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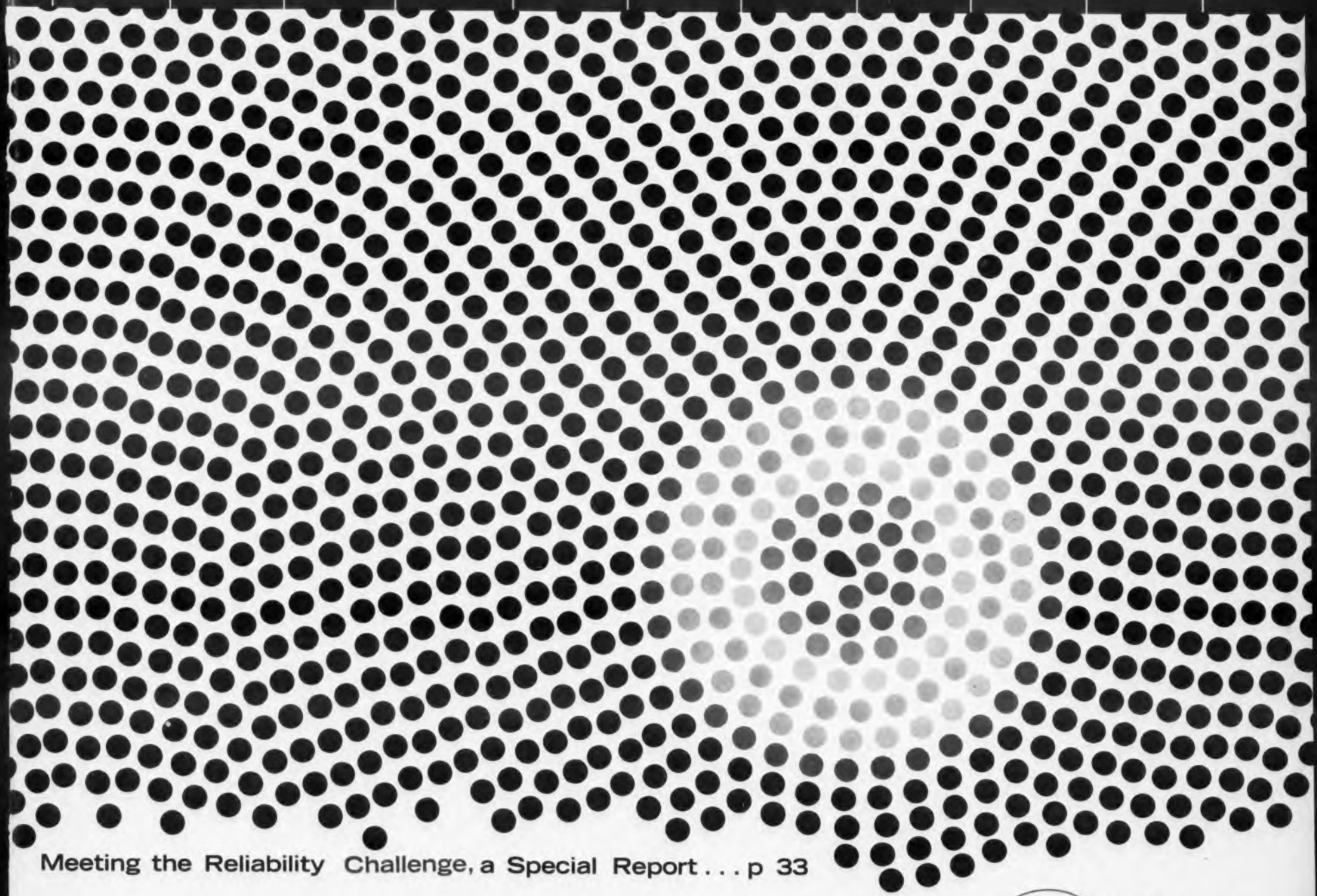

Meeting the Reliability Challenge, a Special Report . . . p 33

MICROWAVES . . . p 177

COVER: A well-designed electronic system containing many components, represented by the series of concentric circles, can be upset by just one single defect, indicated by the teardrop or distorted circle at the center. To call attention to the reliability challenge, the defect is shown in bright red, the same color used to highlight the word challenge.

Sidelights of this Issue

Reliability is probably the most important and widely publicized single word in the electronics industry today. Company pamphlets, product advertisements and technical conferences almost invariably include the subject of reliability. And for good reason. Multi-million dollar space programs, complex weapons systems, and large-scale business computers can be upset by the failure of one mere component.

Despite the erroneous label of "too much talk, too little action" hurled at reliability workers by engineers not involved in complex reliability programs, much has been achieved since the early efforts of simply recording field failures and tempting to diagnose their causes. Complete accounts of production-line as well as in-service field defects, analyses of failures, rapid feedback to design engineers and full-scale, in-plant quality assurance procedures have been combined to achieve considerable product and equipment improvement.

Much is still undone. But from the results and progress announced at recent conferences, the groundwork appears concrete and further gains will undoubtedly be forthcoming at a rapid rate.

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Radar in the Sun

Combining business with pleasure is especially satisfying when the business is itself a pleasure. Earlier this month, *ED* editor Alan Corneretto enjoyed such a situation during a business-vacation trip to Puerto Rico. One scheduled stop—the Advanced Research Project Agency's ionospheric research facility at Arecibo—turned out to be the highlight of the Puerto Rican trip.

As his article on p 8 of this issue indicates, the scope of this radar is overwhelming. Deep in semitropical wilds, swarms of workers are building a reflecting dish 1,000 ft in diameter. The dish sits in a much larger bowl, over which three towers rise about 300 ft from adjacent hills. The sight of this installation taking form in near-jungle is impressive. So is the concept of a radar this size, which originated with Dr. W. E. Gordon of Cornell University.

Dr. Gordon foresaw the usefulness of a radar antenna in which beam mobility would be traded advantageously for resolution. Unlike similar research instruments, the dish near Arecibo will not move; this makes its huge size possible. However, the radar's feed will be mobile enough to provide a conical, though narrow-angle, beam of useful dimensions. Use of a natural depression in Puerto Rico's limestone hills is adding to the savings made possible by the fixed design of the dish.

Although strikes, unusual rainfall, and drainage difficulties have delayed the project, Cornell engineers are confident that the huge radar, able to transmit 2.5-megawatt pulses, will be completed and will make major contributions to knowledge of the ionosphere. In passive operation, as a radio telescope, the dish and its ultra-low-noise receiver are expected to be useful in a variety of radio-astronomy experiments.

Surveying part of the Arecibo radar installation are, from the left, Dr. W. E. Gordon of Cornell University, originator of the project; L. M. LaLonde, project engineer; and Alan Corneretto ELECTRONIC DESIGN news editor.

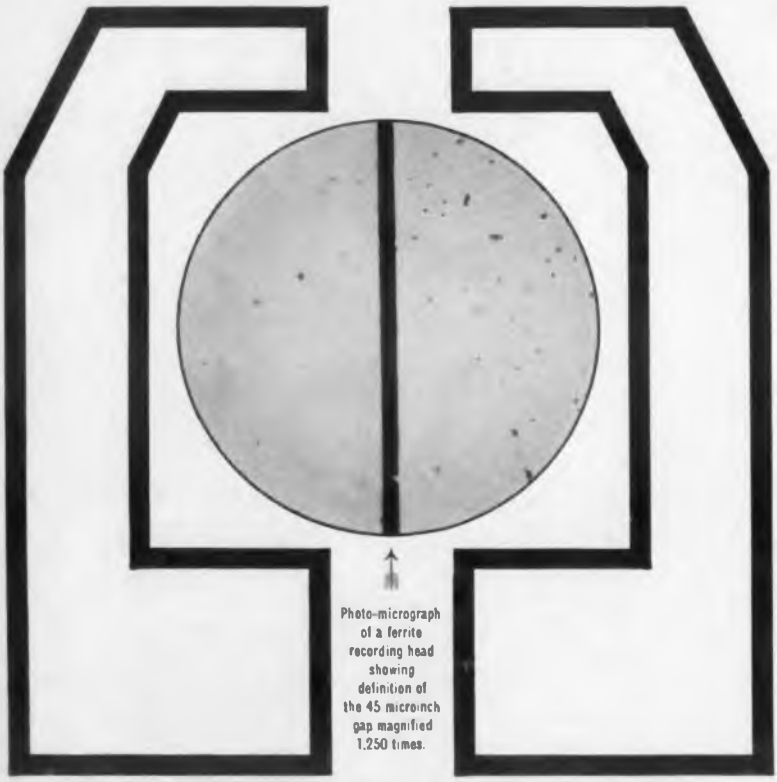

Photo-micrograph of a ferrite recording head showing definition of the 45 microinch gap magnified 1,250 times.

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September 27, 1961
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Electronic Design

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CIRCLE 4 ON READER-SERVICE CARD

Transducers Needed to Spur Process Control

Visitors at ISA Show Hail Advantages of Electronic Approach, But Industry Must Still Rely on Hydraulic, Pneumatic Systems

Thomas E. Mount
West Coast Editor

ON-STREAM analysis for process control is still hampered by a lack of suitable transducers, judging from comments at the Instrument Society of America show in Los Angeles, Sept. 11-15.

Electronic closed-loop systems appear to show great promise, but only in a few instances are they available to the process industries.

John E. Witherspoon of Rocketdyne, the conference program coordinator, said most current process-control systems use hydraulic or pneumatic techniques, even when automatic sampling of the process is available.

The fast response, ease of operation, and reduced accessory equipment, such as compressors, make all-electronic systems desirable, industry spokesmen said. In many processes, however, transducers suitable for automatic control have been lacking. The quantitative analysis of a batch of chemicals in process often is a tricky, lengthy business, frequently susceptible only to indirect techniques, it was agreed.

As an example of an all-electronic closed-loop system, Consolidated Electrodynamics Corp., Pasadena, Calif., showed its Model 26-212 high-speed process chromatograph. Designed for chemical processing—such as petroleum refining, food processing, nuclear reactor control, and drug manufacturing—the system performs continuous quantitative analyses and controls the composition of the chemicals being manufactured.

Chromatographic techniques comprise the sampling of the process stream, stratification of its components according to their boiling points, and quantitative detection of these components. The last is done with a detector, such as a thermal conductivity cell, electrical conductivity detector, or flame ionization.

David Fraade, director of marketing for Consolidated Electrodynamics, said also suitable to closed-loop control techniques are:

Mass spectrography, automatic titration, moisture detection, trace oxygen analysis, trace sulfur detection, refractometry (for fractional distillation processes), viscosity (where vibration-pattern changes in a vibrating reed are detected), and ultra-violet and infrared detection (for measuring the absorption characteristics of chemicals).

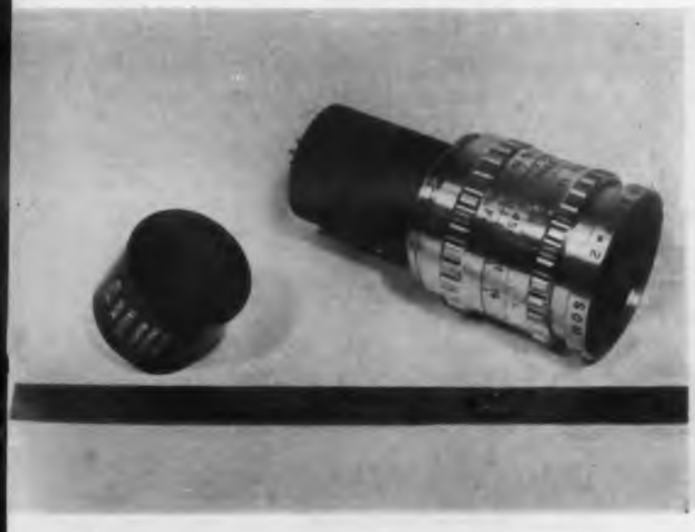
Three manufacturers offer increasingly sophisticated photoelectric transducers this year. Micro Systems, Inc., Pasadena, Calif., showed a line of radiation-tracking transducers designed to detect the position of visible-to-near-infrared radiation simultaneously in two axes. Giannini Controls Corp., Pasadena, Calif., demonstrated a photoelectric potentiometer, dubbed Photopot by the company.

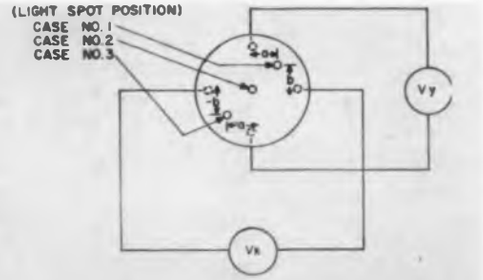
A newly formed company, Data Sensors, Inc., Gardena, Calif., offered a photoelectric accelerometer with low (0.5 per cent) nonlinearity and 0.5 per cent hysteresis. The accelerometer uses two phototransistors, a microminiature tungsten light source, and a cantilever pendulum acting as a shutter. As the transducer is accelerated, the cantilever end is displaced, changing the amount of light intercepted by the phototransistors.

Micro Systems' radiation-tracking transducer comprises a circular silicon solar cell with four opposed contacts on the periphery to delineate the x and y axes. A spot of light focused on the center of the cell causes a lateral flow of current from the center to the circumference.

Applications for the device are said to be in space-communications system alignment, missile-launch alignment, solar and lunar reference sensors for satellite orientation, gyro pickoff, and automatic high-speed autocollimation.

The Giannini photoelectric potentiometer uses a light beam as a wiper arm. The light beam causes semiconductor material, which bridges a gap between a conductor and a resistance element, to become conductive.





Two versions of Micro Systems' radiation tracking transducer, with and without lens system, are shown at left. The principle of operation of the device is illustrated above. With the light spot in the positions shown for three possible cases the following signals would be generated: Case No. 1: $V_x = a$; $V_y = b$. Case No. 2: $V_x = 0$; $V_y = 0$. Case No. 3: $V_x = -a$; $V_y = -b$.

As the light travels the length of the semiconductor-filled slit, the potentiometer's output changes. Because of the lack of friction, long life is expected for the device.

Remote Instrumentation In Oceanography Described

A marine sciences technical session at the show covered oceanographic-measurement theory and problems of remote instrumentation and telemetry. Leon D. Carver, president of Hiac Corp., Claremont, Calif., described the application to the measurement of turbidity of a system for the automatic counting and sizing of particular matter in fluids. The technique originally was developed for detecting and measuring contaminants in oil.

A tiny light beam passes through a small stream of sample fluid. Each time the beam is interrupted by a particle the signal is changed and the particle is counted. Particles as small as five microns can be counted.

Turbidity indirectly is a measure of ocean turbulence and mixing. The system also is useful, Mr. Carver said, for biological science. Organisms of a given size can be "seen" multiplying or diffusing through the water.

The oceanographic tower off Mission Beach, San Diego, was described by William Armstrong of Naval Electronics Laboratory. In addition to the standard recording instrumentation and meteorological equipment, the tower measures internal, below-surface waves. This is done by measuring the level of thermoclines with a thermistor sensor at the end of a line. As the wave passes, the thermocline rises; the extent of its rise is a measure of the size of the wave.

To measure ocean-wave forces on offshore structures, Dr. Thomas Russell of California Research Corp. used eight force dynamometers, a wave gage (a vertical resistance wire), recording instruments, and programing units.

Thomas Ward of Telemetering Corp. of America described what is said to be the first practical application of pcm/fm/fm telemetry to oceanography.

The initial system designed for the Air-Sea Environmental Interaction Research program, headed by A & M College of Texas, contained three pcm-fm subchannels, each supporting the transmission of the 2,000 bit per sec output from a field data-processing unit. The transmitter operates in the 132-144-mc band with a half-watt power output. ■ ■

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CIRCLE 6 ON READER-SERVICE CARD

NEWS

Stretch's Utilization In Business Explained

CEIR Hopes to Use Computer Profitably on Small Problems

EXPECTED usefulness of the IBM 7030 Stretch computer for business data processing was described at the 16th National Meeting of the Association for Computing Machinery in Los Angeles, Sept. 5-8.

William V. Crowley of the Corp. for Economic & Industrial Research, Inc. (CEIR) gave an optimistic appraisal of the potential of the Stretch machine for simultaneous processing of many business problems. CEIR plans to install two of the machines at its computing centers despite failure of the computer to achieve original design objectives.

Stretch was designed by International Business Machines Corp. for complex problems demanding large arithmetic capacity, such as the hydrodynamics problems involved in nuclear work. The first machine was built for the Atomic Energy Commission at Los Alamos, N. M. Mr. Crowley told his audience that the machines can be used profitably for hundreds of smaller problems simultaneously. Small companies will rent processing time on them from the CEIR center for research, design, and planning.

Mr. Crowley asserted that a Stretch system will perform 800 times the operations that could be performed by an IBM 650—for less than 30 times the cost of the 650, or about $1,700 per hour. This comparison was based on arithmetic speeds alone.

"The economics of Stretch-type computers can be demonstrated as much more advantageous than several large-scale computers operating side by side," Mr. Crowley said, adding: "Many of the problems of the future will not be solvable on anything but computers of Stretch-like capacity."

Mr. Crowley asserted that the technical and theoretical communications problems formerly associated with centralized computing operations have been virtually solved.

He went on: "Computer program know-how and computer system management skill now exist to make this type of operation feasible and successful. Very few organi-

zations will have enough of these computer-requiring problems at any one time to justify the buying or leasing of such a large machine for the organization's use only."

The audience took a "wait-and-see" attitude toward Mr. Crowley's estimate.

Stretch was to be delivered to Los Alamos in June, 1960. Due to difficulty—primarily with the half-microsecond memory, which has been discarded in favor of a 2.18-μsec memory—the delivery was delayed until December, and finally to April, 1961. IBM reportedly reduced the price of Stretch from $13 million to $8 million.

Only 10 Stretches are to be built—those that were on order last March—an industry source said. IBM declined to comment on this report.

According to Bengt Carlson, director of computer operations at Los Alamos, Stretch was placed in operation in the middle of May, and has done well since. The system is slower than had been anticipated three years ago, Mr. Carlson said. Depending on programing, Stretch may be 25 per cent or more slower than specifications called for, he estimated. In other types of problems it works just as fast as was anticipated, Mr. Carlson said.

Stretch has a high degree of precision. Word length is the equivalent of 14-1/2 decimal digits.

"Through-put" for Stretch is said to be relatively limited. Programing, Mr. Crowley said, will solve this difficulty. ■ ■

Counter Totals Patterns

Latest version of numa-rete pattern counter developed at the University of Illinois uses a 20-by-20 matrix of photocells as its retina. Threshold-logic circuitry senses n-ness and drives indicator tubes to show count of separate patterns that prevent overhead light from reaching photocells. Response is instantaneous for any combination of a convenient number of patterns.

Design of Project Defender Radar Probe on Schedule

Giant Facility in Puerto Rico to Aid Ionospheric Study; Snags in Building 1,000-ft Dish Delay Opening to Spring

Spherical surface over which a metal mesh will be laid has diameter of 1,000 ft and is several hundred feet deep. Cable-supporting tower rises 250 ft above hill overlooking reflector dish. Tower is one of three to support line feed hanging from a network of cables.

Alan Corneretto
News Editor

BY EARLY next spring, the huge 430-mc radar being built near Arecibo, Puerto Rico, for the Advanced Research Projects Agency of the Defense Department should be collecting data on electron density in the ionosphere.

This is an estimate made in Arecibo earlier this month by scientists of Cornell University's Center for Radiophysics and Space Research, the prime contractor to the Air Force Cambridge Research Laboratory for design and construction of the radar system.

The installation is part of Project Defender, designed to minimize danger from missile attack.

Difficulties in transforming a Puerto Rican valley into a 1,000-ft-diam, mesh-lined dish have postponed operation from July of this year to 1962, but design of the electronic equipment is proceeding according to plan, Cornell scientists report.

Although the 1/6-deg beam transmitted by the radar will be able to cover the sky only within 20 degrees of zenith, the facility is expected to be useful for experiments involving the major planets, the moon, and some space vehicles. This is in addition to its primary tasks of measuring the variation of electron density with height, the fluctuations of electron density at fixed heights, and electron temperatures and magnetic-field strengths at various heights.

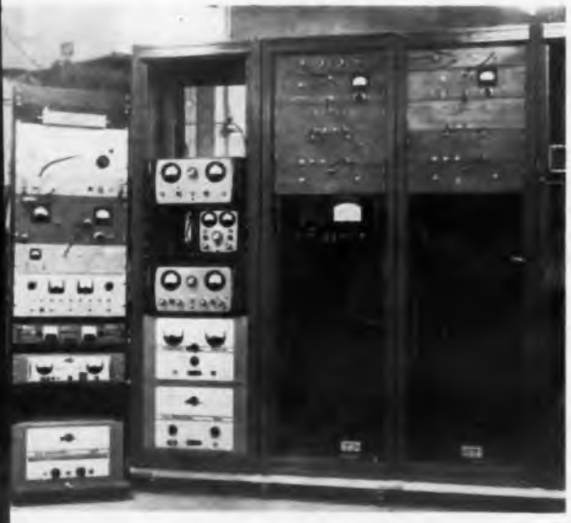
Aperture Surface Tolerance Poses Challenge of Design

The fixed spherical reflector of the radar will be fed by a line feed supported above it on a rotating azimuth truss. The feed will be capable of all types of polarization and will fully illuminate the aperture, which is to have a radius of curvature of 870 ft and a surface tolerance of $+0.1$ ft. Achieving this tolerance is expected to be one of the main structural-design problems connected with the project.

Design goals for the transmitter include: a peak power output of 2.5 megawatts at 430 mc, and an average power of 150 kw, with pulse-to-pulse stability of 0.2 db. Cw power is expected to be 100 kw. Frequency stability of the primary 1-mc oscillator source is designed to be 2.5 parts in 10^9 over periods from 1 sec to 1 hr. Frequency deviation of the rf output from the source frequency is expected to be less than 3 cps. Pulse lengths of 2 to 10,000 μsec are to be available with a repetition rate of 1 to 1,000 pps.

A low-noise receiver, using an electron-beam-type parametric amplifier in its front end will have two channels (one for reserve) and a noise figure of less than 2 db. The receiver front end will be about 1,400 ft from the main 30-mc if amplifier. Gain stability of the equipment is expected to be 0.2 db. Because system accuracy will be important during operation, a single 1-mc stable oscillator will control the receiver local oscillators, transmitter, and clocks.

The feed is being designed to yield a gain of not less than 60 db in the secondary pattern, with sidelobes more than 17 db below the main lobe, and polarization crosstalk below 30 db. Bandwidth will be at least 1 mc. Though the feed, which will hang from tower-supported cables about 430 ft above the reflector surface, will weigh less than 5 tons, the entire feed-supporting structure will weigh about 450 tons. The feed



Receiver for ionospheric radar probe has parametric amplifier front end, left, which helps hold noise figure for the equipment to about 2 db.

is being designed to operate in 30-mph winds and to survive 140-mph hurricanes.

Range-Gate Integration System Stumps Designers

Signals received by the system will be processed by a data-recording and processing subsystem which includes range-gate integrating circuitry for recording electron density versus height, and a spectrum analyzer for determining electron temperature versus height. The Cornell scientists report that design of the range-gate integration system is a problem they have not yet solved.

The receiver feeds a system of 100 gates, which are controlled to be open in sequence for periods varying from 2 μsec to 10 millisec to receive pulses reflected from various sections of the ionosphere. Signal levels of the returning pulses vary over a large dynamic range, from about 10 mv at noise level to 10 v. The problem of designing a single type of gate to handle both the low-strength, ultra-short pulses, and the strong-

CIRCLE 9 ON READER-SERVICE CARD ▶

NEWS

Project Defender ...

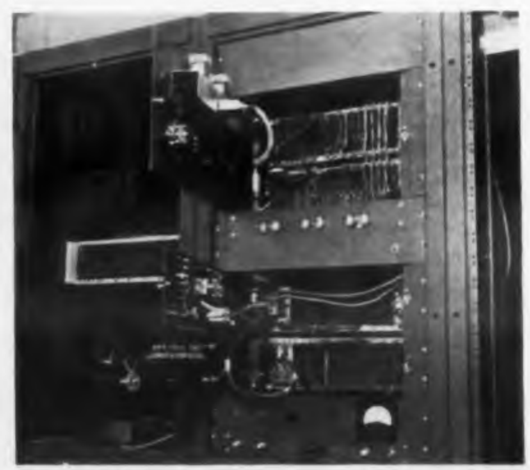
(continued from p 9)

er, longer pulses is delaying completion of the range-gating portion of data-processing system.

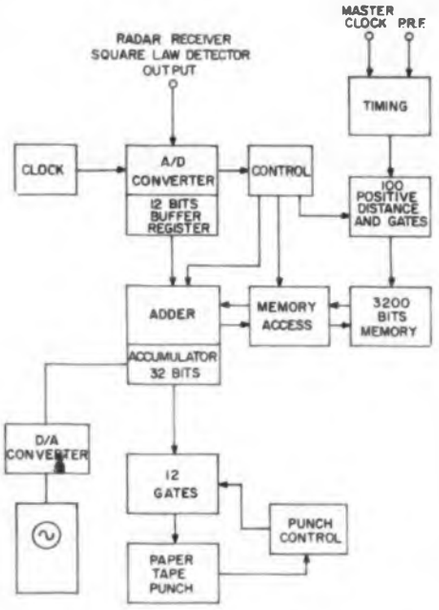
Transistor gates so far designed by the Cornell scientists introduced errors in the form of spikes in the gated output signals. Diode gates turned out to be nonlinear at low signal levels. A four-transistor gate required two pairs of matched diodes and a balanced drive-signal system. These introduced critical adjustment problems and the likelihood of errors in the output signals. No single circuit so far has operated satisfactorily over more than about 60 per cent of the range desired, the scientists said.

Digital Technique, Dual Range-Gate Sets Weighed

Under consideration as a solution is the expensive approach of building two sets of range gates, and a somewhat novel digital technique. Dr. T. E. Talpey, and M. A. Feyjaó, participating in receiver and data-processing design on the project, have proposed that an analog-to-digital converter digitize the output of the receiver for storage in a very fast memory as an increment to a number stored there as a result of previous pulses. Because the range slots are to be spaced as close as 2 μsec, the entire sequence of digitizing, reading out of the



Data-processing section of system has punch-control circuitry, top; digital clock showing Nixie tubes; an analog-to-digital converter, shown open; and a logarithmic amplifier to compress the 30-db dynamic range of incoming signals so they can be handled by an analog-to-digital converter.



Digital range-gate system in rough-idea form is being proposed by Cornell engineers at Arecibo. System would take signals from radar receiver after they were reflected from ionosphere and digitize them for integration in a fast memory. There would be 100 slots spaced 2 μsec apart. The system would permit integration of a million pulses.

memory, adding, and inserting back into the memory, would have to occur in less than 2 μsec.

Whether analog range gating or the proposed digital method is used, the subsystem will be, in effect, a special-purpose computer. Eventually, the project engineers report, a general-purpose computer probably will be provided for data processing at the facility.

If the Arecibo facility were equipped with suitable peripheral equipment it could be used for a variety of radio-astronomy experiments, as well as its primary tasks.

Dr. W. E. Gordon of Cornell, the project director, said the facility could be used to study the spectrum and polarization of solar bursts between 10 and 20 mc, measure the spectrum and polarization of bursts from Jupiter from 15 to 25 mc, make two-wave length comparison of radio sources, make interferometric observations, and partially track deep space probes.

A possibly important application would be the detection of hydromagnetic disturbances and shock waves, such as those caused by passage of a missile or by explosions in space. ■ ■

Electron Beams Form PN Junctions

Automation Based on Programed Video Signals May Eliminate Masking and Etching Processes

Electron-beam equipment for junction formation, developed by CBS Laboratories, operates mostly in the range below 15-kv beam potentials. Beams down to 1/2 mil at 100-μa beam current can be produced by the machine. Further studies are needed to optimize beam energy, substrate temperature, and other factors to make feasible automatic production of devices by this technique.

Robert Haavind
Chief News Editor

AUTOMATED production of semiconductor devices and microcircuitry with electron beams controlled by video signals appears feasible with techniques now under development. Control of the beams by programed video signals might eliminate masking and etching methods now used to make semiconductor devices.

Diodes that are said to have excellent electrical characteristics have been produced in a vacuum chamber at CBS Laboratories, Stamford, Conn., by alloying aluminum onto n-type silicon with an electron beam. Researchers hope that by refining the technique they can also make useful diffused junctions.

Aside from the possibility of automated production, the electron-beam method should have the following advantages:

- Cleaner junctions because of low impurity concentrations in a vacuum chamber and the surface cleaning effect of the beam.
- Faster production—diode microjunctions have been formed in 30 seconds.
- Finer control of junction location and area, if feedback devices are developed.
- Other vacuum techniques, such as thin-film deposition or electron-beam welding and micromachining, could be used in conjunction with the CBS technique.

Feedback System For Beam Positioning Needed to Achieve Automation

One of the important steps needed for automation of the electron-beam method is development of a feedback system for controlling beam position on a substrate. In present work, beam position is controlled visually by the color difference between areas under and surrounding the beam. This suggests an optical feedback system. Since optimum beam energies and substrate temperatures have not yet been determined, however, it is possible that the color difference will not be great enough for this approach.

As a further test of the electron-beam

method, CBS researchers plan to produce a more complex structure, similar to a planar transistor. Before techniques can be optimized, however, much further data—such as best beam energies, impurity materials, and substrate temperatures—must be determined. The studies have been conducted under a year-long $55,000 contract from the Army Signal Corps. The contract recently was renewed for another year at $50,000.

The electron beams used in the CBS approach are operated mostly in the range below 15 kv. Other research organizations have been exploring the uses of electron beams for microcircuitry with beams of higher potential. For example, the Zeiss machine, licensed by Hamilton Standard Div. of United Aircraft Corp., operates in the range over about 25 kv. This range is suitable for welding contacts or micromachining, according to Alexander P. Ramsa, physicist with CBS Laboratories. However, lower energies are necessary for forming junctions.

Vacuum Chambers Likely In Manufacturing Devices

Manufacturing equipment based on electron-beam techniques probably would consist of vacuum chambers with guns of varying energy ranges directed at the processing area. Automatically controlled micro-manipulators and timing and sensing devices also would have to be developed.

One area that needs further study, Mr. Ramsa said, is the choice of doping materials for use in electron beam-formed junctions. Aluminum was chosen for the CBS experiments because of its low vapor pressure.

Other desirable dopants, such as antimony or bismuth, have higher vapor pressures and might be distilled out of the processing chamber by the vacuum system. These materials might be usable if they are combined with other elements, such as tin, to form binary alloys.

Another possibility, which may be explored later, is the use of ion beams to perform doping. The doping material would be used to form the ion beam directed at a semiconductor substrate. Ion guns suitable for such experiments are in development at CBS Laboratories, although they are presently being used for other projects.

Dr. Reinhart W. H. Engelmann has been working with Mr. Ramsa on the electron-beam processes. Dr. Harold Jacobs of the Signal Corps Laboratories and Mr. Ramsa hold two basic patents on the formation of semiconductor junctions by beam techniques. ■ ■

NEWS

Minuteman May Chart New Reliability Techniques

Many of the novel techniques used to produce the electronics portion of the Minuteman intercontinental missile may find their way into standard use in electronic design. Two in particular—worst-case circuit design and reliability improvement through failure analysis and corrective action—may have important effects in the electronics industry. The impact of these techniques was analyzed by Dr. W. J. West, reliability director at Autonetics Div., North American Aviation, Inc., Downey, Calif. Autonetics is the Air Force's prime contractor for most of the missile's airborn electronics equipment.

Dr. West reported at the fall meeting of the Electronic Industries Association, in New York City, Sept. 11-15, that Autonetics is adopting worst-case design based on Monte Carlo analytical techniques throughout the company's design centers.

The methods used by Autonetics are based on extreme derating, wide component tolerances and use of cooling. The company's circuit designers have a budget of reliability, which their circuits may not exceed, but within which reliability may be distributed as desired.

Parts Suppliers Subject To Close Quality Control

According to Dr. West, one of the keys to achieving component reliability is the detailed failure analysis and the effective corrective action to improve a parts supplier's production techniques. This often involves retraining of production workers.

In order to take effective corrective action, however, the prime contractor must examine the procedures used by the supplier inside the supplier's plant. Though some companies may resist this, permitting inspection goes a long way toward assuring reliable parts, Dr. West said. He believes that corrective action, combined with the many other inspection, documentation, and analysis techniques, could enable a company new to the Minuteman program to manufacture parts different from those in the program but at least as reliable. This would take about a year, he said.

For a special report on reliability see p 33 of this issue of ELECTRONIC DESIGN.

Ford Widens Industry Stake With Acquisition of Philco

Acquisition of Philco Corp. by Ford Motor Co. combines two organizations with important roles in space electronics as well as moving the auto-maker into other branches of the industry.

Ford's Aeronutronics Div., Newport Beach, Calif., among other space assignments, is developing the capsule to be landed on the moon from the Ranger spacecraft. This work is being done under a Jet Propulsion Laboratory contract.

Philco's Western Development Laboratories, Mountain View, Calif., is associate prime contractor for electronics in the Midas satellite program, and also is known to be working on the Samos surveillance-satellite system.

Philco's other activities in the semiconductor, computer, radio and television, and appliance fields now give Ford a heavy stake in the industry as a whole.

CBS Sells Plant, Quits Transistor Production

Columbia Broadcasting System, Inc. has sold the last manufacturing facility of its CBS Electronics division.

The company has announced the tentative sale to Raytheon Co. of its recently opened transistor and diode plant at Lowell, Mass. The plant operated only about six months. Earlier this year Columbia closed its operations at Danvers and Newburyport, Mass., and at Windham, Me.

CBS Electronics Laboratories Div., Stamford Conn., will continue operating, the company says.

GE Enters Signal-Diode Competition With PEP

PEP—Planar, Epitaxial, Passivated silicon diodes for high-speed computer use and general-purpose applications represent General Electric's entry into the $100 million diode business.

GE's SD-150 features a minimum conductance of 50 ma at 1 v with a typical conductance of 100 ma and less than 2 nsec recovery time. Typical capacitance is less than 1 pf with 2 pf considered maximum.

The SD-150 is enclosed in a conventional subminiature glass package and a microminiature version, MSD-150, also is available.

NEWS

Atlas Computer Uses New Logic Approach

Ferranti System Has Fast Fixed Store of Wire Mesh, Ferrite Rods

THE Atlas asynchronous computer—designed to run several programs concurrently while appearing as a single-program system to its simultaneous users—is described as the world's most powerful by its producers, Ferranti, Ltd., Hollinwood, England.

The computer is said to execute nearly one million commands per second, to have an access time of 0.3 μsec to its fast fixed store, and to be able to add 48-bit, 40-digit numbers in about 1 μsec each. It is said to cost between $8 million and $10 million.

Atlas was designed jointly by Ferranti and Manchester University, where installation of the first commercial system is nearing completion. Another Atlas has been ordered by the National Institute for Research in Nuclear Science at Harwell, England.

Ferranti reports that the Atlas computer depends primarily on logical design rather than novel hardware for its performance. The most significant electronic innovation in the system, Ferranti says, is a fast fixed store consisting of woven wire mesh into which ferrite rods are inserted to represent digits. This memory has an access time of 0.3 μsec and contains 8,192 48-bit words in the standard size. The fast fixed store can be increased to store a theoretical maximum of more than 262,000 words, the company says. It holds frequently required commands.

The fast store is one of four large memories having different access times. The several stores appear as one memory to the user because of the computer's logical organization, which permits transfer of information between different levels of storage by system routines implemented by appropriate hardware.

'Extra Codes' Usable With Basic Information

Atlas is operated by a relatively simple command code of the single-address type, supported by "extra codes" which provide entry to built-in subroutines. The "extra codes" may be mixed with basic instructions without complications, Ferranti says, and

Ferrite-rod, wire-mesh memory of experimental version of Atlas computer contains fixed instructions and computes on basis of information supplied by slower memories in system. Its access time is said to be 0.3 μsec. An Atlas designer, Dr. R. L. Grimsdale, Manchester University, adjusts a ferrite rod in wire matrix.

without endangering other programs being run simultaneously. The "extra-code" subroutines are stored in the ferrite-rod fast memory.

The Atlas includes a "fast-carry adder" to ensure that the speed of addition is not hampered by carryover propagating from one digit to the next, the company says.

Another feature of the system's logical design is the method used to transfer information between the various stores as required. Built-in subroutines, commanded by the "extra codes," shift required information automatically according to a "page-address" system. In this system, numbers are identified by being in a particular shock, called a page, rather than by addresses signifying physical positions in the stores. The pages have no fixed location; they are moved from one location to another, according to which is needed in the high-speed store for current computing.

The computer is transistorized. Standard data-processing languages such as Fortran and Algol may be used with Atlas, the company says. ■ ■

NEWS

Army Tests New Computer For Use In Combat Areas

A new member of the Army's FIELDATA family of combat-area data processors is undergoing evaluation tests at Fort Monmouth, N. J., Signal Research and Development Laboratory.

Called the Informer, the general-purpose computer will aid intelligence, logistics and personnel operations. It was built by International Business Machines Corp.

Informer is housed in a 2-1/2-ton truck and can be driven over broken terrain in all weather.

The computer's central processing unit, main memory, and power supply take no more space than a five-drawer filing cabinet. Informer requires no air-conditioning. The central processor is said to operate from −25 F to +125 F and in up to 97 per cent humidity. The unit's solid-state components can withstand up to 7.5 g, IBM says.

Computer and Tape Operate X-Ray Diffraction System

By programing a computer to operate a special X-ray diffractometer, researchers at Bell Telephone Laboratories hope to obtain more than 17,000 crystallographic readings a day. An experienced X-ray crystallographer can obtain manually only about 3,000 readings a day, according to Bell.

In Bell's system, called Pexrad (Programed Electronic X-ray Automatic Diffractometer), such information as crystal lattice constants, wavelength of the X-ray beam and instrumental constants are fed to a computer on punched cards, along with a compiling program. The computer generates a magnetic tape, from which a punched paper tape is made. This tape controls the motors that rotate the crystal and receiving scintillation counter of the diffractometer and permits an X-ray beam of proper wavelength to irradiate the crystal for sufficient time.

The intensity of the beam diffracted by the crystal is measured and recorded on punched tape. The crystal is automatically rotated to the next position and the process is repeated. The punched tape from the sys-

Almost completely automatic X-ray diffractometer is operated by punched tape, of the type held here by Dr. S. C. Abrahams, who developed the new system at Bell Telephone Laboratories, Murray Hill, N. J.

tem is converted to a magnetic tape and fed back into the computer, which integrates the intensities, corrects for various factors, and prints out correct data.

Franklin Institute Opens Science Research Service

A Science Information Service has been organized by The Franklin Institute in Philadelphia. The service will aid industry and scientific institutions on R&D projects, primarily by providing extensive literature searches.

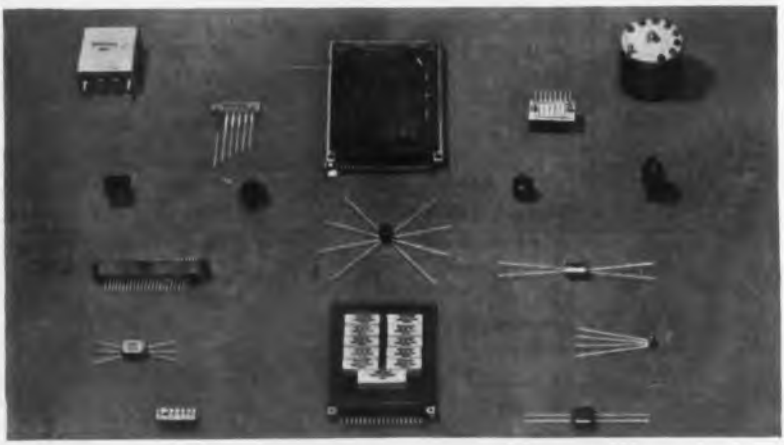
The service will offer searches in any area of mathematics, engineering, physics, chemistry and industrial processing. The service will handle bibliographic compilations, annotated bibliographies, abstracts of articles, current-literature monitoring and translations.

Poll Shows Increased Reliance on Standards

Increasing reliance on standards and standardization programs is indicated in a poll of 67 companies by the American Standards Association.

All responding companies said their standards activities had helped lower costs. The 15 companies giving specific data reported savings of up to 20 per cent of gross income.

Two-thirds of the firms said standardization is being extended, and many indicated wide use of company standards committees.



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CIRCLE 20 ON READER-SERVICE CARD

WASHINGTON REPORT

Albert Warren
Washington Editor

ELECTRONIC HIGHWAY DETOURED

Fully automatic highways are not just ahead for American motorists, despite the demonstrated feasibility of electronic controls of automobile speed, spacing, and stops. This was the consensus even of visionaries among experts at the World Traffic Engineering Conference in Washington.

For one thing, O. K. Norman of the U. S. Bureau of Public Roads said, it would cost $75,000,000 to build a 100-mile stretch of electronic highway with roadside installations and devices attached to cars. For another, he pointed out that all but 5 per cent of trips on American roads run less than 15 miles. Mr. Norman said that such a distance does not justify expensive gadgetry to keep traffic safely in line at 100 mph.

The Bureau of Roads has been playing with the electronic-highway idea, but Mr. Norman reported that it might be five years before any experimental start is made. "It is unlikely that the great monetary investments needed will be forthcoming for a long time to come," he told the conference, at which 31 countries were represented.

Speakers at the meeting agreed, however, that other applications of electronics—such as television controls and computer estimates of vehicular flow—are not only efficient but also can be money-saving. Summing up a series of papers on electronic traffic devices used or planned in the U. S., Great Britain, France, Germany, and India, Baltimore's traffic commissioner, Henry A. Barnes, said: "This type of equipment is no longer considered a gadget." Barnes reported that in his own city electronics had yielded such an increase in street capacity to handle traffic that some new construction projects had been postponed for at least ten years.

AIA CAMPAIGNS FOR ARMS-SPECIFICATIONS REVOLUTION

The Aerospace Industries Association wants to eliminate "obsolete" military material and design specifications which, it asserts, retard technology. Spokesmen for leading electronics, aircraft, and propulsion contractors have been caucusing in Washington preparatory to dispatching an AIA modernization mission to the Pentagon. Their plan is to carry the campaign to Defense Secretary Robert S. McNamara through Assistant Secretary Thomas D. Morris. They hope a joint AIA-Pentagon task force will be mobilized to attack chronic specification and paperwork problems.

Immediate AIA objectives: (1) Selection of specific weapon projects for intense review. (2) Stake-outs of areas to determine where costs can be reduced and lead times shortened. (3) Scrapping of outmoded contract documents. (4) Consolidation of service speci-

fications for the same equipment. (5) Elimination of "obsolete" requirements that hamper design, thus limiting progress in techniques.

Ultimately, the AIA seeks a revolution in Pentagon policy so that performance specifications will replace detailed initial material and design blueprints as main contract criteria.

The AIA complains that the paperwork-bound rigidity of the present Pentagon system not only gives contractors headaches but also inhibits inventors. A common case in point: if a manufacturer is so bold as to make a change from specifications, it isn't enough for him to prove that his improvement will work. He must also justify why he didn't follow the obsoleted specifications in the first place.

RADIO EXPLORES AGE-OLD MYSTERY OF BIRD FLIGHT

Electronics finally may solve a question that has gone unanswered through science's centuries: How do birds navigate with such astonishing precision? The answer could be that they are equipped with physiological devices that react, radar-and-compass-like, to changes in the electromagnetic flux.

Science's latest—and possibly promising—exploration into the mystery of bird flight has been undertaken by the Office of Naval Research, using new radio apparatus developed by Philadelphia's American Electronic Laboratories. Already a 20-mile trip by a homing pigeon to its loft in Philadelphia has been recorded on an elaborate chart providing precise directional data for triangulation-plotting of the bird's exact flight pattern. Researchers of ONR's Biological Orientation Program hope that from this start they can work up a sophisticated system of sensory devices to monitor birds' reactions to magnetic and other environmental changes.

The electronic tool in the initial experiment is a radio unit, weighing less than an ounce, which is strapped to the pigeon. Powered by three mercury-button cells, it has a transistorized oscillator and amplifier with a 1-mw output. Trailing from the package and below the pigeon in flight is a 40-in. half-wave dipole antenna whose first eight inches are stiffened with a fiberglass rod to guard against wing interference. Two specially designed receiving stations, including direction-finding, high-gain Yagi antennas on rotating pedestals, pick up the pigeon's flight signals.

Many explanations of bird navigation and the homing instinct have been advanced. None has been proven. Other hypotheses in addition to the electromagnetic-response theory: (1) Birds somehow react to the Coriolis-effect phenomenon attributed to the earth's rotation. (2) They just observe landmarks and guide themselves accordingly. (3) They chart their courses by taking readings on the sun and moon.

TELEVISION IMAGES IN THE DARK

A new image-intensifier orthicon tube developed by the Radio Corp. of America for the Army Corps of Engineers gives field commanders clear pictures of operations at night—without exposing troops to lights. Demonstrated to newsmen at the Association of the United States Army meeting in Washington, the RCA tube amplifies dim skyglow 100,000 times, bringing otherwise-invisible troops and objects to television screens. In an earlier test at Fort Story, Va., night amphibious landings were observed with clarity far back from the shoreline.

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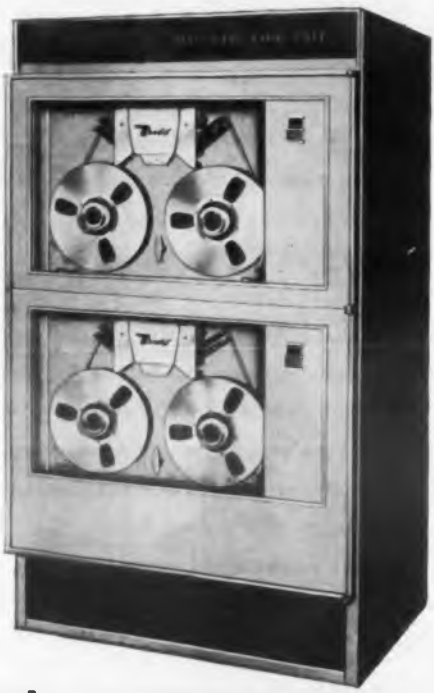

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NEWS

TV Comparator Permits 300-Fold Magnification

Close-up of television-comparator monitor shows full-screen view of postage stamp, printed-circuit disk, and pin head. Magnification is about 10 to 1.

Magnification of up to 300 times is possible with a novel television comparator that permits examination and precise measurement of tiny solid objects.

The closed-circuit TV system enables an operator to inspect components such as transistors, resistors, diodes, microminiature wafers, watch parts, and subassemblies. The unit also can be used to examine live biological specimens and standard laboratory slides.

Using a single aircraft-type control stick, the operator can position the image on the screen and change its magnification through the entire range without loss of focus.

The TV comparator, made by GPL Division of General Precision, Inc., is being shown with a companion device—a microfilm televisor.

The company says the microfilm readout device permits a greater range of magnification than ever before, even at great distances.

Time-Sharing System Studied for FAA Use

A proposed air-traffic-control communication subsystem that would permit voice and data time-sharing on one channel is under study by the Federal Aviation Agency.

Known as ACCESS (Aircraft Communications Electronic Signaling Service), the con-

cept was developed jointly by Motorola, Inc. and General Precision, Inc. It has the two-fold objective of drastically curtailing the volume of voice communications between pilots and ground controllers and of better organizing essential voice communications.

A simple encoder-decoder unit represents a basic module, to which input and output equipment may be added, depending upon the desired degree of participation in digital communications.

Motorola is responsible for the design of the so-called MADE (Minimum Airborne Digital Equipment) box. This encoder-decoder unit, weighing 6 lb, is to cost about $1,361. It could be used with a low-speed printer, costing about $300.

The ACCESS system, using phase-shift keying modulation, will handle digital information within the audio bandwidth available in existing vhf, uhf and hf equipment. A data rate of up to 1,200 bits per sec is reported feasible.

Flight Tester Delivered

This pressure generator, said to be the first operational unit of its type, has been delivered to Republic Aviation Corp. for air-data-computer testing of its F-105 fighter. The unit, designated Master Air Data Computer Automated Tested (MADCAT) was built by U.S. Science Corp., a subsidiary of United Industrial Corp. The portable ground-support equipment converts electrical analogs to precise pressure outputs. It can be used to simulate flight conditions of air speed, altitude, air temperature, and angle of attack.

NEWS

Diamonds, Borazon Made Semiconductive in Lab

Semiconducting diamonds of the p-type, and both p- and n-type borazon (cubic form of boron nitride with hardness equal to diamonds and similar structure) have been produced in the laboratory.

If practical applications are achieved, these materials promise high reliability in extreme environments.

Both materials were made semiconductive by the addition of controlled amounts of impurities by researchers at General Electric Co.'s Research Laboratory, Schenectady, N. Y.

Since both p- and n-type semiconductors will be needed for devices, work is continuing on the development of n-type diamond. The diamonds are made semiconducting by adding impurities, such as boron, beryllium or aluminum, at high temperatures and pressures to a mixture of graphite and a catalyst used by GE to make diamonds.

Either p- or n-type borazon can be grown onto a seed crystal of the opposite type, forming pn junctions. Beryllium is used to produce p-type borazon, and several materials, such as sulfur, silicon, many organic compounds, and potassium cyanide, can be used to get n-type.

The method for producing semiconducting diamonds was developed by Dr. Robert H. Wentorf, Jr., of the GE Research Laboratory, and Harold P. Bovenkerk, of the GE Metallurgical Products Dept.

Dr. Wentorf, who developed the original process for making borazon, also developed semiconducting borazon.

Accuracy Is Our Policy . . .

In the news story "Thin-Film Hall Device Is Nearing Production," which appeared in the Aug. 2, issue, p 6, the open-circuit output sensitivity was incorrectly called the Hall coefficient. The sensitivity is the Hall constant, divided by the film thickness. Further, the article implied that conventional units require more input power. Actually, thin film units require higher power inputs, but at the same time give higher output voltages for the same input current and magnetic field strength.

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APPLICATION NOTES

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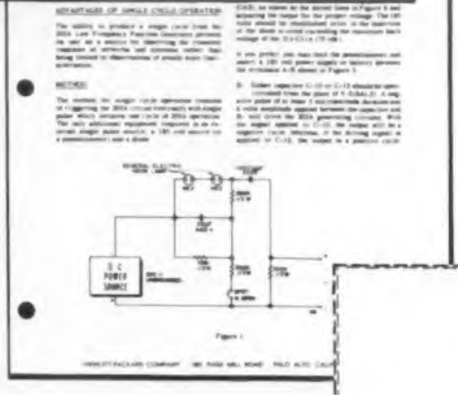

Hewlett-Packard Application Notes, covering a wide variety of subjects, include both theoretical and "how to do it" information. They are composed of information derived from the experience of hp engineers both in general areas of measurement and in solving specific measurement problems. Many interested readers have found Application Notes useful in the past. You may find them helpful, too.

Check this partial list of titles:

- # 2 Frequency Measurement of Low-Level Signals, up to and above 12.4 GC
- # 6 Homodyne Generator Detection System, to measure attenuation, rf leakage, antenna patterns, etc.
- #15 Distortion and Intermodulation
- #36 Sampling Oscillography
- #42 Applications of 416A Ratio Meter, reflectometer techniques
- #43 Continuous Monitoring of Radar Noise Figures
- #44 Use and Usefulness of the 185A 1,000 MC Oscilloscope (44A, Synchronizing the 185A; 44B, Pulse Analysis; 44C, Component Switching Speed Characteristics Measurement)
- #48 Applications of the 218A Pulse and Delay Generator
- #50 How to Make VLF Frequency Comparison Measurements with Standard Laboratory Equipment
- #52 Frequency and Time Standards

Other Application Notes cover such subjects as measuring FM signals, measuring rf pulse carrier frequency, microwave spectrum synthesis, waves on transmission lines, square wave and pulse testing, measurement of cable characteristics, instruments for transducer applications. The Application Notes Index gives a complete listing.

Fill in and mail the attached post card for Application Notes of interest to you, or for a complete list of titles.

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Firm to Share Use Of Optical Scanner

An arrangement has been made between Minneapolis-Honeywell and Farrington Manufacturing Co. of Needham Heights, Mass., for use of Farrington optical scanning-reading equipment on Honeywell electronic-data-processing systems.

Honeywell, under the arrangement, will incorporate Farrington optical scanners as a customer option in its EDP systems to provide an automatic on-line input for the Honeywell 800 and 400 systems.

Farrington electronic reading machines scan ordinary business documents and instantaneously translate the numeric or alpha-numeric information into business machine language for output on punched cards, punched paper tape, or magnetic tape.

Three basic series of optical scanners produced by Farrington are:

- Document Reader Series—Scanner reads numeric or alpha-numeric on card or paper stock.
- Page Reader Series—Scanner reads whole pages of numeric or alpha-numeric data.
- Self-Punching Series—Scanner reads numeric information on unpunched tabulating cards and punches the information back into the same card.

GE Gets Flowmeter Calibrator

Two flowmeter calibration stands, capable of measuring up to 150,000 and 15,000 lb per hr, respectively, have been installed in General Electric Co.'s new flowmeter laboratory, West Lynn, Mass. Repeatability accuracy of both is 0.1 per cent. Temperatures up to 365 F and down to —72 F can be duplicated to test fluids. The new facility will test GE's industrial and aircraft true-mass flowmeters.

NEWS

Recessed Wafers Support Circuits

System Adaptable to Molecular And Conventional Techniques

A "MIDDLE-OF-THE-ROAD" approach to microminiaturization, which uses presently available micromin components, yet is adaptable to deposited circuits and molecular electronic techniques, has been developed by Thompson Ramo Wooldridge, Inc., Canoga Park, Calif.

The recently announced system employs Fotoceram wafers on which the designer can mount conventional micromin circuit elements or which can be imprinted with molecular circuits. The wafers are arranged in stacks by means pressure connectors.

Components lie in cavities preformed into the board and are joined with coplanar leads running along the surface of the board. The connectors are integral with the board and can be mounted on all four sides and in any component area. Boards may be connected in any plane. An entire system can be built up from such wafers without interconnecting wires.

Improved Cooling, High Density Packing Claimed

Each wafer stack is said to embody built-in natural convection channels for improved cooling. Maximum power dissipation for circuits using this technique is cited as 3.5 kw per cu ft. Packing density of 250,000 elements per cu foot is claimed for complete subassemblies, with higher densities attainable on individual wafers.

Other advantages reported for the tech-

Typical function board configuration possible with Thompson Ramo Wooldridge micromin technique. Note recesses in wafers to accept components. The wafers can be connected along any edge and in any plane, according to the company.

One-piece connector used in Thompson Ramo Wooldridge micromin system is shown with microtransistor. Pencil point provides scale.

nique include high environmental tolerance and maintainability. Company spokesmen note that the arrangement of wafers and connectors permits more test points than do conventional printed circuits. Each subsystem can be tested individually before installation and defective wafers can be replaced with a simple tool.

Thompson Ramo officials state that the new technique is ready for production. The cost is said to be about one and a half times that of conventional techniques (assuming equal component costs). ■ ■

Coating Process Permits Controlled Use of Metals

Experimental work in coating various substrates has led to a technique for coating conductive or light-transmissive thin films on plastic or glass substrates.

The technique, developed by Halex, Inc., of El Segundo, Calif., involves deposition of substrates with high-abrasive and corrosion-resistant characteristics to produce both controlled light transmission and conductivity on one surface. The process can be applied both to continuous rolls and discrete sections, according to Halex.

Previously, only relatively soft or low-melting substances could be used in coating mylar or glass substrates; now it is possible through a high-vacuum process to deposit metals such as platinum tantalum, niobium and nichrome in a manner that minimizes the effects of fractional distillation, the company said. As a result, Halex reports that it is able to deposit these thin films on substrates of a wide variety of geometries with an end product of controlled electric conductivity and light-transmissiveness on the same piece of substrate material.

NEWS

Encoder Readied for Weather Duty

A photoelectric encoder mated to a standard Kollsman Altimeter Setting Indicator, left, is shown with digital readout test equipment, right. The equipment, designed by Kollsman Instrument Corp., Elmhurst, N. Y., for a nuclear weather station will transmit barometric-pressure data in digital form twice in a 17-sec period at 3-hr intervals. The station, developed for the Atomic Energy Commission by Martin Co., is scheduled for shipment shortly to northern Canada. (See *ED*, Aug. 2, p 34).

Carburization Cuts Electron Emissions

A process that suppresses emission from portions of cathode surfaces and auxiliary electrodes has been developed by Philip Metalonics of Mount Vernon, N. Y.

The company says the patented technique, which consists of surface carburization, is useful in generating electron beams of special shapes and in preventing electron emission from cathode supports and auxiliary electrodes close to the cathode. Normally, it is difficult to achieve these objectives because most metals become activated by cathode evaporation and migration products.

Emission from barium-activated dispenser cathodes is reduced by one to three orders of magnitude in the normal operating range of 900 to 1,200 C, the company says. The effect can be achieved at still lower temperatures when cathode evaporation rate is low, for instance in the case of auxiliary electrodes used in conjunction with oxide-coated cathodes.

According to the company, the technique also has been used successfully for generating hollow beams, of disk-shaped grids, accelerating anodes, beam focusing and guard electrodes.

Cathodes having beam focusing or guard electrodes now can be produced as a single structure. The method is reported to be effective in eliminating emission from molybdenum end hats in magnetron cathodes.

Solar Generator Designed To Power Irrigation Pump

A solar-thermoelectric generator designed to power a water pump may find economical application in arid underdeveloped lands.

Westinghouse Electric Corp., in cooperation with the Solar Energy Laboratory of the University of Wisconsin, has built and tested a 50-w power plant.

The company now is developing a 200-w unit. This power plant, it is reported, could pump enough water from a depth of 20 ft to irrigate about four acres of land at the rate of 24 in. of water a year.

Westinghouse says a 200-w plant also could supply the personal needs of 1,200 persons on the basis of 5 gal of water per person a day.

To provide the stated amounts of water, the company says the generator would have to work 10 hr a day for 250 days a year, allowing for about a third of the year for inclement weather.

The generator, weighing just over 16 lb, has a peak operating $T_H = 593$ C and $T_C = 65.5$ C.

Kurt Katz, senior engineer at the Westinghouse new-products laboratories, described the thermoelectric generator last month at the United Nations Conference on New Sources of Energy in Rome.

Tracker for Astronaut

This quad-helix steerable array antenna, being checked by G. R. White, Project Mercury manager for Bendix Corp. of Los Angeles, will aim itself automatically as the manned Mercury space craft comes within range, then receive telemetered signals from space. A global network of 18 National Aeronautics and Space Administration stations, employing such antennas, will receive some 90 channels of telemetered data, maintain two-way communications, and transmit ground-controlled backup of the craft's control functions.

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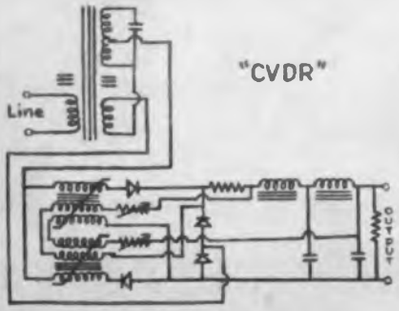

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EDITORIAL

Reliability Is a Function of Attitude

Reliability has been the single most-talked-about subject in the electronics industry for 10 years. It holds an all-time top record. Yet, unreliability is still the chief fault of equipment being produced. Why all the talk and so little action?

The most common answer is, "we don't put our money where our mouth is." When it gets down to greater reliability or greater costs, the latter, as a limiting factor, comes first.

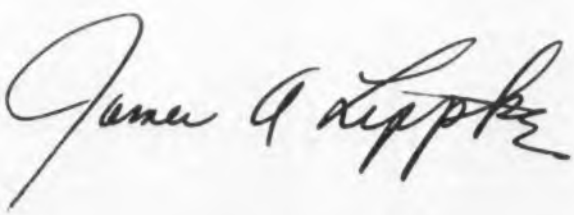
Those who have achieved high reliability know that spending money is not the whole answer. Whether you achieve reliability or not depends on "do you really mean it." Regardless of whether your product is Minuteman or a TV set, to get reliability you have to want it. Reliability, if it is to be achieved, must become almost a personal religion. Like a virtue, it can be talked about endlessly but a state of virtue only comes by living it. Reliability has to be uppermost in one's set of values if it is to become meaningful.

North American Aviation, Inc., learned on the Minuteman Program that you can't readily get followers of the new religion by conversion—not unless these persons could be totally "reborn" again, to draw an analogy from Christian theology.

New plants, new assemblers, new foremen, new outlooks, have proved vital. Assemblers and foremen with ingrained habits often can't acquire the new perspective that is needed. In many instances, "assembly lines" must be broken up into a series of single stations where multiple operations are performed and then thoroughly checked by tests. The procedure often calls for a new plant layout. To achieve reliability, each person involved must know what he is doing in every detail and he must be able to link his actions—such as dropping a component on the floor—with final system reliability.

Fortunately deliberate, costly individual steps in achieving reliability can result in lower final costs. A higher reliability transistor often costs an equipment producer less because he has fewer rejects during final test. A high-quality TV set can produce greater profit for a manufacturer because customers will pay more for a service-free set.

But regardless of cost involved, reliability, or simply, quality, is achieved only when reliability or quality is considered the most important factor.



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CARTRIDGE TYPE

Absolute Max. Rtgs. Res. Ind. Load at 75°C Ambient

EIA TYPE	PEAK INVERSE VOLTAGE (VOLTS)	MAX. RECTIFIED DC OUTPUT CURRENT (ma)
1N1134	1500	100
1N1136	1800	85
1N1138	2400	60
1N1140	3600	65
1N1142	4800	50
1N1143A	6000	65
1N1145	7200	60
1N1147	12000	45
1N1149	16000	45

Operating Temp. Range: −55°C to +150°C Ambient
NOTE: Permissible current at 25°C is 115% of the value at 75°C. Derate linearly from 75°C to zero current at 150°C.

AXIAL LEAD TYPE

MAXIMUM RATINGS

EIA TYPE NUMBER	PEAK INVERSE VOLTAGE (VOLTS)	MAX. AVERAGE RECT. CURRENT * (ma) @ 25°C
1N1730	1000	200
1N1731	1500	200
1N1732	2000	200
1N1733	3000	150
1N1734	5000	100
1N2382	4000	150
1N2383	6000	100
1N2384	8000	70
1N2385	10000	70

*Resistive or Inductive Load
Continuous DC Voltage Same as PIV
Max. Surge Current (8msec.) at 100°C: 2.5 Amperes
Operating Temp. Range: −55°C to +150°C Ambient

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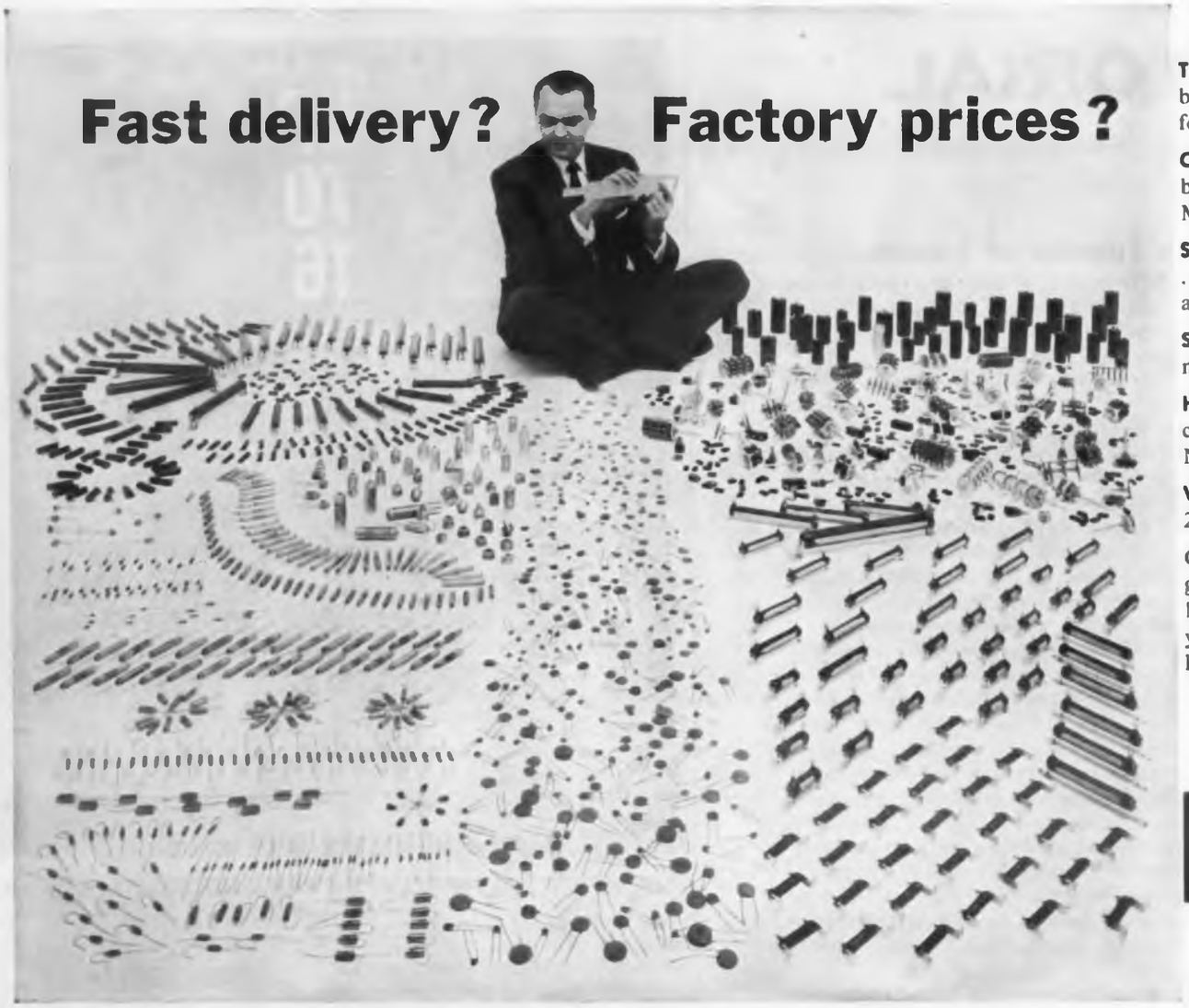

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meeting the reliability challenge—

Howard Bierman
Technical Editor

An ELECTRONIC DESIGN Special Report

Performance characteristics demanded in today's and tomorrow's military weapons and space programs can only be achieved by complexity. Yet complexity for performance gains is certain to be accompanied by a loss in operating time due to component failures and assembly defects due to the sheer number of parts and manufacturing steps involved.

To illustrate the reliability problems facing designers of complex electronic systems, consider the almost unbelievable demands placed on the individual component. From preliminary estimates conducted on a satellite electronic system, no less than 95 per cent certainty of three years mean-time-between-failure (MTBF) is acceptable. Based on the use of 10,000 components in such a system (a conservative estimate), a failure rate of 0.0002 per million hours is required of each part; another way to express this is a MTBF of 508,009,000 hours for each component! As another example, the electronic control and guidance system for the Minuteman missile has an initial objective of 7,000 hours MTBF; this has been likened to running 30,000 TV sets for a year without a single failure. Several orders of magnitude improvement in systems MTBF must be achieved over present-day equipment performances.

The efforts of the Department of Defense in establishing the Ad Hoc Study Group on Parts Specifications Management are outlined in "Parts Specifications Management—The PSMR-1 Report," p 34. **In addition, the activity of government and industry groups to implement the recommendations is discussed.**

The theory and objectives of reliability testing are detailed in "Reliability Testing and its Applications to the TACAN-AGREE Program," **authored by Dr. A. L. Floyd of Hoffman, see** p 38. **Dr. Floyd, as Director of Reliability, was responsible for achieving the following reliability gains in the first test of AGREE-reliability demands: 700 per cent increase in equipment reliability, 10 times improvement in performance and, for added measure, 30 per cent decrease in unit price. The task is detailed in his article.**

What functions should a reliability group perform? How can bickering and time-consuming arguments between the reliability group and engineering, production and control be kept to a minimum? Dr. R. W. Hull, V.P. and Director of Reliability for General Instruments, outlines the duties and responsibilities of the reliability group and also spells out management's role in backing up the group. The organization details are covered in "The Reliability Group: Its Duties and Responsibilities," p 54.

