performance characteristics of a newly developed variable-reluctance, differential pressure transducer have been evaluated for the Air Force. Known as the "wafer gage," the transducer was designed for use primarily in arc-heated, hypervelocity wind tunnels. It provides a series of pressure ranges from 0-0.5 to 0-5.0 psid by interchanging diaphragms. *A Miniature Wafer-Style Pressure Transducer, W. E. Smotherman, Arnold Engineering Development Center, for U. S. Air Force, Oct. 1960, 39 pp, $1. Order PB 171104 from OTS, Washington 25, D. C.*

REPORT BRIEFS

Measuring RFI

An experimental harmonic calorimeter was built to measure harmonic powers in waveguide. By measuring the sum of the power levels of the individual waveguide modes at given harmonic frequencies, the total power can be found without mathematical analysis. This simpler measurement method (compared with the probe-analysis method) is performed at the expense of identification of the individual model power levels. *Measurement and Control of Harmonic and Spurious Microwave Energy, Vernon G. Price, General Electric Microwave Laboratory, Palo Alto, Calif., May 1960, 83 pp, Microfilm $4.80, Photocopy $13.80, Order PB 150281 from Library of Congress, Washington 25, D.C.*

Project Tinkertoy

The Tinkertoy system is one of a number of possible embodiments of the building-block principle of construction. With this principle complicated electronic equipment may be assembled from a number of small standardized units. Each such unit, or module, consists normally of an electron tube and its associated passive components. *Project Tinkertoy: A Bureau of Aeronautics Industry Preparedness Measure, National Bureau of Standards, Washington, D.C., June 1952, 54 pp, Microfilm $3.60, Photocopy $9.30, Order PB 149618 from Library of Congress, Washington 25, D.C.*

Electronic Countermeasures

Two methods are described for generating a multi-polarized wave for electronic countermeasures jamming purposes. They involve the excitation of two orthogonally oriented linear antennas at slightly different frequencies. Discussions and mathematical analyses of the performance of both systems are presented, and some experimental data are included. General design considerations are also outlined. *Generation of Multipolarized Electro-Magnetic Waves for ECM Applications, Edward F. Henry, Melpar, Inc., Falls Church, Va., Apr. 1960, 36 pp, Microfilm $3.00, Photocopy $6.30, Order PB 149751, from Library of Congress, Washington 25, D.C.*

FSK Communication

Optimum incoherent threshold detection of general FSK signals in normal noise is examined. The new feature of decision rejection, as well as decision acceptance, is used. Structure of the optimum threshold system is given, and the error and rejection probabilities associated with the Bayes risk are computed for general signals and arbitrary band lengths. Besides a detailed examination of the binary rejection cases, the theory of the multiple alternative detection process with decision rejection is also outlined. *Optimum Threshold FSK Communication With Decision Rejection, David Middleton, Air Force Cambridge Research Laboratories, Bedford, Mass., April 1960, 61 pp, Microfilm $3.90, Photocopy $10.80. Order PB 152985 from Library of Congress, Washington 25, D. C.*

Thin-Film Circuit

The formation of microminiature, functional thin-film circuit units, of essentially planar form factor, are described. A functional thin-film circuit is an integrated combination of single and/or multi-layer films which transform input energy into a desired form of output energy when connected to associated electronic circuitry. Ultimately a circuit fabrication method will be developed which will reduce size of electronic equipment by several orders of magnitude. See also PB 150808. *Thin Film Circuits Functions, H. J. Beatty, W. N. and others, International Business Machines Corp., Kingston, N.Y., Aug.-Oct. 1959, 72 pp, Microfilm $4.50, Photocopy $12.30, Order PB 150807 from Library of Congress, Washington 25, D.C.*

High-Temperature Semiconductors

This work for the Air Force is to some extent a continuation and extension of research in the field of compound semiconductors and devices undertaken at RCA Laboratories in 1953. Through this research, gallium arsenide and indium phosphide emerged as the most promising semiconductors for high-temperature applications. This report contains a detailed description of the scientific results obtained in research programs on these materials, basic physical measurements, and devices. The section on materials reports progress in the purification, crystal growth, and evaluation of the compounds, GaAs and InP, with major emphasis on GaAs. The section on basic physical measurements contains reports on determination of impurities in GaAs, diffusion in GaAs and InP, and minority carrier lifetime in GaAs. The report on devices describes accomplishments in the fabrication of diodes, rectifiers, and transistors of both GaAs and InP. *High-Temperature Semiconductor Devices, F. D. Rosi and P. Rappaport, Radio Corp. of America for U. S. Air Force, Oct. 1959, 124 pp, $2.75. Order PB 161541 from OTS, Washington 25, D. C.*

