SPECIFICATIONS FOR THE LOW LEVEL OSCILLATOR, THE TL-61:

WEIGHT: 5 ounces
INPUT IMPEDANCE: 50,000 ohms minimum
MODULATION SENSITIVITY: ±10 MV for ±7½% deviation for standard RDB channels

DRIFT: less than ±0.75% of design bandwidth for a period of 8 hours at normal room conditions following 30 minute warmup

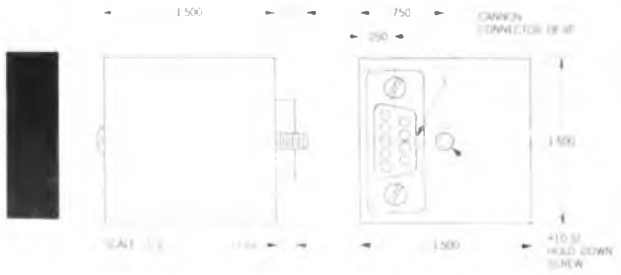
LINEARITY: less than ±0.5% of design bandwidth

INPUT: differential or single ended. Will operate from ungrounded (floating), grounded or partially grounded input sources

COMMON MODE REJECTION: 100 db or better for DC at levels from +5 Volts to −2 Volts. 80 db or better for AC up to 2 KC at 15 Volts peak to peak

OPERATING RANGE: −55°C to +125°C
Center frequency and sensitivity are stable within ±3% of design bandwidth for a temperature change from −20°C to +80°C.

COMPLETELY ENCAPSULATED



CIRCLE 247 ON READER SERVICE CARD

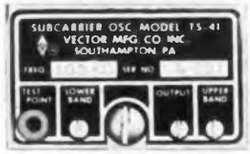
SPECIFICATIONS FOR THE HIGH LEVEL OSCILLATOR, THE TL-63

WEIGHT: 4 ounces
INPUT IMPEDANCE: 1 megohm ±20%
CURRENT CHARACTERISTICS: less than 0.1 microamp reverse current when the input is grounded through a 10K ohm resistor

STABILITY: From −20°C to +80°C a change in the supply voltage of ±10% will vary the center frequency less than ±0.5% of design bandwidth

DRIFT: less than ±0.25% of design bandwidth for a period of 8 hours at ambient temperatures after a 15 minute warm-up.

SENSITIVITY TO SOURCE IMPEDANCE: a change from zero to infinity varies the frequency less than 0.5% of design bandwidth



INTRODUCING THE FLAT-PACK TELEMETRY OSCILLATOR: THE TS-41

SPECIFICATIONS FOR THE TS-41. SUBCARRIER OSCILLATOR:

WEIGHT: 4 ounces

INPUT IMPEDANCE: 1 megohm ±20%

CURRENT CHARACTERISTICS: less than 0.1 microamp reverse current when the input is grounded through a 10K ohm resistor

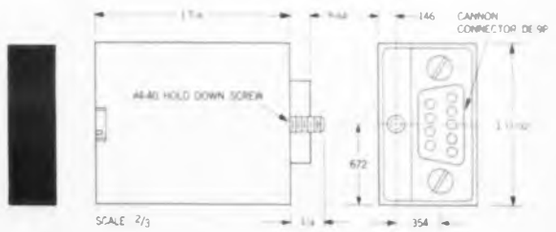
STABILITY: From −20°C to +80°C a change in the supply voltage of ±10% will vary the center frequency less than ±0.5% of design bandwidth

DRIFT: less than ±0.25% of design bandwidth for a period of 8 hours at ambient temperature after a 15 minute warm-up.

SENSITIVITY TO SOURCE IMPEDANCE: a change from zero to infinity varies the frequency less than 0.5% of design bandwidth

TEMPERATURE: Operating range from −55°C to +125°C. At any information input, the output frequency is stable within ±1% of design bandwidth for a temperature change from 0°C to +80°C. The output frequency is stable within ±2% of dbw for a temperature change of −20°C to +80°C.

COMPLETELY ENCAPSULATED



CIRCLE 249 ON READER SERVICE CARD

VECTOR **MANUFACTURING COMPANY, INCORPORATED · SOUTHAMPTON, PENNSYLVANIA**
TELEMETRY SYSTEMS AND COMPONENTS

Tape-Controlled Layout Machine To Drill 48,000 Holes an Hour

An automatic layout machine, designed to drill printed-circuit boards under punched-tape numerical control at rates up to 48,000 holes an hour, will be available within a few months.

The machine, developed by Leland-Gifford Co. of Worcester, Mass., will employ a modified General Electric Mark II numerical positioning control to direct as many as four ganged drilling heads simultaneously.

The Mark II controls positioning of the work table at speeds in excess of 200 in. per min and simultaneous drilling at better than 50 hits per min per spindle. The control, coupled to electrohydraulic machine drives, gives the printed-circuit board a fast positioning response. Positioning accuracy of ±0.001 in. and repeatable accuracies of ±0.0005 in. are produced by a closed-loop servo geared to the machine motions.

The machine features a built-in auto-programer under command of the Mark II. When combined with the Leland-Gifford hole locator, the programer enables the operator to make a punched tape directly from undimensioned drawings.

Leland-Gifford has awarded contracts for the control equipment to General Electric's Specialty Control Dept. of Waynesboro, Va.

Speech Recognizer Under Study

Automatic speech recognizer unit at Air Force Cambridge Research Laboratories, Bedford, Mass., types words spoken into microphone by researcher, Miss H. M. Willet. Behind the typing unit is the computer, which has a drum memory, and Flexowriter. Vocoder for digitizing speech is in another building; it helps the computer form "masks" representing instantaneous power in frequency bands of speech. Masks of spoken words are stored for comparison with words to be recognized. The system has several modes of operation: it can identify speakers or words, or it can be programed to translate from language to language.

◀ CIRCLE 247, 248, 249 ON READER-SERVICE CARD

NEWS

AF Orders Telegraph Distortion Monitor

Three-Unit Equipment Will Permit Checking of Signals And Locating of Circuit Troubles Without Halting Traffic

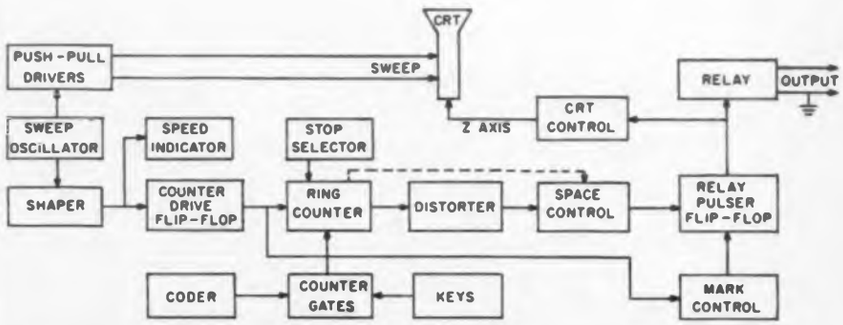
Three-unit telegraph distortion measurement system, mounted above teletype, is designed for teleprinter terminal maintenance and monitoring. Special oscilloscope, at left, analyzes signal reaching receiver, at right, which measures distortion. Unit in center is a transmitter, generating signals at various modulation rates.

AIR FORCE communication centers around the country will soon get a new telegraph distortion measurement system (TDMS), designed to monitor distortion and locate troubles in data circuits without interrupting traffic.

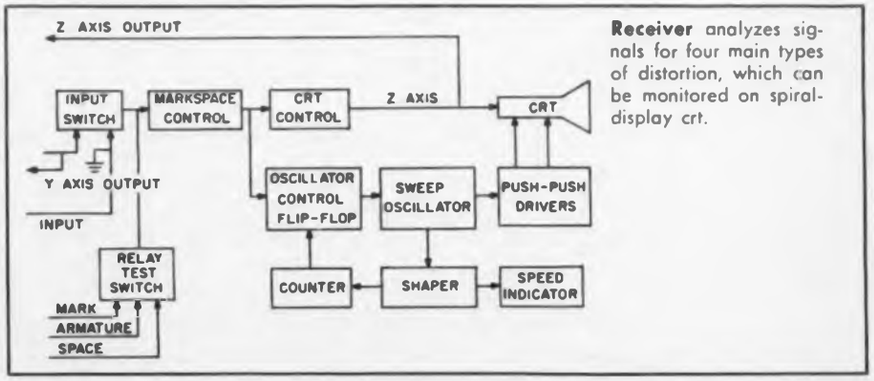
A contract in excess of $700,000 has been let to Radiation, Inc., of Melbourne, Fla., for production of the TDMS. The company will produce a redesigned version of a basic system developed by Automatic Telephone and Electric Co., Ltd., of London.

TDMS comprises three units: a receiver, a transmitter, and an oscilloscope type of monitor.

The transmitter is primarily a telegraph test-signal generator that transmits six types of signals. Modulation rates range from 50-60, 60-80, to 140-160 bauds. Radiation, Inc., reports that up to 50 per cent short or long start-element distortion can be introduced into any test transmission. The unit measures both distortion in its



Transmitter, set up as signal generator or code transmitter, provides test signals at speeds to 160 bauds. High-stability oscillator controls speed approximating one part in 10^3 for long periods and 5 parts in 10^4 for short periods.



Receiver analyzes signals for four main types of distortion, which can be monitored on spiral-display crt.

own test signal and the distortion of signals received from local or distant external sources.

A cathode-ray-tube display on the transmitter permits selective investigation of outgoing or incoming signals. Each changeover appears as a bright dot. Because the display is on a time base, the speed of an incoming signal may be measured by adjusting the speed of a built-in, high-stability oscillator until the dots become stationary.

In the absence of distortion, all dots will be superimposed. Distortion will displace the dots to form an arc, whose length is a measurement of the distortion present.

The unit can also be used to test and adjust relays while they are operating. One position of the control switch provides for the measurement of transmit time and observation of contact bounce. Another position permits observation of neutrality.

Receiver Monitors Signals And Analyzes for Distortion

The receiving unit is the main analyzer of distortion. It monitors either in series by low-impedance current analysis or in parallel by high-impedance voltage analysis. A time-base crt display is also included in the receiver. With the spiral used, each turn is the exact length of one element of a printed signal. Bright dots show on the spiral to indicate transition of the signal from the marking to the spacing condition, or from spacing to marking. With no distortion, the dots form a straight vertical line.

The receiver reportedly analyzes for four main types of distortion: bias distortion, end distortion, characteristic distortion and fortuitous distortion.

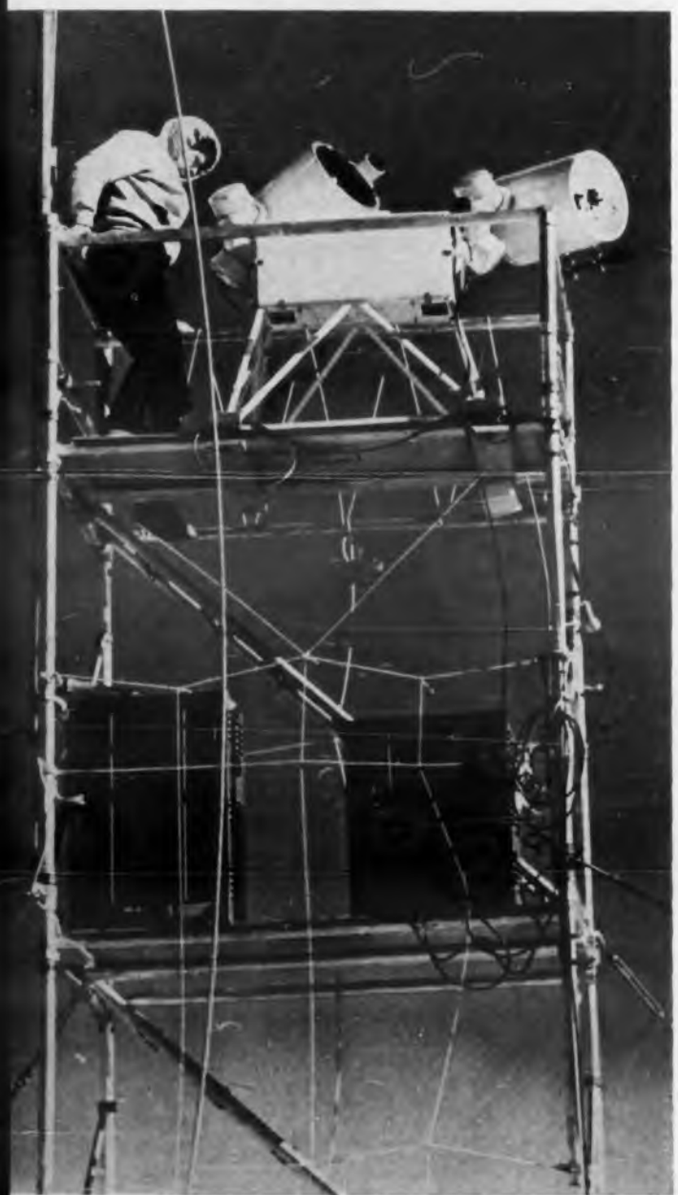
It has limited facilities for measuring transit time and contact bounce of polar relays and similar devices.

Oscilloscope Evaluates Amplitude And Helps Check Waveform

A Tel-A-Scan oscilloscope is the third unit of the system. It is said to have high-gain synchronization and an accurate calibration system. It allows on-line evaluation of the amplitude of the incoming signal and is intended to work with the receiver to provide real-time analysis of the waveform actuating the receiver.

This unit is reported able to measure the voltage of an incoming signal with 5 per cent accuracy without interfering with the waveform presentation. Its vertical amplifier is said to be flat from dc through 7 mc, permitting a rise time display of better than 0.2 μsec. A modified phantastron circuit gives triggered sweeps linear to 1 per cent in 10 ranges from 30 μsec to 3 sec, according to Radiation, Inc. ■ ■

Sunlight-Modulated Communication in Space Is Found Feasible



Experimental Socom transmitter is tested in desert atop 30-ft tower. Transmitter is at left, receiving unit at corner of tower. The transmitter includes a universal optical joint, between the collecting mirror and modulator, which makes direction of transmission independent of the sun's position.

Light collector for Socom is inspected by scientist of Electro Optical Systems, Inc. The company is developing space optics said to weigh less than 0.4 lb per sq ft. Mirrors can be either rigid or foldable.

	Max. Transmission (without auxiliary polarizing)	Transmission Bands (microns)	Linear Aperture (max. practically feasible)	Information Bandwidth (cps)	Power requirements (w/cm^2 per cycle of bandwidth)	Weight (including auxiliaries)
Kerr cell	80%	0.4 to 1.0 1.1 to 1.7	4" x 4" limited by energy requirements	10^9	~0.02	<20 lb
Pockels cell	70%	0.35 to 1.1	4" 0.0 limited by crystal optics	10^5	~0.004	<20 lb
Faraday cell	80%	0.3 to 1.2	2-4" 0.0 limited by energy required	10^6	~10	<20 lb
Stress Optic	25%	0.3 to 1.2	>12" x 12" no serious limitations	10^4 to 10^5	~0.02	<10 lb
Lenticulated Lens plus Grid Shutter	85%	Full range	No serious limit	10^3 or better	~0.003	<10 lb

Characteristics of modulators being considered for use in Socom. No one type has yet shown outstanding advantages in comparison with all the others. Research breakthroughs leading to new classes of optical modulators are needed, Electro Optical Systems says.

But Need for Better Wide-Band, Low-Loss Modulator Is Obstacle

Thomas E. Mount
West Coast Editor

MODULATION of sunlight presents a feasible means for optical communications in space, according to recently completed field tests of a scheme called Socom (Solar Communication). But lack of a really wide-band low-loss optical modulator may restrict this fundamentally promising method.

The Socom approach, developed by Electrical Optical Systems, Inc., of Pasadena, Calif., under a Wright Air Development Div. contract, functioned successfully at simulated distances of up to 10 million miles during tests in the Mojave Desert. With Socom, sunlight collected by a large Cassegrain reflector is beamed through a modulator and on to a distant receiver.

Electro-Optical is recommending to the Air Force that Socom warrants strong consideration wherever tight-beam, secure communication is required. In space vehicles Socom has an edge over rf systems when antenna size and available power are restricted and when the receiving detector is background noise-limited, according to Duane Erway, project supervisor for Socom.

Stressed plate, mechanical and Kerr-cell modulators were alternately employed in the desert tests.

Stressed Glass-Shutter Plate Used to Shift Polarization

The stressed plate modulator, newest of the three types, employs a glass shutter plate, which is deformed by tension applied by a stack of piezoelectric wafers. The resultant stress shifts the polarization of light transmitted by the plate. By interposing the shutter between two crossed polarizers, the transmitted light is thus intensity-modulated, as by a Kerr cell.

The stressed plate shutters tested had a modulation rate of up to 40 bits per sec. At this rate, the message "What hath God wrought" was transmitted in about 5 sec—longer than it would take to say it.

Simulated ranges of several million miles were achieved by interposing dark filters in the beam. Night tests were also conducted, using the full moon and a 100-w bulb as alternate light sources.

In these tests receiver and transmitter were separated by eight miles. At night the beam was

NEWS

successfully received even though attenuated by filters to the point where it was invisible to night-accustomed eyes.

Some difficulty was encountered at night with scintillation and shifting of the beam by variations in atmospheric density. Mr. Erway points out that this might also interfere with space-to-earth communications over extremely narrow beams.

The receiver employed an RCA 7265 photomultiplier with an S-20 cathode. Tests indicated a receiver sensitivity of 10^{-15} w.

Still the problem of developing an optimal modulator remains unsolved. Mr. Erway hopes to boost bandwidths and data rates by refinement of existing modulation techniques, but he concedes that a research breakthrough is necessary for maximum exploitation of Socom's capabilities.

Several Modulation-Schemes Are Now Under Study

A variety of modulation schemes are under consideration. Among these are means of varying the imaging properties of the system (such as focal length) through the use of flexible lenses or plastic reflectors, pivoting mirror systems sweeping past a stop (heliographs), and diverse shutter systems.

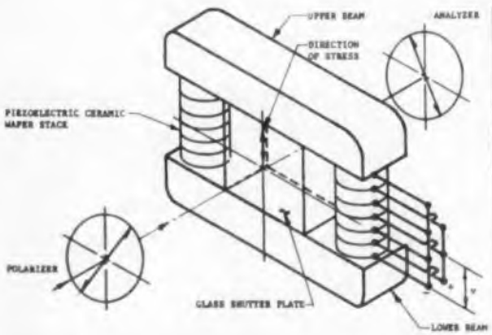
Mechanical modulators so far are the lightest and smallest available. However, the necessity for high-information transmission rates will result in the ultimate obsolescence of mechanical modulators.

Interlens shutters, for example, have relatively long open-and-close time with a subsequent large pulse rise-and-decay time. With louvre shutters, exposure is not simultaneous. Hence from a satellite some parts of the earth would receive a differently shaped pulse than others. In addition, with louvre shutters, any light that is not axially collimated will be intercepted by the flat of the blade.

It is expected that mechanical shutters will suffer in the extreme environment of space, with crystallization and metal fatigue the principal hazards. Enclosing the shutter in an environmental chamber would eliminate the system's inherent advantages of light weight, small volume and low power.

Other advantages of mechanical systems are band pass over the entire spectrum, lack of high-voltage or high-current circuits, and the utilization of highly developed techniques for design and construction of shutter mechanisms.

Of the new techniques of modulation being investigated, one under study is the diffraction of light at ultrasonic-wave fronts in a medium



Stressed-plate modulator used in desert tests of Socom. Action is similar to Kerr cell, but polarization is shifted by stressing the glass-shutter plate by means of the piezoelectric stacks. The advantages of this shutter are said to be high reliability, low power requirements and low thermal absorption. The modulation rate, however, is limited to the low kc range.

like water. A signal carrier is applied to a piezoelectric transducer, and a train of ultrasonic pressure waves travels down the medium.

Thus the medium is broken up into minute, alternate bands of high and low optical density—the equivalent of a defraction grating. The light is defracted around a stop placed on the optical axis.

The maximum bandwidth of this device is about 20 mc. For small bandwidths, a maximum transmission efficiency of about 70 per cent is possible.

Present Polarization Devices Fail To Approach Optimum Requirements

As mechanical modulation becomes obsolete, it will probably not be superseded by presently known polarization devices. None of these approaches optimum requirements.

A disadvantage of all ordinary polarizers is inefficiency. The first polarizer reduces the peak intensity of the light by at least 50 per cent.

One type of polarizer essentially is mechanical. It intercepts a light beam by a wave plate, which is rotated in accordance with a signal. The light transmitted through the plate is polarized in accordance with the degree of rotation.

The large rotation angle needed for adequate changes in the degree of polarization, as well as the use of mechanical equipment, give this scheme no advantage over mechanical shutters.

The Kerr cell is an electro-optical device. Light transmitted through a liquid has its polarization changed in accordance with an electrical signal impressed on the liquid.

The Kerr cell, however, requires auxiliary equipment—a high-power source, low-voltage driving modulator and a power modulator. This

NEWS

Experimental Socom receiver. The photomultiplier tube detected signals at simulated distances of several million miles. A complete Socom system for satellite use would weigh about 40 lb.

auxiliary equipment weighs several times more than the cell itself. (A 2-in. long Kerr cell weighs about 0.2 lb per sq in. of aperture.)

Kerr Cell's Bandwidth Large, But So Is Its Power Requirement

The Kerr cell has a large bandwidth but also a large power requirement. The average power is 0.02 w per sq in. of aperture per cps. Present cells have apertures of several square inches and require 10-to-50-kv pulses.

Pockels cells also are electro-optical devices. A voltage is applied to a basal section of uniaxial crystal. Presently used crystals are ammonium or potassium dihydrogen phosphate. The cells have about 70 per cent transmission efficiency between 0.35 to 1.1 microns.

Pockels cells are low-power devices and would seem to be useful as light modulators. However, the cells are as fragile as ice. They are readily heated by sunlight and expand and crack.

Faraday cells, which are magneto-optical devices, are unsuitable as light modulators because of their high power requirements—about 10 w per sq in. of aperture per cycle bandwidth.

Electro Optical is now developing a Kerr cell modulator with a modulation bandwidth of 5 to 10 kc. Such bandwidth, which would permit transmission of speech, is not difficult to obtain in ordinary Kerr cells, but the device under development has a maximum modulation power requirement of only 20 w.

Mr. Erway sums up the application potentials of the various modulators as follows:

- Mechanical methods, where low bandwidths are adequate and reliability is not critical
- Stressed-plate optics, where somewhat higher rates and extremely good reliability are required
- Kerr cells, ultrasonics, where maximum bandwidth (to the megacycle range) is called for. ■ ■

New Interconnection Techniques Used in Micromin Circuit Blocks

New interconnection techniques have been developed for microminiature encapsulated circuit blocks.

In soldering and unsoldering the leads connecting the modules to the circuit-board harnesses, Convair-Pomona, a division of General Dynamics Corp., has developed a reverse-eyelet design. It allows modules to be inserted or removed in seconds.

The leads from the plastic module are cut to protrude about 1/8 of an inch above the front of the board. The hot solder flows between the eyelet and the lead and between the eyelet flange and the printed-circuit pattern on the board. In effect, the eyelet flange serves both as an electrical link and as a fastener.

In the removal of a module from its harness board, a soldering iron is touched to the eyelets. The solder melts, allowing the eyelets to be slipped off the leads and the leads to be slipped out of their holes.

The technique minimizes the possibility of damage to the module from soldering heat and also facilitates visual inspection of the assembled boards. The assembly method uses an expandable jig holding two sheets of film, each printed with a standard grid. These grids form a three-dimensional envelope within which the components and connecting wires are assembled.

Solid block amplifier circuit, developed by Convair-Pomona, is being used in the infrared guidance system of a missile to boost power to the servo amplifiers.

Impact Studies of Telemetry Units Yielding New Design Clues

Findings Are Spurring Improved Transistor Potting Techniques And High-Acceleration Performance Ratings for Many Components

WHEN AN IMPACT vehicle strikes the moon, a sharp shift in telemetry frequency can be expected because of stresses on transistors.

Information on this and many other important factors in impact-equipment design is being gathered through studies of potted telemetry units for high-acceleration projectiles. Already some of the knowledge that has been acquired is being applied in design of the Ranger lunar-impact vehicle. Meanwhile major high-G telemetry programs in this country and Canada have been extended to encompass impact as well as acceleration effects on electronic equipment.

In the U.S. programs are being considered by Diamond Ordnance Fuze Laboratories in cooperation with the Aberdeen, Md., Proving Grounds; by the Naval Ordnance Laboratory, and by Arnold Engineering Development Center (AEDC) of Tullahoma, Tenn. In Canada similar work is pursued by the Canadian Armament Research and Development Establishment.

In addition to gathering valuable design data for impact equipment, these programs have resulted in improved transistor potting techniques and in acceleration performance ratings for many components.

Tantalum capacitors, for example, have proved unsuitable for high-acceleration or impact missions. Solid tantalums are too brittle and break under stress. The interior portions of wet tantalums shift with high acceleration.

Potting Helps Combat Failure Of Transistors Under Stress

Transistor failure is still one of the biggest problems in these studies, despite the surprise finding that great strength can be expected from them even without potting. Ordinary unpotted transistors can withstand accelerations of 20,000 to 30,000 g, according to Dan Finger, DOFL physicist. One Western Electric transistor, the 2N667, was found capable of withstanding up to 100,000 g without potting.

Since accelerations reached by ordinary impact vehicles, such as bombs, are only about 20,000 g, according to Mr. Finger, the problem with transistors may not be quite as severe as it first appeared.

Potting of transistors has proved quite effective in increasing acceleration tolerance. At first it was found that severe changes in critical parameters resulted from potting of many transistors, and in some cases just exposing the active material to the air was enough to degrade performance significantly. However, transistors have improved, and all of the projectile telemetry groups use greatly improved potting techniques.

The Canadian group uses Araldite 502 mixed with a hardener, type HN951, for potting transistors. DOFL, on the other hand, uses a composition of Shell Chemical's Epon 828 resin and DIMAPA (dimethylaminopropylamine) curing

Plastic sabot fits over projectile inside the gun and breaks away upon firing.

Plastic sabot breaks away from projectile containing telemetry circuits in test at Aberdeen Proving Grounds. Smear camera caught this scene as projectile hurtled from gun muzzle at about 7,000 ft per sec. Some of the plastic pieces are so hot they are self-luminous.

These Passed a G Test

Components for impact vehicles must withstand high-acceleration stresses or their performance deteriorates or fails. The following table shows some of the components tested by the Canadian Armament Research and Development Establishment and the acceleration force that each withstood:

Transistors (Potted)	Acceleration (G)
Philco 2N128	128,000
Philco 2N345	102,000
Philco 2N502	142,000
Philco 2N2078	165,000
Motorola 2N700	133,000
Motorola 2N695	100,000
Fairchild 2N697	192,000
Fairchild 2N706	189,000
GE 2N489	192,000
Capacitors	
Centralab Hikap	118,000
Aerovox DM 15	142,000
Micamold Missilemite	181,000
Vitramon	192,000
Aerovox Cerafil	189,000
Resistors	
Allen-Bradley TR-10	192,000
I. R. C.	100,000
Batteries	
Mallory RM-400R	192,000

agent. DOFL coats the transistor junction with Eastman photo lacquer before applying potting compound.

Internal Construction A Factor In Transistor Performance

In DOFL's tests, transistors were classified according to internal construction. Some construction approaches gave very poor results at high accelerations, while others gave very promising performance.

Transistors using what DOFL terms framed wafer, or billboard, construction, for instance, gave encouraging performance. In this approach, used by three different manufacturers, a semiconductor wafer is supported over most of one surface by a nickel mask, or frame. The mask acts as a base connection, and fine wires are used for emitter and collector connections.