Industrial consultant Dorian Shainin, V.P. and Director of Reliability of Rath and Strong, Inc., details the technique of "Variation Research," p 60 **a tool for improving process and product quality. By means of well-planned statistical experiments, defects can be forced to expose themselves.**

A list of "Military Standards and Specifications on Reliability" **is included on** p 66 **to provide a working guide to the design engineer engaged in defense contracts.**

Finally, to illustrate how absurd reliability prediction techniques can be, Carl O. Holmquist, Capt., U.S.N., provides a magnificent account of the probabilities and statistics encountered with a hammer-nail combination. See how close you can come to predicting the "Over-all Reliability of a Long Established System — The Hammer and Nail," p 52.

reliability

Parts Specifications Management for Reliability—

The PSMR-1 Report: Its Contents and Present Status

"Parts Specifications Management for Reliability (PSMR-1)", more commonly termed the "Darnell Report," created considerable interest when released in the summer of 1960. The background leading to the report preparation, its contents and the efforts of industry and government to put its recommendations in effect are described.

HIGHLY reliable components offer an excellent start for the manufacture of a complex electronic system. Recognizing the needs for adequate parts specifications without frustrating delays and for their dissemination to design and logistics groups as rapidly as possible, the Department of Defense sponsored the Ad Hoc Study on Electronic Parts Specifications Management for Reliability. The study group's recommendations were distributed in July, 1960 and created considerable comment among parts manufacturers and their customers. Among the top questions receiving attention was, "How will the recommendations be implemented?"

Before attempting to answer this question, the background and contents of the study report will be outlined.

Background Lending to the Study Program

In the AGREE report of June 1957, Task Group 5 recommended a complete review of the parts specification program. The Ad Hoc Study on Parts Specifications Management for Reliability was established in July, 1958 and the first meeting was held in October, 1958 with Mr. Paul S. Darnell of the Bell Telephone Laboratories and Consultant to Office, Secretary of Defense, serving as chairman. The study group consisted of a balanced team of military and industry members experienced in parts, electron tubes, semiconductors, equipment and systems design. The joint military-industry representation was deliberately planned to insure consideration of both the manufacturer and customer. The study was concerned only with electronic components; mechanical parts were not included.

The following areas were covered in the study:

1. Specification of reliability of parts in terms of failure rate as a function of time. Test procedures and means to determine compliance with the level specified.
2. Survey of methods used to prepare and coordinate parts specifications.
3. Review of Qualification Approval testing requirements and procedures.
4. Evaluate the adequacy of test requirements with respect to reliability demands and quality control procedures.
5. Establish a program for the exchange of technical characteristics and test data on components.
6. Establish means to develop and disseminate design guides and parts application data (including failure rate data) as a function of circuit application severity level and environment.

What the Darnell Report Is

Report PSMR-1 *P*arts *S*pecifications *M*anagement for *R*eliability) contains the recommendations of the Ad Hoc Study Group and was distributed to government agencies and industry in July, 1960. (The PSMR-1 is often called the Darnell Report since Mr. P. S. Darnell headed the study group.) Volume I, intended primarily for management, relates the recommendations offered by the five task groups engaged in the effort. Volume II, for use by specification writers, covers the concepts and objectives of failure-rate requirements, procedures for incorporating reliability assurance provisions into parts specifications and means of preparing design and procurement documentation for military parts; also included are three prototype specifications (for paper dielectric capacitors, relays and electron tubes.)

The principal recommendations contained in the PSMR-1 include:

1. Establish a high-level government-industry advisory group on management of electronic parts specifications to plan and direct an effective program on a continuous basis.
2. Shift ASESA (Armed Services Electro-Standards Agency) to the Office of the Assistant Secretary of Defense (S & L); this would provide at office, Secretary of Defense level, centrally directed support of the electronic parts specification program.
3. Change the format for specifications to embrace reliability levels, life test plans and environmental limits. Also modify Qualified Approval procedures, acceptance inspection sampling plans and request certified test data be included with shipped individual lots. Finally, procedures are outlined to limit the total time required for specification preparation and printing to 26 weeks maximum; presently, it is possible for similar work to take a year and a half before completion.

What the Darnell Report Is Not

Despite the intensive efforts of all involved in the study, it is obvious that many problems are still to be solved. Therefore, it is of

equal importance to recognize the limitations of the PSMR-1.

1. The PSMR-1 *is not* the last word in parts specifications management. It is a solid foundation upon which a more complete and encompassing program can be built.

2. The prototype specifications contained in Volume II are intended to familiarize the specification writer with the principles established. Items in the prototype guides may require revision to make use of the latest available techniques.

3. The PSMR-1 *is not* a reliability document but rather a recommendation on procedures related to how to specify reliability —high or low level—and procedures to keep the specifications on a timely basis.

4. Last, and obvious, the PSMR-1 *is not* the solution to the parts reliability problem. The specification effort must, of necessity, be supported by a strong program of research and development in the parts area and the capability of industry to produce units to high reliability levels.

How is the Government Implementing the Darnell Report?

The Ad Hoc Study provided recommendations of prime importance for achieving high reliability. High reliability is needed for our military missiles, to safely transport an astronaut into space, to keep our defense communication nets in constant operation and maintain the alertness of our radar warning systems. The recent activity of the DOD, Navy, Army and Air Force to incorporate the Darnell Report recommendations is quite encouraging.

Navy, Bureau of Ships: ARINC Research Corp. is under contract to provide improved semi-conductor specifications, including reliability and life-test sampling procedures, based on analysis of data collected from semiconductor manufacturers, equipment manufacturers and government laboratories. Modes of failure and their distribution, failure prediction techniques, and the most efficient sampling plan to attain high consumer confidence at low testing costs are of prime interest. In addition, ARINC is carefully scrutinizing data involving the application of semi-conductor devices.

The Bureau of Ships has adopted the PSMR-1 prototype format for the preparation of tube specifications. Taking the lead for the DOD, the Bureau of Ships has initiated the revision of capacitor specification in accordance with PSMR-1 recommendations and other specifications to be reworked include those for connectors, relays, resistors and transformers. In addition, the recently released MIL-STD-242 (Navy) "Electronic Equipment Parts—Selected Standards" includes application curves with failure rates plotted for certain parts categories.

Army Signal Corps: The Signal Corps, acting for the DOD and with the cooperation of Battelle Memorial Institute, has revised MIL-R-10509B (except for small lot provisions) to the PSMR-1 principles.

Air Force: The Air Force Systems Command has issued instruction that all AF-generated specs follow the PSMR-1 concept. Gentile Air Force Base is including failure-rate requirements and sampling plans in new tube purchase specifications. The Air Force has also indicated that data accumulated from the Minuteman reliability program will be entered on PSMR-1 format specifications when available.

DOD: Following the release of the Darnell Report, a planning group was set up to resolve problem areas and schedule the necessary implementation. The group consisted of representatives of the office, Director of Defense, Research and Engineering, office, Assistant Secretary of Defense, Installation and Logistics and the military departments. The status of progress resulting from a series of weekly meetings is as follows:

1. The Dept. of Defense has initiated the revision, on a priority basis, of selected specifications for items for which reliability requirements are urgently needed. All new specifications developed by the DOD will contain reliability requirements as recommended in the report. One of the basic objectives of the program to revise or develop new specifications is the establishment of specifications binding upon all military departments and the reduction of single-service specifications.

2. The recommendations contained in the report pertaining to the organization for the management of specifications have been given extensive consideration and an organization structure to achieve the objectives is now under consideration.

3. Qualification approval procedures in the M-205 Manual are being revised in accordance to PSMR-1 suggestions. Products will be qualified to specific failure-rate levels and remain on the Qualified Products List (QPL) only on the basis of continuing to meet the stated life test requirements; the passing failure-rate level will be posted along with the product on the QPL. Also, clearance has been obtained to permit distribution of QPL's to parts users and manufacturers rather than solely to parts users.

4. Changes in the M-200 Series Manuals (DOD standardization manual) to the PSMR-1 recommendations have been drafted and are in the process of tri-service coordination.

5. A MIL-STD document has been prepared to extend contractual requirements for technical data and documentation on parts not fully identified under military standards and specifications. The document is undergoing tri-service coordination while, at the same time, comments are being solicited from industry.

6. A detailed study of existing reliability assurance plans for small lots is under way to develop an effective solution to a difficult problem. The effort is being coordinated with various JEDEC groups of EIA.

7. A guide manual for specification writers is being completed and will be circulated among industry groups.

In addition, a program is being developed to educate and train inspectors on the concepts of sampling plans and procedures. A draft of a tri-service specification for a single elapsed-time indicator standard has been

EIA, AIA, IRE, PGRQC and the ASQC are jointly sponsoring a symposium on "Specifying Reliability in Semiconductor Device Specifications," Oct. 25 and 26. The conference will be held at the Dept. of Interior Auditorium, 18 and C Sts., N.W., Washington, D.C. Mr. Paul Darnell will moderate a panel discussion on "What Price Reliability?"

The Minuteman ICBM program, with an initial objective of a 7,000-hour MTBF for its guidance and control system, represents an enormous reliability challenge. With the component reliability program entering its second year of study, considerable information relating to parts reliability has been collected. ELECTRONIC DESIGN **will soon report the results stemming from the Autonetics division of North American Aviation, Inc. and the 11 component manufacturers involved.**

ELECTRONIC DESIGN **wishes to thank Mr. E. J. Nucci, Coordinator for Reliability, Office of Electronics, Office, Director of Defense (R&E) and Mr. George Ritter, Office of Assistant Secretary of Defense (I&L) for their assistance in furnishing material for the above article.**

finished and is awaiting approval. Finally, it is planned that a time limit of 12 weeks maximum will be set for the preparation or revision of a specification, excluding printing time.

Industry's Efforts in Implementing the Darnell Report

Industry groups, such as the Electronics Industries Association (EIA) and the Aerospace Industries Association (AIA), after close examination of the PSMR-1, endorsed and supported the recommendations contained. Private companies engaged in complex system deliveries had already been involved in specifications management and had been following procedures similar to those outlined in the PSMR-1. Industry's progress in implementing the PSMR-1 can be summarized as follows:

EIA: The Military Products and Parts divisions have provided helpful comments on possible problem areas to be resolved. JEDEC Tube and Semiconductor groups JT-5 and JT-11 are considering the adoption of the Ad Hoc Study Prototype Specification format and contents. The JT-11 group is working closely with the military and industry on improved sampling plans; also in progress are steps to include LTPD (Lot Tolerance Per Cent Defective) figures in new specifications to provide greater customer confidence. These, and other JEDEC efforts, are expected to result in device quality as well as improved specifications.

The EIA M5.2 Reliability Group is collecting parts failure rate data to include in a design-guidance handbook. All companies involved in equipment and component manufacturing have been asked to contribute their data to assist the project. Plans are for the Government to print the handbook and to of-

fer it at the cost of printing to all interested parties.

AIA: The Aerospace Industries Association's Electronic Equipment Technical Committee (EETC) has approved the principles of the PSMR-1 and is in strong support of the recommendation to establish a central group at DOD level to integrate the reliability activity.

Private Companies: Many of the complex systems contractors, including Lockheed, GE Missile and Space Div., Bell Labs, Westinghouse and Hoffman, are already using techniques of PSMR-1 and some have developed specifications similar to the PSMR-1 prototypes; efforts are underway to conduct an exchange of PSMR-1 prepared specs rather than duplicate efforts by several companies on the same spec. Many component manufacturers are engaged in the preparation of specifications for their parts in accordance with the PSMR-1 prototypes. Another trend to the Darnell Report recommendations is the growing number of "certified reliability" ads and brochures offering customers full test data with delivered lots as proof of compliance to stated specifications.

Despite the slow, but steady, progress in the implementation of the PSMR-1, many pitfalls lie ahead. Companies must be prepared to invest in new or improved facilities for testing, manufacturing processes may require extensive revisions to meet stated requirements and a well-planned education and training program for all levels of personnel must be initiated. However, for want of an "easier" way, the concept of high-reliability components to produce a high-reliability system must be strictly adhered to. The benefits to be gained are obvious—the penalty likewise does not require elaboration. ■ ■

Reliability Testing and Its Application to the TACAN-AGREE Program

The first major electronic equipment produced in accordance with the Department of Defense's AGREE reliability procedures was the AN/ARN-21C Airborne TACAN built by Hoffman. Dr. A. L. Floyd, responsible for achieving the 150 hr MTBF for production units containing over 5,600 electrical and mechanical parts, first describes the fundamentals of reliability testing; then the design guides and results achieved for the TACAN program are outlined.

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Director of Plans and Programs
Military Products Div.
Hoffman Electronics Corp.
Los Angeles, Calif.

RELIABILITY has often been criticized for "too much talk, too little action." As an excellent rebuttal, consider the achievements resulting from Hoffman's redesign of TACAN airborne navigational equipment, resulting from a well-planned reliability program: reliability was improved by 700 per cent, performance raised by a factor of 10 and, for added measure, at a 30 per cent decrease in unit cost. To further emphasize the reliability feat, the TACAN equipment was the "guinea pig" selected as the first electronic equipment to comply with the DOD AGREE (Advisory Group on Electronic Reliability) Task Group 3 requirements. TACAN equipment that had been built during the first seven years of production provided a MTBF of only 17 hr (when tested to AGREE environmental stresses). This figure was raised to 150 hr MTBF by (1) following design procedures stemming from reliability studies, (2) testing and removing design causes of failure such as switching transients and misapplication of devices, (3) carefully monitored quality control procedures and (4) reliability testing and failure analysis with follow-up corrective action.

RELIABILITY TESTING

Reliability testing implies determining the reliability of some given equipment, theory or procedure. The first question that must be answered before the test begins is "What is reliability?" In general, reliability means the degree of confidence held that the application of the equipment or theory under consideration will be successful. This definition can be further specialized to the following: reliability is the probability of performing a specified function under given conditions for a specified time interval.[1] By this definition of reliability, three parameters affect reliability: (1) The item under consideration and its tasks; (2) the "given conditions" and (3) the time interval. Thus, when testing for reliability, all of these parameters must be specified and their effect upon the test generally evaluated.

The discussion that follows will be centered on electronic equipments and components, although the concepts are applicable to all reliability tests. For any electrical items being operated under "given" conditions," forces are exerted upon the equipment and can cause failure. All of these forces, i.e., temperature, voltage, vibration, time, test procedure, can be combined into one resultant force or stress capable of causing failure. For the present discussion, this force will be identified as the force of mortality, $F(t)$, and considered to be a function of the electrical item's total life time.

For a large sample of items operating under "given conditions", the force of mortality can be determined by the following procedure: All of the items are placed in operation and a continuous record kept of the number of items that have not failed, i.e., survivors S vs time. Experiments indicate that a continuous analytical function can be fitted to this data by use of the following definition: Force of mortality is equal to the number of units that are operating, that is

$$F(t) = -\frac{1}{S}\frac{ds}{dt}$$

t = the total life time of the units (1)

The above equation can be integrated between limits as follows:

$$\int_{t_1}^{t_2} F(t)dt = -\int_{S_1}^{S_2} \frac{1}{S}\,ds = lnS\Big]_{S_1}^{S_2}$$

$$= ln \frac{S_2}{S_1} \text{ or } S_2 = S_1 e^{-\int_{t_1}^{t_2} F(t)dt} \quad (2)$$

Eq. 2 thus gives a method of computing the number of units surviving vs time interval.

Considering now the definition of reliability, the reliability of the equipment to perform a mission successfully, in a time interval given by $\Delta t = t_2 - t_1$, is the probability of selecting a unit out of the sample, S_1, that will not fail. This is, by definition, the ratio of the number surviving, S_2, at t_2 divided by the sample size S_1 at t_1

$$R = \frac{S_2}{S_1}$$

$$\text{or } R = e^{-\int_{t_1}^{t_2} F(t)dt} \quad (3)$$

Thus, if the force of mortality function is known for a given item operating under the "given conditions," the reliability of the item to perform successfully a mission over any time interval can be computed by Eq. 3. In particular, if the force of mortality, $F(t)$, is a constant, F, Eq. 3 reduces to

$$R = e^{-F\Delta t} \quad (4)$$

Under the condition of constant force of mortality, the exponent F in Eq. 4 is usually identified as the failure rate for the item and is related to the inverse constant, mean time between failures, T, or mean time to failure, by

$$F = \frac{1}{T} \quad (5)$$

It has been demonstrated that, if the force of mortality, $F(t)$, is known for a given item operating under given conditions, all reliability information can be calculated by Eq. 3. It should be emphasized that the force of mortality varies considerably with the "given conditions" as well as with item life time. *The purpose of all reliability testing is the determination of information about the force of mortality for the given item operated under "given conditions."*

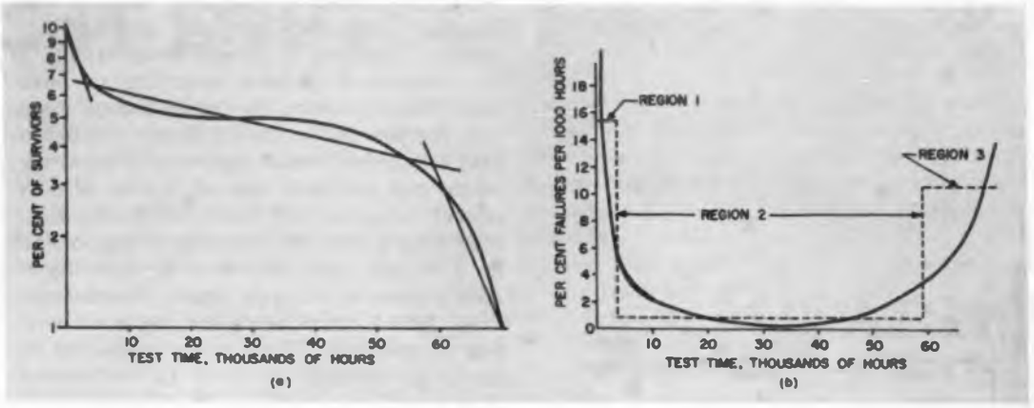

Fig. 1. Typical test data for test-to-failure on individual components. If a large sample of components is operated over a period of time under specified test conditions, the curve in (a) will relate the number of survivors vs time. Three regions of failure are indicated by the straight lines approximating the curve. In (b), the three regions of failure are shown when the number of failures is plotted against time. Region 1 represents early failure due to random effects, region 2 indicates the life span and region 3 shows the wearout period.

General Nature Of The Force Of Mortality

Considerable experience has been accumulated on the nature of the force of mortality. Before designing a reliability test, the effect of test procedure on the force of mortality curve should always be evaluated. The simplest type of force of mortality is associated with unrepairable or unmaintainable units. Typical examples might be electrical components such as resistors, capacitors, and vacuum tubes. If a large sample of such components is placed in operation (on reliability test) under given conditions, a record of per cent survivors (components that have not failed) vs time will give a curve similar to that shown in Fig. 1a. This curve can be approximated by three straight lines representing three regions of failure mode. The first region is called the early failure period and represents high failure rates due to "random" effects. The third region is called the wearout period. Fig. 1b, shows the force of mortality curve corresponding to the failure data of Fig. 1a. The three regions of failure mode are shown by the dotted line. Obviously, one of the tasks of reliability workers is to reduce region 1, early failure period, to a minimum portion of the total life span of the unit. The unit manufacturer accomplishes this through quality and process controls. The unit user reduces the effect of region 1 by screening processes which overstress the units so that defectives are removed, or by unit burn-in. The second reliability mission is to increase the life span of region 2 and decrease the absolute value of the average failure rate experienced. This is usually accomplished by engineering techniques and is generally a function of design or material choice.

The force of mortality for complex equipments not maintained—i.e., missile or satellite equipments—is very similar to the force of mortality for individual components although the absolute values are shifted due to the complexity. However, many equipments are designed, used and reliability tested where maintenance is considered a part of the "general condition" of operation of the equipment. For purposes of the present discussion, only repair type maintenance will be considered as most reliability tests do not allow use of preventive maintenance. Reliability test procedures for equipments consist of selecting an adequate sample—the

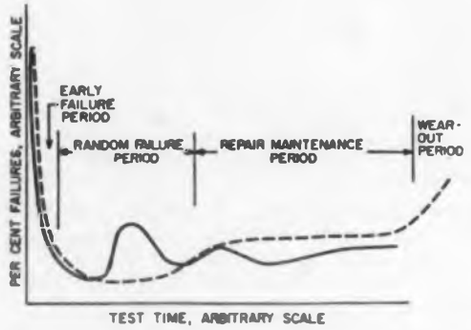

Fig. 2. Force of mortality for complex equipment. The solid curve represents the idealized form where the failure of components other than the one reaching wearout is low. The dotted line indicates the more realistic case where several components approach wearout at about the same time.

method of selection to be discussed in a following section—and placing the sample of equipments on test. When an equipment fails, it is repaired and placed back in test. As the sample size remains constant, the force of mortality is directly proportional to the number of failures occurring per unit time. Usually during the initial phases of the test, the force of mortality is very similar to that for the individual components. However, as the test proceeds, one component or component category will reach its wear-out region long before the remaining components do. This will cause the force of mortality to rise. However, through repair maintenance these failed components are replaced with new components. These new components initially go through an early failure period, then a random period, and finally again to the wearout period.

Thus the force of mortality rises and falls with each cycle the failing components goes through. However, due to statistical variation of time of failure, the width of the rise in the force of mortality caused by the wearout of one component increases with each cycle until finally the force of mortality remains almost constant with life time. The solid-line curve of Fig. 2 shows this effect in idealized form where the failure of components other than the one reaching wearout is very low and the wearout period is rather sudden.

In most cases the wearout period onset is slow and several components start this period at about the same region in time. The dotted curve of Fig. 2 shows the usual effect on the force of mortality of repair maintenance of equipment. As can be seen by Fig. 2, four idealized periods of failure for equipments can be defined; early failure period, random failure period, preventive maintenance period and wearout period where maintenance becomes excessive. In improving equipment reliability through remedial action, obviously the analysis of the causes of initiation of the repair maintenance period is most important. Also, test specification for reliability acceptance testing must consider the effects of these four periods of failure.

Table 1. Comparison of Stress Levels Outlined by the AGREE Procedures for Reliability Testing of Electronic Equipment.

Environmental Conditions	Stress Levels			
	L (Light)	M (Medium)	H (High)	X (Extreme)
Temperature	25 ± 5 C (68 F to 86 F)	40 ± 5 C (95 F to 113 F)	−54 C to +55 C −54 C to +55 C	−65 C to +71 C* (−85 F to 160 F)
Vibration	None	25 ±5 cps at ±0.5 in. max amplitude	Same as M	Same as L
On-Off Cycling	3 hr "on" plus long enough to stabilize at both high and low temp by actual measurement.	Same as L	Same as M	Same as L
Input Voltage	Nominal so long as within equipment specified voltage range.	Max. specified permissible voltage +0−2%	Same as M	Same as M

* The extremes of temperature will be governed by the latest applicable specifications.

Factors Influencing Environmental Conditions of a Reliability Test

In reliability testing of components or equipment, the environmental conditions, part of the "given conditions," greatly affect the force of mortality for the item under test. If the reliability test is designed to give information on the force of mortality function for a component or equipment in use, the complete reliability test should exactly reproduce the expected environmental conditions. There are many reasons why this is not generally done. One reason is that the cost of complete environmental duplication is extremely high; second, it is desirable to reduce the time required to complete a reliability test.

In general, it is not necessary to completely duplicate all used environmental conditions when performing a reliability test on components or equipments to determine information about the force of mortality under use conditions. Failure analysis of defective components and equipments indicate that only a relatively few environmental conditions contribute any major part of the force of mortality. Thus valid reliability tests may be performed by only simulating the contributing conditions. Most failures that occur can be traced to mechanical or chemical causes which result in catastrophic or performance

degradation failure in parts or components. Thus it is necessary to simulate in a reliability test only those conditions that would accelerate mechanical or chemical changes. These include temperature, temperature cycling, vibration and/or shock, on and off cycling, electrical stress such as voltage, and atmospheric conditions, such as humidity. Considerable effort has been expended in order to standardize and minimize the number of environmental conditions required to determine the force of mortality function for given components and equipments. The TR-59-416-1[2] report on components usually limits these conditions to approximately two. For button mica capacitors, covered in MIL-C-10950B, the failure rate is assumed to vary only with voltage stress and temperature. However, it should be remembered that these restrictions are valid only if the force of mortality, i.e. failure rate, is truly affected by these environmental parameters only. For instance, certain designs of paper capacitors, MIL-C-25A, have force of mortalities that are strongly affected by vibration. If tests are performed without this stress, erroneous results will be obtained.

Standardization of Environmental Test Conditions A Pressing Reliability Need

For electronic equipments, considerable effort has been made to define and standardize the environmental conditions affecting the force of mortality function. For general military electronic equipment, the AGREE, in their report on "Reliability of Electronic Equipment"[1] set four standard levels of environmental stress for reliability testing of electronic equipment. These are Level L, for laboratory equipment; Level M, for mobile and shipboard equipment; Level H, for most airborne equipment; and Level X for extreme environmental use of equipments. Four environmental conditions are outlined; operating temperature, temperature cycling, vibration, and operating voltage. Table 1 presents a comparison of these stresses.

The above environmental stresses appear to be adequate for most general applications of military electronic equipment. However, certain equipments that experience peculiar stresses—i.e., dropped from aircraft—must

have these stress levels modified to include all effective environmental stress. Equipments in this latter category are usually single-use equipments where maintenance is not considered part of normal operation.

There are definite advantages to standardizing environmental stress conditions for reliability tests. The only way that reasonably accurate comparison of the reliability for different components and equipments can be made is from test results using identical environmental conditions. At present there appear to be few industry-wide accepted standards for environmental reliability test conditions. One of the most pressing reliability requirements today is standardization of environmental test conditions for reliability tests.

In addition to reliability testing under simulated environmental conditions, sometimes it is desirable to accelerate reliability testing by increasing the environmental stress conditions that contribute to the force of mortality. The interpretation of accelerated reliability test data in terms of actual reliability test data is usually difficult. However, in many cases the cause of failure of an item can be related to one or two parameters. In such cases, the complete force of mortality over the life of the item under test can be approximated in a short test time by performing several reliability tests simultaneously under increasing levels of the stress parameter causing the failure. The most usual effect of increasing stress causing failure is to decrease the time required for onset of the wearout period. If all of the failures are caused by the stress parameter being varied, the same number of failures will occur between the start of test and start of wearout. Thus, the force of mortality will have a higher value due to this compression in time. For items under test that have constant force of mortality, failure rate, over extended periods of time, proportional coefficients can be determined for the life-time contraction due to excess stressing. Thus the force of mortality can be approximately evaluated over the life of an item by performing several reliability tests at different

levels for short periods of time and reducing the data to the desired stress level by proper expansion of the time scale. Extreme care must be exercized in this type of testing to be sure that the stress being varied represents the only cause for failures under consideration.

Establishing Sample Size and Unit Operating Hours for Statistical Test

Two parameters must be considered in the statistical design of a reliability test. The first parameter is the sample size of equipments or units tested. The second is the unit operating hours tested. In general, these two parameters are not independent and usually two or more tests are performed to determine the necessary information concerning the "force of mortality" of an equipment lot. However, for purposes of discussion, the following premise will be followed: The sample size of equipments tested is determined primarily from consideration as to how accurate reliability information obtained from reliability test on the sample represents the reliability status of the equipment universe from which the sample is taken. The second sampling consideration, total equipment operating hours, determines how accurately the reliability information derived from the test represents the reliability status of the sample itself. Each of these considerations will be discussed separately.

The use of these statistical design concepts is best demonstrated by an example. For purpose of this example, assume that an idealized universe of equipments can be assumed to be designed and constructed such that the early failure period is of zero time length and the onset of wear is of infinite time length. Further, assume that in the random period, each equipment has a constant failure rate; the constant is not necessarily the same for all equipments but is approximately distributed in a random manner about some mean value. Now assume that a reliability test is to be run for accepting the universe of equipments based upon a reliability test data obtained from a sample from the universe. As this is to be an acceptance test on these equipments, the con-

ditions for acceptance must be defined before the test is designed. In setting down these acceptance limits the values given by Task Group 3 of AGREE[1] will be followed although other limits could be applied.

The use of a particular equipment dictates a required reliability or, by Eqs. 4 and 5, a required mean time to failure (MTBF). This will be symbolized as T_2. The first decision that must be made is what percentage of equipments in the universe can have a mean time to failure less than T_2 for acceptance of the universe. Obviously, if zero were the choice, all equipments would have to be tested. Uusually this is not desirable so that some other value is chosen. Following AGREE recommendations, assume this value to be 10 per cent. The third consideration is the degree of confidences, in the test results, that the MTBF determined by the sample test is truly greater than T_2. This cannot be 100 per cent as this would imply that all equipments would be tested for their entire life span. Task Group 3 of AGREE has set this confidence value at 90 per cent ($B = 0.9$). The above considerations are called user or customer considerations. Numerical values were taken from Task Group 3 recommendations although any other values might be chosen if circumstances dictated. The user considerations set forth the conditions determining that the universe should not be accepted.

The preceding information is sufficient to permit design of a reliability test. It fixes the equipment sample size and the total accumulated operating hours sample size. First, a test will be designed based upon these assumptions. Then a second group of simplifying conditions, called producer considerations, will be proposed and a second reliability test (a sequential test) designed to demonstrate the test time can be markedly reduced.

Choice of Equipment Sample Size: The choice of sample size from the universe by the preceding consideration must be such that, if the universe has 10 per cent of the equipments below T_2 MTBF, the test will show to 90 per cent confidence these defec-

tives. Thus, the sample size can be computed such that no defective is allowed, one is allowed, etc., by the usual quality control techniques applying laws of probability. First calculate the minimum sample size such that if no defectives are found, then 90 per cent of the time the number of defectives in the universe is less than 10 per cent. Let p be the probability of picking a good equipment out of the universe; let q be the probability of picking a defective equipment out of the universe. By applying the binominal limit law, the relative probability of obtaining 0, 1, 2, 3 defectives is given by evaluating the terms of the expansion

$$(p+q)^n = p^n + npq^{n-1} + \frac{n(n-1)}{2} p^{n-2}q^2 + \cdots (6)$$

Thus for a sample size n, the probability of having no defectives is p^n, the probability of one defective is np^{n-1} q, etc. The test criteria is that this probability must be less than 10 per cent (i.e., 100% − 90%). Thus the sample size for no defectives is given by

$$0.1 = p^n = 0.9^n \text{ as } p = 0.9$$

$$\text{or} \qquad n = 21.75 \approx 22 \qquad (7)$$

If one defective is to be allowed, then the second term must be evaluated for n as above. Thus a sample size can be determined $n \approx 59$; the minimum sample size to be tested is 22.

Choice of Operation Hour Sample: In designing the statistical part of the reliability test, it is necessary to determine the number of operating hours to run vs number of failures experienced to assure to a 90 per cent confidence that the equipment has a true MTBF greater than the prescribed value T_2. The 10 per cent risk of passing equipment with less than T_2 MTBF is called the consumer risk. Is designing the test, it is desirable to set a second risk called the producer risk. That is if the true MTBF is T_1 where $T_1 > T_2$ which is the risk that the equipment will be rejected by the test. The ratio of T_2/T_1 is usually called the discrimination ratio. This can be set at any value: however, the recommendations of AGREE assure that it is 2/3. The producer risks can

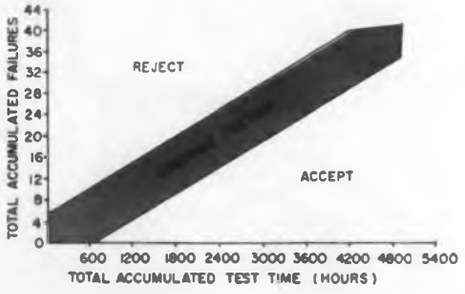

Fig. 3. After the reliability test conditions are established, the equipment is run and failures are plotted against operating time. By use of the reliability test criteria curve (MTBF = 150 hr in the curve shown), a decision to either accept, reject or continue tests can be made.

General Design Guide Used to Achieve the TACAN Reliability Goal of 150 hr MTBF.

1. Resistors

Composition: (In general MIL-R-11A). Operate less than 50 per cent wattage.

Film: (In general MIL-R-10509A). Operate less than 75 per cent of rated wattage. The circuits employing them should be capable of satisfactory operation when the resistance values vary ±2.5 per cent of the rated value for 1 per cent resistors.

Wirewound, Accurate and Power: (In general MIL-R-93A and MIL-R-26B). Operate less than 40 per cent of rated wattage.

2. Capacitors

DC Paper: (In general MIL-C-25A). Operate less than 55 per cent of rated voltage.

Silvered Mica: (In general MIL-C-5A). Operate less than 55 per cent of rated voltage.

Foil Mica: (In general MIL-C-5A). Operate less than 65 per cent of rated voltage.

Button Mica: (In general MIL-C-10950). Operate less than 75 per cent of rated voltage.

Ceramic: (In general MIL-C-20A and MIL-C-11015). Operate less than 40 per cent of rated voltage.

Variable Ceramic: (In general MIL-C-81). Operate less than 40 per cent of rated voltage.

Tantalytic: Very little data available. However, where practicable double case capacitors should be used. Review use with reliability engineers.

3. Transformers and Coils.

Class B Insulation: Maximum hot spot temperature rise should not exceed 20 C.

Specified Insulation: (5,000 hr life at 170 C). This specification is Class T insulation. The maximum hot spot temperature rise should not exceed 50 C.

4. Relays (excluding Choppers).

Sensitive: (Contact current 100 μa to 1.5 amp, coil power less than 0.1 w).

- Employ relays with a 90 per cent survival for 50,000 operations.
- Use between 90 and 10 per cent rated contract current.
- Maximum number of contact sets used should be less than six.

General Purpose: (Contact current 100 μa to 10 amp, coil power above 0.1 w).

- Employ relays with a 90 per cent survival for 50,000 operations.
- Use between 90 and 10 per cent of rated contract current.
- Maximum number of contact sets used should be less than 10.

Power: (Contact ratings above 10 amp). Same as for General Purpose.

5. Switches and Plugs.

Use standard practices with quality connectors.

6. Tubes (In general MIL-STD-200 types)

Diodes: Operate below 90 per cent of full power. Maintain heater voltage between 90 and 100 per cent of rated value.

Triodes: Operate below 90 per cent of full power. Maintain heater voltage between 90 and 100 per cent of rated value.

Tetrodes and Pentodes: Operate below 80 per cent of full power. Maintain heater voltage between 90 and 100 per cent of rated value.

Thyratrons: Avoid use. Where required, use will be reviewed by reliability engineers.

7. Semiconductors—Diodes.

Germanium: Not satisfactory for ARN-21C.

Silicon: Operate below 50 per cent of rated wattage.

Selenium Rectifiers: Not recommended although they can be used where necessary below 15 per cent of rated wattage.

8. Crystals.

Stay within specification limits for operation at 125 C.

be set such that 90 per cent confidence will exist in the test result that the equipment will not be rejected if the true MTBF exceeds $T_1 = 3/2\ T_2$. This additional information would now allow calculation of the actual number of operating hours required such that an accept decision could be made if the failures experienced were less than some value "a" and a reject decision if the failures were greater than "$a + 1$." However, the actual MTBF may be considerably less than T_2 or considerably more than T_1.

In this case, the test time might be considerably shortened if the decision to accept or reject were based on a difference of more than one failure. The design could be constructed this way except that this information is not known until after the test is completed. However, the test can be designed such that the total test time is not fixed; instead, the data obtained during the test is analyzed as it is obtained to determine if sufficient data has been accumulated to reach a conclusion on test results to the confidence required. When a decision can be made, the test is then stopped. This type of test is called a sequential test. In the sequential test, three possible decisions can result after each analysis; in the case under discussion they are: (1) the MTBF is greater than T_1, (2) the MTBF is less than T_2, (3) not enough information is available for a decision, continue the test.

Associated with decision 1-2 are the consumer and producer risks discussed. Let α be the risk that the decision is made that the MTBF is greater than T_1 when, in fact, the MTBF is less than T_2, consumer risk for this case. $\alpha = 1 - 90$ per cent $= 0.1$. Let β be the risk that the decision will be that the MTBF is less than T_2 when, in fact, the MTBF is greater than T_1 (producer risk), for this case $\beta = 0.1$.

The customary method for carrying out the sequential test is to make a "likelihood ratio" calculation with each variable observation. The "likelihood ratio" is defined as

$$L = P_2/P_1 \tag{8}$$

where P_1 is the possibility that the MTBF is T_2. Epstein and Sable[3] have shown that the risk will not be exceeded if when

H_1 is accepted $L \leqslant \beta/1 - \alpha$

H_2 is accepted $L \geqslant 1-\beta/\alpha$ (9)

By the present test assumption, P_1 or P_2, the probability of experiencing N failures

in a given time with T_1 or T_2 MTBF is given by a Poisson distribution—as indicated below:

$$P_1 = \frac{\left(\frac{t}{T_1}\right)^n e^{-t/T_1}}{n!}$$

$$\text{or } P_2 = \frac{\left(\frac{t}{T_2}\right)^n e^{-t/T_2}}{n!} \quad (10)$$

Thus the likelihood ratio "L" for n failures in operating time to is given by

$$L = P_2/P_1 = \left(\frac{T_1}{T_2}\right)^n e^{-\left(\frac{1}{T_2}-\frac{1}{T_1}\right)t} \quad (11)$$

Thus combining Eqs. 9 and 11, the following conditions for continuing the test decision are

$$\frac{\beta}{1-\alpha} > \left(\frac{T_1}{T_2}\right)^n e^{-\left(\frac{1}{T_2}-\frac{1}{T_1}\right)t} > \frac{1-\beta}{\alpha} \quad (12)$$

This inequality can be transformed as the following

$$\frac{-\ln\frac{\beta}{1-\alpha} + n\ln\left(\frac{T_1}{T_2}\right)}{\frac{T_1}{T_2}-1} > \frac{t}{T_1} > \frac{-\ln\frac{1-\beta}{\alpha} + n\ln\left(\frac{T_1}{T_2}\right)}{\frac{T_1}{T_2}-1} \quad (13)$$

Substituting values of α, β, $\frac{T_1}{T_2}$, this becomes

$$0.81\ ln + 4.4 > t/T_1 > 0.81\ ln - 4.4 \quad (14)$$

Fig. 4. The AN/ARN-21C Airborne TACAN is the first major electronic equipment to be produced to the DOD AGREE procedures. The complex system, containing over 5,600 electrical and mechanical parts, consists of a receiver-transmitter (RT-220), channel selector and bearing indicators.

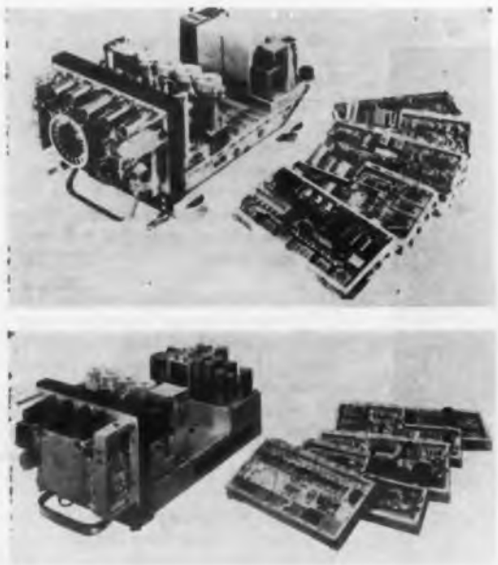

Fig. 5. "Before" and "after" photos illustrating the redesign of modules to meet the new performance requirements set by the Air Force plus the AGREE specifications.

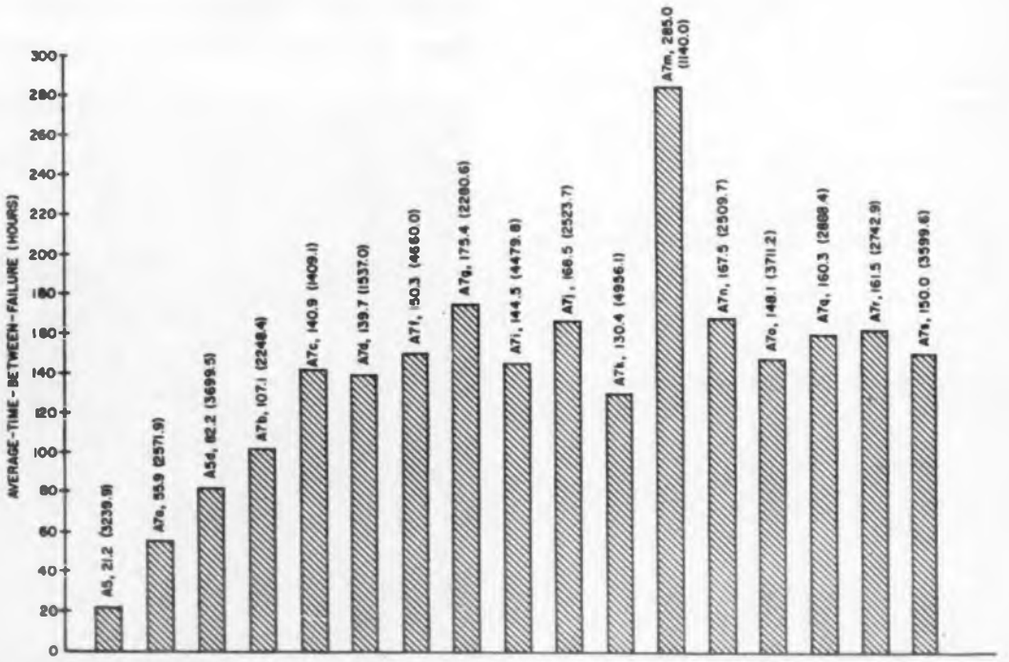

Fig. 6. Average time between failures experienced for RT-220C equipment; the reliability requirement specified a MTBF of 150 hr.

Table 2. Failure Rates for Components of RT-220 Production Units.

Component Category	(a) Predicted Failure Rate	(b) A7f Failure Rate	(c) A7g Failure Rate	(d) A7i Failure Rate	(e) A7j Failure Rate	(f) A7k Failure Rate	(g) A7m Failure Rate	(h) A7n Failure Rate	(i) A7o Failure Rate	(j) A7q Failure Rate	(k) A7r Failure Rate	(l) A7s Failure Rate	(m) Composite Failure Rate	(n) Adjusted Failure Rate
Capacitors	0.08	0.51	0.17	0.09	0	0.16	0.54	0.16	0.11	0.41	0.87	0.55	0.32	0.15
Fixed Resistors	0.09	0.13	0.13	0.13	0	0.06	0	0	0	0	0	0	0.06	0.03
Variable Resistors	0.15	0	0	3.96	2.33	0	0	0	3.17	0	2.14	0	1.27	0.32
Transformers & Inductors	0.27	0.83	0	1.64	0	2.46	0	2.91	0	0.84	2.66	2.03	1.31	0.52
Coils & RF Chokes	0.08	0	0	0	0	0	0	0	0	0	0	0	0.09	0
Tubes	3.8	1.48	3.79	1.54	0	1.74	3.93	2.06	3.25	0.59	2.51	0.48	1.94	1.94
Relays	2.3	0	0	2.24	3.97	0	4.56	3.98	10.78	6.92	0	0	2.96	2.96
Switches & Connectors	0.2	1.13	0	1.18	1.04	0	3.60	0	0	0	0	0	0.57	0.14
Crystals	0.7	0	0	0	0	0	0	0	0	0.27	0.29	0.22	0.06	0.06
Semiconductors	1.0	0.77	3.13	2.40	5.67	2.53	1.63	2.13	0.96	2.47	1.30	2.48	2.21	1.29
Misc. Electrical Parts	1.5	0	0	0	2.48	1.25	0	6.65	4.50	5.77	0	13.85	3.59	3.59
Workmanship	0.03	0.05	0.02	0.04	0.01	0.04	0.04	0.02	0.03	0.02	0	0.02	0.03	0.03

All failure rates in %/1,000 hr. reliability testing

Thus the equipment is accepted if t/T_1 is greater than the number calculated on the left and rejected if less than the number on the right. Fig. 3 shows this relationship in graphic form.

Thus all that remains is to run the equipment under the prescribed operating condition and plot failures vs operating time. By observing the region in which the curve falls, a decision on whether to accept, reject or continue tests can be made.

TACAN-AGREE PROGRAM

The Military Products Div. of Hoffman Electronics Corp. has been carrying out reliability tests on the airborne TACAN Equipment, RT-220 (see Fig. 4) under Task Group 3, Stress Level H, AGREE Procedures since December 1958 (See Table 1). The first test was on RT-220B Equipment which was not designed for Stress Level H. The later test was on RT-220C equipment which was designed for Stress Level H. The theoretical MTBF of the RT-220C at Stress Level H was greater than 200 hr. The statistical design of these tests was identified to the previously discussed design. The contract requirement for MTBF, T_1, was 150 hr. Throughout these tests, each failure experienced was investigated to determine the cause of failure and, where possible, corrective action was implemented to prevent the failure.

During the period of the contract a total of 25 reliability tests have been run on the RT-220C containing approximately 1,000 components, see Fig. 5. As a result of these tests, a total of 78,381 equipments operating hours of experience were accumulated, 895 failures were analyzed and 1,128 specific corrective actions were taken. Nine major reliability reports were written.

Fig. 6 shows the average time between failures experienced for each test, most probable time between failures. This is due to the effect of the early failure period. The equipment sample size for these tests was 7 for the A5 series of tests and 48 for the A7 series of tests. As can be observed by this figure, the average time between failures appears to level off between 140 and 160 hr. This leveling does not necessarily represent an ultimate limit of the design or state-of-the-art. The leveling off represents primarily the limit of data available for control and corrective action provided by the test. Had the test been run on the same statistical basis with an MTBF goal of say 250 hr, more test time would have been accumulated on

each test, more failures experienced and more corrective actions taken. Thus, the average time between failures achieved would further increase. The upper reliability limit for this design is not known or derivable from this data. The failure rates for component categories that are reported below represent those values obtainable within this test time limitation for control.

Failure Rates Experienced For Each Component Category

Table 2 shows the failure rates experienced for each component category listed. Some categories have been combined into one general category for simplification. The first column gives the design estimates for failure rates after testing the RT-220B equipment. The last two columns give the average failure rate achieved over all satisfactory tests and the average failure rate that could have been achieved if the corrective actions had been incorporated on all tests before the test was run. Thus, the last column gives an estimate of the best achievable failure rate as a result of data and corrective action gathered on this series of tests.

Conclusion Based On TACAN Experience

As a result of experience on the TACAN program, several general conclusions seem to follow. These are:

1. Designing equipment according to reliability design data available at start of the project did not in itself result in meeting the reliability requirements, although it was necessary in the chain of reliability activities.
2. Testing and removing design causes of failure—i.e., such as transients during switching, misapplication of tubes, etc. —did not alone result in meeting the reliability requirement.
3. Quality control procedures are not capable of determining that component parts used in building and equipment are satisfactory for reliability requirements if any reasonable economic limits are considered. However, this reliability goal did not require such controls.

4. Reliability testing and failure analysis with corrective action in all phases of company activities associated with the TACAN, RT-220C, (design, production engineering, material procurement, production testing, etc.) resulted in an equipment meeting the reliability requirement.
5. The final reliability achieved was limited by the degree of testing performed on completed equipments for reliability control and corrective action applied as a result of testing rather than design, state-of-the-art, quality control, etc.
6. Testing according to the AGREE statistical requirements for 150 hr MTBF on an equipment having approximately 1,000 electrical components provided sufficient data for reliability control and corrective action to achieve the reliability goal after six tests or a total of approximately 25,500 operating hours. This is 170 multiples of the MTBF specified.

These conclusions are based upon the experience gained with one type of equipment under conditions of medium volume production. Obviously, the experience gained on this equipment will result in a different approach to reliability for future equipments. However, reliability control by exception—i.e., through failure experience—appears to be the most practicable and economic means of achieving a specified reliability goal at this time. ■ ■

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Acknowledgment

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Reliability Analysis of A Long Established System—

The Hammer and Nail

Are reliability analyses a bit unrealistic when compared to actual field results? Capt. Holmquist, author-lecturer on the reliability of Navy weapons systems, is concerned with the many absurd conclusions stemming from shaky assumptions and questionable data. To prove that "rigged" assumptions and erroneous data can prove almost anything, Capt. Holmquist presents a short analysis on the over-all reliability of the hammer-nail combination. He has applied the same line of logical reasoning used in weapon systems studies. Try to guess the over-all reliability before reading the article.

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A HAMMER and its associated component, a nail, are considered by a majority of people to be an exceptionally reliable combination or system. Carpenters with various degrees of skill use the hammer and nail in construction work daily in all parts of the country. Our buildings and houses stand as a national monument to the reliability of the hammer and the nail in construction. This should be sufficient proof for anyone, be he scientist or layman, that this system is without a doubt the epitome of reliability in our modern age.

Since the hammer and nail are a combination which is real and, hence, subject to mathematical analysis and the science of statistics and probability, it is possible to investigate rigorously the system reliability of the hammer and nail combination. In this present enlightened age of scientific achievement, it is common knowledge that mathematics is an exact science and that results obtained by formulae are, *a priori*, also exact.

Let us investigate, with conventional mathematical rigor, the over-all system reliability of a hammer in driving a nail. The theory of probability is used extensively throughout the analysis. All data employed have been obtained from unquestionably reliable sources and have been checked, rechecked and rechecked. The data are considered to be the most accurate available in this country at the present time.

Indisputable Data of Paramount Importance in Analysis

In investigating hammer and nail reliability, the following basic formula is used. Notation used in this formula is defined in the paragraphs following the formula.

$$P_{sh} = P_{ah} \times P_{fh} \times P_{h_1b} \times P_{h_2b} \times P_{ho} \times P_{an} \times P_{fn} \times P_{hn}$$

P_{sh} is the over-all system reliability of a hammer in driving a nail. The purpose of this investigation is to establish rigorously the reliability of this system.

The first term of the right side of the equation (P_{ah}) is defined as the probability that an average man owns a hammer. Obviously, a man cannot drive a nail without a hammer. A house-to-house survey of the entire country shows that 37.3 per cent of the eligible working force of this country owns a hammer. Hence, $P_{ah} = 0.373$.

P_{fh} is defined as the probability that the average man can find a hammer when he needs it. Experience has shown that hammers, like many other things, are easily lost or misplaced. If there are children around the house, the problem increases in complexity. An extensive survey shows that 30 per cent of the time that a hammer owner looks for a hammer, he cannot find it immediately because it has been lost or misplaced. Hence, $P_{fh} = 0.70$.

The term P_{h_1b} is defined as the probability that the handle will not break during the operation of driving a nail. Everyone knows that hammer handles are made of extremely tough and durable wood; hence, the probability of breakage is very low. P_{h_1b} is assigned a value of 0.98.

The term P_{h_2b} is the probability that the hammer head will not break during the hammering operation. Here again the head of a hammer is made of extremely durable metal, usually steel, and the probability of breakage during the operation is extremely low. P_{h_2b} is confidently assigned a value of 0.99.

P_{ho} is the probability that the head of the hammer will not fly off during the hammering operation. Extensive surveys have shown that this failure occurs quite often, at times with disastrous results. P_{ho} was found to have a value of 0.97. However, because of the serious nature of this type of failure, this factor should be given double weight, or $P_{hn} = 0.97 \times 0.97 = 0.94$.

The next term, P_{an}, is defined as the probability that the average man will have a nail to complete the hammer-nail system combination. It is obvious that a man who has not bothered to supply himself with a hammer probably will not bother to obtain nails for the operation either. P_{an} must, therefore, be equal to P_{ah}, or $P_{an} = 0.373$.

P_{fn} is the probability that the average man cannot find a nail even though he owns some. A nation-wide survey has shown that a man normally has 53 times as many nails as ham-

mers in the average household. Obviously, it is much easier to find one of 53 articles than one particular article. After a series of rigorous mathematical analyses, it has been determined that the average man can find a nail 92.1 per cent of the time, or, $P_{fn} = 0.921$.

The last term P_{hn} is defined as the probability that the average man can hit a nail successfully with a hammer. Statistics gathered from governmental sources show that only 7.2 per cent of the working force of America is composed of skilled carpenters and, hence, have experience in hitting nails with hammers. A sampling system has been used to determine the probability that the average inexperienced man can hit a nail with a hammer on the first try without bending the nail, missing the nail, etc. The results of this sampling show that approximately 75 per cent of the time the average man can be expected to hit a nail with a hammer. Considering that 93 per cent of the men of this country are unskilled in hammering, P_{hn} obviously has a value of $0.93 \times 0.75 = 0.696$. This is the only value used in this analysis which is considered to be estimated and not rigorously defensible, since it is based on a sampling process and not on a broad survey.

The Over-all System Reliability Is Rather Surprising

Substituting the above rigorous values into the above likewise rigorous formula, one obtains a rigorous value of 0.057 for P_{sh} as follows:

$$P_{sh} = 0.373 \times 0.70 \times 0.98 \times 0.99 \times 0.94 \times 0.373 \times 0.921 \times 0.696 = 0.057$$

Therefore, this analysis has proved that the over-all system reliability of a hammer in driving a nail is only 5.7 per cent. It is obvious from this evaluation, which is considered conservative, that the reliability of this system must be improved or the future building program of this country will be seriously endangered.

Recommendations Based on the Results Of the Rigorous Analysis

It is strongly recommended that an extensive research and development program be initiated to (a) improve the reliability of the hammer-nail combination, or (b) devise a new system to fill the requirement which has improved reliability. It is further recommended that an ad hoc committee be formed to consider this problem and recommend a course of action to be followed to remedy this gross inadequacy. ■ ■

The Reliability Group: Its Organization and Responsibilities

Much has been written on the urgent need for reliable systems and devices. How does a company supplying components for missile and guidance systems create a reliability group to work in harmony with engineering, quality control and production? Dr. Hull, who has labored through the problems involved in organizing such a staff, outlines the duties and responsibilities of a reliability group—and management's obligation to the group.

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RELIABILITY groups, responsible for reporting the efforts of engineering, production, test and quality control, are subject to sharp criticism since misinterpretation of intentions can upset personalities and projects. For this reason, the formation of a reliability group, its responsibilities and its management merit considerable attention during initial organization planning. Large and small companies alike cannot afford the costly and aggravating losses which may stem from poor cooperation between all groups responsible for the development and production of reliable, high-yield devices and products.

Honesty in Exposing Failures Key to Effective Reliability Program

A considerable number of technical papers and articles have illustrated the need for high-reliability in missile and space programs; the lurid prospects predicted as a penalty for faulty military security have been dramatically outlined. Much of the burden for achieving high reliability falls on the shoulders of the component manufacturer. High reliability parts form the backbone of a highly reliable system.

First let us consider the value of reliability to a component manufacturer. To improve his component quality may cost more than his present engineering effort. Extra test facilities may be required; extensive plant modernization or production machinery improvements may be needed. Such expenses cannot be undertaken without some guarantee that the improvement in product quality will justify the cost and risk. In other words, there is a right reliability for the job. Some of this cost rightly belongs to the manufacturer of the component, who will benefit by higher yields and more output product per input dollar. The customer, in turn, receives an improved product.

When a company embarks upon a reliability program, it is first and foremost embarking upon a program of honesty, both within itself and in its dealings with its customers. There must be a sincere desire on the part of each individual to accomplish in reality the goals that have been set. Many reliability programs, costing millions of dollars, have fallen short of their mark because a test operator or supervisor was afraid to make a defect known. All personnel involved in a reliability program must be urged to practice strict honesty in all details, no matter how small. No problem, reliability or any other type, can be solved without first admitting it exists.

The reliability programs presently being conducted on a number of components have as their goal improvements of the general order of 1,000 times. Such an enormous improvement is possible with a program that progresses systematically from step to step, correcting each source of error, each accident, each weakness in design. First, a test program is prepared to ferret defective components, then special tests are run to find hidden or incipient defects. Each defect is analyzed to ascertain its cause as well as means to remove it from the final product. As each major defect is understood and removed, defects of less frequent occurrence become apparent and are, in turn, reduced. Thus, a reliability program involves gradual, measurable accomplishments to steadily upgrade the quality level of a product.

Reliability Group Must Work With, Not Under, Other Groups

An ambitious reliability program requires a properly organized group to carry on the detailed work and coordinate its many phases. This new group will work closely with engineering, production, quality assurance, testing, customer liaison, and marketing. To properly and completely discharge its functions, it must not be subservient to any of these other basic company necessities. Instead, the reliability group must act as an advisor to all of them and must establish and maintain close cooperation in order to solve mutual problems.

Owing to the many areas of responsibility in which the reliability group will work, it is desirable that it have direct responsibility to top management. In fact, this direct responsibility is the best method of demonstrating to customers that the reliability

group can function in an unbiased manner. In the case of a company with several plants or divisions, the reliability group should be responsible to the plant or division management whose product is to be investigated. If a reliability group is to work at more than one plant, it is necessary to organize an on-the-scenes staff at each plant to oversee and carry out various phases of the program. Management must indicate to all departments concerned the importance of the reliability program to the over-all company structure. Furthermore, it must be made clear that findings of the reliability group will not be used as a weapon to penalize sections contributing to product defects. Instead, procedures will be devised to reduce these failings. Definite budgetary procedures must be established at the time the program is undertaken to pay for the costs incurred in setting up new test facilities.

Organization of an Effective Reliability Group

Different requirements prevailing in different companies may slightly alter the details pertaining to a reliability group. However, the general pattern is shown in Fig.1. Note that the reliability group reports directly to the manager, as do the other groups contributing to product design and production. The quality control group is separated from the reliability section.

In some instances, a satisfactory organization has been built up with quality control and process control reporting to the reliability group. This arrangement is particularly advantageous in cases where the entire plant product is to fall under the reliability program. In this way, the best possible liaison exists between the sources of data and their analysis. In addition, there is an occasional need for compromise in quality, not brought about by lack of diligence but rather the result of having set too optimistic a goal; sometimes the customer requests a trade-off in quality to step up delivery. With process control and quality control linked closely with the reliability group, an intelligent course of action on quality compromise can be quickly outlined and put into action.

The difference between quality control and reliability functions is worth special note. Quality control is concerned entirely with compliance of an item or group of items to a specification. Reliability is concerned with the capability of an entire product or production line. It may not be necessary to

Glossary of Common Reliability Terms

Reliability, R or Probability of Survival, P_S is the probability that a component will perform in a specified manner under specified conditions for a specified length of time.

Reliability Engineering is the exercise of the scientific and technical disciplines, techniques, and skills necessary to achieve reliability objectives.

Confidence is the likelihood that a given statement is true (usually expressed in per cent)

Failure Rate, λ or Hazard is the probability of failure per unit of time for all components still operating at a given time (usually in per cent failure per 1,000 hr). If the failure rate is constant,

$$\lambda = \frac{\text{number of failures}}{\text{total accumulated operating time of all units}}$$

$$\lambda = \frac{1}{\text{MTBF}}$$

Mean Time Between Failures, MTBF, only has meaning in the case of a constant failure rate.

$$\text{MTBF} = \frac{\text{total accumulated operating time of all units}}{\text{number of failures}}$$

$$\text{MTBF} = \frac{1}{\lambda}$$

Mean Time to Failure, MTTF, is used with equipment (usually one-shot) and is similar to MTBF.

$$\text{MTTF} = \frac{\text{total operating time of a piece of equipment}}{\text{number of failures occuring during this time}}$$

Each failure is assumed to be repaired so that the earlier condition of reliability is restored.

Mean Time to First Failure, MTTFF is a special case of MTBF.

$$\text{MTTFF} = \frac{\text{accumulated operating time to first failure of a group of units}}{\text{total number of units}}$$

Mean Life is a general term covering both MTBF and MTTF.

Exponential Distribution of failures means that the distribution of the number of failures with respect to time may be expressed $P_S = e^{-\lambda t}$, (t = time) and the failure rate λ = constant.
The onset of the constant failure rate may be delayed, in which case the distribution is called delayed exponential. Test data is generally insufficient to demonstrate conclusively whether or not the failure rate is constant when it is very small. Fortunately the errors caused by assuming a constant failure rate are generally not serious when small failure rates are considered.

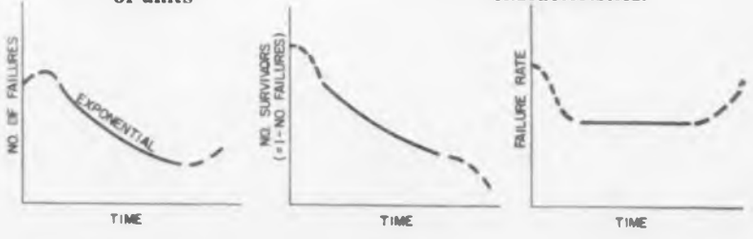
Failure is defined and agreed upon between consumer and producer. Failure definition depends upon application and may include Drift Failure (specified change in characteristics over a specified period of time) and Catastrophic Failure (defined gross degradation of characteristics).

Lot is a group of similar components which have been grouped in either of two ways:
(a) All manufactured in a continuous production run from homogeneous raw materials under constant process parameters.
(b) Assembled from more than one production run and submitted for random sampling and acceptance testing.

Acceptable Quality Level, AQL, is the per cent defects in a given characteristic specified as being acceptable.

Producer's Risk is the probability of rejecting a lot with acceptable characteristics.

Consumer's Risk is the probability of accepting a lot with defective characteristics.



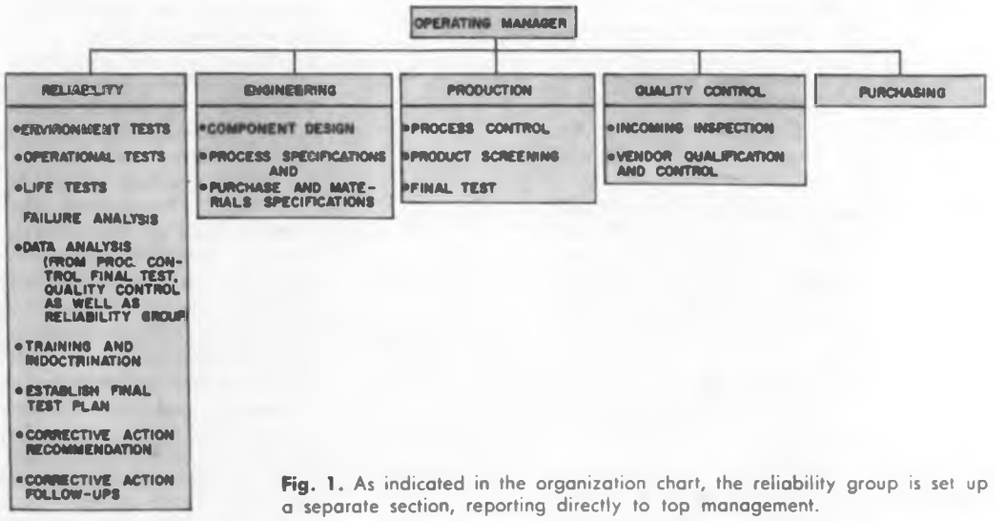


Fig. 1. As indicated in the organization chart, the reliability group is set up as a separate section, reporting directly to top management.

use this full capability to meet a given specification, or it may be that the maximum capability is inadequate and improvements are needed.

Mutual Understanding Between Groups Reduces Bickering

Relations between the production group and the reliability group can be kept friendly so long as each tries to understand the problems and aims of the other. This understanding is furthered by arranging informal get-togethers as well as periodic formal meetings. The educational process of "selling" the reliability concept has been found to work well on an informal basis where the opportunity for individual contact is provided; the "selling" process is an important ingredient of a successful reliability program. Management must recognize the problems facing a reliability group and establish proper programs to permit heads of various groups to work harmoniously toward the same goals. Subordinate employes, from line supervisors to production operators, must be sold the merits of the program and must understand that care and honesty are the goals. Exposing, rather than burying, defects must be encouraged. When this selling job has been adequately done, there is very little clash between diverse interests.

At the completion of a specific reliability program, not only should the product quality improve, but the production rate and the yield should likewise increase. These results stem from the generation of improved operator attitude and more effective tooling. In particular, as process control procedures are improved, (1) process divergence is reduced, (2) the down time caused by loss of control is lowered and (3) production can be channeled to one specific device rather than a group or family.

Product Improvement, Customer Satisfaction Responsibilities of Reliability Group

The reliability group must adopt effective procedures to locate product defects along with means to reduce their occurrence. Each procedure outlined must be qualified with test results stemming from a long series of experiments. Reports must be prepared for management giving progress to date, sources of failure found and suggested methods to reduce them. In addition, the reliability group must supply an analysis of company and competitor component quality and capability plus various test and application information that may be useful to the customer. The future success of the company in the ever-increasing competition for better components hinges, in part, upon the efficiency and capability of the reliability group.

The reliability group also bears a responsibility to the customer expecting components of stated performance to be delivered. Not only are those tests conducted as specified by the customer, but additional tests may be performed which are considered pertinent to a thorough understanding of the component and its failure mechanisms. All necessary precautions must be taken in production to minimize the fabrication of defective components; even in the event a few defects should slip by, a well-planned test program should spot the majority of these.

Causes of Failure Mechanisms Targets of Reliability Program

The prime purpose of a component reliability program is to acquire thorough knowledge of one's own devices from a collection of accumulated test data. These data are analyzed in a systematic way so as to guide the improvements in design and processing necessary to gradually remove the various failure processes or mechanisms. The gain in knowledge of product failure mechanisms and their removal is the reward of a well-planned reliability program.

The accumulated data allow prediction of test procedures, screening and burn-in process steps and the resulting yields and costs to be expected. It may be possible from these data to qualify the entire output of a production line to a given specification so that only detailed parameters need be measured for selection and acceptance of individual components. The feedback loop of a reliability program is shown in Fig. 2.

The source of the accumulated data is a continuous test program in which a small sample from each production lot is tested under all conditions pertinent to the particular device. The test conditions include life and environmental tests under many load conditions. Routine conditions are severe enough to meet or exceed all MIL and customer requirements. An analysis of the data is made to provide process control information and to serve as a guide to the process engineers engaged in failure analysis and device improvement.

The test program examines not only those devices in production but devices in pilot and even developmental stages; experimental devices and device test runs also must be eval-

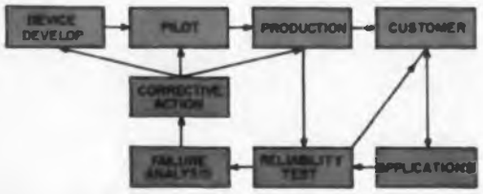


Fig. 2. The feedback loop of a reliability program minimizes product "distortion" and amplifies product "output."

uated. Purchased samples of competitive devices and new devices must be evaluated on a routine basis as a guide to one's relative capability in the industry.

Four Major Factors Contribute to Component Reliability

The reliability of any component depends upon the manufacturing process, the selection program and the device application. All three must be considered in realizing the best achievement of reliability. If the reliability achieved by these three programs is not adequate, it is then necessary to add a fourth program, namely process improvement or device development.

A manufacturing process for a high reliability device is one which operates in a precisely known and controlled way. All materials and all operations performed are described by precise specifications. Process control tests are set up to verify adherence to specifications. Any deviation is cause for immediate corrective action. In order to evaluate the finished product, all work in process is identified. A correlation is made between observed test results and the process parameters or materials which were used in producing that particular lot. Running process averages are maintained at intermediate test points so that deviations may be observed and corrected before large quantities of substandard parts are produced; substandard lots are naturally not used for high-reliability applications.

By careful manufacturing control, a minimum number of marginal quality components come off the production line. It is next necessary to generate a test procedure in which defective devices, or those with incipient defects, can be culled from an otherwise high quality lot. The reliability test program has already established the mechanical and

Fig. 3. A considerable investment in equipment is required to provide the electrical and mechanical facilities needed for reliability testing. A typical group of life test racks, containing component sockets, power supplies and monitoring equipment, for semiconductor tests is shown. (Photo courtesy General Instrument Corp.)

electrical tests necessary to uncover all known failure mechanisms. These tests involve mechanical stresses such as shock or vibration plus storage and operation at elevated temperature. An extended life test setup for semiconductors is shown in Fig. 3. Such screening tests are a routine part of the manufacturing processes and are not to be considered as a sorting for characteristics or an acceptance test.

The device application must also take into account the various failure modes which may be present. It is important that the application be as tolerant as possible of minor drifts of characteristics. Of course, no equipment is expected to work with a grossly degraded device. However, it is important that equipment be analyzed for the effect of various parameter changes so that correct specification limits can be set for each individual

Fig. 4. Human errors in reading and recording the enormous amount of data involved in reliability testing could greatly affect the final failure figures. Thus, an additional refinement, to enhance the reliability program, involves the design and installation of automatic recording equipment. An automatic set-up for reading and recording transistor test data is shown. (Photo courtesy of General Instrument Corp.)

parameter. In general, where high reliability is specified, as much care should go into the application of the device as went into its manufacture.