LETTERS

Pleads for More Technical Ads and Literature

Dear Sir:

An engineer interested in an advertised product wants to know more about it. So he requests the advertiser to send him complete specifications of the item—especially its chemical, physical, electrical, etc., properties—and to explain the method by which the results were obtained.

Instead of clear-cut, detailed technical information, he may receive one of two things: a two or four-page flier, full of generalities but no definite data; or a questionnaire asking several questions that cannot be answered, especially the question about the quantity that the engineer expects to purchase yearly. The worst alternative is the third one: a card asking the engineer to get in touch with the company's sales engineer.

Most of us engineers, design and development, have concluded that it is useless to return a magazine post card with hundreds of numbers, because we do not achieve our aim, which is to have on hand reliable data to be employed in our design work.

Without this explicit and technically correct information we cannot be interested in the advertised product, no matter how colorful it is or which magazine carries it.

Advertisers should realize that most of us are not purchasing agents. We do not buy, but we specify.

Charles L. Pataky
Dover, N.J.

Need a Chain For ELECTRONIC DESIGN?

I wanted to take this opportunity to tell you how much I enjoy Electronic Design. For up-to-the minute reports on what is new and news in the various fields of electronics, *ED* has no equal. I am especially interested in the transistor and tunnel diode circuit design articles and articles on the status of Soviet engineering.

Since I am the sole *ED* recipient in my area, the bi-weekly arrival of my copy is an eagerly awaited event in my office. My copy is read by eight engineering officers and nearly the same number of enlisted technicians. Occasionally I even get to read it first.

The Jan. 18 issue (Vol. 9, No. 2) seems to have been especially popular. After reading the magazine and marking the articles I wished to cut out of my files, I passed *ED* on for circulation. Apparently others liked the same articles; that issue has disappeared, with everyone claiming complete ignorance of its whereabouts.

In view of these circumstances, I wonder if it would be possible to obtain an extra copy of the Jan. 18 issue. It would be greatly appreciated.

Thanks again for an outstanding publication.

Kenneth S. Goldstein
2d Lt., AS(SigC)
Actg Chief, L Branch

▶We confess, as perfectionists, we sometimes doubt we're *that* good. But we wouldn't for the life of us question the word of an officer and gentleman. No, sir. Your copy of the Jan. 18 issue has been sent, sir.

Change Mickey-Mike to Pike?

Dear Sir:

Due to the recent adoption by the industry of the "picofarad" designation for the old "micro-microfarad" one, a change in verbal abbreviation seems appropriate.

The old verbal one was "mickey-mike." The new one could be any of these:

peck, pike, pif, puf

My suggestion is for "pike" since it more nearly follows the actual units designation (pronounced pike-o-farad).

Any comments on this earth-shaking idea?

D. C. Friedmann
Associate Engineer
Westinghouse Electric Corp.
Baltimore, Md.

▶ We think Mr. Friedmann's idea one of the best to come down the pike. Nevertheless, we think pik-o, which is strikingly similar to pico, is more logical in this era of Kiddo and Daddy-o. Other opinions are welcome.

Accuracy Is Our Policy . . .

A missile nose-cone recovery beacon capsule shown in the March 29 issue, p 36, was used in the Atlas and Titan missiles rather than in Project Mercury, as stated. The capsule was developed by Avco Corp. A similar capsule has been used in the Mercury program.

It Doesn't Pay To Be Perfect

"The perfect solution is often the wrong one," says Y. J. Lubkin. "Before you tackle a problem you should know how wrong you should be if you want to do the job right." In "It Doesn't Pay to Be Perfect," Mr. Lubkin gives directly useful equations and curves to help one determine how wrong one should be to be right.