An RCA 2N384, using this construction, survived 78.5 per cent of tests under accelerations of 100,000 to 189,000 g. A similar Motorola 2N655 survived 60 per cent of shots, with accelerations from 100,000 to 218,000 g. A Sylvania 2N94 survived 56.2 per cent of tests, with accelerations ranging from 100,000 to 214,000 g.

An example of the impact resistance of potted telemetry circuits was obtained when one of the Canadian projectiles struck a 2-in, aluminum pipe and split in half. One piece contained the

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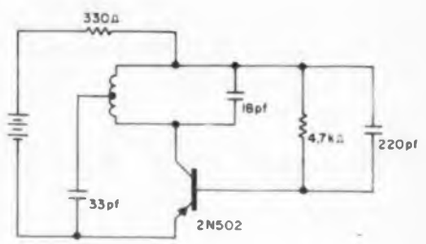


Colpitts-type oscillator with minimum number of components tested successfully in high-acceleration projectiles by Canadian Armament group. The tank coil serves as an rf radiator as well as the inductive element in the tuned circuit. Transmitted power, only a few more watts in this case, can be stepped up by coupling the tank coil to the metallic portion of the carrier, which then would act as the rf radiator. Actual multichannel telemetry system is an fm-fm type in which transducers modulate subcarrier oscillators, which in turn modulate the transmitter.

complete oscillator. When a battery was added to the circuit back in the laboratory, the oscillator was still in good working order.

Tests at the Arnold center indicated the frequency shift that must be expected from transistors on impact. The tests showed that some residual shift can be expected, in addition to the sharp variation at the instant of impact. Further studies of these effects are now in progress. ■ ■

Broadband Analog Divider Designed For Radars and Analog Computers

A relatively simple divider circuit, reportedly with unlimited bandwidth potential, has been designed by engineers at Sperry Gyroscope Co., Great Neck, N.Y. They say it can extend the capabilities of radar systems, analog computers and other systems requiring division of analog signals.

The company declines to describe the circuit in detail, because several proposals for its application are being reviewed by military agencies. Also, "the circuit is so simple we would give everything away if we even hinted at its nature," says one Sperry engineer.

According to the company, closed-loop monopulse radars are generally able to track only one target at a time because of the narrow bandwidth of their gain-control circuitry. If additional if amplifiers for open-loop tracking are added to increase the number of signals that can be processed, the problem of making the amplifiers track while under agc is multiplied.

The proposed divider, according to Sperry,

would permit a single amplifier to process all arriving signals. It would allow the system to open-loop track many aircraft or missiles simultaneously within its bandwidth, while it close-loop tracked one of the targets or the center of gravity of all of them.

The divider would be put in the if circuit of the receiver, where it would divide the azimuth and error signals by the summing signal in real time much more efficiently than does age circuitry of present monopulse radar systems, according to Sperry.

New Circuit Would End Lag in Feedback Time

Normally in monopulse radar there is a tenths-of-a-second time lag that results from running correction signals through feedback circuits; the new circuit would eliminate this delay. Data on range and on the azimuth and elevation angles would be presented instantaneously.

The circuit would be useful also, the company says, in radars more elaborate than monopulse systems, if they required dividing circuitry. A natural application here is said to be height-finding radars. Because better information on height is afforded by comparing two beams than by using data from one, an efficient height-finding radar could be developed around the idea of monopulsing between two adjacent beams of a series of beams, Sperry believes.

For analog computers, the circuit would be installed wherever two signals had to be divided. With slight modifications, it could be used as a multiplier. According to Sperry, it would reduce the need for servo-mechanistic techniques, which have extremely narrow bandwidths and which complicate division circuitry.

Problems would not have to be translated to the slow time required by the servo circuitry, and time-scaling adjustments needed to compute at frequencies higher than 3 cps would be eliminated. Sperry says bandwidths of 5 mc could be achieved easily.

Engineering models have been built to prove that the broadband analog circuit works, the company reports, but the circuits have not yet been incorporated into any equipment.

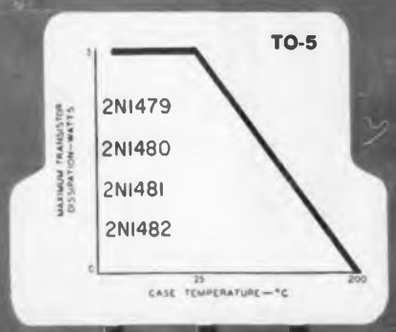
Telefile System Permits Long-Range Banking

A new Telefile system allows savings account transactions to be made at a distant bank.

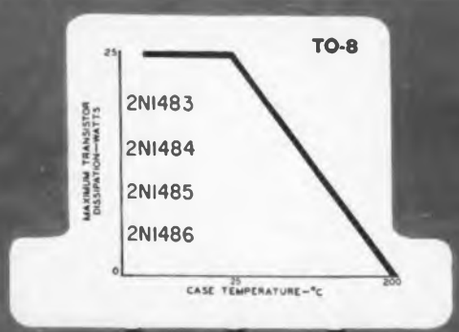
Small banks not related to one another reportedly can use a joint Telefile center and benefit from all its services at nominal cost to each.

The system was developed by Teleregister Corp. of Stamford, Conn.

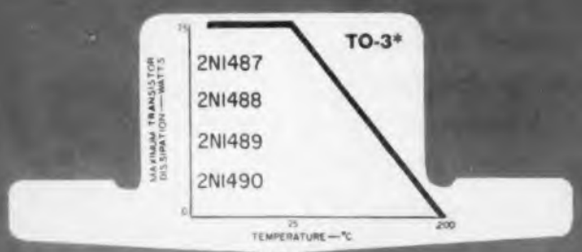
MEDIUM POWER

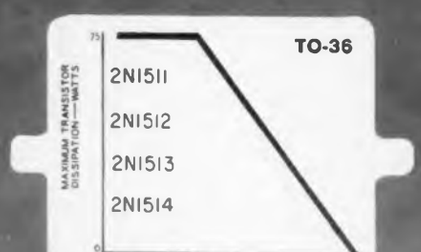


INTERMEDIATE POWER



Upgrade Industrial Circuit Designs With These RCA 200°C Silicon Power Transistors





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COLLECTOR-TO-BASE VOLTS	60V	100V	60V	100V	60V	100V
COLLECTOR-TO-EMITTER VOLTS: With base open (sustaining voltage)	40V	55V	40V	55V	40V	55V
With emitter-to-base reverse biased (V_{EB}=1.5 volts)	60V	100V	60V	100V	60V	100V
EMITTER-TO-BASE VOLTS	12V	12V	12V	12V	10V	10V
COLLECTOR CURRENT (Amps.)	1.5a	1.5a	3a	3a	6a	6a
EMITTER CURRENT (Amps.)	1.75a	1.75a	—3.5a	—3.5a	—8a	—8a
BASE CURRENT (Amps.)	1a	1a	1.5	1.5a	3a	3a
TRANSISTOR DISSIPATION (Watts): At case temperature of 25°C	5w	5w	25w	25w	75w	75w
At case temperature of 100°C	2.86w	2.86w	14.1w	14.1w	43w	43w
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EDITORIAL

The Specialist. Can He Be Interdisciplinary?

As you attend an annual IRE Show and Convention, you cannot help but be conscious of two opposites: on the one hand, you are overwhelmed by the advanced knowledge possessed by many experts. A moment later, however, you are struck by the limited specialization of other so-called experts. It is rare indeed to find one key man in an exhibit booth who can explain thoroughly what he is demonstrating. Even when he is a design engineer on the project, he becomes tongue tied when the black box under discussion isn't of his design.

The keynote address of the 1961 Convention Banquet was entitled, "Where Are the Uncommon Men?" An equally provocative title might have been, "Where Are the Broad Men?" We are daily reminded that we need interdisciplinary specialists to cope with the ever complex world. Biomedical electronics, for example, involves an understanding of biology, medicine, psychology, computers, communications.

Is the interdisciplinary specialist possible? The need for him is there. We frankly doubt, however, whether many of us are capable of mastering more than just a few specialties—at least not at the same time. Rather than feed our frustrations with feelings of remorse and make furtive attempts to do more than seems possible for us, we counsel instead: concentrate first on being a competent specialist; then, and only then, tackle one more field. If you are the uncommon man who can take on more, if you are a brilliant generalist as well as a multi-specialist, we salute you.

But for those of us a bit more common, we can take succor in the knowledge that frequently Nobel Prize winners are good at only one discipline. Indeed, had they spread their energies more, they might have accomplished nothing. The first U. S. Nobel Prize winner, physicist Albert Michelson, was a man who curbed his interest. There is a story that E. O. Lawrence of Cyclotron fame, and a more recent Nobel Prize winner, took renewed heart while he was a young man after visiting Michelson. At that time Michelson was the Dean of Science in this country; yet he confessed readily to Lawrence that he knew little or nothing of atomic physics. It was after this visit that Lawrence felt confident to proceed in his ignorance.

High-Density Electronic Packaging

Design Principles

Part 1

Although semiconductor blocks and molecular devices offer considerable gains in packaging density compared to the high-density packaging technique, the more exotic schemes are still in the developmental stage. High-Density Electronic Packaging (HDEP) is a concept which permits the use of presently available components for miniaturized equipment needed now. Part 1 of this series discusses the concept of HDEP, its applications and the principles involved in the design of a typical systems package. The series will be continued to include layout and design of subassemblies, thermal and structural considerations, the resistance weld process plus tool and jig details.

Paul N. James
The Sippican Corp.
Marion, Mass.

ELECTRONIC equipment for space flight, missiles and satellites must be lightweight, highly reliable, capable of withstanding rigorous environmental shocks and able to operate for a long period without maintenance. Printed-circuit modules do not fully exploit space and weight savings because of connection spacing and supporting structure limitations. More exotic microminiaturization schemes, such as semiconductor circuits or molecular devices, are promising but are not yet available to permit construction of a complete system. To meet the present needs, High-Density Electronic Packaging (HDEP) has been developed and applied in the construction of guidance systems for military applications.

Two major features highlight the HDEP concept, invented in 1957 by Francis Associates, Marion, Mass. First, components are in close physical proximity to take advantage of their compressive strength, thereby eliminating the need for a supporting structure. Second, all-welded construction is used, reducing connection spacing, minimizing thermal-shock damage, upgrading connection reliability and improving circuit producibility. With further development effort the Instrumentation Laboratory of Massachusetts Institute of Technology, Francis Associates and The Sippican Corp. of Marion, Mass., have refined the HDEP concept with matrix subassembles, special connector designs, heat-transfer and encapsulation techniques and improved resistance welding methods.

A typical example of size and weight reduction achieved for an electronic systems package is the IX Series Prototype FBM digital guidance computers designed for the Polaris program. Each computer contains about 6,500 components and occupies a volume of 0.12 ft; total weight, including structural and thermal elements, is approximately 15 lb.

The design and development of a High-Density Electronic Package is based on an analysis of the required system in terms of system logic, circuit capabilities, required reliability, expected maintenance procedures, size and weight requirements and production costs. Once these basic ground rules have been established, the system is designed, using the following principles:

1. Component layout via the "cordwood" scheme.
2. Fabrication of welded wire matrices.
3. Design of specialized connectors.
4. Encapsulation of all components and back-of-panel wiring.
5. Mathematically predictable heat removal techniques.
6. Compressive structural methods.

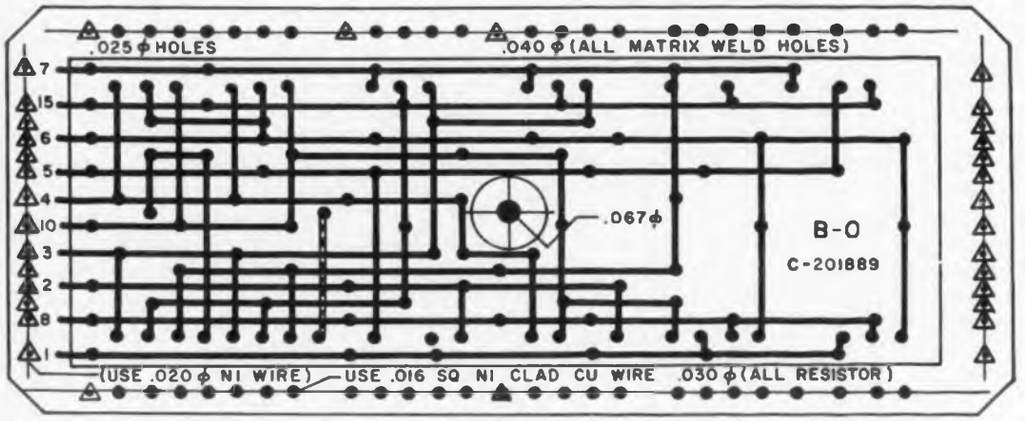
The package design that evolves from the application of these principles normally consists of two electronic subassemblies (circuit modules and wiring modules), an integrated structural-thermal assembly and the necessary connectors and cabling.

Component Stacking: The method employed in the construction of circuit modules is termed the "cordwood" technique, in that components are stacked with their bodies in close physical proximity and their leads parallel. Components that vary in size or shape are arranged to accommodate the least possible space, taking into account thermal and electrical characteristics. High-power dissipating components receive special consideration in the component layout.

Matrix Wiring: The matrix wiring technique, developed by The Sippican Corp. for the Polaris computer logic sticks, is used in the majority of HDEP designs. It is employed with both of the modular subassemblies of a package, circuit modules and wiring modules. Circuit module matrices consist of two layers of wires at right angles to each other, separated by a thin plastic film, such as Mylar or Cronaflex. Welds are made through pre-punched holes in the films to make connections between the perpendicular matrix wires or from a matrix wire to a component lead. The films, as displayed in Figs. 2 and 3, are completely coded to show the weld points, component leads and matrix wire materials. The materials in most common use today are 0.015-

Fig. 1. Various stages of assembly for a logic stick designed for the Polaris computer.

NOR LOGIC



PROGRAMER

Fig. 2. Several circuit module matrix films.

or 0.020-in. diam nickel or copper-nickel alloy wire and 0.016- x 0.016-in. square nickel-clad copper wire.

Matrix wiring is used rather than the more common point-to-point nickel ribbon connections for several reasons. First, the matrix is a testable subassembly, somewhat similar to an etched circuit board, since the circuit is welded together on the film and only needs correct placement of components to complete the assembly.

Second, the large number of crossovers provides ease of engineering layout and often allows complicated wiring patterns to be laid out in one matrix rather than in two or three point-to-point layers. This feature is desirable not only to reduce electrical testing but also because all the matrix and component welds are available during final test and are not covered by a layer of insulating film.

A third advantage of the matrix technique is the ease with which design constraints may be established to speed the layout process. A fourth advantage is the ease with which different conductor materials may be used within one assembly to insure the compatibility of materials to be welded.

The matrix scheme used in the circuit modules is also the basis of the wiring module matrix, Fig. 3. In this case all the electrical connections are made between pins in the wiring module rather than between components or components and output pins. Because of the large number of pins involved—it may be as high as 3,600—multiple layers of matrices must be used. As many as 25 layers have been used to interconnect all the pins in the Polaris wiring module.

Connectors: Since the presently available multipin connectors are an order of magnitude less reliable than the standard permanent connection techniques, such as soldering, welding or crimping, other approaches have been selected to solve the separable connector problem. Two techniques are available today.

The first technique to be developed was the weldable tube and wire scheme used in the Polaris project. This design allows between five and 10 disconnects for each circuit module in the life of the machine. Like the split wire-wrap terminal, to be described, each connection is made individually and therefore may possess the reliability normally associated with permanent crimping and welding techniques.

The second technique, the split wire-wrap terminal design, was developed by Sippican in re-

Advantages of the High-Density Electronic Packaging Technique

Welded vs soldered connections—bending tests have shown that an average of 70 motions was required to fracture a soldered joint compared to 1,152 motions for a welded joint. Welding is less likely to induce thermal stresses in components since heat is more localized than in the soldering process. Finally, welding is a metallurgically sound process that is repeatable and controllable in production.

Use of matrix films—production errors are minimized and component lead and conductor positioning for welding is simplified by means of transparent film sheets bearing the wiring path layout. There is also less restriction of component placement since crossovers and connections can be arranged as desired.

Components—presently available parts can be used now and thin-film or solid-state devices can be included when they become available.

Thermal and structural factors—the HDEP concept contributes to the design of a package rather than making demands upon it. Advantage is taken of the compressive strength of encapsulating compounds subjected to preloading and postloading techniques. Thermal control is achieved by the use of mathematically predictable design configurations.

Environmental resistance—totally encapsulated modular subassemblies with compressive structure members offer high resistance to shock and vibration. A 120-module structure was successfully tested through a range of 0.5 to 3,000 cps at an input force level of 30 g on each of three axes. Shock tests were made in each of the three axes up to 50 g with a time duration of 11 msec half-sine and in one axis up to 100 g for 9-msec duration.

sponse to the need for a connection method possessing the reliability of the tube and wire design but allowing 25 to 50 disconnections within the life of the unit. This terminal is a variation of the original Bell Telephone Laboratories' wire-wrap terminal, developed to replace soldered terminals in Bell's central-office equipment. Because the split terminal uses the wrapping wire only as a means of binding the two half terminals—that is, the solid copper wire is cut off and does not lead to another terminal—the main objection to the original technique in military equipment is eliminated. In this design, fatigue and breakage of the solid wire is not a problem.

These terminals have recently passed tests of 30-g vibration with no detectable difficulties. The units were also subjected to 100-g shock in three axes without any physical damage. They have also been subjected to a full range of standard military environmental tests, including humidity and high and low temperature, after one wrap and after 20 rewraps on each terminal.

Encapsulation: In the HDEP technique, all circuit and wiring modules are encapsulated after welding, regardless of whether they contain components or merely interconnection wiring. This approach offers a considerable increase in environmental resistance that offsets the "throw-away" cost of a defective module. It should be emphasized that environmental resistance includes the ability to withstand a considerable amount of human attack as well as the ability to meet the more standard military specifications. However, circuit module design does not prohibit the fabrication of small, highly reliable modules that have their expensive components, such as transistors and diodes, outside of the potting compound if the environment will allow it. An assembly of a typical circuit module is shown in Fig. 4.

The ideal size and cost of encapsulated circuit modules is a subject of considerable debate at present. Experience has shown that a range of between $100 and $1,000 is not unreasonable for military equipment. Factors to be considered in determining the cost per module include:

1. Type of system logic.
2. Required system reliability.
3. Feasible component and circuit reliability.
4. Number of different modules in a system.
5. Total number of modules in a system.
6. Amount of system or circuit logic in a module.
7. Environmental extremes the system must withstand.
8. Individual component costs within the module.
9. Cost of system down-time.
10. Quality of field repair facilities and personnel.
11. System size and weight requirements.
12. Number of terminals in the system.

Although the technique of encapsulating the intermodule cabling is relatively new, it is valid and necessary, since miniature wire used to cable most airborne and satellite equipment is as vulnerable to damage or failure as most electronic components. Therefore the wire-wrap terminal design and structural designs have assumed the use of completely encapsulated intermodule wiring as well as encapsulated modules. Connections to external assemblies are made through removable cables connected to the wiring modules with wire-wrap terminals or by use of the most reliable military connectors available today. Whenever possible the use of redundant contacts is recommended when connectors are used to help overcome the lack of reliability of these devices.

The types of encapsulating compounds currently in use range in specific gravity from 0.2 to 0.33 for foaming epoxys through 0.7 to 1.0 for microballoon-filled compounds, and up to 1.5 to 2.5 for oxide-filled compounds designed for high thermal conductivity. The choice of a specific compound is determined by the required viscosity, weight and thermal conductivity, as well as such physical factors as compressive modulus and creep. With the exception of the foaming types, all the compounds are vacuum-encapsulated in sealed molds to prevent voids.

Structural Design: The High Density Electronic Packaging approach to the structural design of system assemblies makes use of the compressive strength of encapsulated electronic components. In many current designs individual circuit modules are locked up into centrally supported, post-loaded beams held in compression by means of tension bolts through the center of the modules. This technique provides a considerable saving in the volume and weight assigned to primary fasteners in an assembly, while providing the necessary pressures to allow efficient heat transfer to conductive foils inserted between the modules.

It should be noted that the structural and thermal transfer surfaces of a circuit module are perpendicular to the connector and test-point planes. The use of this rather simple principle increases the flexibility of the heat-removal design, since the module interconnections and the heat-transfer structure do not compete for the same space.

The basic box structure that ties together the cold plates, circuit module beam supports and the wiring module also makes use of the post-stressed concept in its assembly. All the structural pieces of the assembly are fastened to the side frames and mounting feet by means of long bolts that hold the sides of the assembly in compression. The theory underlying this method of assembly has been published in recent literature.[1]

Basically the idea is to balance the compressive and tensile stresses in a structure, so that external loads change the relative proportions of compressive and tensile stress but cause very little deflection until one of these is canceled. The fatigue strength is also increased by this technique. A structure designed according to this principle will have a minimum of elements that require stiffness, the most difficult quality to achieve within a limited space and weight requirement.

The use of this concept in electronic package structures requires a close control of tolerances and careful design of the encapsulated wiring module to allow for the inevitable tolerance build-up and the effects of thermal expansion and contraction. Direct casting of the circuit modules to tolerances of ± 0.002 in. has been proved feasible in production lots.

Thermal Design: A major premise in thermal design concerns the use of conductive heat-transfer techniques to carry the heat generated by the electronic components to a heat sink or to a compact heat exchanger. A primary advantage of this approach is the reliability of both conductive heat transfer and compact heat-exchanger calculations and the ability inherent in the design approach to avoid dangerous hot spots in the equipment.

Two methods of conductive heat transfer within the circuit module are used: highly filled epoxy potting compounds and aluminum conductive plates. The choice between these methods is dependent upon a number of factors. If one class of components has a decidedly lower maximum temperature than the others (often true when germanium transistors are used), an aluminum conductive path from the transistors to the final heat sink is desirable. This method may also be indicated if one component dissipates considerably more power than its neighbors. On the other hand, a conductive potting compound will tend to remove heat from all the components more uniformly than a metal conductor tied to a few selected components.

Conduction of heat from the surface of the circuit modules to the final heat sink or heat exchanger is usually obtained by means of aluminum foils clamped between each module of the post-loaded assemblies. These foils carry the heat to cold plates between the rows of circuit modules if a forced air or liquid-cooling technique is

1. *Machine Design*, Sept. 16, 1960, pp 173-174.

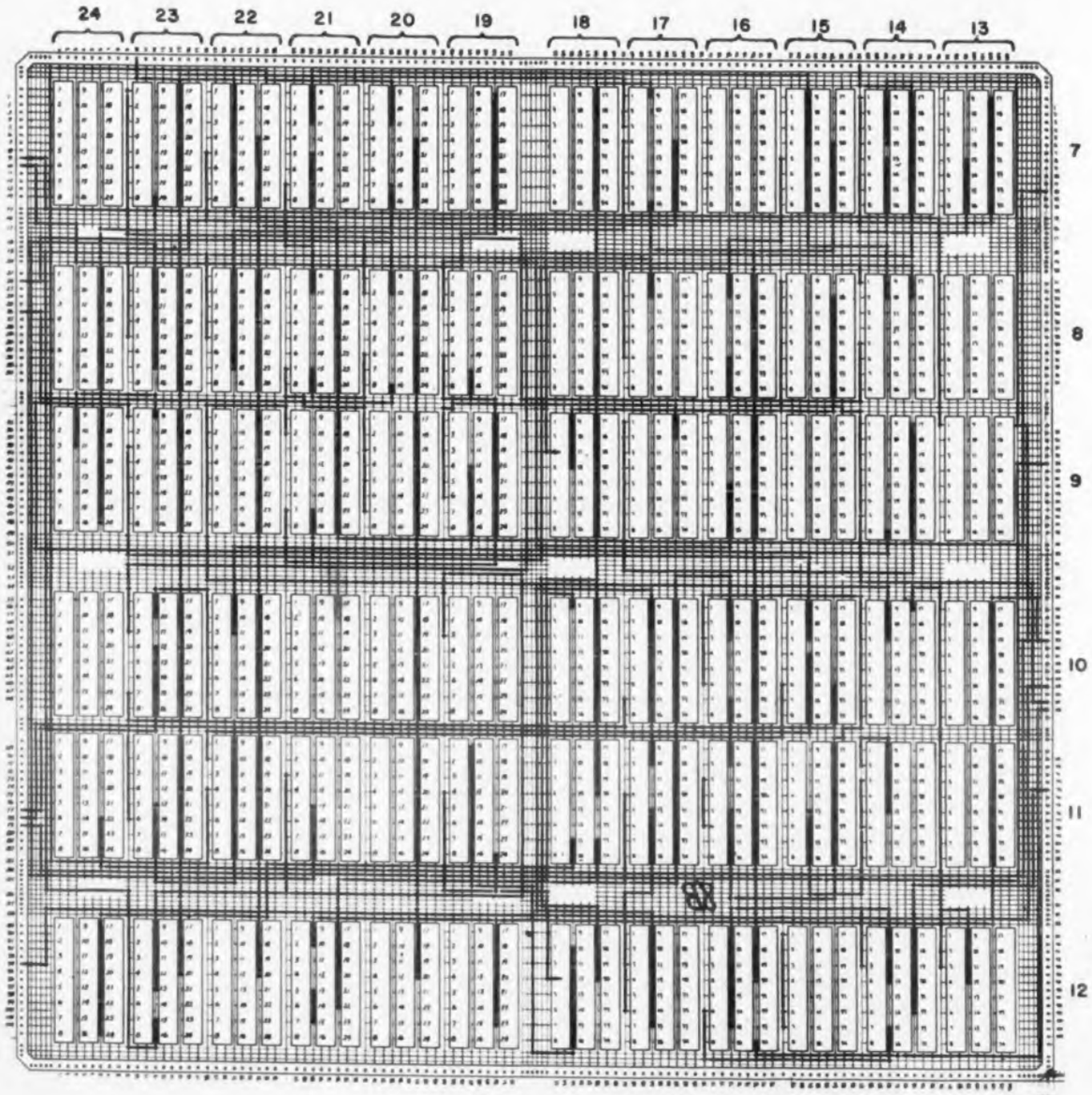
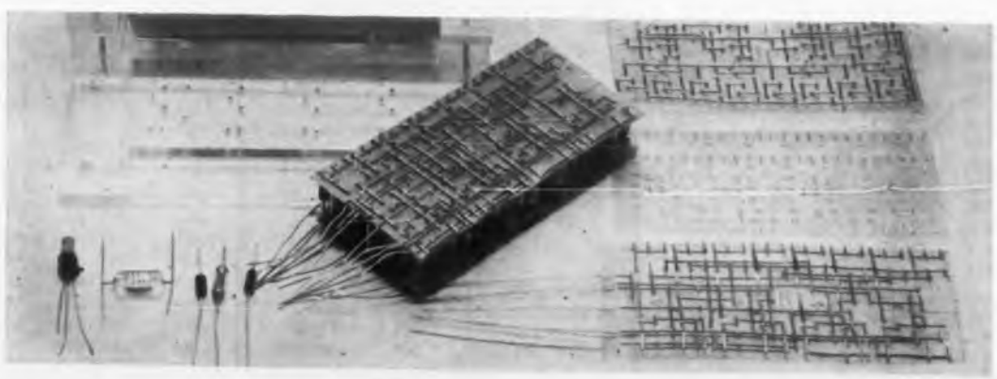


Fig. 3. (left) A wiring module matrix film.

Fig. 4. (below) Circuit module matrices and assembled module; individual components are shown at the left and the assembly jig is in the background.

to be used. Cold plates are highly efficient heat exchangers that can be designed to meet the specific temperatures, pressure drops and mass flow requirements of the system. In addition they provide excellent structural members, having a high stiffness-to-weight ratio.