To verify failure rates in the order of 0.01 to 0.001 per cent per thousand hours, enormous amounts of data must be accumulated. Human errors are to be expected while reading meters, jotting down figures and transposing figures to cards; however, these human errors cannot be tolerated since they will have a significant bearing on the extremely low failure rate figures. For this reason, an added refinement for a well-prepared reliability program should include automatic equipment to measure and record data, see Fig. 4. Finally, statistical analysis and correlation of the collected data should be performed by machine to further reduce the human error factor. ■ ■

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Variation Research—The Science of Forcing Defects to Reveal Themselves

"Why depend on trial and error experiments or sheer guesswork to explain quality variations," author Shainin asks, "when the contributing factors can be forced to expose themselves?" Variation research coupled with the statistically designed experiment can rapidly lead to the "Vital Few" causes of product malfunction. Only when these causes are under control can the "constant failure rate" assumption used in reliability calculations be considered valid.

The faster, less costly road to a reliable product is described and case histories presented to illustrate the technique. Author Shainin is shown conducting an in-plant training program on statistical techniques.

Dorian Shainin, Vice President
Director of Statistical Engineering
Rath and Strong, Inc.
Boston, Mass.

	A HIGH	A LOW
B LOW	(1) 20.40 R HIGH (2) 20.50	(5) 20.60 R LOW (6) 20.40
B HIGH	(3) 22.90 R LOW (4) 23.10	(7) 23.00 R HIGH (8) 22.90

Fig. 1. Results of a series of test runs on two units of a complex pneumatic assembly are charted on a "Latin Square" diagram. The two units selected (High and Low) represent extreme variations in supply-line pressure required for proper operation. Two subassemblies (A and B), suspected of being the cause of the performance variation, are removed from the remainder *R* of the units and reassembled in various combinations (A Low, R High, B High, etc.).

DON'T ATTEMPT to maintain key factors in a search for causes of an effect at constant values—instead, look for variations, encourage them, probe means to achieve differences in results. Such is the philosophy of variation research and its supporting statistically designed experiment, a pair of modern tools for locating causes of deviation in product and process quality. The traditional scientific approach, involving the preparation of a series of assumptions and then conducting experiments to confirm or disprove them, is time-consuming and often fruitless; often, new hypotheses must be drawn up and additional experiments run. Basically, the conventional approach to locate causes of product variation is a "hit or miss" proposition.

Simultaneous Consideration of Many Factors Key to Statistical Experiment

Tracking down factors affecting product quality is generally a long, tedious and frustrating assignment. Relevant factors are usually charted, lengthy measures to control tightly numerous operations must be established and drawn-out experiments conducted. Despite all efforts over an extended length of time, it is not unusual to remain confronted with an endless series of variables, with quality still far from the desired level.

Conventionally the experimenter sets certain factors at constant values and observes the effects of one other factor at a time. Statistical engineering involves the simultaneous consideration of many (all, if necessary) of the possible reasons for product malfunction. Hypotheses, hunches and guesswork are not neglected in the procedure, but do not seriously hamper the experiments if they prove to be incorrect. Many of the possible causes in large groups can be directly adjudged as irrelevant after a short period of gathering of key data; this permits concentrated efforts to be applied to the *few* remaining possibilities.

The unusual degree of objectivity offered by the statistical approach is based on the following logic:

1. Every effect has one or more causes.
2. Relatively few causes, rather than several, have a controlling influence on the effect. Call these the "Vital Few" causes.
3. Causes and effects are not constant—they vary.
4. If the variation of an effect is studied in a particular way, it can lead to the single cause (or to the combination of causes) of that effect. That particular way is to dissect a group of *all* possible causes into smaller groups, eliminate those associated with trivial variability; dissect the smaller group or groups with relatively large variability into still smaller groups, eliminating again those

with trivial variability. Case histories show that this successive elimination procedure only has to be carried out two or three steps (sometimes only one) to unearth quite unexpected causes.

An important difference, as compared to current engineering analysis, is brought out by this approach. One does not look at past or current data that happen to be available when a problem arises, and draw any valid statistical inferences from the data, because data have to be gathered in a different way to be properly discernible. Statistical engineering is first planning how the data shall be gathered with a view toward the later analysis of these data.

There is nothing wrong with taking a side excursion whenever the data have been gathered by a plan and an unexpected, but plausible, engineering inference is suggested by the results. Go after it; see if you can turn the effect off and on. If you cannot, return to the sequence of objective, process-of-elimination, statistical steps. Just keep the difference in mind. You are then equipped with two important tools; sometimes one, sometimes the other does the better job. Often one helps the other do the job.

5. Being able virtually to turn a difficulty on and off obviously represents clear evidence that you are ready to form decisions as to ways to control the effect. Despite its elementary nature, in far too many cases this checking action has been deemed unnecessary, and a costly engineering error has been made.

Case Study #1: Unit-to-Unit Variation In Production of Complex Pneumatic Device

Consider the case study[3] involving unit-to-unit variations encountered in the manufacture of a complex pneumatic unit. A relatively high percentage of units coming off the assembly line required much higher supply-line pressure than other units despite numerous changes in dimensions, tolerances, assembly steps and test procedures. The statistical engineer, convinced that performance variation was caused by physical differences he was unaware of, selected two units from a day's production; one was tagged "High," the other "Low." Each represented the extreme variation in pressure required for proper operation.

Next, a short conference with several design engineers and the statistical engineer led to the possibility that either of two subassemblies in the unit was the possible cause of variation, the difference in pressure required. The pair of subassemblies was removed from each unit and tagged "A" and "B"; the remainder of each unit was termed "R." Thus, six components were on hand for the test—an "A", "B" and "R" from "Low" and another three from "High." Units were reassembled and checked in the following manner:

(1) A High, B Low, R High
(2) A Low, B Low, R Low
(3) A High, B High, R Low
(4) A Low, B High, R High

Using the "Latin Square" to Determine Effects of Variables

Experiments were conducted twice for each combination for a total of eight tests. To reduce the possibility of incorrect results due to unforeseen environmental factors, the tests were run in random sequence[4]. The readings (in lb/sq in.) were placed in a "Latin Square" diagram along with the number of the test run, see Fig. 1.

Here is how the Latin Square permits a rapid check on the differences caused by a change in one particular variable:

1. The effect of A High differing from A Low is evidenced by the difference between the average of the four readings in each vertical column.
2. The effect of B Low changing to B High is shown by the average of the four readings in each horizontal row.
3. The effects of R High differing from R Low can be seen by averaging the diagonal readings; upper left and lower right readings represent the common presence of R High while lower left and upper right are with R Low.

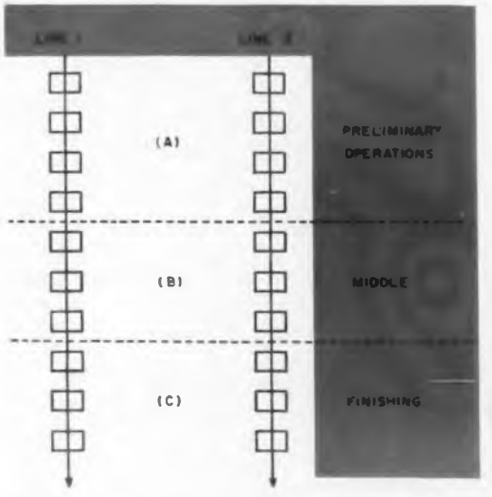

Fig. 2. Parallel production lines, line 1 and line 2, for fabricating micro-alloy transistors produced devices which varied in critical parameters significantly with time. The series of manufacturing steps was divided into three distinct operations, A, B and C and various combinations of operations were used to process small runs.

From the balanced Latin square, the main effects of any one variable are indicated while those of the other two variables are neutralized.

This computation rapidly revealed that subassembly B was responsible for a large variation between the units. Upon close examination of B subassemblies, it was noted that a difference in length existed between a fulcrum and an actuating point on an arm. By more closely controlling this dimension in later production runs, performance variations were markedly reduced.

Case Study #2: Improvement in Yield of Semiconductor Production

In the course of investigating the performance of parallel production lines for micro-alloy transistors, of various type numbers, a variation analysis study was con-

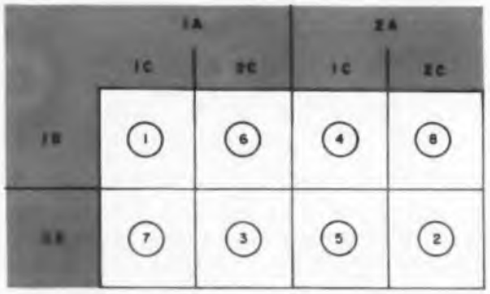

Fig. 3. The combinations used to track down the variation in transistor quality output is shown. The encircled number in each box indicates the production path number.

"Why Resort to the Statistically Designed Experiment?"

Key Advantages Include . . . .

1. Obtaining leads to the causes of production variations is considerably quicker with statistical techniques than conventional "trial and error" quality-assurance approaches. A number of case histories, illustrating how one or two weeks of carefully selected experiments have solved problems plaguing companies for years, bear evidence to this fact.

2. The rapid answers obtained permit almost immediate production modifications to upgrade the product or process yield; rejects drop, delivery is stepped up and savings can be realized in a short time.

3. Production is, in most cases, rarely slowed up since experiments are often brief but searching. Generally only a small number of units are involved in the test. On-line production changes are kept to a minimum.

4. The statistical evaluation of product quality can be continued to upgrade the product quality beyond the initial goals set.

5. The statistically designed experiment is not limited to giant organizations; small companies can make use of the technique since the preparation of tests, the actual experiments and final analyses are generally fast and relatively inexpensive without the need to temporarily halt or slow down operations.

6. Interactions due to several variables can be spotted.

7. More information per test run can be obtained than with conventional approaches.

8. The optimum combination of controlling factors can be established.

9. This approach can lead to important variables which may otherwise elude the searcher.

But Bear in Mind . . . .

1. The statistically designed experimental procedure is not a "do-it-yourself" project. A small but qualified group of statistical-engineering personnel is needed. A large company may easily set up a group for training in this approach; smaller firms could make use of a consultant to set up the program and assign the part-time services of one or two people to collect and analyze the data with the consultant. Skill must be developed to

- **a) recognize the identifying signs of variability and**
- **b) refrain from identifying specific causes until the probability of success is high.**

2. The statistical experiment is a well established philosophy—but immediate results cannot be guaranteed every time. Solid engineering background in the problem areas involved and close teamwork among production, engineering and management members are important ingredients for reaching a rapid solution.

ducted. It revealed that distributions of critical parameters varied significantly with time, from line to line. The parameters giving trouble were I_{cbo}, I_{ebo}, h_{fe} (β), and V_{pt}.

Engineers studying these statistical results reasoned that certain factors logically could cause the difficulties, but one by one these process inputs were modified with no significant effects on the outputs.

During a period when one line was running at a higher yield than another (although both lines were presumably operating to identical specifications) a series of short experiments were planned to isolate further the causes of the failure of several units to meet specifications.

Line 1, at that time, was the "better" line; line 2 was the "worse" one. The series of manufacturing steps was divided into three distinct groups of operations as shown in Fig. 2.

The plan was to process small, equal-sized lots of product through each one of the eight distinct paths through which transistors could be made. The normal paths are 1 and 2; the new combinations, using some of both lines, are 3 to 8.

Path 1:	1A	—	1B	—	1C
Path 2:	2A	—	2B	—	2C
Path 3:	1A	—	2B	—	2C
Path 4:	2A	—	1B	—	1C
Path 5:	2A	—	2B	—	1C
Path 6:	1A	—	1B	—	2C
Path 7:	1A	—	2B	—	1C
Path 8:	2A	—	1B	—	2C

Fig. 3 shows the diagram of this experimental plan, from which it can be seen that section A's effect (line 1 compared to line 2) will show up as a difference between the average result under 1A and that under 2A. All other sections will have contributed equally to these two averages, and so their main effects will be neutralized. The eight distinct paths are circled in Fig. 3.

In a similar way, the main effect of B can be separated from A and C; and that of C from A and B. Also this plan, called a full-factorial experimental design, can evaluate the interactions of one part of a line with one or two other parts.

A table of random numbers determined the sequence with which one line of the eight was run after another. Then the eight

were run again, using still another random sequence. The average difference between runs with the same line would represent experimental error caused by any other factor not characteristic of a section of a line.

Interestingly, no two parameters were revealed as being influenced by similar sections or by the same combination of sections. No wonder previous, conventional engineering trouble shooting was running into difficulties.

It was determined that h_{fe} (Beta) values were highly dependent upon sections A and B, while totally indifferent to whichever section C the units were processed in. The best units came from paths 1 and 6, while the worst were products of paths 5 and 2. Medium results were obtained in the remaining paths.

Likewise, I_{cbo}, I_{ebo} reverse current values were the result of an interaction among factors in all three sections. While path 1 gave good results, an unexpected outcome emphasized the relatively great amount of information available from the statistically designed experiment: path 6, made up of two sections of line 1 and one section of line 2, was even better.

Punch-through voltage V_{pt} turned out to be a function primarily of which section A was involved. The best units came from paths 1, 6, 7 and 3; while the worst went through 4, 8, 5 and 2.

With the results of these tests in hand, it was possible to begin a systematic search for the specific inputs and *combinations* of inputs which were responsible for yield variation. Trade-offs were made to reach optimum conditions for all important parameters.

Without the benefit of running tests through all possible paths, the important interactions would have been missed. Through the discovery of these rather subtle phenomena, yields were increased and it was possible to establish new and different, more effective controls to maintain the much higher yields.

Process of Elimination Rapidly Pinpoints Key Variables

Suppose neither subassembly A or B were responsible for variations and a large difference in averages turned out to be in R.

what would the next step be? Two other subassemblies, C and D, would be selected and the experiment repeated. Eventually, by the process of elimination, the source of variation would be found.

If large differences are found in readings *within* boxes, this would indicate test equipment or environmental condition difficulties. If all the readings in one of the four boxes were markedly different than those in the other three, this would indicate an interaction among two or more parts. Interaction is also indicated when, say, one R Low box shows fairly high readings while the other R Low box shows fairly low results. To solve interaction problems, the "factorial" designed experiment is recommended[4]. Both techniques are similar in principle but the factorial design involves running every possible combination at least twice.

Basic Rules for Applying the Variation Research Technique

1. Start to compile data as soon as you have any hardware—even before you may have many difficulties. Such data can often lead to important changes to *prevent* difficulties.
2. Instead of spending excessive time putting out fires, reserve some time for fire prevention.
3. Contrary to conventional experimental philosophy, don't try to keep certain things constant; look for variation, encourage it, rack your brain to bring about differences in results. Let this nonagreement lead you to the reasons for it. Instead of keeping unwanted influences out by holding them constant, force them by statistical planning to show their total effect in a separate, residual term.
4. There are a large number of statistical, analytical techniques to identify the nature of variations. Among these are Multi-Vari charts, statistical control charts, numbered histograms and correlation analyses. Those applicable to working with small numbers of hardware are of particular interest to industrial experimenters. Variability may be

The Logic Behind Variation Research

1. Every effect has one or more causes.
2. Relatively few causes (called the Vital Few) have a controlling influence on the effect.
3. These few major causes are not constant in their action on the quality of the end product (the effect).
4. By careful analysis of the variations in final product output, one part of the total variations can be expected to reveal itself as more dominant than the others; a cause or causes associated with this particular part is one or more of the "Vital Few."

Thus, every effect is considered to have one or more predominant causes. Since causes vary in intensity, corresponding variations in an effect are considered an output of related causes. By analyzing the variations in effects by appropriate statistical techniques, factors affecting product quality are revealed by the process of elimination.

encouraged with only one unit of product available:

(a) By operating the unit repeatably and using the lack of agreement in results to provide useful information.
(b) By disassembling, reassembling and rerunning the unit to get a still different variation for profitable analysis.
(c) By purposely modifying the severity and/or kind of environment to artificially cause still more variability in the product's responses.

Be patient. Take steps to develop skill to practice statistical engineering like a professional. Recognize that engineering is dynamic, requiring new knowledge and approaches as it continues to develop at a faster and faster pace. ■ ■

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2. "The Design of Experiments", Sir Ronald A. Fisher, London, Oliver and Boyd, Ltd., 1935.
3. "The Statistically Designed Experiment: A Tool for Process and Product Improvement", Dorian Shainin, Harvard Business Rev., July-August 1957.
4. "Statistics: A New Approach", W. Allen Walls and Harry V. Roberts, The Free Press, 1956, p 119 and pp 479-481.

reliability

Military Standards and Specifications on Reliability

MIL-STD-105E (DOD-ARMY) 12/31/58	Sampling Procedures and Tables for Inspection by Attributes	Quality Control
MIL-STD-108D (BUSHIPS) 6/27/58	Definitions of and Basic Requirements for Enclosures for Electric and Electronic Equipment	Equipment, Navy General
MIL-P-116C (DOD) 2/27/57	Methods of Preservation	Environment
MIL-T-152A (DOD) 12/14/55	Treatment—Moisture and Fungus-Resistant, of Communications, Electronic and Associated Equipment	Environment
MIL-C-172C (DOD) 12/8/58	Cases; Bases, Mounting; and Mounts, Vibration (For use with Electronic Equipment in Aircraft)	Environment
MIL-STD-200E 3/2/60	Electron Tubes and Semiconductor Devices, Diode	Parts
MIL-STD-202A 10/24/56	Test Methods for Electronic and Electrical Component Parts	Quality Control
MIL-STD-210A (DOD-S&L) 8/2/57	Climatic Extremes for Military Equipment	Equipment
MIL-STD-242 (SHIPS) 3/15/55	Electronic Equipment Parts (Selected Standards)	Parts
MIL-STD-414 (DOD-S&L 6/11/57	Sampling Procedures and Tables for Inspection by Variables for Percent Defective	Quality Control
MIL-STD-415A (ARMY-SIG.) 3/31/58	Test Points and Test Facilities, Design Standards for	Equipment
MIL-STD-439 (AER) 5/1/58	Electronic Circuits	Circuits and Modules
MIL-STD-441 6/20/58	Reliability of Military Electronic Equipment	Reliability
MIL-STD-446 (AER) 4/28/59	Environmental Requirements for Electronic Component Parts	Parts

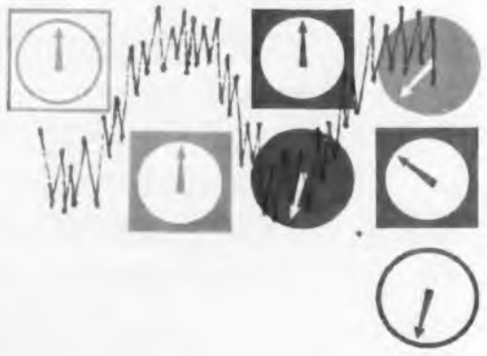
This listing was presented by H. L. Wuerrfel of RCA at the Seventh National Symposium on Reliability and Quality Control in his paper, "Military Specifications Affecting Reliability."

A handy tabulation of government documents related to reliability standards and testing procedures. Only those parts specifications which contain explicit reliability information are included.

SPEC BUL 506 (USAF) 5/11/59	Reliability Monitoring Program for Use in the Design, Development, and Production of Air Weapon Systems and Support Systems	Reliability
SPEC BUL 510 (USAF-WADD) 6/30/59	Guides for Reliability Organization	Reliability, Organization
MIL-STD-701 8/15/58	Transistors	Parts
MIL-T-945A (DOD) 3/7/50	Test Equipment, for Use with Electronic Equipment, General Specification	Equipment
MIL-E-2036A (NAVY) 4/4/52	Enclosures for Electric and Electronic Equipment (Naval Shipboard Use)	Environment
MIL-E-4158B (USAF) 1/3/58	Electronic Equipment Ground, General Requirements for	Equipment
MIL-T-4807A (USAF) 10/7/58	Tests, Vibration and Shock, Ground Electronic Equipment, General Requirements for	Environment
MIL-T-4860C (USAF) 10/1/58	Trainers, Operational Procedure, General Requirements for	Equipment
MIL-E-4970A (USAF) 3/3/59	Environmental Testing, Ground Support Equipment, General Specification for	Testing
MIL-W-5088B (ASG) 6/18/56	Wiring, Aircraft, Installation of	Wiring
MIL-E-5272C (ASG) 4/13/59	Environmental Testing, Aeronautical and Associated Equipment, General Specification for	Environment
MIL-E-5400D (ASG) 11/30/59	Electronic Equipment, Aircraft, General Specification for	Equipment
MIL-E-5422D (ASG) 11/1/57	Environmental Testing, Aircraft Electrical Equipment	Environment
MIL-I-006051B (USAF) 1/23/59	Electrical-Electronic System Compatibility and Interference Control Requirements for Aeronautical Weapons Systems and Associated Subsystems	Weapons Systems
MIL-W-008160C (USAF) 4/7/59	Wiring, Guided Missile, Installation of, General Specification for	Wiring

MIL-E-8189B (ASG)	Electronic Equipment, Guided Missiles, General Specification for	Equipment
MIL-I-8700 (ASG) 8/27/54	Installation and Test of Electronic Equipment in Aircraft, General Specification for	Testing
MIL-D-9310B (USAF) 6/19/59	Data for Aeronautical Weapons and Support Systems	Weapons Systems
MIL-S-9372B (USAF) 2/25/55	Shields, Electron Tubes Dissipating	Parts, Tubes, Shields
MIL-W-9411A (USAF) 6/19/59	Weapons Systems, Aeronautical, General Specification for	Weapons Systems
MIL-D-9412C (USAF) 6/10/58	Data for Ground Support of Weapons Systems, Support Systems, Subsystems, and Equipment	Weapons Systems
MIL-Q-9858 4/9/59	Quality Control System Requirements	Quality Control
MIL-E-16400C (NAVY) 7/1/59	Electronic Equipment, Naval Ship and Shore, General Specification for	Equipment
MIL-T-18306A (BUAER, NAVY) 1/1/55	Test Equipment and Test Bench	Equipment
MIL-E-19100A (SHIPS) 7/5/57	Electronic Training Equipment, Naval Shipboard, General Specification for	Equipment
MIL-E-19600A (WEP) 12/1/59	Electronic Modules, Aircraft, General Requirements for	Circuits and Modules
MIL-R-19610 (AER) 9/15/56	Reliability of Production Electronic Equipment, General Specification for	Reliability
MIL-Q-19614 (AER) 2/1/58	Quality Assurance Provisions, Modules, Electronic, for Use in Aircraft	Quality Control
MIL-N-19900A (SHIPS) 8/15/58	Nuclear Propulsion Control and Instrumentation Equipment	Equipment
MIL-T-21200A (ASG) 11/30/59	Test Equipment for Use with Electronic and Fire Control Systems, General Specification for	Equipment
MIL-Q-21549A (NOrd)	Quality Control System Requirements	Quality Control
MIL-R-22256 (AER-BUWEPS) 11/20/59	Reliability Requirements for Design of Electronic Equipment or Systems	Reliability
MIL-E-0025366B (USAF) 8/18/58	Electric and Electronic Equipment and Systems, Guided Missiles, Installation of, General Specification for	Equipment
MIL-R-25717C (USAF) 3/9/59	Reliability Assurance Program for Electronic Equipment	Reliability
MIL-H-25946 (USAF) 11/26/57	Human Factors Data for Maned Aircraft Weapon Systems	Environment
MIL-T-26046 (USAF) 3/26/57	Trainers, Guided Missile, Maintenance, Classroom, General Requirements for	Equipment
MIL-D-26207 (USAF)	Human Factors, Data for Guided Missile Weapons Systems	Environment
MIL-C-26244 (USAF) 1/31/58	Capacitors, Fixed, Paper (or Paper-Plastic) Dielectric, d-c, High-Reliability, (Hermetically Sealed in Metallic Cases)	Parts
MIL-R-26474 (USAF) 6/10/59	Reliability Requirements for Production Ground Electronic Equipment	Reliability

MIL-R-26484 (USAF) 6/2/58	Reliability Requirements for Development of Electronic Subsystems or Equipment)	Reliability
MIL-M-26512 (USAF) 6/18/59	Maintainability Requirements for Weapon Systems and Subsystems	Maintainability
MIL-I-26550 (USAF-WADD) 11/25/58	Indicator, Elapsed Time	Testing
MIL-I-26600 (USAF) 6/2/58	Interference Control Requirements, Aeronautical Equipment	Environment
MIL-R-26667A (USAF) 6/2/59	Reliability and Longevity Requirements, Electronic Equipment, General Specification for	Reliability
MIL-R-26674 (USAF) 6/18/59	Reliability Requirements for Weapon Systems	Reliability
MIL-R-27173 (USAF) 7/6/59	Reliability Requirements for Electronic Ground Checkout Equipment	Reliability
EXHIBIT 58-10 (AFBM) 6/1/59	Reliability Program for Ballistic Missile and Space Systems	Reliability
EXHIBIT 59-32 (AFBM)		
EXHIBIT 2629 (USAF-RADC)	Reliability Requirements for Ground Electronic Equipment (Production and Pre-Production)	Reliability
AD 114247 (ASTIA)	Reliability Factors for Ground Electronic Equipment	
AD 131152 (ASTIA)	Air Force Ground Electronic Equipment—Reliability Improvement Program	
AD 148556 (ASTIA)	Philosophy and Guidelines—Prediction on Ground Electronic Equipment	
AD 148801 (ASTIA) (RADC TN-58-183	Methods of Field Data Acquisition, Reduction and Analysis for Ground Electronic Equipment Reliability Measurement	
AD 148868 (ASTIA) (RADC-TR-58-111)	RADC Reliability Notebook	
AD 148977 (ASTIA) (RADC TN-58-307)	The Prediction and Measurement of Air Force Ground Electronic Reliability	
WADC-TR-56-488	Human Engineering Guide for Equipment Design (Woodson)	
PB 121839	NEL Reliability Design Handbook (Now BuShips)	
PB131678	Reliability Stress Analysis for Electronic Equipment	
AGREE Report 6/4/57	Reliability of Military Electronic Equipment	Reliability
RELIABILITY POLICIES AND PROCEDURES (AFBM-STL) 7/14/59	Reliability Policies and Procedures	Reliability
ACGMR REPORT 4/58	DOD Proposed Reliability Monitoring Program for Guided Missile	Reliability
PSMR-1 Vols. 1 & 2 5/60	Parts Specification Management for Reliability	Reliability
NAV-AER 16-1-519	Handbook of Preferred Circuits	
NEL	Suggestions for Designers of Electronic Equipment	



Measurement Techniques for Low-Noise Transistor Input Stages

In a previous article (ED, Sept. 13, p 48) William Rheinfelder discussed the general design objectives for low-noise transistor input stages. Here, he defines and describes the measurements the engineer must often make on these circuits.

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NOISE figure, F, has been defined to provide a figure of merit for receiver performance. It is given by the ratio of input signal-to-noise ratio, to output signal-to-noise ratio, and can be conveniently measured using a noise generator. The procedure most generally used is to increase the generator output until noise power in the output is doubled. At this point the noise of the generator is the same as that produced by the circuit. The equivalent noise above ideal thermal noise (the noise figure) can be read directly off the generator. The effective noise bandwidth need not be determined. This procedure may be used only when the amplifier under test has a constant gain with signal, and a linear meter is used to read the output.

A more accurate method, and one which must be used when agc or a nonlinear meter is employed, uses a 3-db attenuator. First, a measurement of noise is made with the generator turned off. Then a 3-db pad is inserted between the noise generating circuit and the nonlinear amplifier. The noise generator is adjusted until the same reading is obtained on the output meter. A nonlinear meter may be used. Since the output voltage is unchanged, agc and gain will be the same as before and no error is introduced.

Contribution of noise by the following amplifiers may be taken into account by using the formula:

$$F = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} \qquad (1)$$

where

F = over-all noise figure
F_1 = noise figure of first stage
F_2 = noise figure of second stage
F_3 = noise figure of third stage
G_1 = power gain of first stage
G_2 = power gain of second stage

If the 3-db attenuator method is used, no correction is necessary for the noise contributed by the amplifier following the pad. This is shown in the discussion which follows.

The noise power applied to the input of the second stage, Fig. 1, is

$$P = P_1 G_1 + P_2 \qquad (2)$$

where

P = total noise power into second noise-free stage
P_1 = noise power into first stage including noise due to the first stage
P_2 = noise contributed by the second stage
G_1 = power gain of first stage

To double the noise power in the output a new input noise power P_1' is required, so that

$$2P = P_1' G_1 + P_2 \qquad (3)$$

and

$$P_1' = \frac{2P - P_2}{G_1} \qquad (4)$$

Substituting P from Eq. 2, we obtain

$$P_1' = 2P_1 + \frac{P_2}{G_1} \qquad (5)$$

The generator is calibrated to read correct noise figure if the input noise power

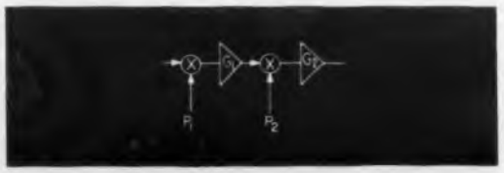

Fig. 1. Simplified diagram of two-stage amplifier, where P1 and P2 represent noise powers contributed by each stage.

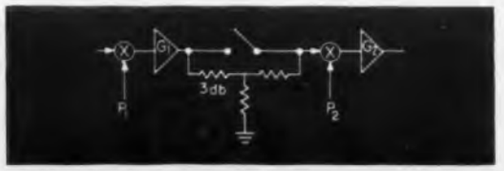

Fig. 2. Simplified diagram of two-stage amplifier shows location of 3-db pad used when making noise-figure measurements.

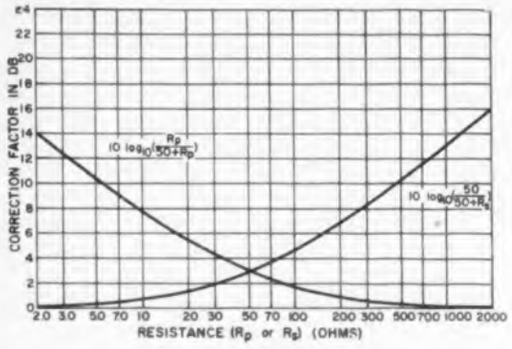

Fig. 3 Correct noise-figure reading is obtained from noise generator after correction factors, necessary when series or parallel resistors are placed between generator and circuit, are subtracted.

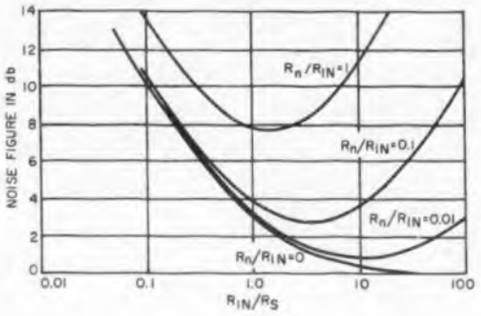

Fig. 4. Equivalent noise resistance of a transistor circuit is found with the aid of these noise-figure curves.

is doubled; that is:

$$P_1' = 2\ P_1$$

According to Eq. 5, a correction is needed.

Let us now consider the 3-db method, Fig. 2. In the case without pad, Eq. 2 still holds. After inserting the pad, and adjusting the noise generator for the same noise power in the output, we have:

$$P = P_1' \frac{G_1}{2} + P_2 \qquad (6)$$

or

$$P_1' = \frac{2(P - P_2)}{G_1} \qquad (7)$$

Substituting P from Eq. 2, we obtain:

$$P_1' = 2\ P_1$$

The generator reading will be correct and independent of the noise of the second stage or the gain of the first stage. Thus, if the noise figure of a whole receiver is to be measured the 3-db pad should be placed after the noise producing stages because only the noise figure of the stages ahead of the 3-db pad will be measured.

Another way to take the noise in the second stage into account is as follows:

The first stage transistor is removed and a noise voltage E_1 is observed in the output. Stage *1* is put back into operation and, with the noise generator off, E_2 is read in the output. The generator is now adjusted until a voltage $E_3 = \sqrt{2E_2^2 - E_1^2}$ is indicated in the output. The noise figure of the first stage can be read directly off the generator. Since the output voltage changes, this method implies a linear amplifier and meter.

Frequently it is desired to measure noise figure as a function of source resistance. Since mismatching takes place, the generator reading will be incorrect because the noise actually applied to the circuit will be less than indicated. Hence, a certain correction must be subtracted from the noise figure reading obtained from the noise generator meter.

The noise figure is the ratio of the signal-to-noise ratios of the input to the output. If the correction is made properly no change in input signal to noise must result due to the change in source resistance. It is not possible to correct the reading by calculating the actual noise power going into the circuit because of the mismatch. Instead, available noise power must be used for a correction. The input signal to noise remains unchanged and a correction noise figure reading is obtained.

The available noise power is simply:

$$P_{AV} = \frac{E^2}{4\ R_o} \qquad (9)$$

where E = generator voltage
R_o = source resistance.

This power is dissipated in the load only under matched conditions and, at all other times, is less. If a resistance R_s is connected in series with R_o the available noise power is reduced by the factor $R_o / (R_o + R_s)$. The available noise power is, therefore:

$$P_{AV} = \frac{E^2}{4(R_o + R_s)} \text{ with a series resistance } R_s \qquad (10)$$

If a parallel resistor R_p is connected across the generator, the loss factor is $R_p / (R_o + R_p)$, and the available power is

$$P_{AV} = \frac{E^2 R_p}{4\ R_o(R_o + R_p)} \qquad (11)$$

The correction factors $R_o / (R_o + R_s)$ and $R_p / (R_o + R_p)$ have been converted to decibels and are plotted in Fig. 3 for $R_o = 50$ ohms. This decibel figure must be subtracted from the reading on the noise generator to obtain the correct noise figure when the series or parallel resistors are used between the generator and circuit under test.

How to Measure Equivalent Noise Resistance

In measuring the equivalent noise resistance directly with transistor circuits certain difficulties arise. First, let us describe the direct method used with vacuum tubes.

With the operating dc conditions maintained, the input is shorted (by-passed) for the frequencies under test. The noise output voltage is observed. A resistance is then inserted between input and ground which doubles the noise voltage in the output. This resistance value is the equivalent noise resistance.

This method may not be used with transistors because base current rather than base-emitter voltage is involved. In a modification of this method one might think of using the open circuit input noise as a reference and then proceeding as with tubes.

A better, indirect method of determining the equivalent noise resistance makes uses of the curves shown in Fig. 4. These curves are perfectly general and true for any four-terminal network. They present plots of noise figure vs mismatch ratio. The point of minimum noise figure is shifted to one side depending upon the curve parameter that is a function of noise resistance.

The procedure is to measure the noise figure vs source resistance (mismatch ratio) as described above. The point of minimum noise figure is best obtained by plotting a curve. Optimum mismatch ratio can then be determined for best noise figure.

From Fig. 4 the parameter of the curve may be determined and the equivalent noise resistance calculated if the total input resistance of the transistor in parallel with the tuned circuit resistance is known. These can be measured separately.

It must be remembered that when these methods are applied to transistors, it takes two equivalent noise resistances to

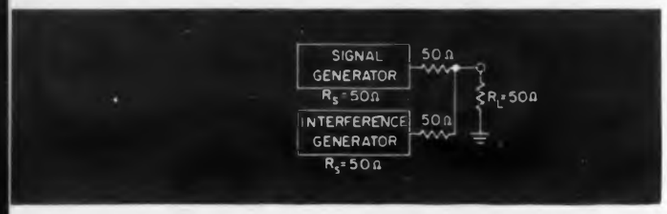

Fig. 5. Receiver cross modulation is measured by connecting two generators in parallel, through a matching network, to the circuit under test.

adequately describe circuit performance.

A new equivalent noise circuit for transistors has been developed by the author and will be described in a subsequent article. This circuit permits the analytical treatment of an input circuit for optimum noise performance. The use of equivalent noise resistances thus seems impractical with transistors. However, if a determination is desired for some other reason, the methods outlined above may be used in some modification, depending on the equivalent circuit.

How To Determine The Optimum DC Operating Conditions

Determining the optimum dc conditions is usually a time-consuming process because many dependent variables are involved. Since only one can be varied continuously, the other adjustments must be done in steps.

For instance, it is quite likely that a different current is optimum for a different source resistance, or collector voltage, or slight mistuning, etc. Hence merely to minimize the noise figure by adjusting the current and leaving everything else constant, only gives the minimum of one of many curves. Only if a complete set of measurements is available can one determine which of the many minima is best. This tedious process can be shortened by observing the slope of the minimum.

For instance, it may be found that noise figure varies quickly with current changes and slowly with voltage changes. It would therefore be advisable to make the current continuously variable and change the source resistance and voltage in steps.

How To Measure Cross Modulation

The most accurate measurement of cross modulation is made with two signal generators connected through a matching network to the circuit under test. It is important to first check whether any cross modulation is caused by the connection of the two generators. After this check proves satisfactory the receiver may be tested.

The generators are connected in parallel using a matching network as shown in Figs. 5 and 6. Since the input resistance of the circuit under test may change with level, it is advisable to use the value of the available generator power output. Each generator can then be adjusted for twice the voltage plotted because of the loss in the matching network. We shall call the two generators the "signal generator" when it is set to the same frequency as the receiver, and the "interference generator" when its frequency varies.

Both generators are modulated with the same percentage am, for instance 30 per cent. First, the signal generator with modulation is turned on and a convenient carrier level set, say 1 mv. The demodulated audio signal is read on an audio vtvm. The frequency is varied to obtain a maximum reading on the meter.

Next, the signal generator is turned off and the interference generator with modulation is turned on. Its frequency is adjusted outside the if pass band. However, its level may be made equal to the signal generators, for instance 1 mv. If the signal generator is now turned on without modulation, the cross modulation can be read on the vtvm.

Cross modulation is expressed as a cross modulation index—the percentage of undesired modulation on the desired carrier produced by a 100 per cent modulated interference generator. A 100 per cent modulated interference generator producing 10 per cent modulation, or a 50 per cent modulated interference generator producing 5 per cent, have the same modulation index of 10 per cent. Since both signal and interference generators are modulated at the same percentage, it is necessary only to obtain the ratio between the two vtvm readings to calculate the cross modulation index. (The first reading is taken with the modulated signal generator on and the interference generator off; the second reading with modulated interference generator and unmodulated signal generator on).

It is possible to vary the dc operating conditions for the lowest cross modulation index. Also, one can vary the interference carrier level to obtain a given cross modulation of 1 per cent (40 db down) or 5 per cent (26 db down) and plot it versus dc conditions. Generally, a null will be found where the characteristic curve has least third order curvature. This would be the best dc operating point.

How To Measure Effective Selectivity

Effective selectivity can be measured as follows: First, with modulated signal generator tuned to the frequency received by the receiver, a certain level is set, say 1 mv. Next the modulation of the signal generator is turned off, and the interference generator, both carrier and modulation, is turned on. The level of the interference generator is adjusted until a specified cross modulation index is reached. Plotted on the ordinate is the ratio of interference to signal generator voltage and on the abcissa frequency deviation between interference and signal generator.

The voltage or frequency of the signal generator may be used as a parameter. The measurement should be made over the whole frequency range of the receiver including image and if frequencies, etc. Curves so obtained are a true measure of selectivity and are much wider than the if selectivity of the receiver.

Intermodulation may be tested by using two generators with their frequency difference equal to the frequency tuned in by the receiver. All other details and ways to plot the results are analogous to the cross modulation tests just described.

How To Measure Noise Modulation

While noise modulation behaves in the same way as intermodulation (not as cross modulation) and can be measured similarly, it is usual to measure it together with the normal age characteristic of the receiver. The input signal is varied from 1 μv to 1 v, while the output signal is plotted with

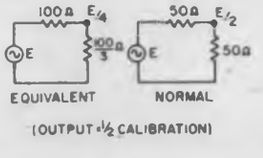

Fig. 6. Equivalent circuit for the measurement circuit of Fig. 5.

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The cost of miniaturization just dropped 20%

Trends can be overpowering. Once established, they're tough to reverse.

Take the cost of miniaturization, for example. As electronic packages get smaller, price tags get bigger. No one seems surprised. It's a trend.

There's a reason, of course. Tiny things are hard to build, especially within space-age reliability requirements.

Amphenol designers decided that if ever a trend needed reversing—it was this one.

"How" was another question. They knew that conventional miniaturized pin and socket connectors were about as small as they were ever going to be. The spring member in the female contact (necessary for a snug, low-resistance connection) took up valuable space and set a lower limit for practical center-to-center contact spacing. The spring was obviously holding up progress in miniaturization. It had to go.

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►Amphenol designers developed the Wire-Form Poke-Home® contact, a male contact that supplies its own tension and can be crimped or welded before assembly. Overnight, contact spacing plunged from .175 inch to .100 inch. And, best of all, the new contact was less costly to manufacture. (It's built on automatic equipment.)

The trend reversal was well on its way. Amphenol designers had a new contact—the next step: putting it to work in connectors.

To answer the need for an economical micro-miniature rack and panel connector, the Micro-Rac was unveiled. Space-saving Wire-Form contacts and an integral-body-dielectric construction made it possible to pack 20% more connections in the same space—and at nearly half the previous cost. As for reliability, after 1,000 repeated insertion and withdrawal cycles, the Micro-Rac retained its original low resistance characteristics.

►Next came the Strip Connector, six-inch lengths of Lexan* plastic with contact holes on .100 inch centers. A do-it-yourselfer's delight, strips can be cut and stacked to suit hundreds of applications where a connector is a must—but for which no other economical connector exists. Example: strips can be stacked to form micro-miniature programming boards or instrumentation terminations. They also can be used as economical tape cable connectors, modular connectors, logic card connectors, to mention a few.

Wire-Form contacts can be used separately, too. Example: contacts can be crimped or welded to modules and plugged into special eyelet-type receptacles on printed circuit boards. Non-modular components, such as transistors, become pluggable by crimping Wire-Form contacts to their leads.

And that was that. The trend was reversed.

►If you would like more information about Wire-Form Poke-Home contacts, Micro-Rac 52- and 104-contact rack and panel connectors, Strip Connectors (or any Amphenol Connector for that matter) call your Amphenol Sales Engineer. Or, write to Dick Hall, Vice President, Marketing, Amphenol Connector Division, 1830 S. 54th Avenue, Chicago 50, Illinois.

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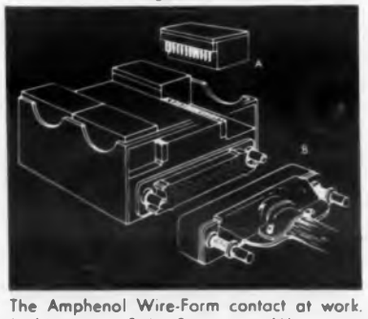
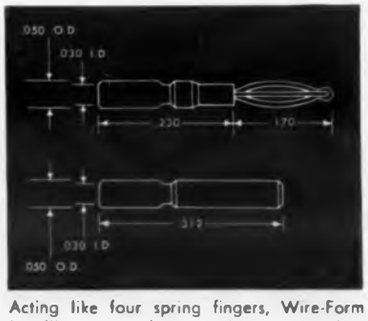


The Amphenol Wire-Form contact at work. Multi-purpose Strip Connectors (A) connect modules to chassis; Micro-Rac Connectors (B) connect chassis to cable assembly.



Acting like four spring fingers, Wire-Form beryllium-copper beam sections assure a low resistance connection (.0025 to .0030 ohm) even after 1,000 insertion-withdrawal cycles.

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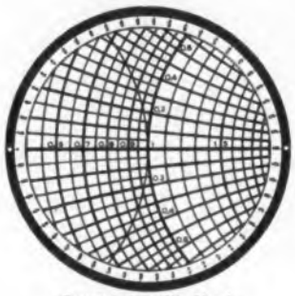
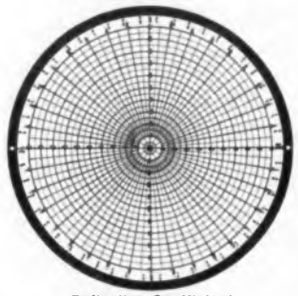
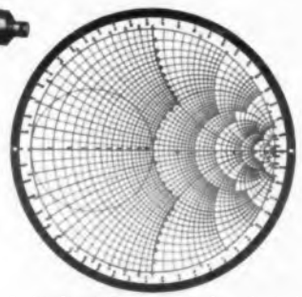


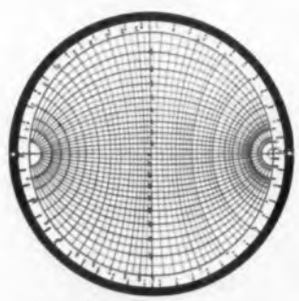
Expanded Smith Chart



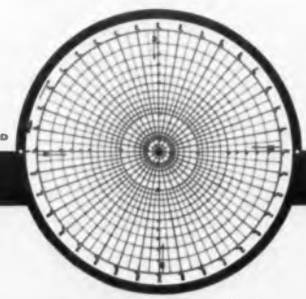
Reflection Coefficient



Smith Chart (Rectangular Coordinates)



Carter Chart (Polar Coordinates)



Attenuation and Phase Angle

ROHDE & SCHWARZ

111 Lexington Ave., Passaic, N. J. • PRescott 3-8010

CIRCLE 27 ON READER-SERVICE CARD

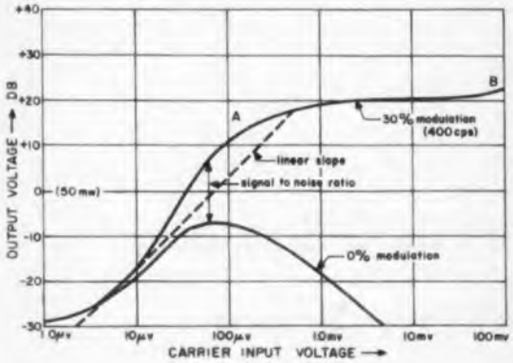


Fig. 7. Curve shows that as agc becomes effective (A) unmodulated carrier (noise) signal decreases and signal to noise rises. At *B* last if stage overloads and agc loses control.

30 per cent and with zero modulation. The difference between the two curves is the effective signal to noise ratio. Noise modulation shows itself as an increase of the lower curve with voltage.

Without noise modulation the output with unmodulated carrier (noise output) is constant until agc becomes operative. At this point the noise should decrease with the gain. A typical curve is shown in Fig. 7. Delayed agc is used as can be seen. At *A* the delay voltage is overcome and full agc becomes effective; below this point there is no agc. At *B* the last if stage overloads and agc loses control. This area also causes severe modulation rise and increased noise.

Generally the curves must be taken on the receiver during its developmental stage. They give a true picture of actual performance. Output should be plotted in decibels (0 db = 50 mv) on a linear scale, and input on a 6-cycle log scale. The volume control of the receiver should be used as a multiplier so that the audio amplifier is never overloaded.

For instance, if a reading of 50 mv is reached, the volume control is used to reduce the voltage to one tenth and the voltmeter is switched one range. This method has now been accepted as standard, because it provides the receiver designer with a wealth of information in a short time. Fig. 7 also indicates, for example, that several stages are underbiased because the gain increases with signal at small signal levels before agc becomes effective. ■ ■

W/L on target!

New METOHM line exceeds MIL-R-10509D

As a supplement to the unexcelled VITROHM resistors, Ward Leonard now offers to designers of commercial, military and industrial electronic equipment a line of molded metal film precision resistors, designed and tested to exceed the requirements of MIL-R-10509D, characteristics B, C and E. You can stake your reputation on Ward Leonard resistors.

Available in ⅛, ¼ and ½ watt sizes, W/L METOHM precision resistors feature the highest degree of built-in reliability and operating stability. Temperature coefficients, over the range −55°C to +175°C, may be as low as ±25 parts per million. Standard tolerance ±1%. Tolerances down to ±0.1% on special order.

METOHM TYPE	MIL EQUIVALENT	RATED WATTS	OHMIC VALUES		MAX. VOLTAGE RATING
			MIN.	MAX.	
WL 60	RN 60	⅛	30	500K	250 V.
WL 65	RN 65	¼	50	1 meg.	300 V.
WL 70	RN 70	½	50	1.5 meg.	350 V.

Write for complete specifications and a list of distributors. Ward Leonard Electric Co., 77 South Street, Mount Vernon, New York. 0.10

RESULT-ENGINEERED CONTROLS

WARD LEONARD ELECTRIC CO. MOUNT VERNON, NEW YORK

RESISTORS • RHEOSTATS • RELAYS • CONTROLS • DIMMERS

CIRCLE 58 ON READER-SERVICE CARD

Low Hysteresis G-Sensor Features High Output

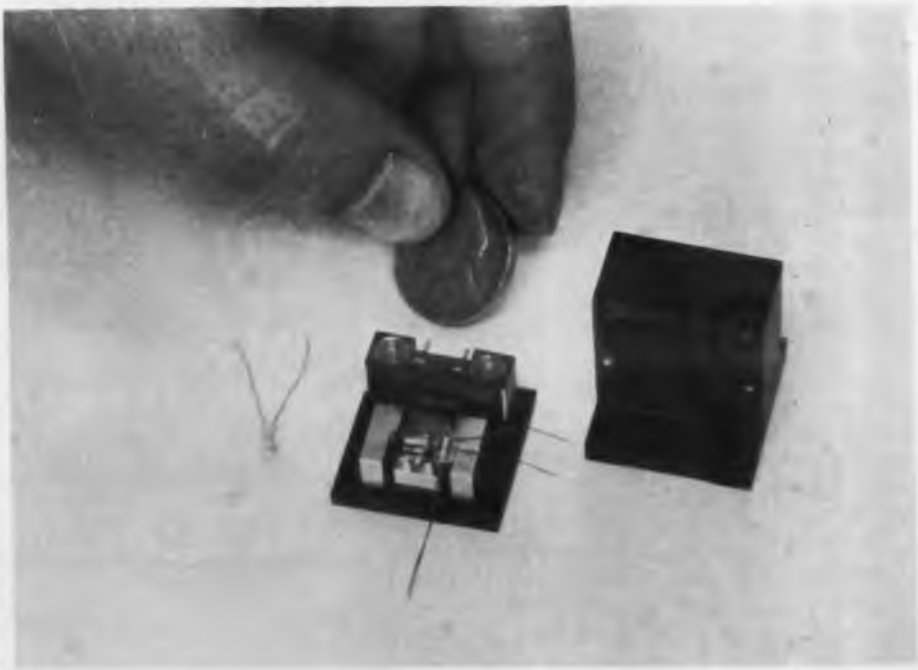
AN ACCELEROMETER output of 0 to 5 v makes it possible to use this 1-cu.-in. transducer without expensive low-level amplifiers. The accelerometer's regular, predictable nonlinearity—no more than 1 per cent—permits easy programing into computers and other equipment.

Normally, with nonlinearity programed out of a transducer's data, the next most important problem is hysteresis. In the accelerometers manufactured by Data Sensors, Inc., 13112 S. Crenshaw Blvd., Gardena, Calif., hysteresis is said to be virtually eliminated. It is rated at 0.25 per cent, compared with the 1 to 2.5 per cent found in conventional strain-gage accelerometers.

The new accelerometer is designed with a microminiature light source, a cantilever pendulum acting as a shutter and two photo transistors. The flexure of the cantilever, under the force of acceleration, modulates the quantity of light seen by the phototransistors. Output from the phototransistors is ± 2.5 v with 10 v excitation, a transfer efficiency of 50 per cent. Strain-gage accelerometers may have only 4 or 5 per cent transfer efficiency.

One-Flexure Design Minimizes Hysteresis

According to Julian Hernandez, vice president of engineering for Data Sensors, the 0.25 per cent hys-



teresis figure is only a formality. "Hysteresis is so small we can't properly measure it", he said.

"The reason for this is there is only one flexure—at the point where the cantilever beam bends. There are no other mechanical restraints on the system; consequently, no other source of mechanical hysteresis."

Another benefit of the photo transistor technique is reported to be the high natural frequency for the transducer. Compact, simple construction permits an inherently high natural frequency. In this case it is about 500 cps; later models will have natural frequencies on the order of 1 kc, dependent to some extent on range.

Frequency response of the transducer is flat to 200 cps. Other specifications for the accelerometer are: nonlinearity, 1 per cent; drift, 0.1 per cent in 24 hr; repeatability, 0.1 per cent of full scale; temperature error, ±1 per cent per 100 F; resolution, infinite.

Compactness Suited To Aerospace Needs

Of interest to aerospace instrumentation engineers is the transducer's size (1.3 cu in.) and low per cent of full scale; temperature weight (2 oz). No additional weight or space is required for amplifiers to provide a standard, voltage-controlled oscillator with ±2.5 v; excitation for the device is 10 v or 28 v unregulated dc.

The operating principle of the new accelerometer can be applied to the design of transducers for sensing load, displacement, angular position and torque.

The accelerometer costs about $500, the company reports; availability is 30 days, on receipt of order.

For more information on these high-output, low-hysteresis accelerometers, turn to the Reader-Service Card and circle 251.

0.5 nanosecond

the time it takes for light to cross the palm of your hand

Lumatron developed and delivered the first commercial nanosecond sampling oscilloscopes — in 1958. Today Lumatron model 112A's outperform all others — 0.2 ns risetime (2 kmc bandpass), 3mv/cm sensitivity, sweep speeds to 0.05ns/cm. Lumatron also pioneered **automatic** switching time measurements. Today's **improved** Model 400A series instruments measure all switching and delay characteristics in transistors, diodes and circuits — from 0.5 ns to 2 us, with better than 5% accuracy. 5,000 tests per hour. You push a button — the Test Set does the rest.

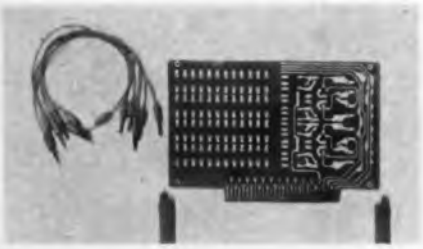
If you do nanosecond work, write now for free data chart, and detailed specifications.

LUMATRON
Electronics, Inc.

115 County Courthouse Road, New Hyde Park, N.Y. • Pioneer 7-3200

CIRCLE 60 ON READER-SERVICE CARD

Building-Block Circuit Boards



ENGINEERING TIME and development costs for circuit breadboarding are reduced by these quality printed-circuit mounting boards. Available in two basic types, the Proto-Card is so designed that the components themselves provide most of the circuit connections.

Manufactured by Circuit Structures Laboratory, Laguna Beach, Calif., Proto-Cards can be used for preliminary circuit development and testing by "tacking-in" circuit elements.

The all-purpose type has five power buss lines and isolated transistor and component pads. The transistor card has eight collector output lines and 16 input lines, with printed leads to the connector pins. Fifteen of the connector lines are terminated at eyelets to provide maximum flexibility for input wiring.

The digital circuit type has four power lines, eight collector output lines and 16 input lines, with printed leads to the connector pins. The eight transistor emitters are bussed to a common line. A variety of digital circuits can be formed by adding the active and passive circuit elements to

form the desired circuit functions.

A prepared drawing sheet comes with each card to simplify the development of schematic diagrams. Each card comes ready for use.

Proto-Cards can be used to mount functional circuits for first-article electronic equipment. The procedure recommended is as follows:

1. Complete the blank schematic sheet supplied with the Proto-Card by laying in the circuit interconnections. Build the circuit as you design by making quick, solderless, connections on a CSL Circuit Builder. This device and its use were covered in the March 16, 1960 issue of ELECTRONIC DESIGN. All components will be in the open and connections are easily accessible for test and revision.

2. Transfer the breadboarded circuit to a CSL Proto-Card. Only a minimum of jumper wiring is required since all of the basic circuits are provided for a variety of analog and digital devices. Components are soldered into place by standard assembly techniques.

3. Circuit interconnections can be formed by patch-cord interconnections on the model 84100 Inter-Card Patch Panel. The over-all performance and circuit compatibility can be determined from tests on the prototype cards interconnected through the patch panels.

4. Design errors can be corrected easily by changing the circuit elements and interconnections on the Proto-Cards. Marginal circuit conditions can be determined by introducing variations in circuit parameters on the prototype circuit cards.

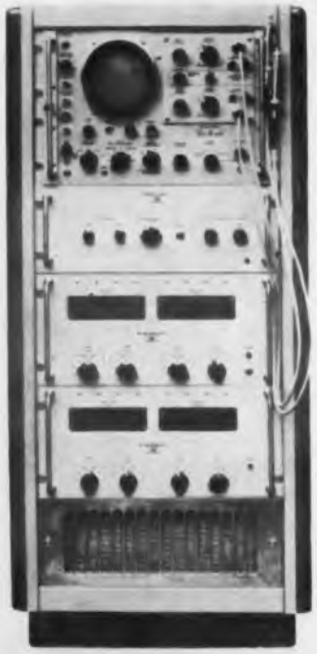
The final packaging of first-article electronic equipment can be simplified using CSL Chassis Modules or card holder modules with the associated connector mounting frames. The card holders have a capacity of 27 Proto-Cards.

The Proto-Cards offered at this time are available in four models, each in a left- and right-hand version. All are available within 10 days after receipt of order at $7.50 each, in lots of one to nine, and $6.60 each, in lots of 50 to 99.

For further information on these time-saving devices, turn to the Reader-Service Card and circle 252.

NEW PRODUCTS

Covering all new products generally specified by engineers designing electronic original equipment. This issue features the new products to be displayed at the National Electronic Conference to be held at Chicago, Oct. 9 to 11. Use the Reader-Service Card for more information on any product. Merely circle number corresponding to that appearing at the top of each description.



Waveform Measuring System Automatically Tests Transistors 258

Transistor testing is facilitated by this automatic waveform measuring system. Designated model DY-5844, the system measures the time interval between any two points on stimulus and response test pulses. Unskilled persons can operate the equipment, or the system can be automated for unattended operation. Accuracy is better than 4% of full scale. The system measures delay, rise, storage, and fall time of transistors, diodes, magnetic cords and various high-speed components and circuits. Parameters are measured in 1/4 sec. Information is presented on an oscilloscope and a digital display.

Dymec Div., Hewlett Packard Co., Dept. ED, 395 Page Mill Road, Palo Alto, Calif.

***P&A:** $8,000 to $12,000; 10 to 16 weeks.*

Tape Transport Device Controls Speed and Tension 256

Made to regulate take-up reel speed and tension on tape transports, this device provides resistance variations equivalent to variations in tape tension. Forces of 5 to 15 g move an actuator over a distance of 1/8 in. Contacts, arranged in a bank, are actuated sequentially as the force increases. External resistors connected to the contacts regulate the power to be fed to the take up motor. The contacts handle up to 240 w and have a life estimated at more than 200 million operations.

Electric Regulator Corp., Dept. ED, Pearl St., Norwalk, Conn.

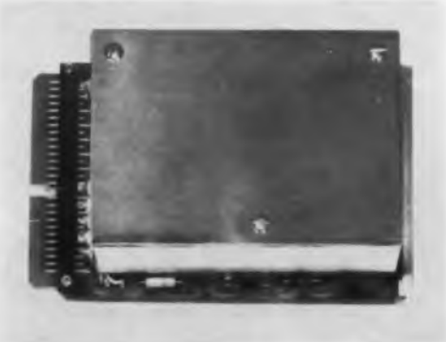
***P&A:** $50 in single units; one week.*

Acoustic Serial Memory Stores 1,600 Bits at 16 Mc 259

Using a fused-silica acoustic delay line, this digital serial memory has a 1,600-bit capacity. Designated model SM-40, the device provides pulse delays of 20 to 100 μsec and operates at 8 to 16-mc frequencies. Without requiring carrier modulation, the module accepts up to 16 million bits per sec. The package, a plug-in unit, contains all necessary input-output logic, and is compatible with the firm's H-PAC digital modules. Temperature control is unnecessary.

Computer Control Co., Inc., Dept. ED, 983 Concord St., Framingham, Mass.

***P&A:** $997; 6 to 8 weeks.*



Subminiature Slip-Ring Contains 28 Circuits 257

Designed for inertial guidance equipment, the model 1408 slip-ring cartridge measures less than an inch long and 3/8 in. in diam. The cylinder contains 28 circuits. Circuits in the assembly can handle from 0.5 to 2 amp continuously, and withstand 500 v dc. The cartridge has a torque of only 40 gm-cm. Noise is low. Contact surfaces, made of precious metal, resist corrosion and are compatible with a fluorocarbon environment.

Slip-Ring Co. of America, Dept. ED, 3612 W. Jefferson Blvd., Los Angeles 16, Calif.

P&A: about $650; 6 weeks.

Converter Takes 15,000 Readings Per Sec 255

With an error no greater than 1% plus one digit, this analog-to-digital converter takes 15,000 voltage readings per sec. Designated model 5000, the converter uses precision high-frequency resistors, a stable comparison amplifier and a temperature-regulated power supply to achieve its accuracy. Made to operate as a digital voltmeter, the instrument has bi-polar operation. Input amplifier setting time is 4 μsec; kick-back is negligible. An adapted converter, model 5000B, has straight binary output. The units are completely transistorized.

Non-Linear Systems, Inc., Dept. ED, Del Mar, Calif.

P&A: $6,950; from stock.

See at NEC Show Booth 3.

CIRCLE 62 ON READER-SERVICE CARD ➤

New Products Directory

A complete index of all new products contained in this issue of ELECTRONIC DESIGN, *including page and reader-service numbers.*

NEW PRODUCTS

RF Attenuators 526

Range is dc to 500 mc for this rotary adjustable attenuator that is made in seven types, four with 75 ohms impedance and three with 50 ohms impedance. Power dissipation is either 0.25 or 0.50 w, according to the model. Units can attain zero db and proceed in steps of 0.1 db. Custom built models are available.

Ortho Industries Inc., Dept. ED, 7 Paterson St., Paterson 2, N. J.

FM Radio Tuner 527

If bandwidth is 450 kc at 6 db down for good stereo reception of the main and subcarrier signals. Tuner model 311-0009 is designed for receiving multiplex fm broadcasts. Unit incorporates automatic frequency control and agc is the rf stage.

Waller Corp., Dept. ED, Industrial Center, Crystal Lake, Ill.

Memory Storage Unit 521

For analog computers, unit can store answers or values to problems for presentation later when the operator wants to compare new values to those previously computed. Two values at a time can be stored in one memory package.

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

Transistorized Controls 479

Pulse logic monitoring devices continuously check and control automatic machine operations. Units will stop a machine immediately upon detecting any malfunction such as misfeed, improper positioning, improper parts transfer, buckling, and end of material. Visual signals alert the supervisor and the machine is instantly stopped.

Weldotron Corp., Dept. ED, 907 Frelinghuysen Ave., Newark 14, N. J.

Cable Connectors 618

Aluminum arc-proof power cable connectors can be installed hot in 45 sec, if necessary, with complete safety to the lineman. Interlocking parts and spring action employed in the fittings make it impossible to install the connectors in any way but the correct way.

Steele Manufacturing Co., Inc., Dept. ED, 2103 Loop 323 E., Tyler, Tex.

Radiation Test Set 528

A complete system for measuring and evaluating radiometric parameters is offered in model 16-110 infrared radiation test set. Components are a motor-chopper assembly, detector-preamplifier assembly, and synchronous rectifier amplifier units.

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

◀ CIRCLE 249 ON READER-SERVICE CARD

Accurate, automatic measurements of TI semiconductor reliability are provided with CART (Central Automatic Reliability Tester). This unique TI facility life tests 30,000 operating devices at a time to assure maximum reliability.

You Get Predictable Semiconductor Reliability From Unique TI Skills

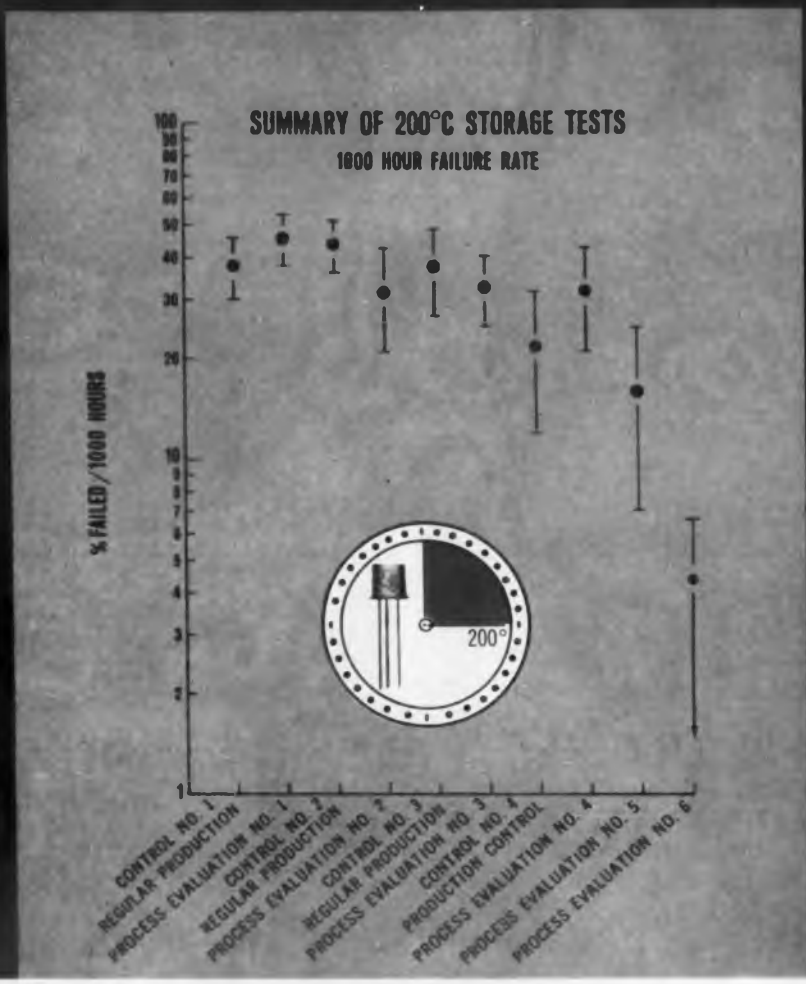
HERE'S WHY: *Data from well over one-billion life-test hours* — ensures the quality assurance techniques that give you statistically predictable device performance. TI can run operating life tests on 90,000 semiconductor devices at one time — more than 500-million unit hours per year!

TI leadership in production and test equipment — TI's semiconductor plant houses more than *800 separate automatic facilities*, designed for fail-safe, dependable production and testing. For example, TI-built CART minimizes possible machine and human error. Testing 30,000 devices at a time under both accelerated and derated conditions, CART automatically measures and records each parameter.

Punched-card readouts are computer-processed and used for predicting performance and evaluating process changes. Result: uniform product reliability — possible only with rapid, accurate mechanized equipment.

TI maintains an independent Quality Assurance department for every existing product line. Completely separate from product departments, these QA groups measure on-line production as well as finished device reliability. Result: Quality Assurance is your representative at TI — specifically organized to assure you of predictable TI product reliability.

TEXAS



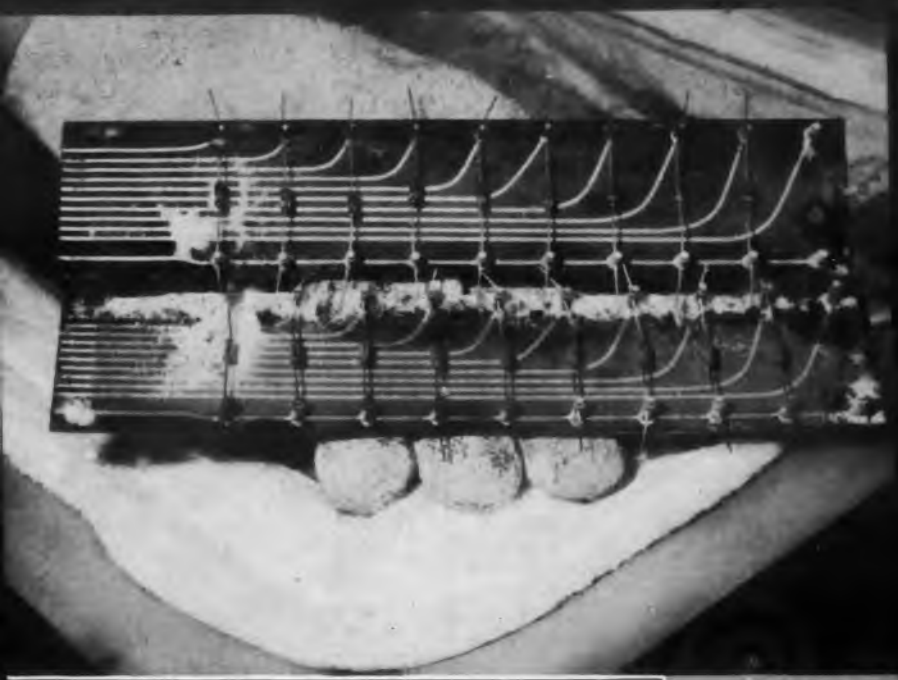
From TI Transistor Products Division

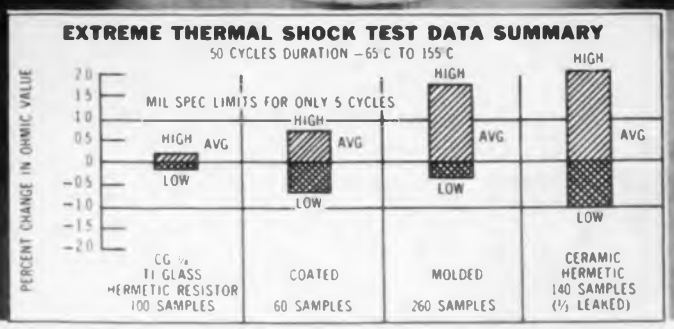
Continuing Process and Product Analysis Assures Maximum Transistor Reliability

The test graph above demonstrates TI's constant search for new ways to achieve the ultimate in product reliability. Several hundred TI 2N705 germanium mesa transistors from five experimental production processes were subjected to 200° C storage life tests (twice the normal maximum rated temperature for the 2N705 device). Severe as these tests were, one process (No. 6 above) yielded failure rates as low as 5%/1000 hours. Result: An improved process technique, now standard at TI, for producing higher temperature devices.