Yale Jay Lubkin
Loral Electronics Corp.
New York, N.Y.

"THERE COMES a time to shoot the designers and start production."

This motto hangs over many a production man's desk. It is considered in a class with divine revelation. Generally, the designer, the production engineer, and the program manager have little quarrel over the statement *per se*; the fireworks start over the question "When do you start production?"

All interested parties will have definite opinions on the subject, and all opinions will likely differ from one another. This article will explore techniques for arriving at a more-or-less objective decision on timing. Application of the techniques will provide a rational basis for decision, but will not guarantee harmonious relations.

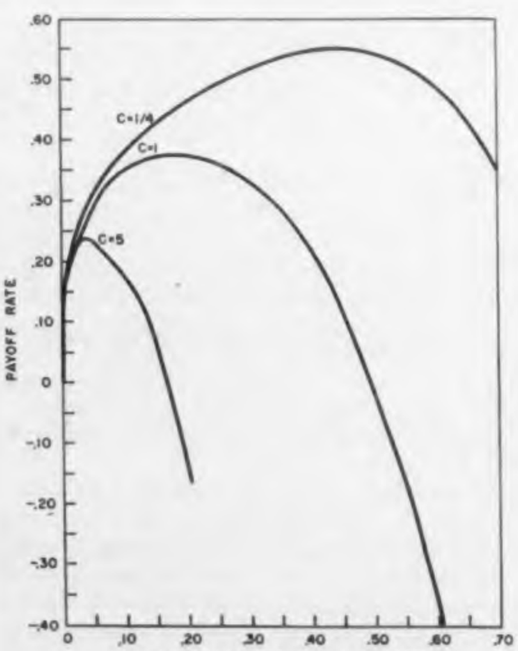

Fig. 1. Payoff rate plotted against probability of wrong decision with an assumption of no waiting time between problems.

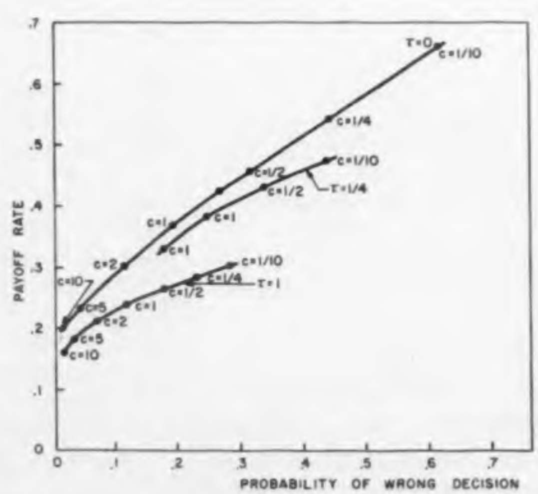

Fig. 2. Payoff rate at maximum payoff plotted against probability of wrong decisions for different time delays (τ) between problems.

Steady-State Problem Can Be Considered First

The first problem to be considered is a steady-state situation. The steady state never really occurs in life since one must start at some finite time and finish at some finite time. But it is a convenient starting point for analysis, as many problems can be approximated conveniently by a steady-state approach. Steady-state approximations hold well in those problems where the reward for successful completion is substantially constant over the anticipated solution time.

We assume that the number of problems to be solved (or designs to be designed) is boundless so that as soon as one is finished another can be started, that there are only good designs and bad designs (no *almost* good designs, for instance), that the reward for a good design is one unit, and the penalty for a bad design is c units. We assume that the state-of-the-art is static so that a good solution is worth one unit no matter when the solution is completed. Lastly, we assume that it takes an infinite amount of time to be absolutely certain of getting a good design, and that, in general, the probability of having a good design after working on it for t days is

$$p_g = 1 - e^{-t} \qquad (1)$$

This set of conditions applies to a wide variety of problems—circuit design, stock trading, techniques programs, hiring personnel and sorting oranges, for example.

If we assume that the reward for any problem equals the reward for any other problem and that the penalties for all problems are equal, then the time one should spend on a solution is the same for all problems. If this time is t days, then the average reward per problem is

$$\text{Reward} = 1 - e^{-t} \qquad (2$$

The average penalty per problem is

$$\text{Penalty} = ce^{-t} \qquad (3)$$

and the payoff rate, the average net reward per unit time, is

$$P = \frac{1}{t}\left[1 - (1 + c)e^{-t}\right] \qquad (4)$$

Payoff rate (reward or penalty) can be expressed in such terms as dollars per day.