When a heat sink is used, the foils may be attached to conductive plates that are in turn clamped to the heat sink. Transient cooling techniques may also be incorporated in these systems by making use of the heat of fusion. This can be done by building low-melting-temperature alloys or waxes into the conductive transfer structure. ■ ■



Recommended Transistors for Use in Signal Corps Developmental Equipment

To promote the use of newly developed, newly specified and USASRDL evaluated transistor types, the following list has been prepared.

Irving J. Ross
U.S. Army Signal Research and Development Lab.
Fort Monmouth, N. J.

A LIST OF transistors recommended for use by contractors of Signal Corps electronic equipment has been prepared to supplement the existing standard MIL-STD-701A. The following criteria were used in determining which types were to be included.

- The existence of military specifications and qualified sources for transistors.
- The inclusion of newly developed types for which an Army need has been established and which have been thoroughly tested and evaluated by the Signal Corps.
- The inclusion of the entire distribution of transistor generic types where firm military equipment requirements exist.
- The omission of certain types which were included in MIL-STD-701A because newer and better types are available.

The list is published as a Technical Specifica-

Table 1. Numerical listing of recommended transistor types with applicable military specification reference.

Type		Specification
USAF	2N167A	MIL-S-19500/11A
JAN	2N174	MIL-T-19500/13A
JAN	2N220	MIL-T-19500/1
USA	2N274	MIL-T-19500/26
USA	2N297A	MIL-T-19500/36A
JAN	2N326	MIL-S-19500/40
USA	2N327A	SCL 7002/56
USA	2N328A	MIL-S-19500/110
USA	2N329A	MIL-S-19500/111
JAN	2N331	MIL-T-19500/4A
USN	2N332	MIL-T-19500/37A
USN	2N333	MIL-T-19500/37A
USN	2N334	MIL-T-19500/37A
USN	2N335	MIL-T-19500/37A
USN	2N336	in preparation
USN	2N337	MIL-S-19500/69B
USN	2N338	MIL-S-19500/69B
USN	2N341	in preparation
JAN	2N342	MIL-T-19500/16B
JAN	2N343	MIL-T-19500/16B
JAN	2N358A	MIL-S-19500/63B
JAN	2N384	MIL-S-19500/27A
USN	2N388	MIL-T-19500/65
USN	2N389	in preparation
USA	2N393	MIL-S-19500/77A
USN	2N396A	MIL-S-19500/64A
USAF	2N404	MIL-T-19500/20
USA	2N416	MIL-T-19500/56A
USA	2N417	MIL-T-19500/57A
USN	2N424	in preparation
USA	2N425	MIL-T-19500/41A
USA	2N426	MIL-T-19500/42A
USA	2N427	MIL-T-19500/43A
JAN	2N428	MIL-S-19500/44B
USA	2N465	MIL-T-19500/50A
JAN	2N466	MIL-S-19500/51B
USA	2N467	MIL-T-19500/52B
USA	2N495	MIL-T-19500/54A
USA	2N496	MIL-S-19500/85
USN	2N497	MIL-T-19500/74
USN	2N498	MIL-T-19500/74
USA	2N499	MIL-S-19500/72A
USA	2N501A	MIL-T-19500/62
USA	2N502A	MIL-S-19500/112
JAN	2N526	MIL-S-19500/60C
USA	2N537	MIL-S-19500/100
USN	2N539	MIL-T-19500/38
JAN	2N560	MIL-S-19500/73A
USA	2N600	SCL 7002/100
USA	2N624	MIL-T-19500/82
USN	2N656	MIL-T-19500/74
USN	2N657	MIL-T-19500/74
USA	2N665	MIL-T-19500/58A
USA	2N696	MIL-S-19500/99A
USA	2N697	MIL-S-19500/99A
USA	2N699	in preparation
USA	2N700A	MIL-S-19500/123
USA	2N702	MIL-S-19500/153
USN	2N705	MIL-S-19500/86
USA	2N706	MIL-S-19500/120
USA	2N716	MIL-S-19500/154
USA	2N718	SCL 7002/91
USA	2N1000	MIL-T-19500/79
USA	2N1011	MIL-T-19500/67
USA	2N1026	MIL-S-19500/78A
USA	2N1034	SCL 7002/59
USA	2N1035	SCL 7002/60
USA	2N1036	SCL 7002/61
USA	2N1037	SCL 7002/62
USN	2N1039	MIL-S-19500/89
USN	2N1041	MIL-S-19500/89
USA	2N1042	MIL-S-19500/137
USA	2N1043	MIL-S-19500/137
USA	2N1044	MIL-S-19500/137
USA	2N1045	MIL-S-19500/137
USN	2N1046	MIL-S-19500/88
USN	2N1047A	in preparation
USN	2N1048A	in preparation
USN	2N1049A	in preparation
USN	2N1050A	in preparation
USA	2N1079	SCL 7002/70
USA	2N1080	SCL 7002/71
USA	2N1081	SCL 7002/89
USA	2N1082	MIL-S-19500/103
USA	2N1084	in preparation
USA	2N1085	SCL 7002/80
USA	2N1118	MIL-S-19500/138
USA	2N1119	MIL-S-19500/139
USA	2N1120	MIL-T-19500/68
USN	2N1131	in preparation
USN	2N1132	in preparation
USN	2N1142	MIL-S-19500/87
USA	2N1158A	MIL-S-19500/113
USA	2N1183	MIL-S-19500/143
USA	2N1183A	MIL-S-19500/143
USA	2N1183B	MIL-S-19500/143
USA	2N1184	MIL-S-19500/143
USA	2N1184A	MIL-S-19500/143
USA	2N1184B	MIL-S-19500/143
JAN	2N1195	MIL-S-19500/71B
USA	2N1196	MIL-S-19500/164
USA	2N1197	MIL-S-19500/165
USA	2N1199A	MIL-S-19500/131
USA	2N1200	MIL-S-19500/105
USA	2N1201	MIL-S-19500/101
USA	2N1224	in preparation
USA	2N1225	in preparation
USA	2N1358	MIL-S-19500/122
USA	2N1411	MIL-S-19500/133
USN	2N1412	MIL-S-19500/76
USA	2N1430	SCL 7002/25A
USA	2N1470	SCL 7002/98
USA	2N1479	SCL 7002/76A
USA	2N1480	SCL 7002/76A
USA	2N1481	SCL 7002/76A
USA	2N1482	SCL 7002/76A
USA	2N1483	SCL 7002/74A
USA	2N1484	SCL 7002/74A
USA	2N1485	SCL 7002/74A
USA	2N1486	SCL 7002/74A
USA	2N1487	SCL 7002/75A
USA	2N1488	SCL 7002/75A
USA	2N1489	SCL 7002/75A
USA	2N1490	SCL 7002/75A
USA	2N1500	MIL-S-19500/125
USA	2N1505	in preparation
USA	2N1506	in preparation
USA	2N1528	SCL 7002/106
USA	3N35	MIL-T-19500/80

tion Sheet SCL 6200/9 dated Nov. 1, 1960, which forms part of specification SCL 6200 "Parts, Materials, Processes Used in Ground Signal Equipment." It is the purpose of this specification to provide guide lines and procedures for the selection and application of the most suitable parts and materials in the development of military electronic equipments.

The list, divided into two sections, is subject to periodic revision as types listed become obsolete or newly developed types are added. The list shown, Table 2, uses the format of MIL-STD-701A by categorizing transistors as to application, frequency, and power ranges. There is no division between preferred and guidance types as in MIL-STD-701A. The first part, Table 1, lists the types in numerical order by 2N-number and cites the applicable military specification which the contractor should use in his purchase orders for transistors.

The notation SCL 7002 indicates that a laboratory specification has been prepared for a given type. In most cases, these SCL 7002 specifications will ultimately be superseded by Signal Corps MIL specifications. However, the SCL specification can be used as a valid procurement document in the interim period. ■ ■

Table 2. Listing of Signal Corps recommended transistor types by application, frequency and power ratings.

		Germanium		Silicon	
		PNP	NPN	PNP	NPN
Low Power <300 mw	Audio Freq < 3 mc	2N220* 2N331* 2N465* 2N466 2N467 2N526*		2N1026* 2N1034 2N1035 2N1036 2N1037	2N332 2N333* 2N334 2N335* 2N336
	Med. Freq. 3-30 mc	2N274 2N416 2N417 2N624 2N1224		2N495* 2N1118 2N1196 2N1197	2N338* 2N1082 2N1200 2N1201 2N1528
	High Freq. > 30 mc	2N384* 2N499 2N502A 2N537* 2N700A* 2N1142 2N1158A 2N1225			3N35*
Switching	Low Speed > 5 μsec TOTAL TIME			2N327A 2N328A* 2N329A*	
	Med. Speed 1-5 μsec	2N396A* 2N404* 2N425 2N426 2N427 2N428*	2N167A 2N358A* 2N388* 2N1000	2N496* 2N1119	2N337*
	High Speed < 1 μsec	2N393* 2N501A* 2N705 2N1195* 2N1411 2N1500		2N1131 2N1132*	2N560* 2N702 2N706 2N1199A

*Listed in MIL-STD-701A, dated 31 May 1960

		Germanium		Silicon	
		PNP	NPN	PNP	NPN
Med. Pwr. High Freq.					2N716 2N1505 2N1506
Power	Medium 300 mw-3 watts	2N600 2N1039* 2N1041			2N341* 2N342 2N343* 2N696 2N697* 2N699 2N718
	Intermediate 3 w-30 w	2N539* 2N1042 2N1043 2N1044 2N1045 2N1183 2N1183A 2N1183B 2N1184 2N1184A 2N1184B	2N326*	2N1084	2N497* 2N498* 2N656* 2N657* 2N1079 2N1081 2N1085 2N1479 2N1480 2N1481 2N1482 2N1483 2N1484 2N1485 2N1486
	High > 30 w	2N174* 2N297A* 2N665* 2N1011 2N1046 2N1120* 2N1358 2N1412 2N1430			2N389* 2N424* 2N1047A 2N1048A 2N1049A 2N1050A 2N1470 2N1080 2N1487 2N1488 2N1489 2N1490

All-Pass Networks — Part 5
When to Stop Designing

The all-pass network is so useful in improving the performance of other networks that the designer is easily tempted to continue improving without limit. The first four articles in this series (ED, Oct. 12, Oct. 26, 1960, Feb. 15, March 1, 1961), showed how all-pass networks could be used to design superior networks. Here, in the concluding part of the series, Mr. Lubkin shows when to stop improving network design and, indeed, when not to use the all-pass network at all.

Reprints of this five-part series of articles are available to readers who write to Public Relations Dept., Loral Electronics Corp., 825 Bronx River Ave., New York 72, N. Y.

Yale Jay Lubkin
Loral Electronics Corp.
The Bronx, N. Y.

WHEN TO STOP designing is a key problem for electronic design engineers. The first four articles in this series showed the value of all-pass networks in designing superior networks. But it is still necessary for the designer to know when to stop designing and how close he is to the theoretical optimum.

The Laurent formula for rise time (Eq. 1), can serve as a valuable guide.

$$t_r = \frac{\pi}{\int_0 A(\omega) \cos(\omega t_d - \phi)\, d\omega} \qquad (1)$$

The earlier articles in this series gave examples of improvements possible by judicious choice of all-pass compensating nets. We can now consider an example to illustrate some pitfalls.

Rise Time of Real Amplifier Differs from that of Ideal

We can use the Laurent equation to calculate the envelope rise time of a real and of an idealized if amplifier.

Suppose, for ease in calculation, that both amplifiers have a bandwidth of 2 mc (12.6 megaradians/sec). In calculation of the envelope response, frequency deviations from the if center frequency are important. The envelope response of the if amplifier is the same as the step response of a low-pass filter with a phase and amplitude characteristic at ω which is equal to that of the if amplifier at $\omega_0 + \omega$, where ω_0 is the if center frequency.

In considering the real amplifier, we will take the active elements (tubes or transistors) to be perfectly linear and distortionless. This is a generally satisfactory approximation.

The idealized if amplifier will have an amplitude characteristic that is constant throughout the passband and zero outside the passband. It will have zero phase distortion throughout the passband. This is illustrated in Fig. 1. In Eq. 1 we take $\phi = \omega t_d$ and $A = 1$ for $0 < \omega < 2\pi$ times $(10)^6$, and $A = 0$ for $\omega > 2\pi\,(10)^6$. The rise time is then calculated to be exactly 0.5 μsec.

This is a useful relationship to remember: "An idealized if amplifier of bandwidth f cps has an envelope rise time of $1/f$ sec."

The particular if amplifier characteristic chosen for analysis is the triple stagger-tuned circuit described in Seely's "Vacuum Tube Circuits," Second Edition, p 356. The circuit is found in many television sets. The phase error and the amplitude response of the network are readily calculated. One can use Seely's data and calculate phase and amplitude response separately for each of the tuned circuits, then combine the responses to get the over-all characteristic.

The results, shown in Fig. 2, consider the if bandwidth to be the bandwidth between points at which the amplitude response is down 3 db from its peak. By integrating the product $A \cos \Delta\phi$, $(\Delta\phi = \omega t_d - \phi)$, we find that the rise time of the if amplifier is 0.35 μsec,—only 2/3 of the rise time of the idealized amplifier. Thus the real amplifier appears to have a much better transient response than the idealized amplifier.

A Paradox: Real Amplifier Has Better Response than Ideal

At first thought, these results appear wrong. How can the transient response of the real amplifier possibly be better than that of the idealized amplifier?

Consider the curves of Fig. 2. The first thing to note is that the amplitude response falls off rather slowly and the area under the amplitude curve is much greater than the area under the amplitude curve of the idealized amplifier. It actually is about 60 per cent greater.

Thus, as far as transient response is concerned, the effective bandwidth of the real amplifier is not 2 mc, but about 3.2 mc. The statement that the real amplifier has a bandwidth of 2 mc should be examined more closely. If bandwidth were to be measured at values of attenuation other than at the conventional 3-db points, the results would be quite different. Bandwidth beyond these points contributes substantially to rise time. If the real amplifier has a 6-db bandwidth of 2 mc, the rise time is 0.48 μsec; for 10 db, it is 0.63 μsec, and for 20 db, it is 1.0 μsec.

For the area under the amplitude curve to equal the area under that of the idealized amplifier, the bandwidth would have to be measured at the 8-db-down points. In this case the rise time is 0.57 μsec, somewhat worse than the idealized amplifier.

Triple-Tuned Circuit Shows Low Phase Distortion

The second thing to note is that the phase distortion is extremely low. Though the 3-db bandwidth is 2 mc, the cosine of the phase error, $\Delta\phi$, is greater than 0.9 over a 4-mc bandwidth and the phase error is less than 90 deg over a 6-mc bandwidth.

For comparison, look at the phase error curve, Fig. 3, for the critically damped transformer analyzed in the second part of the series (*ED*, Oct. 26, 1960, p 70). Normally it would not pay to provide phase compensation for the triple-tuned amplifier because the Laurent formula shows that the maximum possible gain in rise time is only 14 per cent.

The third thing to notice is that the phase response is overcompensated, i.e., a small excess of

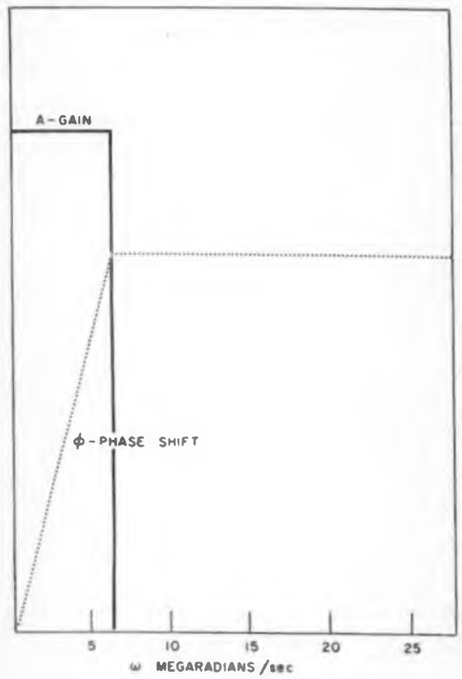


Fig. 1. Gain and phase shift of idealized intermediate frequency amplifier.

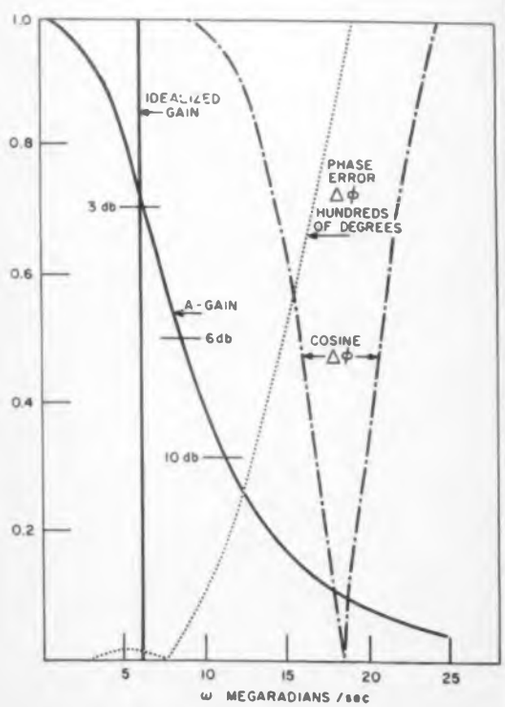


Fig. 2. Gain and phase shift of triple stagger-tuned amplifier.

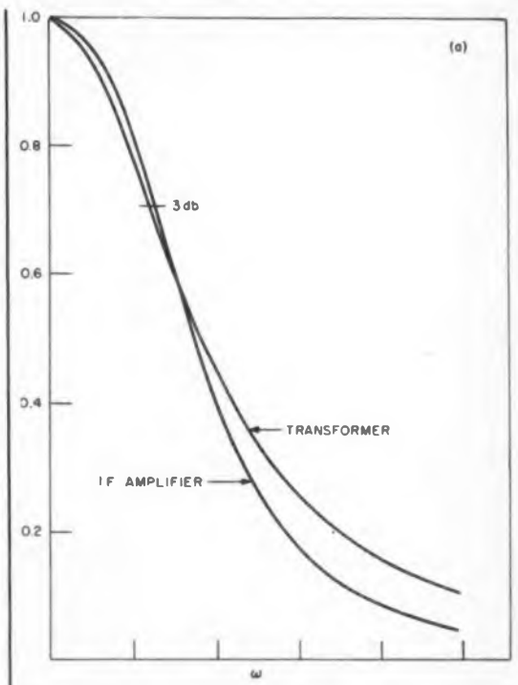


Fig. 3. Comparison of gain *(a)* and phase error *(b)* of intermediate-frequency amplifier and critically damped transformer.

phase shift (here about 1.5 deg) is taken in order that the phase error remain low at higher frequencies. This is a generally useful technique to extend the phase bandwidth. Its use has been illustrated in connection with delay-line design and compensation of the critically damped transformer. An excess phase shift of 30 deg is not too much for pulse work.

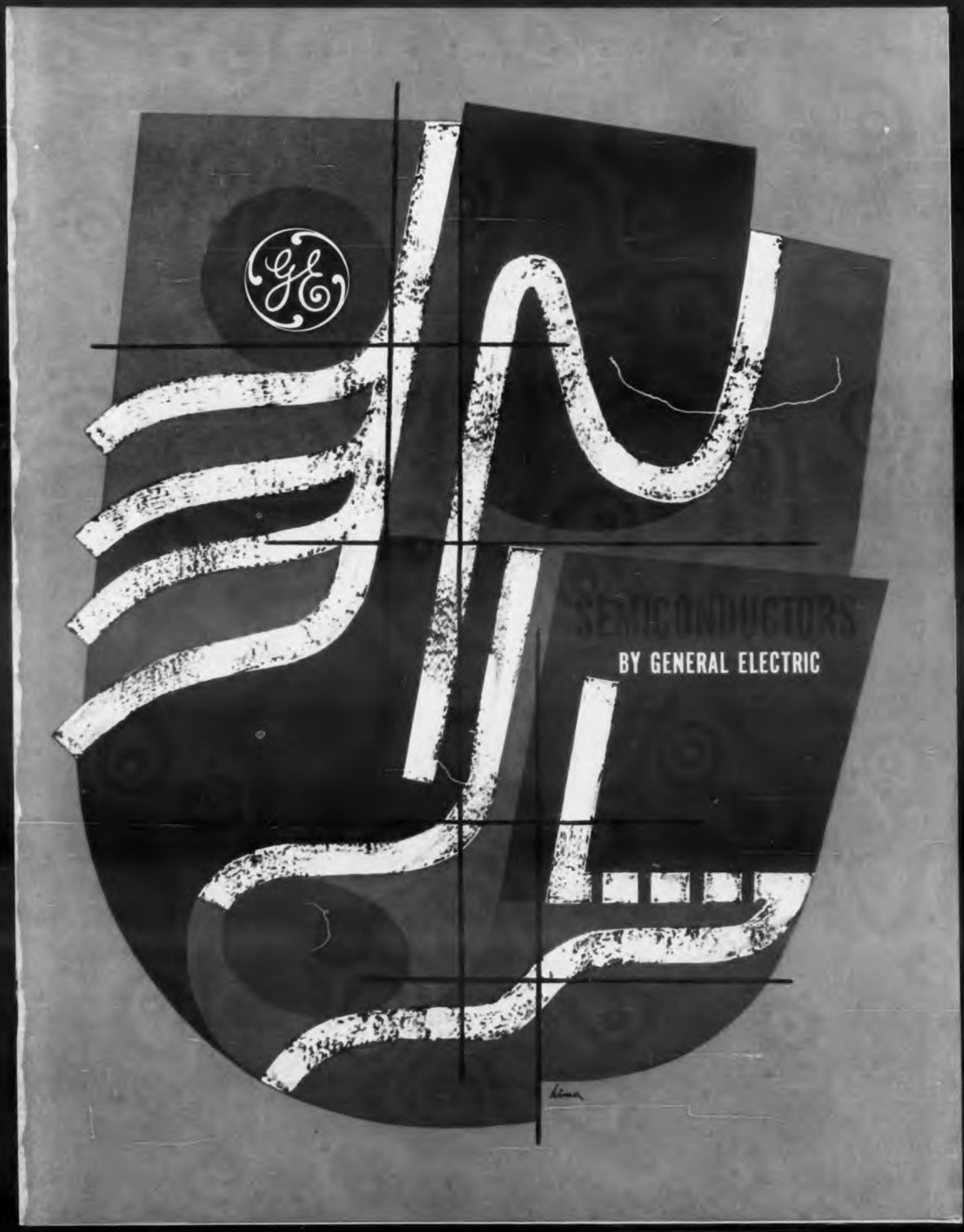
Finally, note that the cosine of the phase error falls off much more rapidly than does the amplitude response. This is a condition which leads to a small amount of ripple and overshoot.

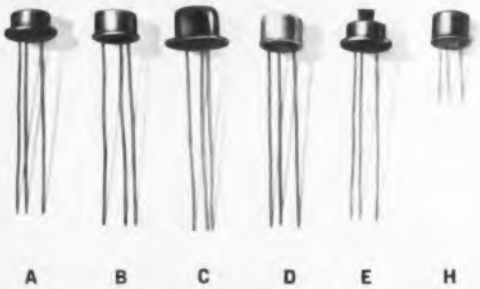
It is evident that the triple-tuned circuit has rather good transient response. The designer is generally advised to leave it alone—provided he is happy with the amplitude characteristic. This situation will frequently occur. In each case the designer must determine the point at which it no longer is economical to improve his basic circuit.

Some results discussed in this series of articles are here summarized to help the designer concerned with transient response.

Guidelines in Designing For Optimum Transient Response

1. In any situation, improvement of phase linearity is beneficial.


SEMICONDUCTORS
BY GENERAL ELECTRIC



A B C D E H

TRANSISTORS

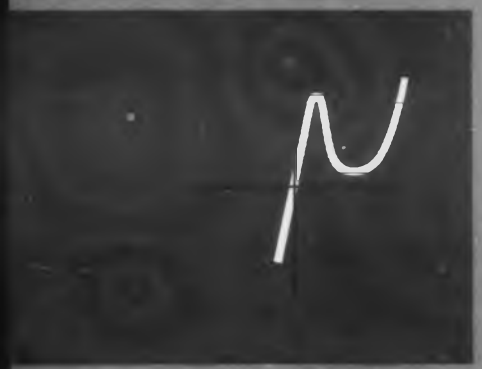
General Electric transistors have earned a reputation for reliability without equal in the industry. Superior quality is built into all G-E semiconductors — by careful control of every step, from refining the raw materials to packaging the finished products.

Among the more than 42,000 transistors on G-E's cycled life test racks at any time are Series 2N43 PNP germanium devices dating back to 1954. Each has clocked at least 48,000 hours—or six years of "power on" operation without failure.

But life testing is only one of the product quality assurance procedures through which all General Electric semiconductors must pass. The average is sixteen separate tests—electrical, mechanical and environmental, as well as life.

General Electric has also introduced a series of design improvements which have raised reliability expectations to a new peak. G.E.'s Fixed Bed Mounting, for example, almost overnight changed delicate grown-junction devices into rugged units with extreme stability and inherently higher power dissipation. One Fixed Bed Mounted Series, types 2N332A through 2N336A, can dissipate up to 500 mw without a heat sink at 25°C, providing an unusually wide safety factor.

TUNNEL DIODE



F

G

Tightly-controlled parameters, low capacitance and a high peak-to-valley current ratio are three outstanding features of General Electric's tunnel diode.

Pioneered by General Electric, this newest arrival in the fast-growing family of electronic devices is smaller, simpler, and many times faster than a transistor. It takes advantage of quantum mechanical tunneling to attain unique negative conductance and very high frequency performance.

G-E germanium tunnel diodes provide switching times of 2 millimicroseconds and self-resonant frequencies covering the S band. The new microwave tunnel diode stripline package has inductance less than .000,000,000,4 henries. This small stripline type package is designed for microwave communications, radar, very high frequency amplifiers, and oscillator applications.

See your G-E Semiconductor District Sales Manager for additional application data and specifications.