Besides aiding in developing process technologies, reliability testing at TI also plays an important role in maintaining highest possible manufacturing standards. The manufacture of 2N705 transistors, for example, includes 100% inspection at several production points. At one of these points, 100% hermetic-seal inspection is performed by a mass spectrometer method. Additional QA sampling inspection is performed at selective control points during production. This kind of quality assurance testing — from process analysis to finished device — means built-in product reliability.

INSTRUMENTS
INCORPORATED
13500 N. CENTRAL EXPRESSWAY
P. O. BOX 5012 DALLAS 22, TEXAS





From TI Components Division

Comprehensive QA Program Proves Reliability of TI Hard-Glass Resistors

A comprehensive Quality Assurance program was an integral part in the successful development of TI's high-reliability hard-glass resistor. Tests far more rigorous than those in common use were devised to prove out the basic design and materials for this superior product. In the *Extreme Thermal Shock Test Data Summary* above, resistors remained 45 minutes in a cold chamber (–65°C), then went to a heated oven (155°C) for 45 minutes, then returned to the cold chamber. At each temperature, the units were loaded at full rated power for 15 minutes. Fifty cycles produced the results shown in the chart above . . . 0.21% maximum change, 0.04% average change.

Extended Load-Life Tests to 3000 hours demonstrated a failure rate for hard-glass resistors of 0.04×10^{-5} with a 95% confidence level under a variety of temperature and power conditions. In this test, a failure was defined as any resistance change in excess of 3%.

TI hard-glass resistor QA tests also include extended moisture, short-time overload, acceleration, shock, vibration, and hermetic seal . . . typical of QA programs on all TI products. Regularly published data from these programs prove, with statistical evidence, TI product reliability.

For detailed reliability information about any TI semiconductor product or component, write on your company letterhead (attention mail station 472), outlining your specific requirements.

NEW PRODUCTS

120-V Soldering Iron 536

For do-it-yourself fans as well as production-line operations. The Pen-line-120 is available with 30- and 50-w integral tip-and-heater assemblies. A 40-w assembly with 20 ironclad and copper tips will be introduced soon. Pyramid, chisel, spade, and cone tips, 3/16 to 3/8 in. will be offered.

General Electric Co., Dept. ED, Schenectady, N. Y.

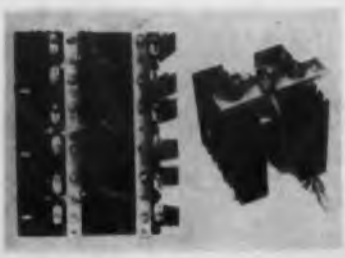
P&A: *under $5; in quantity, late September.*

Nylon Hardware 537

Toughness, chemical resistance, and non-conductivity are features of nylon drawer handles and cabinet hinges. Rust-resistance has led to their use by the Navy in electronic installations. The hinges have low friction facing and a non-abrasive surface that require no lubrication.

Hardware Designers, Inc., Dept. ED, P. O. Box 4. South Hackensack, N. J.

Heat Sink 534



Effective heat dissipation in a small volume is claimed for mod-

Available in 7 JEDEC types.
Shown above, 2N681 Trinistor is enlarged 6 times.

el 2507 heat sink. Under a load of 75 w, the unit provides a thermal resistance of 0.68 C per w. It measures 4 x 4 x 4 in. Bus bars and mounting-hardware variations permit a wide range of applications in bridge circuits demanding adequate convection cooling.

Astro Dynamics, Inc., Dept. ED, Northwest Industrial Park, Burlington, Mass.

Availability: *from stock.*

Telemetering Equipment 519

For simple digital telemetering applications such as the telemetering of kilowatt-hours on electrical utility systems or positive displacement on pipelines the equipment is designated type DL. Data are transmitted over any telegraphic channel in binary-coded decimal form by means of long and short pulses and spaces.

Westinghouse Electric Corp., Dept. ED, P. O. Box 2099, Pittsburgh 30, Pa.

Miniature Diodes 529

Resistance to moisture, contamination, and mechanical stress is featured in a new line of miniature gold-bonded germanium glass diodes. They are one-eighth the size of standard subminiature types. The package is glass encapsulated.

Clevite Transistor, Dept. ED, Waltham, Mass.

◀ CIRCLE 68 ON READER-SERVICE CARD

NEW PRODUCTS

DC Amplifier 484

Push-pull dc amplifier model 1058 was originally designed for use in airborne speed-control applications, but can also be used in many applications where the input is from elements such as thermocouples, strain gages and photoelectric cells. The output can be used with devices such as torque motors and relays with hydraulic or pneumatic servos.

Lumen, Inc., Dept. ED, P. O. Box 905, Joliet, Ill.

Hydrogen Thyratrons 616

Uses include radar transmitters, linear accelerators and other pulse switching equipment. Thyratron type CX1140 is for use as a pulse modulator switch and type FX297 is for use as an inverse diode. Piv for both types is 25 kv. Average plate current is 1.25 amp; peak plate current is 500 amp for the FX297 and 1,000 amp for the CX1140.

English Electric Valve Co., Ltd., Dept. ED, Chelmsford, England.

Controls Analyzer 482

For servomechanisms and feedback control systems, model 440 controls analyzer has a brushless rotating transducer which developes sinusoidal and sinusoidally modulated test signals of 0.03 to 300 cps. Carrier frequencies to 5,000 cps can be accommodated. A self-contained response channel is included.

Superior Manufacturing & Instrument Corp., Dept. ED, 36-07 20th Ave., Long Island City 5, N. Y.

◀ CIRCLE 66 ON READER-SERVICE CARD

Control Synchros 422

Size 23, for 400-cps operation, made to meet MIL-S-16892 and FXS-1066. A typical unit in this line of control synchros, model VCX23/344a transmitter, has an input impedance of 480 ohms at 85 C, 1.5-deg nominal phase shift, 90 gm per cm² moment of inertia, and ±8 min electrical error maximum.

Vernitron Corp., Dept. ED, 125 Old Country Road, Carle Place, L. I., N. Y.

Logic Element 477

Miniature logic elements, called Micrologic, are available in gate and half-shift register which match the firm's buffer, half-adder and counter adapter. Average dissipation is 3 mw, and temperature range is −55 to +125 C. The elements look like transistors, but have eight leads.

Fairchild Semiconductor Div. of Fairchild Camera and Instrument Corp., Dept. ED, Syosset, L. I., N. Y.

P&A: *$120; in small quantities.*

Noise-Field Intensity Meter 488

Covers 14 kc to 1,000 mc in three ranges. Model T-X/NF-105 noise and field intensity meter is compatible with existing NF-105 units. Nominal bandwidth is 1 kc and sensitivity is 0.1 mv full scale. Accessory items also available include a 36-in. loop antenna, a 41-in. vertical antenna and a line probe.

Empire Devices, Inc., Dept. ED, Amsterdam, N. Y.

CIRCLE 67 ON READER-SERVICE CARD ▶

have you tried BIRD?

READ RF WATTS DIRECTLY

Today everyone who measures RF power in coaxial systems wants the answer in watts. The BIRD Model 43 THRULINE reads watts!

Connect the Model 43 between transmitter and antenna or load. The meter reads RF power directly. Measure forward or reflected power instantly.

No calibration charts. No adjustments. No calculations. No auxiliary power.

Plug-in elements are used to cover 2 to 1000 mc, and powers to 1000 watts.

BIRD Quick-Change (QC) Connectors eliminate adapters. Any standard series of coaxial line fittings may be accommodated.

Write, TWX or call us for complete specifications on the Model 43 and other BIRD products.

BIRD Model 43
Thruline Wattmeter

Price:
Instrument only . . . . $95.00 each
Plug-in elements . . . . $30.00 each
FOB, Factory

BIRD ELECTRONIC CORPORATION
30303 Aurora Rd., Cleveland 39 (Solon), Ohio
CHurchill 8-1200 TWX CGN FS 679
Western Representative:
VAN GROOS COMPANY, Woodland Hills, Calif.
See us at NEC—Booth No. 500

CIRCLE 69 ON READER-SERVICE CARD

NEW PRODUCTS

DC Power Supplies 595

Sub-miniature, solid state, high voltage dc power supplies are self-contained and provide either regulated or non-regulated outputs. Ac types operate from a 105-125 source, 60 or 400 cps; dc types from a 25 to 29 volt input. Outputs for all types correspond to 1, 3 or 5 kv dc with a standard current rating of 100 μamp. Regulation is better than 0.5% for input and load variations; ripple is less than 0.5% rms. Units are encapsulated in transformer type housings.

Electronic Research Associates, Inc., Dept. ED, 67 Factory Place, Cedar Grove, N. J.
P&A: *from $105; from stock.*

Rectifier Tube 603

Supplying 840 v at 165 ma or 730 v at 275 ma, rectifier tube type 5R4WGB is a military standard 200E preferred type used in power supplies for airborne, mobile and shipboard radars and communications equipment. Maximum piv is 2,900 v at an altitude of 35,000 ft, and 1,850 v at 60,000 ft.

Raytheon Co., Industrial Components Div., Dept. ED, 55 Chapel St., Newton 58, Mass.

Continuity Tester 691

Exploding bridgewire checkout unit is used to test exploding bridgewires and provide the user with a positive indication of wire and circuit continuity in units such as exploding bridgewire igniters, pressure cartridges, and other exploding bridgewire devices. Voltages in the mv region are used to perform the checkout.

Special Devices, Inc., Dept. ED, 16830 W. Placerita Canyon Road, Newhall, Calif.

Digital Relay Timer 581

Measures time characteristics of relays. Applications include production testing, receiving inspection testing, etc. Ranges are 1.999 to 199.9 with accuracies from 0.001 msec to 0.1 msec. Timer will accommodate relays with up to six poles, with contact forms A, B, C and D. Display is direct reading, four digits plus decimal point.

Leach Corp., Dept. ED, 18435 Susana Road, Compton, Calif.

Price: *$2,295.*

Crystal Adapter 688

Accommodates 50 crystals which allows selection of as many as 50 crystal controlled channels from the front of the company's NC-400 general communications receiver. This assures fixed channel reception of practically any frequency. Designation is MX-400.

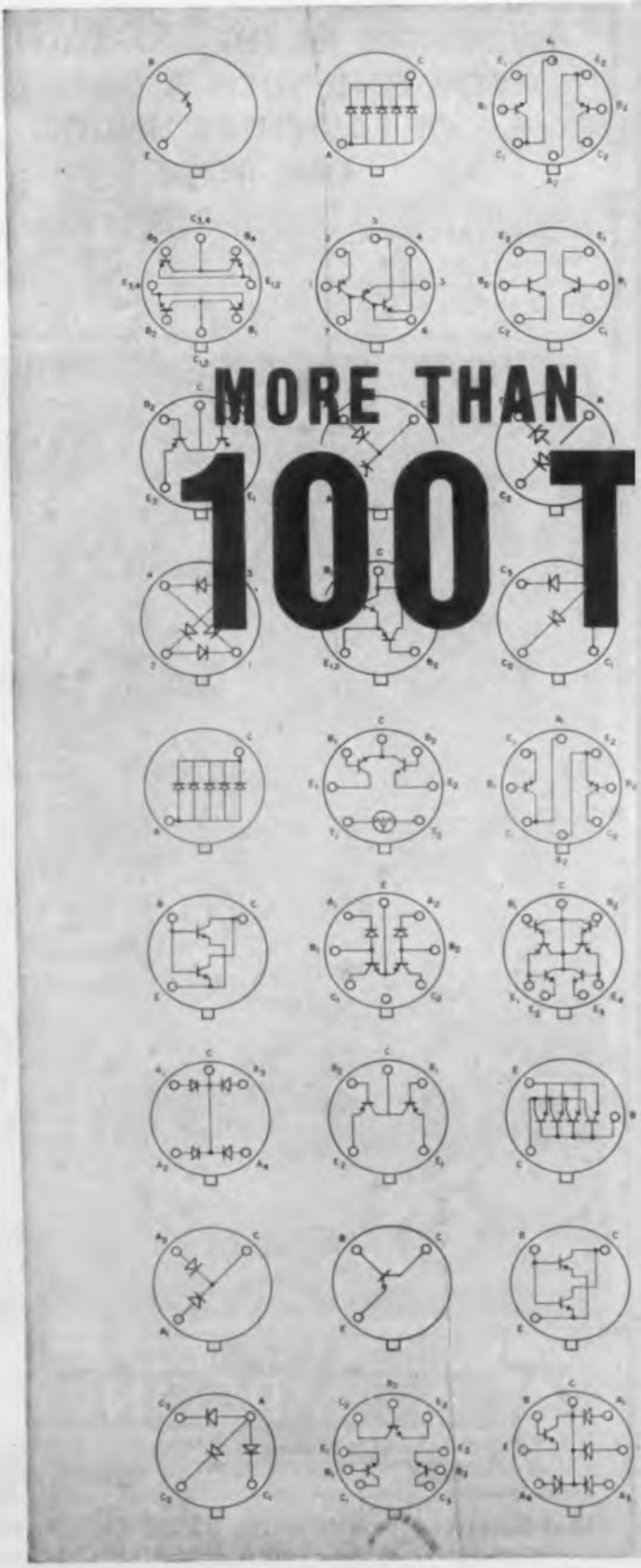
National Radio Co., Melrose, Mass.

Price: *approximately $50.*

Marking Machine 580

For wire and tube, wire marking machine KW-7 marks wire or tube with its own individual circuit number or code reference at 2 to 10 in. intervals along the entire length of each wire, thus eliminating the need for color coded wire.

Kingsley Machine Co., Dept. ED, 850 Cahuenga Blvd., Hollywood 38, Calif.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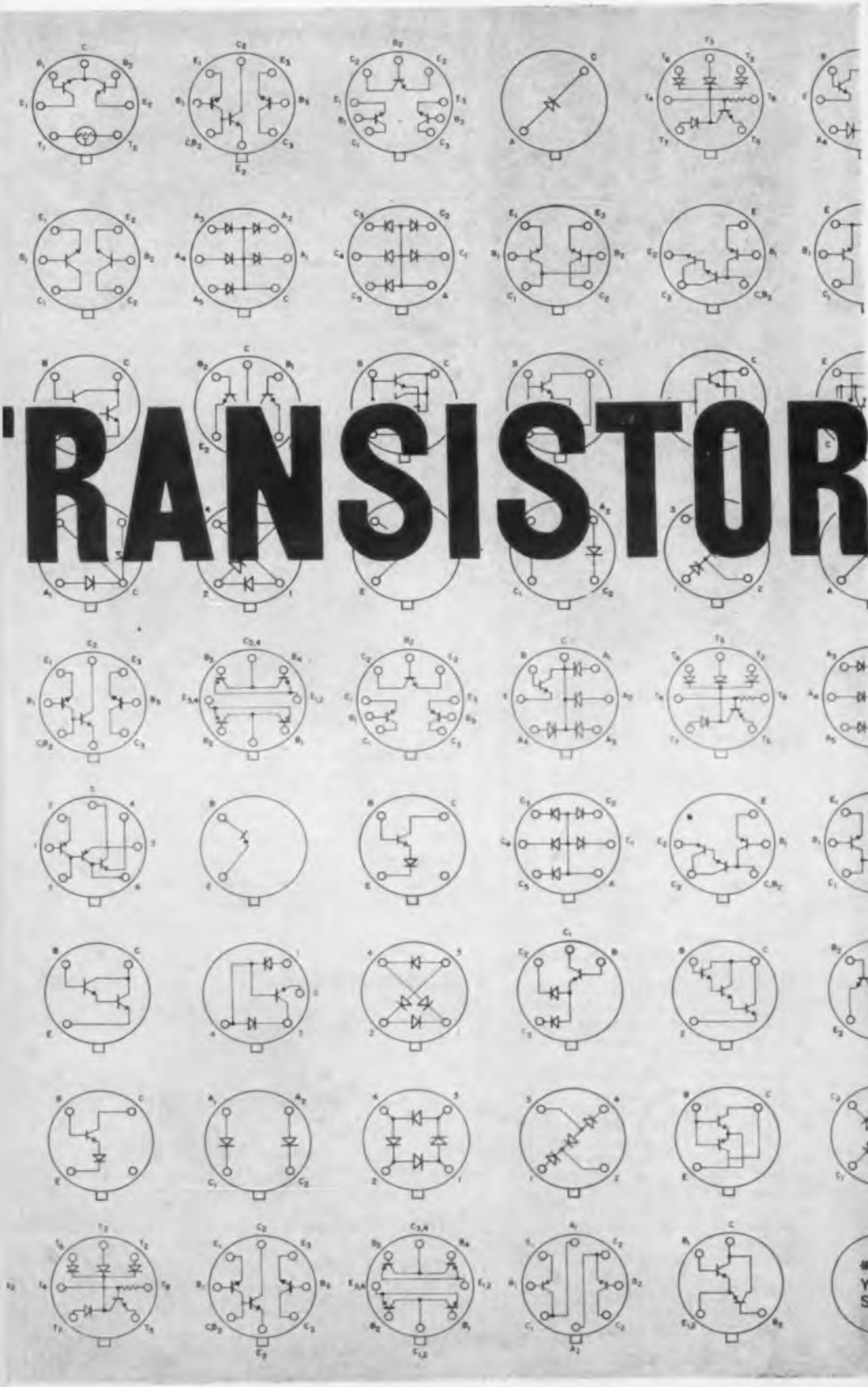
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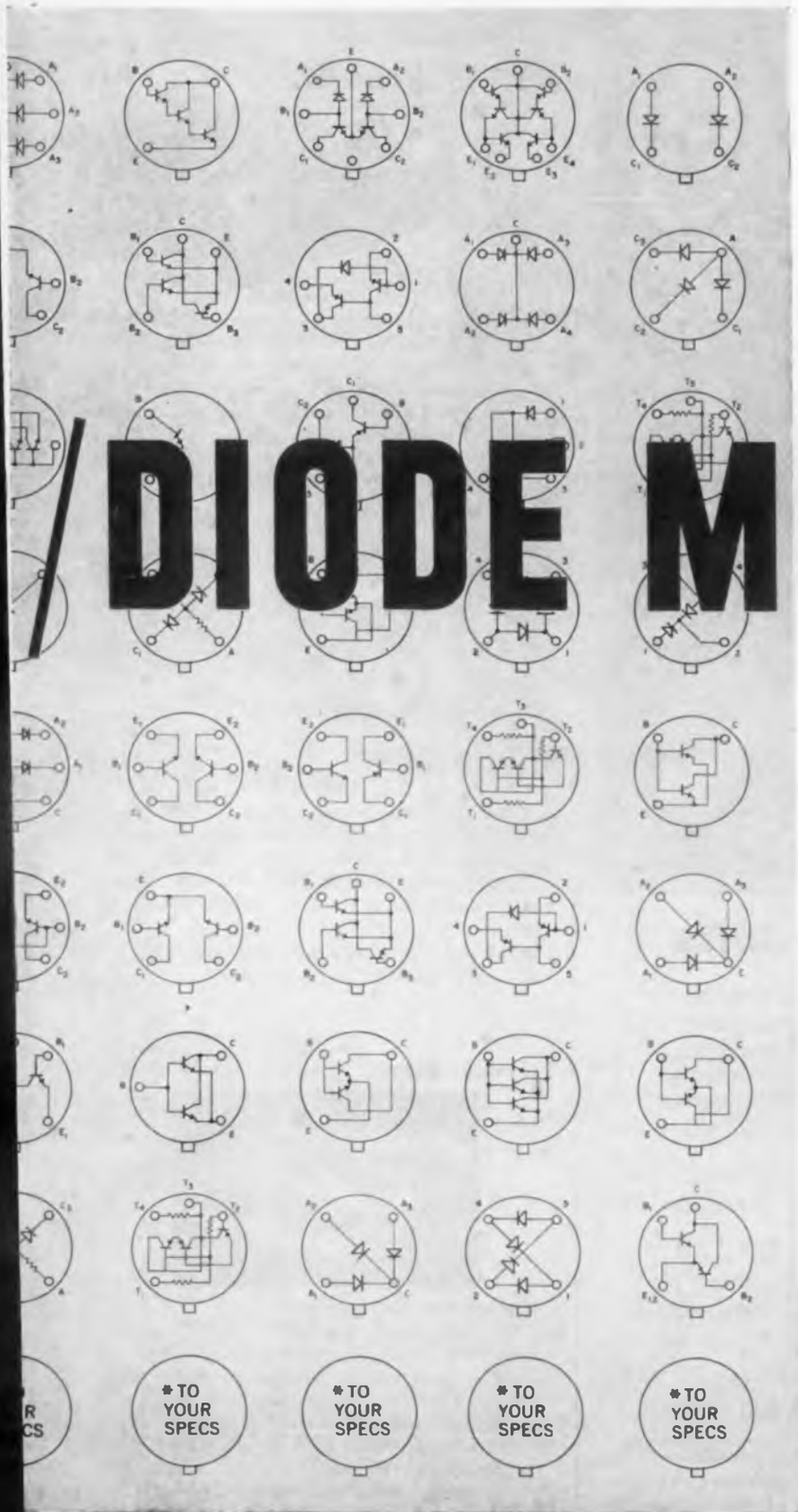

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DIODE MULTIPLES

- **Lower Assembly Cost... Greater Reliability**

  Fewer soldered connections reduce assembly cost... provide increased circuit reliability.

- **Up to 80% Space Reduction**

  Space savings with increased design flexibility.

- **PLANAR Stability Assures Matched Performance**

  Electrical match available... thermal match provided through heat conductive header.

- **Standard Transistor Packaging**

  Combinations of transistors or diodes are assembled in a **single** TO-5 type package. TO-18 type packages available.

- ***To Your Own Specifications**

  Assemblies to your specifications available on quantity orders.

Write for Special Products Handbook... contains specifications, outline drawings and commentary.

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545 WHISMAN ROAD, MOUNTAIN VIEW, CALIF. · YORKSHIRE 8-8161 · TWX: MN VW CAL 853

A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION

CIRCLE 73 ON READER-SERVICE CARD

NEW PRODUCTS

Self-Locking Fastener 478

Clip-on, self-locking fastener type LHA4972 can be used on any sheet-metal or fiber-glass assembly where the 0.02-in. clip thickness between mating surfaces can be tolerated. A locating eyelet formed on the base plate snaps into a hole drilled or punched in the sheet.

Elastic Stop Nut Corp. of America, Dept. ED, 2330 Vauxhall Road, Union, N. J.

Subminiature Lamps 590

Drawing 5 ma, Micro Lamps operate on 1.2 or 1.5 v. Light output is 40 to 60 millilumens. Minimum life is 1,000 hr. Five types are available with sizes ranging from 0.134 in. length x 0.039 in. diam. to 0.177 in. length x 0.079 in. diam.

Miniature Lamp Engineering Co., Dept. ED, 350 Broadway, New York 13, N. Y.

Polyester Belts 579

Endless flat flexible belts are available in any length. Belts made of DuPont Mylar come in widths from 1/4 in. or less to 60 in., and thickness from one to 10 mils or more. Belts made of DuPont Cronar are available with standard perforations and widths from 16 to 70 mm, and thickness of 4 or 7.5 mils.

International Ultrasonics, Inc., Dept. ED, 331 Centennial Ave., Cranford, N. J.

Power Supply 489

Chopper - stabilized, dual - regulated power supply model PS/200/3.5 provides simultaneous outputs at 0 to 200 ma of −300 and +300 v dc. Hum, noise and ripple are less than 200 μv rms; load regulation, line regulation and drift are within 0.001%. Uses are simulation, analog computing and sensitive-instrument applications.

Embree Electronics Corp., Dept. ED, West Hartford, Conn.

Three-Phase Transformers 604

Size is 1 x 1 x 17/32 in. for the series SX transformers. Units are hermetically sealed in accordance with MIL-T-27A, grade 5, class R. Primary windings can be provided to handle any voltage up to 200 v at 400 cps. Secondary windings can be provided to produce any voltage up to 200 v at 2 watts output.

Titan Transformer Co., Dept. ED, 229 Binney St., Cambridge, Mass.

Semiconductor Strain Gage 598

An ultra-thin semi-conductor strain gage, model MS632-120 has a U-shaped configuration with leads on the same end. It is proof-tested to 3,000 microstrain, and has an ultimate strain capacity of 5,000 microstrain. Gage factor is 110 with a resistance of 120 ohms. Operational temperature range is from −320 to +400 F.

Micro Systems, Inc., Dept. ED, 319 Agostino Road, San Gabriel, Calif.

***P&A:** $98 for a package of four; immediate.*

CIRCLE 75 ON READER-SERVICE CARD ▶

NEW PRODUCTS

Laboratory Kit 594

Two models, SK-1 and SK-2, of laboratory service kits combine three functions in one housing. Included are a 25-w pencil type iron for printed circuit soldering, a continuity checker and convenience outlet box. SK-1 has a 6-v iron, SK-2 has a 110-v iron.

C.B.C. Electronics Co., Inc., Dept. ED, 2601 N. Howard St., Philadelphia, Pa.

Tape Punch 596

Model P76 tape punch is for punching 5, 6, 7, and 8-channel paper or mylar-aluminum tape at the rate of 20 characters per sec. It measures 15 in. in width, 14-1/2 in. in depth and is 21 in. in height with cover open. Weight is 40 lb.

General Instrument Corp., Systematics Div., Dept. ED, 3216 W. El Segundo Blvd., Hawthorne, Calif.

Availability: *30 days.*

Insulation-Leakage Tester 475

Breakdown tests and insulation leakage can both be measured by model 8527 test set. The Hypot section provides 0 to 1.5 kv ac, continuously variable, with readout lights to indicate breakdown and leakage current above a preset value. The Vibrotest megommeter section measures insulation resistance to 50 K.

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

CIRCLE 79 ON READER-SERVICE CARD ▶

unmatched peak in penmanship...

The totally new Brush Recorder Mark 200 made these incredibly crisp tracings. No other recorder in existence can match them. Note the line width. It never varies . . . regardless of writing velocity, regardless of chart speed. The writing mechanism is electrically signaled by the position-seeking "Metrisite" transducer . . . no parts to wear, infinite resolution, verifiable dynamic ½% accuracy. Traces are permanent, high-contrast, reproducible . . . on low cost chart paper. The Mark 200 has but three standard controls . . . attenuator, pen position, chart speed. Such fidelity, simplicity and economy are possible with no other direct writing recorder. Write for details . . . they'll speak for themselves.

brush INSTRUMENTS
DIVISION OF
37TH AND PERKINS CLEVITE CORPORATION CLEVELAND 14, OHIO

TOGGLE SWITCH MODEL 20

PRECISION HIGH FREQUENCY ATTENUATORS

DC TO 500 MEGACYCLES

- 50, 70, or 90 ohm impedance
- High-Frequency, Precision Teflon & Silver Switches
- 1% Carbon Film Resistors ■ Fully Shielded Units
- Up to 101 db ■ Fixed 0 or 10 db insertion loss
- **SWR:** 1.2 : 1 max up to 250 mc
  1.4 : 1 max 250 to 500 mc
- **Min. Insertion*:** 0.1 db at 250 mc; 0.2 db at 500 mc
- **Accuracy:** At Full Attenuation: 0.5 db at 250 mc, 1.2 db from 250 to 500 mc
- **Price:** (Model 20) $79.00 f.o.b. factory
  ($87.00 F.A.S. N. Y.)

*Zero insertion loss (Model 20-0) $75.00 f.o.b. factory

KAY ELECTRIC COMPANY
DEPT. ED-9 • MAPLE AVENUE • PINE BROOK, N. J. • CAPITAL 6-4000

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KAY
ELECTRONIC INSTRUMENTS

Sweeping Oscillators
Frequency Markers
Audio Spectrum Analyzers
Pulse — Pulsed RF Generators
Precision Attenuators
Random Noise Generators

Kilo-Sweeps ®
Rada-Sweeps ®
Ligna-Sweeps ®
Sona-Sweeps ®
Marka-Sweeps ®
Vari-Sweeps ©
Mega-Sweeps ®

CIRCLE 78 ON READER-SERVICE CARD

AC Gear Motors 403

Fractional horse-power ac gear motors are available in hysteresis synchronous and low-slip induction types. Both can be supplied to meet customer requirements, with a torque range of up to 300 oz-in. at 1 rpm in the induction units. Lengths of the units are from 3-1/4 to 6 in.

Ashland Electric Products, Inc., Dept. ED, 32-02 Queens Blvd., Long Island City 1, N. Y.

Feed-Through Capacitors 700

Eyelet feed-through capacitors have an integral form for mounting, eliminating the need for solder preforms in chassis assembly operations. Type 7427 has a center lead, type 7528 has no lead; both have a capacity of 1,000 pf with a 500 wvdc.

Aerovox Corp., Hi-Q Div., Dept. ED, Myrtle Beach, S.C.

Wide Band Oscilloscope 360

Range is dc to 5 mc on oscilloscope model ES-150. Sensitivity is 70 mv per in. for dc and 25 mv rms per in. for ac. Frequency response is down 3 db at 4.5 mc and down 5 db at 5 mc. Rise time is better than 0.08 μsec. Input impedance is 1.5 meg.

Precision Apparatus Co., Inc., Dept. ED, 70-31 84th St., Glendale 27, N. Y.
***Price:** $149.95.*

PULSE POINTERS

NEW PRODUCTS AT NEC

Rigid Coaxial Line 679

For high-power transmissions, this rigid coaxial transmission line is available in either aluminum or copper. The 75-ohm line is 6-1/8 in. in diameter; 50-ohm line comes in different sizes. Straight sections, connectors, elbows, hardware and accessories are available. The line can be pressurized and dehydrated.

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

Price: *$13 per ft.*

See at NEC Show Booth 850.

Ratio Transformer 574

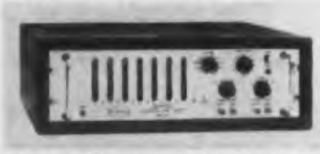
Accuracy of 0.001% is provided by the model RT-60 ratio transformer. Operating range is 50 to 10,000 cps. Unit has high input impedance, low effective series impedance, and low phase shift. Five decades of shifting are provided. Housed in a cast aluminum case, the instrument is made as a bench model, but can be adapted for rack mounting.

Gertsch Products, Inc., Dept. ED, 3211 S. La Cienega Blvd., Los Angeles 16, Calif.

P&A: *$275; from stock.*

See at NEC Show Booth 709.

10-Mc Frequency Counter 572



Accurate within one count at 10-mc frequencies, the model 5370 counter has digital display output. Oscillator stability is 3 parts in 10^7 per week. Sensitivity is 0.2 v rms. Instrument measures frequencies from dc to 10 mc, time intervals from 0.3 μsec to 10^7 sec, periods from 0 to 10 mc, and ratios from 1 to 10^7 from dc to 10 mc. Circuitry is all solid-state.

Beckman Instruments, Berkeley Div., Dept. ED, 2200 Wright Ave., Richmond 3, Calif.

P&A: *$2,750; available in November.*

See at NEC Show Booth 644.

DC Microvoltmeter 663

Inputs from 100 μv to 1000 v full scale are available on the model 127A-L dc microvoltmeter in 15 ranges. Input impedance is 1 to 60 meg. Output is 2.5 v dc at 1 ma. Basic accuracy is 1%. Instrument has individual calibration controls.

Millivac Instruments, Inc., Dept. ED, P. O. Box 997, Schnectady, N. Y.

P&A: *$395; 2 to 4 weeks.*

See at NEC Show Booth 8.

Brakes and Clutches 683

Fractional horsepower brakes and clutches have diameters from 1 to 4 in. Torque ratings are 1.5 to 240 lb-in. Devices operate at cycle rates of 50 per sec.

Warner Electric Brake and Clutch Co., Dept. ED, Beloit, Wis.

See at NEC Show Booth 841.

Contour Switch Knobs 668

Positive finger grip is said to be assured on these series M-1177 and 1178 contour switches. Knobs are made for the firm's Telever line of switches. Red, black, and milky-white knobs are available.

Switchcraft Inc., Dept. ED, 5555 N. Elston Ave., Chicago 30, Ill.

See at NEC Show Booth 537.

NEW PRODUCTS AT NEC

1-Kw Bridge Rectifier 681

Occupying less than 0.25 cu in., the model 7702-2 bridge rectifier provides 1 kw dc power. Device is rated at 2,000 v piv, 750 ma average forward current. Reverse current at 25 C is 1 μa max. Operating ambient temperature is −55 to +150 C. Unit is epoxy encapsulated; circuit is insulated from mounting stud.

Varo Inc., Dept. ED, 2201 Walnut St., Garland, Tex.

See at NEC Show Booth 845-847.

Lever Switches 678

Single and multiple lever switches, series LK and MLK, have two or three positions, locking or non-locking. Contacts are silver or palladium, rated 3 amp, 300 w max. Switch extends 2-3/32 in. deep behind mounting panel. Units are made for talk-listen applications.

Switchcraft, Inc., Dept. ED, 5555 N. Elston Ave., Chicago 30, Ill.

See at NEC Show Booth 537.

Core Memory Systems 571

From 20,480 to 163,840 bit storage capacities with access times of 2.5 to 4 μsec and read-write cycle times of 5 to 10 μsec are obtained with this line of 1-mc S-PAC digital modules, series TCM. Cards measure 19 x 18 x 24-1/2 in. Ambient temperature range is 0 to 50 C.

Computer Control Co., Inc., Dept. ED, 983 Concord St., Framingham, Mass.

***P&A:** about $0.25 per bit; 2 to 4 months.*

See at NEC Show Booth 214.

NEW PRODUCTS AT NEC

Vertical Rack Cabinet Enclosure 566

A variety of colors are available in this series of vertical rack cabinet enclosures. Hardware made especially for the cabinets includes extruded black adonized hinges, handles, pulls, and nylon-protected panel screws. Sides are readily removable from outside. Corners are reinforced. Side struts can be moved or removed for equipment installation. Doors are removable and do not sag.

Equipto Electronics Corp., Dept. ED, 319 N. Webster St., Naperville, Ill.

See at NEC Show Booth 744.

Static Voltage Regulator 565

Nominal output of 115 v is adjustable from 110 to 120 v on the Sta-Vo-Trol static voltage regulator. Rated output is 1 kva. Accuracy is within 0.25% bandwidth. Unit has Zender-diode sensing, remote response and sensing, and has no moving parts.

General Electric Co., Transformer Div., Dept. ED, 100 Woodlawn Ave., Pittsfield, Mass.

See at NEC Show Booth 605-613.

Rotary Wire Stripper 560

Portable rotary wire stripper operates where bench models are inconvenient, as in stripping wires from large panels, air frames, heavy harnesses and multi-conductor cables. Designated model 79, the device strips extruded or wrapped insulations, including Teflon, without nicking the conductor. Complete unit weighs 7-1/2 oz; hand-piece weighs 12 oz.

Carpenter Manufacturing Co., Inc., Dept. ED, P. O. Box 217, DeWitt 14, N. Y.

P&A: $250; two weeks.

See at NEC Show Booth 804.

◀ CIRCLE 85 ON READER-SERVICE CARD

Rack Cabinet Enclosures 567

Vertical rack cabinet enclosures have sloping fronts. Sides are easily removed from outside of cabinet. Side strut supports can be moved or removed to facilitate equipment installation. Slope inclines at 15 deg.

Equipto Electronics Corp., Dept. ED, 319 N. Webster St., Naperville, Ill.

See at NEC Show Booth 744.

NOR Circuit Modules 568

Operating at 1 mc rates, this line of NOR circuit modules includes a dual NOR circuit, a dual power driver, and a converter. Designated models U-301, U-302, and U-303 respectively, the units combine to make flip-flop, one-shot, and multivibrator circuits. Power requirements are ±12 v and −6 v dc, ±5%. Signal amplitude is between −5.5 and −12.6 v.

Engineered Electronics Co., Dept. ED, 1441 E. Chestnut Ave., Santa Ana, Calif.

P&A: $12 to $29; stock to 2 weeks.

See at NEC Show Booth 533 to 535.

Logic Symbol Sticker Kit 563

For use with the firm's modules, this kit contains a complete set of symbol stickers for digital logic circuits. They are drawn in ink, photographically reduced, and printed on acetate overlay with a pressure-sensitive backing. Stickers are useful in preparing engineering drawings and handbooks.

Computer Control Co., Inc., Dept. ED, 983 Concord St., Framingham, Mass.

Availability: from stock.

See at NEC Show Booth 214

Serial Number Markers 562

For marking electronic components, these serial number markers come in 0.06 x 0.2 and 0.12 x 0.2 in. sizes. Markers adhere to component body in ambient temperatures up to 300 C. Special information such as company trademark can also appear on markers. A variety of materials are available.

W. H. Brady Co., Dept. 138, Dept. ED, 727 W. Glendale Ave., Milwaukee 9, Wis.

See at NEC Show Booth 229.

CIRCLE 86 ON READER-SERVICE CARD ▶

NEW PRODUCTS AT NEC

DC Micro-Volt-Ammeter 658

With 1% basic accuracy, the model MV-07B dc micro-volt-ammeter offers recorder output. Full-scale ranges are from 10 μv to 1 kv and 10 $\mu\mu$a to 1 ma. Readings are subject to drifts of 2 μv and 2 $\mu\mu$a.

Millivac Instruments, Dept. ED, P. O. Box 997, Schenectady, N. Y.

***P&A:** $495; 2 to 4 weeks.*

See at NEC Show Booth 8.

Stack Switches 670

Miniature and telephone-relay stack switches have welded silver or palladium contacts. Springs are nickel silver; spacers are paper-base phenolic. Miniature units, called Tini-Stack, are 1-3/4 in. long.

Switchcraft, Inc., Dept. ED, 5555 N. Elston Ave., Chicago 30, Ill.

See at NEC Show Booth 537.

Microwave Antennas 680

Dual-polarized microwave antennas operate from 5,925 to 7,425 mc. Feed can be pressurized; guy wires are not needed. Heated or unheated radomes designed especially for the antennas are available. Diameters of 4, 6, 8, and 10 ft are in stock.

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

***P&A:** $600 to $1,500; from stock.*

See at NEC Show Booth 850.

Induction Voltage Regulator 564

Rated up to 10,000 kva, the Inductrol induction voltage regulators have 97% to 99% efficiency. Standard single-phase units are rated up to 600 v, 240 va; standard three phase units, 600 v, 720 va. Higher ratings are available on special order. Regulators have drift-free control, 100% overload capacity, and compensation for load, power factor, and frequency. There are no brushes or contacts.

General Electric Co., Transformer Div., Dept. ED, 100 Woodlawn Ave., Pittsfield, Mass.

See at NEC Show Booth 605-613.

5-Mc Digital Modules 569

Transistorized flip-flops and other logic circuits are available in modular form. Part of the S-PAC line, the units operate at 5-mc frequencies, and have as many as four flip-flops to a board. Mounted on glass epoxy cards, 4-1/2 x 7 in., the circuits plug into the firm's S-BLOC mounting chassis. Modules made to military specifications are available on special order.

Computer Control Co., Inc., Dept. ED, 983 Concord St., Framingham, Mass.

***Availability:** 6 to 8 weeks.*

See at NEC Show Booth 214.

Frequency Standards 561

Transistorized oscillator is combined with a tuning-fork resonator in these frequency standards, series 300. Output frequencies are from 400 to 3,000 cps, accurate to 0.05% from −55 to +85 C, to 0.01% from 0 to +85 C. No oven is required at these temperatures. Output is 0.5 v ptp sine-wave or 15 v ptp square wave. Units measure 1-17/64 x 1-17/64 x 1-3/4 in. and weigh less than 2.9 oz.

Melpar, Inc., Special Products Div., Dept. ED, 3000 Arlington Blvd., Falls Church, Va.

***Price:** $91 for 50 to 100.*

See at NEC Show Booth 143.

CIRCLE 773 ON READER-SERVICE CARD ▶

MICROMINIATURE MULTI-PIN CONNECTORS

Visualize 61 contacts in the diameter of a dime . . . think of slashing connector weight requirements by 33% . . . estimate the dollar savings in time and inventory of a connector with complete interchangeability of parts. This unique combination of advantages—and more—are built-in features of Microdot's new multi-pins.

In airborne and ground support applications where size, weight and reliability are vital factors, Microdot's unique new multi-pin connector stands alone. Available in three shell sizes and a variety of mounting versions, these rugged connectors are adaptable to a wide range of specific applications (you specify from a wide variety of standard, interchangeable multi-pin component parts to arrive at a connector tailored to your specific application).

Inserts are available in a variety of straight power, straight coaxial, and power-coaxial layouts. Power contacts are interchangeable without changing inserts, allowing hermaphroditic contact arrangements (a mixture of male and female contacts within the same plug or receptacle, allowing hot leads to both plug and receptacle). Closed entry, pure coin silver socket contacts allow heavy currents with low temperature rise. Contact resistance is almost nil. Write today for detailed descriptive literature, Bulletin MP-O.

SIZE DESIGNATION	PLUG O.D.	NO. OF COAXIAL CONTACTS	NO. OF POWER CONTACTS
A	⅞"	up to 7	up to 19
B	1⅛"	up to 12	up to 37
C	1⅜"	up to 19	up to 61

Microdot Multi-Pins are available in disassembled "kit" form or, if you prefer, factory assembled with Microdot cable.

MICRODOT INC.

220 Pasadena Ave / South Pasadena, Calif.

NEW PRODUCTS AT NEC

Switch for Shock Environments 677

Actuator is locked in switching position in the Shock-Lock Telever switch. Knob must be twisted to lock or unlock switch and a plunger must be pushed to move actuator. Switch cannot be accidently switched despite shock, vibration, or fatigue.

Switchcraft Inc., Dept. ED, 5555 N. Elston Ave., Chicago 30, Ill.

See at NEC Show Booth 537.

Modern-Styled Meters 591

With 4-1/2 in. scales, the model 2041 Aristocrat meters have modern styling. Arc is 100 deg. Mountings have either 2, 3, or 4 studs. Mechanisms are available with self-shielded core magnets or with external magnets. Normal accuracy is 2%. Dc sensitivity is as low as 20 μa; rectifier-type ac units are also available.

Sun Electric Co., Dept. ED, 6323 Avondale Ave., Chicago 31, Ill.

***P&A:** $7.90 up; stock in November.*

See at NEC Show Booth 612.

Tuning Forks 656

No oven is needed with these miniature tuning forks. Accuracy is within ±0.05% over a temperature range of −55 to +85 C, and with-

in ±0.01% from 0 to +85 C. Frequencies from 400 to 3,000 cps are available. Resonating element is of an invar-type alloy, supported at a nodal point. Shock and vibration are withstood; output is sinusoidal; starting time is less than 7 sec. Units measure 1-17/64 x 1-17/64 x 1-3/4 in. and weigh 2.6 oz.

Special Products Div., Melpar, Inc., Dept. ED, 3000 Arlington Blvd., Falls Church, Va.
Price: *$53 for 50 to 100.*
See at NEC Show Booth 143.

Low-Noise Amplifier 657

Gain of 10 to 80 db ±10 db is selectable in 10-db steps. Model VS-68A low-noise amplifier uses both transistors and vacuum tubes. It has two 6-v internal dry cells and uses an external 12-v battery for power. Frequency response is 3 db down at 2 cps and 180 kc. Output impedance is less than 2 K, with 0.1 v maximum rms output. Input impedance is 10 K and 10 meg. Distortion is 1% at 50 mv ptp, 2.5% at 100 mv ptp.

Millivac Instruments, Inc., Dept. ED, P. O. Box 997, Schenectady, N. Y.
P&A: *$495; 2 to 4 weeks.*
See at NEC Show Booth 8.

Retractile Coil Cords 573

Extending to 25 ft from 48 in. retracted length, these retractile coil cords are made for communication cord and test lead wire. Shorter lengths are available. Conductors can be individually shielded or pigtailed. Jackets, neoprene, withstand constant use and resist oil and weather damage.

Alpha Wire Corp., Dept. ED, 200 Varick St., New York 14, N. Y.
See at NEC Show Booth 337.

NEW PRODUCTS AT NEC

Direct-Reading Ohmmeter 661

Accurate to 1% over the entire scale, the model MV-279B ohmmeter has 14 full-scale ranges from 1 ohm to 2.5 meg, each with an individual calibration control. Measurement power source is a 1.4-v mercury cell, operating at constant current.

Millivac Instruments, Dept. ED, P. O. Box 997, Schnectady, N. Y.
P&A: $465; 2 to 4 weeks.
See at NEC Show Booth 8.

Rotary Seal 575

Hermetically sealed rotary seal is made for precision potentiometers. Back-lash is 0.05 deg at 1 oz-in. applied torque load. Maximum torque to turn shaft is 0.5 oz. Case measures 1/2 in. OD x 1/2 in. long. Operating speed is 100 rpm; life is estimated at 250,000 revolutions continuous. Device is constructed of stainless steel, and withstands 35-g vibration from 20 to 2,000 cps.

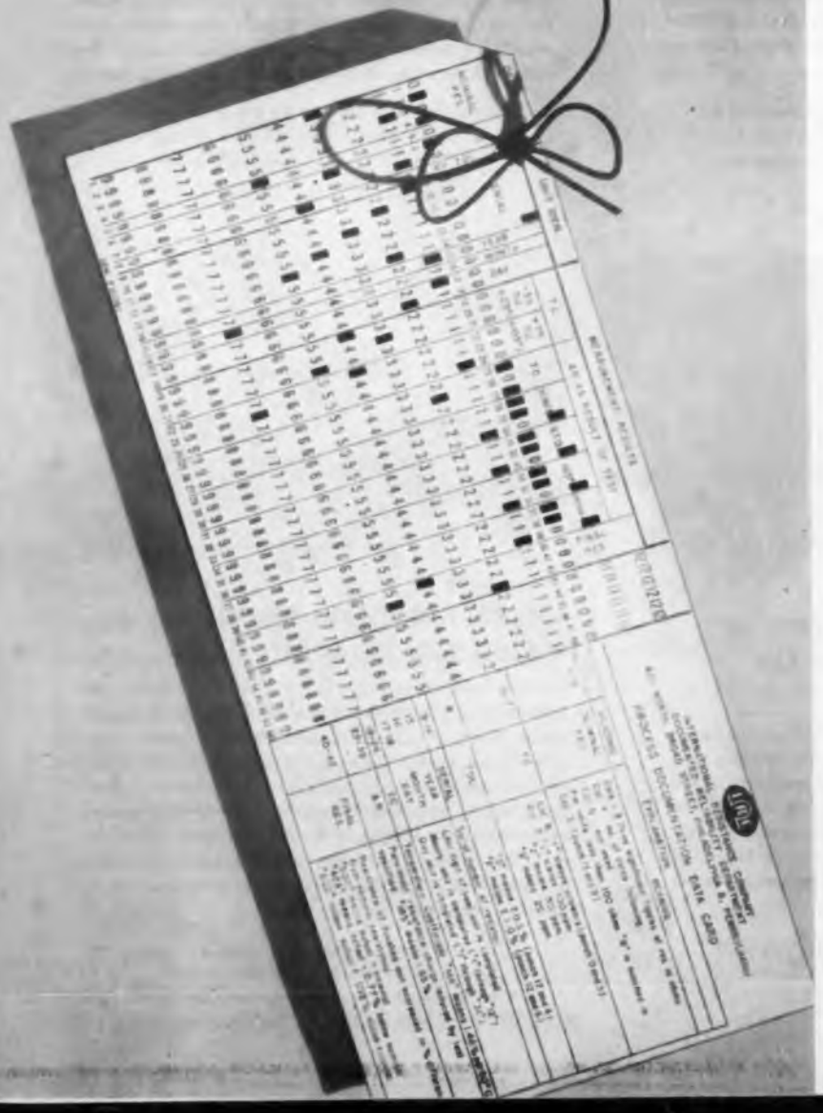
Mechtronics Corp., Dept. ED, 11431 Joanne Place, Culver City, Calif.
P&A: $200 each in quantities of 100; 30 days.
See at NEC Show Booth 721.

COMPONENT RELIABILITY

if it's news, expect it first from IRC

Now available...
resistor reliability
developed for MINUTEMAN

DOCUMENTED RELIABILITY



XLT resistor developed for Minuteman missile

XLT offers you proven reliability

IRC's new subminiature, hermetically sealed, evaporated metal film resistor provides DOCUMENTED RELIABILITY in the form of an individual punched data card carrying the complete production history of each unit.

Every control, guidance and computer system can now benefit by the 99.9996% resistor reliability developed for MINUTEMAN. Quantity production above Minuteman requirements is now available for other applications. Type XLT is rated 1/8th watt at 125°C.

Send for new brochure, "Resistors with Documented Reliability." International Resistance Company, Documented Reliability Dept., 401 North Broad Street, Philadelphia 8, Pa.

IRC

When Reliability Counts Most

NEW PRODUCTS AT NEC

Modular Power Supplies 682

Magnetic-amplifier regulated power supplies, called Power-Bloc modules, have ratings from 1 v, 10 amp to 30 v, 0.8 amp. The magnetic amplifier is used to balance a bridge rectifier network, said to produce considerably faster response than conventional magnetic-amplifier supplies. Modules, epoxy-sealed with aluminum housings, measure as small as 4 x 2 x 5-3/8 in. Units can replace central high-current supplies.

Varo Inc., Dept. ED, 2201 Walnut St., Garland, Tex.

***Price:** $150 to $295.*

See at NEC Show Booth 845-847.

Battery-Operated AC Voltmeter 665

From 5 cps to 1 mc vms voltages are measured by this battery-operated ac voltmeter. Unit is completely transistorized. Full-scale ranges are from 0.001 to 300 v rms. Input impedance is 2 meg. Noise is less than 2% full scale on all except lowest range, where it is 4%. Accuracy is ±3% of full scale from 5 cps to 500 kc and ±5% from 500 kc to 1 mc. Batteries, two mercury cells, have 300-hour lives and can be checked while in the unit. Weight is less than 4-1/2 lb.

Radiation Electronics Co., Dept. ED, 5600 Jarvis Ave., Chicago 48, Ill.

***P&A:** $240; six weeks.*

See at NEC Show Booth 239.

Accuracy Is Our Policy

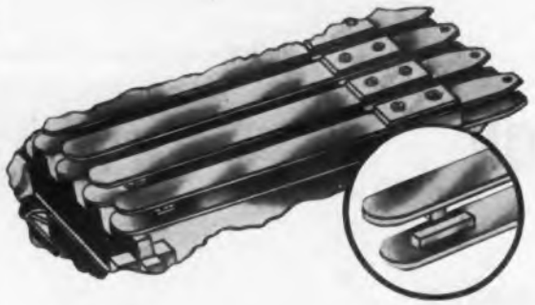
The series number of the rf oscillator manufactured by Trak Electronics Co., Inc., Wilton, Conn., which appeared on p 91 of the June 7 issue of ELECTRONIC DESIGN, should be the SO series rather than the 50 series.

FOR LOW COST PURIFICATION AND DRYING OF HYDROGEN AND OTHER GASES

The Deoxo Catalytic Purifier removes oxygen to less than one part per million from hydrogen gas. It can also be used with other gases such as Nitrogen, Nitrogen-Hydrogen Mixture, Argon, Helium, and Carbon Dioxide. • A combination unit, the Deoxo Dual Puridryer, contains the Deoxo Catalytic Purifier plus an extremely efficient automatically operated drying unit. Removes oxygen to less than 1 PPM from hydrogen and dries the purified gas to a low point of minus 100°F. It will also purify and dry other gases in a similar manner.

INDUSTRIAL EQUIPMENT DIVISION
GAS EQUIPMENT SECTION
113 ASTOR STREET • NEWARK, N. J.

CIRCLE 797 ON READER-SERVICE CARD



ECONOTAPE CONTACTS ARE MOST EFFICIENT FOR ELECTRICAL RELAYS

High reliability welded contacts and contact assemblies available for your relays. Weld strength guaranteed. • Overall contact height held within ±.00025. Assemblies are available in gold, platinum, palladium, silver and their various alloys—both solid and laminated. Single contact usable for various contact ratings, for wet and dry circuitry—assemblies protected for shelf life and handling. Designs for attachment to header by welding or brazing. Complete electrical and mechanical design services available.

D. E. MAKEPEACE DIVISION
PINE & DUNHAM STREET • ATTLEBORO, MASS.

CIRCLE 799 ON READER-SERVICE CARD

LOOK TO AMERSIL FOR ALL HIGH PURITY FUSED QUARTZ REQUIREMENTS

Amersil manufactures and fabricates high purity fused quartz for ultraviolet transmission application, laboratory ware and production equipment. These products include standard apparatus, plain tubing in many intricate fabrications, crucibles, trays, cylindrical containers and piping in a full range of sizes up to 25" in diameter. Ingots and plates are available in general commercial quality as well as in special optical grades. Amersil engineers are also prepared to assist in developing fused quartz and silica equipment for special requirements.

AMERSIL QUARTZ DIVISION
685 RAMSEY AVENUE • HILLSIDE, N. J.

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Please send literature as indicated below, addressed to my attention:

☐ Deoxo Purifier—Puridryer ☐ Econotape

☐ High Diffusion Purifier ☐ Thermometal

☐ Fused Quartz ☐ Nitroneal Generator

☐ Hermach-Engelhard Volt-Ammeters

NAME .....

TITLE .....

FIRM .....

STREET .....

CITY ..... ZONE ..... STATE .....

DC Micro-Micro-Ammeter 664

In twenty ranges the model 111A-L dc micro-micro-ammeter covers 100 $\mu\mu$a to 250 ma full scale. Shunt-resistance ranges from 1 meg to 0.004 ohm. Output is 2.5 v, 1 ma dc. Basic accuracy is 1%. Voltage drop is about 1 mv. Instrument has individual calibration controls.

Millivac Instruments, Inc., Dept. ED, P. O. Box 997, Schnectady, N. Y.

P&A: *$420; 2 to 4 weeks.*

See at NEC Show Booth 8.

Modern-Styled Meters 666

Accurate to 2%, the Gem Line of meters is modernly styled in 2-1/2 and 3-1/2 in. cases. Designated models 2821 and 2831, the meters have shock-resistant movements, self-shielded core magnets, and anti-static acrylic covers. Standard dc and rectifier-type ac meters are available.

Sun Electric Corp., Dept. ED, 6323 Avondale Ave., Chicago 31, Ill.

P&A: *$5.06 and up; stock.*

See at NEC Show Booth 612.

Acoustic Serial Memory 570

Stores 1600 bits at 16 mc. Digital serial memory with pulse delays ranging from 20 to 100 μsec at operating frequencies of 8 to 16 mc is available in a compact plug-in package. Designated type SM-40, the unit is self-contained and compatible with the firm's H-PAC digital modules. Delay line, fused silica, has a temperature coefficient of ±2 ppm per C max, requiring no temperature compensation below 35 C.

Computer Control Co., Inc., Dept. ED, 983 Concord St., Framingham, Mass.

P&A: *$997; 6 to 8 weeks.*

See at NEC Show Booth 214.

THE WEDGE-ACTION MARK II RELAY

...Strong Link to Reliability

No longer must your design make allowances for unreliable relays. Use the Mark II relay with complete confidence. Shock it with 100 G's . . . freeze it at —65° C or roast it at 200° C . . . give it 30 G's vibration from 5 to 2000 cps . . . or switch it from dry circuit levels to 2 amps.

The Mark II can take such punishment because of its exclusive contact action. The moving contact slides with a wedge action . . . it cleans itself . . . and the increasing pressure during overtravel virtually eliminates contact bounce, chatter and other relay problems.

Make the relay the strong link in your system . . . specify the Mark II. Literature now available.

ELECTRO-TEC CORP.

Dimensions: 1-7/8 x 1-3/16 inches

TWX-032-08-01 CApital 8-1500

West Caldwell, N. J.
Blacksburg, Va.—Ormond Beach, Fla.

MODELS AVAILABLE AT COMPETITIVE PRICES

This equipment is manufactured under exclusive license in ten western states by PACIFIC SCIENTIFIC COMPANY, P.O. Box 22019, Los Angeles, California

CIRCLE 92 ON READER-SERVICE CARD

NEW PRODUCTS

Voltage-Regulator Diodes 486

Silicon Zener voltage-regulator diodes have nearly a 90-deg Zener response and low dynamic resistance. JEDEC type 1N3000 diodes, rated at 1 w, need no heat sink and dissipate maximum power to 25 C. JEDEC type 1N2900 diodes, rated at 10 w, for chassis or cooling-fin assembly, dissipate maximum power to 55 C.

Fansteel Metallurgical Corp., Rectifier-Capacitor Div., Dept. ED, N. Chicago, Ill.
Availability: *stock.*

Video Amplifier 512

With four signal outputs, model TDA2 transistorized video-pulse distribution amplifier is interchangeable with tube-type amplifiers without alteration of existing cables. It has its own power supply and draws 4 w at 115 v. Input impedance is 75 ohms; outputs are also terminated at 75 ohms.

International Nuclear Corp., Dept. ED, 501 Elysian Fields, Nashville 11, Tenn.

Miniature Recorder 513

Size is 3-1/16 x 5-5/8 x 1-1/16 in. for this instrument that is designated Amprobe Recorder. Unit will accommodate any signal that can be converted to an equivalent electrical signal. Paper feeds at speeds up to 15 in. per hr. It is available in a number of versions, each in several ranges.

Amprobe Instrument Corp., Dept. ED, 630 Merrick Road, Lynbrook, N. Y.

Magnetic-Field Detector 538

DC magnetic fields as low as 1/4 gauss can be measured by model 501 detector. Based on the "Hall-Effect" principle and utilizing high-gain Siemens Hall generators, the unit operates without amplifiers. It provides a center to full scale deflection of 0 to 5 gauss. Power is supplied by only one mercury cell, resulting in compactness.

Halltest Div., Instrument Systems Corp., Dept. ED, 129-07 18th Ave., College Point, N. Y.

Battery Charger 535

Automatic shutoff and cycling mode are incorporated in model 2-271 transistorized universal battery charger. It can charge from one to 32 battery cells (total range, 0 to 50 v) at a constant current adjustable from 0.1 to 10 amp. Batteries can be accurately charged at sites far removed from the charger.

Electro Development Corp., Dept. ED, 4530 Union Bay Place N.E., Seattle 5, Wash.

Spark Gap 522

Peak currents of over 10,000 amp can be handled by the triggered spark gap type GP-15. Unit is ceramic-metal with 70 kv hold-off voltage. Triggering is accomplished by a pulse of 25 kv. Delay time is 0.5 μsec at 80% of maximum hold-off voltage. No filament voltage is required.

Edgerton, Germeshausen & Grier, Inc., Dept. ED, 160 Brookline Ave., Boston 15, Mass.

CIRCLE 94 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Galvanometer Protector 698

Coil burn-out of the firm's magnetically damped galvonometers is prevented by this protector device. A replaceable insert permits repeated use of the device. Insertion resistance of the unit is 4 ohms nominal at 75 F. Phase shift is 1 deg max from dc to 10 kc. With the input open circuited and the output terminated in a 27 ohm load, the protector does not generate more than 1 μv when subjected to an environment where the temperature is changing at the rate of 1.8 F per sec between 0 and 150 F.

Consolidated Electrodynamics Corp., Dept. ED, 360 Sierra Madre Villa, Pasadena, Calif.

Contact Terminals 387

Wire-wrap terminals, series FD-900, are for both single and double sided printed-circuit boards. Units have glass-reinforced dielectric and gold-plated beryllium-copper contacts. Terminals accept up to four 20-gage wires, each wrapped five times.

Methode Electronics, Inc., Dept. ED, 7447 W. Wilson Ave., Chicago 31, Ill.

Fiber Optic Tube 699

Fiber optic cathode ray tubes print recording directly from the tube face without the use of conventional lens systems at speeds up to 50 times faster than possible with conventional systems. Model SC-3303, electrostatically focused and deflected, is for the experimenter who wishes to determine the advantages of fiber optics; model SC-3304, electromagnetically deflected and focused, is for small spot size. Active fiber optic area is 2-3/4 x 1/4 in., composed of one mil fibers on one mil centers.

American Optical Co., Dept. ED, Southbridge, Mass.

***P&A:** SC-3303, $795, SC-3304, $995; from stock, Oct. 1, 1961.*

Machine-Tool Control 503

A measuring system called the Moire Fringe Measuring System, is designed for continuous-path control of machine tools and can also be used to coordinate machine tool tables. Its essential element is a length of optical diffraction grating. Measurements are in units of 0.001 to 0.00005 in.

Ferranti Electronics Inc., Dept. ED, Industrial Park No. 1, Plainview, L. I., N. Y.

Availability: *made to order.*

Straight Filament Lamp 697

Ribbon type filament used in this lamp results in a gain of directional candlepower at no increase in wattage. The filament is spring tensioned and remains straight during operation, permitting precise location with reference to the surface to be illuminated. It is particularly useful in punched card readout devices.

Chicago Miniature Lamp Works, Dept. ED, 1500 N. Ogden Ave., Chicago 10, Ill.

Pulse Switches 494

Ratings are 2 to 10 amp for standard transistorized pulse switches. Pulse repetition rates are from 2 to 1,000 cps; duty cycles are from 10% to 80%. Functions generated include automatic cycling, triggered pulsing, timing control and pre-coded pulsing. Special units can be made to order.

Applied Magnetics Corp., Dept. ED, 1407 Norman Firestone Road, Goleta, Calif.

Availability: *stock.*

MISSILES

Sparrow
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LaCrosse
Nike Hercules
Nike Ajax
Bomarc
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Polaris
Mace
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Titan
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AIRCRAFT

F-102
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B-58
B-70
A3J
F4H
S2F-1
F11F

the world's most accurate and reliable

precision potentiometer

The mirror-smooth conductive film resistance element, produced by advanced solid-state techniques, mated with precious metal multi-fingered wipers and all-welded precision construction results in:

- INFINITE RESOLUTION
- LINEAR AND NON-LINEAR OUTPUTS TO 0.01%
- MICROVOLT OPERATIONAL NOISE
- LIFE GREATER THAN 30 MILLION REVOLUTIONS

LINEAR AND ROTARY POTENTIOMETERS IN ALL SIZES AND SHAPES. WRITE FOR FREE CATALOG

COMPUTER INSTRUMENTS CORPORATION
92 MADISON AVENUE • HEMPSTEAD, L. I., NEW YORK

first in film pots

CIC

AVAILABLE FROM STOCK!

C. I. C.
PRECISION FILM POTS

You can have any of these precision film pots on their way to you within hours. No need to wait for "custom" pots.

LINEAR SINGLE TURN FILM POTENTIOMETERS

Diameter	Resistance	Linearity
1/2"	1K	± .5%
	10K	± .5%
	50K	± .5%
7/8"	1K	± .5%
	10K	± .5%
	50K	± .5%
	1K	± .25%
	10K	± .25%
	50K	± .25%
1-3/32"	1K	± .5%
	10K	± .5%
	50K	± .5%
	1K	± .25%
	10K	± .25%
	50K	± .25%
2"	5K	± .25%
	20K	± .25%
	50K	± .25%
	5K	± .1%
	20K	± .1%
	50K	± .1%
3"	5K	± .1%
	20K	± .1%
	50K	± .1%
	5K	± .05%
	20K	± .05%
	50K	± .05%

SINE-COSINE SINGLE TURN FILM POTENTIOMETERS

Diameter	Resistance	Conformity
1-3/32"	10K	± .75%
	20K	± .75%
2"	10K	± .25%
	20K	± .25%
3"	10K	± .15%
	20K	± .15%

LINEAR MOTION FILM POTENTIOMETERS

Size	Resistance	Stroke	Linearity
1" Sq.	10K	1" Stroke	± .5%
	20K	1" Stroke	± .5%
	10K	2" Stroke	± .25%
	20K	2" Stroke	± .25%
	10K	3" Stroke	± .1%
	20K	3" Stroke	± .1%

WRITE OR CALL IN YOUR ORDER! POTENTIOMETERS WILL BE IN YOUR PLANT WITHIN 24 HOURS!

FIRST IN FILM POTS

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COMPUTER INSTRUMENTS CORPORATION
92 MADISON AVE., HEMPSTEAD, L. I., N. Y.

CIRCLE 101 ON READER-SERVICE CARD

◀ CIRCLE 102 ON READER-SERVICE CARD

NEW PRODUCTS

Induction Generator 624

The equivalent of 50 kw can be induced into a square inch of surface by the Thermonic dual frequency induction generator. Shallow depth penetration at normal operating frequencies of 5 to 8 mc permits efficient coupling of high power to small diameters. Output control of all frequencies is by saturable reactor.

Induction Heating Corp., Dept. ED, 181 Wythe Ave., Brooklyn 11, N. Y.

Photoelectric Reader 510

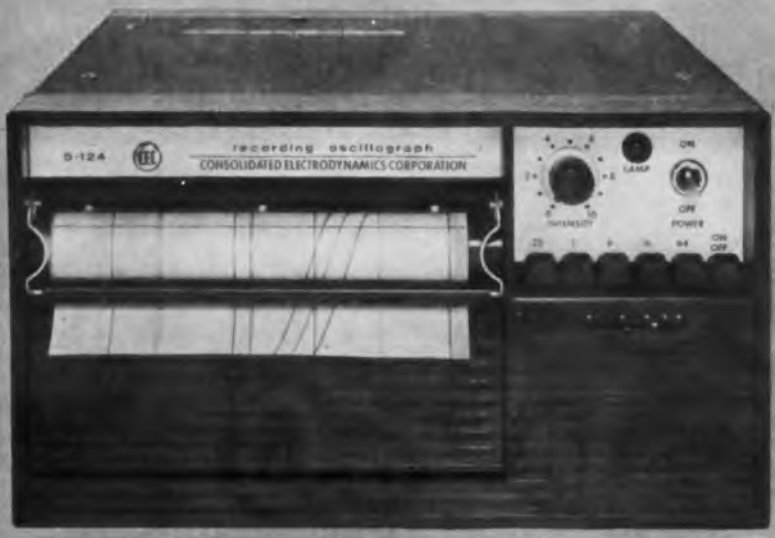
Single-package photoelectric reader model 200 is for applications such as position control, cueing, sorting and inspecting by number shade, color and size. The lamp and photocell are separated by an opaque shield which optically divides the lens. Control units can also be furnished.

Melpar, Inc., Special Products Div., Dept. ED, Falls Church, Va.

Wideband Converter 701

The VLF-1 Caliverter, a vlf to hf wideband converter provides reception of vlf signals on a standard hf communications receiver. Transistor circuitry and Zener-regulated ac supply are contained in a basic 6-1/2 x 3 x 4 in. enclosure. Sensitivity is less than 0.1 μv, and output is at 5.000 mc plus the vlf frequency.

Aerospace Research, Inc., Dept. ED, 94 Massachusetts Ave., Cambridge 39, Mass.
***P&A:** $269.50; from stock.*



Inside this portable recording oscillograph...

A FOCUSED PRECISION OPTICAL SYSTEM TO ASSURE HIGHEST TRACE RESOLUTION

The high-efficiency optical system of CEC's 5-124 Recording Oscillograph concentrates more high actinic light on the record... permits a writing speed of 50,000 ips with trace widths of 0.010" or less.

Optics are specially treated for higher light transmissibility. This means "big" oscillograph capability in a portable, low-cost instrument. The 5-124 easily records and resolves phenomena occurring in intervals as short as 500 microseconds... boasts 18-channel capacity... delivers ready-to-read print-out records that eliminate processing problems.

Among the 5-124's standard features are pushbutton control, intensity control, unexposed footage indicator, individual input connectors and automatically regulated galvanometer lamp circuit. These optional features are available: grid lines (1/10" or mm), trace identification and numbering, full-width timing lines and galvanometer block heaters.

For complete information, call your nearest CEC sales and service office or write for Bulletin CEC 5124-X19.

Data Recorders Division CEC

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

Bell & Howell · POWER PRODUCTS THROUGH IMAGINATION

NEW PRODUCTS

Storage Capacitors 520

Discharge is as low as 1 μsec. Designated as HI-PAK, the units have near zero self-inductance. Standard designs are available in metal housings and in a polyester wrap, resin filled fabrication.