Designer Must Try To Maximize Payoff

We now take a flying leap into fancy and assume that the rational designer will wish to maximize his payoff rate. If we take the appropriate derivatives, we find that the probability of a bad design at the maximum payoff rate is

$$p_b = e^{-t} = \frac{1}{(1 + c)\,(1 + t)} \qquad (5)$$

Consideration of the probability of a bad design at maximum payoff rate leads naturally to the question of how wrong one should be to maximize his payoff. This is a tricky question because, generally, one's boss is not so concerned with overrunning on time as he is with occasional bad solutions.

Eq. 5, plotted in Fig. 1, shows the payoff rate

as a function of the probability of a wrong decision. Note that when the penalty for being wrong is low ($c = 1/4$) it pays to be wrong very often—half the time or even more. The payoff rate is very high under these conditions. Many successful stock-market speculators have become rich because of this phenomenon.*

As the penalty for being wrong increases, it becomes more necessary to be right, and the payoff rate drops. When the penalty for a bad design equals the reward for a good one, the maximum return occurs when one is wrong about 20 per cent of the time. As the penalty increases, one must be more nearly perfect, and the maximum payoff rate drops.

More General Case Allows Time Between Problems

If we change one of the ground rules, we can obtain some very useful information. The previous problem considered the natural environment for a designer—enough work is piled on his desk so that he never has to wait between problems. Now, we will allow a breathing spell of τ days between problems.

The equations for payoff rate and probability of bad design, equivalent to Eqs. 4 and 5, now become.

$$P = \frac{1}{t+\tau}\left[1 - (1+c)e^{-t}\right] \qquad (6)$$

$$p_b = e^{-t} = \frac{1}{(1+c)\,(1+t+\tau)} \qquad (7)$$

Eqs. 6 and 7 are plotted in Fig. 2. We can see immediately that the best payoff occurs when there is no waiting time between problems—just as we would expect.

More important than the drop in payoff is the required decrease in the probability of being wrong as the waiting time increases. For example, with a small penalty, $c = 0.1$, one should be wrong 60 per cent of the time with no waiting time; 44 per cent with 1/4 day waiting time, and 27 per cent with one day waiting time, as shown in Fig. 2. In the last case, Eq. 7 shows 1.3 days will be spent solving the problem.

Steady-State Approach Is Not Always Possible

Frequently one is not able to work with steady-state problems. In initial system design, for instance, the sooner a good design is finished the more it is worth, because the system tends to be frozen as time goes on.

*For those of an adventurous bent, the rules are: (1) Don't buy unless you expect the stock to double. (2) Cut your losses and let your profits run. If you follow these rules, c is about 0.15.

Conversely, a bad design at the very beginning has a good chance of being caught before production, while one deferred until just before system design is frozen, may not be discovered until system test.

In the experience of the author, initial system design presents so many problems that no waiting time is necessary and the situation is similar to that shown in the $\tau = 0$ curve of Fig 2. At the start of a system design, the designer will be at a point of the curve given by some low value of c. He should arrange his operations so as to be fast rather than extremely accurate. As the job advances, c increases, and the optimum point moves down the curve. As time passes, the designer should devote more effort to accuracy and less to speed.

Good Manager Makes Rapid Decisions

Under certain circumstances, one is perpetually in a situation of initial system design since further design is left to one's staff or to another group. This is typified by an advanced systems group or by a high-level manager. In examining the characteristics of spectacularly successful managers, one is struck by the preponderance of people noted for making quick decisions.

In all situations covered so far, the probability of being right increased with time. This is not always the case; the probability may, for instance, rise to some maximum level, then fall. It may even fall abruptly to zero, as in the case of a pedestrian in the process of being run down by a taxi. If he waits too long to decide which way to jump, the decision becomes academic.

We can also consider cases where the reward and penalty vary with time; in fact, we have already done so. In considering preliminary systems design, we tacitly assumed that the reward and penalty varied much more slowly than the probability of success. If this is not the case, the analysis becomes more difficult.