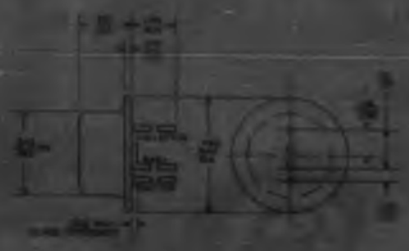
GERMANIUM

Use	Type No.	Case	Outline Drwg.	Max. Forward Current (−55 to +100°C) (ma)	Max. Reverse Current (−55 to +100°C) (ma)	Max. Storage Temp. (°C)	Max. Oper. Junction Temp.	Lead Temp. 1/16" ± 1/32" (From Case for 10 Sec. (°C)	Peak Point Current (ma) I_P	Valley Point Current (ma) I_V	Peak Point Volt. (mv) V_P	Valley Point Volt. (mv) V_V	Rev. Volt. (mv) V_R	Forward Peak Point Current Volt. (mv) V_{FP}	Peak Point Current to Valley Point Current Ratio I_P/I_V	Neg. Conductance (mho) −G	Total Cap. (pf) C	Series* Inductance (nh) L_s	Series Resistance (ohm) R_s
Low Level Switching	1N2939	G	4	5	10	−55 to + 100	−55 to + 100	260	1.0 ± 10%	0.10	60	350	30 Min.	500	10	6.6×10^{-3}	5.0	6	1.5
	1N2940	G	4	5	10	−55 to + 100	−55 to + 100	260	1.0 ± 10%	0.10	60	350	30 Min.	500	10	6.6×10^{-3}	5.0	6	1.5
	1N2941	G	4	25	50	−55 to + 100	−55 to + 100	260	4.7 ± 10%	0.6	60	350	30 Min.	500	8	30×10^{-3}	15	6	0.5
	1N2969	G	4	10	20	−55 to + 100	−55 to + 100	260	2.2 ± 10%	.29	60	350	30 Min.	500	8	16×10^{-3}	8	6	1.0
	1N3149	G	4	50	50	−55 to + 100	−55 to + 100	260	10.0 ± 10%	1.3	60	350	30 Min.	500	8	60×10^{-3}	30	6	.25
	1N3150	G	4	100	100	−55 to + 100	−55 to + 100	260	22 ± 10%	2.8	60	350	30 Min.	500	8	100×10^{-3}	60	6	.15
	1N2938A	G	4	5	10	−55 to + 100	−55 to + 100	260	1.0 ± 2.5%	0.10	60	350	30 Min.	500	10	6.6×10^{-3}	4.0	6	1.5
	1N2940A	G	4	5	10	−55 to + 100	−55 to + 100	260	1.0 ± 2.5%	0.10	60	350	30 Min.	500	8	6.6×10^{-3}	4.0	6	1.5
	1N2941A	G	4	25	50	−55 to + 100	−55 to + 100	260	4.7 ± 2.5%	0.6	60	350	30 Min.	500	8	30×10^{-3}	10	6	0.5
	1N2969A	G	4	10	20	−55 to + 100	−55 to + 100	260	2.2 ± 2.5%	.29	60	350	30 Min.	500	8	16×10^{-3}	6	6	1.0
	1N3149A	G	4	50	50	−55 to + 100	−55 to + 100	260	10.0 ± 2.5%	1.3	60	350	30 Min.	500	8	60×10^{-3}	25	6	.25
Microwave Communication	1N3218	F	7	5	10	−55 to + 100			1.0 ± 10%	0.13	60	350	20	500		5×10^{-3}	1	0.3	1.5
	1N3218A	F	7	5	10	−55 to + 100			1.0 ± 10%	0.13	60	350	20	500		4×10^{-3}	4	0.3	1.5
	1N3219	F	7	5	10	−55 to + 100			2.2 ± 10%	.28	60	350	20	500		12×10^{-3}	14	0.3	0.7
	1N3219A	F	7	5	10	−55 to + 100			2.2 ± 10%	.28	60	350	20	500		12×10^{-3}	7	0.3	0.7

*Inductance will vary 1 – 12 nh (10^{-9} henries) depending on lead length.

TRANSISTOR OUTLINE DRAWINGS

1



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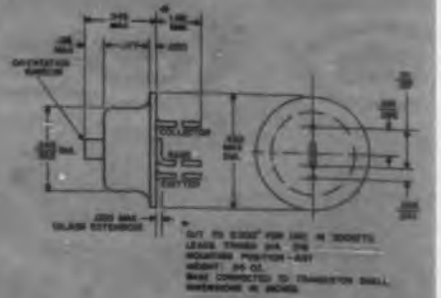

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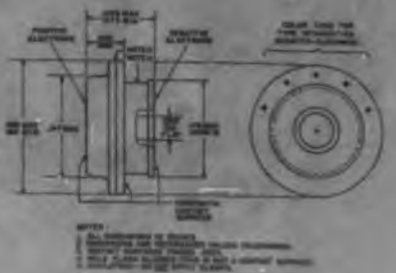

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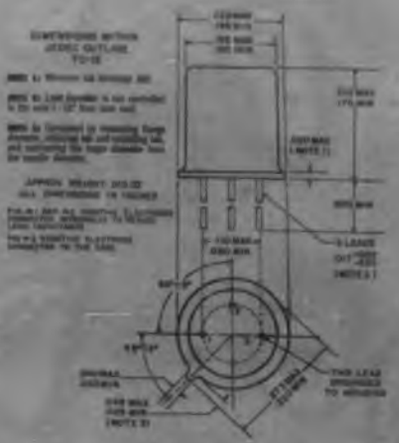

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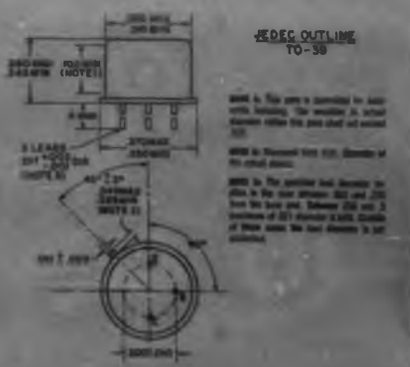

RATINGS

Material	Use	Type No.	Case	Outline Drawing	Maximum Dissipation @ 25°C Pc (mw)	[illegible]	Maximum Rated Voltage (Volts)	[illegible]	Maximum Collector Current (ma)
SILICON	AMPLIFIER AND COMPUTER NPN (Ceramic Fixed-Bed Construction)	2N332 (Per MIL-T-19500/37A) (NAVY)	D	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N333 (Per MIL-T-19500/37A) (NAVY)	D	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N334 (Per MIL-T-19500/37A) (NAVY)	D	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N335 (Per MIL-T-19500/37A) (NAVY)	D	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N336	D	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N332A	D	4	500	[illegible]	[illegible]	[illegible]	[illegible]
		2N333A	D	4	500	[illegible]	[illegible]	[illegible]	[illegible]
		2N334A	D	4	500	[illegible]	[illegible]	[illegible]	[illegible]
		2N335A	D	4	500	[illegible]	[illegible]	[illegible]	[illegible]
		2N336A	D	4	500	[illegible]	[illegible]	[illegible]	[illegible]
		2N335B	D	4	500	[illegible]	[illegible]	[illegible]	[illegible]
		2N337 (Per MIL-T-19500/69C) (NAVY)	D	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N338 (Per MIL-T-19500/69C) (NAVY)	D	4	125	[illegible]	[illegible]	[illegible]	[illegible]
		2N1277	D	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N1278	D	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N1279	D	4	150	[illegible]	[illegible]	[illegible]	[illegible]
	UNIJUNCTION PN (Ceramic Fixed-Bed Construction)						V_{BB} (MAX)		I_E
		2N489 (Per MIL-T-19500/75) (USAF)	D	5	[illegible]		[illegible]		[illegible]
		2N490 (Per MIL-T-19500/75) (USAF)	D	5	[illegible]		[illegible]		[illegible]
		2N491 (Per MIL-T-19500/75) (USAF)	D	5	[illegible]		[illegible]		[illegible]
		2N492 (Per MIL-T-19500/75) (USAF)	D	5	[illegible]		[illegible]		[illegible]
		2N493 (Per MIL-T-19500/75) (USAF)	D	5	[illegible]		[illegible]		[illegible]
		2N494 (Per MIL-T-19500/75) (USAF)	D	5	[illegible]		[illegible]		[illegible]
		2N1671	D	5	[illegible]				[illegible]
		2N1671A	D	5	[illegible]				[illegible]
		2N1671B	D	5	450				[illegible]
	AUDIO NPN Mesa						V_{CBO}		I_C
		2N497	B	2	[illegible]	[illegible]	[illegible]	[illegible]	
		2N498	B	2	[illegible]	[illegible]	[illegible]	[illegible]	
		2N656	B	2	[illegible]	[illegible]	[illegible]	[illegible]	
		2N657	B	2	[illegible]	[illegible]	100	[illegible]	
		2N497A	B	2	[illegible]	[illegible]	[illegible]	[illegible]	
		2N498A	B	2	[illegible]	[illegible]	[illegible]	[illegible]	
		2N656A	B	2	[illegible]	[illegible]	[illegible]	[illegible]	
		2N657A	B	2	[illegible]	[illegible]	[illegible]	[illegible]	
GERMANIUM	AUDIO PNP	2N43	A	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N43A (Per MIL-T-19500/18) (USAF)	A	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N44	A	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N44A (Per MIL-T-19500/6) (USAF)	A	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N524	B	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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		2N527	B	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N1175	B	2	200	[illegible]	[illegible]	[illegible]	[illegible]
		2N1175A	B	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N1413	B	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N1414	B	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N1415	B	2	200	[illegible]	[illegible]	[illegible]	[illegible]
	COMPUTER PNP	2N123 (Per MIL-T-19500/30) (USAF)	E	6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N394A	B	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N395	B	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N396	B	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N396A (Per MIL-S-19500/64A) (NAVY)	B	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N397	B	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N404 (Per MIL-T-19500/20A) (USAF)	B	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N404A	B	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N413	B	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N414	B	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N450	E	6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N1057	A	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N1614	A	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	MEDIUM FREQ. AMPLIFIER NPN	2N78	C	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N78A (Certified to meet MIL-S-19500/90)	C	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N169A	C	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	COMPUTER NPN	2N167	C	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N167A (Per MIL-S-19500/11A) (USAF)	C	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N377	B	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N385	B	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N388 (Per MIL-T-19500/65) (NAVY)	B	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N634A	B	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N635A	B	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N636A	B	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N1196	C	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N1217	C	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N1288	H	9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N1289	H	9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N1304	B	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N1306	B	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N1308	B	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N1510	C	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		2N1694	C	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TYPICAL SPECIFICATIONS

CURRENT GAIN h_{FE} MIN.	CURRENT GAIN h_{FE} MAX.	CURRENT GAIN h_{fe} MIN.	CURRENT GAIN h_{fe} MAX.	ALPHA CUTOFF FREQ. $f_{\alpha b}$ (mc)	POWER GAIN (db) Ge (1000 Cyc.) (5 mc)*	SATURATION VOLTAGE (VOLTS) V_{CE} (SAT) R_{ac} (ohms)*	COLLECTOR CAPACITY ($\mu\mu f$) C_{ob}	COLLECTOR TO BASE CURRENT MAX I_{CO}	(μa) @	V_{CB}
	14 typ	9	22	10	14*	90*	7	2	25°C	30
	31 typ	18	44	12	14*	80*	7	2	25°C	30
	38 typ	18	90	13	13*	75*	7	2	25°C	30
	56 typ	37	90	14	13*	70*	7	2	25°C	30
	100 typ	76	333	15	12*	70*	7	2	25°C	30
	16 typ	9	22	10	11*	0.5	7	20	150°C	30
	27 typ	18	44	11	11*	0.45	7	20	150°C	30
	36 typ	18	90	12	12*	0.42	7	20	150°C	30
	45 typ	37	90	13	12*	0.4	7	20	150°C	30
	75 typ	76	333	15	12*	0.4	7	20	150°C	30
28	90	37	90	13	12*	.4	7	500	25°C	30
20	55	18		30		75*	1.4	1	25°C	20
45	150	39		45		75*	1.4	1	25°C	20
		18	44	30	39	0.53	2	50	150°C	30
		37	90	30	44	0.56	2	50	150°C	30
		76	333	34	45	0.47	2	50	150°C	30

α MIN.	α MAX.			f_{MAX} (mc)	R_{BBO} (K ohms)	V_E (SAT)	I_{B2} (ma)	I_{EO}		V_{B2E}
.51	.62			0.9	5.6	3.1	12	20	150°C	10
.51	.62			0.7	7.5	3.3	12	20	150°C	10
.56	.68			0.8	5.6	3.4	12	20	150°C	10
.56	.68			0.7	7.5	3.6	12	20	150°C	10
.62	.75			0.7	5.6	3.8	12	20	150°C	10
.62	.75			0.65	7.5	3.9	12	20	150°C	10
0.47	0.62				9.1 Max.	5 Max.	12	12	25°C	30
0.47	0.62				9.1 Max.	5 Max.	12	12	25°C	30
0.47	0.62					5 Max.	0.2 Max.	0.2	25°C	30

h_{FE} MIN.	h_{FE} MAX.			$f_{\alpha b}$ (mc)	Ge	V_{CE} (SAT) R_{ac} (ohms)*	C_{ob}	MAX. I_{CO}		V_{CB}
12	36			10		25 Max.		10	25°C	30
12	36			10		25 Max.		10	25°C	30
30	90			10		25 Max.		10	25°C	30
30	90			10		25 Max.		10	25°C	30
12	36			10		10*		10	25°C	30
12	36			10		10*		10	25°C	30
30	90			10		10*		10	25°C	30
30	90			10		10*		10	25°C	30
34	85	20		1.3		0.090	40	16	25°C	45
18	43			1		0.090	40	16	25°C	45
25	42	18	41	2		0.070	25	10	25°C	30
34	85	20	84	2.5		0.075	25	10	25°C	30
53	90	44	88	3		0.080	25	10	25°C	30
72	121	60	120	3.3		0.090	25	10	25°C	30
70	140	60	120	4.2		0.090	26	12	25°C	30
70	140	60	120	4.2		0.090	26	12	25°C	30
25	42	20	41	3.2		0.070	26	12	25°C	30
34	85	20	84	3.5		0.075	26	12	25°C	30
53	90	44	88	4.0		0.080	26	12	25°C	30
30	150			5 Min.		0.15	20 Max.	6	25°C	20
30	120			5 Min.		.15 Max.	20 Max.	6	25°C	13
30	150			3 Min.		0.1	20 Max.	6	25°C	15
30	150			5 Min.		0.08	20 Max.	6	25°C	20
30	150			5 Min.		0.2 Max.	20 Max.	6	25°C	20
40	150			10 Min.		0.07	20 Max.	6	25°C	12
				4 Min.		0.14	20 Max.	5	25°C	12
				4 Min.		.15 Max.	20 Max.	90	80°C	12
		30 typ		6			12	5	25°C	12
		60 typ		7			12	5	25°C	12
20				5 Min.		0.2 Max.	20 Max.	6	25°C	12
34	90			1.3		0.08	40	16	25°C	45
18	43			1.3		.090	40	25	25°C	65
40	135	30	200	9	31 (455Kc)		3	3	25°C	15
45	135	30	200	9	31 (455Kc)		3	3	25°C	15
34	200			9	28 (455Kc)	0.23	2.4	5	25°C	15
17	90	20	200	9		0.35	2.5	1.5	25°C	15
17	90	20	200	9		0.35	2.5	29	71°C	15
20	60			6			12	20	25°C	25
30	110			6.0				35	25°C	25
60	180			5 Min.			12	10	25°C	25
40	120			8		0.10	12	80	71°C	25
80	240			12.5		0.085	12	80	71°C	25
100	300			17		0.075	12	80	71°C	25
17	90	20	200	9		0.35	2.5	1.5	25°C	15
40	150			9.0		0.1	2.5	1.5	25°C	15
30	300			60		0.2	6	5	25°C	10
30	300			60		0.2	6	5	25°C	15
40	200			8		0.10	12	6	25°C	25
60	300			12		0.09	12	6	25°C	25
80				17		0.08	12	6	25°C	25
8	90					0.26		5	25°C	75
17	90			9.0		0.1	2.5	1.5	25°C	15

RECTIFIER CELLS

General Electric's work in subduing Thermal Fatigue, a major Semiconductor killer, has helped earn it the reputation of being the quality Semiconductor Rectifier producer of the industry. In addition, the Rectifier Components Department has recognized the problems associated with Transient Voltages and has rated its devices accordingly.

In the medium and high-current rectifiers, General Electric has completely eliminated soft solder joints, thus greatly reducing the problem of thermal fatigue. This means that G-E Rectifiers and Controlled Rectifiers can be worked right up to maximum current and temperature ratings, even on highly cyclical loads.

In addition, all General Electric rectifiers and Controlled Rectifiers carry *transient* PRV ratings which give the user additional protection against voltage transients.

The rectifier cells shown are listed in ascending order based on forward current ratings in each section. Maximum full load voltage drop is taken at full cycle average.

Complete specifications are available through your Semiconductor Products District Sales office or through your authorized G-E Semiconductor Distributor.

GERMANIUM LOW CURRENT RECTIFIER CELLS
UP TO 1200 MA — UP TO 400 PRV

JEDEC or GE Type Number	PRV	Max. I_{DC} at T°C	Max. Peak Surge Current	Max. Rev. Current (Half Cycle Av.)	Max. Full Load Voltage Drop	Max. Oper. Temp. °C
		@ 55°C Amb.				
1N93	300	75 ma	25 A	.6 ma	.18V	95°
USN 1N93	300	75 ma	25 A	.6 ma	.18V	95°
1N315	300	75 ma	25 A	Min. Fwd./Rev. Ratio-700 @ 55°C		85°
USAF 1N315	300	75 ma	25 A	Min. Fwd./Rev. Ratio-700 @ 55°C		85°
1N368	200	100 ma	25 A	.3 ma @ 150 V.D.C.	.48V	55°
1N92	200	100 ma	25 A	.95 ma	.19V	95°
1N91	100	150 ma	25 A	1.35 ma	.22V	95°
1N153	300	750 ma	25 A			95°
1N158	400	1000 ma	25 A			95°
1N152	200	1000 ma	25 A			95°
1N151	100	1200 ma	25 A			95°

COMMENTS

Industry standard for high reliability units. Feature extremely low forward resistance, high back resistance.

SILICON SUBMINIATURE GLASS RECTIFIER CELLS (Lead Mounted)
UP TO 400 MA — UP TO 600 PRV

JEDEC or GE Type Number	Repetitive PRV	Transient PRV	Max. I_{DC} at T°C	Max. Rev. Cur. (Full Cycle Av.)	Max. Full Load Voltage Drop	Max. Oper. Temp. °C
			@ 25°C	@ 100°C	@ 25°C	
1N645	225	275	400 ma	15 μa	1V	175°
1N646	300	360	400 ma	15 μa	1V	175°
1N647	400	480	400 ma	20 μa	1V	175°
1N648	500	600	400 ma	20 μa	1V	175°
1N649	600	720	400 ma	25 μa	1V	175°
1N677	100	120	400 ma	.2 ma @ 150°C	1V	175°

1N676-1N679, 1N681-1N687 and 1N689 are also available in this package.

COMMENTS

Designed for maximum thermal conductance. Rugged design to meet military requirements.

SILICON LOW CURRENT RECTIFIER CELLS (Lead Mounted)
UP TO 750 MA — UP TO 1000 PRV

JEDEC or GE Type Number	PRV	Max. Io @ T°C Amb.	Max. Peak 1 cycle Surge	Max. Rev. Cur. (Full cycle Av.)	Max. Full Load Voltage Drop	Max. Oper. °C	COMMENTS
		@ 50°C		@ 25°C	@ 25°C		
1N440	100	300 ma	15 A	.3 μa	1.5V	150°	
1N441	200	300 ma	15 A	.75 μa	1.5V	150°	
1N442	300	300 ma	15 A	1.0 μa	1.5V	150°	Refer also to 1N440-B-5B Specification Sheet.
1N443	400	300 ma	15 A	1.5 μa	1.5V	150°	
1N444	500	300 ma	15 A	1.75 μa	1.5V	150°	
1N445	600	300 ma	15 A	2.0 μa	1.5V	150°	
		@ 25°C			@ 200 ma		
1N599	50	600 ma	10 A	1.0 μa	1.5V	150°	
1N599A	50	600 ma	10 A	1.0 μa	1.5V	150°	
1N600	100	600 ma	10 A	1.0 μa	1.5V	150°	
1N600A	100	600 ma	10 A	1.0 μa	1.5V	150°	
1N601	150	600 ma	10 A	1.0 μa	1.5V	150°	
1N601A	150	600 ma	10 A	1.0 μa	1.5V	150°	
1N602	200	600 ma	10 A	1.0 μa	1.5V	150°	
1N602A	200	600 ma	10 A	1.0 μa	1.5V	150°	Refer also to 1N440-B-5B Specification Sheet.
1N603	300	600 ma	10 A	1.0 μa	1.5V	150°	
1N603A	300	600 ma	10 A	1.0 μa	1.5V	150°	
1N604	400	600 ma	10 A	1.5 μa	1.5V	150°	
1N604A	400	600 ma	10 A	1.5 μa	1.5V	150°	
1N605	500	600 ma	10 A	2.0 μa	1.5V	150°	
1N605A	500	600 ma	10 A	2.0 μa	1.5V	150°	
1N606	600	600 ma	10 A	2.5 μa	1.5V	150°	
1N606A	600	600 ma	10 A	2.5 μa	1.5V	150°	
		@ 30°C		@ 150°C	@ 150°C		
1N560	800	600 ma	15 A	.3 ma	0.5V	150°	Now with transient PRV ratings up to 1200V.
1N561	1000	600 ma	15 A	.3 ma	0.5V	150°	
		@ 50°C		@ 100°C	@ 100°C		
1N1692	100	600 ma	20 A	.5 ma	0.6V	115°	
1N1693	200	600 ma	20 A	.5 ma	0.6V	115°	Similar to 1N536-47 series except for lower temp. and current operation. Lowest priced series.
1N1694	300	600 ma	20 A	.5 ma	0.6V	115°	
1N1695	400	600 ma	20 A	.5 ma	0.6V	115°	
1N1696	500	600 ma	20 A	.5 ma	0.6V	115°	
1N1697	600	600 ma	20 A	.5 ma	0.6V	115°	
				@ 25°C	@ 25°C		
1N444B	500	650 ma	15 A	1.75 ma	1.5V	150°	
1N445B	600	650 ma	15 A	2.0 ma	1.5V	150°	Very low leakage. Ideal for magnetic-amplifier applications. Premium price.
1N440B	100	750 ma	15 A	0.3 ma	1.5V	165°	
1N441B	200	750 ma	15 A	0.75 ma	1.5V	165°	
1N442B	300	750 ma	15 A	1.0 ma	1.5V	165°	
1N443B	400	750 ma	15 A	1.5 ma	1.5V	165°	
		@ 50°C		@ 150°C			
1N1100	100	750 ma	15 A	.3 ma	1.5V	165°	
1N1101	200	750 ma	15 A	.3 ma	1.5V	165°	Refer also to 1N536-540 Specification Sheet.
1N1102	300	750 ma	15 A	.3 ma	1.5V	165°	
1N1103	400	750 ma	15 A	.3 ma	1.5V	165°	
		@ 25°C		@ 125°C	@ 125°C		
1N1487	100	750 ma	15 A	.4 ma	.55V	140°	
1N1488	200	750 ma	15 A	.3 ma	.55V	140°	Similar to 1N536-47 series. Intermediate temp. operation. Lower priced.
1N1489	300	750 ma	15 A	.3 ma	.55V	140°	
1N1490	400	750 ma	15 A	.3 ma	.55V	140°	
1N1491	500	750 ma	15 A	.3 ma	.55V	125°	
1N1492	600	750 ma	15 A	.3 ma	.55V	120°	
		@ 50°C		@ 150°C	@ 150°C		
1N536	50	750 ma	15 A	.4 ma	.5V	165°	
1N537	100	750 ma	15 A	.4 ma	.5V	165°	
1N538	200	750 ma	15 A	.3 ma	.5V	165°	The popular line. Provides maximum forward conductance at high operating temperatures (165°C). Now with transient PRV ratings up to 800V.
1N539	300	750 ma	15 A	.3 ma	.5V	165°	
1N540	400	750 ma	15 A	.3 ma	.5V	165°	
1N1095	500	750 ma	15 A	.3 ma	.5V	150°	
1N1096	600	750 ma	15 A	.3 ma	.5V	150°	
1N547	600	750 ma	15 A	.3 ma	.5V	165°	

SILICON LOW CURRENT RECTIFIER CELLS (Insulated Stud)
UP TO 1.5 AMPS — UP TO 600 PRV

JEDEC or GE Type Number	PRV	Max. Io @ T°C	Max. Peak 1 cycle Surge	Max. Rev. Cur. (Full cycle Av.)	Max. Full Load Voltage Drop	Max. Oper. °C	COMMENTS
1N2481	500	@ 50°C Case 1.5 Amps	25 Amps	@ 130°C .3 ma	@ 130°C .65V	150°	Identical to the 1N1115-1N1120 series except the stud is electrically insulated from the junction.
1N2482	600	1.5 Amps	25 Amps	.3 ma	.65V	150°	
		@ 75°C Case		@150°C	@ 150°C		
1N2483	100	1.5 Amps	25 Amps	.4 ma	.65V	165°	
1N2484	200	1.5 Amps	25 Amps	.3 ma	.65V	165°	
1N2485	300	1.5 Amps	25 Amps	.3 ma	.65V	165°	
1N2486	400	1.5 Amps	25 Amps	.3 ma	.65V	165°	

SILICON LOW CURRENT RECTIFIER CELLS (Stud Mounted)
UP TO 1.5 AMPS UP TO 1000 PRV

[illegible] GE Type [illegible]	PRV	Max. Io [illegible]	[illegible] 1 cycle [illegible]	Max. [illegible] Cur. (Full [illegible])	[illegible] Lead Volt [illegible]	Max. Oper. °C	COMMENTS
		@ 135° Case		@ 135°C			Refer also to 1N1115-1120 Specification Sheet.
1N256	570	200 ma	1 A, 3ms	25 ma	2V @ 500 ma	150°	
		@ 150° Case		@ 150°C			For applications requiring moderate currents operating up to 170°C.
1N340	100	200 ma	.10 A	1 ma	2V @ 400 ma	170°	
1N349	100	200 ma	.10 A	1 ma	2V @ 400 ma	170°	
1N337	200	200 ma	.10 A	1 ma	2V @ 400 ma	170°	
1N346	200	200 ma	.10 A	5 ma	2V @ 400 ma	170°	
1N335	300	200 ma	.10 A	2 ma	2V @ 400 ma	170°	
1N344	300	200 ma	.10 A	5 ma	2V @ 400 ma	170°	
1N333	400	200 ma	.10 A	2 ma	2V @ 400 ma	170°	
1N342	400	200 ma	.10 A	5 ma	2V @ 400 ma	170°	
1N339	100	400 ma	.15 A	1 ma	2V @ 800 ma	170°	
1N348	100	400 ma	.15 A	5 ma	2V @ 800 ma	170°	
1N336	200	400 ma	.15 A	1 ma	2V @ 800 ma	170°	
1N345	200	400 ma	.15 A	5 ma	2V @ 800 ma	170°	
1N334	300	400 ma	.15 A	2 ma	2V @ 800 ma	170°	
1N343	300	400 ma	.15 A	5 ma	2V @ 800 ma	170°	
1N332	400	400 ma	.15 A	2 ma	2V @ 800 ma	170°	
1N341	400	400 ma	.15 A	5 ma	2V @ 800 ma	170°	
1N562	800	400 ma*	.15 A	3 ma	.65V @ 150°C	150°	1N560-61 mounted on studs. Popular model.
1N563	1000	400 ma*	.15 A	3 ma	.65V @ 150°C	150°	
		@ 100° Amb.		@ 25°C			Very low leakage for magnetic amplifier applications. The 1N440B-5B series mounted on studs.
1N550	100	500 ma	4 A, 3ms	.5 µa	1.5V @ 25°C	150°	
1N551	200	500 ma	4 A, 3ms	1.0 µa	1.5V @ 25°C	150°	
1N552	300	500 ma	4 A, 3ms	1.5 µa	1.5V @ 25°C	150°	
1N553	400	500 ma	4 A, 3ms	2.5 µa	1.5V @ 25°C	150°	
1N554	500	500 ma	4 A, 3ms	3.5 µa	1.5V @ 25°C	150°	
1N555	600	500 ma	4 A, 3ms	5.0 µa	1.5V @ 25°C	150°	
		@ 135° Case		@ 135°C			Refer also to 1N1115-1120 Specification Sheet.
1N254	190	400 ma	1.5 A, 3ms	.1 ma	1.5V @ 500 ma	150°	
1N255	380	400 ma	1.5 A, 3ms	.15 ma	1.5V @ 500 ma	150°	
		@ 100° Amb.		@ 25°C	@ 25°C		Refer also to 1N1115-1120 Specification Sheet, and the 1N550-5 Specification Sheet.
1N607	50	1 A	2 A, 1 sec	.025 ma	1.5V @ 200 ma	150°	
1N607A	50	1 A	2 A, 1 sec	.001 ma	1.5V @ 200 ma	150°	
1N608	100	1 A	2 A, 1 sec	.025 ma	1.5V @ 200 ma	150°	
1N608A	100	1 A	2 A, 1 sec	.001 ma	1.5V @ 200 ma	150°	
1N609	150	1 A	2 A, 1 sec	.025 ma	1.5V @ 200 ma	150°	
1N609A	150	1 A	2 A, 1 sec	.001 ma	1.5V @ 200 ma	150°	
1N610	200	1 A	2 A, 1 sec	.025 ma	1.5V @ 200 ma	150°	
1N610A	200	1 A	2 A, 1 sec	.001 ma	1.5V @ 200 ma	150°	
1N611	300	1 A	2 A, 1 sec	.025 ma	1.5V @ 200 ma	150°	
1N611A	300	1 A	2 A, 1 sec	.001 ma	1.5V @ 200 ma	150°	
1N612	400	1 A	2 A, 1 sec	.025 ma	1.5V @ 200 ma	150°	
1N612A	400	1 A	2 A, 1 sec	.0015 ma	1.5V @ 200 ma	150°	
1N613	500	1 A	2 A, 1 sec	.025 ma	1.5V @ 200 ma	150°	
1N613A	500	1 A	2 A, 1 sec	.002 ma	1.5V @ 200 ma	150°	
1N614	600	1 A	2 A, 1 sec	.025 ma	1.5V @ 200 ma	150°	
1N614A	600	1 A	2 A, 1 sec	.0025 ma	1.5V @ 200 ma	150°	
		@ 85° Case		@ 150°C			The popular line. 1N536-40, 1N547, 1N1095-6 mounted on studs.
1N1115	100	1.5 A	15 A	.4 ma	.65V @ 150°C	170°	
1N1116	200	1.5 A	15 A	.3 ma	.65V @ 150°C	170°	
1N1117	300	1.5 A	15 A	.3 ma	.65V @ 150°C	170°	
1N1118	400	1.5 A	15 A	.3 ma	.65V @ 150°C	170°	
1N1119	500	1.3 A	15 A	.3 ma	.65V @ 150°C	155°	
1N1120	600	1.3 A	15 A	.3 ma	.65V @ 150°C	155°	
		@ 135° Case		@ 135°C			Refer also to 1N1115-1120 Specification Sheet.
1N253	95	1 A	4 A, 3ms	.1 ma	1.5V @ 1 A	150°	
*at 100°C Case							

SILICON HIGH CURRENT RECTIFIER CELLS
UP TO 70A UP TO 600 PRV

JEDEC or GE Type Number	Repetitive PRV	Transient PRV	Max. Io @ 150°C Stud Single Phase	Max. 1 Cycle Surge	Max. Instant. Leakage I at Rated PRV (milliamps.)	Max. Forward Voltage Drop @ 70A DC Single Phase 150°C	Max. Oper. Temp. °C
4JA70B	200	300	70 A	1600 A	30	.45V	200°C
4JA70C	300	400	70 A	1600 A	25	.45V	200°C
4JA70D	400	525	70 A	1600 A	20	.45V	200°C
4JA70E	500	650	70 A	1600 A	16	.45V	200°C
4JA70M	600	800	70 A	1600 A	13	.45V	200°C

COMMENTS

Large area junction rectifiers for applications requiring d-c output as high as 70 amps per rectifying element at rms input voltages up to 420 Volts. The 4JA70 is a "double diffused, all hard solder rectifier," which has high surge current capabilities and is highly resistant to thermal fatigue.