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

Tungsten-Rhenium Alloys 438

In wire and strip form. A tungsten-26% rhenium alloy can be produced in wire sizes as fine as 0.0005 in. in diameter and in continuous lengths of over 2,000 ft. Physical properties include very high tensile strength at high temperatures, excellent electrical resistivity and a melting point of about 5,800 F.

Hoskins Manufacturing Co., Dept. ED, 4445 Lawton Ave., Detroit 8, Mich.

Microvolt Level Relay 531

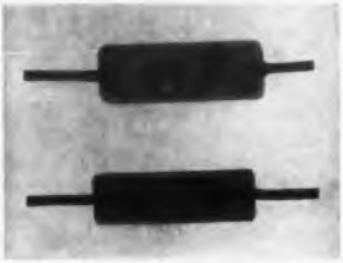
Reliability under extreme military and commercial environments is claimed for the 3PDT Micro-Scan relay for sampling, multiplexing, time-sharing, and control circuiting. The 3PDT permits

complete switching of low-level two-wire transducer data.

James Electronics, Inc., Dept. ED, 4050 N. Rockwell St., Chicago 18, Ill.

P&A: *$30 to $40; samples from stock.*

Epoxy Molded Resistors 524



Ratings from 1/10 to 1 w are available for a new series of epoxy moulded carbon and metal film resistors. Units exceed all requirements of MIL-R-10509D, characteristics B, D and F for the carbon film, and C and E for the metal film. Resistors maintain stability without change in characteristics in shock tests from −60 to +365 F.

Key Resistor Corp., Dept. ED, 321 W. Redondo Beach Blvd., Gardena, Calif.

Availability: *30 days.*

Precision Limit Stop 530

Settings from 0 to 100 turns are possible in a precision limit stop only 7/8 in. in length. Hardened pins that make radial contact allow for precise stops without binding. Impact speed is 1/5 of the imput speed.

Dynamic Gear Co., Dept. ED, Amityville, L. I., N. Y.

Cary Electrometers measure insulation resistance of 10^{15} ohms at potentials of one volt or less with ±1% accuracy

Provide fast accurate leakage measurements; eliminate instrument loading of the test circuit

In addition to measuring large resistance values Cary Electrometers are used for measuring charging phenomena, hysteresis and photo effects of semi-conductors and insulating materials. Applications include air ionization studies, measurement of ion currents in mass spectrometry, radioactivity measurements of solids, liquids and gases and Hall effect studies.

Cary Electrometers detect currents as small as 10^{-17} amperes; charges to 6×10^{-16} coulombs; and voltages as low as 20 microvolts.

High stability (less than 5×10^{-17} amperes steady drift), high accuracy (±0.25% using a precision potentiometer), and operation independent of changes in vacuum tube and component characteristics are just a few of the features contributing to the superior performance of Cary Electrometers.

Choose from several models: MODEL 31 for measuring currents from grounded sources and voltages from ungrounded sources; MODEL 31V for voltage measurements from grounded sources; MODEL 31-31V for measuring voltage or current from grounded sources.

Cary INSTRUMENTS

Additional information on Cary Electrometers and Accessories is yours for the asking. Write for data file M14-91

Electrometers • UV—Visible—Near IR and Raman Spectrophotometers

APPLIED PHYSICS CORPORATION • 2724 So. Peck Rd., Monrovia, Calif.

NEW PRODUCTS

Infrared-Detector Tester 511

For space and satellite programs. The infrared-detector production tester is for large-volume production testing of multi-element, infrared-sensitive photoconductor arrays in guidance and surveillance. It records signal, noise, noise-to-signal ratio, cell current, cell voltage and other parameters.

Infrared Industries, Inc., Western Div., Dept. ED, Santa Barbara, Calif.
***P&A:** $180,000; 90 to 120 days.*

Bi-Metal Thermostat 506

Fixed-setting thermostat model MS has single-pole, single-wire controls. Contacts open with a rise in temperature. Range is 70 to 600 F. It has a ceramic body, push-on lugs and fine silver contacts.

American Thermostat Corp., Dept. ED, South Cairo, N. Y.

Micro-Micro Ammeter 485

Low-drift, micro-micro ammeter model R660 has a highly stable, temperature-compensated, transistorized amplifier with an electrometer-tube input arranged to produce almost 100% feedback. A total of 20 ranges cover from 3 x 10^{-3} to 1 x 10^{-12} amp. Drift is less than ±2% of full scale per week after an initial warm-up of 10 min.

Radiation Technology, Inc., Dept. ED, Atlanta, Ga.

CIRCLE 103 ON READER-SERVICE CARD ▶

Centralab®

introduces

four styles of

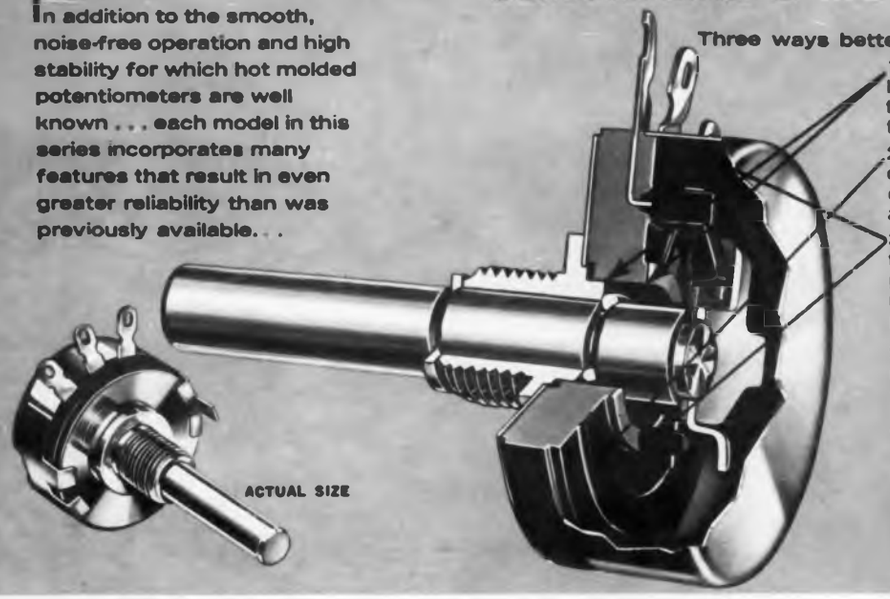
HOT MOLDED CARBON POTENTIOMETERS

For smooth, noise free operation and high stability . . . The widest selection anywhere . . . Designed to meet MIL-R-94 environmental and test requirements

Centralab . . . producer of carbon potentiometers for over 35 years

CENTRALAB'S MODEL A (RV4 Style)

In addition to the smooth, noise-free operation and high stability for which hot molded potentiometers are well known . . . each model in this series incorporates many features that result in even greater reliability than was previously available. . .



Three ways better than other hot molded units

1. Greatly increased high voltage capability, due to the wide clearance between the bushing and the collector track.
2. Greater freedom from contamination of dirt, carbon particles and sealing compounds, due to the elevated resistance track construction.
3. Exceptionally long noise free operation that actually improves with use, provided by the carbon composition material of which both the collector and pick-off brushes are constructed.

SPECIFICATIONS:

RATING: 2 watts at 70° C.

SIZE: 1-3/32" diameter, 37/64" deep from mounting surface.

CONSTRUCTION: Completely enclosed. All metallic parts are non-magnetic and corrosion resistant. Available in tandem, triple or dual concentric construction.

ROTATION: 312° ±3°.

TORQUE: 1.0 to 6.0 ounce inches

RESISTANCES: Linear taper, 50 ohms to 5 MEG. Log taper, 100 ohms to 2.5 MEG.

MODEL N

This intermediate size potentiometer has never before been offered. Rated at ¾ watt, the Model "N" can replace 2 watt units in many military and commercial applications where size is important.

A flush resistance track is protected against contamination by the raised rim of the insulating base. Although small in size, the model "N" also has carbon composition pick up and collector brushes for long noise-free operation.

The one-piece metal case and bushing is spun over the molded insulating base to provide a near-perfect seal. Triple shaft seals and water-tight panel seals can be supplied.

SPECIFICATIONS:

RATING: 3/4 watt at 70° C.

SIZE: 23/32" diameter, 1/2" deep from mounting surface.

CONSTRUCTION: Completely enclosed. All metallic parts are non-magnetic and corrosion resistant.

ROTATION: 300° ±3°

TORQUE: 5.0 ounce inches average.

RESISTANCES: Linear taper, 50 ohms to 5 MEG. Log taper, 100 ohms to 2.5 MEG.

MODEL P (RV6 Style)

Although much smaller than the Model "N", the Model "P" is rated at ½ watt and is similar in external construction.

The resistance track is hot molded, flush type. An outstanding feature of the Model "P" is the single carbon brush that serves both collector and pick-off purposes. The one-piece aluminum case is spun over the insulating base to provide a near-perfect seal.

This unit meets all applicable military requirements.

SPECIFICATIONS:

RATING: 1/2 watt at 70° C.

SIZE: 1/2" diameter, 15/32" deep from mounting surface.

CONSTRUCTION: Completely enclosed.

ROTATION: 290° ±3°.

TORQUE: 1.5 ounce inches.

RESISTANCES: Linear taper, 100 ohms to 5 MEG. Log taper, 500 ohms to 2.5 MEG.

MODEL T

This unique trimmer resistor, or locking-type trimmer potentiometer, is the only hot molded, single turn unit available on today's market. Rated at ⅓ watt, it has been designed primarily for printed-circuit board applications.

The Model "T" has a positive screw actuated lock and is extremely resistant to shock, vibration and acceleration.

These units can be encapsulated in a rigid resin without damage.

SPECIFICATIONS:

RATING: 1/3 watt at 70° C.

SIZE: 19/32" diameter, 11/32" deep from mounting surface.

CONSTRUCTION: Open (however, rugged construction permits potting of all types).

ROTATION: 300° ±3°.

TORQUE: Locking type.

RESISTANCES: Linear taper, 500 ohms to 5 MEG.

IMMEDIATE DELIVERY FROM STOCK

A full range of values of all four types of Centralab hot molded carbon potentiometers are available in quantity, from stock, through Centralab industrial distributors.

Centralab

THE ELECTRONICS DIVISION OF GLOBE-UNION INC.
900 E. KEEFE AVENUE • MILWAUKEE 1, WISCONSIN
In Canada: Centralab Canada Ltd. P.O. Box 400, Ajax, Ontario

CIRCLE 103 ON READER-SERVICE CARD

DC Power Supply 378

Output is 28 v, 1 amp maximum for power supply model 205A. Unit is for use with the company's line of step-servo components. It is hermetically sealed in a 3 x 4-1/4 x 5 in. can. Unit requires 115 v, 60 cps, 40 w, single phase. The module weighs 6 lb.

Automation Development Corp., Dept. ED, 11824 W. Jefferson Blvd., Culver City, Calif.
P&A: *$99; from stock to four weeks.*

Three-Conductor Plug 388

For polarized applications, this plug has a 0.206 in. diameter shaft. Model S-260 has a plastic handle and screw type terminals; model S-290 has a shielded handle. Sleeve, tip and body are machined from brass and bright nickel plated. Terminals are brass, hot tin-dipped screw-type. Insulation is nylon.

Switchcraft, Inc., Dept. ED, 5555 N. Elston Ave., Chicago 30, Ill.

Solid Tantalum Capacitors 412

Rated at 0.0071 to 0.82 μf. Part of the Tan-TI-Cap line of solid tantalum capacitors, the units are available in 20 or 35-v dc ratings with tolerances of ±10% or ±20%. Case dimensions are 0.125 x 0.250 in. Requirements of MIL-C-26655A are met. Units are made for satellite projects, transceivers and common-carrier systems.

Texas Instruments Inc., Dept. ED, P. O. Box 5012, Dallas 22, Tex.

◀ CIRCLE 103 ON READER-SERVICE CARD

UPI Photo

INSTANT DISCHARGE OF STORED ENERGY

The sting of the *Vespa Crabro* hornet is immediate! Faster yet – in as little as 0.1 microsecond – tough HI-JUL high energy storage capacitors dependably deliver full discharge of stored energy with negligible power loss.

APPLICATIONS–

nuclear systems • explosive initiating circuits • low impedance pulsers • plasma research • radiation • magnetic field generation and controls • explosive forming • welding • photoflash. Designs for customers' special applications are also available.

Unique *cartwheel* construction of rugged HI-JUL capacitors minimizes self-inductance and reduces series resistance to a minor value. Other excellent features: electrode terminations provide low contact resistance, high ringing frequency, maximum Joules (watt-second) per cubic inch and per pound.

Units offered in metal housings and in a recent Dearborn development of economical polyester-wrap, resin-filled fabrication, offering extremely low inductance characteristics previously restricted to metal housings.

WRITE FOR BULLETIN 8-TB-61

Dearborn ELECTRONIC LABORATORIES INC.

P O Box 3431 • Orlando, Florida • TErrace 8-5400

CIRCLE 112 ON READER-SERVICE CARD

NEW PRODUCTS

Horsepower Meter 355

Continuous measurement of shaft horsepower is possible with the Thor power meter. Unit is mounted directly on the shaft and transmits readings to a remote location without wires, slip rings, or other physical connections between rotating equipment and other stationary equipment. Accuracy is within 1%. Unit weighs 3.5 lb.

Unilectron, Inc., Dept. ED, 129 Binney St., Cambridge 42, Mass.

UHV Capacitors 546

For dc filtering, nuclear accelerators, pulse networks, radar and high-voltage test equipment, these uhv capacitors are rectangular, bakelite tubes. Nine ranges cover 50 to 250 kv dc. They can be operated at 60 C for 10,000 hr and may be used to 0 C. Dielectric construction consists of a plastic film and multi-layers of thin kraft paper impregnated with mineral oil.

Corson Electric Manufacturing Corp., Dept. ED, 540 39th St., Union City, N. J.

Heavy Duty Rectifier 351

Oil-immersed, fin-cooled rectifier measures 10 x 12 x 12-1/4 in. Continuous operating current is 5 amp; piv is 50 kv. Maximum power dissipation is 50 kw and maximum ambient operating temperature is 55 C. Unit is made for transmitter power supplies and has radio, radar and loran applications.

North American Electronics, Inc., Dept. ED, 71 Linden St., West Lynn, Mass.

Magnetic Multiplier 441

Accuracy is 1% full scale. Magnetic multiplier model 300AX is for converting the product of two electrical inputs into a single proportional ac output. A dc input from 0 to ±100 μa plus an ac input from 0 to 2.3 v, phase reversing, generates a phase sensitive ac output from 0 to 1.2 v. Unit is operable from 300 to 1,000 cps.

Transmagnetics, Inc., Dept. ED, 40-66 Lawrence St., Flushing 54, N. Y.

***P&A:** $99 and up; 2 to 3 weeks for samples.*

Numerical Control System 433

For machine tools. The point-to-point numerical control system is for boring, drilling and similar machine tool operations that require positioning in one plane. It can be programed to within 0.0001 in. and has full control of acceleration and deceleration. Accuracy is 0.001 in. It is transistorized, modular.

Thompson Ramo Wooldridge Inc., Dept. ED, 455 Sheridan Ave., Michigan City, Ind.

Panel Meters 442

Suspension type panel meters use a short narrow band tightly suspended on special spring terminals to support the coil and its moving counterparts. Instruments are available in 2-1/2, 3-1/2, 4-1/2, 6, 7 and 8 in. case sizes.

Triplett Electrical Instrument Co., Dept. ED, Bluffton, Ohio.

CIRCLE 241, 242 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Miniature Magnetic Modulator 363

For dc-to-ac proportional conversion in servo and control systems, the model 202 magnetic modulator requires 26-v, 400-cps excitation. Unit converts 0 to 30 μa dc into 0 to 0.42 v, 400 cps ac. Load impedance is 10 K. Input current drift is less than 0.3 μa over a -25 to $+105$ C range. Device measures 23/32 x 23/32 x 15/16 in., and is hermetically sealed and potted.

Transmagnetics, Inc., Dept. ED, 40-66 Lawrence St., Flushing 54, N. Y.

P&A: *$70 up; 1 to 2 weeks for samples.*

Telemetry Transmitter 356

For human or machine stress, the Midas, miniature data acquisition system, is an fm/-fm, multi-channel telemetry system. It is capable of sensing and transmitting respiration rate, heartbeat, pressure, strain, acceleration and other phenomena. A three-channel unit measures 1-3/8 x 1-3/8 x 6-1/4 in.

Unilectron, Inc., Dept. ED, 129 Binney St., Cambridge 42, Mass.

Miniature Switchlights 364

Push-button switches are lit by standard panel lamps. Release mechanism is solenoid-activated, permitting devices to be switched off remotely. Contact arrangements up to 4pst and dpdt are available. Units are rated at 28 v dc, 125 v ac, 2 amp. Solenoid coils are available for 6, 12, or 28 v operation.

Pendar, Inc., Dept. ED, 15755 Arminta St., Van Nuys, Calif.

Angular Accelerometer 447

Spin-up acceleration can be monitored with angular accelerometer model 4575. Ranges are available from ±500 to ±1,500 rad per sec². Linearity is within 0.05%; resolution is better than 0.0001% of full scale. Nominal output is ±7.5 v. Weight is 4 oz.

Donner Scientific Co., Dept. ED, Concord, Calif.

***P&A:** $710; 30 days.*

Telemetry Receiver 435

For use at 216 to 260 mc. Said to perform in any known telemetry system, model TMR-2A telemetry receiver meets standard fm-fm and pdb/fm applications as well as pcm/fm requirements for systems using up to 1 million bits per sec. It has a front-panel selectable video bandwidth filter with 12-db per octave roll-off.

Defense Electronics, Inc., Dept. ED, Washington-Rockville Industrial Park, 5451-B Randolph Road, Rockville, Md.

***P&A:** $2,495; 30 to 60 days.*

Brakes and Clutches 444

Torque ratings of 1.5 to 240 lb-in. are available on miniature fractional hp electric brakes, clutches and clutch-brake packages. Diameters of the units range from less than 1 in. to 4 in. Units, useful at up to 50 cps, are made for aircraft components, servos, data equipment, and similar applications.

Warner Electric Brake & Clutch Co., Dept. ED, Beloit, Wis.

CIRCLE 117 ON READER-SERVICE CARD ▶

NEW PRODUCTS

Variable Reluctance Pressure Transducer 381

Error band is 1% on the model A-40-1 variable reluctance pressure transducer. Tolerance is ±2% under any operable environmental conditions. Device has high power output and low output impedance, and can drive meter movements directly.

Astromics Div., Mitchell Camera Corp., Dept. ED, 611 W. Harvard St., Glendale 4, Calif.
***P&A:** $595; 45 days.*

Terminal Headers 368

A variety of shapes is available in this line of molded terminal headers. Headers are molded from a mineral-filled phenolic of high mechanical and dielectric strength. Pins are gold-plated brass. Units come in configurations suitable for transformers, electrolytic capacitors, plug-in modules, tube sockets and other plug-in components.

U. S. Engineering Co., Dept. ED, 13536 Saticoy St., Van Nuys, Calif.

Miniature Connector Kits 366

All components for assembling miniature connectors are provided by these kits. Units can be assembled with 6, 12, or 18 pin contact configurations. Assembly is accomplished by staking sockets and pins in place with tool provided, soldering wires to contacts, and snapping plastic hood into place.

Omega Precision, Inc., Dept. ED, 757 N. Coney Ave., Azusa, Calif.
***P&A:** $50; from stock.*

Vertical Amplifier 443

High-grain amplifier 162D has maximum sensitivity of 5 mv per cm, with 11 other ranges to 20 v per cm. With scope 170A, rise time is less than 10 nsec. Differential input is provided, with 40-db common mode rejection. Isolation between inputs is at least 80 db.

Hewlett-Packard Co., Dept. ED, 1501 Page Mill Road, Palo Alto, Calif.

P&A: *$225; 10 weeks.*

Trimmer Potentiometer 432

Microminiature trimmer potentiometers are rated at 1 w at 50 C, derating to zero at 175 C. Weighing 3/4 g, they have a high-temperature plastic case, wirewound resistance element, moisture-resistant seal and Teflon-insulated lead wires or locked-in terminal pins. Both continuous and clutch-stop models are available.

Techno-Components Corp., Dept. ED, 18232 Parthenia St., Northridge, Calif.

Germanium Transistors 445

Withstand high voltages. Germanium transistors 2N1924, 2N1925 and 2N1926 are rated to 60 v and have a high gain characteristic. Applications include af switching circuits and high-voltage amplifier circuits.

General Electric Co., Kelley Building, Dept. ED, Liverpool, N. Y.

P&A: *$1.25 to $1.65 ea, OEM; stock.*

CIRCLE 120 ON READER-SERVICE CARD ▶

NEW PRODUCTS

Thermocouple 542

Accurate, miniature Monitemp Mark III thermocouple holds heat dissipation to a minimum. A stainless-steel retaining nut, independent of the thermocouple, permits installation without twisting the cable.

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

Instrument Counters 448

Dual bank counter model 4-4-Y-9425-R-AC is made for digital readout applications where plus and minus, right and left, or directional readings are required. Instrument counter model 4-D-9268, single bank, has luminous figures. Torque is 0.3 in. oz; counter is capable of speeds to 1,500 rpm.

Durant Manufacturing Co., Dept. ED, 1929 N. Buffum St., Milwaukee 1, Wis.

Teflon Tubing 545

Meets Mil specs. Extruded Teflon tubing can be furnished to meet exact customer specifications. Compounding of Teflon with metals and other materials for special applications can also be provided.

Timely Technical Products, Inc., Dept. ED, 100 Pine St., Verona, N. J.

Silicon Resins 541

Metal-filled silicon resins, designated Epocast H-1759 systems, are rubber-like materials filled with steel, bronze or lead. Applications include aircraft, electronics, missile, construction, nuclear-radiation shielding and consumer products.

Furane Plastics Inc., Dept. ED, 4516 Brazil St., Los Angeles 39, Calif.

◀ CIRCLE 121 ON READER-SERVICE CARD

Delay Line 430

For air-traffic controls, radar, airborne equipment, and similar applications. Model 52-44 transponder delay line has a delay-to-risetime ratio of 40:1. Impedance is 470 ohms; attenuation is 4 db; temperature range is −55 to +125 C. Dimensions are 1 x 2 x 3 in., and weight is 6 oz.

ESC Electronics Corp., Dept. ED, 534 Bergen Blvd., Palisades Park, N. J.

Rubidium Frequency Standard 446

Accurate to 5 parts in 10^{10}, the model 304-S rubidium frequency standard has a long term stability of 2 parts in 10^{10}. Optical pumping of rubidium at the 6834-mc ground state stabilizes a quartz crystal oscillator at a subharmonic. A synthesizer converts the output to 0.1, 1, and 5 mc. Other frequencies can be produced on special order. Active elements are solid state. Power requirements are 117 v ac or 26 v dc, 27 w.

Clauser Technology Corp., Dept. ED, 3510 Torrance Blvd., Torrance, Calif.

***P&A:** $14,800 each; 90 days.*

Precision Resistors 428

Weldable leads are available on 1% deposited carbon resistors rated at 1/8, 1/4, 1/2, 1 and 2 w in all common resistances. The leads are designed for where high-speed welding is employed instead of the usual soldering techniques.

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

Metal-Cased Thermostat 540

Vibration resistant, with rapid thermal response. Type HS-5300 metal-cased thermostat measures 9/16 in., outside diameter, 37/64 in. high, with normally open or closed contacts. Temperature settings are −65 to +500 F.

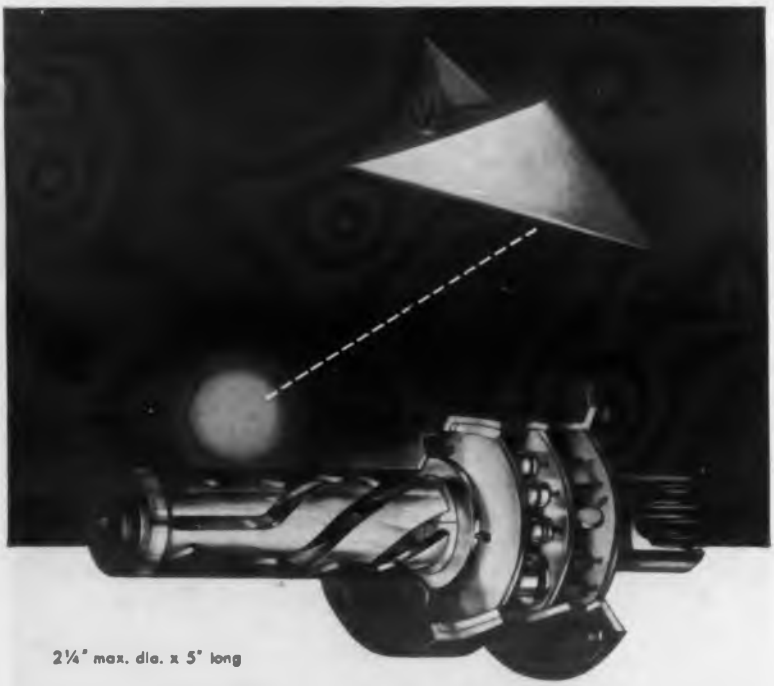
Therm-O-Stats Inc., Dept. ED, P. O. Box 303, Chartley, Mass.

CIRCLE 122 ON READER-SERVICE CARD ▶

ENGINEERING

REPORT

ON BENDIX COMPONENTS



2¼" max. dia. x 5" long

BENDIX SUN SENSOR— RELIABLE REFERENCE FOR SPACE VEHICLE CONTROL

An important current E-P program is to develop components with high accuracy to meet spacecraft control system requirements.

The Bendix Sun Sensor combines a unique optical system with a simple four-section photo detector element. Result: a versatile instrument for many spacecraft control reference problems.

The sensor's signals are approximately proportional over a 2π steradian field of view to the sun's displacement angle with respect to the sensor boresight axis. The signals are also proportional, with a linearity of $\pm 1°$ over a field of view of 15° about the boresight axis. Resolution and tracking accuracy are $\pm 0.05°$, with a detector output signal gradient of 7.5 MV/0.1°.

Of significant advantage to null seeking control systems is the capability of deriving rate signals from the preamplifier output over the entire hemispherical field of view. Because of its highly linear, stable output gradient about null, the unit is also ideal for control systems requiring calibrated displacement signals.

Ask about the Sun Sensor's applications to specific control system functional, environmental and packaging requirements.

Eclipse-Pioneer Division
Teterboro, N. J.

The Bendix Corporation

District Offices: Burbank, and San Francisco, Calif.; Seattle, Wash.; Dayton, Ohio; and Washington, D. C.
Export Sales & Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.

CIRCLE 123 ON READER-SERVICE CARD

NEW PRODUCTS

Transistor Socket and Dissipater 365

For printed circuits, this combination transistor socket and heat dissipator measures 9/16 in. in diameter and 9/16 in. high. Unit can be mounted in larger sinks or soldered to the printed-circuit board. Dissipator is electrically insulated from the transistor base. Pin, turret, and solder-pot terminal styles are available.

Omega Precision, Inc., Dept. ED, 757 N. Coney Ave., Azusa, Calif.

P&A: *$0.75 to $1.25; from stock.*

Insulated Wire 552

Aluminum-oxide film insulation is used with aluminum wire and strip conductors. The flexible thin-film insulation has a melting point of almost 2,000 C, which allows the use of the material at temperatures up to the melting point of the conductor. Standard wire is available in gauges from 10 to 46 AWG; rectangular wire and strip comes in thicknesses from 0.0008 to 0.060 in.

Permaluster, Inc., Dept. ED, 2012 Burbank Blvd., Burbank, Calif.

Automatic Circuit Tester 369

Random access, card-programed automatic circuit tester is used for checking wiring harnesses and electrical assemblies for current continuity and high potential. Unit, designated FACT-RC, has a capacity of 1,200 wire terminations. One IBM card is required for each circuit. The tester can process 72 cards per minute.

Hughes Aircraft Co., El Segundo Div., Dept., ED, P.O. Box 90426, Airport Station, Los Angeles 45, Calif.

P&A: *$34,500; 90 days.*

Displacement Transducer 370

Ranges of ±0.005 to ±0.25 in. are available on this displacement transducer, type 3632-12. Unit operates to 300 F. Teflon-insulated leads are anchored in epoxy resin. Magnetic shield and core are chromium plated.

United Aero Products Corp., Dept. ED, Burlington, N. J.

Availability: *immediate.*

Water-Proof Limit Switch 559

For humid environments. Precision snap-action unit is designed for a minimim life capacity of 1,000,000 cycles and has be actuated 200,000 times with full overtravel under 1 in. head of water wthout leaking. The plunger is made of delrin, and sealed in a neoprene boot. The casing is nylon. Unit is available with wire leads potted in epoxy resin or spade terminals.

Controls Co. of America, Dept. ED, 9555 Soreng Ave., Schiller Park, Ill.

Strain Indicator 377

Providing digital readout, strain gage indicator type 20 has a gage factor range from 1.5 to 4.5. Unit will accommodate most available strain gages in 1-, 2-, or 4-arm networks. The instrument will also work with strain gage transducers, bonded or unbonded. Readings are in ranges from 0 to 5,000 μin. per in. Accuracy of the system is 0.1% of reading or 5 μin.

Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div., Dept. ED, 42 Fourth Ave., Waltham 54, Mass.

NEW PRODUCTS

Beacon Transmitter 372

Made to locate objects at sea, this beacon transmitter has a 2-w output. Unit is tunable from 2,250 to 2,800 kc, uses a crystal oscillator. Transistorized, the device requires 24-v dc power. Pulse or frequency-shift data transmission is possible. Transmitting antenna may be submerged or shorted to ground for five minutes without damage to transmitter.

HRB-Singer Inc., Dept. ED, Science Park, State College, Pa.
P&A: *$150 to 200; 8 weeks.*

Linkage System 547

Bi-directional linkage system, called the Addaverter, samples analog channels, converts to digital and delivers data to the digital-computer memory. It subsequently converts the digital results to analog values and presents this data to the analog computer. It is for use with the Electronics Associates analog computer and the Bendix G-15 digital computer.

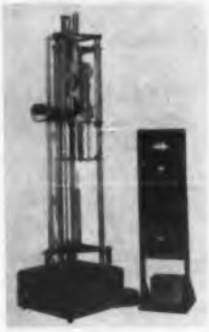
EPSCO, Inc., EPSCO Systems Div., Dept. ED, Cambridge, Mass.

Microminiature Shift Register 367

Made for space vehicles, this modular shift register occupies 1/16 cu in. per bit and weighs 2 g. Units, operating at shift rates up to 250 kc, provide 5-v flat-topped output pulses at switching ratios better than 8 to 1. Devices operate from a single missile battery with low current drain. Units are made for information conversion, buffer storage, and counting. Compatible semiconductor modules are available.

Magnetics Research Co., Inc., Dept. ED, 179 Westmoreland Ave., White Plains, N. Y.
P&A: *$12 to $16; 30 to 45 days.*

Digital Comparators 359



Data from digital measuring instruments is converted into go no-go form by these digital comparators. Model 54 has four digits; model 55 has five. Bipolar data from 0.0001 up to 1,000 are handled by each instrument. Go no-go indication is issued within 10 msec after preset digital limits are exceeded. Units have plug-in board modular construction.

Non-Linear Systems, Inc., Dept. ED, Del Mar, Calif.

P&A: *$2,000 to $2,900; from stock.*

Tantalum Foil Capacitors 421

Rectangular tantalum-foil capacitors type CM are made to customer requirements in a wide variety of models. Typical values for 125 C polar types are 3 to 250 v and 38 to 250,000 μf. For non-polar types at 125 C, capacitances can be from 19 to 200,000 μf. A 1-f unit is housed in a container measuring 4 x 6 x 6-1/2 in.

Tansitor Electronics, Inc., Dept. ED, West Road, Bennington, Vt.

Availability: *made to order.*

Pulse Transformers 383

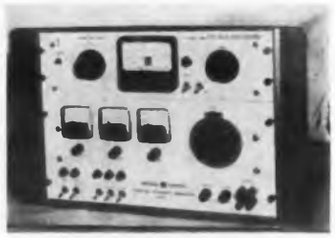
Epoxy transfer molded miniature pulse transformers are available with oriented-grain silicon steel ribbon core units, ferrite toroid cores and ferrite cup cores. Transformer cases have an accuracy of shape to within 10 mils. All units are available in flame-retardant or self-extinguishing epoxies and with weldable leads.

Pulse Engineering Inc., Dept. ED, 560 Robert Ave., Santa Clara, Calif.

P&A: *$5.50 ea; stock to 21 days.*

NEW PRODUCTS

Mass Spectrometer 373



For vacuum analysis, the tube and magnet assembly of this mass spectrometer is made to be baked out at 450 C. Individual mass peaks up to mass 150 can be distinguished. System operates over a total pressure range of 10^{-5} to 10^{-10} mm Hg, and detects partial pressures on the order of 10^{-12} mm Hg. Instrument is portable, weighs less than 40 lb.

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

P&A: *less than $6,000; 60 days.*

Tape Head 420

For monaural recording. Type RH-2 tape head is designed for monaural half-track recording on 1/4-in. tape. Frequency response at a tape speed of 7.5 in. per sec is −10 db at 10,000 cps with an output of 3 mv at 1,000 cps. It can be used at 3-3/4 in. per sec with the frequency response at −15 db at 10,000 cps with an output of 1 mv at 1,000 cps. An erase head is also available.

Sonotone Corp., Dept. ED, Elmsford, N. Y.

P&A: *$10; to OEM.*

Coupling Device 417

For missile and aircraft uses. The coupling device is a quick-connect/disconnect type with environmental protection. A 0.7-lb force can extract the pins. Connection can be made with an angular misalignment of 5 deg between the two surfaces of the coupling. A lateral misalignment of 1/16 in. still permits perfect electrical mating.

Kellett Aircraft Corp., Dept. ED, Willow Grove, Pa.

Push-Type Posts 549

Made of nickel-plated brass. Series 29-100 push-type posts are offered in these three mounting sizes: No. 29-100 for 11/64-in. mounting hole, No. 29-101 for standard banana plug, No. 29-104 for 25/64-in. mounting hole. Teflon insulating washers and special button caps can be furnished for high-temperature applications.

Grayhill Inc., Dept. ED, 575 W. Hillgrove Ave., La Grange, Ill.

P&A: *$0.35 to $0.50; from stock.*

Pressure Transducer 393

Strain-gage pressure transducer model 206 is for sensing and measurement of dynamic pressures as in jet or turbine engines; model 206-1 is for corrosive media pressures; model 206-2 is for measuring air water and other fluids. Output voltage is proportional to pressure applied within ±0.25%.

Taber Instrument Corp., Dept. ED, 107 Goundry St., North Tonawanda, N. Y.

Static Power Transfer 551

Fast response, low noise level and long life are features of the static power bus transfer, which transfers from one 60-cps bus to another in a few milliseconds. It performs the function of bus transfer switches per MIL-S-17773-A. Operation is not affected by relative phase between busses, power factor of load or nonlinear loads.

Vickers, Inc., Electric Products Div., Dept. ED, 1815 Locust St., St. Louis 3, Mo.

Subminiature Solenoids 423

Respond in 1,500 to 2,000 μsec. Subminiature solenoids actuate 1 lb over 0.015 in. with a power input of 20 to 25 w at 3 to 6 v. Units can be furnished for greater power inputs and long periods of pulse-type duty. Applications include clutch actuation, electromechanical control, card sorting and valve actuation.

Marshall Industries, Wahlgren Magnetics, Solenoid Dept., Dept. ED, 1900 Walker Ave., Monrovia, Calif.

simple, low-cost way to increase equipment MTBF

Patented

retrofit with **IERC TR Series Heat-dissipating Electronic Tube Shields** *for increased tube life and equipment reliability!*

The easiest low cost answer for increasing electronic equipment Mean Time Between Failures is to recognize that 70% of equipment downtime is caused by tube failures!

IERC TR shields effectively safeguard tube life up to twelve times longer—automatically eliminate equipment downtime and replacement costs due to tube failures caused by heat. The easy way to meet your MTBF reliability contract requirements is to start with the tubes—it costs so little to make them "TR safe"!

WRITE TODAY FOR IERC TR TECH BULLETIN NO. 1121.

IERC DIVISION

International Electronic Research Corporation
135 West Magnolia Boulevard, Burbank, California

Foreign Manufacturers: Europelec, Paris, France. Garrard Mfg. & Eng. Co., Ltd., Swindon, England

CIRCLE 130 ON READER-SERVICE CARD

NEW PRODUCTS

Industrial Batch Ovens 391

Provide 356 or 600 F maximum temperatures. Having capacities from 16 to 96 cu ft, these industrial batch ovens are for general aging, drying, preheat-tempering, and similar uses. They are equipped with an indicating thermostat. Construction is heavy steel.

Blue M Electric Co., Dept. ED, 138th & Chatham St., Blue Island, Ill.

Computer Diode 556

Therma Bond, a heat-pressure method for permanently affixing the silicon disk adds stability to a new computer diode. The unit provides ultra-fast forward and reverse recovery time for high-speed pulse applications, including computer logic, pulse clamping, gating and locking.

U.S. Semiconducter Products, Dept. ED, Phoenix, Ariz.

Availability: *engineering samples.*

Tape Punch 407

For 5 to 8-channel paper or Mylar-aluminum tape. Model P76 tape punch operates at the rate of 20 characters per sec. A soundproof enclosure of 3/16-in. cast aluminum reduces noise level of punch operation. The tape supply has a capacity of 1,000 ft of tape and tape reels provide for 400 ft.

General Instrument Corp., Systematics Div., Dept. ED, 3216 W. El Segundo Blvd., Hawthorne, Calif.

Availability: *30 days.*

Rectifiers 440

High-voltage rectifiers and full-wave bridge rectifiers. High-voltage types PS2501 through PS2515 cover from 2,000 to 25,000 piv and measure 0.25 x 0.15 in. Bridge types PS2470 through PS2486 cover 2,500 to 20,000 piv; dimensions are from 0.5 x 0.5 x 0.35 to 1.94 x 1.94 x 0.35 in.

Pacific Semiconductors, Inc., Dept. ED, 12955 Chadron Ave., Hawthorne, Calif.

P&A: *$15.30 up and $85 up in quantities of 100; stock.*

Humidity Controller 543

Accuracy is 1% RH throughout the entire relative humidity range at temperatures up to 180 F. The Hygrocon-1 humidity reader and controller incorporates the PCRC electro-humidity transducer as its sensing element. It has five RH ranges. Recorder terminals are available.

Phys-Chemical Research Corp., Dept. ED, 40 E. 12th St., New York 3, N. Y.

P&A: *$750; 4 to 6 weeks.*

Vacuum System 539

Bell-jar vacuum system series 2100 model VSC-20 can be exhausted to 2 x 10^{-5} mm Hg in 30 min and has ultimate pressures in the range of 10^{-6}. It is a self-contained, 32-in., desk-high console for lab use and small-parts production coating in optical, infrared, electronic and semiconductor fields. The operator can view the work and the instruments and manipulate all controls.

Vacuum Specialties, Inc., Dept. ED, 34 Linden St., Somerville, Mass.

Remote Readouts 436

For digital voltmeters. Any number of these remote readouts can be used with a digital voltmeter or other digital-data source. The assembly measures 3-1/2 x 19 x 17-1/2 in. It accepts binary-coded-decimal 8-4-2-1, gives decimal visual readout and supplies binary-coded-decimal and decimal-data outputs.

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

CIRCLE 132 ON READER-SERVICE CARD ➤

meet individual customer's requirements.

The AMPHENOL connector line, on the other hand, offers you the most complete selection of UC-types available from a single manufacturer as well as *Push-On*®, *Quick-Crimp*®, and *Subminax*® connectors.

So, you see, you really don't have to choose between the two. RF Products offers you industry's most complete line of standard coaxial connectors—AMPHENOL—as well as the custom engineered line—*ipc*. Together, they can solve all your connector problems.

You can get full details by writing for Catalog D3 which presents the AMPHENOL line in detail, and Catalog 11 which describes the *ipc* connector line. If you don't find the connector you want in these catalogs, call your nearest RF Products representative. He'll be happy to work with you to develop exactly the connector you need. *Registered Trademark*

RF PRODUCTS | ipc by AMPHENOL

Division of Amphenol-Borg Electronics Corporation • 33 East Franklin St., Danbury, Conn.

NEW PRODUCTS

Servo Drive 379

For digital system application, step servo drive model 622A reverses instantly at speeds up to 200 pps, when used with the company's standard step-servo controllers and pulse sources. Unit requires 28 v dc, 1 amp maximum. Stall torque at 25 C, is 5 in.-oz.

Automation Development Corp., Dept. ED, 11824 W. Jefferson Blvd., Culver City, Calif. ***P&A:** $142; from stock to six weeks.*

Decimal Indicators 371

From 3 to 6 decimal digits are projected in-line by these decimal indicators. Displays are said to be visible at wide angles. Input is binary-coded decimal for series 500, binary for series 1000, either parallel or serial. Units are transistorized, self-contained.

Howard Instrument Co., Dept. ED, Red Bank, N. J.

Temperature Transducer 354

Range is 0 to 2,000 F for surface resistance-temperature transducer model 2508. The platinum element resistance is 100 ohms ±1% at 77 F. Unit can be installed with response times in the msec range. Size is 1-9/16 x 9/16 x 0.014 in. thick. Unit can be cemented or welded to the surface under test.

Winsco Instruments & Controls Co., Dept. ED, 11789 W. Pico Blvd., Los Angeles 64, Calif.

Oscilloscope Cart 380

Collapsible for storage, this oscilloscope cart has a 25-deg tilt. Cart is 29-in. high, 15-in. wide and 27-in. long, with 4-in. caster wheels. Frame is 1-in. steel tubing; trays are 20-gage rolled steel.

Atlantis Electronics Corp., Dept. ED, P. O. Box 451, Garland, Tex.
***Price:** $29.95 fob Garland.*

Ceramic Capacitors 357

For transistor circuits, these layer-built ceramic capacitors, series N030, have a nominal temperature coefficient of 30 ppm/C. Standard units are available with ratings from 51 to 5,100 pf at 200 v dc at 85 C, or 50 v dc at 125 C. Standard tolerances are ±10%, ±5% and ±2%. Tolerances of ±1% are available on special order.

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

Recording Voltmeter 376

Monitors voltage fluctuations while unattended for extended periods of time. Instrument, designated model 1122B-60, responds fully to a 0.1-sec pulse. Unit detects voltage changes as small as 0.25 v in a 120-v system. It is capable of functioning on line without attention for weeks at a time. Unit comes with a recorder.

Brenner-Fiedler & Associates, Inc., Dept. ED, 7563 Melrose Ave., Los Angeles 46, Calif.

DRAFTING TRENDS

New, improved Rotolite Expeediter conveniently makes sepia reproducibles and diazo films in addition to low cost whiteprints.

Make your own whiteprints in two minutes or less

Here's a new, fast, economy whiteprinter that fills a real need in small drafting rooms or large engineering departments.

Workprints for architects, consulting engineers, surveyors, contractors. The Rotolite Expeediter can handle *all* copying needs for the two- or three-man drafting operation, is always ready to cope with rush jobs, even after hours. With POST Super Vapo Papers, print production can be doubled.

Quick checkprints for larger manufacturers. Even huge, multi-department engineering divisions with their own reproduction departments or outside sources praise Expeediter's practical, on-the-spot convenience for quick copies of preliminary sketches, checkprints, conference data, visual presentations. Hundreds of companies have placed Rotolites advantageously in each of their several engineering and drafting rooms for "self-service" whiteprints in a hurry.

No preheating or other delays—Rotolite makes prints immediately. There's a choice of three models to take 18", 27" or 42" wide tracings of any length. Furnished with dry-developing ammonia tube. Rotolite is easily hung on wall or placed flat on a table top, plugs into any standard convenience outlet. With new dial speed control, you can make cloth and film reproductions immediately, as well as paper prints. Provides clean, sharp prints every time through simple design, durable construction. Single lamp simplicity is entirely adequate for every "quick print" need.

Recommended print materials. Use POST diazotype sensitized products —Vapo paper, sepia vellum, cloth or film—for best results. Get full information on Expeediter and standard Rotolite whiteprinters from your POST dealer or write Frederick Post Company, 3644 N. Avondale Avenue, Chicago 18, Ill.

POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

CIRCLE 135 ON READER-SERVICE CARD

now... analyze **both SSB & AM** transmitters & receivers faster, with uniform sensitivity over entire **100 cps-40 mc** range

AT MINIMUM COST

new — improved

PANORAMIC

SSB-3a

SPECTRUM ANALYZER

Panoramic adds important NEW design features to the time-proven Model SSB-3! Now, in one convenient, compact package, you get the comprehensive unit you need to set up, adjust, monitor and trouble shoot SSB and AM transmitters and receivers.

TWO TONE TEST*

Fixed sweep width 2000 cps. Full scale log sideband tones 1.5 kc and 2.1 kc from carrier (not shown). Odd order 1. M. distortion products down 37 db.

HUM TEST*

Indication of one sideband in above photo increased 20 db. Sweep width set to 150 cps reveals hum sidebands down 53 db and 60 db.

*See Panoramic Analyzer No. 3 describing testing techniques, etc., for single sidebands. A copy is yours for the asking.

GREATER FREQUENCY RANGE New Optional REC-1 Range Converter extends SSB-3a 2 mc-40 mc range down to 100 cps . . . speeds distortion analysis of receiver AF and IF outputs, transmitter bass band.

NEW 2-TONE AF GENERATOR MODEL TTG-2 2 generator frequencies, each selectable from 100 cps-10 kc • Resettable to 3 significant digits • Accuracy: ± 1% • Output Levels: each adjustable from 2 to 4 volts into matched 600 ohm load • Output DB Meter • Spurious, hum, etc, less than —60 db. • 100 db precision attenuation in 1 db steps.

FASTER-NEW TUNING HEAD FEATURES RAPID "SIGNAL SEARCH" PLUS PRECISE FINE TUNING.

ALL THESE NEW FEATURES . . . PLUS A SENSITIVE SPECTRUM ANALYZER

Panoramic's Model SB-12aS Panalyzer. Pre-set sweep widths of 150, 500, 2000, 10,000 and 30,000 cps with automatic optimum resolution for fast, easy operation. Continuously variable sweep width up to 100 kc for additional flexibility. 60 db dynamic range. 60 cps hum sidebands measurable to —60 db. High order sweep stability thru AFC network. Precisely calibrated lin & log amplitude scales. Standard 5" CRT with camera mount bezel. Two auxiliary outputs for chart recorder or large screen CRT.

INTERNAL CALIBRATING CIRCUITRY Two RF signal sources simulate two-tone test and check internal distortion and hum of analyzer. Center frequency marker with external AM provisions for sweep width calibrations. Write, wire, phone RIGHT NOW for technical bulletin and prices on the new SSB-3a. Send for our new CATALOG DIGEST and ask to be put on our regular mailing list for The PANORAMIC ANALYZER featuring application data.

the pacemaker in test equipment

Panoramic
ELECTRONICS, INC.

dependable CERTIFIED SPECIFICATIONS for accurate data

Formerly Panoramic Radio Products, Inc.

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PANORAMIC ELECTRONICS, INC.

524 So. Fulton Ave., Mount Vernon, N. Y. • Phone: OWens 9-4600
TWX: MT-V-NY-5229 • Cables: Panoramic, Mount Vernon N. Y. State

Sec. 2900

CIRCLE 136 ON READER-SERVICE CARD

NEW PRODUCTS

Component Sorter 416

Automatic component sorter, called the Test-Amatic, sorts axial-lead components according to electronic value. Sorting resistors in standard, sequenced operation, it handles 3,396 units per hr. It comprises an input hopper, a testing station and three or more receptacle bins.

Develop-Amatic Engineering, Dept. ED, 923 Industrial Ave., Palo Alto, Calif.

P&A: *$1,475; 90 days.*

Electric Soldering Pots 400

Stripping and tinning of plastic insulated wire and leads on small parts can be done simultaneously with electric soldering pots type 875, rated at 150 w, and type 875T, rated at 300 w. Type 875T can be furnished with an adjustable thermostat.

Electric Soldering Iron Co., Inc., Dept. ED, Deep River, Conn.

Static Teletypewriter Relay 361

For a specific application in a teletypewriter repeater, this static relay gives 0.02 or 0.05 amp output for 120 or 155 to 180 v input. Relay is activated by square waves from a vacuum-tube circuit. A lifetime of 10,000 hours of 200 cps operation is expected.

Kidde Electronics Laboratories, Dept. ED, Brighton Road, Clifton, N. J.

Oscilloscope 394

For severe environments, model 945 oscilloscope with model MC preamplifier permit measurements from dc to 24 mc. Operating environmental limits are: temperature, −40 to +71 C; vibration, 5 g at 55 cps and 0.03 in. peak to peak; shock, 400-lb hammer drop; altitude, 20,000 ft.

Tektronix, Inc., Dept. ED, P. O. Box 500, Beaverton, Ore.

Differential DC Amplifier 395

Gain is 1 to 1,000, adjustable. Model 611-B chopper-input amplifier has an output of ±10 v at an impedance of less than 0.5 ohm. Zero stability is better than 0.02% per day. Rise time is 20 msec to 99.9% of full value. Miles of cables at input or output do not effect performance.

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

Ceramic-to-Metal Terminals 389

Alumina ceramic-to-metal terminals, for hermetically sealed electronic equipment, can be used at temperatures to 1,700 F. The Advac line consists of 20 standard sizes from 5/16 to 1-1/2 in. in diameter. Made to MIL-T-27, they withstand over 27-kv flashover voltage.

Advanced Vacuum Products, Inc., Dept. ED, 430 Fairfield Ave., Stamford, Conn.

***P&A:** $2 to $26; stock.*

ROBINSON
All-Metal Mounting Systems

Isolate VIBRATION

Reduce SHOCK

Increase RELIABILITY

Uncontrolled vibration is the mortal enemy of performance. It impairs the reliability of electronic and other equipment — shortens service life — increases costly maintenance.

Robinson has specialized in the engineered control of vibration and shock for over twenty-five years. Robinson mounting systems have been thoroughly proven in practice in virtually every field of application — aircraft, missile, shipboard, mobile, industrial and commercial. 100% all-metal construction (even the MET-L-FLEX cushions) makes Robinson mounts deterioration resistant — able to meet and exceed exacting space-age specifications.

Send for FREE brochure.

Radial type mounts were developed by Robinson for the resilient support and protection of individual instruments used in many aircraft and missiles.

All-metal, high temperature resistant engine mounting systems make possible smooth, vibration-free, noise-free flight for the latest jet aircraft.

Robinson has designed and produced in quantity low frequency mounting systems for many types of Naval shipboard equipment ***(exclusive with Robinson)*** now in service throughout the fleet.

Typical base type mounting system assures high vibration isolation for the protection of many types of electronic and electro-mechanical equipment.

ROBINSON VIBRASHOCK DIVISION
Vibration and Shock Control
ROBINSON *Technical Products Inc.* TETERBORO, NEW JERSEY

WEST COAST ENGINEERING OFFICE • SANTA MONICA, CALIF.

NEW PRODUCTS

Angular Accelerometer 384

For missile applications, the model 4575 angular accelerometer has full scale ranges from ±500 to ±1,500 rad per sec^2. Nominal output is ±7.5 v, linear within 0.05%. Unit measures 2 x 1-1/4 x 1-1/2 in., weighs less than 4 oz.

Donner Scientific Co., Dept. ED, Concord, Calif.

***P&A:** $710; 30 days.*

Trimmer Potentiometers 396

Rated at 100 ohms to 20 K, model 224 trimmer potentiometers are designed for high-reliability system applications. Resolution is 1% for the 100-ohm types, 0.2% for types rated at 20 K. Power rating is 0.5 w at 70 C. Quality-control records can be furnished.

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

***Availability:** stock.*

Military Relay 406

Withstands 50-g vibration at 3,000 cps and 500-g shock. Hermetically sealed, 4pdt dc relay has a dry circuit to 5-amp contact rating. Insulation resistance is 1,000 meg, dielectric strength is 1,000 v rms. The relay is capable of switching high and low power levels interchangeably.

Couch Ordnance, Inc., Dept. ED, 3 Arlington St., North Quincy 71, Mass.

Crystal and Component Ovens 398

Are stable to ±0.5 or ±2 C. The DFO-900 crystal and component ovens operate in the temperature range of −55 to +100 C, on inputs of 6.3 to 117 v ac or dc with heater power of 5 to 30 w. The crystal ovens hold one or two HC/18, HC/6 or HC/13 crystals; the component oven has a cavity of 1 x 2-11/32 in. with a 9-pin socket for module plug-in.

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

P&A: *$5.50 to $14.25; stock to 3 weeks.*

AC Voltage Standard 411

Accuracy is ±0.01% from 1.5 to 1,125 v from 20 to 50,000 cps. Model FLH portable ac voltage standard directly measures the influence of frequency on the indication of voltmeters, calibrators and other transfer standards. Resolution is 0.005% min.

Sensitive Research Instrument Corp., Dept. ED, 310 Main St., New Rochelle, N. Y.

Price: *$1,685.*

DC Relays 402

Withstand 35-g vibration at 3,000 cps and 150-g shock for 11 msec. Series VR miniature dc relays are built for missile applications. They have 0.2-in. grid-spaced terminals for printed-circuit use. Contacts are dpdt, rated at 3 amp, resistive, at 28 v dc. Life is 100,000 operations or more.

Elgin National Watch Co., Dept. ED, 2435 N. Naomi St., Burbank, Calif.

Availability: *stock or made to order.*

NEW PRODUCTS

Latching Relays 401

General-purpose latching relays type LFA, rated at 5 amp, and LFB, rated at 10 amp, are available in a variety of ac and dc coil voltages. Contact arrangements are spdt, dpdt or 3pdt. Operating power is 2 to 3 w dc and 3 to 4 w ac. Mechanical life expectancy is 500,000 operations.

Elgin National Watch Co., Electronics Div., Dept. ED, 2435 N. Naomi St., Burbank, Calif. ***Availability:*** *4 to 8 weeks.*

Liquid-Level Control 397

For cryogenics. Called the Cryolevel, the liquid-level control can be used with liquid helium, hydrogen, nitrogen and other cryogenic liquids. It maintains the liquid to within ±1/4 to 6 in. of a preset level. It can be adapted to any standard cryogenic container or storage tank. Manual operation is possible.

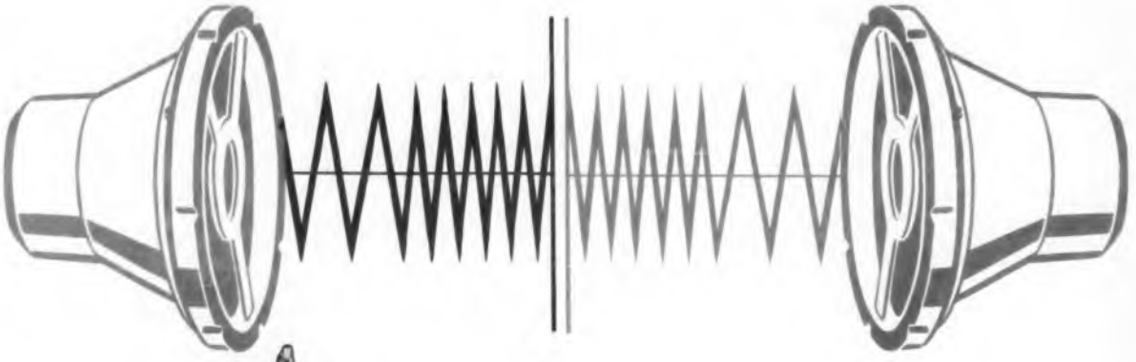
Cryotronics, Inc., Dept. ED, Mountainside, N. J.

Galvanometer Protector 390

Prevents coil burnout of the firm's magnetically damped galvanometers. The galvanometer protector has an insertion resistance of 4 ohms at 75 F. Parallel resistance is greater than 7.5 K for inputs of ±100 mv or less. Phase shift is 1 deg max from 0 to 10 kc.

Bell & Howell Co., Data Recorders Div. of Consolidated Electrodynamics Corp., Dept. ED, 360 Sierra Madre Villa, Pasadena, Calif.

ELECTRON TUBE NEWS from SYLVANIA



New! Sylvania-6JK8 especially designed for

FM Tuners for Stereo Multiplex

Features strap frame grid! Provides high signal-to-noise!

Sylvania-6JK8, double triode, opens new design possibilities for high gain, low noise performance in a low-cost, compact FM tuner. 6JK8 combines a strap frame grid RF amplifier and an oscillator-mixer in a T-6½ envelope with miniature 9-pin circle. It enables the design of a simplified circuit capable of better than 40db quieting with less than 10 μVolts signal input for superb multiplex performance. Equally significant, 6JK8 and its associated family – 8JK8, 17JK8–cost less than two single triodes of comparable performance.

TYPICAL CHARACTERISTICS–6JK8
Ef – 6.3V If – 400mA

	Triode # 1	Triode #2*	Units
Eb	150	135	V
Ec_1	−1	−1.2	V
Ib	5.3	11.5	mA
Gm	6800	14,500	μmhos
Mu	50	70	

*Utilizes Strap Frame Grid

SYLVANIA 10-PIN TYPES FOR 1-TUBE FM TUNER FRONT ENDS

Sylvania-6/17C9 combines two high performance sharp-cutoff tetrodes in a T-6½ envelope. Tenth pin enables separate connections for cathodes and the use of effective shielding to reduce undesirable oscillator signal radiation. They are designed for VHF service as an RF amplifier and autodyne mixer.

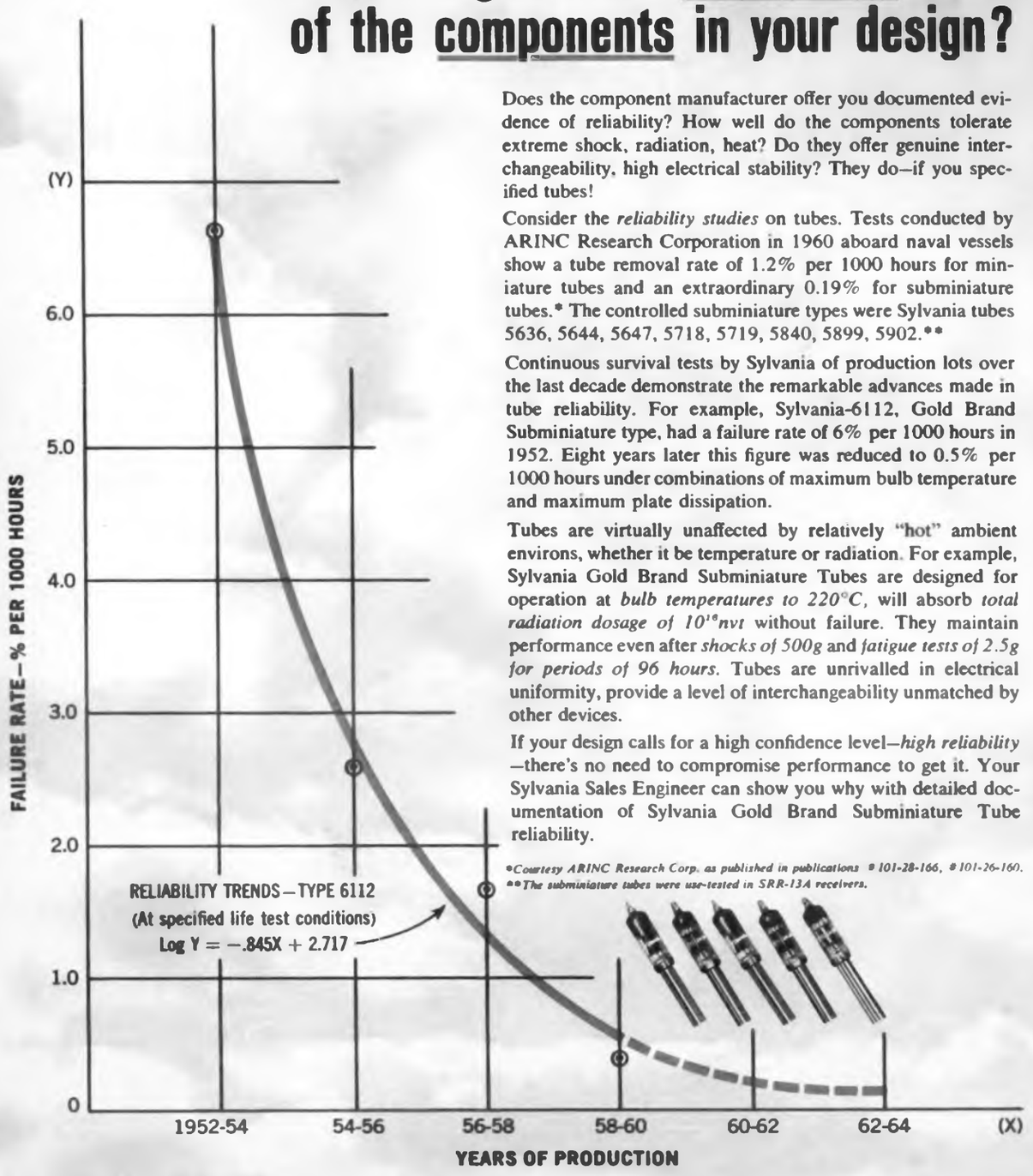
Sylvania SR-2946A, triple triode in a T-6½ bulb. Ten-pin base provides excellent isolation, heater from cathodes, facilitating circuit design for series string operation. SR-2946A provides the combined functions of RF amplifier, oscillator-mixer, AFC control.

IMPROVED SYLVANIA TYPES FOR SUB-CARRIER GENERATORS

Sylvania-12AT7, 12AU7A, 12AX7A are improved versions of these popular types featuring low hum, noise and microphonics and offering amplification factors of 62, 20, 100 respectively.

For further information, contact your Sylvania Sales Engineering Office. For technical data on specific types, write Electronic Tubes Division, Sylvania Electric Products Inc., 1100 Main St., Buffalo 9, N.Y.

How high is the confidence level of the components in your design?



Does the component manufacturer offer you documented evidence of reliability? How well do the components tolerate extreme shock, radiation, heat? Do they offer genuine interchangeability, high electrical stability? They do—if you specified tubes!

Consider the *reliability studies* on tubes. Tests conducted by ARINC Research Corporation in 1960 aboard naval vessels show a tube removal rate of 1.2% per 1000 hours for miniature tubes and an extraordinary 0.19% for subminiature tubes.* The controlled subminiature types were Sylvania tubes 5636, 5644, 5647, 5718, 5719, 5840, 5899, 5902.**

Continuous survival tests by Sylvania of production lots over the last decade demonstrate the remarkable advances made in tube reliability. For example, Sylvania-6112, Gold Brand Subminiature type, had a failure rate of 6% per 1000 hours in 1952. Eight years later this figure was reduced to 0.5% per 1000 hours under combinations of maximum bulb temperature and maximum plate dissipation.

Tubes are virtually unaffected by relatively "hot" ambient environs, whether it be temperature or radiation. For example, Sylvania Gold Brand Subminiature Tubes are designed for operation at *bulb temperatures to 220°C*, will absorb *total radiation dosage of 10^{18}nvt* without failure. They maintain performance even after *shocks of 500g* and *fatigue tests of 2.5g for periods of 96 hours*. Tubes are unrivalled in electrical uniformity, provide a level of interchangeability unmatched by other devices.

If your design calls for a high confidence level—*high reliability*—there's no need to compromise performance to get it. Your Sylvania Sales Engineer can show you why with detailed documentation of Sylvania Gold Brand Subminiature Tube reliability.

*Courtesy ARINC Research Corp. as published in publications # 101-28-166, # 101-26-160.
**The subminiature tubes were use-tested in SRR-13A receivers.

EQUIPMENT SALES OFFICES

CHICAGO, 200 N. Canal Ave., Mount Prospect, Ill., ESterbrook 9-2525; CINCINNATI, 411 Oak St., Plaza 1-8454; DALLAS, 1600 Firelyne St., Riverside 1-4836; DAYTON, 333 W. First St., BAldwin 3-6227; FORT WAYNE, Ind., 4740 Coldwater Rd., 13-1145; LOS ANGELES, 6505 E. Gayhart St., Rhymond 3-5371; NEW YORK CITY, 1000 Hayler St., Teterboro, N. J., ATlas 9-9884; N.Y.-UPSTATE, Seneca Falls, LOgan 6-5881; ORLANDO, Suite C, 1520 Edgewater Dr., P.O. Box 7240, Orlando, Fla., GArden 4-8245; SAN FRANCISCO, 1011 Adrian Rd., Burlingame, Calif., OXford 7-3500; WASHINGTON, D.C., 1120 Connecticut, N.W., FEderal 7-6000; WILMINGTON, MASS., 201 Main St., OLiver 8-3357.

SYLVANIA

SUBSIDIARY OF

GENERAL TELEPHONE & ELECTRONICS

GENERAL TELEPHONE SYSTEM

P-896-3

Telemetering Equipment 414

Frequency-type telemetering equipment, called Tele-Dac, consists of a 15 to 35 cps transmitter-receiver combination able to communicate any quantity that can be converted to a proportional dc mv signal. Over-all accuracy is ±1%. The equipment is suitable for rack mounting.

Westinghouse Electric Corp., Dept. ED, P. O. Box 2099, Pittsburgh 30, Pa.

Miniature Fan 418

Moves 17.5 cfm under free-delivery conditions. The 60-cps Propimax 2 fan measures slightly over 3 in. in diameter, 1-1/2 in. deep and weighs 6-1/2 oz. It is physically and aerodynamically symmetrical, permitting reversal of air flow by turning end-for-end.

Rotron Manufacturing Co., Inc., Dept. ED, Woodstock, N. Y.

Static Inverter 382

Rated 100-va, 3-phase, the model K33 static inverter provides sine wave output from 28-v dc input. Output is regulated, contains no radio noise, has 2% max harmonic distortion, and meets MIL-E-7894 specifications. Components are solid-state, temperature-compensated. Unit is potted and hermetically sealed, and meets MIL-E-5272C specs. Device measures 4 x 7-3/4 x 2-1/2 in.

Arnold Magnetics Corp., Dept. ED, 6050 W. Jefferson Blvd., Los Angeles 16, Calif.
***P&A:** $600; 30 days.*

NEW PRODUCTS

Clear Cement 429

High dielectric strength for adhering wires to all types of surfaces is provided by Dekophane clear, acrylic resin-base cement. It forms an air-tight, moisture-proof seal, does not become brittle, and withstands temperatures to 120 C.

The Crystal Essence Corp., Dept. ED, P. O. Box 108, Bound Brook, N. J.

Data Plotter 437

Magnetic-tape X-Y data plotter series 3440 automatically reduces digital data to graphic form on 30 x 30-in. or smaller sheets. Plotting speeds are to 4,500 line segments per min. Data may be read from punched cards or punched paper tape as well as magnetic tape.

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

Coating Test Device 544

Nondestructive test device Type EC gages nonconductive coatings on aluminum and its alloys. It also measures thickness of nonferrous metal on a nonferrous base, thickness of a nonferrous coating on a nonconductor and the conductivity of nonferrous materials.

Twin City Testing Corp., Dept. ED, 533 S. Niagara St., Tonawanda, N. Y.

Computer Tape 427

Two types are offered. Series 832 computer tape exceeds 300,000 error-free passes on the firm's FR-300 digital-tape transport at a packing density of 556 bits per in. Also offered, series 834 exceeds 25,000 error-free passes at the same packing density.

Ampex Corp., Magnetic Tape Products, Dept. ED, Opelika, Ala. ***Availability:** through distributors.*

Battery Substitute 425

Output is 1.015 to 1.045 v dc at a load current of 10, 6, 5 or 1 amp. The Batt-Sub battery substitute operates from a 177-v ac supply. The output is regulated by a two-stage Zener diode network. Model BS-1 replaces dry

◀ CIRCLE 145 ON READER-SERVICE CARD

cells in potentiometer instruments and model BS(TC)-1 replaces the dry cell, standardizing mechanism, and standard cell.

Dynage, Inc., Dept. ED, 390 Capitol Ave., Hartford, Conn.

Core-Memory Tester 431

For industrial computer and business-type data processing systems. Called the Core Memory Exerciser, the core-memory tester checks systems of up to 4,096 words with 26 bits per word. It checks systems before or after installation in computers.

Radio Corp. of America, Dept. ED, 30 Rockefeller Plaza, New York 20, N. Y.

Clean Room 424

Packaged, mobile clean rooms include air conditioning, filtration systems, lighting, electrical outlets and other facilities. The standard 500-ft size can be expanded by attaching additional mobile units by means of air-shower interlocks.

Controlled Atmosphere Enclosures Manufacturing Co., Dept. ED, P. O. Box 5864, Jacksonville 7, Fla. ***Availability:*** *on a rental basis.*

Potting Compounds 426

A wide variety of compounds for potting, impregnating and encapsulating can be furnished. Mixtures 2000 and 2008, for example, meet MIL-I-16923C for embedding compounds in type C applications. Mixture 2008, for use at 180 C in commercial applications, also meets MIL-I-16923C for 155 C use in type D applications.