Under certain conditions the reward may vary with time in an unknown manner, and there may be a penalty for failing to reach a decision by a certain known or unknown time. Problems of this sort include trying to be first on the market with a new product and deciding when to fire in a duel. Solutions to these problems involve considerably more work than is indicated here and fall into the realm of operations analysis.

At the beginning of the article, it was implied that knowledge of the technique discussed would not necessarily lead to three-part harmony. In posing a problem, one has to specify the reward, penalty, and probability of success as a function of time. These, presumably, are more accurately specified than the time one should spend on the problem. ■ ■

YOUR CAREER

NEWS AND NOTES

Where do engineers fit into President Kennedy's New Frontier? They can help the country best by continual development of their professional skills, says Jerome B. Wiesner, scientific adviser to the President. His observation was contained in a reply to the following questions from Electronic Design:

- What can an electronic engineer do to promote the national growth, which President Kenedy says is so necessary to the future of this country?
- Does the Administration favor aid or other encouragement to engineers who are furthering their education?

Avoiding the question of Government educational aid to engineers, Mr. Wiesner said: "We need to continue to develop and further the professional skills of our nation's practicing engineers. The engineer, no less than the medical doctor, must seek a deeper understanding of the sciences on which he builds and the materials and techniques he uses.

Though Mr. Wiesner didn't mention how, he did say that all parts of the national community—industry, universities and public institutions—should encourage engineers to develop their special capacities for helping solve the problems of our time.

Aside from the fact that these statements came from a Presidential adviser, they did not appear a great deal different from many others that engineers have been hearing for some time. Electronic Design would be interested to hear its readers' views on what they think engineers can do for their country and what their country can do for them. If you have opinions, write Editor, Career Section, Electronic Design, 850 Third Ave., New York 22, N.Y.

• • •

Research of potential importance to electronics is being carried out by at least six of the thirteen young scientists now in the National Bureau of Standards Post-Doctoral Research Associate Program. The men and their research interests are:

- Dr. Solomon J. Glass, physicist—theory of irreversible processes with particular application to electrical conductivity in solids.
- Dr. Robert E. La Villa, physical chemist—characteristic energy losses of electronics in metals and alloys.
- Dr. Frederick H. Meis, chemist—energy transfer of collision between atoms and molecules.
- Dr. Robert S. Powers, physical chemist—

effects of plasma sheaths during electron beam-plasma oscillations.

■ Dr. Theodore N. Sarachman, physical chemist—hindered internal rotation and related intramolecular interactions in halogenated derivatives of hydrocarbons by the microwave spectroscopic techniques in use at NBS.

■ Dr. James F. Schooley, physicist—cryophysics investigations in paramagnetism, to study the thermal properties of diamagnetic crystals in contact with magnetically cooled paramagnetics.

Though the researchers are all either physicists, chemists or physical chemists, the work they are doing is directly related to the future of electronics.

• • •

Engineering freshmen enrollments have dropped in the nation's colleges for the third consecutive year, according to the Engineering Manpower Commission of the Engineers Joint Council, New York, and the Scientific Manpower Commission, Washington, D.C.

Registrations for the 1960-61 academic year were only about 100 less than the previous year's 67,700, but total college freshmen enrollments rose 12.4 per cent during the same interval. The proportion of engineering freshmen to total freshmen has declined steadily—from 10.8 per cent in 1957 to 7.3 per cent in 1960.

Meanwhile graduate engineering enrollments continue to rise: master's, up 5.1 per cent (31,200), and doctor's, up 14.3 per cent (6,400).

• • •

Job recruiting at major engineering technical meetings is fast getting out of hand, says Deutsch & Shea, Inc., technical manpower consultants.

Not only is it making some companies reluctant to send their engineers and scientists to the sessions, the New York agency contends, but it is also giving the public a poor image of the professional societies.

In a letter to the IRE, AIEE, etc., Deutsch & Shea has asked that they:

■ Agree to ban all interviewing, hospitality suites and recruitment advertising during technical meetings.

■ Request private companies at the shows to desist from job recruiting.

■ Urge the members of professional engineering societies to cooperate in the recruiting ban.