SILICON MEDIUM CURRENT RECTIFIER CELLS
UP TO 25 AMPS UP TO 600 PRV

					@ 150°C Stud	@ 150°C Stud	
1N1341A	50	100	6A	150A	3 ma	.64V	200°
1N1342A	100	200	6A	150A	2.5 ma	.64V	200°
1N1343A	150	300	6A	150A	2.25 ma	.64V	200°
1N1344A	200	350	6A	150A	2.0 ma	.64V	200°
1N1345A	300	450	6A	150A	1.75 ma	.64V	200°
1N1346A	400	600	6A	150A	1.5 ma	.64V	200°
1N1347A	500	700	6A	150A	1.25 ma	.64V	200°
1N1348A	600	800	6A	150A	1.0 ma	.64V	200°
1N1199A	50	100	12A	240A	3 ma	.55V	200°
1N1200A	100	200	12A	240A	2.5 ma	.55V	200°
1N1201A	150	300	12A	240A	2.25 ma	.55V	200°
1N1202A	200	350	12A	240A	2.0 ma	.55V	200°
1N1203A	300	450	12A	240A	1.75 ma	.55V	200°
1N1204A	400	600	12A	240A	1.5 ma	.55V	200°
1N1205A	500	700	12A	240A	1.25 ma	.55V	200°
1N1206A	600	800	12A	240A	1.0 ma	.55V	200°
						25°C T_J	
1N248	50		10A	200A	5 ma	1.5V*	175°
1N249	100		10A	200A	5 ma	1.5V*	175°
1N250	200		10A	200A	5 ma	1.5V*	175°
1N248A	50		20A	350A	5 ma	1.5V**	175°
1N249A	100		20A	350A	5 ma	1.5V**	175°
1N250A	200		20A	350A	5 ma	1.5V**	175°
USA-1N2135A	400		20A	250A	40 ma @ 145°C Stud	1.5V @ 145°C Stud	150°
1N2154	50	100	25A	300A	5 ma	0.6V	200°
1N2155	100	200	25A	300A	4.5 ma	0.6V	200°
1N2156	200	350	25A	300A	4.0 ma	0.6V	200°
1N2157	300	450	25A	300A	3.5 ma	0.6V	200°
1N2158	400	600	25A	300A	3.0 ma	0.6V	200°
1N2159	500	700	25A	300A	2.5 ma	0.6V	200°
1N2160	600	800	25A	300A	2.0 ma	0.6V	200°

*@ 25A **@ 90A

COMMENTS

Designed for use in the 2 to 30 ampere range. High junction temperature rating and extremely low forward voltage drop and thermal impedance permit high current operation with minimum space requirements. May be mounted directly to a chassis or fin or may be insulated by using insulating kit provided. All units are also available with negative polarity (stud is anode).

THESE GENERAL ELECTRIC SILICON AND GERMANIUM RECTIFIERS MEET MILITARY SPECIFICATIONS

MILITARY TYPES

Type	Military Specification	Single Phase Max. Ratings	
		PRV	I_{DC} @ Temp.
Germanium			
USN 1N83	MIL-E-1/895	300 Volts	75 ma @ 55°C amb.
USAF 1N315	MIL-E-1/1058	100 Volts	100 ma @ 71°C amb.
Silicon			
USA 1N249B| USA 1N250B	MIL-S-19500/134	125 Volts 250 Volts	20 A @ 150°C case 20 A @ 150°C case
JAN 1N253	MIL-E-1/1024A	100 Volts	1 A @ 135°C case
JAN 1N254	MIL-E-1/9898	200 Volts	400 ma @ 135°C case
JAN 1N255	MIL-E-1/9908	400 Volts	400 ma @ 135°C case
JAN 1N256	MIL-E-1/9918	600 Volts	200 ma @ 135°C case
JAN 1N538	MIL-E-1/1084A	240 Volts	250 ma @ 150°C amb.
USAF 1N538	MIL-E-1/1089	240 Volts	250 ma @ 150°C amb.
JAN 1N540	MIL-E-1/1085A	480 Volts	250 ma @ 150°C amb.
USAF 1N546	MIL-E-1/1089	400 Volts	250 ma @ 150°C amb.
JAN 1N547	MIL-E-1/1083A	720 Volts	250 ma @ 150°C amb.
USAF 1N547	MIL-E-1/1089	600 Volts	250 ma @ 150°C amb.
USA 1N2135A	MIL-S-19500/134	500 Volts	20 A @ 150°C case

RECTIFIER STACKS

GERMANIUM LOW CURRENT

Up to 6 amps @ 55°C amb.
Up to 630 PRV.

4JA211 Stacks: The industry's most widely-used semiconductor rectifier series. Hundreds of thousands in use. May be arranged in stacks up to 12 fins to produce more than 160 various circuit configurations. Small, lightweight, excellent regulation.

SILICON LOW CURRENT

Up to 18 amps @ 25°C amb.
Up to 3360 PRV.

4JA411 Stacks: Combine high temperature operation (up to 150° C.) with increased ratings (up to 18 amps d-c). Hundreds of stack combinations to meet a variety of circuit conditions. High efficiency plus excellent regulation.

SILICON MEDIUM CURRENT

Up to 65 amps @ 55° C amb.
Up to 1800 PRV.

4JA2011 Stacks: Provide a wide range of power applications with d-c outputs up to 32 amps.
4JA2511 Stacks: Provide a wide range of power applications with d-c outputs up to 50 amps.
4JA3511 Stacks: Provide a wide-range of power applications with d-c outputs up to 65 amps.

SILICON MEDIUM CURRENT (5" FIN)

Up to 108 amps @ 55°C amb.
Up to 1800 PRV.

4JA3512 Stacks: This 5" square fin assembly makes optimum use of the 1N2154 series 25 Ampere cell. This stack provides a wide range of power applications with d-c outputs up to 108 Amperes.

SILICON HIGH CURRENT

Up to 573 amps @ 35° C amb.
Up to 840 PRV.

4JA6011 Stacks: Hundreds of combinations available in various circuit configurations. D-c outputs up to 573 amps.

POTTED RECTIFIER CIRCUITS

	Up to:		Up to:
4JA220	.4	amps @ 55°C amb.	1800 PRV.
4JA420	2.0	amps @ 50°C amb.	3000 PRV.
4JA421	.65	amps @ 25°C amb.	10000 PRV.
4JA422	1.50	amps @ 25°C amb.	2000 PRV.

4JA220, 4JA420-421-422 Series: Mounted in standard eight-pin tube base (4JA220-420 Series) or in rectangular design with solder lug connections (4JA221-421-422 Series). Available in a large number of circuit configurations. One to 20 cells may be potted in a single circuit. Individual cell specifications determine ratings. 4JA220 Series utilize germanium 1N91-93 cells. 4JA420-421-422 Series utilize silicon 1N536-540, 1N1095 cells. (See BASIC-RECTIFIER-CELL LISTING.)

SILICON CONTROLLED RECTIFIERS

These revolutionary devices, introduced by General Electric, can do the work of thyratrons, ignitrons, magnetic amplifiers, power transistors, relays, switches and circuit breakers in many power control and switching applications.

Presenting:

A FULL LINE OF SILICON CONTROLLED RECTIFIERS

SILICON LOW CURRENT CONTROLLED RECTIFIERS
UP TO 7.0 AMPS — UP TO 400 PRV

ZJ203

ZJ203U	25	1 A @ 82°C case	125°	125°	.75V, 200 μa @ 25°C T_j
ZJ203F	50	1 A @ 82°C case	125°	125°	.75V, 200 μa @ 25°C T_j
ZJ203A	100	1 A @ 82°C case	125°	125°	.75V, 200 μa @ 25°C T_j
ZJ203G	150	1 A @ 82°C case	125°	125°	.75V, 200 μa @ 25°C T_j
ZJ203B	200	1 A @ 82°C case	125°	125°	.75V, 200 μa @ 25°C T_j
ZJ203H	250	1 A @ 82°C case	125°	125°	.75V, 200 μa @ 25°C T_j
ZJ203C	300	1 A @ 82°C case	125°	125°	.75V, 200 μa @ 25°C T_j

2N1929-2N1935

2N1929	25	1.1 A @ 25°C case	125°	150°	2V, 8 ma @ 125°C T_j
2N1930	50	1.1 A @ 25°C case	125°	150°	2V, 8 ma @ 125°C T_j
2N1931	100	1.1 A @ 25°C case	125°	150°	2V, 8 ma @ 125°C T_j
2N1932	150	1.1 A @ 25°C case	125°	150°	2V, 8 ma @ 125°C T_j
2N1933	200	1.1 A @ 25°C case	125°	150°	2V, 8 ma @ 125°C T_j
2N1934	250	1.1 A @ 25°C case	125°	150°	2V, 8 ma @ 125°C T_j
2N1935	300	1.1 A @ 25°C case	125°	150°	2V, 8 ma @ 125°C T_j

2N1770A—2N1777A
2N1770—2N1777

2N1770A	25	7 A @ 115°C stud	150°	150°	2V, 6 ma @ 150°C T_j
2N1771A	50	7 A @ 115°C stud	150°	150°	2V, 6 ma @ 150°C T_j
2N1772A	100	7 A @ 115°C stud	150°	150°	2V, 6 ma @ 150°C T_j
2N1773A	150	7 A @ 115°C stud	150°	150°	2V, 6 ma @ 150°C T_j
2N1774A	200	7 A @ 115°C stud	150°	150°	2V, 6 ma @ 150°C T_j
2N1775A	250	7 A @ 115°C stud	150°	150°	2V, 6 ma @ 150°C T_j
2N1776A	300	7 A @ 115°C stud	150°	150°	2V, 6 ma @ 150°C T_j
2N1777A	400	7 A @ 115°C stud	150°	150°	2V, 6 ma @ 150°C T_j
2N1770	25	6 A @ 70°C stud	125°	150°	2V, 8 ma @ 125°C T_j
2N1771	50	6 A @ 70°C stud	125°	150°	2V, 8 ma @ 125°C T_j
2N1772	100	6 A @ 70°C stud	125°	150°	2V, 8 ma @ 125°C T_j
2N1773	150	6 A @ 70°C stud	125°	150°	2V, 8 ma @ 125°C T_j
2N1774	200	6 A @ 70°C stud	125°	150°	2V, 8 ma @ 125°C T_j
2N1775	250	6 A @ 70°C stud	125°	150°	2V, 8 ma @ 125°C T_j
2N1776	300	6 A @ 70°C stud	125°	150°	2V, 8 ma @ 125°C T_j
2N1777	400	6 A @ 70°C stud	125°	150°	2V, 8 ma @ 125°C T_j

SILICON MEDIUM CURRENT CONTROLLED RECTIFIERS
UP TO 25 AMPS — UP TO 500 PRV

2N681—2N689
2N1842—2N1850
C40 Series (25V to 300V)

2N681	25	25 A @ 57°C stud	125°	150°	3V, 25 ma @ 125°C T_j
2N682	50	25 A @ 57°C stud	125°	150°	3V, 25 ma @ 125°C T_j
2N683	100	25 A @ 57°C stud	125°	150°	3V, 25 ma @ 125°C T_j
2N684	150	25 A @ 57°C stud	125°	150°	3V, 25 ma @ 125°C T_j
2N685	200	25 A @ 57°C stud	125°	150°	3V, 25 ma @ 125°C T_j
2N686	250	25 A @ 57°C stud	125°	150°	3V, 25 ma @ 125°C T_j
2N687	300	25 A @ 57°C stud	125°	150°	3V, 25 ma @ 125°C T_j
2N688	400	25 A @ 57°C stud	125°	150°	3V, 25 ma @ 125°C T_j
2N689	500	25 A @ 57°C stud	125°	150°	3V, 25 ma @ 125°C T_j
2N1842	25	16 A @ 25°C stud	100°	125°	3.5V, 50 ma @ 100°C T_j
2N1843	50	16 A @ 25°C stud	100°	125°	3.5V, 50 ma @ 100°C T_j
2N1844	100	16 A @ 25°C stud	100°	125°	3.5V, 50 ma @ 100°C T_j
2N1845	150	16 A @ 25°C stud	100°	125°	3.5V, 50 ma @ 100°C T_j
2N1846	200	16 A @ 25°C stud	100°	125°	3.5V, 50 ma @ 100°C T_j
2N1847	250	16 A @ 25°C stud	100°	125°	3.5V, 50 ma @ 100°C T_j
2N1848	300	16 A @ 25°C stud	100°	125°	3.5V, 50 ma @ 100°C T_j
2N1849	400	16 A @ 25°C stud	100°	125°	3.5V, 50 ma @ 100°C T_j
2N1850	500	16 A @ 25°C stud	100°	125°	3.5V, 50 ma @ 100°C T_j
C40U	25				
C40F	50				
C40A	100				
C40G	150				
C40B	200				
C40H	250				
C40C	300				

Other ratings and characteristics are the same as for 2N681-689, except that turn-off time is guaranteed at less than 12 microseconds. These units are designed specifically for fast turn-off time for inverter applications.

2N1909-2N1916
C55 Series
(25V to 400V)

SILICON HIGH CURRENT CONTROLLED RECTIFIERS
UP TO 110 AMPS — UP TO 400 PRV

2N1909	25	110 A @ 59°C stud	125°	125°	3V, 40 ma @ 125°C T_j
2N1910	50	110 A @ 59°C stud	125°	125°	3V, 40 ma @ 125°C T_j
2N1911	100	110 A @ 59°C stud	125°	125°	3V, 40 ma @ 125°C T_j
2N1912	150	110 A @ 59°C stud	125°	125°	3V, 40 ma @ 125°C T_j
2N1913	200	110 A @ 59°C stud	125°	125°	3V, 40 ma @ 125°C T_j
2N1914	250	110 A @ 59°C stud	125°	125°	3V, 40 ma @ 125°C T_j
2N1915	300	110 A @ 59°C stud	125°	125°	3V, 40 ma @ 125°C T_j
2N1916	400	110 A @ 59°C stud	125°	125°	3V, 40 ma @ 125°C T_j
C55U	25	Other ratings and characteristics are the same as for C50, except that turn-off time is guaranteed at less than 20 microseconds. These units are designed specifically for fast turn-off times for inverter applications.			
C55F	50				
C55A	100				
C55G	150				
C55B	200				
C55H	250				
C55C	300				

SELENIUM RECTIFIERS

General Electric's unique ACE* vacuum process provides highly reliable selenium cells, known for long life and high temperature operation. This Vac U-Sel® process assures you of uniformity from cell to cell and excellent margins of safety.

Capitalize on the low cost versatility of design inherent in quality selenium products. Typical G-E types are shown in a variety of voltages and cell sizes, finishes and mountings. Many other types to suit individual needs are available on request.

*Automatic Continuous Evaporation

Three dual diode types are offered as universal replacements for AFC circuits in most TV receivers. The G-E units have proven reliability, with more units in service than any other make. See ECG-459 for more details.

This is a truly high quality device being offered for the first time by G-E to the so-called entertainment market. It can be used for any conventional 65 ma power supply in radios, phonos, intercoms, etc., using this type of product. It has full UL approval and provides both size and cost advantages.

Many special types have been developed to meet unusual requirements. Some of these are (B) the total "bridge" hermetically sealed in oil (O) the metal-clad pee-wee for very low power ratings for extremely dependable service (L) a multi-element unit for a fourteen stage "gate" used on a high speed printer.

Thyrector Diodes are a recent production item in the selenium line. They have unique capabilities which enable them to be used as voltage surge protectors for guarding single crystal rectifiers and transistors against damaging voltage transients. See 180.30 for complete application and catalogue information.

Tubular assemblies house cells from 3/32" dia. to 13/32" dia. stack up to as many as 250 in series. This provides a range of ratings from a few microamperes at 15 volts up to a few hundred milliamperes at 15,000 volts.

The "paper tube" line is designed for commercial applications with lowest cost at no sacrifice in quality. The package is used on all 3 miniature cell sizes, 5/32", 9/32" and 13/32" round, in both standard and contact protection (arc suppression) types.

GENERAL ELECTRIC INTRODUCES THE FIRST SILICON CONTROLLED RECTIFIERS TO MEET MILITARY SPECIFICATIONS

MILITARY TYPES

Type	Military Specification	Single Phase Max. Ratings	
		PRV	Io @ Temp.
USN 2N681	MIL-S-19500/108	25	25 A @ 57°C stud
USN 2N682	MIL-S-19500/108	50	25 A @ 57°C stud
USN 2N683	MIL-S-19500/108	100	25 A @ 57°C stud
USN 2N684	MIL-S-19500/108	150	25 A @ 57°C stud
USN 2N685	MIL-S-19500/108	200	25 A @ 57°C stud
USN 2N686	MIL-S-19500/108	250	25 A @ 57°C stud
USN 2N687	MIL-S-19500/108	300	25 A @ 57°C stud
USN 2N688	MIL-S-19500/108	400	25 A @ 57°C stud

NEW SELENIUM PRODUCTS

Soon to be in production is a complete new line of cartridge (tubular) miniature rectifiers. These will incorporate a new "thin cell" which will greatly reduce the size of the units. The illustration demonstrates this by comparing one of the new types (A) to our present type (and typical competitive units) (B).
The substantial improvement is made at no reduction in performance but at a reduction in price. Available now in limited quantity.

A

B

The standard stud intermediate line includes some of the most reliable products in its power range . . . 100 ma to 1 amp. 15 to over 4,000 volts. The cost per watt is particularly attractive.

The riveted (and tube mounted) assembly is limited to a dozen or more cells per unit. It is very compact and can even be provided with no spacing on very tight jobs. No derating is required on Vac-U-Sel rectifiers.

Imbedded cell configurations demonstrate the high temperature ratings of Vac-U-Sel rectifiers. Even though imbedded, no current or voltage derating is necessary. Available in all cell sizes up to 2" square.

Large plate stacks use cells up to 5 x 6" in size, and are rated to 36 Vrms per cell. The high density capabilities of Vac-U-Sel rectifiers very often enable them to be substituted for cells of much more active area with no sacrifice of life expectancy.

Oil immersed units are used to satisfy very unusual operating conditions such as highly corrosive atmospheres, heavy surge currents, etc., where size is no objection.

Copper Oxide rectifiers have been manufactured by General Electric for over 30 years. This line has proven reliability and has been able to do jobs beyond the reach of other semiconductors. Its low voltage drop, high thermal capacity and virtually indestructible characteristics make it unique in the field.

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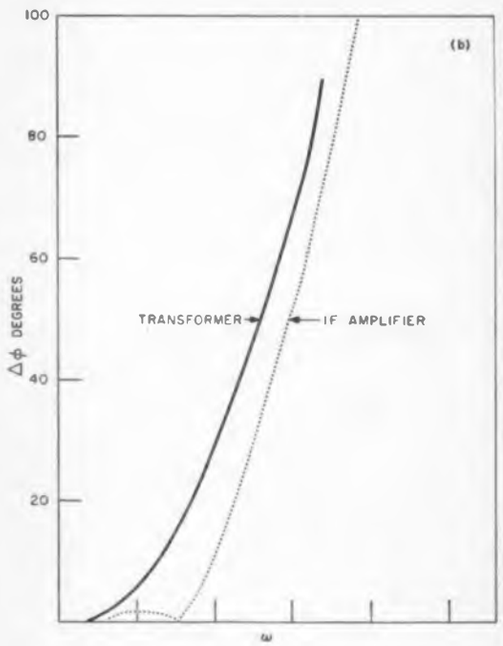
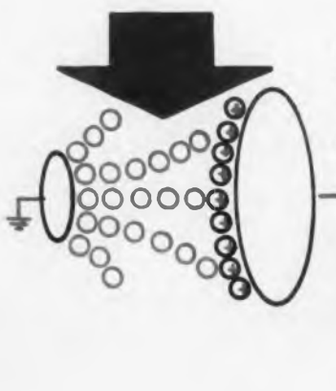


2. Rise time depends, among other things, on a per cent tolerance of phase deviation from linearity. Phase deviation should not be frequency weighted.
3. Ripple in the response to a step depends, among other things, on a phase deviation weighted inversely with frequency so as to make the low frequencies important.
4. Minimal rise time requires unity gain till the over-all phase deviation is 90 deg. Then the gain should fall away rapidly.
5. Minimal ripple requires a slowly falling gain which is low when the phase deviation is large.
6. Phase linearity should be better than amplitude linearity so cascading will decrease ripple.
7. Complete ripple control requires a lot of bandwidth.
8. The maximum delay-to-rise-time ratio obtainable by cascading sections equals the number of sections for a low-pass section, and double the number of sections for an all-pass or bandpass section.
9. If it is necessary to make a high quality network by cascading sections, it is better to use fewer high quality sections than more low quality sections.
10. Sometimes it is best to leave well enough alone. ■ ■

◀ CIRCLE 39 ON READER-SERVICE CARD



Transistor Switching Speed from Base Storage Charges and their Lifetimes

Part 2

Sample predictions are illustrated for determining rise, fall, storage and delay time using the stored charge and lifetime concept outlined in Part 1 (ELECTRONIC DESIGN, March 15, 1961, p 52). The precision of the predictions is within 10 to 15 per cent in most cases. Methods for measurement of carrier lifetime are outlined.

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BASE STORAGE charges and their lifetimes have been shown to be basic quantities which can be used to characterize a switching transistor (Part 1, *ED*, March 15, 1961, p 52). Predictions of rise, fall, delay and storage time can be made with accuracies in the order of a few nanoseconds in many cases. Sample predictions for alloy and mesa devices show agreement between experimental and predicted rise and delay times in the order of 10 per cent; storage and fall time agreement is within 15 per cent.

Measurement of the Lifetime

Two quantities which have been previously defined are

$$\tau_a = \frac{Q_B}{I_B} \text{ in the active state or below saturation}$$

$$\tau_b = \frac{Q_{BX}}{I_{BX}} \text{ in the static state or in saturation}$$

τ_a applies to the lifetime of the carriers in the active state, during turn-on and turn-off, and τ_b applies to the lifetime when recombination and replenishing charges are in equilibrium and when the transistor has been saturated for a sufficiently long time. Sufficiently, as used here, means that an equilibrium of charge gradient is assumed for times greater than at least three times the lifetime, τ_a (see Eq. 4).

τ_b is then related to the storage time by

$$t_s \text{ (flat portion)} = \tau_b \ln \frac{I_{B1} - I_{B2}}{I_{BS} - I_{B2}} \qquad (18)$$

and τ_a to the rise time by

$$t_{r\ (10\%\ \text{to}\ 90\%)} = \tau_a \ln \frac{I_{B1} - 0.1\, I_{BS}}{I_{B1} - 0.9\, I_{BS}} \qquad (19)$$

when R_L in the collector circuit is negligible, and the forced beta is not small enough to allow the use of Eq. 5. For the measurement of τ_b, the circuit shown in Fig. 7 is used.

By changing V_{IN} through a known ratio, and keeping I_{B2} small, τ_b is obtained by

$$\tau_b = \frac{\Delta t_s}{\ln \text{ (current ratio)}} \qquad (20)$$

For both alloy and mesa transistors τ_b is fairly constant throughout the range tested. An alternative circuit, as shown in Fig. 8, is used for measuring τ_b. By adjusting V_{IN}, a plot of Δt_s vs voltage, on semi log paper, is obtained. Notice that the slope of Δt_s *ln (voltage ratio)* is constant and equal to τ_b.

Next, τ_a is of interest, not because Eq. 19 is directly to be used for calculating switching time, but because τ_a is fundamentally related to the h_{fe} of the transistor; also, knowing the range of τ_a, predictions of t_r and t_f with constant current drive can be made with assurance by using Eqs. 6 to 9.

From Eq. 19, if $I_{B1} = I_{BS}$ and $R_L \cong 0$, then

$$t_{r\ (0-90\%)} = \tau_a \ln \frac{I_{BS}}{0.1\, I_{BS}} = 2.31\, \tau_a \qquad (21)$$

the circuit, shown in Fig. 9 is used for measuring τ_a. A Tektronix current probe, model P6016, and amplifier, type 131, is used in the collector circuit.

Since the probe impedance is very low (about 0.005 ohms, and 1.5 pf in shunt), the transistor remains below saturation when a constant current drive, I_{B1}, is applied. A plot of τ_a vs current I_C is illustrated by Fig. 10, where it is observed that the variation is similar to h_{fe} vs I_C. The same circuit is used for mesa-type transistors. Since the τ_a for mesa transistors is in the range of 20 to 100 nsec, reasonable readings can still be obtained. A plot of τ_a vs I_C for the ZJ-42 is shown in Fig. 11.

Example of Rise-Time Prediction

Conditions: 2N396 Unit #2-12; $Q_B{}^{\bullet}{}_{o}{}^{90\%}$ at $V_{CC} = 10$ v.

$Q_B{}^{\bullet}$ test results: $V_{CC} = 10$ v; $I_{CS} = 1$ ma; $Q_B{}^{\bullet}{}_{o}{}^{90\%} = 200$ μμC.
$V_{CC} = 10$ v; $I_{CS} = 10$ ma; $Q_B{}^{\bullet}{}_{o}{}^{90\%} = 446$ μμC.