Acme Wire Co., National Aniline Div., Dept. ED, 40 Rector St., New York 6, N. Y.

Frequency Standards 434

Range is 360 cps to 4 kc for both frequency standards. Type SMA high-precision unit measures 1-5/8 x 1-5/8 x 1-5/8 in., weighs about 2 oz, and fits flat into printed-circuit boards. Type SM has a vertical design. Both provide complete frequency stabilization in 30 sec after application of power.

Accurate Instrument Co., Dept. ED, 2418 Alabama, Houston 6, Tex.

ANOTHER MULLARD FRAME-GRID TUBE

Increased gain, reduced microphonics, and better controlled characteristics - these are the advantages you get when you specify Mullard frame-grid television tubes.

EF183 VARIABLE MU RF PENTODE

6EH7

Frame-grid variable-mu r.f. pentode for use as an automatic gain controlled i.f. amplifier in television receivers.

CHARACTERISTICS

V_a	170	200	230	V
V_{g2}	90	90	90	V
V_{g3}	0	0	0	V
I_a	14	12	10.5	mA
I_{g2}	5.3	4.5	3.6	mA
V_{g1}	-1.8	-2.0	-2.1	V
gm	14	12.5	10.6	mA/V
r_a	350	500	650	kΩ
r_{g1} (f=40Mc s)	11.6	13	15.3	kΩ

SUPPLIES AVAILABLE FROM:

IN THE U.S.A.
International Electronics Corporation
81 Spring Street, New York 12, N.Y.
Worth 6-0780

IN CANADA
Rogers Electronic Tubes & Components
116 Vanderhoof Avenue, Toronto 17, Ontario.
Hudson 9-9821

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Mullard
ELECTRONIC TUBES

BRITAINS FIRST CHOICE FOR FIRST EQUIPMENTS

MULLARD OVERSEAS LTD, MULLARD HOUSE, TORRINGTON PLACE, LONDON, ENGLAND

MEV 3

NEW PRODUCTS

Electronic Timers 362

Hermetically sealed crystal case timer package weighs 0.8 oz and measures 1.0 x 0.8 x 0.4 in. Temperature range is from −55 to +125C. Minimum adjustment range available is from 0.05 to 1 sec. Maximum adjustment range is from 3 to 60 sec. Accuracy rating is ±10% of nominal time delay. Units are for 28 v dc input.

Tempo Instrument Inc., Dept. ED, Hicksville, N. Y.

Frequency-to-DC Converter 413

For telemetering flow and tachometer data. The FR-84 airborne frequency-to-dc converter provides an output of 0 to 5 v dc with ±0.25% linearity, over-range limiting at 6.8 v and a power consumption of 45 ma at 27.5 v. Consisting of solid-state circuitry on printed-circuit cards, it withstands 100-g shock and 20-g vibration. Weight is less than 1 lb.

Waugh Engineering Div., The Foxboro Co., Dept. ED, 7740 Lemona Ave., Van Nuys, Calif.

Digital Ohmmeter 352

Range is 0.1 ohm to 10 meg for digital ohmmeter model NLS 784. Unit is fully automatic, with automatic range changing, positioning of the decimal point, and built-in controls for automatic readout to data printers. It can read at an average rate of 1 reading per sec, with an accuracy of ±0.05% of reading plus one digit.

Non-Linear Systems, Inc., Dept. ED, Del Mar, Calif.

P&A: *$1,650; from stock.*

Microminiature Components 409

A sample kit, type A, contains all the microminiature components necessary to build 10-kc flip-flop with set and reset capabilities and occupying 0.179 cu in. Type B kit contains the same components and accessories, plus interconnecting materials, terminals and encapsulating materials for building a variety of other circuits.

P. R. Mallory & Co., Inc., Microcomponents Dept., Dept. ED, Indianapolis 6, Ind.
Price: *A, $44.95; B, $139.95.*

Coaxial Switch 405

For use to 200 mc. Model CU 723 spdt coaxial switch has a vswr of less than 1.15, isolation of better than 33 db, insertion loss of less than 0.1 db, power capability of 150 w and switching time of 7 msec. Life is 100,000 actuations. Other types of connectors can be furnished.

Bay-Roy Electronics, Inc., Dept. ED, P. O. Box 7503, Cleveland 30, Ohio.

Zero-Bias Power Triodes 375

Used as class-B linear amplifiers in audio or rf applications, these power tubes require no bias. Typical power gain is 20 in grounded-grid circuits. Triodes provide 0.5 to 20 kw pep. Types 3-400Z, 3-1000Z, and 3X3000F7 are of glass and metal construction; types 3CX10.000A7 and 3CV20.000A3 are ceramic and metal.

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

NEW PRODUCTS

Alloying Furnace 474

Temperatures to 1,000 C can be reached with this vertical alloying furnace. Vertical stacking zone is 2 in. in diameter and 8 in. high. Unit has an inconel muffle and pedestal. Furnace is three-zone type, with working and end zone reactors controlled. Other arrangements are available on special order.

Research Instrument Co., Inc., Dept. ED, 558 Main St., Westbury, N. Y.

P&A: $5,000 and up; 2 to 4 months.

Breadboard Kit 358

Rapid assembly of prototype electronic equipment is possible with the 3-D breadboarding kit. Designer is able to complete prototypes without using any power tools except a soldering iron. Kit comprises an assortment of prepunched laminated phenolic panels, terminal strips, volume-control strips, punched chassis-frames, rack-mounting plates and assorted hardware.

Precision Metal Products Co., Dept. ED, 41 Elm St., Stoneham, Mass.

Price: $13.95.

Refrigeration Chamber 548

For metallurgical chilling. Model ST-120-15 refrigeration chamber measures 36 x 24 x 30 in. and has a capacity of 4,000 BTU per hr at −120 F. It can chill 200 lb of steel per hr from ambient to −120 F. Construction is of 14-gage steel.

Cincinnati Sub Zero Products, Dept. ED, 3932 Reading Road, Cincinnati 29, Ohio.

Fixed Resistors 553

Ceramic-metal fixed resistors, Ceradot, are stable at temperatures to 600 C. Resistances are from 50 ohms to 100 K. Power rating is 0.1 w at 125 C, derated linearly to zero at 200 C. Temperature coefficient is 300 ppm. Units are 0.05 in. in diameter and 0.03 in. thick.

CTS Corp., Dept. ED, Elkhart, Ind.

P&A: $1 to $3; samples, 2 weeks; quantities, 4 weeks.

Tape Head 392

For stereo recording. Type RH-4 tape head operates with four-track stereo tape systems. Frequency response at 3-3/4 in. per sec is −10 db at 10,000 cps with an output of 3 mv at 1,000 cps. It also plays at 7.5 in. per sec with a frequency response of −5 db at 10,000 cps and an output of 3 mv at 1,000 cps. A matching erase head is available.

Sonotone Corp., Dept. ED, Elmsford, N. Y. *P&A: $28.50; to OEM.*

Cable-Continuity Tester 410

For instantaneous checking of individual circuits in multi-conductor assemblies. Model NT-103 cable-continuity tester can be used for checkout of 57 conductors at one time and is suitable for missile-systems cable checkout. It is portable, measures 13 x 17 x 23 in. and operates on 110 v ac.

Noble-Tanksley Corp., Dept. ED, 1650 Collamer Road, Cleveland 10, Ohio.

Semiconductor Mount 404

For JEDEC TO-3 power transistors, diodes and rectifiers. Type CFG mount is black phenolic as per MIL-N-14; type MME, melamine per MIL-M-14; type SDG, diallyl phthalate per MIL-M-18794. Contacts are spring-temper phosphor bronze, electrotin plated, accepting 0.04 or 0.05-in. pins.

Augat, Inc., Dept. ED, 33 Perry Ave., Attleboro, Mass.

NEW PRODUCTS

Cooling-Heating Module 557

Thermoelectric modules use 10 per cent of the power normally required to do an equivalent job of heating or cooling. Units can be used to cool electronic components and laboratory instrumentation devices. They may find application in consumer products by eliminating the noise and bulk of motor-compressor refrigerator units.

Jepson Thermoelectrics, Inc., Dept. ED, 139 Nevada St. El Segundo, Calif.

Missile and Space Timers 408

Accuracy is 0.1% for time bases from hundredths of a second to 100 sec over the temperature range of −65 to +165 F. Based on magnetic-core oscillation techniques, the missile and space timers are miniature in design and are able to withstand shock of 4,000 g. Power consumption is low.

Minneapolis-Honeywell Regulator Co., Ordnance Div., Dept. ED, 600 Second St., N. Hopkins, Minn.

Rack and Panel Connectors 385

For switching and re-routing applications these rack and panel connectors have polarizing pins that provide positive mating. Receptacle series 2P-SD-600 have low voltage drop after repeated insertions. Plugs are designated series 2P-MD-600. Contacts are spring tempered, gold-plated phosphor bronze.

Methode Electronics, Inc., Dept. ED, 7447 W. Wilson Ave., Chicago 31, Ill.

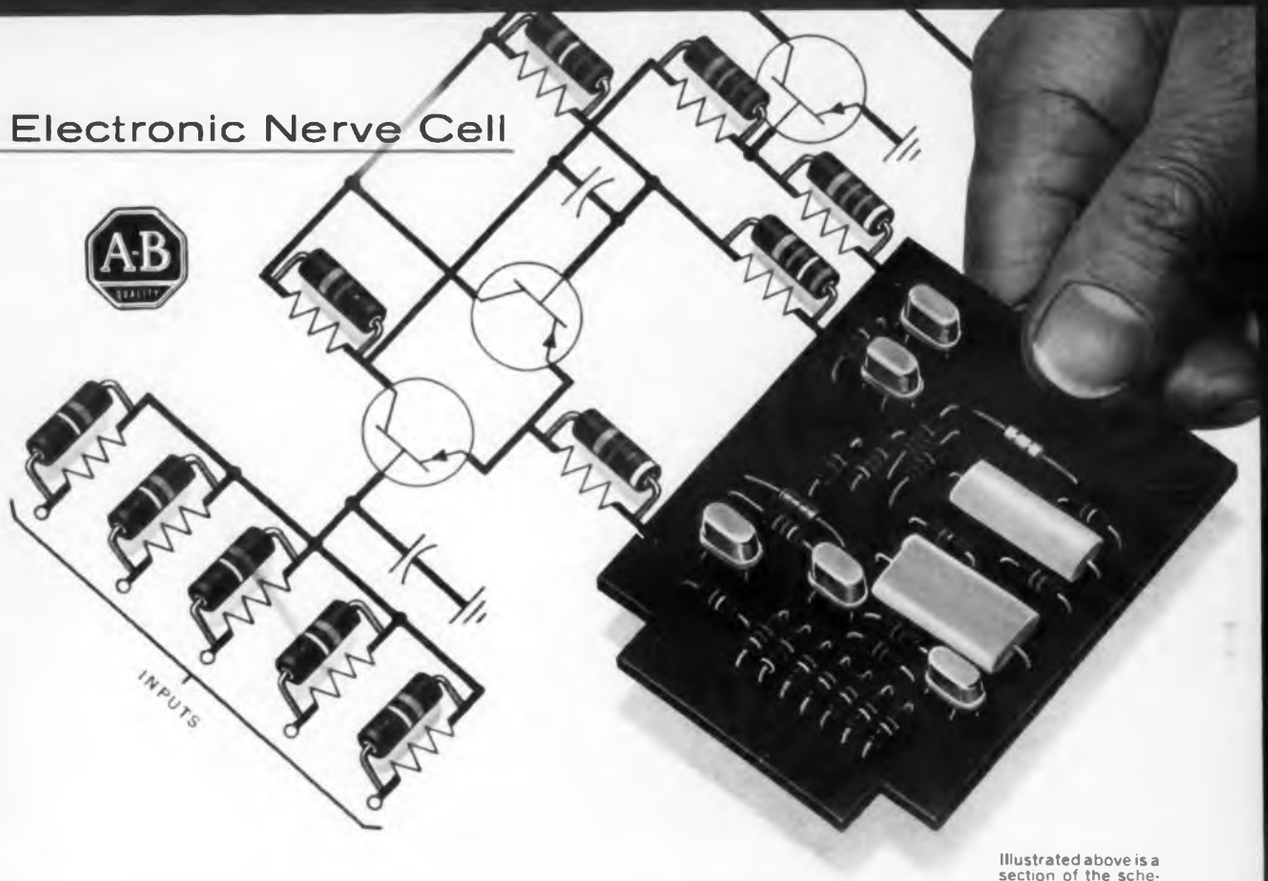
Metal and Plastic Compound 555

For tool and die processes, the new metal and plastic compound can be used in industries such as aircraft, missiles, plastic and metal forming. It comes in dry powder form, can be poured into a mold and liquified by heat and hardens to the shape of the mold as it cools. Tolerance can be as close as 0.001 in.

The Boeing Co., Dept. ED, Seattle 24, Wash.

CIRCLE 161 ON READER-SERVICE CARD ➤

Electronic Nerve Cell



Illustrated above is a section of the schematic diagram for the artificial neuron (nerve cell).

Goal of New Research Project
MORE EFFICIENT COMMUNICATION SYSTEMS

Research to explore the information processing in nervous systems is now underway at Bell Telephone Laboratories. Here, scientists are experimenting with newly developed electronic elements which are designed to imitate the actions of a living nerve cell. Too little is yet known about living cells to permit exact electronic duplication. However, experiments with groups of artificial neurons have roughly duplicated some of the eye's basic reaction to light. This new approach to studying basic nerve network functions can provide clues for stimulating further exploration into the fundamentals of the transmission of intelligence.

Allen-Bradley is very happy that the quality of their hot molded resistors caused them to be selected for these exacting experiments. With their uniform properties and conservative ratings—A-B resistors will provide the same superior performance in your electronic circuits. Be certain you specify A-B hot molded resistors—especially for your critical jobs. Send for Publication 6024.

A-B Hot Molded Composition Resistors

SHOWN ACTUAL SIZE

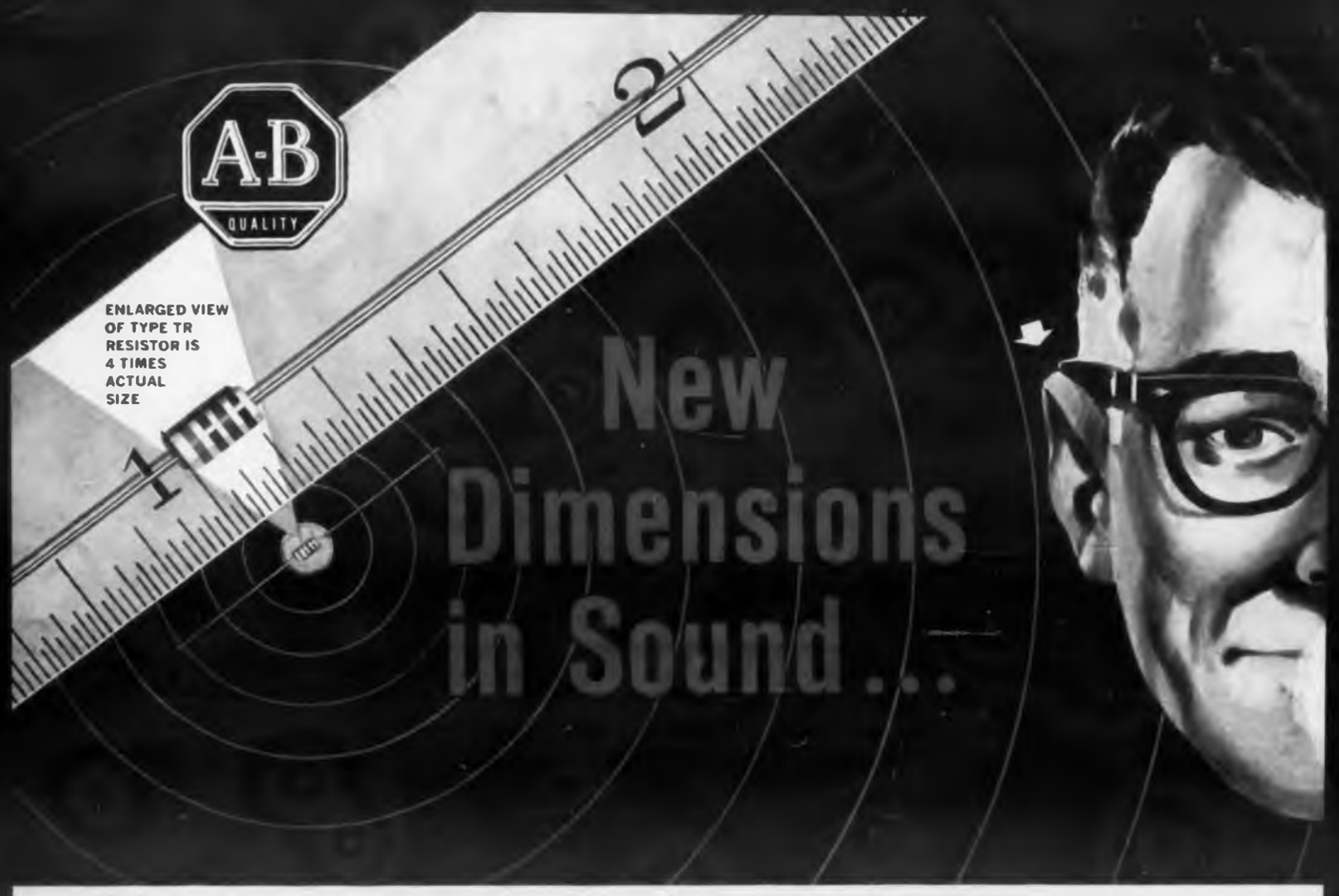
Hot molded composition resistors are available in all standard EIA and MIL-R-11 resistance values and tolerances.

Pending MIL Spec Assignment

9-61-E

ALLEN-BRADLEY
Quality Electronic Components

Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, Ontario



ALLEN-BRADLEY TYPE TR RESISTORS

are STANDARD for today's miniaturized hearing aids

Because of the engineering ingenuity of the manufacturers, hearing aids have become so tiny they are hardly noticeable—since the principal objection to wearing a hearing aid has been overcome, ever increasing thousands are enjoying this remarkable contribution to the joy of hearing.

Allen-Bradley is proud to play a part in this important development. The extremely tiny Type TR fixed resistor (actually smaller than a grain of rice) is used by virtually every hearing aid manufacturer to help achieve today's amazing miniaturization—without sacrificing reliability!

Tiny as they are, these miniature resistors—made by Allen-Bradley's exclusive hot molding process—*have never experienced catastrophic failure in service.* They are remarkably "uniform" to their resistance rating. Therefore, you are only fair to yourself—and your customers—when you insist on the reliability of the A-B Type TR resistors.

For complete details, please send for Technical Bulletin 5001, and Publication 6024 which also includes information on other A-B space-saving electronic components.

SOME OF THE MANUFACTURERS OF HEARING AIDS WHO RELY ON A-B TYPE TR RESISTORS

American Sound Products, Inc.
Audivox, Inc.
Beltone Hearing Aid Company
Busse Electronics Company
Dahlberg Company
Dictograph Products, Inc.
Electro Acoustic Research Labs., Ltd.
Gem Ear Phone Co., Inc.
Halhen Widex, Inc.
Johnston Hearing Aid & Electronics, Inc.
Maico Electronics, Inc.
The Microtone Company
E. A. Myers & Sons, Inc.
Otarion Listener Corp.
Qualitone Company, Inc.
Sonotone Corp.
Telex, Inc.
Unex Laboratories
Vari Electronics, Inc.

8-61-E

ALLEN-BRADLEY

Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

QUALITY
ELECTRONIC COMPONENTS

Portable Drafting Kit 399

Weighs 1.5 lb and measures 9-1/2 x 13 x 1-1/2 in. The portable drafting kit includes a drafting instrument with 3 x 5 or 4 x 6 in. scale and a 180-deg protractor, 50 sheets of paper, and a pencil. It comes in a vinyl, self-locking binder.

Draftette Co., Dept. ED, P. O. Box 794, Beverly Hills, Calif.

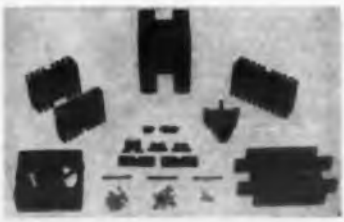
Price: *$8 or $9.*

Selenium Rectifiers 353

Paper base phenolic cartridge houses thin cell selenium rectifiers. Cells are made of 0.010 in. aluminum stock. Stacks have up to 500 cells. Cells operate at 130 C ambient temperature. A single stack used in a half wave circuit will accommodate 15,000 v and will block a peak reverse voltage of 31,500 v.

General Electric Co., Rectifier Components Dept., Dept. ED, W. Genesee St., Auburn, N. Y.

Heat-Sink Kit 415



Complete heat-sink kit series A contains 17 natural-convection, conduction and forced-convection units as well as three sets of mounting kits. The heat sinks provide a range of thermal resistance to cover all possible transistor applications. Natural convection units range from 0.68 to 1.9 C per w.

Astro Dynamics, Inc., Dept. ED, Northwest Industrial Park, Burlington, Mass.

P&A: *$37.50; stock.*

◀ CIRCLE 161 ON READER-SERVICE CARD

EVEN AT HIGH TEMPERATURES, MYLAR® HELPS MOTORS RUN TROUBLE-FREE LONGER!

Mylar* polyester film resists the three main causes of motor failure—heat, humidity and physical stress. Temperatures in the Class B range have relatively little effect on the electrical characteristics of "Mylar". It's also 35 times more moisture-repellent than rag paper . . . 8 times stronger . . . and can't dry out because it contains no plasticizer. "Mylar" also helps reduce size and weight of motors, and gives them an extra safety margin from shock because it repels moisture so well.

Capacitors benefit from "Mylar", too. Last longer, are more reliable . . . at no greater cost than paper units for similar service. In a wide variety of applications, "Mylar" can improve performance, lower costs. Here are some more reasons: • dielectric strength of 4,000 v/mil.** • thermal stability from –60°C. to over 150°C. • resistance to chemicals, aging, abrasion and tearing. Best of all, you can use less, often pay less . . . because you get all these advantages in thinner gauges. Evaluate "Mylar" for your product. Write for free booklet (SC) detailing properties and applications. Du Pont Co., Film Dept., Wilmington 98, Delaware.

DU PONT
REG. U.S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

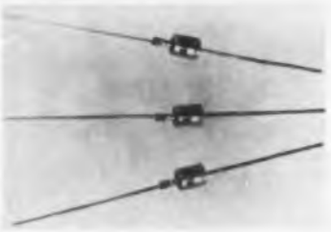
DU PONT MYLAR® POLYESTER FILM

*Registered Du Pont Trademark.
**ASTM D-149.

CIRCLE 162 ON READER-SERVICE CARD

NEW PRODUCTS

Zener Regulators 508



Rated at 1 w. Zener regulators range from 2.8 to 200 v and can carry up to 150-ma test current. JETEC types are 1N1766 through 1N1802; NAE types are PRS3011 through PRS3017, in voltages from 2.8 to 5 v. They are storage tested at 200 C and are hermetically sealed.

North American Electronics, Inc., Dept. ED, 71 Linden St., West Lynn, Mass.

Transient Voltage Indicator 507

Has two ranges: 0 to 200 v at ±5% full-scale accuracy and 0 to 2,000 v at ±2%. Self-contained and portable, the transient voltage indicator detects pulses down to 1 μsec. Input impedance is 5 pf in shunt with 1 meg, both ranges. Battery power is used.

Vapor Heating Corp., Dept. ED, 6444 W. Howard St., Chicago 48, Ill.

Availability: *through distributors.*

Vibration Monitor 628

A transistorized monitor to detect and measure vibration amplitudes is modular in construction and portable. Frequency range is 10 to 1,000 cps and displacement range is 1.5, 5, and 15 mils. Dimensions are 8-3/4 x 3-5/8 x 7-1/2 in.; weight is 4 lb without filters.

Lehigh Valley Electronics, Inc., Dept. ED, Allentown, Pa.

Decade Scaler 686

One mc counter module is a count-to-ten device that utilizes the 8-4-2-1 binary code to count random serial pulses at any rate to 1 mc. Any number of these units can be cascaded by means of front panel connectors. Visual display is by neon-lighted decimal digits. An analog voltage equivalent of the final count is available on the front panel.

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

P&A: *$141.40; from stock.*

Insulating Cloths and Tapes 608

Temperature ranges from 150 to 300 C are offered for the insulating tape designated Mica-Seal. Tape is a pre-stretched fabric coated with mica particles. It is adaptable to potting operations and is useful as slot liners and phase insulation for motors and dielectric for capacitors.

McMillan Industrial Corp., Electronic Components Div., Dept. ED, Brownville Ave., Ipswich, Mass.

Availability: *from stock.*

Bulb for Pilot Lights 496

Miniature, 6-w bulb for pilot lights produces 36 lumens. Filament design spreads light so that lenses of all colors may be used. Voltage rating is 125 v, giving the bulb a life of 1,500 hr avg. Two 3-w coiled tungsten filaments are connected in series and separate mounts protect each filament.

General Electric Co., Dept. ED, Nela Park, Cleveland 12, Ohio.

P&A: *$0.95; to OEM.*

0.01% total — from this new transistorized power supply

Add up *all* the factors: line and load regulation of 0.0005%; short-term drift of 0.001%; and, hum and noise of 50uv rms. Result: total stability of 0.01%!

Krohn-Hite's new Model UHR-T361 transistorized power supply is an important new bench supply for development, measurement and research. Its phenomenal stability also makes it ideal for component tests, and powering computer circuits.

Voltage range: 0-36 volts. Current: 0-1 ampere. AC output impedance: 250 microhms. Transient response: 25 usec. Line voltage: 115/230; 50-400 cps.

The extremely tight line and load regulation of the Model UHR-T361, plus its remote sensing feature, permit remote operation with better regulation at 100 feet, 0.001%, than most other supplies at their terminals. The supply also features remote voltage control for automatic programming.

Constant voltage or constant current can be obtained from this supply. The voltage is constant under pulsed or steady-state resistive or reactive loads. The current is constant to within 0.01%.

Krohn-Hite's new UHR-T361 is convection-cooled, and fully protected against short-circuit, overvoltage, overtemperature, and on/off voltage surges.

Get full information on the UHR-T361, and the 3, 5, and 10 amp Krohn-Hite transistorized power supplies.

KROHN-HITE CORPORATION

580 Massachusetts Avenue • Cambridge 39, Mass.

Pioneering in Quality Electronic Instruments

CIRCLE 169 ON READER-SERVICE CARD

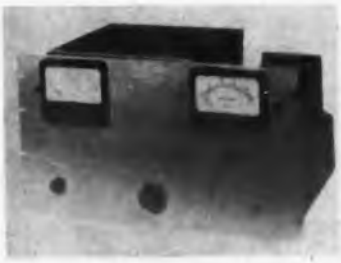
NEW PRODUCTS

Solid State Timers 684

Range is from several seconds to 15 min. Units have wide application as sequencers, time delay relays and automatic cycling switches. Standard operative voltage is 18 to 28 v dc. Other voltages are available on request.

Crane Electronics Co., Dept. ED, 4345 Hollister Ave., Santa Barbara, Calif.

Power Supply 692



Output is 15 to 40 kv at 2 ma, continuously variable, for the power supply model 2M-40. A bar shorts the high voltage output when the unit is not in use. Unit is useful in insulation testing, plastic pinning, electrostatic flocking and painting and other applications.

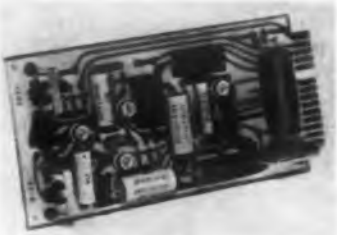
Spellman High Voltage Co., Dept. ED, 1930 Adee Ave., Bronx 67, N. Y.

Multiturn Potentiometers 643

Range is 5 to 600 K ohms for the potentiometers series 3600. Units are available in both 3 and 10-turn models. Resolution is down to 0.004% and 135 tap positions are possible. Operating temperature range is from −55 to +105 C. Standard resistance is ±3%. Power rating at 40 C derating to 0 at 105 C is 5 w for the 3-turn model and 7 w for the 10-turn model.

Duncan Electronics, Inc., Dept. ED, 2865 Fairview Road, Costa Mesa, Calif.

Chopper Stabilizing Amplifier 696



A single-ended, non-inverting device, the series 100 chopper stabilizing amplifier utilizes solid-state circuitry and a 10,000-hr mechanical chopper. It has a stable 80 db dc-to-dc gain with ±5 v output. Terminals provide for either internally filtered or unfiltered output. The unit can be driven from source impedance up to 50 K.

C.E.S. Electronic Products, Dept. ED, 5026 Newport Ave., San Diego 7, Calif.

Blowing Equipment 695

For enclosed rack, cabinet or console use, the Trans-Aire blower line is for use where excessive heat is generated. Units are available in three sizes with air displacement ranges from 100 to 700 cfm. All models have thermal overload protection and automatic reset.

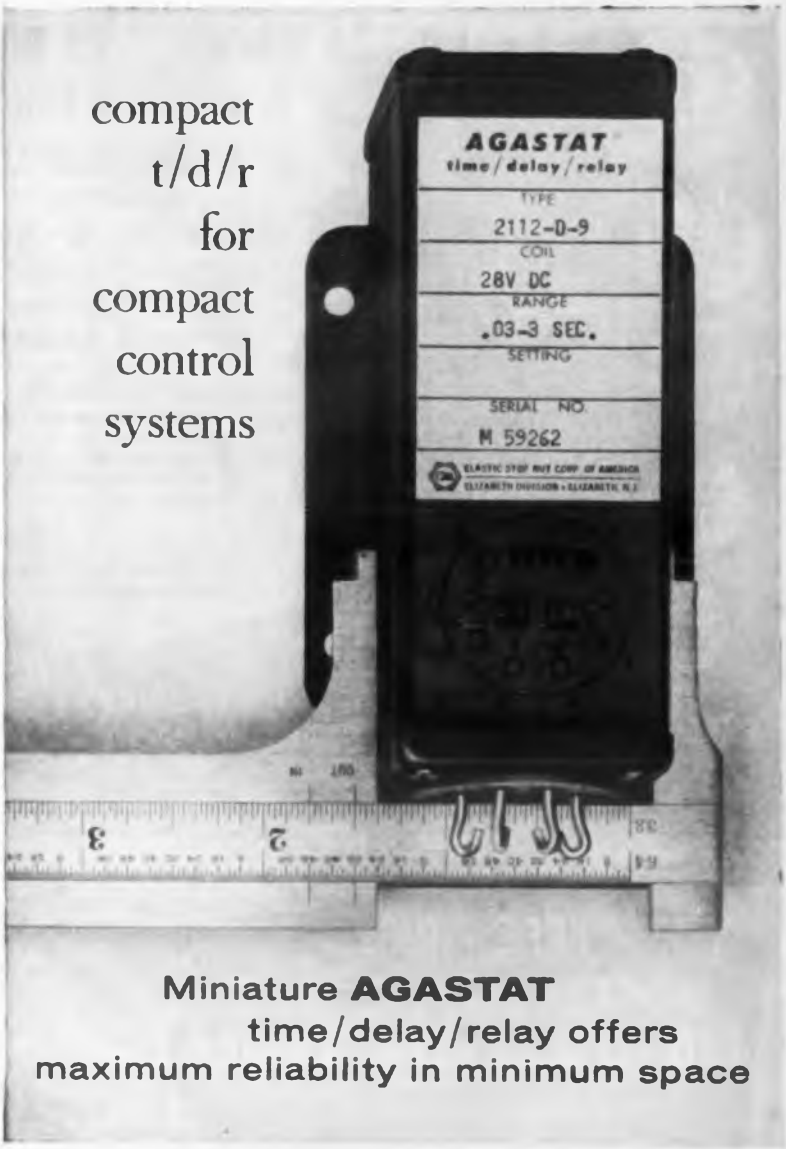
Bud Radio, Inc., Dept. ED, 2118 E. 55th St., Cleveland 5, Ohio.

Follower Amplifier 689

Plug-in follower amplifier model K2-BJ is used as a booster with the company's militarized operational amplifiers. Unit provides for the operational amplifiers an increased steady-state output of 20 ma at ±100 v, gain about 0.8, and output impedance about 250 ohm before feedback.

Philbrick Researches, Inc., Dept. ED, 127 Clarendon St., Boston 16, Mass.
Price: *$49.*

compact
t/d/r
for
compact
control
systems



Miniature **AGASTAT** time/delay/relay offers maximum reliability in minimum space

For control systems where reliability *and* size are important design considerations, specify the Miniature AGASTAT time/delay/relay.

Only 1½ in. square, less than 5 in. high, and weighs as little as 15 oz. Four adjustable models provide delays from .03 sec. to 3 minutes—on pull-in or drop-out. Electrically-operated, pneumatically timed for instant recycling and freedom from voltage-variation drift. Choice of ac and dc operating voltages, with solder lug, octal plug or AN connector terminals.

Since 1931, AGASTAT time/delay/relays have been specified for reliability and accuracy in almost every industry with electrical control requirements. Wouldn't this be a good time to learn what this proven performance can mean in your timing circuit?

We'll gladly send complete details. Just write Dept. M2-49

AGASTAT® TIMING INSTRUMENTS

ELASTIC STOP NUT CORPORATION OF AMERICA
ELIZABETH DIVISION ■ ELIZABETH, NEW JERSEY

IN CANADA: ESNA CANADA, LTD., 12 GOWER ST., TORONTO 16, ONTARIO, CANADA

CIRCLE 172 ON READER-SERVICE CARD

NEW PRODUCTS

Connector Sleeve 646

Entries from 0.156 to 2.375 in. in 1/8 in. increments are available for the connector sleeve assembly G91. Assembly is made watertight through use of an internal grommet and follower at the cable end and an O-ring seal to the connector itself. Underwater tests have qualified fully assembled connector, cable and sleeve to 15 psi for 4 hr.

Glenair, Inc., Dept. ED, 1211 Airway, Glendale, Calif.

Availability: *from stock.*

Temperature Controllers 610

Range is −20 to +125 C for thermistor type temperature controllers model TCK and model TCC. Sensitivity is ±0.05 C. Relay is 10 amp spdt type. Extension cables with male or female connectors or continuous cables to 1,000 ft are available.

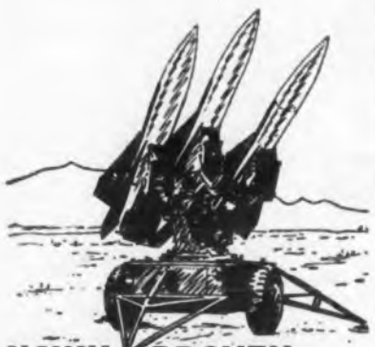
Tri-R Instruments, Dept. ED, 144-13 Jamaica Ave., Jamaica 35, N. Y.

Price: *$125, model TCK; $56, model TCC.*

Vapor Degreaser 694

Heating capacity is 2,000 w for the ultrasonic vapor degreaser. Unit is powered by a solid state 500-w generator which features Magnatrak automatic tuning. Degreaser contains a boiling compartment to remove gross contaminants from metal parts or assemblies and an ultrasonic compartment for a final clean and rinse. Both compartments are stainless steel.

Westinghouse Electric Corp., Industrial Electronics Dept., Dept. ED, 2519 Wilkens Ave., Baltimore 3, Md.



HAWK-PROVEN CONNECTORS

LIONEL
Series S-20

Extra Reliability With—

- Shell-Enclosed, Die-Cast Housings
- Diallyl Phthalate Moldings
- Positive Alignment & Polarization
- Minimum Depth in Mated Position
- Beryllium Copper Contacts for Extended Insertion/Withdrawal Life

4 sizes: 13 to 41 high voltage contacts, 2 and 4 coaxial contacts; Meet applicable MIL specs; Materials & specifications modified to meet your special needs.

• *Write Dept. 19-HW for Series S-20 Dimensional Data Sheets*

Lionel Electronic Laboratories

(Formerly Anton Electronic Laboratories)

1226 Flushing Ave.

Brooklyn 37, N.Y.

CIRCLE 175 ON READER-SERVICE CARD

Flat Capacitor 647

Range is 0.01 to 0.33 μfd for the capacitor 605. Rating is 50 v. Temperature range is −55 to +125 C at full rated voltage. Tolerances are ±20, ±10 and ±5%. Metal case is hermetically sealed and is a flat shape with oval cross section. Units meet all military environmental requirements and vibration specifications of NIL-C-19978A.

Good-All Electric Manufacturing Co., Dept. ED, Ogallala, Neb.

Power Operators 685

For control drive applications, three models of Powertork power operators develop output torques of 30, 60 and 120 ft-lb. at 1/2 rpm. Gear train is completely immersed in a high dielectric, radioactive-shielding oil which is suitable for service from −30 to +200 F. Drive motor is an 1,800 rpm reversible split capacitor type, also immersed.

Electro-Mech Corp., Reliance Instrument Div., Dept. ED, 500 Livingston St., Norwood, N. J.

Accuracy Is Our Policy

The photograph accompanying the description of the ADC-1B analog-to-digital converter manufactured by Systems Engineering Laboratories, Inc., Fort Lauderdale, Fla., which appeared on p 68 of the June 21 issue of ELECTRONIC DESIGN, showed the five different types of circuit cards used in its construction rather than the converter. Also, the line that reads only five different circuit cards are used . . ., should have read, only five different types of circuit cards are used.

Extra High Purity Gold Plate!

Sel-Rex®

TEMPEREX® HD*

TEMPEREX HD electroplate meets or surpasses the most exacting specifications of the electronics industry. Its deposits of 99.99+ purity provide a uniformity of metallurgical characteristics never before attainable in gold electroplate.

Other advantages: 75 Knoop hardness; easy to solder or weld; and an exceptional ductility that permits *cork-screw twisting of electroformed strips without fracturing!*

Write for details.

*Patent applied for

SEL-REX CORPORATION

NUTLEY 10, NEW JERSEY

World's largest selling precious metal plating processes

CIRCLE 176 ON READER-SERVICE CARD

FAST ECONOMICAL SERVICE ON

short run

BERYLLIUM COPPER

screw machine products

Consult—

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on prototypes and sample quantities

Our modern plant and facilities for turning, grinding, milling, drilling, threading, heat-treating and electroplating are available for small or large volume. Simple or intricate, flanged or tapered designs from .020" to 1.00" diameters. Send drawings and specifications for quotations.

INSTRUMENT SPECIALTIES CO • INC

270 Bergen Boulevard

Little Falls, New Jersey

Telephone: CLifford 6-3500

CIRCLE 177 ON READER-SERVICE CARD

NEW PRODUCTS

Recording/Reproducing System 649

Ten simultaneous audio transmissions can be recorded on 1/2 in. tape for the multichannel recording/reproducing system model T-1510. A fail-safe feature instantaneously detects mechanical or electronic failure and automatically starts standby recorder. System is adaptable for language laboratories, airport communications, etc.

Magnasync Corp., Dept. ED, 5546 Satsuma Ave., North Hollywood, Calif.

Matching Transformers 601

Broadband high frequency matching transformers are available with ratings of 1, 5 and 20 kw. Frequency range is 2 to 30 mc. Units can be supplied in any of the following four standard impedance transformations: 50 ohms unbalanced to 70 ohms, 150 ohms, 300 ohms or 600 ohms, balanced. Transformers are for indoor or outdoor use.

Barker & Williamson, Dept. ED, Bristol, Pa.

Temperature Controllers 644

Range is —300 to 2,000 F for indicating temperature controller series 6000-A. Units utilize a Wheatstone bridge circuit with a choice of four control modes covering the complete range of temperature control from on-off through proportional and 3-position operation. A fail-safe resistance sensing element is used.

Electronic Processing Corp., Dept. ED, 436 Bryant St., San Francisco, Calif.

Price: *from $185 to $250.*

YOUR PRIVATE **ED** LINES

When employment information is obtained through *ELECTRONIC DESIGN*, it's sent direct to your home, so that only you and one prospective employer at a time know about it. You can conduct your employment campaign privately—as it should be conducted.

This is why every Reader Service Card reserves a line for your home address, and why circled numbers are detached from Career Inquiry Service Forms sent to companies. You can apply for many jobs simultaneously . . . only *you* will know how many.

Use the Career Inquiry Service Form, and the Reader Service Card when job hunting. They're your *private lines* to employment opportunities . . . another service for you from *ELECTRONIC DESIGN*.

Relay Socket 492

Microminiature relay socket model 2999, designed to fit the firm's four-pole relay, has a fiber-glass filled diallyl FS5 body and terminals of heat-treated beryllium copper with gold over silver plate. Dielectric strength is 1,500 v rms between terminals. The 14 socket holes have 0.1-in. spacing.

Branson Corp., Dept. ED, P. O. Box 234, Whippany, N. Y.

Gold Salts 638

A stress-free, pure, ductile, and tight-grained deposit is claimed for Orotemp 24, a new 24-karat neutral gold salt. The salt contains no brighteners or free cyanide. Discoloration under heat is prevented by the salt's purity. Orotemp 24 fuses with gold-silicon eutectic alloy without discoloration and plates directly on stainless steel, monel, kovar, and other alloys.

Technic, Inc., Dept. ED, Box 965, Providence, R. I.

Prices: *$45 to $42 per troy oz.*

Overvoltage Protector 480

Responds in 2 μsec. Designed for permanent mounting in transistorized equipment, the overvoltage protector places a short across the power input terminals to the semiconductor circuit and discharges capacitors. It can be furnished for up to 400 v. Overvoltage pulses of 1% with a duration of 1/3 μsec will trigger the protector.

The Victoreen Instrument Co., Jordan Electronics, Dept. ED, 121 S. Palm Ave., P. O. Box 2047, Alhambra, Calif.

P&A: *$32.50; 30 days.*

solid
state
airborne

TELEMETRY

system

Applied Electronics Corporation of N. J. are producers of the most reliable solid state telemetry systems available today.

Supplied for use on Titan, Minute Man, Sub Roc and other major missile programs with an outstanding record of operational performance. In addition to the company's standard line of PAM, PDM and PCM systems, a new family of satelite telemeters is being produced and supplied for

QUALIFIED.....

use on several satelite projects. These equipments are characterized by low power dissipation, small size and high accuracy. Technical Specialization has enabled us to produce the most advanced and reliable completely solid state telemetry systems. Several of these are briefly described opposite.

Applied Electronics Corporation
OF NEW JERSEY

METUCHEN, N. J.
TWX — METU 708
Liberty 9-9200

45 x 20 PDM MULTICODER
MODEL MDH — 4 SERIES

PDM Multicoders solid state designed with utmost compactness, highest accuracy with low power dissipation. This equipment contains power supply, commutator and pulse duration modulator. The equipment is also available for low level applications

HIGH SPEED SOLID STATE
PCM MULTICODER MCH SERIES

PCM System or digital Telemeter includes a high resolution electronic commutator which accurately samples up to 120 channels, coder and power supply in a package size of 6" x 6" x 9"—the smallest working digital telemeter available today

PDM, PCM, PAM

30 CHANNEL LOW LEVEL PAM
MULTICODER MAL-3 SERIES

PAM are available in all standard IRIG sampling and channel configurations. Solid State, high reliability, long life and low power dissipation —also available for low level applications

30 CHANNEL TWO POLE
SOLID STATE PAM MULTICODER
MODEL MAH-3-2 SERIES

Engineering Specifications are available on all available AEC Designed Equipment, our Engineering and Research, and Design Departments are always available to discuss your specific telemetry problems

OFFICES
WASHINGTON — EX 3-0451
SANTA MONICA, CALIF
— GL 1-2214

CIRCLE 183 ON READER-SERVICE CARD

NEW PRODUCTS

Conductive Molding Compound 439

Corrosion resistance and physical strength are properties of Grade X-1011-F conductive compound of fiber glass reinforced polyester. It can be molded into blowers for explosion-proof equipment. Impact strength is 5 ft-lb per in., flexural strength is 16,000 psi and tensile strength is 5,000 psi.

The Glastic Corp., Dept. ED, 4321 Glenridge Road, Cleveland 21, Ohio.

Price: *$0.63 to $0.69 per lb.*

Recording Voltmeter 533

For maintaining and trouble-shooting electrical systems, the Amprobe Recorder Voltmeter offers a miniature recording device. The unit is inkless, uses smudgeless, pressure-sensitive paper. The internal-core meter movement, motor and chart-drive mechanism are shielded by Mylar.

Amprobe Instrument Corp., Dept. ED, 630 Merrick Road, Lynbrook, L. I., N. Y.

P&A: *$79.85, regular-scale model; $84.85, expanded-scale model; from stock.*

Explosion-Proof Motor 532

For Class I, Group D and Class II, Groups F and G environments. Explosion-proof motors are avail-

able in 1- to 3-phase induction or synchronous types, 1/150 to 1/20 hp. Torque or dynamic brake types also are available.

Holtzer-Cabot Motor Div., National Pneumatic Co., Inc., Dept. ED, 125 Armory St., Boston 19, Mass.

Squib Testing Device 523

0.01 C temperature rise in a squib wire can be detected by this squib testing device. Unit is for testing missile and rocket systems for dangerous rf energy. Self-contained and battery operated, it has all transistor circuitry and five selective ranges of sensitivity.

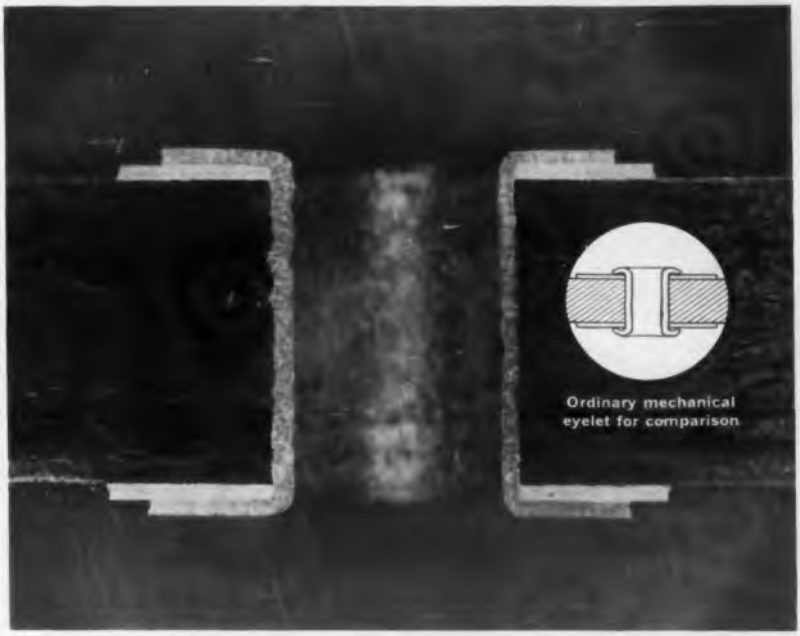
KeXplore Electronics, Inc., Dept. ED, Houston, Tex.
***P&A:** $379; less than 60 days.*

DC-to-DC Dynamotor 525

Output is 500 w at 25 C for 5,000 hr and 500 w at 85 C for 1,000 hr for any output voltage between 100 and 2,000 v dc and 250 w at 25 C for 5,000 hr and 250 w at 85 C for 1,000 hr for any output voltage between 12 and 100 v dc. Input is 24 to 30 v dc with transient capabilities up to 34 v dc.

NJE Corporation, Dept. ED, 20 Boright Ave., Kenilworth, N. J.

A NEW IMPORTANT EXCLUSIVE IMPROVEMENT IN THRU CONNECTIONS



The Electroformed Eyelet

Here's a welcome answer to your printed circuitry problems—the **Electroformed Eyelet,** new from Graphik Circuits. This remarkable thru connection is as strong as an eyelet, as reliable as the finest plated thru-hole. A new GC technique eliminates failures due to gas entrapment as well as other common eyelet troubles caused by vibration, intermittancy, or high electrical resistance at mechanical connections. Economical, too—if a precious metal finish, such as gold, is desired in the thru-hole, use of the **Electroformed Eyelet** eliminates the need to gold-plate the entire pattern and conductor paths. Extremely close line width and spacing tolerances are possible, as are heavy wall deposits of .005 or greater without danger of excessive build-up on surface conductors.

The Electroformed Eyelet is just one more example of the superb craftsmanship you always find in Graphik Circuits printed circuitry.

Write us, or call your nearby Cinch Manufacturing office.

PRINTED DOT CIRCUITS

Cinch

Graphik Circuits

Division of Cinch Manufacturing Company, 200 So. Turnbull Canyon Road, City of Industry (Los Angeles), Calif.
Offices in 19 Principal Cities throughout United States listed under Cinch Mfg. Co. or United-Carr Fastener Corp.

CIRCLE 186 ON READER-SERVICE CARD

Another reliable GENERAL MAGNETICS "MAG MOD" Miniature

Continuous Accuracy within ± 5% of Theoretical Product over the entire Ambient Temperature Range

NEW MAGNETIC multiplying MODULATOR

Specifically designed to deliver an analog output voltage which is the continuous product of two variable input voltages. One of these is an excitation voltage which varies over a pre-determined range; in this case, 0 to 1 VRMS 400 cycles per second. The other signal is a DC current which varies between 0 and ± 400 μa. The output voltage is 400 cycles AC, and is always in phase or 180° out of phase with the variable excitation or fixed reference, i.e., in phase when the variable amplitude DC signal is positive, and 180° out of phase when the DC signal is negative.

TYPE MCM 515-1 SHOWN ACTUAL SIZE. COMPLETELY RUGGEDIZED, VIRTUALLY SHOCK AND VIBRATION PROOF. WEIGHS ONLY ONE OZ.

THERE IS NO SUBSTITUTE FOR RELIABILITY!

Specify "MAG MOD" miniature components for infinite life, faster response time, negligible hysteresis and extreme stability. Call or write for new Brochure 102 on "MAG MOD" Miniaturized Magnetic Modulators and Magnetic Multiplying Modulators.

General Magnetics • Inc

135 BLOOMFIELD AVENUE
BLOOMFIELD, NEW JERSEY
Telephone: Pilgrim 8-2400

CIRCLE 187 ON READER-SERVICE CARD

REMOTE DATA RETRIEVERS, EVENT AND DATA RECORDERS

117.50
121.00
122.99
127.99

PRINT AND PLOT SIMULTANEOUSLY

OPERATION MONITOR • PRINTERS • PLOTTERS • TIME QUANTIZERS

SPECTRUM ANALYSIS, DENSITOMETERS, FACSIMILE RECORDERS

HOGAN FAXimile recorders are available with up to 2000 individual styli for simultaneous recording. A wide range of stylus spacings is offered—up to 100 to the inch for high-speed facsimile, television and radar recorders and high resolution printers and plotters. Chart widths to 30" and feed rates to 50" per second.

Hogan specializes in electrolytic techniques for event, spectrum analysis, oscillograph and facsimile recording, frequency time analysis and special purpose binary and gray scale record applications. Hogan electrolytic recording papers provide a permanent high contrast black on white record which is reproducible on most conventional office duplicators.

Whatever your recording problem may be — contact *HOGAN FAXimile, a subsidiary of TELautograph Corporation, 635 Greenwich Street, New York 14, N. Y.*

HOGAN FAXimile Corporation • 635 Greenwich St., New York 14, N. Y.
A SUBSIDIARY OF TELAUTOGRAPH CORPORATION

CIRCLE 188 ON READER-SERVICE CARD

NEW PRODUCTS

Vacuum Tube Voltmeter 690

Frequency range is 10 cycles to 2 mc for the ac vtvm model 58. Unit has a frequency and temperature compensated decade attenuator, calibrated both in voltage and 10 db steps, consisting of 0.5% film resistors. Allowing for 10% variation of line voltage, accuracy is still 1% of full scale from 30 cps to 100 kc, and 2% from 10 to 30 cps and from 100 kc to 2 mc.

Precision Apparatus Co., Inc., Dept. ED, 70-31 84th St., Glendale 27, N. Y.

Loop Antenna 639

This balanced, self-supporting, electrostatically shielded loop antenna (L-1) has been designed for outdoor installation in any environment. The unit is designed for low and very-low frequencies where electrostatic shielding is needed for reception. The loop is for calibrated measurement as well as for normal reception.

Aerospace Research, Inc., Dept. ED, 94 Massachusetts Ave., Cambridge 39, Mass.
P&A: *$98.50; from stock.*

Recording System 620

Analog voltage inputs, corresponding to differential and absolute temperatures and thermal radiation levels, are measured, integrated and recorded by this recording system. The system has a capacity of 36 channels. Input data are sampled for value and sign, stored and integrated for a one hr period, then recorded via a tape punch. Sampling rate is 100 samples per channel per hr.

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

Accelerometer Switch 687

Air damping and flexure suspension are features of the accelerometer switch type AS24-0201-1. Unit is useful in testing where the actual accelerations are not known. When the desired acceleration level is determined the switch can be furnished in production quantities with exactly the same dynamic characteristics with pre-set range.

Humphrey, Inc., Dept. ED, 2805 Canon St., San Diego 6, Calif.

Index Mechanism 600

Rotary switch index mechanism will achieve a minimum of 50,000 cycles. Designation is Tri-Spring, Tri-Ball mechanism. The mechanism can be specified for the company's 20 deg throw, 18 position switches and for 15 deg throw, 24 position switches.

Oak Manufacturing Co., Dept. ED, Crystal Lake, Ill.

Radio Navigation System 554

Pulsed, hyperbolic radio nagivation system, Loran C, provides continuous position-fixing information for land, sea and air navigation. Transmission frequency is 100 kc. Applications include in submarines, underwater cable laying, mapping and surveying.

Collins Radio Co., Dept. ED, P. O. Box 1891, Dallas 21, Tex.

Epoxy Material 626

One-component, epoxy-based material, in dry powder form is designed for easy handling in potting applications. Low shrinkage and low coefficient of thermal expansion approach inorganic materials in value. Exceptionally high thermal conductivity is claimed for the material.

Hysol Corp., Dept. ED, Olean, N. Y.

Engineers! Designers!

THERE IS NO SUBSTITUTE FOR RELIABILITY!

Specify—

PERFORMANCE PROVEN "MAG MOD"

MAGNETIC MODULATORS

Actual Size

For complete specifications and application data on "Mag Mod" Miniature and Standard Components, call or write.

Miniaturized design permits engineers to employ these new components in transistorized printed circuit assemblies and wafer type structures. All models offer maximum reliability, fully ruggedized construction and conform to MIL-T-27A specifications.

- **COMPLETE RELIABILITY**
- **INFINITE LIFE**
- **FASTER RESPONSE TIME**
- **NEGLIGIBLE HYSTERESIS**
- **EXTREME STABILITY** (Ambient Temp. Range from −75° to +135°C)
- **COMPACT SIZE**
- **LIGHTWEIGHT**

Typical circuit applications for Magnetic Modulators are algebraic addition, subtraction, multiplying, raising to a power, controlling amplifier gains, mechanical chopper replacement in DC to fundamental frequency conversion, filtering and low signal level amplification.

GENERAL MAGNETICS • INC

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Telephone: Pilgrim 8-2400

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..HIGH VOLTAGE TESTING

of Electronic Cables, Components, Materials and Completed Assemblies

Mobile D-C HYPOT

Rugged . . Mobile . . for Production, Installation and Maintenance Testing

Output . . 120 kv models provide up to 5000 microamperes d-c. 75 and 45 kv models offer up to 10 ma. d-c.

115v A-C Line . . Input through three-conductor power cord with standard two prong plug and grounding clip.

Self-Contained, Fully Portable . . Single mobile housing with rubber tired wheels and push handle contains metering circuitry and high voltage supply (oil immersed above 45 kv).

Safe, Simple Operation . . Direct reading of insulation leakage current. Fully interlocked, cabinet grounded, output cable shielded . . to protect operator and equipment.

. . for Every Application

Heavy Duty HYPOTS®
A-C or D-C, to 150 kv.

Bench Type HYPOTS®
A-C to 35 kv, 2 kva
D-C to 45 kv, 25 ma

Mobile HYPOTS®
A-C to 30 kv, 10 kva
D-C to 120 kv, 10 ma

Portable HYPOTS®
A-C to 10 kv, 230 va
D-C to 5 kv, 2 ma

Write for Manual J-67

"Methods for Insulation Testing . . Engineering . . Production . . Maintenance

ASSOCIATED RESEARCH, Incorporated

3769 W. Belmont Ave., Chicago 18, Illinois

CIRCLE 192 ON READER-SERVICE CARD

test . . . test . . . test . . .

If you feel you *must* make your own pots to get exactly what you need, don't overlook quality control along the way! And this can be a messy business, what with special, elaborate techniques to quality-check *every* production stage! Oh, you'll get involved in maddening bouts with visual comparitors, ratiometers, environmental testing labs — and when you've finished — *and* made a few hundred revisions — you *might* have the quality you want!

So, before you go fly a kite — consider Ace. We've been all through this before, and have what is regarded to be the finest quality control system in the industry. It enables us to keep our final costs down, by rejecting sub-standards at each stage, without waiting for the final inspection. Although it's more work this way, we can offer a higher degree of resolution and linearity at a lower price. So, for precision-at-price, see your ACErep!

Here's 0.3% linearity in a ½" pot: the Series 500 ACEPOT®. Single-turn, −55° to 125°C range. As with all Ace components, tested in every stage of its manufacture!

ACE ELECTRONICS ASSOCIATES, INC.
99 Dover Street, Somerville 44, Mass.
SOmerset 6-5130 TMX SMVL 181 West. Union WUX

Acepot® Acetrim® Acesel® Acohm® *Reg. Appl. for

CIRCLE 193 ON READER-SERVICE CARD

NEW PRODUCTS

Multiple Function Meter 630

Model VM-235 phase angle voltmeter combines the functions of an ac voltmeter, phase sensitive null indicator, power factor meter and measures separately the in-phase and quadrature components of a signal. Twelve ranges cover from 1 mv to 300 v full scale. Accuracy as a phase angle is ±3% full scale, and ±2% of full scale as an ac voltmeter. Null sensitivity is 2 μv and harmonic rejection is greater than 55 db in the phase sensitive operating mode.

North Atlantic Industries, Inc., Dept. ED, Terminal Drive, Plainview, L. I., N. Y.

Silicon Transistors 419

Switch up to 120 w without heat sinks. Having a volume of 0.028 cu in., types 2N2033, 2N2034 and 2N2035 silicon transistors are intended for use at collector currents of 500 ma, 1 amp and 1.5 amp, respectively. Types 2N2033 and 2N2034 are in the TO-5 package; type 2N2035, the TO-8 package.

Silicon Transistor Corp., Dept. ED, Carle Place, N. Y.

Bi-directional Counter 619

Fully transistorized bi-directional counter is applicable for numerical information readout, recording or process control. The counter indicates true position while going through zero in either direction, eliminating the need for external reset to establish a reference. Specifications are: weight, 30 lb; counting rate, 45,000 counts per sec; readout, 5 standard decades and polarity indicator; signal output, up to 100 v on 53 pins.

Crane Co., Hydro-Aire Div., Dept. ED, 300 Winona Blvd., Burbank, Calif.

Tape Punch 648

Motorless direct-drive paper tape punch that will perforate a 5-, 6-, 7- or 8-hole tape at rates up to 20 characters per sec is designated model P-100. Unit is available in a cabinet for bench or desk use, without a back cover for oem mounting, and with a 19-in. front panel for rack mounting. Punches are actuated directly by solenoids.

Invac Corp., Dept. ED, 14 Huron Drive, Natick, Mass.

P&A: $495; 90 days.

Strip Conductor 599

Aluminum coil strip conductor with smooth precontoured edges is available in 0.16 to 0.51 in. thicknesses.

Reynolds Metals Co., Dept. ED, Richmond 18, Va.

Printing Tube 614

Rate is 10,000 lines per minute for the 8-1/2 in. electrostatic charge printing tube type SC-3075. Tube uses magnetic deflection and focus. Uses include reproduction of charts, photographs, numbers and words.

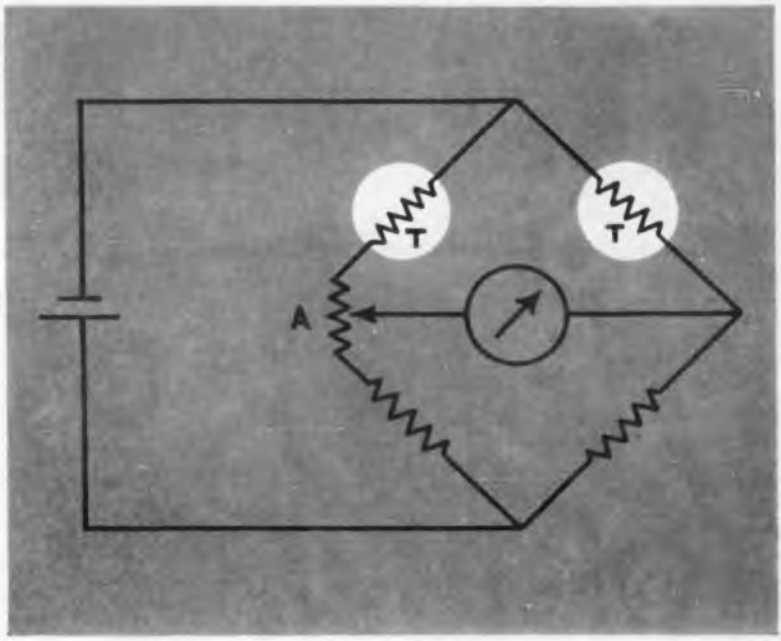
Sylvania Electric Products, Inc., Dept. ED, 730 Third Ave., New York 17, N. Y.

Recording System 497

Sweeping-image recording system model 339B is for the study of transient events with velocities to 200,000 ft per sec and duration as short as 5 x 10^{-9} sec. Applications include flash-tube and spark-discharge phenomena, simultaneity of plane-wave generation and simulated nose-cone re-entry studies.

Beckman & Whitley, Inc., Dept. ED, San Carlos, Calif.

ONE OF A SERIES EXPLORING **THERMISTOR** APPLICATIONS



A little thermistor makes a big difference in many thermal conductivity instruments

Place two small bead thermistors in a bridge circuit where enough current flows to heat them to 150° C, and you'll find you have an instrument for the measurement of many different physical phenomena. *For example:*

GAS ANALYZER — Place the thermistors in small cavities filled with indentical gases, and balance the bridge by varying the setting of "A". A change in the gas in one of the cavities will either raise or lower the resistance of the thermistor because of a change in the thermal conductivity. This will unbalance the bridge and give a reading on a meter.

FLOW METER — Seal a thermistor in a cavity, and place the other thermistor in a pipe. Balance the bridge when there is no flow through the pipe. When the flow starts, the resistance of the thermistor changes, and the bridge becomes unbalanced.

ANEMOMETER — Design the instrument with a sensing thermistor held in free air, and it will be capable of measuring air velocity from the slightest breeze to a gale.

VACUUM GAUGE — Place one of the thermistors in an evacuated bulb and the other in a chamber connected to a vacuum pump. Pump the chamber down to a high vacuum, and balance the bridge. A reading can be obtained when the chamber is not a high vacuum because the presence of air will cool the thermistor and raise its resistance.

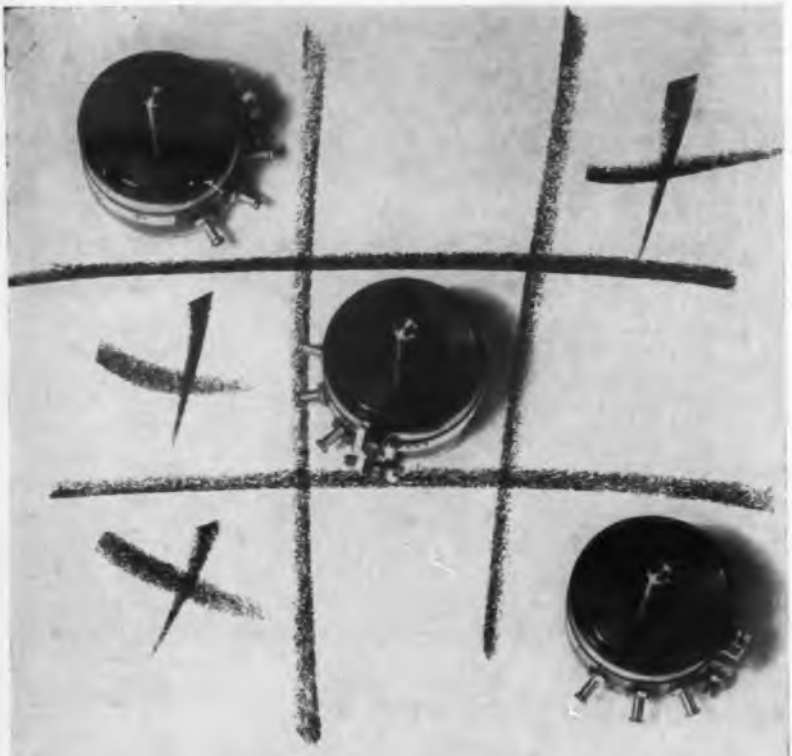
Thermistors can be used in many other circuits to great advantage. For details, application assistance and new Thermistor Catalog EMC 4, write:

Fenwal Electronics' new, modern production facility and offices mean better service and better products for you.

Fenwal Electronics

63 FOUNTAIN STREET
FRAMINGHAM, MASS.

CIRCLE 196 ON READER-SERVICE CARD



WINNER!

It's not the game, it's winning that counts—and Duncan potentiometers score right down the line. Precision, quality and reliability (three in a row) offer a combination that thwarts competition. Simple? Only because Duncan has improved design and manufacturing techniques—become expert in potentiometer oneupmanship.

Our pots can fill that blank spot on your board. The next move is yours. Put your x on this advertisement (name and address will further clarify) and return it to us. We'll be pleased to send you a complete list of the Duncan winners.

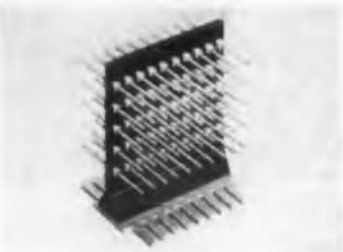
Exceptional vibration and shock performance (30g to 2,000 cps vibration and 50g shock) make Duncan's miniature ½" single turn Model 1201 above, particularly suitable for military servo packages. Diallyl pthalate housing withstands shock and protects against fungus, acid and alkali attack. Operating temperatures to 150°C are available.

DUNCAN ELECTRONICS, INC.
2865 FAIRVIEW ROAD • COSTA MESA, CALIFORNIA

CIRCLE 197 ON READER-SERVICE CARD

NEW PRODUCTS

Wire Wrap Terminal Block 629



For use with a variety of commercially available wire wrap tools, this series of terminal blocks is available with standard assemblies of 10 and 20 terminals per row. Terminals are 0.045 in. sq on 0.220 x 0.375 in. centers. They are locked in place with nylon bushings in a block of anodized aluminum. Base is fiber glass reinforced plastic with slots for wire fanning.

Magnetic Controls Co., ADC Products Div., Dept. ED, Minneapolis, Minn.

Epoxy System 609

Temperatures to 500 F can be withstood for continuous operation at extended periods of time. Mereco 43-21 is a low viscosity epoxy impregnating and casting system. Heat distortion temperature is 148 C. System has a working life of at least four weeks. It is useful in vacuum impregnating operations and laminating applications.

Mereco Products, Div. of Metachem Resins Corp., Dept. ED, 530 Wellington Ave., Cranston, 10, R. I.

Wirewound Resistors 650

Range is 1 ohm to 1 meg for wirewound resistors types 447-P and 446-P. Rating is 1/8 w from −65 to +125 C, derated 5% per deg C over 125 C. Standard tolerances available to 0.01%. Temperature coefficient is 2 ppm per C. Size of resistor type 447-P is 1/4 x 1/4 x 1/8 in. with printed circuit type leads. Size of type 446-P is 1/2 x 1/4 x 1/8 in.

Kelvin Electric Co., Dept. ED, 5907 Noble Ave., Van Nuys, Calif.

Brushless DC Fan 499

Moves 100 cfm at free delivery. Model 3201 bushless dc motor-fan, rated for 28-v operation, measures 1-3/4 in. deep by 4-11/16 in. sq. A variety of speeds, directly proportional to inputs of 20 to 40 v dc, are possible. Frame and impeller are of aluminum.

Astro Dynamics, Inc., Dept. ED, Northwest Industrial Park, Burlington, Mass.

Beryllia Oxide 606

Ceramic-to-metal seals of beryllia oxide are inorganic and have the characteristic pure oxide properties of high resistivity and low dielectric loss at elevated temperatures. Vacuum tightness has been tested with a mass spectrometer to 2 x 10^{-10} cc/sec of helium.

Electronic Materials Corp., Dept. ED, 131 Lexington St., Waltham 54, Mass.