"Recent years," Deutsch & Shea notes, "have seen a sharp rise in lavish hospitality suites, stunts and gimmicks, massive advertising, hiring-hall procedures and other techniques more suitable for high-pressure sales exhibitions than for professional conferences."

At the recent IRE Show in New York about 3,000 engineers registered with such centers.

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Write Phil Nienstedt (Dept. 602)

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General Electric 2N1217 NPN's are characterized for starvation circuits under 2ma

Type No.	Maximum Ratings: P_T (mw) @ 25°C	B_{VCE} B_{VCB}	I_C ma	Electrical Parameters (25°C): MIN h_{FE}	@ I_C ma	MIN $f_{\alpha b}$ mc	MIN G_e db	MAX I_{CO}* (μa)	@ V_{CB}	Application
2N78	75	15	20	45	1	5	29	3	15	RF Amplifier
2N78A	75	20	20	45	1	5	29	3	15	RF Amplifier
2N78A (cert)	65	20	20	45	1	5	29	3	15	RF Amplifier
USA2N78A (per Mil-S-19500/90)	65	20	20	45	1	5	29	3	15	RF Amplifier
2N167	75	30	75	17	8	5	—	1.5	15	High Reliability High Speed Computer Switch
2N167A	75	30	75	17	8	5	—	1.5	15	
USAF 2N167A (per MIL-S-19500/11B)	70	30	75	17	8	5	—	1.5	15	
2N169A	75	25	20	34	1	—	27	5	15	General Purpose Low Noise Amplifier
2N1198	75	25	75	17	8	5	—	1.5	15	Computer Switch
2N1217	75	20	25	40	.5 – 2	6	—	1.5	15	Starvation Switch
2N1510	75	75	20	8	1		—	5	75	Neon Indicator Driver
2N1694	75	20	25	17	1	3	—	1.5	15	Decade Counter Switch

*Typical Ico at 70°C is less than 10 μa

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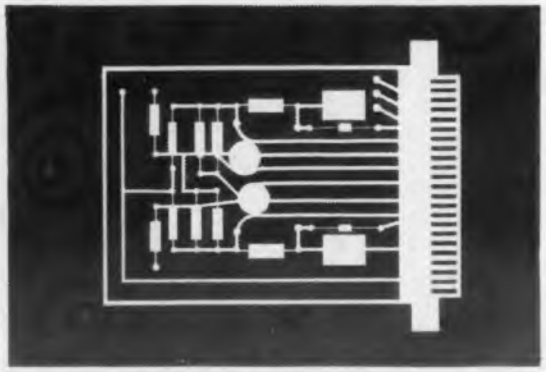

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USE BEFORE JULY 19th, 1961

C

Name ____________ Title ____________

Company ____________

Company Address ____________ City ____________ Zone ____ State ____

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290
1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161	171	181	191	201	211	221	231	241	251	261	271	281	291
2	12	22	32	42	52	62	72	82	92	102	112	122	132	142	152	162	172	182	192	202	212	222	232	242	252	262	272	282	292
3	13	23	33	43	53	63	73	83	93	103	113	123	133	143	153	163	173	183	193	203	213	223	233	243	253	263	273	283	293
4	14	24	34	44	54	64	74	84	94	104	114	124	134	144	154	164	174	184	194	204	214	224	234	244	254	264	274	284	294
5	15	25	35	45	55	65	75	85	95	105	115	125	135	145	155	165	175	185	195	205	215	225	235	245	255	265	275	285	295
6	16	26	36	46	56	66	76	86	96	106	116	126	136	146	156	166	176	186	196	206	216	226	236	246	256	266	276	286	296
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306	316	326	336	346	356	366	376	386	396	406	416	426	436	446	456	466	476	486	496	506	516	526	536	546	556	566	576	586	596
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609	619	629	639	649	659	669	679	689	699	709	719	729	739	749	759	769	779	789	799	809	819	829	839	849	859	869	879	889	899

For employment brochures give home address ____________ City ____________ Zone ____ State ____

Home Address ____________

For Change of Address:

Old Company Name ____________

Old Company Address ____________ City ____________ Zone ____ State ____

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ELECTRONIC DESIGN · ONE DAY SERVICE

USE BEFORE JULY 19th, 1961

D

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