Desired results (1) Rise time at $V_{CC} = 5$ v; $I_{CS} = 100$ ma; $I_{B1} = 10$ ma.
(2) Rise time at $V_{CC} = 15$ v; $I_{CS} = 1$ ma; $I_{B1} = 0.1$ ma.

(a). Rise time at $V_{CC} = 5$ v; $I_{CS} = 100$ ma; $I_{B1} = 10$ ma.

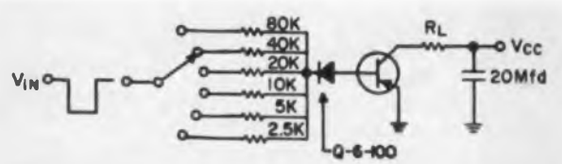


Fig. 7. Circuit used for the measurement of τ_b, carrier lifetime when the transistor has been saturated for a sufficiently long time.

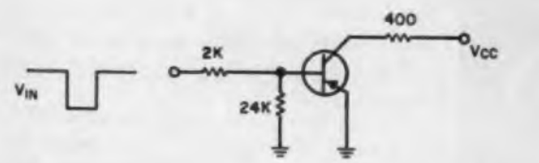


Fig. 8. An alternative circuit for measurement of carrier lifetime τ_b.

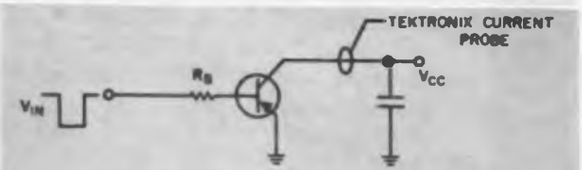


Fig. 9. Circuit for measurement of τ_a, the lifetime of carriers in the active state or below saturation.

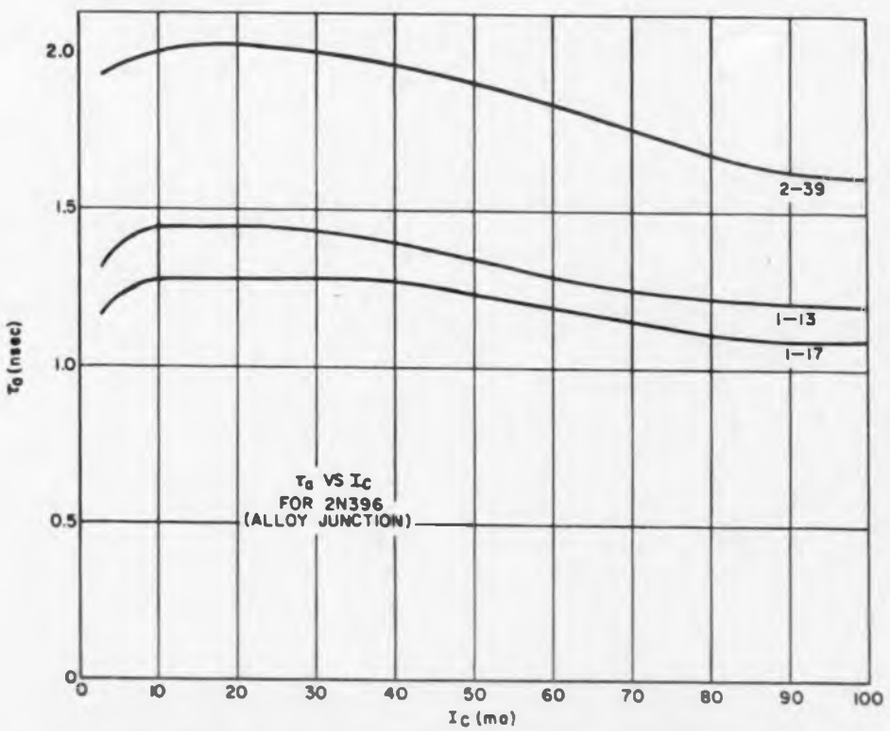


Fig. 10. Carrier lifetime τ_a vs collector current I_c for an alloy transistor.

(1) Find Q_C at 10-v supply voltage.

$$Q_C\,(10\text{v})\Big|_0^{90\%} = 200 - \frac{(446 - 200)}{9\text{ ma}} = 200 - 27.3 = 172.7\ \mu\mu\text{C}.$$

(2) Convert this to Q_C at desired V_{CC}.

$$Q_{C(5\text{v})}\Big|_0^{90\%} = \left[Q_{C(10\text{v})}\Big|_0^{90\%}\right] \times \left[\frac{\sqrt{5}}{\sqrt{10}}\right]$$

$$= \frac{Q_{C(10)}\Big|_0^{90\%}}{\sqrt{2}} = \frac{172.7}{\sqrt{2}} = 122\ \mu\mu\text{C}.$$

(3) Find Q_B per unit and desired Q_B at current of interest.

$$\frac{Q_B}{\Delta I_C} = \left(\frac{446 - 200}{9\text{ ma}}\right) = 27.3\ \mu\mu\text{C/ma}.$$

Q_B at 100 ma $= 27.3 \times 100 = 2{,}730\ \mu\mu$C.

(4) Combine Q_B and Q_C for $Q_B{}^{\bullet}$. at 5 v, 100 ma.

$$Q_B{}^{\bullet}\Big|_0^{90\%} = Q_B + Q_C\Big|_0^{90\%} = 2{,}730 + 122 = 2{,}852\ \mu\mu\text{C}.$$

(continued on p 52)

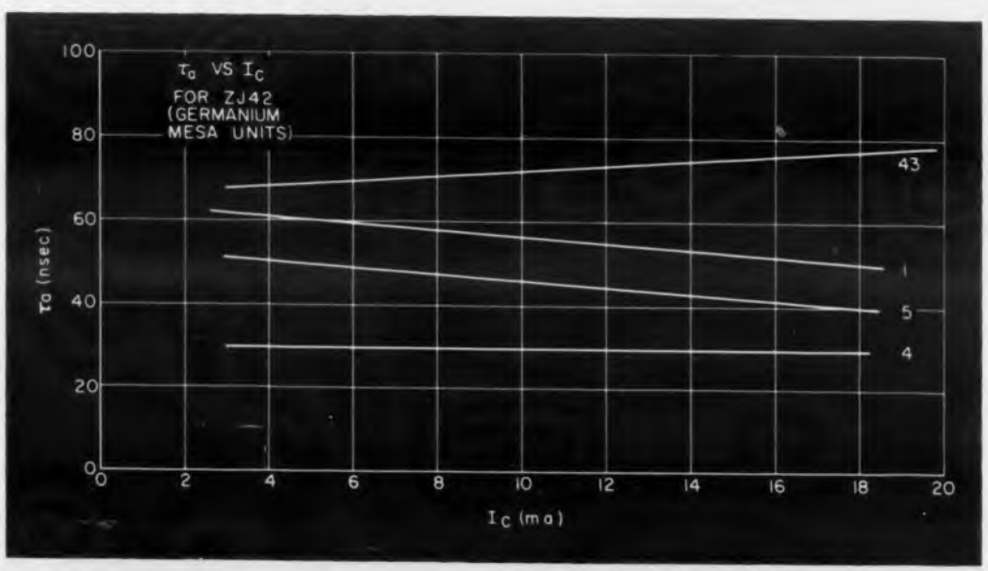
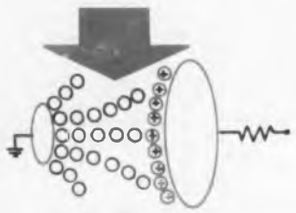


Fig. 11. Carrier lifetime τ_a vs collector current I_c for a mesa transistor.



(5) Find rise time and check with circuit value.

$$t_{r(10-90\%)} = \frac{8}{9}\frac{Q_{B^*}\Big|_0^{90\%}}{I_{B1}} = \frac{(0.89)\ (2{,}852)}{10} = 254 \text{ nsec}$$

circuit value = 250 nsec.
deviation predicated t_r = 4 nsec = 1.6%.
from measured t_r.

(b). Rise time at V_{CC} = 15 v; I_{CS} = 1 ma; I_{B1} = 0.1 ma.

(1) Find Q_C at 15-v supply voltage using previously obtained Q_C at 10 v.

$$Q_{C(15v)}\Big|_0^{90\%} = Q_{C(10v)}\Big|_0^{90\%} \times \frac{\sqrt{15}}{\sqrt{10}}$$

$$= 1.228 \times Q_{C\,(10)} = 172.7$$
$$\times 1.228 = 212\ \mu\mu\text{C}.$$

$$1.228 \times Q_{C\,(10)} = 172.7 \times 1.228 = 212\ \mu\mu\text{C}.$$

(2) From (a) (3), Q_B per unit = 27.3 μμC/ma.
(3) Combine Q_B and Q_C for $Q_B{}^*$ at 15 v, 1 ma.

$$Q_{B^*}\Big|_0^{90\%} = Q_B + Q_C\Big|_0^{90\%} = 27.3$$
$$+ 212 = 239.3\ \mu\mu\text{C}.$$

(4) Find rise time and check with circuit value.

$$t_{r\,(10-90\%)} = \frac{8}{9}\frac{Q_{B^*}\Big|_0^{90\%}}{I_{B1}} = \frac{(0.89)\ (239.3)}{0.1}$$
$$= 2.13\ \mu\text{sec}.$$

circuit value = 2.20 μsec.
deviation predicated t_r from measured t_r = 0.07 μsec.
= −3.3%.

Example of Delay Prediction

Conditions: ZJ-42 Unit #2 C_B = 6.15 pf from test results.

$V_{BE2} = V_{BE}$ (after turn on) ≈ 0.4 v from test results.

In circuit of Fig. 1, when $R_1 = R_2$ = 2K, R_L = 400 ohms, V_{CC} = −5 v.

V_{IN} = −7 v pulse, 60 nsec width

Find T_D for V_{BB} = 0, +1.32 v, +2.68 v.

$$T_D = \frac{V_{BE_1}\text{ (before turn on)}}{I_{B1}}\,C_E = \left(\frac{V_{BB}}{2}\right)\left(\frac{C_E}{I_{B1}}\right)$$

At V_{BB} = 0 : T_D predicted = 0
Actual observed T_D = 2 nsec.
∴ Propagation constant = +2 nsec.

At V_{BB} = +1.32 v : First find I_{B1},

$$I_1 = \frac{V_{BE2} - V_{IN}}{2K};\ I_2 = \frac{V_{BB} - V_{BE2}}{2K}$$

$$I_B = I_1 - I_2 = \frac{2V_{BE2} - V_{IN} - V_{BB}}{2K}$$

$$I_{B1} = \frac{-0.8\text{ v} + 7\text{ v} - 1.32\text{ v}}{2\ K} = 2.44\text{ ma}.$$

$$T_D = \frac{1.32\text{ v}}{2}\,\frac{6.15\text{ pf}}{2.44\text{ ma}} = 1.7\text{ nsec}.$$

Adding propagation constant = 2 nsec.
Total T_D predicted = 3.7 nsec.
Actual observed T_D = 3.8 nsec.

At V_{BB} = +2.68 v :

$$T_D = \frac{2.68\text{ v}}{2}\,\frac{6.15\text{ pf}}{1.76\text{ ma}} = 4.7\text{ nsec}.$$

Adding propagation constant = 2 nsec.
Total T_D predicted = 6.7 nsec.
Actual observed T_D = 7.2 nsec.

From Eq. 15, $\dfrac{1/9\ Q_{B^*}\Big|_0^{90\%}}{I_{B1}}$ must be added to obtain T_D (to 10%)

Storage Prediction For Long Pulse

Conditions: ZJ-42 Unit # 2
From test results, $V_{BE} \approx 0.4$ v, τ_b = 113 nsec.
I_{BS} = 0.24 ma
$Q_B{}^*$ (100%) − $Q_B{}^*$ (90%) at V_{CC} = 5 v, is essentially Q_C (100%) − Q_C (90%) at V_{CC} = −5 v, = 6 μμC. Circuit is the same as used in delay time prediction. V_{IN} = −7 v pulse, 520 nsec width.

For V_{BB} = +1.32 v: As shown before, I_{B1} = 2.44 ma, I_{B2} = −1.06 ma

$$t_s\,(\text{to } 90\%) = \tau_b\, ln\left(1 + \frac{I_{B1} - I_{BS}}{I_{BS} - I_{B2}}\right) + \frac{\Delta\ Q_{B^*}\ (100\%\text{ to }90\%)}{-I_{B2}}$$

$$t_s\,(\text{to } 90\%) = 113\text{ nsec}\ ln\left(1 + \frac{2.44\text{ ma} - 0.24\text{ ma}}{0.24\text{ ma} + 1.06\text{ ma}}\right) + \frac{6\mu\mu\text{C}}{1.06\text{ ma}}$$

$$t_s\,(\text{to } 90\%) = 113\text{ nsec}\ ln\,(2.69) + 5.7\text{ nsec}$$

$$t_s\,(\text{to } 90\%) = 111.8\text{ nsec} + 5.7\text{ nsec} = 117.5\text{ nsec}$$

Predicted t_s (to 90%) = 117.5 nsec.
Actual observed t_s (to 90%) = 130 nsec.

Prediction Of Fall Time

Conditions = ZJ-42 Unit # 2
The same circuit is used as for delay and storage time predictions.

Given from test results τ_a = 50 nsec. Also,

$$Q_{B^*}\,(90\%) \cong Q_{B^*}\,(90\%) \text{ at } \frac{4.5\text{ v}}{400\ \Omega}$$
$$\cong Q_{B^*}\,(90\%) \text{ at } 11.25\text{ ma} \cong 42.6\ \mu\mu\text{C}.$$

Q_C (90%) at −5 v = 33.8 μμC.

$Q_B = Q_{B^*}\,(90\%) - Q_C$ = 8.8 μμC.

At V_{BB} = +1.32 v bias: I_{B2} as shown before = −1.06 ma.

$$t_f\,(10\%\text{ to }90\%) = \frac{\frac{8}{9}\,Q_{B^*}\Big|_0^{90\%}}{-I_{B2} + \frac{Q_B}{2\tau_a}}$$

$$= \frac{\frac{8}{9}\,(42.6)\ \mu\mu\text{C}}{1.06\text{ ma} + \frac{8.8\ \mu\mu\text{C}}{2\ (50\text{ nsec.})}}$$

Predicted t_f (10% to 90%) = 32.9 nsec.
Actual observed t_f (10% to 90%) = 27 nsec.

Experiments Verify Validity Of Switching Speed Predictions

Rise Time (t_r): Using the simplified relation for rise time prediction, Eqs. 5, 6 and 7, comparison of measured with predicted rise times for typical samples of the alloy 2N396 and the mesa ZJ-42 transistors shows good correlation. For the 2N396 units, the comparison of predicted vs measured rise time was within five per cent. For the ZJ-42 units, using the circuit of Fig. 1 with $R_1 = R_2$ = 2 K, R_L = 1 K, and V_{CC} = −10 v, and V_{BB} = +1.32 v as a typical example, data was taken for square-wave input pulse amplitudes of −10 v, −7 v, −5 v, and −3.5 v. For rise times of about 14 nsec and 20 nsec observed, the error of prediction was within 1.3 nsec. For rise times of about 40 nsec observed, the error of prediction was within 1.5 nsec. For rise times of about 85 nsec, most errors of prediction were within 4 nsec. For the ZJ-42, V_{BE} was measured at V_{IN} = −5 v, and this average was used to obtain I_{B1} at all input voltages. Greater accuracy of V_{BE} at the input voltages would increase the accuracies of prediction.

Delay plus Rise Time ($t_d + t_r$): For the ZJ-42, using Fig. 1, where R_1 = 2K, R_2 = 22K, R_L = 1K, C_1 (across R_1) = 2 pf, V_{CC} = −10 v and V_{BB} = 0 v, as a typical example, the input pulse

amplitude was changed to the values $V_{IN} = -10$ v, -7 v, -5 v, -3.5 v. The values of charge transferred through C_1, $[V_{IN} - V_{BB}]\, C_1$, must be subtracted from $Q_B{}^\bullet$ for this case so that

$$(t_d + t_r) = \frac{Q_B{}^\bullet - {}^r(V_{IN} - V_{BE})\, C_1}{I_{B1}}$$

With $(t_d + t_r)$ observed values of about 8 nsec, 13 nsec, and 19 nsec, the errors of prediction were within 1 nsec, while for observed values of about 30 nsec, the errors were within 2 nsec.

Delay Time (t_d): For the ZJ-42, calculating t_d as shown in the sample prediction section for $V_{BB} = +1.32$ v, $+2.68$ v with observed delay times of 4 nsec and 8 nsec, the errors of prediction are within 1 nsec.

Fall Time (t_f): For the ZJ-42, fall time, t_f, was calculated as shown in the sample prediction section for $V_{BB} = 0$, $+1.32$ v, $+2.68$ v. For observed fall times of 20 nsec, errors of prediction are less than 3 nsec. For observed fall times of about 30 nsec, errors of prediction are less than 6 nsec for most cases. Where there is no applied off-bias, so that the actual I_{B2} is difficult to determine, the observed fall times were about 90 nsec. Nevertheless, errors of prediction were within 17 nsec for most cases.

Storage Time after Long Pulse (t_s): Storage time, t_s, calculated as shown in the sample prediction section, was within plus or minus 15 per cent for the 2N396. For the ZJ-42, t_s was calculated as shown in the sample prediction section for $V_{BB} = +1.32$ v, $+2.68$ v. For observed storage times of about 65 nsec, the errors of prediction were less than 10 nsec for most cases. For observed storage times of about 110 nsec, the errors of prediction were less than 13 nsec for most cases. At zero bias, where I_{B2} is difficult to predict accurately, the observed storage times were about 220 nsec. Even so, the errors were still within 34 nsec for most cases.

Thus, it may be concluded that $Q_B{}^\bullet$, τ_a and τ_b are the most fundamental quantities that define a transistor regarding its ability as a switching device; many other derived parameters can be obtained from them. Most obviously, the ratio Q_B to I_C is one possible parameter, which Sparkes has called τ_c.† Or, the ratio $Q_B{}^\bullet$ to I_C can be another, which Simmons has called τ_{BE}.‡ ■ ■

Acknowledgments

The authors wish to acknowledge the help given by many of our colleagues, in particular to U. S. Davidsohn and G. B. Ober for their many suggestions and critical review. R Sobus has been of great help in obtaining the data and calculations. This work would never have been compiled without the encouragement of R. P. Frenzel and C. A. Shaw.

†See Reference 6, part I, *ED*, March 15, 1961, p 55.
‡See Reference 7, part I, *ED*, March 15, 1961, p 55.

Protective Insulation Can Increase Voltage Breakdowns

Instead of gaining increased high-voltage protection, added insulation can sometimes increase the frequency of equipment breakdowns. Author Rocco tells why.

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THE MINIATURIZATION of electrical equipment has caused the high-voltage-circuit designer to rely more and more on dielectric barriers. In cases where dielectric is used judiciously, good results are obtained. However, in many instances, indiscriminate use of insulating material can actually increase the tendency of the circuit to arc and break down.

Added Dielectric Imposes New Field Conditions

The typical approach to the solution of an arcing problem is simply to cover the danger areas with sheets or cylinders of dielectric, without analyzing the new set of conditions set up in the region. For instance, recently the author was involved in a program for the development of an airborne radar beacon. Its reliability was seriously hampered by occasional high voltage breakdown in the power supply, particularly in the region of the magnetron anode. The designers, recognizing a potential trouble spot, had designed a thin-walled teflon sleeve to fit over the magnetron anode. The sleeve covered the anode but did not completely fill the air gap with dielectric. This resulted in a change of the electric field configuration in the air region. Rather than help the situation, the insulation had only aggravated the arcing condition further.

The reason for the increased arcing may be understood by referring to a simplified model of an arc-gap, Fig. 1. Here, the gap is treated as a parallel-plate capacitor partially filled with dielectric. Working with the basic definitions for a capacitor, that is, $Q = CE$, $C = K\varepsilon/d$, and realizing that the areas of dielectric constant ε_1 and ε_2 may be considered as capacitors in series, the

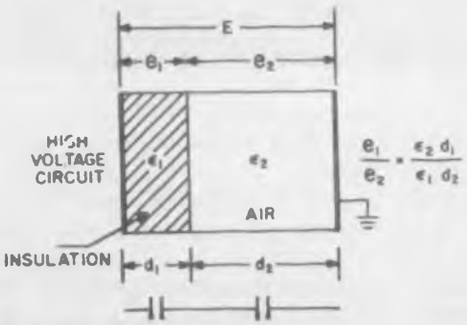


Fig. 1. Breakdown region from equipment to ground is represented by a parallel plate capacitor of gap $d = d_1 + d_2$, partially filled with dielectric of width d_1, dielectric constant ε_1.

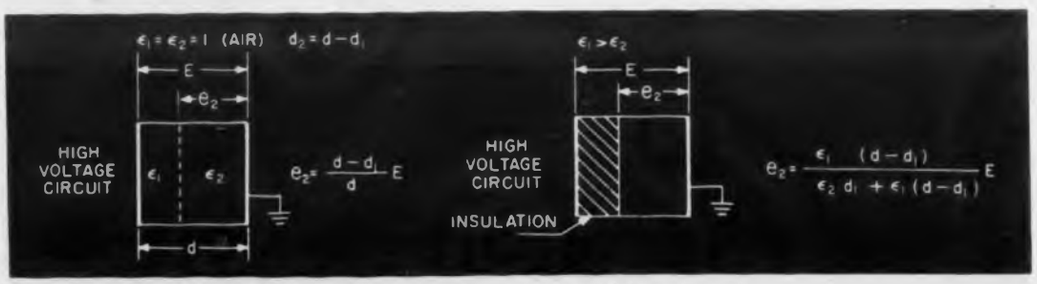


Fig. 2. (a) No protective insulation is added. Voltage e_2 from circuit to ground varies linearly. (b) With added insulation, voltage e_2 depends on thickness, d_1.

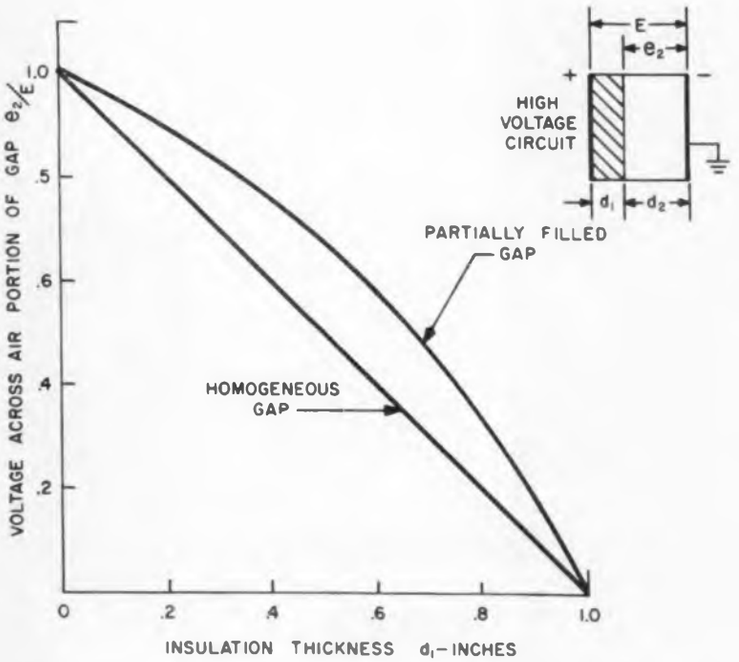


Fig. 3. Partial filling of air gap with insulation causes air gap voltage, e_2, to be greater than if no insulation had been added, or if insulation completely filled gap (straight line).

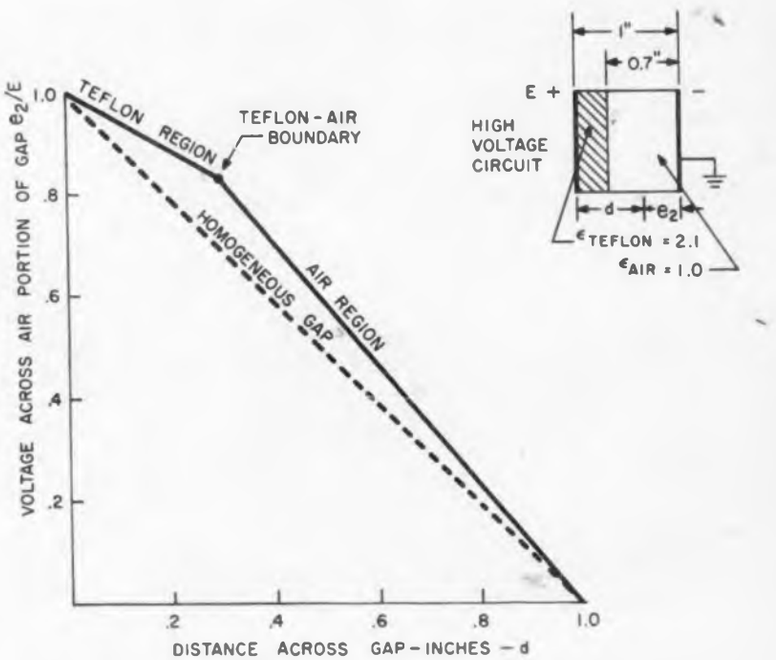


Fig. 4. Example shows that with Teflon partially filling gap, voltage varies discontinuously; voltage across air gap is everywhere increased. Chance of voltage breakdown is, therefore, greater.

following equation for the voltage drop across the insulating material can be derived:

$$e_2 = \frac{\epsilon_1 d_2 E}{\epsilon_2 d_1 + \epsilon_1 d_2} \qquad (1)$$

There are two conditions which must be compared. In condition 1, $\epsilon_1 = \epsilon_2$, or the gap is completely homogenous, Fig. 2a. If the gap dielectric is air ($\epsilon = 1$), the voltage at any point in the gap is (from Eq. 1, with $d_2 = d - d_1$):

$$e_2 = \frac{d - d_1}{d} E \qquad (2)$$

This is a linear relationship.

In condition 2, $\epsilon_1 \neq \epsilon_2$, or a sheet of dielectric of thickness d_1 has been inserted to partially fill the gap, Fig. 2b. Now the voltage across the air gap is:

$$e_2 = \frac{\epsilon_1 (d - d_1) E}{\epsilon_2 d_1 + \epsilon_1 (d - d_1)} \qquad (3)$$

and depends upon the dielectric thickness.

Eqs. 2 and 3 are plotted in Fig. 3 for a gap 1-in. wide, with $\epsilon_1 = 2.1$ (Teflon) and $\epsilon_2 = 1$ (air).

It is clear from Fig. 3 that the voltage across the air portion of the gap, for all thickness of dielectric, is greater than if the dielectric had been completely omitted.

Greater insight into conditions existing in the arc gap may be had by examining Fig. 4. A dielectric of fixed thickness (arbitrarily chosen at 0.3 in.) was inserted in a 1-in. gap. From the previous equations defining e_2, a plot of e_2 was made. For a gap completely filled with either air or solid dielectric, the voltage gradient follows a conventional path. However, with the insertion of the slab of solid dielectric, the gradient becomes a discontinuous function. Since the slope of the graph, that is, v/d, represents the electric field intensity, it follows that a redistribution of the electric field occurs in the gap. Thus, the presence of the solid dielectric has caused a build-up of electric field intensity in the adjacent air region.

Dielectric Should Fill Completely Rather Than Partially

It can be concluded from the graphs that two principles should be followed for reducing the danger of voltage breakdown.