Aluminum Oxide 550

Purity is 99.8%. Aluminum oxide can be furnished in particle sizes ranging from 0.3 to 0.7 microns. This high-density powder is suitable for applications such as ceramics, insulators and high-temperature coatings.

Republic Foil, Inc., Dept. ED, 55 Triangle St., Danbury, Conn.

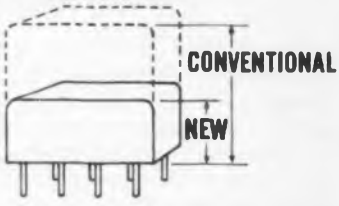
Availability: *in samples.*

Connector Kit 622

A designer's kit that provides wide flexibility in the use of ribbon cable includes everything needed to fabricate special cable assemblies. The Tape-Term connectors are for use in terminating or connecting ribbon cable to almost any type of electrical connection, including wire type connectors.

Digital Sensors, Inc., Dept. ED, 6443 N. Figueroa St., Los Angeles 42, Calif.

NEW LEACH HALF-SIZE CRYSTAL CAN RELAY



REVOLUTIONIZES PRINTED CIRCUIT PACKAGING

It's only .400 inches high. Weighs only .250 ounces. New Leach M-250 is so tiny it uses less than half the space needed by standard subminiature crystal can relays!

Space is saved on printed circuit boards because three M-250s will replace one ordinary, horizontally-mounted crystal can relay. And with its 0.2-inch terminal spacing and internal terminal connections, it is interchangeable with conventional crystal can relays.

Simplified design, mechanized production with minimum human contact, rotary balanced armature design and small space requirement—four reasons why you should specify Leach Half-Size Crystal Can Relays for your printed circuits (and that's just half the story!)

Available *now:*

Contact Ratings . . . . . Low level to 2 amps.
Normal Coil Operating Voltages . . . . . 6 to 26.5 VDC
Meets or exceeds all requirements of Mil-R-5757D.

Get the whole story. Write for complete technical specifications and application information.

LEACH *CORPORATION*

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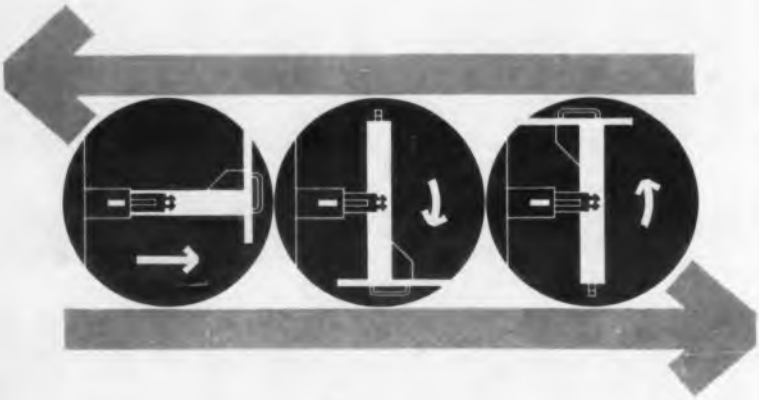
EXPORT: Leach International, S. A.

CIRCLE 200 ON READER-SERVICE CARD

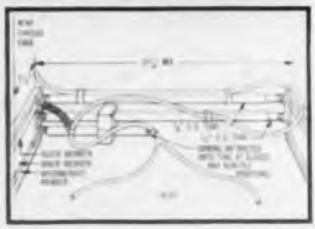


The Ins and Outs of System Packaging

Development of the common cabinet drawer was as important a contribution to storage as the wheel to mobility. Use of ball-bearings appreciably improves the action of both. Advanced drawer design has been applied by Jonathan to electronic chassis storage in the form of close tolerance, extruded aluminum ball-bearing slides for precision packaging. Now chassis are instantly accessible for maintenance and replacement. Gear of any weight may be accommodated without restriction of length and travel, and with tilting and locking features.

First Precision-Designed

Cable Carrier



The new Power Track Cable Carrier facilitates servicing rack mounted electronic chassis without disconnecting the power source. It is the first cable carrier with uniform telescopic action in the carrier and the slides. Telescopic supporting arms are mounted to opposing sides of 3-member Jonathan Thinline telescoping chassis slides, forming a carrier along which the cable is supported. This transfers cable weight to the strong, smooth-running arms and ball-bearing slides, effectively preventing damaging vibration and shock.

The telescoping action allows full drawer extension and 90° tilting up and down. Since the cables are unable to sag or bind, there is no longer risk to other stored electronic chassis. Cable is compactly stored in minimum depth. The carrier system meets all applicable military standards.

Write for new 16 page descriptive brochure.

JONATHAN
MANUFACTURING COMPANY

720 East Walnut Avenue
Fullerton, California

Eastern District Offices
1209 Teaneck Road
Teaneck, New Jersey

CIRCLE 201 ON READER-SERVICE CARD

NEW PRODUCTS

Potentiometer Recorder 627

Self-balancing potentiometer recorder, the Recordette-4 measures 6-3/4 x 8-1/2 x 10 in. Specifications include: accuracy, 1/2%; full scale balancing time, 3/4 sec; maximum permissible source resistance, 50 K; chart width, 4 in.; chart speeds, 1/4 in. per hr to 12 in. per min. Input circuit is floating with separate chassis ground.

Instrument Corp. of America, Dept. ED, 516 Glenwood Ave., Baltimore 12, Md.
P&A: *$380; one month.*

Receptacle Jack 637

For printed circuit or wiring applications that incorporate test points at various circuitry positions. The SKT-111PC jack is only 0.381 in. in height before spin-over of mounting stud. It accepts a standard 0.080 in. D probe x 0.250 in. L maximum. Overall diameter of the Teflon body is 0.218 in.

Sealectro Corp., Dept. ED, 139 Hoyt St., Mamaroneck, L.I., N. Y.

DC Recording Amplifiers 607

Frequency response is dc to 5 kc ±1 db for the amplifier RA-1665 that consists of an input chopper-modulator, stabilized band-pass amplifier and an output chopper demodulator. Sensitivity is ±20 mv for ±0.45 ma to the record head. A RA-1666 chopper oscillator supplies the high-frequency square wave signals for up to 13 amplifiers.

Wextrex Recording Equipment, Dept. ED, 335 N. Maple Drive, Beverly Hills, Calif.

Receiving System 621

Six-channel vlf receiving system covers the 10 to 30 kc frequency range. Sensitivity is better than 1 μv per meter for 0 db signal to

noise ratio in 100 cps if noise bandwidth. All circuits are solid-state, each channel is fixed-tuned with plug-in filters. Channel filters may be changed by replacing the plug-in rf filter and changing the local oscillator frequency.

Develco, Inc., Dept. ED, 440 Pepper St., Palo Alto, Calif.

P&A: *six channel system, without local oscillator synthesizer, $3,600; stock to 60 days.*

Magnetic Amplifier 498

Proportional-power magnetic amplifier type 300 SRMA D 73312 is designed for precise control applications. A linear change in the system input produces a percentage change in process power. It operates from a 110 v, single-phase, 60-cps line with a 0 to 5 ma input; the output is 0 to 85 v dc.

Hevi-Duty Electric Co., Dept. ED, 304 Hart St., Watertown, Wis.

Phase-Angle Counter 500

Range is 0.005 to 500 cps. Model 1002 phase-angle counter measures instantaneous value of phase angle between two signal voltages. No amplitude adjustment is needed from 2 to 100 v rms. Direct reading in degrees is expressed in four digits with a resolution of 0.1 deg.

Ad-Yu Electronics Laboratory, Inc., Dept. ED, 249-259 Terhune Ave., Passaic, N. J.

Price: *$948.*

Accuracy Is Our Policy

The photograph accompanying the description of the model V-46 digital voltmeter manufactured by Cubic Corp., San Diego, Calif., which appeared on p 115 of the Aug. 2 issue of ELECTRONIC DESIGN, shows the S-46 data acquisition system rather than the V-46 voltmeter. The model V-46 digital voltmeter is a smaller unit measuring 19 x 5-1/4 x 14 in. deep.

The CAMBION® Teflon* Line

E-X-P-A-N-D-S

More Types...More Advantages

Now you have 138 basic types of CAMBION Teflon-insulated terminals to choose from . . . including all the popular sizes and mounts!

Thanks to their excellent electrical stability, environmental endurance and mechanical strength, CAMBION Teflon terminals bring new solutions to old design problems. For example, they can be easily inserted directly into chassis with a positive grip. This cuts production time and costs. Also, these terminals can be readily removed and replaced for design changes. Meeting applicable government specifications they function over broad temperature and humidity ranges and withstand severe shock, vibration and other hazards. Learn how CAMBION Teflon terminals can benefit *you*. Write Cambridge Thermionic Corporation, 457 Concord Avenue, Cambridge 38, Mass.

*Reg. Dupont T.M.

CAMBRIDGE THERMIONIC CORPORATION

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The guaranteed electronic components

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Bell Electronic Corp
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(FA 1-5802)

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Newark Electronics Co., Inc.
4747 W. Century Blvd.
(OR 8-0441)

CALIFORNIA, Menlo Park
Bell Electronic Corp
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CIRCLE 204 ON READER-SERVICE CARD

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Standard Pressed Steel Co., Dept. ED, Jenkintown, Pa.

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CONAP, Inc., Dept. ED, 184 E. Union St., Allegany, N. Y.

P&A: *$15 for 1-lb kit and hardener.*

Voltage References 605

Stability range is ±0.01 to ±.002% for a series of 6.3 v voltage references. Each device is certified as to its stability after 1,000 hr of operation. Each certified reference is sold with a complete history of readings taken on the device during the 1,000 hr operation period.

Transitron Electronic Corp., Dept. ED, 168 Albion St., Wakefield, Mass.

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200,000 random pulses per sec can be amplified by the linear pulse amplifier model 15-A-002. Regular pulse train to 1 mc can also be amplified. Voltage gain is 300 min and frequency response is 0.5 to 5 mc. Paired pulse

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Franklin Systems, Inc., Dept. ED, 2734 Hillsboro Road, West Palm Beach, Fla.
Price: *from $100 to $150.*

Expanded-Scale Voltmeters 487

In ac and dc types, the expanded-scale voltmeters can be used in applications such as recording line, bus and feeder voltage on power systems, motor overload studies and checking computer circuits. A permanent-magnet moving coil measuring system is used.

Esterline Angus Instrument Co., Inc., Dept. ED, P. O. Box 596, Indianapolis 6, Ind.
P&A: *$490; stock.*

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Air-cooled shielded grid triode type 6544, rated at megawatt, is for use in radar-pulse modulators. It features a beamed oxide coated cathode structure, a squirrel-cage control grid and a shield grid internally connected to the cathode. It is 10 in. high and 5-1/4 in. in diameter.

Nuclear Corp. of America, Central Electronic Manufacturer's Div., Dept. ED, 2 Richwood Place, Denville, N. J.

Receiving Tubes 602

All-glass base novar receiving tubes have a maximum piv of 5,500 v. Maximum dc plate current is 180 ma. Maximum peak plate current rating is 1,100 ma. Tube types 6BC3, 17BH3 and 22BH3 are half-wave vacuum rectifier tubes for use as damper diodes in horizontal deflection circuits of TV receivers.

Radio Corp. of America, Dept. ED, 30 Rockefeller Plaza, New York 20, N. Y.

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General Characteristics

Standard Operating Voltages:
3 to 32 VDC; 6 to 120 VAC 60 Cycle.
Maximum Coil Resistance: 13,000 ohms
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0.05 watt at standard contact rating; 0.3 watt at maximum contact rating for DC relays; 1.2 volt-amperes for AC relays.
Contact Combination: SPDT
Contact Ratings:
Standard 1 amp.; optional ratings, with special construction, to 3 amps. Ratings apply to resistive loads to 26.5 VDC or 115 VAC.
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Dielectric Strength: 500 VRMS, minimum

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CIRCLE 208 ON READER-SERVICE CARD

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Terminal Swaging Tools 501

Self-aligning swaging tools hold the two mating dies that secure the terminal to the board. Designed for field or production use, it is furnished in two models: ST-300 and ST-600 with 3- and 6-in. throats. In production, they can be secured to the bed of a hand or air-operated arbor press developing 500 psi.

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

Electronic Counter 615

Impulse counting device, designated 8001 universal counter, provides a pre-settable, count-controlled output impulse on each tenth input pulse. The count can be changed to a nine, eight, etc., down to a two or one-count. Modular units can be coupled directly in tandem for number or word structure. Frequency is 10-30,000 cps.

Vector Manufacturing Co., Inc., Commercial and Industrial Div., Dept. ED, Southampton, Pa.

Mylar Film Punch 655

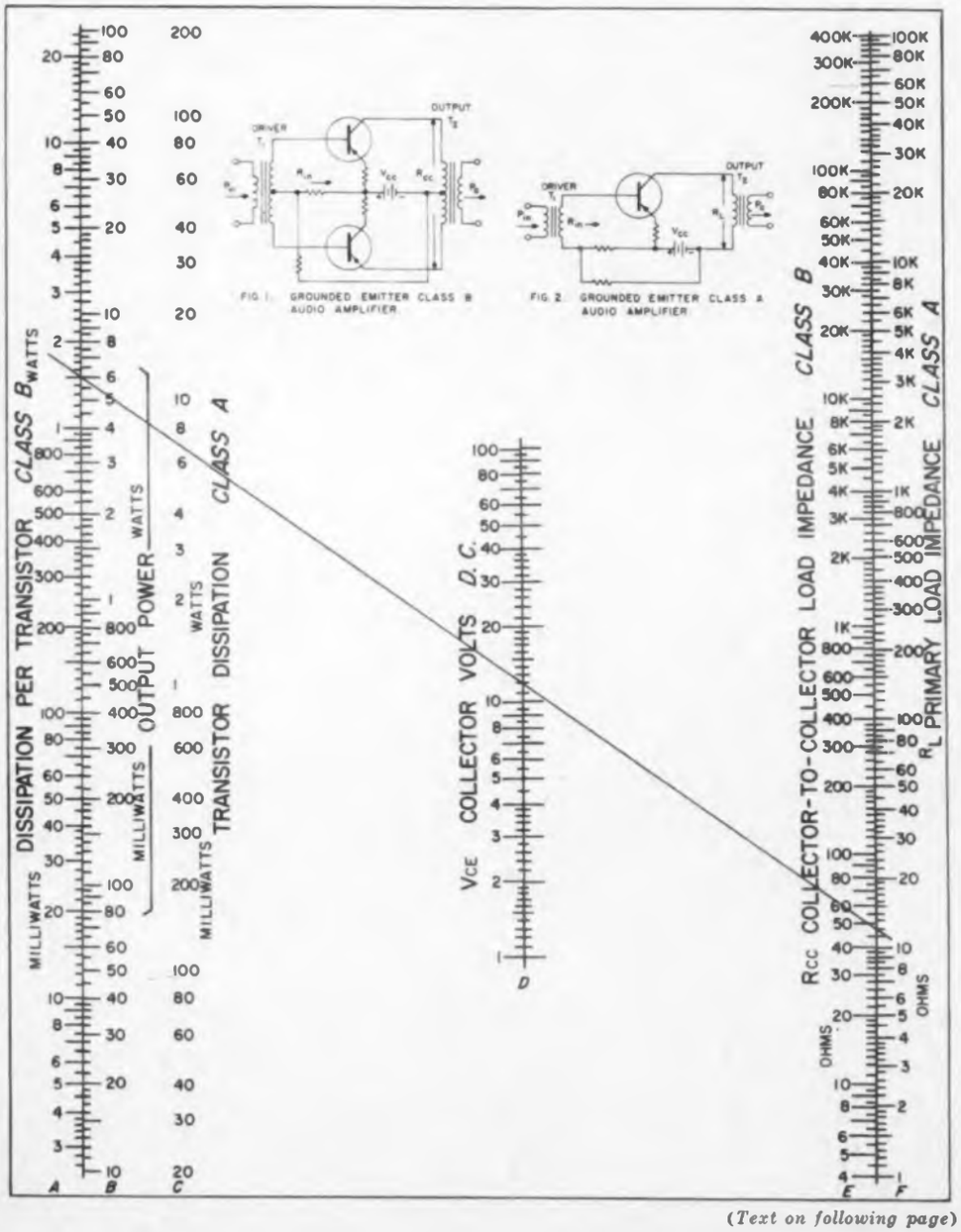
Hole diameters from 0.016 to 0.125 in. are possible with the mylar film punch MP-100. Unit is solenoid actuated (60 cps, 110 v) by a foot-operated switch. Standard punch and die sets are available with 0.016, 0.021, 0.028, 0.035, 0.040, 0.062 and 0.125 in. diameters. Punches are ground, hardened steel. Unit has a built-in base light.

Wems, Inc., Dept. ED, 4807 W. 118th Pl., Hawthorne, Calif.

***P&A:** $390; from stock.*

Transistor Load Impedance And Dissipation Nomogram

Albert J. Eisenberg
Microtran Co., Inc.
Valley Stream, N. Y.



(Text on following page)

Transistor Load Impedance and Dissipation Nomogram

(Nomogram on preceding page)

CALCULATIONS involved in the design of class A and B audio and servo amplifiers can be tedious and time-consuming. With the nomogram presented, the primary and secondary impedance of driver and output transformers can be quickly found. Transistor dissipation and driving power can also be read from the nomogram.

Typical Examples Illustrating Use of the Nomogram

Problem 1: To determine required primary impedance of output transformer T_2 and transistor dissipation, see Fig. 1.

Given: $V_{CE} = 12$ v $\approx V_{cc}$ (power supply voltage)
$P_o = 5$ w to speaker load

Solution: Assume transformer efficiency of 80 per cent. Then the transistor output power required $= 5/0.8 = 6$ w.

A) Using nomogram, draw a straight line from output pow .r of 6 w on scale *B* through collector volts, V_{cc} of 12 on scale *D*. Extend line and read primary impedance R_{cc} of 48 ohms C. T. for class B operation on scale *E*, or R_L of 12 ohms for class A on scale *F*.

B) Read transistor dissipation of 1.5 w each for class B operation on scale A, or 12 w for class A on scale *C*. Verify that transistor power dissipation ratings are not exceeded.

Problem 2: To determine primary and secondary impedances of driver transformer (T_1) to match transistor input impedance (R_{in}). Also determine the required driving power (P_{in}).
Use the following equations:

For class B output stage (Fig. 1)

$$R_{in} \approx 4\,h_{ie}$$

$$P_{in} \approx \frac{4\,h_{ie}PO_{pp}}{(h_{fe})^2\,R_{cc}}$$

For class A output stage (Fig. 2)

$$R_{in} \approx h_{ie}$$

$$P_{in} \approx \frac{h_{ie}PO_A}{(h_{fe})^2\,R_L}$$

Given: Assume 2N656A's or 2N1481's in class B output stage of Fig. 1.
Transistor output power $PO_{pp} = 6$ w. $V_{CE} = 12$ v.
Primary impedance R_{cc} of $T_2 = 48$ ohms C.T.

Solution: A) Transistor handbook ratings for 2N656A are: $h_{fe} \approx 40$ and $h_{ie} \approx 200$.

B) $R_{in} \approx 4h_{ie} = 4 \times 200 = 800$ ohms C.T. secondary impedance of T_1.

C) $$P_{in} \approx \frac{4h_{ie}\,PO_{pp}}{(h_{fe})^2\,R_{cc}}$$

$$= \frac{4\times200\times6}{(40)^2\times48} = 62.5 \text{ mw.}$$

Allowing for typical transformer efficiency of 75 per cent, input power to T_1 should be $62.5/0.75 = 83.3$ mw.

D) Use nomogram to determine primary impedance of driver transformer T_1 by drawing line from 83.3 mw on scale B through 12 v dc on scale *D*. Read class A primary impedance of 850 ohms on scale *F*.

Reference Information

Class A Formulas

Transistor power output, $PO_A = \frac{V_{CE}}{2R_L}$;

Power gain, $G_{eA} \approx \frac{(h_{fe})^2 R_L}{h_{ie}}$

Power in, $P_{in} = \frac{PO_A}{G_{eA}} = \frac{h_{ie}PO_A}{(h_{fe})^2\,R_L}$

(Assumes > 10 mw power level)

Class B Formulas

Transistor power output $PO_{pp} = \frac{V_{CE}}{2R_L}$

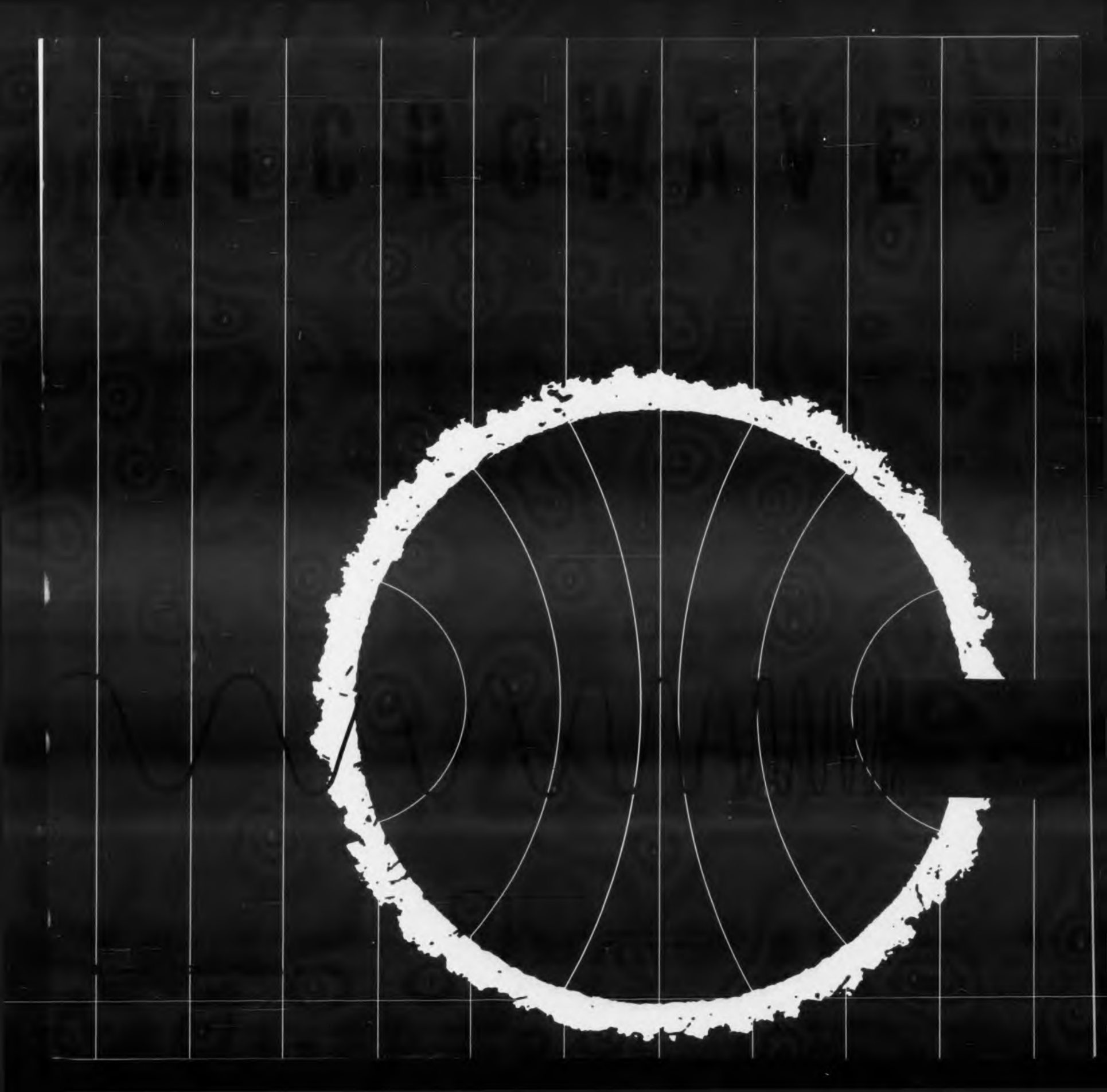
Power gain $G_{eB} \approx \frac{(h_{fe})^2\,R_{cc}}{4h_{ie}}$

Power in, $P_{in} = \frac{PO_{pp}}{G_{eB}} \approx \frac{4h_{ie}PO_{pp}}{(h_{fe})^2\,R_{cc}}$

(Assumes > 50 mw power level)

References

Motorola 1960 Power Transistor Handbook, pp 64-81.
G.E. Transistor Manual 5th edition, pp 44-47.



MICROWAVES

The (Strip) Line Forms on the Right

The venerable strip transmission line has been with us long enough for development of the necessary applications know-how. Much of this knowledge is distilled into the article by Jesse Taub beginning on p 182 of this issue. With the technique's novelty largely worn off, the time has come for intelligent applications.

The same is true of parametric frequency generators, slated for increased use in microwave systems as described in the article on the opposite page.

The transition from laboratory to practical hardware involves a certain time lag. Here are two instances where the process is more or less completed. So step right up and take advantage of these useful, proved techniques in the design of your own equipment.

Efficient circuits and increased power capabilities underlie the current emphasis on solid-state microwave generators reported in

The many strip transmission lines now on the market and their best use in microwave design are described in

A time-saving design tool is presented in

Millimeter-wave Fresnel-zone-plate antennas, a line of polyrod antennas, a receiver for precision attenuation measurements, and a miniature high-speed coaxial switch head the

Systems Applications Due for Parametric Frequency Multipliers

Manfred Meisels
Technical Editor

A RAPIDLY expanding market is anticipated by manufacturers of parametric frequency multipliers. The emergence of efficient multiplier circuits has opened many microwave-system applications calling for an all-solid-state, stable-frequency source of low to moderate power.

Such uses include:

- Local oscillators
- Transmitter exciters
- Parametric amplifier pumps
- Telemetry transmitters
- Test equipment

Parametric multipliers have found limited but important use in all these areas, and design plans call for their continued application in larger quantities.

NASA, for example, has specified these devices for telemetry transmission in its Surveyor probe and Orbiting Astronomical Observatory. Surveyor will carry a 2-w, 2.2-Gc unit, while a 20-w, 400-mc transmitter will be carried aboard the observatory. Both transmitters are being manufactured by the Hughes Aircraft Co.

Other frequency multipliers slated for use as transmitters, exciters or local oscillators in classified military equipment are being developed by Microwave Associates, Convair-Pomona, Space Technology Laboratories and Micromega.

Commercial applications still are restricted by the relatively high cost of these devices. One instance of commercial interest, however, is evidenced by Canadian Marconi's unsuccessful bid to buy American parametric local oscillators at about $1,000 per copy for the company's microwave—relay equipment. It is reported that the Canadian firm now plans to manufacture these units itself.

Test-equipment applications, especially on production lines, where a reliable, preset and twiddle-proof frequency source is often needed, are stressed by the apparatus division of Texas Instruments. The company has been marketing a fairly extensive line of such instruments since late 1960. An indication of Texas Instruments' ambitions in this area is its unwillingness to disclose sales figures or future marketing plans.

"There are still only a few outfits really active here, and we don't want to encourage any new entries," a company spokesman declared.

Firms Report Brisk Response To Parametric Multipliers

Other companies are relatively satisfied with their business in parametric frequency multipliers. Micromega, Calif., admits to having delivered 25 units during the past year and reports that new inquiries are coming at an average of three per week.

Microwave Associates has delivered some 50 units to date and is similarly encouraged by the rate of inquiries.

The key to this recent interest in parametric frequency multipliers has been the development of considerably more efficient circuitry. At frequencies below 1 Gc, conversion efficiencies of up to 90 per cent are said to be possible. At X-band, efficiencies drop off to between 10 and 30 per cent, but performance is nevertheless adequate for many low-power applications.

Microwave Associates is in the midst of an Air Force-sponsored program calling for development of a 9-Gc source delivering 200 mw. This is to be achieved by a tripler circuit driven with a 3-Gc signal, likewise developed by a parametric multiplier chain.

Space Technology Laboratories is reported to have operated a similar 9-Gc unit deliv-

Complete parametric multiplier package developed by Pacific Semiconductors, Inc. and Space Technology Laboratories delivers 2.5 w at 2.25 Gc. From left to right: crystal-controlled 94-mc oscillator and preamp; transistorized amplifier with 13-w output; tripler and two successive doubler stages delivering 4 w at 1.1 Gc; final doubler stage.

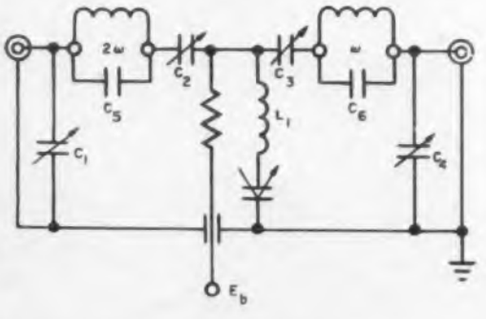
ering 130 mw with 1/2 w input to the final tripler stage. The latter company's work is generally supported by its affiliate—Pacific Semiconductors, Inc. The two companies jointly demonstrated at WESCON a 2.25-Gc telemetry transmitter developing 2.5 w.

There seems to be no clear-cut preference among designers in the use of doublers, triplers or quadruplers. Some believe that quadruplers will have greater efficiency at low frequencies than an equivalent combination of two cascaded doublers. One advantage of using quadruplers and possibly triplers, especially at low frequencies, is the ability to "leap-frog" over the awkward region between 500 and 1,000 mc where both distributed and lumped circuit elements come into play.

Much of the performance attainable by the circuits depends on the choice of varactor. Square-law-response diodes typified by the silicon-alloy junction type are thought by some to be best suited to tripler circuits and to be more efficient generators of the higher harmonics.

Cube-law diodes, typified by the silicon-mesa type, are favored by others as being less temperature-sensitive than the alloy junction diode.

Commonly agreed upon power limits now feasible—at various frequencies range from approximately 5 w at S-band down to 1 w at X-band. These limits assume, however, the use of a single diode per stage. Designers at Micromega and Hughes, however, have explored the paralleling of several veractors per stage. Micromega spokesmen are particularly optimistic about such techniques and claim to be well along in developing procedures for matching and compensating the several diodes in each stage.



High-efficiency frequency doubler with common inductance developed by Pacific Semiconductors, Inc. in its parametric multiplier units. Measured over-all efficiency of this circuit at 125 mc input was 70 per cent.

In any event, design of parametric multiplier circuits is by no means a stagnating art. David Leeson, of Stanford University and Hughes Aircraft, is among those working to establish a theoretical foundation for the design of multipliers. "At present," he notes, "hardware development has outstripped the theory." A designer at Convair-Pomona comments: "The multiplier circuits that I've seen don't begin to exploit the characteristics of currently available diodes."

A useful contribution in this area may be the charts and nomograms derived by Bliss Diamond of the Lincoln Laboratory that completely predict the performance of multipliers given the pertinent varactor characteristic. Mr. Diamond indicates that the validity of his data was confirmed by the performance of several amplifiers designed according to his charts.

While the interest in parametric multipliers has been heightened by the promise of reasonably high power, some designers believe the real future for these devices lies in the already achieved low-power circuits. This view is exemplified by Thomas Hylton of Texas Instruments, whose company has effectively declared itself out of the watt-power race. "If a customer wants high power, he's better off with a hybrid device with a vacuum tube or twt output stage," Mr. Hylton told ELECTRONIC DESIGN.

"For a klystron local oscillator replacement, an all-solid-stage generator is ideal, but the race for higher and higher power is not where these converters belong.

"When you drive varactors to their power limits you're destroying much of the reliability that makes them attractive in the first place," Mr. Hylton added.

Parametric Multiplier Boasts Low Power Drain, Stability

Mr. Hylton emphasized that the real advantage of the crystal-controlled parametric multiplier is its low power drain and stability. In this respect, many designers believe that it will supplant the stabilized klystron local oscillator, with price an important advantage as quantity production develops.

Typical harmonic generator built by Microwave Associates. This model 799C employs 500-mw 11-Gc input to deliver 33 Gc output with 20 db conversion loss. Device incorporates input and output filters.

For many applications, broad-band performance is required. The efficiencies and outputs cited for the multipliers generally assume single-frequency operation. Designers now are trying to achieve similar performance in broad-band devices. A bandwidth of about 10 per cent generally is required in many of the oscillator, exciter and transmitter applications for which parametric multipliers are considered. Microwave Associates, Micromega and Convair-Pomona are particularly active in this aspect of circuit design.

In efforts to reach higher frequencies, diode manufacturers are attempting fabrication of ever-smaller structures. One development, reported by Semiconductor Devices, Newport Beach, Calif., is manufacture of an epitaxial silicon mesa structure only 0.0005 in. across. Zero bias capacitances down to 0.3 $\mu\mu f$ are possible, according to the company officials.

Silicon appears to be the favored varactor material for multiplier diodes. Texas Instruments, however, employs gallium arsenide diodes of its own design at higher frequencies.

Spurious harmonic output of the parametric frequency multipliers is generally held to at least 30 db below the signal by proper filtering. Noise is said to be below that generated by equivalent vacuum-tube circuits if the varactors are not driven hard. At higher powers, the multipliers tend to be somewhat noisier than vacuum tubes, it is reported. ■ ■

When to Use Strip Transmission Line

MICROWAVES

Microwave designers are learning the hard way that strip transmission line circuits do not always save size and weight when reasonably high performance is required. On a cost basis, however, strip lines are often quite attractive in comparison with waveguide and coaxial line. Author Jesse Taub here examines the several types of strip line on the market and points out how they can be profitably applied in the design of microwave components and systems.

Jesse Taub
Airborne Instruments Laboratory
Div. of Cutler Hammer, Inc.
Deer Park, N. Y.

WITH THE ADVENT of strip transmission line development it was commonly believed that the apparent cost, size and weight advantages of strip lines would render waveguide and coaxial cable obsolete in many areas of microwave design.

Experience has shown, however, that devices made of strip transmission line are often larger than those made of waveguide, especially where reasonably good electrical performance is required. The major reason for consideration of strip line remains economy, and here, the technique has indeed fulfilled expectations.

The alert microwave designer should, nevertheless, appreciate that for many specialized applications, strip line offers an economical and versatile alternative to rigid waveguide.

The five types of strip transmission line in use are:

- Microstrip
- Solid strip transmission line
- Stripline[4]
- Triplate[4]
- High-power strip transmission line.

Construction of these lines is illustrated in Figs. 1 through 5.

Microstrip, developed by ITT Laboratories, employs a single ground plane (Fig. 1). Radiation losses are minimized by keeping the strip close to the ground plane. Although Microstrip is the least expensive type of strip line, it has a higher attenuation constant [1, 2, 3] than strip lines using two ground planes. Applications described in this article require lower attenuation constants than are available with Microstrip.

Solid strip transmission line consists of a single strip conductor located symmetrically between two ground planes (see Fig. 2); the dielectric medium is air. Loss characteristics of this line are comparable to coaxial line[4] of the same cross-sectional area. Since the double set of ground planes minimizes radiation losses, attenuation is due mainly to conductor losses.

To achieve low attenuation, strip symmetry must be maintained by regularly placed dielectric supports. The swr effect of these supports is similar to that of bead supports on coaxial lines. With careful design, a low swr can be achieved.

Stripline, developed by Airborne Instruments Laboratory, is slightly more lossy than solid strip transmission line, but is more easily supported. The main strip (see Fig. 3) is formed by a pair of thin copper strips bonded to a dielectric sheet. If the total thickness of the main strip is t, the line's properties will be similar to those of a strip transmission line having a solid strip of thickness t.

The dielectric separating the two strips has little effect on the line's characteristic impedance and attenuation because the electric field penetration is small.[4] Dielectric loss due to the fringe field is minimized by using thin dielectric sheets. A sheet thickness of 0.020 in. is typical.

Stripline is readily supported by metal pins spaced about one ground plane from the edges of the strip.

Triplate, developed by Sanders Associates, has a cross section similar to that of solid strip transmission line, but employs a solid dielectric (See Fig. 4).

The main advantage of this dielectric sandwich line is that it is self-supporting. Sandwich lines can be made in much smaller sizes than the other double-ground-plane types; components having ground-plane spacings of 1/32 in. are typical. Because of

Table 1. Characteristics of strip transmission lines.

Type of Strip Transmission Line	Advantages	Disadvantages
Microstrip	Compact Light Inexpensive Self-supporting	High losses
Solid strip transmission line	Very low losses (mainly I2R losses) Light	Bulky Not self-supporting
Stripline	Low losses Sturdy	Bulky
Triplate	Compact Self-supporting	Comparably higher losses Heavy
High-power strip transmission line	Megawatt power handling	Bulky Expensive (but may be cheaper than high-power waveguide) Not self-supporting

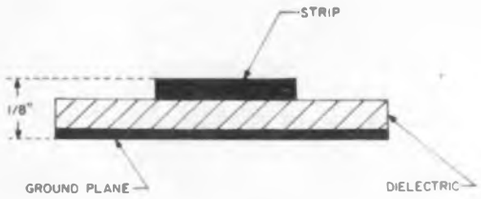


Fig. 1. Microstrip line consists of a single strip and single ground plane separated by a dielectric. This line is relatively inexpensive but has higher attenuation than lines with two ground planes.

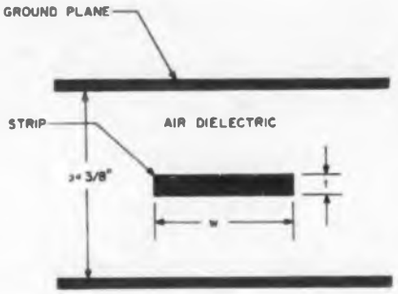


Fig. 2. Solid strip transmission line uses two ground planes and an air dielectric. Losses are comparable to coaxial line of similar cross-sectional area.

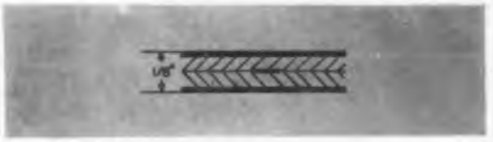


Fig. 4. Triplate line is self-supporting and is available in considerably smaller sizes than other strip lines. Attenuation is increased, however, because of dissipation in the dielectric.

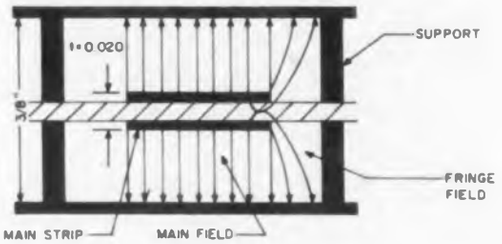


Fig. 3. Strip line employs two conducting strips separated by a dielectric and two ground planes with an air dielectric. This construction permits convenient support of conducting strip despite use of an air dielectric.

Fig. 5. High-power strip line uses thick, rounded strips to reduce corona effects. Megawatt powers can be handled and line is less expensive than many waveguide high-power components.

construction problems, other double-ground-plane types rarely use spacings of less than 1/4 in.

The sandwich line has a higher attenuation than other double-ground-plane types because of its small size and because of dissipation in the dielectric. Sandwich lines are best suited to applications where some attenuation loss can be tolerated.

High Power Line Operates At Megawatt Power Levels

High-power strip transmission line can be operated at megawatt peak-power levels. To reduce corona effects, the strips are thicker than in other lines (1/8 in. or greater) and are rounded at the edges (see Fig. 5). The dielectric is air. As in solid strip transmission line, strip symmetry is necessary and is maintained by regularly placed stub supports. Although the high-power line is the most expensive of the five strip lines discussed here, it is nevertheless more economical than many waveguide highpower components.

Characteristics of the five-strip transmission lines are summarized in Table 1. Impedance and attenuation properties of strip transmission line have been derived by S. B. Cohn.[5] His curves are reproduced here as Figs. 6 and 7. They give the characteristics of the transmission line as a function of ground-plane spacing, strip width, strip thickness, and the dielectric constant of the medium.

These curves are directly applicable to solid strip transmission line and to Triplate.

The characteristic impedance curves are about 4 per cent too high for Stripline but somewhat low in their estimate of Stripline attenuation. The exact attenuation correction depends on the frequency. For most appli-

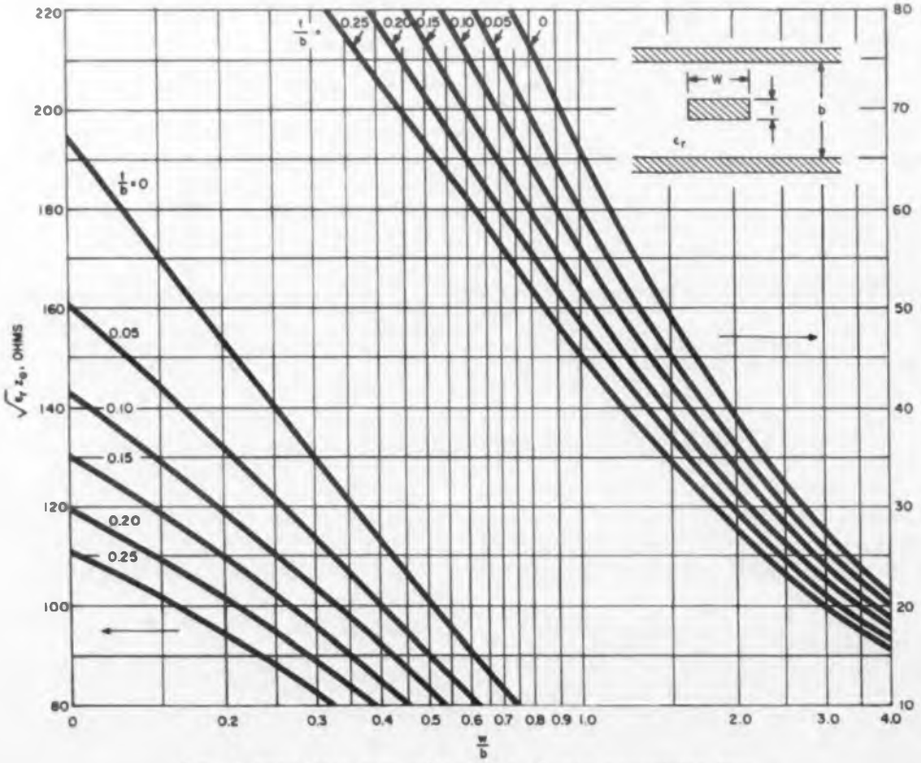


Fig. 6. Impedance curves for design of strip transmission lines.

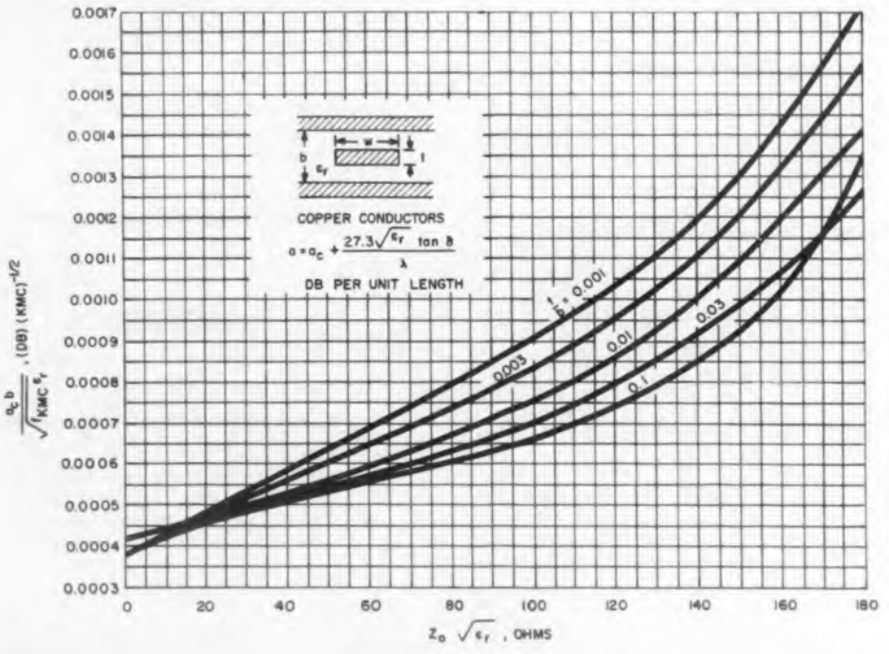


Fig. 7. Theoretical attenuation of copper-shielded solid strip transmission line in a dielectric medium ε_r.

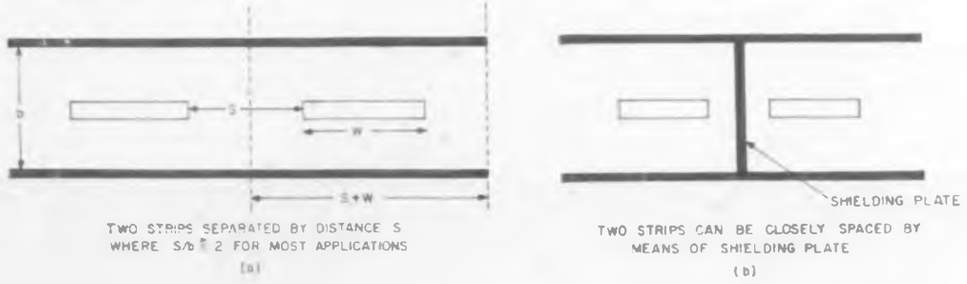


Fig. 8. Separation of two adjacent strip transmission lines to minimize coupling.

cations below 5 Gc, the accuracy is within 10 per cent.

The curves can be used for the high-power strip line by taking the width of the strip as w.

Design Examples for Strip Line Using Curves Are Given

To illustrate the use of these curves in designing strip lines, consider two typical examples:

Example 1. A solid strip transmission line operating at 5 Gc with 1/4 in. ground-plane spacing (b) is to be designed for 50 ohms impedance using 0.025 in. thick (t) strips. Find the width (w) and the attenuation per unit length (α).

Using Fig. 6, set

$$t/b = \frac{0.025}{0.250} = 0.1 \text{ and } \sqrt{\varepsilon_r}Z_o = 50$$

($\sqrt{\varepsilon_r} = 1$ for an air dielectric). We obtain $w/b = 1.15$, or $w = 0.2875$ in. Fig. 7 gives a value of $\alpha_c b/\sqrt{f_{kmc}\ \varepsilon_r}$ of 0.00053 for $t/b = 0.1$ and $Z_o = 50$ ohms. At 5 Gc the resultant α is 0.057 db per ft.

Example 2. A Triplate line filled with a dielectric having $\varepsilon_r = 2.5$ and loss tangent (tan δ) of 0.0001 (typical of Rexolite 1422) is to be designed for 50 ohms at 5 Gc; $b = 1/8$ in. and $t = 0.005$ in. Find w and α.

Using Fig. 6 for

$t/b = 0.005/0.125 = 0.04$ and

$\sqrt{\varepsilon_r}Z_o = \sqrt{2.5}\ 50 = 79$, gives $w/b = 0.65$, or $w = 0.081$ in.

The attenuation constant due to the copper losses (α_c) obtained from $\alpha_c b/\sqrt{f_{kmc}\varepsilon_r} = 0.00063$, is 0.214 db per ft. To obtain the total attenuation loss, use the relation $\alpha = \alpha_c + \frac{27.3\sqrt{\varepsilon_r}\tan\delta}{\lambda}$. The second term is 0.218 db per ft. resulting in a total attenuation constant of 0.432 db per ft.

Strip transmission lines do not always effect savings in size and weight. In using them as low-loss transmission lines, certain restrictions on the minimum ground-plane spacing (b) and strip width (w) must be recognized.[5]

If two or more lines are to be packaged close together, the minimum spacing between strips (s) is limited by mutual coupling. Separating two adjacent strips by one ground plane spacing results in a decoupling of about 27 db.[4] For most applications at least two ground plane spacings between adjacent strips are required, as shown in Fig. 8. This restriction can be eliminated if a shielding bar is placed between the strips, but this adds to the cost and is therefore considered undesirable.

The restriction on minimum strip separation gives an over-all cross-sectional area of $b\ (s + w)$. For the typical case of $s = 2b$ and $w = b$, the cross-sectional area is $3b^2$.

When minimum circuit size is desired, the designer should compare strip lines and waveguides of the same attenuation before making a decision. Consider, for example, a strip transmission line (Fig. 2) operating at 9 Gc in which $w = b = 0.375$ in. and $t/b = 0.05$ (all conductors are silver-plated). The attenuation constant of this line is 0.064 db per ft.

Silver-plated rectangular waveguide, operating in the TE_{10} mode and having dimensions of 0.195 in. by 0.900 in., for an area of 0.175 in.^{2}, has the same attenuation constant. The equivalent strip transmission line cross section is 0.375 in. by 1.125 in. (assuming $s = 2b$) for an area of 0.495 in.^{2}

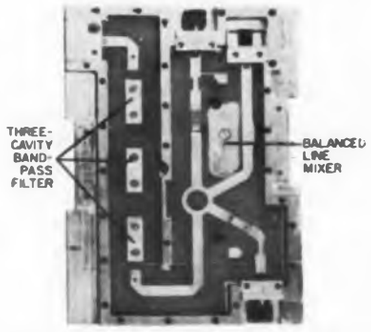


Fig. 9. Three-cavity band-pass filter coupled to a strip line balanced mixer. Device has a 20-mc, 3-db bandwidth at a center frequency of 9 Gc.

Thus, for equal attenuation constants, waveguide may actually be smaller than strip line.

The use of strip transmission line rarely results in unacceptable increases in size. Comparative weights of waveguide and strip line construction are not discussed here because the circuit occupying the smallest volume probably will be the lightest.

Low Cost, Rather Than Size, Is Chief Advantage of Strip Lines

Experience has shown that strip transmission line usually yields the most inexpensive microwave circuits but does not necessarily offer advantages in size, weight and electrical performance over waveguide.

The microwave designer should consider strip transmission line when he is able to compromise slightly on size, weight and performance. If so, considerable economy can result—particularly when large numbers of components are involved.

System designers, on the other hand, often must select the type of transmission line to be used for a group of microwave components. The correct choice may often involve structures that utilize strip transmission line in conjunction with waveguide or coaxial line. For example, a filter-mixer front end may benefit from the combination of a waveguide filter for low-loss and a strip transmission line mixer for simplicity. Strip-to-waveguide or strip-to-coaxial transition designs are available that make such composite structures practical.

Some useful strip transmission line components illustrating advantageous use of the

Fig. 10. Balanced mixer constructed of Stripline. The unit operates at a local-oscillator frequency of 9 Gc. Mixer has an 8-db noise figure—0.5 db more than similar waveguide component.

Fig. 11. Seven channel Stripline mixer using power divider for local oscillator distribution. Attenuation in the strips is less than 2 db.

Fig. 12. Front end of missile receiver uses single-layer strip transmission line packaging. Mixers and preselectors are incorporated in this unit.

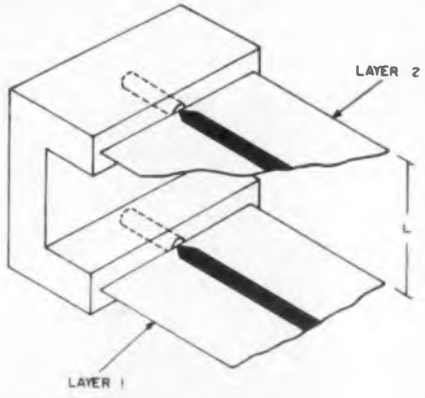


Fig. 13. Double waveguide to strip transition for multi-layer strip assemblies.

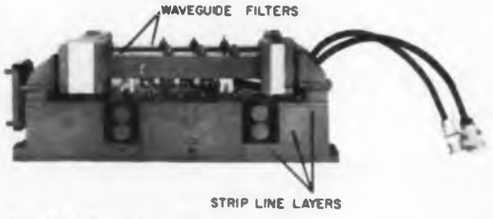


Fig. 14. Three-layer version of the assembly shown in Fig. 12. Connection between layers is via the waveguide-to-strip transition shown in Fig. 13.

technique are described here. Since design data on Triplate components are readily available,[6] only components using Stripline and solid strip transmission line are discussed here.

A three-cavity band-pass filter (coupled to a balanced mixer) having a 20-mc 3-db bandwidth at a center frequency of 9 Gc is shown in Fig. 9. This component was built for a surface-to-surface missile. Strip transmission line was chosen for this application because it was the most inexpensive transmission medium available, yet gave adequate performance.

A requirement for minimum frequency shift with temperature would have necessitated that a waveguide filter be constructed from Invar. The solid strip transmission line utilized Invar for the strips and aluminum for the ground planes. The strip line was built in limited quantity for about $100 per copy—half the cost of an equivalent waveguide filter.

A Stripline balanced mixer used in a proximity fuse application is shown in Fig. 10. This mixer operates at a local oscillator frequency of 9 Gc. It has an 8-db noise figure compared with 7.5 db for a waveguide type. Since the crystal mounts represent a significant portion of the fabrication cost, and Stripline is used in the ring-type hybrid junction, a slight reduction in over-all cost is achieved.

Stripline has proved useful in microwave power dividers, such as the seven-channel, C-band mixer shown in Fig. 11. Local oscillator power is fed to seven mixers through a power-dividing network.

The entire power divider is photoetched on the same sheet as the mixers. Attenuation in the strips is under 2 db—a tolerable value in this application. This divider was built for use in a multichannel shipboard receiver.

Power dividers also have been used in high-power applications. Rotary joints with multiple point feeding of the coaxial center section[7] have recently been designed to handle up to three megawatts in air at atmospheric pressure. Such rotary joints, built for multi-beam L- and S-band radars, use high-power strip transmission line power dividers and yield considerable economy over waveguide power dividers. High-power strip transmission line also should be useful in distributing power to complex transmitting antenna arrays, an application that has not yet been sufficiently exploited.

Combination of Strip Line With Other Techniques Proving Useful

In evolving the over-all layout of a microwave subsystem using strip transmission line, flexibility is important in adapting the form factor to the available space. A typical microwave package may combine strip transmission line with waveguide or coaxial line. Most of the early strip transmission line packaging was of the two-dimensional type. The front end of a missile receiver shown in Fig. 12 is typical of this construction. With the development of low-swr transitions from strip to coaxial line and strip to waveguide transitions (Fig. 13), more use has been made of multi-layer packaging.

Thus, a multi-layer version of the receiver front end shown in Fig. 12 was designed (see Fig. 14). The circuit consists of a group of Stripline mixers and a pair of Invar waveguide filters. It was originally assembled in two dimensions and then repackaged using

three stacked layers of strip transmission line circuitry.

Similar electrical performance was achieved for both arrangements. Microwave power was transmitted from one layer to the next through a pair of strip-to-waveguide transitions of the type illustrated in Fig. 13.

The strip transmission line couples first to a short coaxial line and then to waveguide by means of a coaxial-to-waveguide transition. Power is transmitted up the waveguide to the next layer and coupled to the strip transmission line through a second waveguide-to-coaxial line adapter and a second coaxial-to-strip transition. The separation (l) between each layer is almost equal to the ground plane spacing. These transitions can be matched to swr's under 1.1 over 30 per cent frequency bands—quite adequate for many applications.

The designer should utilize transitions from strip transmission line to other lines as an aid in achieving a desired form factor. Transitions also are helpful in designing circuits that use strip transmission line in conjunction with waveguide or coaxial line.

Contrary to a former belief, strip transmission line circuits do not always save size and weight when reasonably high-quality electrical performance is required. Strip transmission line circuitry, however, can often be manufactured at a lower cost than waveguide and coaxial line. This is the main reason for its consideration.

Designers should encourage the use of structures using strip transmission line in conjunction with other transmission lines. High-power strip transmission line, for example, can be used to a greater extent than previously believed. It is particularly useful for transmitting antenna arrays using complex waveguide distribution networks. ■ ■

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2. J. A. Kostriza, "Microstrip Components", Proc. IRE, Vol 40, pp 1658-1663, Dec. 1952.
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5. S. B. Cohn, "Problems in Strip Transmission Lines", Trans. IRE PGMTT, Vol MTT-3, pp 119-126, March 1955.
6. Sanders Associates Staff, "Handbook of Triplate Microwave Components", Sanders Associates, 1956.
7. E. Fubini, W. Fromm, and H. Keen, "A New Type of Rotary Joint", IRE Conv. Rec., Part 1, pp 78-82, 1958.

Cavity Nomogram

Peter Ravenhill, Harold Smith
Weapon Control Department
Westinghouse Electric Corp.
Baltimore, Md.

THE nomogram is based on the formula

$$\log_{10}\left(\frac{F_2 - F_0}{F_1 - F_0}\right)^{2N} + \log_{10}(0.2589\,R) = 0 \qquad (1)$$

where

N = number of cavities
R = required rejection
and F_0, F_1 and F_2 are center and pass band frequencies as shown in Fig. 1.

To use the nomogram of Fig. 2 first determine Y, the ratio of the stop band to the pass band.

$$Y = \frac{F_2 - F_0}{F_1 - F_0} \qquad (2)$$

Extend a line from the computed value of Y to the desired rejection value on the R scale of the nomogram. Its intersection with the N scale denotes the required number of cavities.

For example: determine the number of cavities required for a filter having a pass band between 4.040 and 4.240 Gc with 40-db rejection at 3.820 and 4.440 Gc.

From Eq. 2,

$$Y = \frac{4.44 - 4.14}{4.24 - 4.14} = 3.$$

The line between $Y = 3$ and $R = 4$ intersects the N scale at 4.8. Thus, the filter would require 5 cavities.

Speeds Design of Symmetrical Band-Pass Filters

This nomogram solves the time-consuming first step in the design of uhf and microwave band pass filters—determining the number of cavities. Authors Ravenhill (left) and Smith developed the nomogram while designing filters for radar equipment requiring signals with very low spurious content.

Performance of a 5-cavity filter designed with the aid of the nomogram is illustrated in Fig. 3. Also shown is the computed response of a 4-cavity filter. Note that the 4-cavity filter will not provide the required 40-db rejection at the extreme limits of the pass band. Insertion loss of the 5-cavity filter within its narrower pass band is less than 2 db.

A developmental 5-cavity filter is shown in Fig. 4. This pre-production model consists of slotted rigid coaxial line. The length and position of the cavities can be adjusted by sliding the blocks along the line. The pointed supporting screws permit the designer to quickly measure the length of the cavities merely by pressing the whole assembly against a sheet of metal and thereby measuring the distances between the resulting indentations. ■ ■

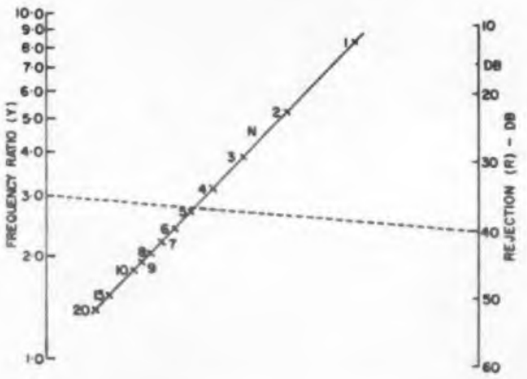


Fig. 2. Cavity nomogram for symmetrical band-pass filters.

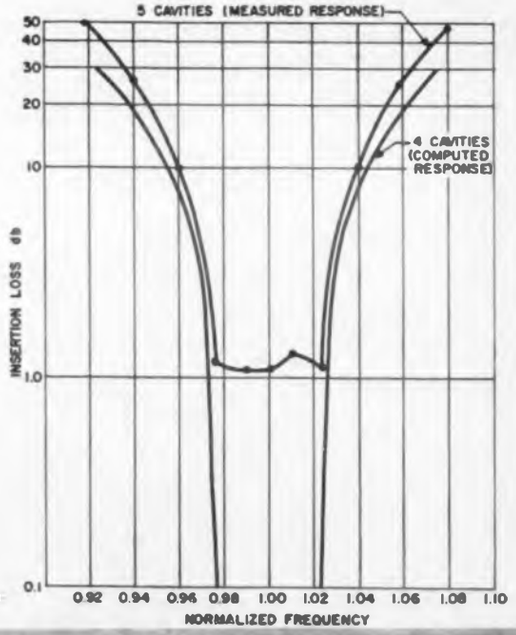


Fig. 3. Measured response of five-cavity filter and computed response of four-cavity filter.

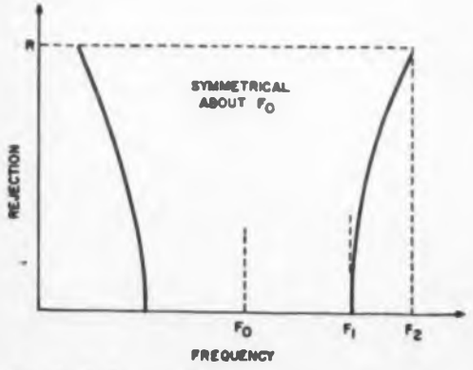


Fig. 1. Definition of terms in nomogram equation.

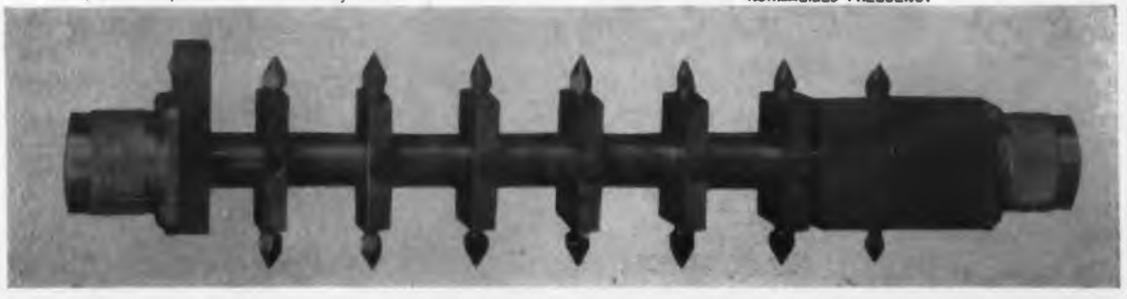


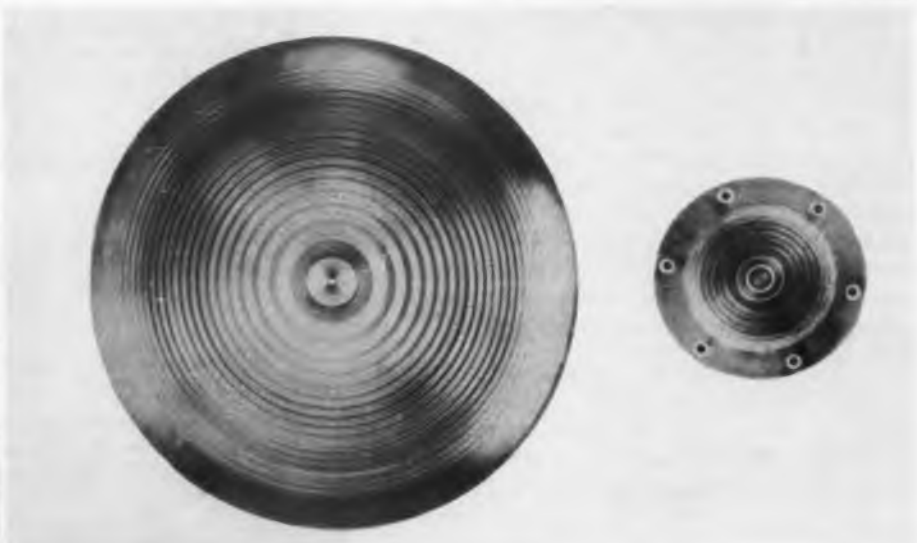
Fig. 4. Developmental five-cavity filter using slotted coaxial line. Blocks are movable for adjusting length and position of the cavities.

MICROWAVE PRODUCTS

Dielectric Antenna 473

A gun of sorts, it's really a dielectric antenna. Ball-joint mounted and boresighted, the antenna can be quickly set up and directed at remote units a few miles distant. There is little problem of windloading. The antenna has a nominal gain of 15 db with a 3-db beamwidth of about 28 deg, and covers frequencies from 2.7 to 3 Gc. Called a polyrod antenna, model STP-1, the device is made for site surveys and data communication links. Antenna is about 30 in. long.

Applied Technology Inc., Dept. ED, 930 Industrial Ave., Palo Alto, Calif.
***P&A:** $450; 60 days.*



Fresnel-Zone Plates 472

Bull's eye for millimeter waves, these Fresnel-zone plates are made for transmitting and receiving antennas. Acting as lenses, they focus 70-Gc-and-up millimeter waves into a plane-wave beam. At the receiving antenna, another zone plate focuses the beam to a point. Plates normally have diameters of 3 to 15 in., although special 4-ft plates for high-power transmissions have been produced. Plates are polystyrene, ground to different thicknesses at the proper diameters to produce the desired phase delay. Speeds faster than f/1 have been achieved.

Electronic Communications, Inc., Dept ED, 1830 York Road, Timonium, Md.
***P&A:** $200 up; 2 weeks in small quantities.*

Microwave Receiver System 470

Precision attenuation measurements over dynamic ranges of 100 db are possible with the model 61A1 microwave receiver. Attenuator accuracy of 0.00005% and readout resolution of 0.02 db are attained. The test signal is compared with an internal reference signal by a solid-state if input switch, and output is fed to a null detector. No preamplifier or plug-in heads are required. Over-all noise figure is 3 db. Accessory mixers and local oscillator couplers for 2.6 through 40 Gc are available.

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

***P&A:** $1,750; from stock.*

Solid-State Switch 471

Handling from 0.1 to 400 mc, the model 201 spdt solid-state switch operates at 50-nsec speeds. The unit measures 3/4 x 1-3/4 x 3-3/4 in. and weighs less than 2-1/2 oz. Power rating is from 20 to 200 mw; vswr is 1.1. At 200 to 400 mc, isolation is 30 to 60 db, and insertion loss is less than 1 db. Temperature range is −65 to +70 C. Shock of 30 *g* for 11 msec and vibration of 20 *g* are survived.

Sanders Associates, Inc., Dept. ED, 95 Canal St., Nashua, N. H.

***P&A:** $65 each in production quantities; 45 days.*

MICROWAVES PRODUCTS

Amplifier for 7 to 11 Gc 449

A gain of 30 db and noise figure of 11 db are claimed for the type SHA-1b amplifier. The device operates from 7 to 11 Gc, and is built to withstand severe environments. Unit, with a self-contained thermostatically-controlled heater, operates from −40 to +55 C. Vibration to 2,000 cps at 10 g and shock at 20 g are survived. Unit uses a ppm traveling wave tube.

Applied Technology Inc., Dept. ED, 930 Industrial Ave., Palo Alto, Calif.

P&A: $5,680; 60 days.

Low Pass Filters 459

Cutoff from 200 to 2,000 mc at increments of 5 mc is provided by the series TLP low pass filters. Cutoff frequencies are said to be exceptionally sharp and band-pass attenuation low. Center frequency, bandwidth, and cutoff points may be specified for individual requirements. Units can be adapted for most connectors, and can be hermetically sealed.

Telonic Engineering Corp., Dept. ED, Laguna Beach, Calif.

Coaxial Variable Attenuator 451

Measuring 4-1/16 x 1 x 1 in., the model A-4 coaxial variable attenuator is a miniature device. Frequency range is 5 to 7.5 Gc, with screw-driver or micrometer control. Insertion loss is less than 0.5 db, and vswr is under 1.35. Attenuation range is 5 db min.

Merrimac Research and Development, Inc., Dept. ED, 517 Lyons Ave., Irvington, N. J.

Circulator 588

High-power broad band three-port circulator may be converted into a microwave switch by replacing the permanent magnet with an electromagnet. Models are available with power handling capabilities of more than 50 kw. Frequency range is 8.0 to 10.5 Gc; isolation is 20 db min; insertion loss, 0.4 db max, vswr. 1.20 max; power, 25 w average. Connectors mate with UG/39/U.

Kearfott Div. of General Precision, Inc., Dept. ED, 14844 Oxnard St., Van Nuys, Calif.

Traveling-Wave Tube 675

Traveling-wave tube; model WJ-217, 10 w, operates from 2 to 4 Gc. Small signal gain is 40 db min, ±3 db, and vswr is 1.5. Device is ppm-focused, is 13 in. long and 1-3/8 in. in diameter, and weighs 3 lb.

Watkins Johnson Co., Dept. ED, 3333 Hillview Ave., Stanford Industrial Park, Palo Alto, Calif.

Availability: *90 days.*

Radar Test Set 674

Portable radar test set, model 121, provides on-the-ramp testing of weather, navigation, **and anti-collision** radar systems, and radio altimeters. Does not require physical connection to aircraft. Set simulates aircraft moving at 120 to 600 knots. Peak power can be measured, accurate to ±1.5 db. Transmitted output signal, 1 mw, is variable over 50 db, and has a 1-μsec pulse width.

Republic Electronic Industries Corp., Dept. ED, 111 Gazza Blvd., Farmingdale, N. Y.

Availability: *immediate.*

MICROWAVES *PRODUCTS*

Attenuation Measurement System 672

Covering 100 mc to 12.4 Gc frequencies, the model VM-1 standard attenuator comparator measures attenuation of 40 mv to 0.2 μv, corresponding to −15 to −121 dbm in a 50-ohm system. Standards laboratory accuracy can be obtained over a 60-db dynamic range. Unit is direct-reading in decibels; no correction charts or calibrations are needed.

Weinschel Engineering Co., Dept. ED, Kensington, Md.

Miniature Ferrite Isolators 461

For aircraft and missiles, these coaxial ferrite isolators operate at any frequency from 4 to 11 Gc. The X-band isolator, illustrated, is 2-11/16 in. long and weighs 4 oz. It has a 20 to 1 isolation to insertion-loss ratio and a 10% bandwidth. Environmental specifications are said to match those of larger devices.

Sylvania Electric Products, Inc., Dept. ED, 1100 Main St., Buffalo 9, N. Y.
Availability: *four weeks.*

Synchronizer Measures Frequencies to 12.4 Gc 465

Accuracy of 3 parts in 10^8 is possible with the model DY-5796 transfer oscillator synchronizer. The instrument is used with a transfer oscillator and an electronic counter to provide

frequency measurements from 0.2 to 12.4 Gc. Synchronizer automatically locks the transfer oscillator to signal frequency. Accuracy depends on counter time base; an external time base can be even more accurate.

Dymec Div., Hewlett-Packard Co., Dept. ED, 395 Page Mill Road, Palo Alto, Calif.
P&A: *$685; immediate.*

Insulation Adhesive 464

Applicable by brush or spatula, Rexolite 12517 adhesive is made to bond the firm's uhf insulating material to itself. Curing requires two hr at 175 C.

William Brand-Rex Div., American Enka Corp., 31 Sudbury Road, Concord, Mass.

Parabolic Antennas for 806 to 960 Mc 467

Spun and mesh reflector parabolic antennas come in 4- to 12-ft sizes. Antennas are made for 806 to 960 mc operation. Feeds, mounted on either front or back, are adjustable throughout 360 deg, in 90-deg steps on mesh models, continuously on spun models.

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

Radar Test Set 462

Beacon checkout test set model RBT-202 measures beacon transmit frequencies, power levels and beacon coding ability. Unit is for L- to X-band use. It can be rack or bench mounted and can be used for field tests, full-scale production tests and lab evaluation of high sensitivity code-interrogated beacons.

Remanco, Inc., Dept. ED, 1805 Colorado Ave., Santa Monica, Calif.

MICROWAVES *PRODUCTS*

Crystal Holder 583

Tunable detector mount allows any crystal to be matched to the line. Holders can be used as balanced pairs in mixer circuits, and seals allow use in pressurized systems. Crystals can be matched to less than 2.0 vswr, and selected crystals to less than 1.5 vswr.

Technical Research Group, Antenna and Microwave Dept., Dept. ED, 9 Union Square, Somerville, Mass.

Tuned Attenuators 374

Low vswr attenuators for systems applications are fixed-tuned to a desired frequency from 1 to 4 Gc. Attenuation values are from 1 to 20 db. The vswr is 1.05 max at center frequency and 1.10 over a ±10% bandwidth. Attenuation accuracy is ±0.3 db, 1 to 10 db, and ±0.5 db, 11 to 20 db. Attenuators are bidirectional and have type N or C connectors.

Maury and Associates, Dept. ED, 10373 Mills Ave., Montclair, Calif.

P&A: *$70 to $75; 3 to 4 weeks.*

Polyurethane Foam 481

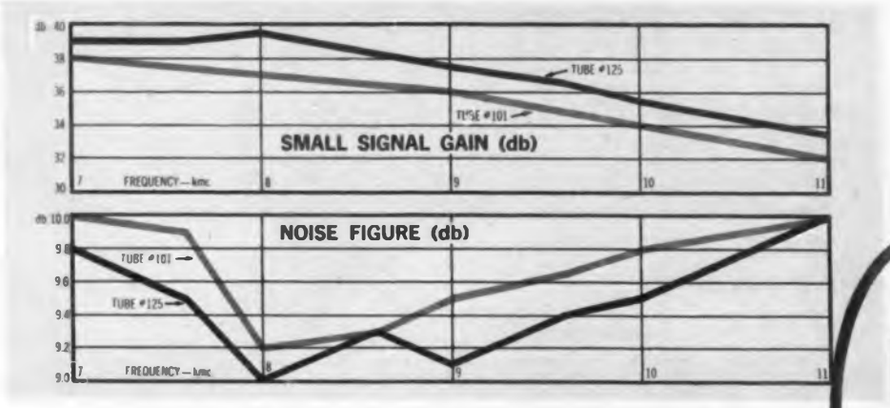
Dielectric constant is 1.2 to 3.0. Foam plastic with ferrous or nonferrous mixture has controlled dielectric properties. Density can be varied from 2 to 25 lb per cu ft. Material has high strength-to-weight ratio and is not affected by environmental conditions.

PolyStructures, Inc., Dept. ED, 41 Montvale Ave., Stoneham, Mass.

MEC *Reports on....*

Low Noise TWT's with PPM Focusing

S, C and X-Band, Metal-Ceramic, PPM Focused, Magnetically Shielded, 10 mw Output and 30 db Gain with Maximum Broadband Noise Figure of 10 db.



REPEATABILITY MEANS RELIABILITY. Notice how closely the small signal gain and noise figure characteristics for the first M2105 (#101) compare with those of the last member in the first lot (#125).

Typical of MEC's advanced family of metal ceramic low noise traveling-wave tubes is the new M2105. Rugged and reliable, this tube is the result of engineering skill and manufacturing care appropriately combined to form a production tube with truly reproducible characteristics.

Shielding of the tube and its focusing structure, an advantage of the PPM format, eliminates the effect of stray magnetic fields and permits use of tubes in close proximity to magnetic materials or to each other. Elimination of the focusing solenoid and power supply reduces power consumption to less than 3 watts, including heaters, and does away with auxiliary cooling.

Reliability—
A Built-in Feature of MEC Tubes

Metal-ceramic construction gives MEC tubes a headstart on reliability. They are evacuated at higher temperatures (650°C), producing a higher vacuum and cleaner environment for long cathode life.

Inherently rugged, they provide superior performance over environmental extremes. (The M2105 withstands 15 g shock and 15 g vibration between 5 and 2000 cycles with no degradation in performance. Temperature compensation work is now being completed.)

MEC construction features also include a stacked ceramic gun and a helix rigidly supported by three ceramic rods. Critical turn spacing is accurately maintained to assure uniform gain characteristics from tube-to-tube. The tube can be operated in any position without change in characteristics.

TYPICAL LOW NOISE TWT TUBES IN PRODUCTION

PPM FOCUSED TUBES	Frequency Range	Small Signal Gain	Saturation Power	Noise Figure
M2103 Series (Family)	2 - 4 kmc	30 db	10 mw	10 db
	(over 0.5 kmc portion of the band)	30	10	8
	2.3 - 4.4	30	10	10
	2 - 4	30	10	15
M2112 Series	4 - 8	30	10	10
	4.3 - 7.4	30	10	10
	4 - 8	30	10	15
M2105 Series	7 - 11	30	10	10
	7 - 11	30	10	15
	8 - 12.4	30	10	15
M2114	12.4 - 18	30	5	14
SOLENOID FOCUSED TUBES				
M2103 Series	2.0 - 4.0 kmc	30 db	5 mw	8 db
	(over 0.5 kmc portion of the band)	30	5	6
M2107	4.0 - 8.0	30	5	10
M2101 Series	7.0 - 11.0	30	10	9
M2114	12.4 - 18.0	30	5	12

Model M2105 Low Noise TWT weighs 5 pounds and is 12⅝" long.

Ask for your copy of our new catalog....

MEC's new short form catalog with complete information on our production engineered line of traveling-wave tubes is available now. In addition to low noise types, the catalog covers medium and low power, serrodyne, and special purpose tubes. For your free copy, call your nearest MEC engineering representative or write to us.

MEC

MICROWAVE ELECTRONICS CORPORATION
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DAvenport 1-1770

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MINIATURIZED SOLID STATE DEVICES

ALL NEW!

Model No.	Frequency (GC)	Max. Power Peak (Kw)	Max. Power *Avg. (w)	Insertion Loss (db) Max.	Isolation (db) Min.	Max. VSWR	Transmission Line	Connectors Input	Connectors Output	Dimensions (in.) L	Dimensions (in.) D	Weight (oz.) Approx.
D44L7	1.25 -1.35	5	5	0.9	15.0	1.20	⅜" coax.	N Ma	N Fe	6 39/64	25/32	6¼
D44L7-6	1.435-1.535	5	5	0.6	16.0	1.15	⅜" coax.	N Ma	N Fe	6 39/64	25/32	6¼
D44L33-25	1.7 -2.3	5	10	1.0	13.0	1.20	⅜" coax.	N Ma	N Fe	9 15/16	25/32	8
D44L33-23	2.12 -2.305	5	5	0.7	13.0	1.15	⅜" coax.	N Ma	N Ma	5¼	25/32	5
D44S7	2.7 -3.1	5	5	0.9	15.0	1.20	⅜" coax.	N Ma	N Fe	4 11/32	25/32	5
D44C7	5.4 -5.9	5	5	0.9	15.0	1.20	⅜" coax.	N Ma	N Fe	4 11/32	25/32	5

*Assume 2:1 Max. Load VSWR

BROADBAND LOW POWER

ALL NEW!

Model No.	Frequency (GC)	Max. Power Peak (Kw)	Max. Power *Avg. (w)	Insertion Loss (db) Max.	Isolation (db) Min.	Max. VSWR	Transmission Line	Connectors Input	Connectors Output	Dimensions (in.) L	Dimensions (in.) W	Dimensions (in.) H	Weight (lbs.) Approx.
D44L2(72L2)	1- 2	10	10	1.0	10.0	1.25	⅜" coax.	N Ma	N Fe	14⅛	1⅜	1 45/64	2 lb. 2 oz.
D44L3(72L3)	2- 4	10	10	1.0	10.0	1.20	⅜" coax.	N Ma	N Fe	11 11/64	1⅜	1 45/64	1 lb. 7 oz.
D44C3(72C3)	4- 7	10	10	1.0	10.0	1.20	⅜" coax.	N Ma	N Fe	6 7/16	1 41/64	1 23/32	1 lb. 4 oz.
D44X3(72M3)	7-11	10	10	1.0	10.0	1.25	⅜" coax.	N Ma	N Fe	6 7/16	2¼	2⅜	1 lb. 6 oz.

*Assume 2:1 Max. Load VSWR

BROADBAND HIGH POWER

ALL NEW!

Model No.	Frequency (GC)	Max. Power Peak (Kw)	Max. Power *Avg. (w)	Insertion Loss (db) Max.	Isolation (db) Min.	Max. VSWR	Transmission Line	Connectors Input	Connectors Output	Dimensions (in.) L	Dimensions (in.) W	Dimensions (in.) H	Weight (lbs.) Approx.
D44L3-7	.95-2.35	10	200	1.0	10.0	1.25	⅞" coax.	L-T Ma	L-T Fe	15⅜	2 1/16	3 9/16	5¾
D44L6	1.25-1.365	20	200	0.7	15.0	1.20	⅞" coax.	N Ma	N Fe	11⅜	2 1/16	3 9/16	5¼
D44S2	2.0 -4.0	20	200	1.0	10.0	1.20	⅞" coax.	UG-46/U	UG-45/U	#12¼	2 1/16	3 9/16	4½
D44S3-5	2.35-5.0	10	200	1.0	10.0	1.25	⅞" coax.	L-T Ma	L-T Fe	13	2 1/16	3 9/16	4½

*Assume 2:1 Max. Load VSWR

#Insertion Length

STRIP TRANSMISSION LINE

ALL NEW!

Model No.	Frequency (GC)	Max. Power Peak (Kw)	Max. Power *Avg. (w)	Insertion Loss (db) Max.	Isolation (db) Min.	Max. VSWR	Transmission Line	Connectors Input	Connectors Output	Dimensions (in.) L	Dimensions (in.) W	Dimensions (in.) H	Weight Approx.
D46J7	.400-.450	5	5	1.0	10.0	1.20	Strip	N Ma.	N Fe	7 37/64	3	1½	3 lbs. 7 oz.
D46P1-8	.870-.990	5	5	1.2	20.0	1.20	Strip	N Ma.	N Fe	7 37/64	3	1½	3 lbs. 7 oz.

*Assume 2:1 Max. Load VSWR

BROADBAND WAVEGUIDE

ALL NEW!

Model No.	Frequency (GC)	Max. Power Peak (Kw)	Max. Power #Avg. (w)	Insertion Loss (db) Max.	Isolation (db) Min.	Max. VSWR	Transmission Line	Connectors Input & Output	Dimensions (Length - Inches)	Weight (lbs.) Approx.
D41SS	2.6 - 3.95	10	10	1.0	15	1.10	RG 48/U	UG 53/U	11	12½
D41CS	3.95- 5.85	10	10	1.0	20	1.15	RG 49/U	UG 149 A/U	8	6¼
D41GS	5.85- 8.2	10	10	1.0	25	1.15	RG 50/U	UG 344/U	6⅛	3
D41XS	8.2 -12.4	10	10	1.0	30	1.15	RG 52/U	UG 39/U	6⅛	2
D41US	12.4 -18.0	10	10	1.0	30	1.15	RG 91/U	UG 419/U	*6	2

#Assume 2:1 Max. Load VSWR

*Tentative

Most of these units available from stock. We will welcome your inquiries for more complete information.

DIVISION OF SPERRY RAND CORPORATION

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MICROWAVE ELECTRONICS COMPANY,

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Microline Instruments • Radar Test Sets • Systems Instrumentation • Solid State Devices and Materials • Microwave Components and Antennas

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MICROWAVES PRODUCTS

Ferrites 386

Single crystals of yttrium iron garnet (YIG) and lithium ferrite are available as polished or rough-ground spheres, cubes, disks, special shapes, or unfinished. YIG resonance linewidth is 0.4 to 0.45 oersted; lithium ferrite linewidth is less than 10 oersteds. Optimum frequency ranges of the materials are, respectively, 2 to 4 Gc and 5 to 10 Gc. YIG crystals of 95 g have been grown.

Airtron Div., Litton Industries, Dept. ED, 200 E. Hanover Ave., Morris Plains, N. J.

Standard-Gain Horn Antennas 466

To determine gain of uncalibrated antennas, this waveguide horn can be used as a standard. Units are calibrated for a gain of 15 ± 0.3 db at the specified frequency. Frequencies from 2.6 to 40 Gc are available. Beam width is about 30 deg; vswr averages 1.2. Horns serve as either transmitters or receivers.

Waveline, Inc., Dept. ED, Caldwell, N. J. ***Price:*** *$45 to $115.*

Feed Horns 422

Linear-circular polarized feed horns, series 897, are designed for parabolic reflectors having a 0.3 f/d ratio. Models for use at 3.2, 4, and 8.6 mm wavelengths are available. Rotation of a portion of the feed through 45 deg switches polarization from circular to linear. The vswr is less than 1.3. Axial ratio is 0.7 db max over a 4% frequency band.

Technical Research Group, Inc., Antenna and Microwave Dept., Dept. ED, 9 Union Square Somerville, Mass.

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Q217	1100.
M217	995.
E217	1650.

Just because you're working in millimeter bands is no reason to "make do" with lesser specs than you get from L to KU Bands. It's true that it's more difficult to maintain top specs at 90,000 mc than at X Band, for example, but in most cases Narda does it! And especially, in our slotted lines!

Precision instruments in every way, Narda millimeter Impedance Meters give you these important benefits: Smooth, stable carriage travel, absolutely parallel to the transmission line axis, with complete freedom from backlash. Imperceptible slope (0.01 max.), thanks to precision milling of tellurium copper main transmission line, followed by a silver plate of molecular thickness and a rhodium flash.

Residual VSWR is under 1.01 for K and V Bands; 1.02 for Q, M and E. Position of the built-in probe is measured with a precision dial indicator having a least count of 0.001". And as an added advantage, the probe is usable with any waveguide detector.

All in all, an exceptionally fine instrument — and yet, typical of all Narda millimeter products. For complete information on the entire line, write for a free catalog. Address: Dept. ED-6.

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COMPACT C-BAND TWT, QKW 928, utilizes PPM focusing for lightweight construction. VSWR is 1.1 over any 50 Mc channel. Tube is also available with coaxial fittings for full octave (4-8 kMc) coverage.

Raytheon introduces low-cost 12-watt TWT for long-life microwave relay operation

Rugged all metal-ceramic tube for 5,925 to 7,125 Mc range designed for power amplifier service in unattended stations.

The QKW 928 offers a combination of advantages never before available in a traveling wave tube for communications applications.

This 12-watt tube's periodic permanent magnet focusing permits a new, simpler, more compact construction that assures long life and permits a lower cost. The new design reduces external magnetic fields so that two tubes can be mounted in close proximity to each other.

Write today for detailed technical data or application service to Microwave and Power Tube Division, Raytheon Company, Waltham 54, Massachusetts. In Canada: Waterloo, Ontario.

QKW 928 TYPICAL OPERATING CHARACTERISTICS	
Frequency Range	5,925-7,125 Mc
Power Output (saturated)	12 Watts minimum
Small Signal Gain	36 db
Helix Voltage	2,600 Vdc
Collector Voltage	2,600 Vdc*
Anode Voltage	2,650 Vdc
Filament Voltage	6.3 Volts

*Can be depressed to 1,400 volts for improved efficiency.

RAYTHEON

RAYTHEON COMPANY

MICROWAVE AND POWER TUBE DIVISION

MICROWAVES PRODUCTS

DC Blocks 669

For counter-measures systems, these dc blocks operate from 1 to 7 Gc. Model 875 has a range of 1 to 1 Gc with an insertion loss of 0.3 db max and a vswr of 1.25 max. Model 876 has a range of 2 to 7 Gc with an insertion loss of 0.4 db max and vswr of 1.3 max. Units dissipate 4 w at 100 v. Bodies, black anodized aluminum, measure 1-15/16 in. long and 5/8 in. in diameter.

Weinschel Engineering Co., Dept. ED, Kensington, Md.
***P&A:** $60.00; 10 weeks.*

Standard Coaxial Switches 460

More than 80% of the coaxial switch functions can be handled by this standard line of switches, the firm says. They operate from 1 to 4,000 mc at power ratings of 100 to 1,000 w. The vswr is 1.3. Both manual and electromagnetically operated switches are available in a variety of switch functions up to 12 throws, single and double pole. Design includes shorted, non-shorted, and resistor terminations.

RF Products Div., Amphenol-Borg Corp., Dept. ED, 33 E. Franklin St., Danbury, Conn.
***Price:** $18 each for 100 or more.*

C-Band Circulator 453

Light-weight, compact C-band circulator operates over a wide temperature range. Designated model CC03, the circulator operates from 5.4 to 5.9 Gc with inser-

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tion losses less than 1.2 db. Isolation is greater than 12 db. Temperature range is −55 to +105 C. Device permits use of antennas for simultaneous transmission and reception.

Motorola, Inc., Solid State Electronics Dept., Dept. ED, P. O. Box 5409, Phoenix, Ariz.

Coaxial Shutter 454

For fail-safe protection from rf overloads, the model S-70 coaxial shutter provides 40-db isolation up to 4 Gc upon failure or removal of actuator power. Operating time is 6 msec. Shutters measure 2.9 x 0.9 x 1.5 in., weigh 1.5 oz, operate from −65 to +160 F, and meet MIL-E-5272 specs.

Don-Lan Electronics Inc., Dept. ED, 2520 Colorado Ave., Santa Monica, Calif.

Waveguide Shutter Switch 450

Miniature waveguide shutter switch, model 890444, weighs less than 3-1/2 oz and occupies 1.65 cu in. Unit operates in the X-band with a vswr of 1.1. Over a 10% bandwidth, the vane-closed attenuation is 30 db min. Vane-open attenuation is 0.2 db max. Switch is made to protect radar receiver crystals resulting from strong local signals when receiver is turned off.

Litton Industries, Dept. ED, 200 E. Hanover Ave., Morris Plains, N. J.

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To the engineer working with missiles, weapons systems, airborne gear, ground support equipment, instrumentation, navigation equipment, computers, controls... SERVOSCOPE is an accepted part of the program. Understandably so. From the simplest to the most complex electronic, electrohydraulic, electromechanical, and electropneumatic servo system, they find, SERVOSCOPE provides them with reliable answers in a hurry. By measuring the changes in phase, gain, and transient response which occur when signals of various frequencies are fed to the design, the investigator can safely evaluate the behavior pattern of the system to meet ultimate operating conditions.

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NEW LITERATURE

Temperature Recording 261

Operation of a platinum resistance temperature detector is outlined in this 12-page booklet. Bridge circuits and calibration tables are shown. Brush Instruments, 37th and Perkins, Cleveland 14, Ohio.

Torque Measurements 262

Methods of measuring torque characteristics and speed of motors, gear trains, servo mechanisms, and potentiometers are described in this 12-page brochure. Torques from 1/4 to 200 lb-in. are included. Power Instruments, Inc., 7352 N. Lawndale Ave., Skokie, Ill.

Precision Resistors 263

The firm's line of precision deposited carbon-film resistors for commercial, subminiature, MIL-type, high-resistance, high-voltage, and microwave resistor applications is described in this eight-page catalog. Pyrofilm Resistor Co., Inc., U. S. Highway 46, Parsippany, N. J.

Weight and Thrust Measurements 264

Typical instrumentation systems for jet engine test facilities and electronic methods of weight and thrust measurements and calibrations as used in ICBM facilities are discussed in 32-page technical bulletin No. TD-106. Gilmore Industries, Inc., 13015 Woodland Ave., Cleveland 20, Ohio.

Tables and Formulas 265

Tables of weights and measures, math symbols and constants, the Greek alphabet, temperature conversions, binary numbers, powers of numbers, electrical formulas, the fundamentals of Boolean algebra, and similar information is available in this 32-page booklet, "Tables and Formulae." Automatic Electric Sales, Industrial Products Div., Control Equipment Sales, Northlake, Ill.

Graphical Symbols

Seventy-eight recommended graphical symbols for machines, transformers, primary cells, and batteries are given in 30-page publication No. 117-2 of the International Electrotechnical Commission. *Send $2.40 to American Standards Association, Dept. P-209, Dept. ED, 10 E. 40 St., New York 16, N. Y.*

Flexible Laminates 266

Flexible laminates for temperature classes A and B are described in this eight-page brochure. Typical properties and applications of varnished cambric and polyester film laminations combined with various other laminating materials are listed. Minnesota Mining and Manufacturing Co., Irvington Div., Dept. W1-193, 900 Bush Ave., St. Paul 6, Minn.

Regulated Power Supplies 267

The firm's line of regulated transistorized power supplies is listed in this 44-page long-form catalog. Descriptions, illustrations, specifications, output curves, and prices are given for over 20 instruments. Harrison Laboratories, Inc., 45 Industrial Road, Berkeley Heights, N. J.

Instrument Tubes

Characteristics and applications of instrument tubes, including frame-grid and secondary emission tubes, are given in eight-page bulletin No. PA-391. *Write on company letterhead to CBS Electronics, Dept. ED, 100 Endicott St., Danvers, Mass.*

Microminiature Flip-Flops 268

A series of microminiature flip-flops, called Micrologic elements, are described in this eight-page brochure. Logic design and applications of the devices are described. Fairchild Semiconductor Corp., 545 Whisman Road, Mountain View, Calif.

Epitaxial Devices 269

Germanium and silicon epitaxial transistors and diodes are described in this eight-page booklet entitled "A Case History in Progress." Mechanical and electrical characteristics of six units are given and compared with those of some conventional types. Sylvania Electric Products, Inc., 1100 Main St., Buffalo 9, N. Y.

Microwave Components

The firm's microwave instruments and components are described and illustrated in 32-page catalog No. SH-61. Electrical and mechanical specifications of the devices are given. Some general microwave theory, including methods of impedance measurement, is presented in text. *Write on company letterhead to Alford Manufacturing Co., Dept. ED, 299 Atlantic Ave., Boston 10, Mass.*

NEW LITERATURE

Electron Tubes 270

Called "Electron Tube Application Notes," this 58-page illustrated brochure reviews many of the "do's and don'ts" of electron tube applications. Sylvania Electric Products, Inc., 1100 Main St., Buffalo 9, N. Y.

Power Supplies 271

A line of isolated power supplies and transformers, current sources, integrators and indicators, and dc amplifiers are described in this series of catalogs. A price list is also available. Elcor, Inc., 1225 W. Broad St., Falls Church, Va.

Space Re-Entry Vehicles 272

The development of re-entry vehicles in the U.S. space programs is surveyed in this 33-page, illustrated booklet entitled "Progress in Re-Entry and Recovery Vehicle Development" General Electric Co., Missile and Space Vehicle Dept., 3198 Chestnut St., Philadelphia 1, Pa.

Microwave Antennas 273

Plane and dual polarized parabolic microwave antennas operating from 0.8 to 13 Gc are described in this 14-page catalog, No. 100. Electrical and physical specifications are included. Technical Appliance Corp., Sherburne, N. Y.

Coaxial Lines 274

Aluminum and copper coaxial transmission lines are described in 40-page catalog No. 595. Installation procedures and recommendations and electrical characteristics are given. Prodelin, Inc., 307 Bergen Ave., Kearney, N. J.

Thermocouple References 275

The firm's line of thermocouple reference junctions is described in this eight-page booklet. Materials used, specifications and operating characteristics are given. Genistron, Inc., 6320 W. Arizona Circle, Los Angeles 45, Calif.

Transistor Testers 276

Go-no-go and absolute-readout transistor testers are described in this 12-page brochure. Specifications for several models are given, and theory of operation is discussed. Fairchild Semiconductor Corp., 545 Whisman Road, Mountain View, Calif.

Wire Products 277

Over 6,000 electronic wire, cable, and tubing products are described in 52-page catalog No. 62. Included are military hookup wire, Teflon and magnet wire, cables, tubing products are described in 52-page pha Wire Corp., 200 Varick St., New York 14, N. Y.

Microwave Instruments 278

Microwave signal sources, levelers, amplifiers, low-noise amplifiers, and power supplies are described in this eight-page short-form catalog entitled "Microwave Tube Instrumentation." Illustrations, descriptions, and specifications are included. Wave Particle, 150 S. Second St., Richmond, Calif.

Tachometers 279

The firm's line of ac and dc tachometer generators and indicators are described in 12-page bulletin No. GEZ-3251. Information on application, calibration, accuracy, and selection is given. Specifications, schematics, and photos of the systems are included. General Electric Co., Schenectady 5, N. Y.

Selenium Rectifiers 280

A line of selenium rectifiers, including high-voltage, high-current, arc-supressing, and encapsulated units, is described and illustrated in eight-page bulletin 101. Electrical ratings are included. Edal Industries, Inc., 4 Short Beach Road, East Haven, Conn.

Pilot Lights 281

Subminiature indicator lights, pilot lights with resistors for neon lamps, enclosed assemblies for neon and incandescent lamps, oil-tight lights, dimmers, press-to-tests lamps, lens holders, and similar lights and lamps are described and illustrated in 24-page catalog L-161C. Dialight Corp., 60 Stewart Ave., Brooklyn 37, N. Y.

Portable Meters 282

A line of ac and dc voltmeters, ammeters, ohmmeters, industrial meters and circuit testers, current transformers, ac clamp meters, light meters, and similar instruments are described and illustrated in eight-page catalog Z-54. Specifications and prices are given. Daystrom, Inc., Weston Instruments Div., 614 Frelinghuysen Ave., Newark, N. J.

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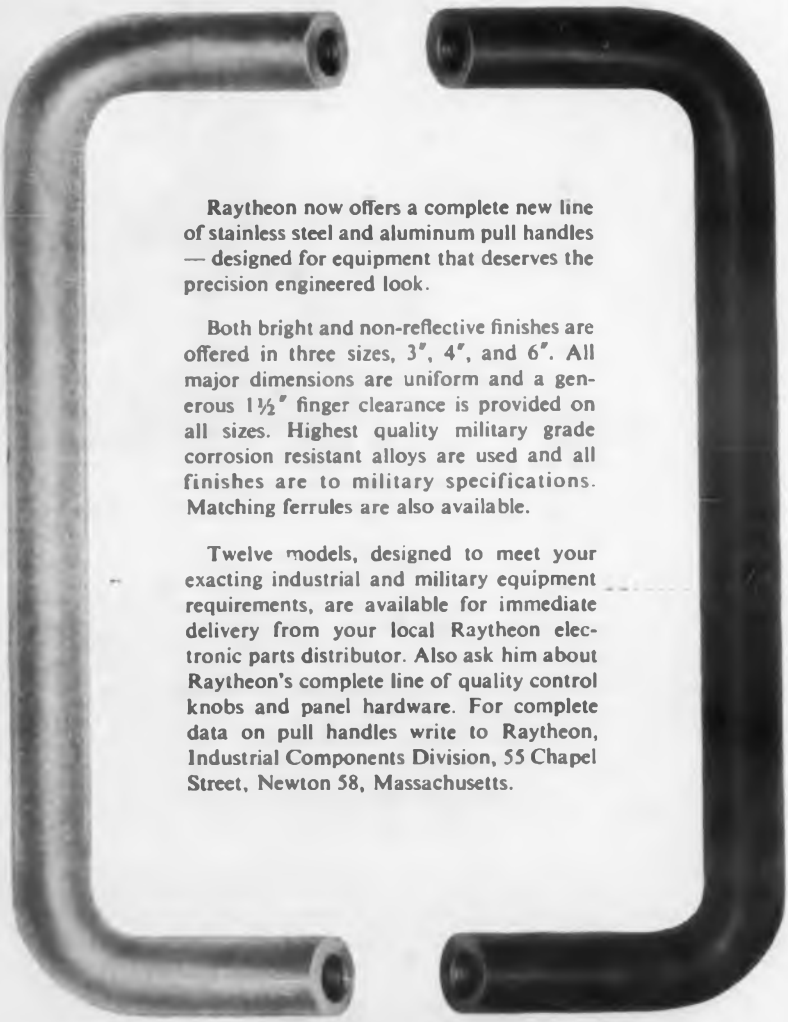
QUALITY PULL HANDLES in STAINLESS or ALUMINUM from Factory Stock or Raytheon's 350 Distributors



Raytheon now offers a complete new line of stainless steel and aluminum pull handles — designed for equipment that deserves the precision engineered look.

Both bright and non-reflective finishes are offered in three sizes, 3″, 4″, and 6″. All major dimensions are uniform and a generous 1½″ finger clearance is provided on all sizes. Highest quality military grade corrosion resistant alloys are used and all finishes are to military specifications. Matching ferrules are also available.

Twelve models, designed to meet your exacting industrial and military equipment requirements, are available for immediate delivery from your local Raytheon electronic parts distributor. Also ask him about Raytheon's complete line of quality control knobs and panel hardware. For complete data on pull handles write to Raytheon, Industrial Components Division, 55 Chapel Street, Newton 58, Massachusetts.

RAYTHEON

RAYTHEON COMPANY

INDUSTRIAL COMPONENTS DIVISION

CIRCLE 237 ON READER-SERVICE CARD

NEW LITERATURE

Materials Test Instruments 283

Optical and physical properties of materials can be investigated with the equipment described in this 28-page general catalog. Among the devices included are abrasion testers, color differentiators, scratch-thickness gages, glossmeters, reflectometers, and viscosity cups. Illustrations, descriptions, general specifications, and prices are given. Gardner Laboratory, Inc., P. O. Box 5728, Bethesda 14, Md.

Potentiometers 284

Loading, trimming, linearity, and life expectancy of potentiometers is discussed in this bulletin. Load and quadrature compensated potentiometers, single-turn precision potentiometers, and rotation-to-voltage transducers are described and illustrated. Analogue Controls, Inc., 200 Frand Road, Hicksville, N. Y.

Terminal Selection 285

The proper size terminal or splice barrel for any given size of solid, stranded, rectangular, or square wire can be selected with this catalog. Tables and a nomogram aid in estimation of circular mil area of wire, from which the proper terminal can be selected. A stud hole chart is included. AMP Inc., Eisenhower Blvd., Harrisburg, Pa.

Conductive Cements 286

Thermosetting silver and gold cements suitable for use in place of solder are described in 4-page bulletin No. CP-7-361. Application and curing of cements and use in laminations are considered. Testing procedures are outlined. Thinners are described, and methods of storage are suggested. Physical properties are briefly tabulated, E. I. DuPont de Nemours and Co., Wilmington 98, Del.

Power Supplies 287

Solid-state and vacuum-tube power supplies, regulated and unregulated, are listed in this 16-page catalog. Illustrations, descriptions, specifications, and prices are included. NJE Corp., 20 Boright Ave., Kenilworth, N. J.

Chemicals 288

Bright dips, carbon removers, cleaners, scale removers, wire strippers, ultrasonic descalers, and other chemicals for use in electronic parts manufacture are listed in this catalog. Fidelity Chemical Products Corp., Electronic Chemicals Div., 470-474 Frelinghuysen Ave., Newark 14, N. J.

Germanium Transistors 289

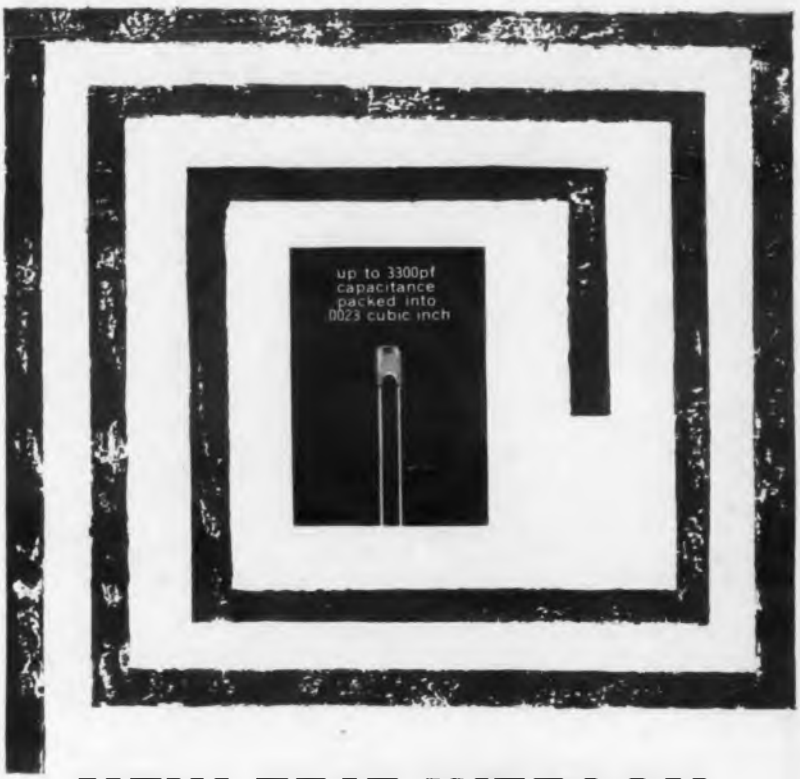
The firm's line of germanium transistors is cataloged in bulletin AO-3. Over 452 types are listed with electrical specifications in eight pages. Electronic Transistors Corp., 9226 Hudson Blvd., North Bergen, N. J.

Transformers

Data on miniature transformers are contained in this looseleaf handbook. Called the "Transformer Handbook Manual", this publication includes a transistor load impedance nomogram, MIL designation information, terminal connection sheets, environmental guides, and a cross-reference index. Technical data on the firm's line is given. *Write on company letterhead to Microtran Co., Inc., 145 E. Mineola Ave., Valley Stream, N. Y.*

Wave Tube Catalog 290

Data and outline drawings of many types of millimeter wave tubes are given in this 52-page catalog. Included are monitor diodes, noise tubes, high power floating drift tube klystrons, reflex klystrons and others. Also included are noise tube mounts and adjustable waveguide mounts. Litton Industries, Electron Tube Div., 960 Industrial Road, San Carlos, Calif.



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Coating:	Dipped, resin coated

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Max. Size	.150x .150	.200x .200	.300x .300	.400x .400	.500x .500	.600x .500
Thickness	.100"	.100"	.100"	.100"	.150"	.150"
Capacitance	6pf to 3300pf	11pf to 6200pf	25pf to .0135mf	48pf to .025mf	76pf to .040mf	90pf to .05mf

For more information on WEECON Ceramicons, write for New Product Bulletin NP-128-1.

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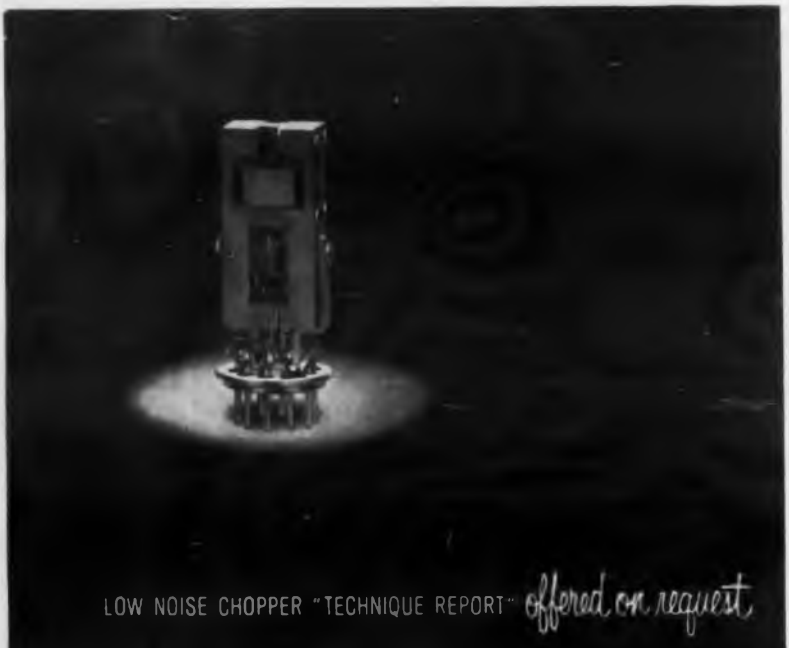

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BOOKS

1961 Radio Diagrams and Servicing Information

M. N. Beitman, Supreme Publications, 1760 Balsam Road, Highland Park, Ill., 192 pp, $2.50

A collection of the "most often needed" 1961 radio schematics. Also includes servicing information.

Introduction To Nuclear Science

Alvin Glassner, D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, N. J., 215 pp, $3.75

An elementary survey of nuclear science and its impact upon other physical and natural sciences. Reviews atomic structure detection methods, forms of radiation; describes nuclear reactions, and surveys accelerators and reactors.

The Theory of Equations, Volume 1 & 2

William Snow Burnside and Arthur William Panton, Dover Publications, Inc., 180 Varick St., New York 14, N. Y., 300 pp and 335 pp, $1.85 each vol. (paperbound).

Advances In Electronics and Electron Physics, Volume XIII

L. Marton, Academic Press Inc., 111 Fifth Ave., New York 3, N. Y., 454 pp, $13.50

Describes the latest developments in the technical areas of electron probe microanalysis, television camera tubes, field ionization and field ion microscopy, velocity distribution in electron streams, and inelastic collisions between atomic systems.

Alternating Current Electricity

Alexander Efron, John F. Rider Publisher Inc., 116 W. 14 St., New York 11, N. Y., 144 pp, $2.90

Very basic approach to alternating current circuits, measuring instruments, and power machinery.

Automatic Data-Processing Systems

Robert H. Gregory and Richard L. Van Horn, Wadsworth Publishing Co., Inc., San Francisco, Calif., 705 pp

Principles and procedures of business data-processing are presented from the point of view of management. Text is written on the layman's level and includes material on computer programing and systems analysis.

Introduction To Ceramics

W. D. Kingery, John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 781 pp, $15.00

Considers the physical and chemical properties of the various types of ceramics. Ceramic materials and processes are presented as a basis for engineering applications.

Optics and Optical Instruments

B. K. Johnson, Dover Publications, Inc., 180 Varick St., New York 14, N. Y., 234 pp, $1.65 (paperbound).

Deals mainly with the practical application of optical principles, instruments and components.

Guide to U. S. Government Statistics (3rd Edition)

John L. Andriot, Documents Index, Box 453, Arlington 10, V., 402 pp, $15.00

A collection of sources for U. S. Government statistical information.

Progress in Operations Research, Vol. 1

Russell L. Ackoff, Editor; John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 505 pp, $11.50

The initial volume of a series which will review and evaluate the development of new concepts and techniques in operations research. Volume I stresses the progress made in inventory theory, linear and dynamic programming, queuing, sequencing and replacement theory, simulation and gaming.

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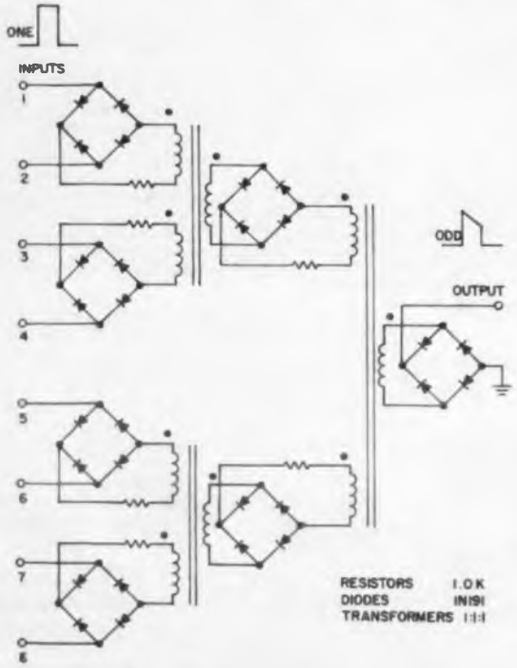
IDEAS FOR DESIGN

Transformer-Coupled "Tree" 740 Checks Binary Word Parity

A simple and dependable circuit was required for making parity checks of a perforated tape reader. The circuit's function was to determine if the sum of the eight binary bits read out is even or odd. The circuit shown accomplishes this by using transformer-coupled diode logic.



Transformer-coupled parity checker produces output if sum of the eight-binary-bit word is odd.

The parallel input from the reader consists of rectangular, 10-msec pulses representing "ones;" absence of pulses representing "zeros." The individual sections of the circuit are connected in a tree arrangement. Each section produces an output only if its two inputs differ. Therefore, the last stage produces an output if the parity is odd. The number of stages possible is limited by the transformer fidelity and the required repetition rate.

Stewart Coffin, Head of Engineering, Dynamic Controls Co., Cambridge, Mass.

If this Idea is valuable to you, give it a vote by circling Reader-Service number 740.

$50 "Most Valuable of Issue" Award for Improved Null Detector

Yale Jay Lubkin, senior staff engineer with Loral Electronics Corp., New York, N. Y. has won ELECTRONIC DESIGN's ninth $50 Most Valuable of Issue Award.

Mr. Lubkin receives the award for his Idea for Design, "Two-Transistor Circuit Increases Null-Detector Sensitivity," which appeared in the July 19 issue. The idea described a circuit which permitted high-accuracy bridge measurements to be made with a relatively insensitive null-detecting device.

Fast Pulse Train Synched To Slow Input Trigger 748

We needed a circuit that would generate a pulse train synchronized to an external trigger pulse. The three-transistor circuit we developed, shown in the figure, was originally designed to produce a 625-kc pulse train synched to a 333-cps trigger. However, we found that with the proper combination of inductor L_1 and capacitor C_2, we could synch a 1.5-mc train to a trigger frequency as low as 100 cps.

The output pulse train is generated by a Colpitts oscillator, of which transistor Q_2 is a part. The trigger pulse, of $\pm$10-v amplitude, is applied to capacitor C_1. The pulse is then differentiated by the capacitor to turn on transistor Q_1.

With Q_1 turned on, Q_2 is forced into saturation and the oscillations of the Colpitts are stopped. When the differentiated input pulse decays enough to allow Q_1 to cut off, Q_2 resumes oscillating.

Transistor Q_3 is part of a saturated amplifier which clips and shapes the output of Q_2.

The width and amplitude of the input trigger may be varied so that the first pulse after the trigger will be either positive or negative. The waveforms shown in the figure are of the input pulse and the output pulse train when a negative pulse was required as the first pulse after the trigger.

Paul M. Danzer, Electrical Engineer, Lockheed Electronics Co., Plainfield, N. J.

If this Idea is valuable to you, give it a vote by circling Reader-Service number 748.

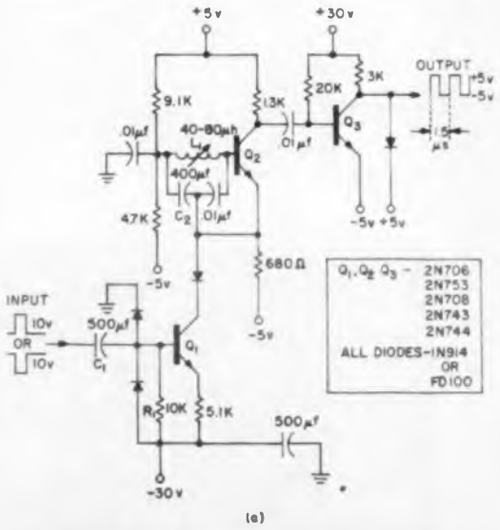
Vote for Ideas Valuable to You

Vote for the Ideas which are valuable to you. Other engineers will vote for the Ideas which are most valuable to them. The Idea which receives the most "Valuable" votes will be judged "Most Valuable of Issue." Its author will receive a $50 award.

Choose the Ideas which suggest a solution to a problem of your own or stimulate your thinking or which you think are clever.

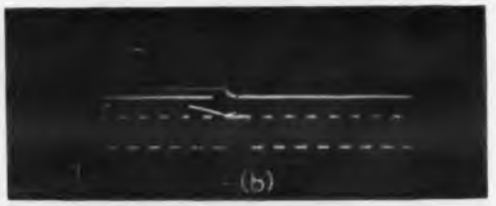
The Ideas chosen as the most valuable in each issue will be eligible for the $1,000 Idea of the Year Award.

So vote for the Ideas you find most valuable. And, after you've voted, why not send in an Idea of your own?



(a)

(a) Three-transistor circuit produces a 625-kc pulse train, synched to 333-cps trigger.



(b) Photo of input and output waveforms.

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. The Idea selected as the most valuable in the issue in which it appears will receive $50.
3. The Idea selected as the Idea of the Year will receive a Grand Prize of $1,000 in cash.

The Idea of the Year will be selected from those entries chosen Most Valuable of the Issue.

Most Valuable of the Issue and Idea of the Year selections will be made by the readers of ELECTRONIC DESIGN. The readers will select the outstanding Ideas by circling keyed numbers on the 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.

SEVENTH ANNIVERSARY AWARDS

IDEAS-FOR-DESIGN

Entry Blank

Ideas-for-Design Editor
ELECTRONIC DESIGN
850 Third Ave.
New York 22, N. Y.

Idea (State the problem and then give your solution. Include sketches or photos that will help get the idea across.)

(Use separate sheet if necessary)

I submit my Idea for Design for publication in ELECTRONIC DESIGN. I understand it will be eligible for the Seventh Anniversary Awards—$20 if published, $50 if chosen Most Valuable of Issue, $1,000 if chosen Idea of the Year.

I have not submitted my Idea for Design for publication elsewhere. It is entirely original with me and does not violate or infringe any copyrights, patents or trademarks or the property rights of any other person, firm or corporation.
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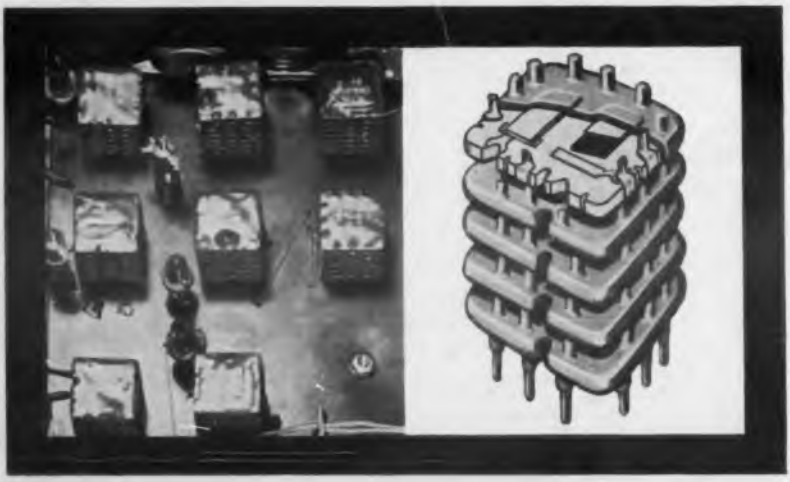

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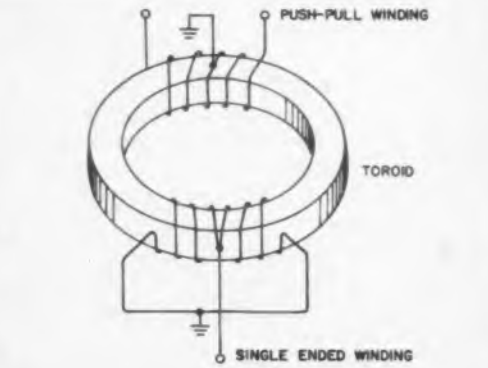
IDEAS FOR DESIGN

Balanced Xformer Windings Can Be Single-Ended or Push-Pull 735

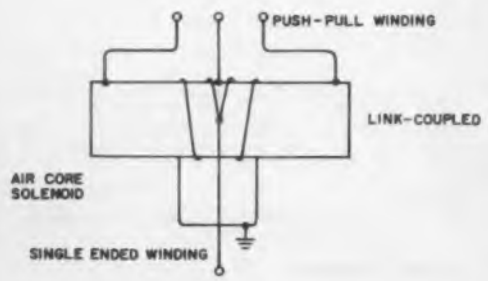
It is often necessary, in many aspects of electronics, to make a transformer that can be changed from single-ended to push-pull, or vice versa. These transformers may be air-cored or core-wound for use at higher frequencies.

The primary difficulty that this change produces is the capacitive unbalance which occurs because one side of the single-ended winding is grounded. In phase-splitting transformers this results in phase unbalance in the push-pull winding. In link-coupled, air-core arrangements the maximum voltage swing and power output, with no loss of linearity, are limited similarly.

This unbalance can be entirely eliminated by the method shown in the figure. It has been used on small ferrite toroids in phase splitters, balanced modulators and phase discriminators. In one case the linear voltage swing of a large power amplifier was almost doubled by rewinding the single-ended link in this fashion.



(a)



(b)

Transformer windings can be readily changed from single-ended to push-pull connection for (a) toroidal or (b) link-coupled units.

The single-ended winding consists of two windings in parallel, each having the required number of turns. These are wound from the center out, as shown, and the outer ends are joined and become the ground connection. It is seen that the flux in the two windings do not oppose, but rather aid each other. Although there is more winding capacitance due to the additional turns it is more than compensated for by the improvement in balance conditions.

For link-coupled transformers, the single-ended winding is similarly wound, with the single-ended winding centered over the center tap on the push-pull winding.

Martin Plotkin, Electrical Engineer, Brookhaven National Laboratory, Upton, Long Island, N. Y.

If this idea is valuable to you, give it a vote by circling Reader-Service number 735.

Compensating Voltage Reduces Zener Diode Variations 738

When a Zener diode (or ballast lamp, VR tube, etc.) is used as a half-wave ac clipper or dc regulator, Fig. 1, its internal resistance causes the output voltage to vary slightly with changing input. This variation can be eliminated if a compensating voltage, E_R, of equal slope, Fig. 2, is generated at a lower voltage level. The output is then taken between these two levels. This tends to eliminate the output voltage variations.

Resistor R can be adjusted for nearly perfect compensation at any current value. Because of device nonlinearity there will be a slight second-order change in output vs input. However, at least a five-to-one improvement has been obtained. This technique can be applied to dc voltage regulators, square-wave calibrators, electronic tachometers and similar circuits.

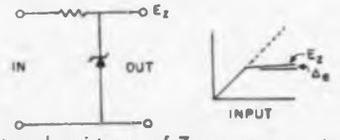


Fig. 1. Internal resistance of Zener causes output voltage to vary by dc as input changes.

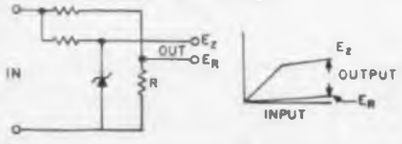


Fig. 2. Output variations are reduced when compensating voltage E_R is generated to form part of output.

Theodore Byles, Project Engineer, Motorola, Inc., Franklin Park, Ill.

If this idea is valuable to you, give it a vote by circling Reader-Service number 738.

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LETTERS

Fan Mail Department

Dear Sir:

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Often weeks and months will slip by and for one reason or another I won't have time to look at my magazines, then all of a sudden the "need to know" occurs and I'll spend many hours pouring over back issues, the "Send for information" cards are old, yet the advertising is still doing a job—for both of us.

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Your effort has made my job easier.

Edward Goodrich
A. B. Dick Co.
Chicago, Ill.

Carbon-Film Pot Answer to Gold Pot

Dear Sir:

I have read your editorial of May 24, 1961 and the answers you have received from various manufacturers of potentiometers, July 19, 1961, protesting your editorial comments.

The engineer and his visitor, in your editorial, were not familiar with the Computer Instruments Corp.'s line of potentiometers. Other manufacturers did not care to mention our units in their protests to you. Mr. D. C. McNeely lists six reasons by which the customer aggravates a so-called problem. But Mr. McNeely sees potentiometers through the eyes of the wirewound potentiometer manufacturer. Three of the six causes listed are not problems when Computer Instruments Corp.'s precision infinite resolution carbon film pots are employed. The three so-called causes for "unreliable" pots are not

the cause of the requirement, but the cause of the pot manufacturer, who tries to attain characteristics beyond the capability of his unit. I refer to causes 2, 3, and 4.

2. Resolution and/or linearity requirements dictated by the system need not be sacrificed. Carbon film potentiometers offer a virtually infinite resolution and size for size or length for length offers accuracies better than those available from any other manufacturer.

3. Compensation for errors caused by other components in the system, resulting in tight specification on linearity or conformity are commonplace. Computer Instruments Corp. solves problems of this type daily.

4. Servo response is constantly getting faster. Servo-loop gains are higher. The infinite resolution of Computer Instruments Corp.'s potentiometer, along with its low inertia and running torques . . . allows rapid servo response. Dither does not affect the potentiometer in the majority of servo designs that will cause a wirewound unit to oscillate. Failure after much use is not catastrophic since the complete circuit does not open.

The Computer Instruments Corp. carbon film potentiometer was designed with reliability in mind. Connections are all multiple (paralleled). Terminations are welded or united. Multiple wipers, of different resonant frequencies (different lengths) are employed for both the rotary and pick off connections. The apparent reliability is in an article by H. H. Adise entitled "Reliability of Precision Potentiometers," an analysis using probability theory, copies of which are available in limited quantity from Computer Instruments Corp., 92 Madison Ave., Hempstead, Long Island, N. Y.

In addition to the above, carbon-film potentiometers have a rated life of 5 to 50 millions of revolutions depending on circuitry. They operate without quadrature as they are noninductive. They operate in both dc and ac circuits as well as in the megacycle region, have withstood shock to 115 g, and most important, have received field reject rates and reliability reports that conclusively show that the engineer and his visitor were not familiar with our product.

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Sales Manager
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YOUR CAREER

Will Physicist Replace Electronic Engineer?

The electronic engineer is slowly being replaced by the physicist and physical chemist, says Lee Fox, employment consultant in Chicago with Executive Consultants, specialists in finding executive and engineering talent.

Mr. Fox says he has already seen signs of a trend toward replacing electronic engineers with physicists in key creative areas of electronics. He believes that in five or ten years the EE will be relegated to a secondary role, similar in status to that now held by the ME in electronics. The EE, Mr. Fox contends, will no longer be in on the original circuit concepts but will work at the packaging, chassis, heat-shielding and radiation-shielding levels.

The initial signs to which Mr. Fox refers center on the increased demand by electronics companies for men with graduate academic backgrounds in solid-state physics. These are the men the companies are hiring for advanced programs to compound present circuits into solid-state functional blocks. The men must be capable of rearranging molecules in solids to produce electrical effects.

Demand for Systems Engineers Linked to Military Programs

Others in industry have felt this phenomenon will merely upgrade the EE into the systems aspects of uniting functional blocks into larger equipments, but Mr. Fox is pessimistic about this possibility. He believes the present demand for systems engineers will last only so long as the military build-up continues. In industrial and consumer areas the electronic equipment will be either so small or so mass-produced, he says, that it will amount to merely larger functional blocks.

Mr. Fox did not, however, discuss the very real possibility of larger industrial systems, which would need systems engineers as much as present military systems. Nor did he comment on the possibility that EE's would still be needed for initial lumped-parameter breadboards of new designs before these were committed to functional blocks.

As for the physicist, Mr. Fox recalls the advice he recently gave to a physicist friend who was trying to decide where to direct his graduate studies.

"If you go into the chemical field,' Mr. Fox told him, "you will probably only be offered eight and a half to nine thousand a year

Advancement Your Goal?

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ELECTRONIC DESIGN'S Confidential Career Inquiry Service helps engineers "sell" themselves to employers—*as confidentially and discreetly as they would do in person.* The service is fast. It is the first of its kind in the electronics field and is receiving high praise from personnel managers.

To present your job qualifications immediately to companies, simply fill in the attached resume.

Study the employment opportunity ads in this section. Then circle the numbers at the bottom of the form that correspond to the numbers of the ads that interest you.

ELECTRONIC DESIGN will act as your secretary, type neat duplicates of your application and send them to all companies you select—*the same day the resume is received.*

The standardized form permits personnel managers to inspect your qualifications rapidly. If they are interested, they will get in touch with you.

Painstaking procedures have been set up to ensure that your application receives complete, confidential protection. We take the following precautions:

- All forms are delivered unopened to one reliable specialist at ELECTRONIC DESIGN.
- Your form is kept confidential and is processed only by this specialist.
- The "circle number" portion of the form is detached before the application is sent to an employer, so that no company will know how many numbers you have circled.
- All original applications are placed in confidential files at ELECTRONIC DESIGN, and after a reasonable lapse of time, they are destroyed.

If you are seeking a new job, act now!

ELECTRONIC DESIGN CAREER INQUIRY SERVICE

USE BEFORE NOV. 8, 1961

After completing, mail career form to ELECTRONIC DESIGN, 850 Third Avenue, New York, N. Y. Our Reader Service Department will forward copies to the companies you select below.

(20)

(Please print with a soft pencil or type.)

Name _____ *Telephone* _____

Home Address _____ *City* _____ *Zone* _____ *State* _____

Date of Birth _____ *Place of Birth* _____ *Citizenship* _____

Position Desired _____

Educational History

College	*Dates*	*Degree*	*Major*	*Honors*

Recent Special Training _____

Employment History

Company	*City and State*	*Dates*	*Title*	*Engineering Specialty*

Outstanding Engineering and Administrative Experience _____

Professional Societies _____

Published Articles _____

Minimum Salary Requirements (Optional) _____

Use section below instead of Reader Service Card. Do not write personal data below this line. This section will be detached before processing.

Circle Career Inquiry numbers of companies that interest you

900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924
925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949

CAREERS

when you get your Ph.D. But if you think ahead and go into an electronics-oriented solid-state course, you will surely command eleven to twelve thousand a year."

Looking at the present employment picture, Mr. Fox says that in his Chicago area demand continues for the BSEE with three or more years' experience in transistor circuitry or microwaves, and for the systems engineer in flight control and inertial guidance.

The emphasis is still on men with unusual records of circuit and systems creativity, Mr. Fox says. And to illustrate the difficulty in obtaining really creative men, Mr. Fox notes ruefully that although he reviewed the qualifications of about 4,000 men last year, only one really met the criterion of creativity.

* * *

Is your vacation the proper time for you to look for a job? Men now change jobs at any time of the year, but vacations are the poorest time of the year to do it, advises Lon D. Barton of the employment counselling firm, Cadillac Associates, Inc., Chicago.

A two- or three-week vacation period does not afford sufficient time to find good opportunities and make such an important decision as changing jobs. A vacation should be a time to refuel your mind with a complete change of pace, then return to work refreshed and much better able to conduct a search for a new job, if you are so inclined.

* * *

A new graduate study program has been announced by the MITRE Corp., enabling selected technical personnel to pursue advanced degrees. The "Staff Scholar Program" permits four members of the technical staff to continue their studies at the school of their choice, beginning in the fall. They are: Socrates Litsios, Air Traffic Control Department, seeking to complete a doctorate in electrical engineering at MIT; Alan Braver, Command Systems Department, seeking his master's degree in mathematics at MIT; Irwin W. Miller, Human Factors Department, who will attend Michigan State University for his doctorate in psychology; and Charles C. Joyce, Jr., Weapons Control and Sensor Systems Department, who will seek a master's degree in industrial management at MIT.

Industry and university graduate schools are steadily merging their efforts to obtain both better research and better engineers. While some purists in education might say this will errode the freedom of the university, the trend shows every sign of becoming an increasing one.

Latest signpost is the announcement by Iowa State University, Ames, Iowa, that it is expanding its industry affiliate research program. Under the program, said Iowa's President, Dr. James H. Hilton, industrial organizations have an opportunity to participate in Iowa's solid-state research at the Iowa Engineering Experiment Station.

An obvious reason for this expansion is that it will open the way for further industry funding of university research projects.

In return the affiliate companies will have direct access to the new ideas and applications developed in the program. They will also probably be in a better position to make offers to the graduate students trained in solid-state.

Industry affiliates are to provide $5,000 annually with the option of terminating support at a year's notice. The Experimental Station, itself, will choose the research activities, President Hilton said. An important feature of this type of support is that it will make it possible for research to be maintained for a long period of time rather than on a year-to-year basis. For advanced research, such as basic solid-state phenomena investigations this is important.

The results of all research will also be available to the general public. In accordance with Iowa procedure, any patents resulting from the program will be assigned to the University Research Foundation. Sponsoring affiliates will be granted nonexclusive licenses to any inventions and discoveries coming from research they have supported.

Compared to other industry-university research programs in solid-state, Iowa believes its program is less limited to only those areas which show promise of immediate commercial success. Four major solid-state research areas will be encompassed in this program:

- Thin films: studies of magnetic and nonmagnetic thin film materials for use in memory circuits and logical elements of computers.
- Thermoelectric devices: direct conversion of heat into electricity.
- Semiconductor material application: use of new semiconductor materials to improve electronic devices.
- Bio-medical instrumentation: search for better transducer materials.

CAREERS

A record of 242 papers on developments in computer hardware and concepts leading total systems control have been sifted down to 31 selected for presentation to the Eastern Joint Computer Conference, Dec. 12-14, in Washington.

For the first time, the proceedings will be bound in a hard-cover edition, and the semi-annual computer conference will be under the sponsorship of the American Federation of Information Processing Sciences, comprising the Institute of Radio Engineers, the American Institute of Electrical Engineers and the Association for Computing Machinery.

It is estimated that more than 60 manufacturers will be represented. The theme will be "Computers—Key to Total Systems Control."

* * *

The Keogh-Utt bill would end one form of tax discrimination against self-employed professionals, the National Society of Professional Engineers has told the Senate Finance Committee. The bill (H.R.10) would permit self-employed persons with less than four regular employes to establish retirement plans, deferring up to 10 per cent of their earnings (or $2,500 if that is less).

Self-employed persons with four or more employes, however, would be required to set up a nondiscriminatory retirement program for their employes before they could establish one for themselves.

The Keough-Utt bill has already been passed by the House.

* * *

CIRCLE 904 ON CAREER INQUIRY FORM ▶

ADVERTISERS' INDEX

September 27, 1961

*Manufacturers' catalog appears in 1960-1961 ELECTRONIC DESIGNERS' CATALOG

*Manufacturers' catalog appears in 1960-1961 ELECTRONIC DESIGNERS' CATALOG

G-E LEXAN® POLYCARBONATE RESIN

GOOD DIELECTRIC—AND MUCH MORE!

STABLE ELECTRICALS. Binding posts made of LEXAN resin retain electricals even under moist, hot conditions. They do not loosen, are molded in six attractive LEXAN colors for coding. Other features are: low loss and power factor, low dielectric constant, high voltage insulation, non-sink surfaces.
(Superior Electric)

HEAT RESISTANCE. Beautiful handles of LEXAN polycarbonate resin are used in rugged service on U.L. approved soldering irons. They resist the impact, heat and abrasion of daily bench work. The hard, glossy handles are light in weight. Molded in three pastel colors, they provide toughness and sales appeal.
(Ungar Electric Tools)

TRANSPARENCY of LEXAN resin is important in chart guide for recorder. LEXAN resin is the only transparent plastic able to withstand heat generated by internal lights. It is distortion-free at temperatures up to 270°F and self-extinguishing. Its extremely high impact strength eliminates cracking of guides.
(The Foxboro Co.)

DIMENSIONAL STABILITY. Maximum allowable change in this 5-inch aircraft instrument part is only 5 mils over a temperature range of —65° to 300°F! And it must maintain this tolerance under high humidity. Part is injection molded of LEXAN resin as half spheres which are solvent cemented, lathe-turned and painted. (Lear, Inc.)

TOUGHNESS. Press-fitted into metal gear used in an electric drill, bushing of LEXAN polycarbonate resin provides safety from electric shock . . . helps eliminate need for additional grounding. Strength and creep resistance of LEXAN resin enables bushing to withstand torque and load requirements of drill.
(Millers Falls Co.)

ARE YOU LOOKING FOR A PLASTIC THAT CAN REALLY TAKE IT?

To demonstrate the toughness of LEXAN resin, salesmen will sometimes slam and hammer a product made of the material. LEXAN has the highest impact strength of any plastic – amounting to 12-16 foot-pounds per inch of notch – and it usually emerges unscathed from encounters with such "merchandising stresses". It is a high-performance material, likewise, with regard to high-temperature behavior and dimensional stability.

Its many other advantages make it a priority material for thorough investigation by all designers, engineers and molders. We will be pleased to supply you with information on the properties, processing and end-uses of LEXAN resin. Don't hesitate to write to us. General Electric, Chemical Materials Department, Section ED-51, Pittsfield, Mass.

LEXAN®
Polycarbonate Resin
GENERAL ELECTRIC

CIRCLE 757 ON READER-SERVICE CARD

*Manufacturers' catalog appears in 1960-1961 ELECTRONIC DESIGNERS' CATALOG

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ELECTRONIC DESIGN - ONE DAY SERVICE

USE BEFORE NOVEMBER 8th, 1961

A

Name _____ Title _____

Company _____

Company Address _____ City _____ Zone _____ State _____

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- ☐ I Do Design Work
- ☐ I Supervise Design Work
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ELECTRONIC DESIGN - ONE DAY SERVICE

USE BEFORE NOVEMBER 8th, 1961

B

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Company _____

Company Address _____ City _____ Zone _____ State _____

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To publish promptly corrections brought to our attention.
To not knowingly publish misleading advertisements.
To reserve the right to refuse any advertisement.

Readers noting errors or misstatements of facts are encouraged to write the editor.

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1,000,000 nuvistors

...and now the new RCA-6DS4 high-mu TV and FM tuner triode with semi-remote-cutoff characteristic to reduce cross-modulation distortion

In July, 1961 RCA produced its millionth nuvistor...evidence of the fast-growing popularity of this remarkable tube family.

Newest member of the nuvistor family is the RCA-6DS4, a high-mu triode for TV and FM tuner designs. In VHF TV tuners, the 6DS4 makes possible better reception in many difficult station areas. In addition, the semiremote-cutoff characteristic of the 6DS4 reduces cross-modulation distortion. The 6DS4 makes possible the design of compact TV and FM tuners with very low noise figure and high sensitivity.

This newest nuvistor triode owes its high gain and low-noise capabilities to very high transconductance and excellent transconductance-to-plate current ratio (12500 μmhos at a plate current of 8 ma and plate voltage of 70 volts).

The 6DS4 is just one of 6 commercial nuvistors now at your design command. The others are:

RCA-7587 General-purpose sharp-cutoff industrial tetrode
RCA-7586 General-purpose medium-mu industrial triode
RCA-7895 High-mu industrial triode
RCA-6CW4 TV and FM tuner triode
RCA-2CW4 TV and FM tuner triode

Inherent nuvistor design features include: low heater drain • exceptional mechanical ruggedness due to all ceramic and metal construction • exceptional uniformity of characteristics from tube to tube • extremely low interelectrode leakage • high sensitivity and stability • very small size and light weight.

Discover for yourself how much more you can expect from *nuvistorized* circuitry. See your RCA Field representative or write: Commercial Engineering, Section I-18-DE-2, RCA Electron Tube Division, Harrison, N. J.

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