1. Whenever possible, the breakdown region should be entirely filled with homogenous dielectric material.

2. A dielectric with low dielectric constant in addition to high dielectric strength should be used.

When point 1 cannot be met, it may be useful to know for what dielectric thickness the greatest increase in potential will occur in the air region. This can be calculated from Eq. 3, which expresses the potential, e_2, at the dielectric-air gap interface, and from Eq. 2, which expressed the potential, e'_2, at any point in a homogenous air gap. Denoting the difference between e_2 and e'_2 by λ:

$$\lambda = e_2 - e'_2 \qquad (4)$$

$$\lambda = \frac{(\epsilon_1 d - \epsilon_1 d_1) E}{\epsilon_2 1 + \epsilon_1 d - \epsilon_1 d_1} + \frac{E d_1}{d} - C \qquad (5)$$

Differentiating Eq. 5 and setting it equal to zero shows that the maximum increase in potential occurs for a dielectric thickness d_{1max} of:

$$d_{1max} = \frac{d (\sqrt{\epsilon_1 \epsilon_2} - \epsilon_1)}{\epsilon_2 - \epsilon_1} \qquad (6)$$

Double-Frame-Grid Pentode Yields High Gain-Bandwidth

WITH BOTH control and screen grids using frame-grid construction, a new pentode boasts performance features that far surpass those available in conventional pentodes.

Compared with some of the better pentodes using conventional construction, the new tube, type 7788, is said to offer a gain-bandwidth figure-of-merit of 400 mc (vs 130 mc), a transconductance of 50,000 μmhos (vs 10,000), an equivalent noise resistance of 100 ohms (vs 200 to 300), and a much higher plate-to-screen-current ratio.

Available from Amperex Electronic Corp., 230 Duffy Ave., Hicksville, L.I., N.Y., the new tube minimizes the shift in characteristics when one switches from low to high anode currents. The rigidly constructed, precisely positioned control and screen grids yield a very low spread in characteristics from tube to tube as well as very low levels of microphonics. The frame-constructed screen grid gives better than usual screening of the control grid, resulting in the high plate-to-screen-current ratio.

The sturdy construction provided by the grid frames allows the control-grid to be made of wire only 5 microns in diameter—about half the thickness of the finest grid wire normally used. This allows more turns to be wound per inch while it minimizes grid current.

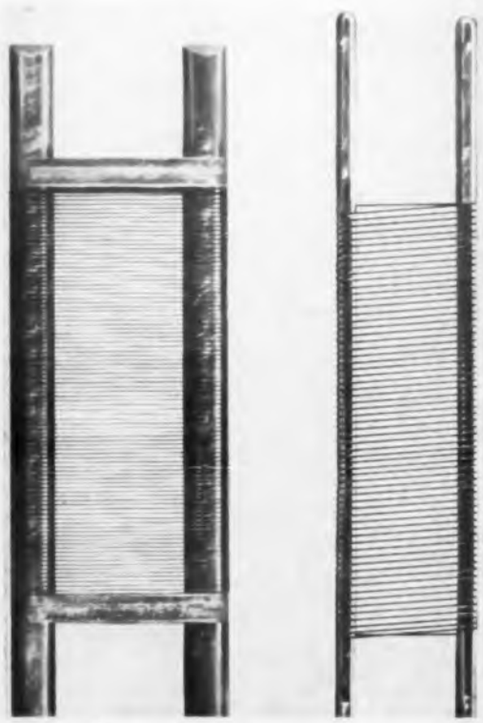
Though the closely spaced grid wires provide rather high input and ouput capacitances (16 pf at the input and 3.5 at the output), this is more than made up for by the high G_m. Thus, though the capacitances may be twice as large as the capacitances in good pentodes, the G_m is at least five times as large. Hence,

the G_m-to-C ratio is unusually high, resulting in the very high gain-bandwidth product.

The 7788, with 6.3-v, 340-ma filament requirements is rated, typically, to draw 35 ma of plate current with a 135-v plate supply. Yet the tube can conduct 65 ma for 1,000 hr and 50 ma for 10,000 hr.

The nine-pin miniature tube sells for $7.95 in quantities greater than 50. In smaller quantities, the unit price is $10.50. Delivery is from stock.

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

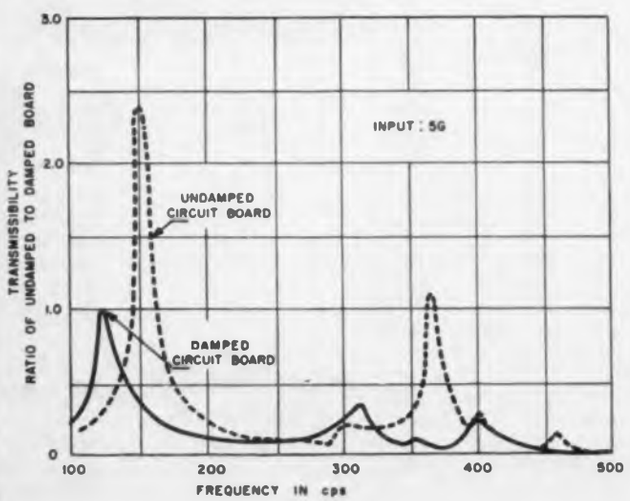


Frame-grid construction (left) compared with conventional grid construction. Mica spacers, difficult to manufacture to tight tolerances, are used in conjunction with the grid wire to maintain proper spacing of the support rods in conventional grids. In the frame grid, spot welded cross bars keep the grid supports accurately positioned. The grid wire has only an electrical function.

Damped Printed-Circuit Boards Reduce Vibration Effects

A RADICALLY NEW, highly damped material for printed-circuit boards will give design engineers another tool for use in raising reliability standards. The material converts vibratory energy into shear strains which are dissipated in an elastomeric layer bonded between elements of epoxy-fiberglass laminate. The elastomer, which adapts to normal processing methods, exhibits unchanging characteristics under all environmental conditions.

Dyna-damp Printed Circuit Boards produced by the Lord Manufacturing Co., Erie, Pa., represent the first successful use of integrally damped material developed for printed circuitry. The new material will greatly extend design freedom and aid miniaturization in high-density electronic packaging. The designer need not worry about structural response characteristics or local circuit board resonances. More sensitive components, smaller and lighter than previ-



Typical curve shows drastic reduction in resonant transmissibility made possible by use of Dyna-damp printed-circuit board material. Degree of reduction depends on specific design and density characteristics of any given board.

ous designs can be used and located to best advantage.

Two Basic Problems Are Caused By Structural Response

The complex dynamic disturbances associated with the operation of high-performance jet aircraft and missiles produce two effects which cause unreliability of printed boards: excessive amplitude and high g-loads. Both are functions of structural response. Current high-performance aerospace craft components are subjected to disturbances of higher frequencies than those which were encountered just a few years ago. The top disturbing frequency in jet specifications used to be 55 cps; today 500 cps is considered nominal and excitations may range as high as 5,000 cps in missiles. The nature of these excitations can be exceedingly complex and, in addition, sustained accelerations up to 25 g can be present.

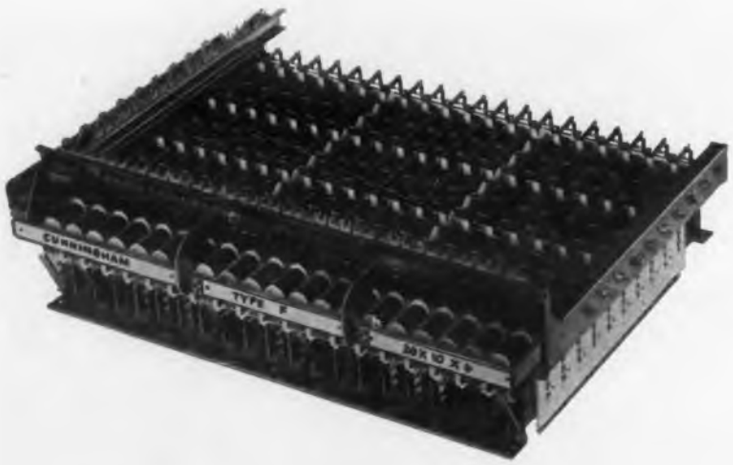
Resonant Frequency Response Can Cause Failures

Printed-circuit boards are lightly damped, rigid structures incorporating fragile components which are susceptible to destruction under these dynamic conditions. When resonant response occurs either of two things can happen. The board may respond at its resonant frequency, producing oscillation beyond its alloted space envelope and strike adjacent structures; or the energy transmitted through the board may exceed the g levels which the components can withstand.

The damped laminate approach minimizes resonant structural response, thereby controlling amplitude and g load. Tests already completed on the Dyna-damp material show that transmissibility under resonant conditions is reduced from 50 to 66-2/3 per cent over that exhibited by undamped material.

Fabrication techniques used with standard boards can be employed with Dyna-damp boards. Where double-sided boards are concerned, ferrules can be used in the lead holes. Samples of this new material can be had immediately. The Lord Manufacturing Co. plans to produce the printed circuit boards in specified sizes and configurations.

For further information on these circuit boards turn to the Reader-Service Card and circle 253.



Tolerance Buildup No Bugaboo with Punched Laminated Plastics Parts

The compounding of individual tolerances on several punched holes or cutouts over the length of the piece is not the bugaboo that many designers believe. Careful die work and good working knowledge of the laminate used minimizes tolerance buildup. A good example of what can be done is the insulated pusher fabricated by Taylor for a high-performance crossbar switch manufactured by James Cunningham, Son & Co., Inc., Rochester, N.Y.

These switches are 3-dimensional conductor matrices, with from 30 to 1200 switching contacts, which bring intelligence from as many as 600 sources to one or more readout or signal points. They are basic components in computers, machine tool programming systems, high frequency scanning systems, thermocouple and strain gage monitoring, and similar equipment.

The insulated pusher, only 2.955 in. long and .031 in. thick, and fabricated from Taylor Grade GEC-500 glass epoxy laminate, is a critical part of the crossbar. It must be held flat within ±.005 in., with total over-length buildup not exceeding ±.002 in.

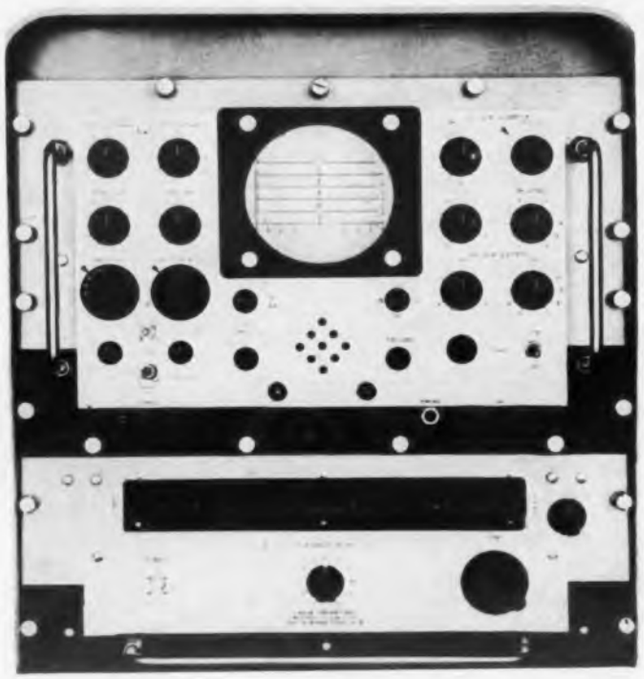
The materials used before to fabricate the pusher proved difficult to hold to the tolerances required. The success of the GEC-500 laminate fabricated by Taylor is evidenced by marked reduction in rejects and a 20% gain in production.

Taylor Fibre's Fabricating Division has the manpower, experience and equipment to produce parts to close tolerances from any of the company's raw materials. Send us your problem—we will recommend the best material for the job and quote on production runs. Write Taylor Fibre Co., Norristown 48, Pa.

Taylor

LAMINATED PLASTICS ■ VULCANIZED FIBRE

CIRCLE 46 ON READER-SERVICE CARD



High-Resolution Spectrum Analyzer Offers Wide Dynamic Range

EVALUATION of a frequency spectrum containing many signals of widely differing characteristics is made possible by the LA-21 spectrum analyzer. Designed for communications work, the instrument covers the most widely used commercial and military frequencies.

An outstanding feature of the LA-21 is its ability to discriminate between signals differing in amplitude by as much as 80 db and separated by only 50 kc. Resolution is extended to 90 db when the signals are 150 kc apart. Narrow resolution of 5 kc can be expected when signal levels are equal in amplitude.

A signal sensitivity of better than 90 dbm is provided over the fundamental frequency range of 10 mc to 680 mc, with slightly reduced sensitivity to 1,180

mc using harmonic operation of the triode local oscillator. Sensitivity can be improved to 110 dbm on special order. Applications of the instrument, made by Lavoie Laboratories, Morganville, N. J., include the evaluation of spurious response, signal stability testing, filter network evaluation, and frequency spectrum monitoring.

The visual display, on a type 5ADP7 cathode-ray tube, is supplemented by an aural monitoring system. A built-in speaker calls attention to changes in the signal and aids in signal identification. A jack for headphones is also provided.

An internal crystal calibrator is used for convenient and extremely accurate calibration of the spectrum being viewed; markers at 100 kc and 1 mc are selected from the front panel. Tuning dial is of the slide-rule type, with one frequency range visible at a time. Maximum stability is provided by electronically regulated plate and filament power supplies. Power requirements are 115 v ±10%, 50 to 400 cps, 250 w.

Dual attenuators provide 100 db of continuously variable attenuation of the input signal over the entire frequency range. The if attenuation range is 0 to 60 db, step-variable in 6-db steps. Detection mode is selected from square-law, linear, and logarithmic types. Frequency dispersion is continuously adjustable from 100 kc to 2 mc. Centering controls allow an additional 1 mc on each side of the spectrum center.

Synchronization sensitivity is adjustable at the front panel. A signal of 3.0 v peak is required for external synchronization. Sweep rate is 0.5 to 20 cps, continuously adjustable. Video signal and horizontal drive are brought to front-panel connectors for X-Y and roll-chart recording. Photographic recording is facilitated by intensification of trace on fast rise and decay, with automatic baseline extinction.

The instrument measures 21-3/4 in. high, 19-1/2 in. wide, and 18-7/16 in. deep. It operates in ambient temperatures ranging from 0 to 55 C.

Price of the LA-21 is $5,450. Delivery time is 60 days.

For more information on this high-resolution spectrum analyzer, turn to the Reader-Service Card and circle 252.

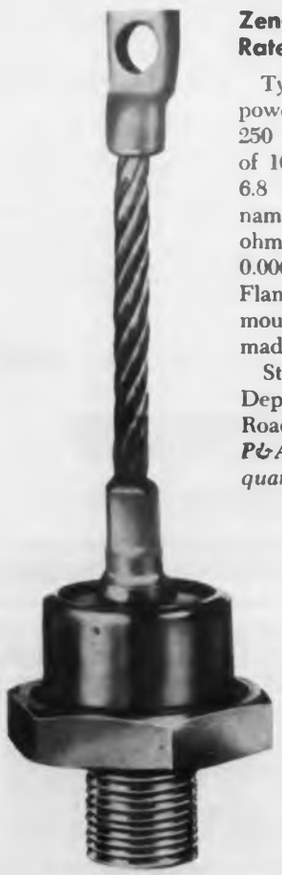
NEW PRODUCTS

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

Glass-To-Metal Seal Withstands 600 C — 257

Made with ferrous alloys or tungsten and molybdenum, these glass-to-metal seals can withstand sustained temperatures of 500 to 600 C, and are not damaged by temperatures of nearly 800 C for short periods. The low-cost seal is said to be more easily made and formed than ceramic-to-metal seals.

Hermetite Corp., Dept. ED, 100 Ladge Drive, Avon, Mass.
Availability: *Immediate.*



Zener Diode Rated at 250 W — 256

Type 250 Z is a Zener power regulator rated at 250 w at case temperature of 100 C. Voltage range is 6.8 to 30 v. Typical dynamic impedance is 0.06 ohm max for 30-v type, 0.006 ohm for 6.8-v type. Flange-mounted and stud-mounted packages are made.

Standard Rectifier Corp., Dept. ED, 620 E. Dyer Road, Santa Ana, Calif.
P&A: *$60 to $75 ea, sample quantities; 2 to 3 weeks.*

Digital Counter Has Continuous Display — 255

Type 1130-A digital time and frequency meter uses four decades for storage and continuous display, while the remaining four decades count continuously. At the end of counting interval, total is transferred in 100 μsec to the storage and display decades. Ranges are: frequency, dc to 10 mc; period, 10 μsec to 10^7 sec; interval, 1 μsec to 10^7 sec. Circuits are designed for maximum reliability. Plug-in time-base oscillators are available with stabilities up to 5 parts in 10^{10} per min.

General Radio Co., Dept. ED, West Concord, Mass.
Price: *from $2,585 to $2,950.*

Miniature Photocell Delivers Up to 300 Ma — 258

A light-actuated pnpn silicon switch, the Photran has over 10-meg impedance when off, 10 ohms when triggered on by light. Measuring 0.200 in. long by 0.185 in. OD, the device can deliver up to 300-ma load current at up to 200 v with an efficiency exceeding 98%. Output is determined by load and is independent of light input at all intensities above the triggering level, typically 200 ft-c. High output often allows direct actuation of load without intermediate relays or amplifiers. Anode voltages range from 15 to 200 v in 6 ratings. Surge current is 5 amp, 8 msec.

Solid State Products, Inc., Dept. ED, 1 Pingree St., Salem, Mass.

Price & Availability: *$10 to $35; 1 week.*

Plug-In IF Amplifier With Gain to 80 Db — 259

The Amplitran is a transistor if amplifier with single-stage gain from 15 to 20 db, with up to 80 db in cascaded units. Center frequencies are 455 kc, 1.0, 4.3, 10.7, and 30.0 mc. Bandwidth of the 30.0-mc cascaded unit is 1.8 mc, power gain 68 db. A 4-stage unit measures 4-1/2 x 1-1/4 x 2-1/4 in. Dual and triple sizes are also made.

Ferrotran Electronics Co., Inc., Dept. ED, 693 Broadway, New York 12, N.Y.

Price: *$50 to $60, 1-stage; $300 to $340, 4-stage.*

CIRCLE 48 ON READER-SERVICE CARD ▶

MODEL 240

MODEL 241

pick the accuracy you need from these Keithley high voltage supplies

MODEL 241 — *0.05% accuracy*

Here is the successor to dc secondary standards that employ mechanical choppers and standard cells. The new 241, featuring a Keithley-designed long-life photo-chopper, offers five-dial resolution from 0 to 1000 volts at up to 20 milliamperes. Stability is within 0.005%. Output — plus, minus or floating — can be dialed from 0 to 1000 volts in 0.01 volt steps, with noise and hum below 1 mv RMS. The 241 is unaffected by shock or vibration and cannot be damaged in ordinary use. It is most useful in calibration of meters and transducers, testing insulation and leakage resistances, and as a voltage reference for analog computers.

MODEL 240 — *1% accuracy*

This voltage supply is a general-purpose version of the 241, with similar features and somewhat reduced accuracy and regulation. Three calibrated dials permit dialing any output to 1000 volts in one-volt steps. The switch includes an "off" position, facilitating timed measurements. Stability is within 0.02 volts ±0.02% the first hour, or in subsequent 24-hour periods. The Model 240 can be used to furnish stable dc potentials in checking dc amplifier gains, and for production tests of transistors. Used with a Keithley electrometer, resistances over the range of 0.1 ohm to 10^{16} ohms can be measured.

brief specifications

Model	Output				Regulation			Price
	Voltage	Current ma	Accuracy	Z ohms	Ripple	Line	Load	
241	0-1000	0-20	.05%	.05	1mv	.005%	.005%	$800.00
240	0-1000	0-10	1%	15	3mv	.02%	.02%	$325.00

KEITHLEY INSTRUMENTS, INC.
12415 EUCLID AVENUE CLEVELAND 6, OHIO

CIRCLE 49 ON READER-SERVICE CARD

NEW PRODUCTS

Pressure Gauge 456

A small, rugged pressure transducer is used with this pressure gauge for measurements from 0 to 2,500 psig. Intended for use in air and gaseous systems, device operates on thermopile principle. Multi-position gages using up to 5 transducers with a single instrument are also made. Transducers are interchangeable without recalibration or adjustment.

Hastings-Raydist, Inc., Dept. ED, Hampton, Va.

Price & Availability: $257.50; immediate.

Servo Amplifiers 450

A size 18, 60-cps servo motor, rated at 9 w per phase, may be driven with these servo amplifiers. Outputs are identical; inputs differ to accept one-speed ac data (model 746-A), two-speed synchro data (747-A) and dc input signals (747-A and 797-A). Amplifiers include damping networks for proper loop stabilization, and generate the carrier shift necessary for quadrature across the motor. Size is 4 x 8 x 3 in., weight under 36 oz.

Industrial Control Co., Dept. ED, Central Ave. at Pinelawn, Farmingdale, L. I., N. Y.

Linear Amplifier 458

With integral pulse-height analyzer, the N-328 amplifier has high-speed, nonoverload character-

istics plus optional pick-off for 40-nsec range coincidence. Gain is 7,000; amplifier has double delay-line pulse shaping and a choice of integral or differential discriminators. It is suitable for use where large overload signals are present, and in counting at rates to 250 kc.

Hamner Electronics Co., Inc., Dept. ED, P. O. Box 531, Princeton, N. J.

Numerical Comparator 452

Developed for automatic control, digital comparator uses numerical commands to control machinery to 110,000th of an inch at rates up to 30 in. per min. Information is obtained from punched tape program. Unit is composed of command and feedback displacement counters, a differential analog converter and associated circuitry. It is suitable for short-run production and rapid-readout inspection testing.

Hycon Manufacturing Co., Dept. ED, 1030 S. Arroyo Parkway, Pasadena, Calif.
Availability: stock.

Decade Scaler 457

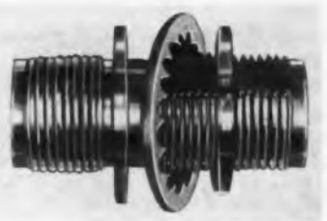
Operating at 10 mc, this decade scaler uses 8-4-2-1 binary code to count random series pulses. Any number of units can be cascaded by front panel connectors. Total count is displayed in lighted decimal digits. Binary and analog outputs are available on front panel. The solid-state unit is compatible with other Data-Bloc modules.

Harvey-Wells Electronics, Inc., Dept. ED, 14 Huron Drive, Natick, Mass.
P&A: $239.50; 30 days in quantities to 100.

This is the time of our annual subscription renewal; Return your card to us.

NEW PRODUCTS

Firewall Connectors 467



The 6342 series HN firewall connectors are capable of withstanding 2,000 F. Units have a nominal 50-ohm characteristic impedance.

Gremar Manufacturing Co., Inc., Dept. ED, Wakefield, Mass.

Press Control 474

Slide transfer presses are protected from overload due to faulty part transfer by the Autotransfer control device. Provision is also made for sensing end-of-material, buckling, and misfeed.

Wintriss Controls Div., Industrionics Controls, Inc., Dept. ED, 20-24 Vandam St., New York 13, N.Y.

Vaneaxial Blower 468

Operating on 115 v, ac or dc, VAX-3-GN vaneaxial blower delivers 68 cfm at 1.5 in. static pressure. Used in ground-support equipment, unit weighs 1 lb. Diameter is 3 in., length 3-1/4 in. Mounting is made by clamping to servo rim. Blower meets pertinent military specifications.

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

Phase-Sensitive Voltmeter 480

For use in test panels, this phase-sensitive voltmeter is 3 in. in diameter and 5 in. long. Input signal attenuator is integral with the cylindrical assembly, while meter movement may be remotely located. Quadrature rejection is 50:1, 3rd harmonic rejection —40 db. A 3-mv input gives full-scale deflection. Attenuator range is 3 mv to 300 v in 9 steps. Frequency range is 60 cps to 20 kc, linearity is 2%.

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

Price & Availability: $150 ea; 30-day delivery.

Piston Capacitors 477

Variable trimmer piston capacitors TT901 through TT904, for panels or circuit boards, meet requirements of MIL-C-14409A. Minimum capacitance is 0.5 pf; maximum is 2.0, 3.0, 5.0 or 7.0 pf. Overall diameter is 1/8 in., length above panel 35/64 to 1-1/64 in. Units are rated at 500 wvdc. Adjust mechanism has 102 turns per in. Temperature coefficient is low; operating range is —55 to +125 C. The Q factor is 500.

JFD Electronics Corp., Dept. ED, 6101 16th Ave., Brooklyn 4, N.Y.

CIRCLE 52 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Printed Cable 455

Multi-conductor Teflon cable can be imprinted with code numbers or letters, eliminating necessity of color-coding. Fluorocarbon resin inks are sintered so that the numbers or letters become a permanent part of the insulation.

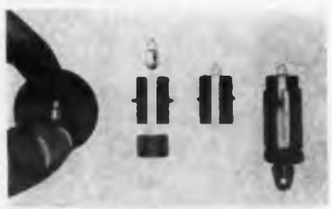
American Super-Temperature Wires, Inc., Dept. ED, Winooski, Vt.

Capacitor Shielding 464

Environmental electrical shielding is available for variable capacitors. Full shielding permits capacitor use in any circuit or location under any radiation conditions. Capacitance curve is protected against outside electrical effects.

Hammarlund Manufacturing Co., Inc., Dept. ED, 460 W. 34th St., New York 1, N. Y.

Lamp Adapter 449



T-1 ultraminiature incandescent lamps can be used in any standard bayonet-base socket with this adapter. Lamp, measuring 1/8 in. OD by 3/8 in. long, can be supplied.

Industrial Electronic Engineers, Inc., Dept. ED, 5528 Vineland Ave., North Hollywood, Calif.

P&A: $0.40 ea, $3.75 with lamp; stock.

Have you sent us your subscription renewal form?

Strain Relief 469

Used with electrical connectors having molded backshells, strain relief assembly G77 effectively reduces strain on wires at the solder pots. Assembly consists of body, three straps, and clamp.

Glenair, Inc., Dept. ED, Glendale 1, Calif.

Power Supply 481

Outputs of 225 to 325 v at 0 to 50 ma are provided by model RS305A power supply. A filament output of 6.3 v ac at 3 amp is also furnished. Versions include modular, rack-mounting, and rack-mounting with 3-1/4 in. meters. Voltage regulation is 0.05% load, 0.05% line; ripple and noise are 5 mv max peak to peak. Transient recovery time is less than 25 μsec. Input is 105 to 125 v ac, 55 to 400 cps. Rack units have 3-1/2 in. panel.

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

P&A: $55.50 up; immediate.

Resistance Standard 479

Five primary resistance standards in the MRS-105 package range from 100 ohms to 1 meg. Accuracy is 0.0015% at values of 1 K to 1 meg and 0.003% at 100 ohms. Stability is better than 0.0015% per year. Case is 9-3/8 x 31/32 x 3 in. Elements are oil immersed and hermetically sealed.

Julie Research Laboratories, Inc., Dept. ED, 603 W. 130th St., New York 27, N.Y.

CIRCLE 55 ON READER-SERVICE CARD ▶

NEW PRODUCTS

Magnetic Amplifiers 451

Operating with null stability in the 10^{-16} region, these amplifiers withstand severe environmental conditions. Output may be ±dc, phase-reversing ac, or variable pulse duration. Current gain is stable over temperature range of —55 C to 135 C within about ±5% without optional feedback. Power may be 115 v, 400 cps, or dc from 3 to 28 v.

Incra-Magnetics, Co., Dept. ED, P. O. Box 137, River Forest, Ill.

Transistorized Inverter 438

Peak loads up to 1,300 w and continuous loads to 500 w are handled by transistorized dc/ac inverter model PI 1341. This unit converts 12 v dc to 115 v 60 cps. It is designed to power ac motors with high peak starting current surges and low starting power factors, efficiency is 80% at full load.

Power Instruments Corp., Dept. ED, 235 Oregon St., El Segundo, Calif.
P&A: $300 ea; from stock.

Power Triode 483

Providing 5 megawatts peak output at 250 mc on long pulses and up to 10 megawatts on short pulses, the ceramic-metal RCA-7835 is useful in radar and particle accelerator service. Full ratings may be applied up to 300 mc. Variants of the water-cooled tube can be supplied for cw operation with output levels to 1/2 megawatt.

Radio Corp. of America, Electron Tube Div., Industrial Tube Products Dept., Dept. ED, Harrison, N.J.

Don't miss an issue of ELECTRONIC DESIGN; Return your renewal card.

Fractional HP Motor 439

Available from 1/20 through 1/4 hp, type AR is a six-pole motor. Designed for heavy-duty applications, it has higher starting and running torques than conventional shaded-pole motors. It is 4-7/8 in. in diameter.

Redmond Co., Inc., Dept. ED, Owosso, Mich.

Tape Terminator 453

Flexible copper conductive tape is easily connected with the Flex-Term terminator. Crimping action locks tape in terminator. Sleeve is soft annealed copper, tab is beryllium copper; insulation is natural Teflon tubing. Metal surfaces are gold-plated. Contact resistance is less than 1 milliohm. Solder tab type is model FT100, screw lug FT225.

Hi-Shear Corp., Dept. ED, 2600 W. 247th St., Torrance, Calif.

Power Amplifier 441

Distortion is less than 0.25% with full output power of 50 w, mid-band, for model 250B power amplifier. Specifications are: frequency response, ±0.5 db from 12 cps to 45 kc; output impedance, 0.7 to 600 ohms; hum and noise, 95 db down; sensitivity, 0.5 v rms for full output; input impedance, 100 K.

H. H. Scott Inc., Dept. ED, 111 Powdermill Road, Maynard, Mass.

Price: *$175 fob Maynard.*

NEW PRODUCTS

Polystyrene Capacitor 446

Hermetically sealed in metal cases with glass-to-metal end seals, polystyrene capacitors have high insulation resistance and low dissipation factor. Negative temperature coefficient is 120 ±30 ppm per deg C; temperature range is –55 C to +85 C. Capacitors meet or exceed requirements of MIL-C-19978, characteristic P.

General Products Corp., Dept. ED, Union Springs, N. Y.

Silicon Diodes 440

MIL-S-19500/118 qualified silicon diodes types 1N483B, 1N485B, and 1N486 B have leakage that is typically 1 μa at 150 C. Forward conductance is 100 ma min at 1 v; reverse voltages range up to 250 v. They are in standard glass, hermetically sealed, DO-7 packages.

Rheem Semiconductor Corp., Dept. ED, 350 Ellis St., Mountain View, Calif.

P&A: From $1.90 to $3.75, 100 to 999; from stock.

Centrifuge 445

With electronic speed control, model B931 centifuge holds drift from angular velocity of main rotating arm or outboard table to below 0.001%. A crystal-controlled oscillator is used to determine over-all setting accuracy. The system can be set to maintain a spatially stable platform for the test object or to create several discrete sinusoidal or constant g accelerations. Nominal radius of rotating arm is 24 in. between its center of rotation and that of the outboard table, which is 8 in. in diameter.

Genisco, Inc., Dept. ED, 2233 Federal Ave., Los Angeles 64, Calif.

Don't forget to mail your renewal form to continue receiving ELECTRONIC DESIGN.

Indicator Light 472

A momentary-action push-button switch is combined with transistor circuitry and neon indicator in a unit mounting on 5/8 in. centers. Lamp is transistor-controlled from small signals; integral switch is offered in A or B forms.

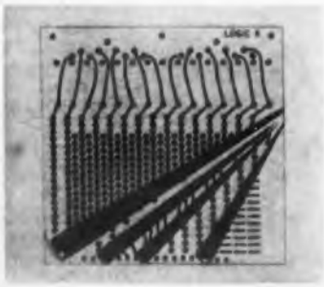
Transistor Electronics Corp., Dept. ED, 3357 Republic Ave., Minneapolis 26, Minn.

Rectifier Stack Assembly 473

Made for high-voltage transmitter use, these rectifier stack assemblies are capable of handling 44 kv at 7.2 amp. Assembly consists of double-diffused silicon junction rectifier stacks in a three-phase bridge assembly, arranged for maximum heat dissipation.

Trans-Sil Corp., Dept. ED, 55 Honeck St., Englewood, N.J.
Availability: *30-day delivery.*

Printed Circuits 475



Multi-layered printed circuitry is made with cross-over connections internally bonded. Each layer is 0.006 in. thick; four layers of circuitry make a plane 0.025 in. thick. Connections are brought out to numbered points on the board.

Scientific Components Div., Intellux, Inc., Dept. ED, 30 S. Salsipuedes St., Santa Barbara, Calif.

CIRCLE 59 ON READER-SERVICE CARD ▶

NEW PRODUCTS

Acceleration Switch 470

A spring-mass, fluid-damped device, acceleration switch model 18001 may be used to open or close a circuit in the presence of acceleration. It is immune to large accelerations caused by vibration and shock. Standard ranges extend from 0.02 to 200 g; accuracy is 0.01 g to 1%. Current rating of spdt contacts is 250 ma resistive, with up to 40 amp on special order. Optional configurations include packaging with latching or unlatching release, time delay devices, solenoids, etc.

U. S. Science Corp., Dept. ED, 5221 W. 102nd St., Los Angeles 45, Calif.

Germanium Mesa Transistors 482

For use in high-speed logic circuits, the pnp diffused-base germanium mesa transistors 2N705, 2N710 and 2N711 are enclosed in completely welded, hermetically sealed TO-18 cases. Switching times are: for the 2N705 and 2N710, 60 nsec; 2N711, 70 nsec.

Raytheon Co., Semiconductor Div., 215 First Ave., Needham, Mass.

P&A: From $1.95 to $10 ea, 100 to 999; immediate.

Power Supplies 471

Constant voltage and constant current outputs are available in the Mercury series of transistorized power supplies. There are five output combinations: 15 v, 10 amp; 36 v, 2.5 amp; 36 v, 5 amp; 60 v, 2.5 amp; and 160 v, 1 amp. Current and voltage are continuously variable, zero to maximum. Dynamic regulation is better than 0.05%, with a response time of 50 μsec. Ripple

◀ CIRCLE 60 ON READER-SERVICE CARD

is less than 1 mv rms. Adjustable current limiting is provided. Panel height is 3-1/2 in.

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

P&A: $365 to $485; 4-week delivery.

Zener Diodes **476**

Rated at 1 and 10 w, silicon Zener diodes conform to military requirements. Approved 10-w types are the 6.2-v USA 1N1804, the 8.2-v USA 1N1807, the 12-v USA 1N1353, the 22-v 1N1358 and the 27-v USA 1N1361. Approved 1-w types are the 18-v USA 1N1777 and 27-v USA 1N1781.

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

P&A: $7 to $12 ea, 1 to 99; stock.

Servo Accelerometers **466**

For guidance, navigation and other systems requiring secondary acceleration sensing in two or more planes, servo accelerometers are made in triaxial, biaxial and unidirectional types. Internal axes are oriented orthogonally to within 1 min of arc. Required voltage is ±15 v dc or 28 v dc.

Gulton Instrumentation Div., Dept. ED, 212 Durham Ave., Metuchen, N.J.

***Price & Availability:** Unidirectional, $445; 90 days.*

CIRCLE 61 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Digital Decoder 443

Interrupted tone signals from any voice channel are received and decoded by model RPD-620 digital decoder. Designed primarily for wire-line applications, it works equally well over carrier, microwave and radio circuits in any combination. Decoders provide dry output circuits and can be equipped with selectors which provide up to five separate coded outputs.

Secode Corp., Dept. ED, 555 Minnesota St., San Francisco 7, Calif.
P&A: $165 to $190; from stock.

Current-Limiting Relay 448

Protection from excessive current is provided by the CL series current-limiting relay. Contacts lock on a sustained overload and cannot be reclosed, even momentarily, until overload has been corrected. Models are available for a wide range of applications. Electrically insulated dust cover protects against shocks and ambient conditions.

Line Electric Co., Dept. ED, 231 River St., Orange, N. J.

Static Machine Controls 447

With transistor logic, static system controls hydraulic, magnetic, and pneumatic devices. Applications range from one-station assembly to large, integrated systems. Operating speed is about 10 μsec. Fail-safe action is provided. System design results in longer life for input switches and output devices.

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

Have you sent us your subscription renewal form?

ELECTRON TUBE NEWS
...from SYLVANIA

- INCREASED GAIN!
- DECREASED NOISE FACTOR!
- IMPROVED Gm/Ib RATIO!

...outstanding advantages of new

BIKINI CATHODES
plus STRAP FRAME GRIDS

in 4 new Gold Brand Subminiature Tubes

From Sylvania comes an important new cathode design—*Bikini Cathode*—destined to upgrade industry standards for high performance tubes. Sylvania complements this remarkable cathode design with the advantages of *Strap Frame Grid* in exceptionally rugged, premium-quality Gold Brand Subminiature Tubes. The end effect: high reliability tubes for superlative VHF and UHF performance in compact, environmentalized equipment.

Exceptionally smooth, ultra-uniform in density . . . *Bikini Cathode* is a precast film of emissive material, of precise dimensions, bonded to the *two major sides* of a flat cathode sleeve. *Bikini Cathode* minimizes stray emission. Further, consistent density of cathode material eliminates "hot spots," assures uniform temperature and emission over the entire cathode surface. Smooth cathode surface minimizes possibility of grid-to-cathode arcing.

Bikini Cathode is ideally mated with Sylvania *Strap Frame Grid*. Both possess exceedingly flat surfaces, providing outstanding uniformity in grid-cathode spacing with resultant narrow dispersion of electrical characteristics, improved cutoff control, high stability and improved speed and uniformity of electron transit time. Add to this the singular advantages of rugged *Strap Frame Grid*—very fine grid wire, high T.P.I., extreme accuracy of grid pitch—and the result is a near ideal combination for high db gain, unusually low noise and exceptional ratio of Gm per mA of plate current.

New Sylvania Gold Brand Subminiature Tubes

featuring Bikini Cathodes and Strap Frame Grids

. . . for cascode RF amplifier-mixer, high-speed multivibrator service.

SYLVANIA SR-2662B is a medium-mu double triode (similar to 6111) featuring *very low heater power of 0.7W per section* and low Eb of 30V per section. Gm per mA of Ib for a single section is 1120. Gm per section is 9000 μmhos, 80% higher than Gm of conventional prototypes. It is subjected to the intensive testing characteristic of all Sylvania Gold Brand Subminiature Tubes. Examples: shock tests of 500g; vibrational acceleration of 2.5g; heater life tests of 2000 cycles, one minute "on", four "off." It's capable of withstanding ambient bulb temperatures of 220°C and intense radiation dosage.

SYLVANIA SR-2662C, medium-mu double triode, is a high-performance version of the popular, general purpose 6021 with a Gm of 13,000 μmhos. Ratio of Gm/Ib provides a figure of merit of 1730 per section.

. . . for grounded-cathode RF amplifier applications

SYLVANIA SR-2941A is a high-mu triode with Gm of 12,000 μmhos. It only draws 125 mA @ 6.3V heater power. Gm per mA Ib is 1300. SR-2941A provides 2.5 db better gain than usually encountered in present high-performance types.

. . . for grounded-grid RF amplifier applications

SYLVANIA SR-2942B, high-mu triode, featuring low heater power of 125 mA @ 6.3V and high Gm of 13,500 μmhos. It offers a 2.5 to 7 db gain improvement, 1.5 to 4 db noise improvement at 480MC than usually encountered with popular grounded-grid RF amplifier types.

These are the first types to utilize *Bikini Cathodes* and *Strap Frame Grids*. Ask your Sylvania Sales Engineer to keep you up to date on further developments. For technical data on specific types, write Electronic Tubes Division, Sylvania Electric Products Inc., Dept. D1, 1100 Main St., Buffalo 9, N. Y.

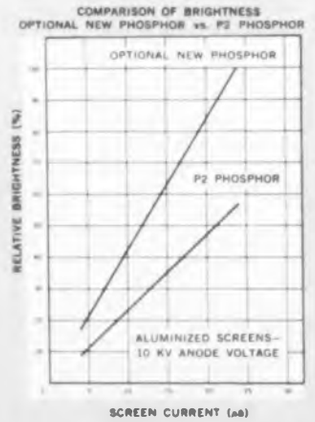
AVERAGE CHARACTERISTICS

	SR-2662B	SR-2662C	SR-2941A	SR-2942B	Units
Ef	6.3	6.3	6.3	6.3	V
If	235	375	125	125	mA
Eb	60	100	110	150	V
E_{c_1}	–	–	−1.0	–	V
Rk	220*	270*	–	100	ohms
Ib	8.0*	7.5*	9.0	14.3	mA
Gm	9,000*	13,000*	12,000	13,560	μmhos
Gm/Ib	1,120*	1,730*	1,300	945	μmhos/mA
Mu	20*	40*	58	55.2	
Noise-matched Conditions	**Grounded Cathode Circuit (200MC)**			**Grounded Grid (480MC)**	
Gain	14.8*	15.1*	17.5	14.5	db
Bandwidth	8.0*	9.5*	11.8	9.5	MC
NF	4.0*	4.0*	4.4	7.2	db

*Single section

SYLVANIA SPIRAL ACCELERATORS-5BGP-, -5BHP-

- High deflection sensitivity
- High resolution • High reliability
- High writing speed



Graph illustrates the improved brightness of new phosphor, a medium-short decay phosphor having green fluorescence and phosphorescence. Sylvania-5BGP-, -5BHP- are available also in a wide range of other phosphors.

Every Spiral Accelerator gun is inspected on a high-magnification optical comparator for spacing and dimensions.

now available with new, brighter phosphor and "Bonded Shield" safety cap

Sylvania Spiral Accelerator cathode ray tubes provide superior-quality displays with minimal pattern distortion. Consider the reasons—guns, for example, are assembled on Sylvania-developed mounting jigs accurate to 0.001". High-magnification optical comparators critically inspect spacings and dimensions. The internal helical resistance coating, too, undergoes extremely tight controls for linear resistance, and uniformity of application. Further, completed tubes receive extensive tests for electrical characteristics, distortion, brightness. Spot size is microscopically measured at extreme corners of required minimum scan. Perpendicularity of horizontal and vertical scan lines is physically measured to meet 1.0° acceptance standards. In addition, Sylvania-5BGP-, -5BHP- must meet severe cycled life tests.

Sylvania Spiral Accelerators are also available with "Bonded Shield" safety cap for increased image readability. "Bonded Shield" improves mounting and styling, strengthens tube face, simplifies cleaning of tube face.

Development is now under way at Sylvania on square-faced Spiral Accelerators. Ask your Sylvania Sales Engineer for price and delivery information. For technical data, write Electronic Tubes Division, Sylvania Electric Products Inc., Dept. D2, 1100 Main St., Buffalo 9, N. Y.

MICROWAVE DEVICE NEWS from SYLVANIA

120KW

20 KW to 120 KW
peak power output

with Sylvania Ka Band Magnetrons

20KW

Sylvania Ka Band Magnetrons offer a remarkable range of powers, fill virtually all your Ka band requirements. They include extremely compact types with exceptional power-to-weight ratios. All are fixed-frequency types for pulsed operation, utilize stabilized magnets, and exhibit outstanding reliability and longevity.

SYLVANIA-5789, first commercially available U. S. type for Ka band, uses 22-vane "rising sun" anode, and improved dispenser-type cathode. With hermetically sealed input and pressurized output, it is highly adaptable to high altitude operation.

SYLVANIA-6799 features 120KW peak power output and is a proven high-power millimeter wave source. It is available for use with longer pulses and higher duty cycles at slightly reduced power.

SYLVANIA M-4155A, *ruggedized* version of the 5789, features compact size and weight of only 9 lbs., improved heat dissipation and excellent stability. It utilizes a special cone-shaped cathode support and "building block" mounting arrangement for added mechanical strength. M-4155A possesses both long- and short-pulse capabilities.

SYLVANIA XM-4064, *ruggedized* magnetron, offers exceptional stability under severe environmental conditions. Only 9 lbs. in weight, it provides peak power output of 70KW for a remarkably good power-to-weight ratio.

SYLVANIA XM-4158, *ruggedized* magnetron, provides 120KW peak power output. Weight is only 27 lbs. It uses E type magnets for a uniform, flat surface configuration that can be used as a structural part of the chassis. XM-4158 is compatible with either long- or short-pulse operation.

SYLVANIA XM-4218, *ruggedized* tube, provides a power-to-weight ratio of 8:1 making it especially suited for portable, field-type radar. It uses metal-to-ceramic seals, ceramic cathode capsule, cantilever cathode support. The tube withstands 50g shock, 10g vibration tests. XM-4218 provides a lower pushing factor than tubes of comparable performance.

SYLVANIA XM-4206 is a *ruggedized*, compact tube with encapsulated cathode. Only 10.5 lbs., it provides 40KW peak power output.

SYLVANIA Ka BAND MAGNETRONS

	Frequency (KMC)	Peak Power Output (KW)	Max. Duty Cycle	Max. Pulse Width (μsec)
5789	34.512 – 35.208	40	.0006	1.0
6799	34.512 – 35.208	120	.0005	1.0
M-4155A	34.512 – 35.208	40	.0006	1.0
XM-4064	34.512 – 35.208	70	.0008	1.0
XM-4158	34.512 – 35.208	120	.0006	1.0
XM-4218	34.512 – 35.207	32	.0006	0.4
XM-4206	34.7 – 35.0	40	.0006	1.1

Investigate the design advantages of Sylvania Ka band magnetrons *and* associated Ka band TR tubes. Contact your Sylvania Sales Engineer for complete information. For technical data on specific types, write Electronic Tubes Division, Sylvania Electric Products Inc., Dept. MDO-D, 1100 Main St., Buffalo 9, N. Y.

SYLVANIA

SUBSIDIARY OF

GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

NEW PRODUCTS

Precision Resistors 690

Ceramic bobbin wirewound resistors of series CB feature all-welded construction. Designed for applications requiring long-term accuracy and stability, standard tolerances are 1, 0.5, 0.25, and 0.1%. Temperature coefficient is ±20 ppm per deg C from −50 to +85 C for values above 500 ohms.

Kelvin Electric Co., Dept. ED, 5907 Noble Ave., Van Nuys, Calif.

Control Relay 368

For automation control panel applications, the type BF relay measures 3-1/8 in. high and 1-11/16 in. wide. Current rating is 6 amp at 300 v ac. The relay is available in any combination of normally open or normally closed contacts, two to eight poles, with a maximum of four normally closed. Operating time on pickup is 12.5 to 18.0 msec, dropout 6.25 to 12.5 msec.

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

Twin Planar Transistor 575

Capable of boosting 10-fold the voltage of a standard battery, the "twin-planar" transistor will be offered initially as a dc chopper-amplifier. The two silicon transistors incorporated in the device share a common collector. Close matching characteristics eliminate the necessity of transistor selection.

Radio Corp. of America, Semiconductor and Materials Div., Dept. ED, 30 Rockefeller Plaza, New York 20, N.Y.

***Price:** Under $25 per unit in thousand lots.*

CIRCLE 63 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Pressure Transducer 617

Medium-to-high range pressure transducer type 4-329 utilizes the unbonded strain gage principle. Specifications are: electrical excitation, 20 v dc or ac rms with a carrier frequency of 0 to 20 kc; sensitivity, 50 mv ±0.25 mv measured through a 50-K load; input impedance, 700 ohms min; output impedance, 350 ohms; temperature range, −100 to +300 F; pressure ranges, 0 to 100 through 0 to 5,000 psi.

Consolidated Electrodynamics Corp., Dept. ED, 360 Sierra Madre Villa, Pasadena, Calif.

Pulse Generator 363

Rugged and reliable, the Tri-Pulse generator is designed to supply 10, 100 or 1,000 pulses per sec to as many as 10 telemetering devices. Power for the 1-1/2 lb unit is supplied by a miniature 30-v battery. Size is 1-1/2 in. high, 4 in. wide, and 5 in. long. The generator has performed within 1% of selected frequency in rocket sled tests to 40 g acceleration.

The Harwood Co., Dept. ED, 1141 W. Valley Blvd., Alhambra, Calif.

Data Converter 369

The CV-772 radiosonde data converter is designed to operate with the AN/GMD-1 semiautomatic sounding system. The converter senses and records contact closures representing baroswitch reference contact numbers. It measures elapsed time in increments of 0.01 min. Remote control operation is possible from 210 ft.

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

Silicon Rectifiers 582

Rated at 20 amp, these stud-mounted, diffused-junction silicon rectifiers are designed for military and industrial power supplies. Types 1N248-C, 1N249-C, 1N250-C, and 1N1195-A through 1N1198-A are also available in reverse-polarity versions. Peak surge-current rating is 350 amp; peak inverse voltage ratings range from 55 to 600 v. In a D0-5 package, temperature range is −65 to +175 C.

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

Power Supply 367

Capacitor-discharge power supply model 1046 MA is designed for welding extremely fine wires. Low range is 0.004 to 1.3 w-sec, high range 0.04 to 13 sec. Discharge time is about 1 msec. Watt-sec meter and stepless heat control are provided. Rate is 50 to 150 welds per minute. Unit measures 6-1/8 in. high, 8-1/4 in. wide and 13-5/8 in. deep.

Weldmatic Div., Unitek Corp., Dept. ED, 950 Royal Oaks Drive, Monrovia, Calif.

Impulse Magnetizer 378

Automatic or semi-automatic operation is possible with this half-cycle impulse magnetizer. Consisting of an ignitron tube and control circuitry, the device may be triggered as often as desired; no charging interval is necessary. Magnetizer uses 220/600 v ac, single phase; control circuit operates on 110 v ac.

Indiana Steel Products Div., Indiana General Corp., Dept. ED, Valparaiso, Ind.

CIRCLE 65 ON READER-SERVICE CARD

NEW PRODUCTS

Power Supply 365

Delivering 0 to 36 v dc and 0 to 10 amp, model 809A power supply may be operated as a constant current or constant voltage source. Changeover from either mode is made by plugging in the appropriate circuit card. Line and card regulation is less than 15 mv for constant-voltage operation; ripple and noise are less than 1 mv. Supplies may be paralleled. Panel is 5-1/4 in. high.

Harrison Laboratories, Inc., Dept. ED, 45 Industrial Road, Berkeley Heights, N. J.
Price: $625.

Rectifier Test Set 374

An oscilloscope display of the reverse characteristics of high-voltage diodes and rectifiers is provided by rectifier test set model 1826. It provides a wide range of reverse voltages up to 5 kv and reverse currents from less than 1 μa to 1 amp.

Dynatron Electronics Corp., Dept. ED, 178 Herricks Road, Mineola, N.Y.

Sector Potentiometer 362

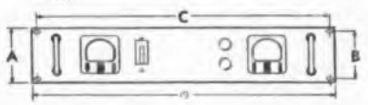
Small angular movements are measured with an accuracy within 7.2 min by the CP13-0301-1 circular sector potentiometer. Electrical travel is ±3 deg; resolution is 0.5%. The 11-oz unit withstands 500 F for 3 min, humidity of 95 to 100% at 160 F, linear acceleration of 50 g and shock of 100 g along 3 axes. Zero adjustment is external.

Humphrey, Inc., Dept. ED, 2805 Canon St., San Diego 6, Calif.

DIMENSION DRAWINGS

← Top View of All Models

Front View ↓



	MODEL †		
	LA 50-03A LA 20-05A LA 8-08A	LA 100-03A LA 40-05A LA 15-08A	LA 200-03A LA 80-05A LA 30-08A
A	3½"	7"	10½"
B	3"	*4"	*7½"
C	18⅝"	18¼"	18¼"
D	14⅜"	14⅜"	16½"

* These models notched per RETMA Standards
† Includes metered models with suffix "M"

COMPLETE SPECIFICATIONS OF LAMBDA LA SERIES

DC OUTPUT (Regulated for line and load)

Model	Voltage Range	Current Range	Minimum Voltage (1)	Voltage Steps (1)	Price(2)
LA 50-03A	0- 34 VDC	0- 5 AMP	0	2, 4, 8, 16, and 0- 4 volt vernier	$ 395
LA100-03A	0- 34 VDC	0-10 AMP	0	2, 4, 8, 16, and 0- 4 volt vernier	510
LA200-03A	0- 34 VDC	0-20 AMP	0	2, 4, 8, 16, and 0- 4 volt vernier	795
LA 20-05A	20-105 VDC	0- 2 AMP	20	5, 10, 20, 40, and 0-10 volt vernier	350
LA 40-05A	20-105 VDC	0- 4 AMP	20	5, 10, 20, 40, and 0-10 volt vernier	495
LA 80-05A	20-105 VDC	0- 8 AMP	20	5, 10, 20, 40, and 0-10 volt vernier	780
LA 8-08A	75-330 VDC	0- 0.8 AMP	75	15, 30, 60, 120, and 0-30 volt vernier	395
LA 15-08A	75-330 VDC	0- 1.5 AMP	75	15, 30, 60, 120, and 0-30 volt vernier	560
LA 30-08A	75-330 VDC	0- 3 AMP	75	15, 30, 60, 120, and 0-30 volt vernier	860

(1) The DC output voltage for each model is completely covered by four selector switches plus vernier control. The DC output voltage is the summation of the minimum voltage plus the voltage steps and the continuously variable DC vernier.

(2) Prices are for unmetered models. For metered models add the suffix "M" and add $30.00 to the price.

Regulation (line) ..... Better than 0.05 per cent or 8 millivolts (whichever is greater). For input variations from 100-130 VAC.

Regulation (load) ..... Better than 0.10 per cent or 15 millivolts (whichever is greater). For load variations from 0 to full load.

Transient Response ..... Output voltage is constant within regulation specifications for step function:

(line) ..... line voltage change from 100-130 VAC or 130-100 VAC.

(load) ..... load change from 0 to full load or full load to 0 within 50 microseconds after application.

Internal Impedance ..... LA 50-03A less than .008 ohms
LA100-03A less than .004 ohms
LA200-03A less than .002 ohms
LA 20-05A less than .06 ohms
LA 40-05A less than .03 ohms
LA 80-05A less than .015 ohms
LA 8-08A less than .5 ohms
LA 15-08A less than .25 ohms
LA 30-08A less than .15 ohms

Ripple and Noise ..... Less than 1 millivolt rms with either terminal grounded.

Polarity ..... Either positive or negative terminal may be grounded.

Temperature Coefficient ..... Better than 0.025 %/°C

AC INPUT ..... 100-130 VAC, 60 ± 0.3 cycle[3]
LA 50-03A ..... 360 watts[4]
LA100-03A ..... 680 watts[4]
LA200-03A ..... 1225 watts[4]
LA 20-05A ..... 390 watts[4]
LA 40-05A ..... 710 watts[4]
LA 80-05A ..... 1350 watts[4]
LA 8-08A ..... 415 watts[4]
LA 15-08A ..... 760 watts[4]
LA 30-08A ..... 1450 watts[4]

[3]This frequency band amply covers standard commercial power lines in the United States and Canada.
[4]With output loaded to full rating and input at 130 VAC.

AMBIENT TEMPERATURE AND DUTY CYCLE Continuous duty at full load up to 50°C (122°F) ambient.

OVERLOAD PROTECTION:

Electrical ..... Magnetic circuit breaker front panel mounted. Special transistor circuitry provides independent protection against transistor complement overload. Fuses provide internal failure protection. Unit cannot be injured by short circuit or overload.

Thermal ..... Thermostat, manual reset, rear of chassis. Thermal overload indicator light front panel.

METERS ..... Voltmeter and ammeter on metered models.

CONTROLS:

DC Output Controls ..... Voltage selector switches and adjustable vernier-control rear of chassis.

Power ..... Magnetic circuit breaker, front panel.

Remote DC Vernier ..... Provision for remote operation of DC vernier.

Remote Sensing ..... Provision is made for remote sensing to minimize effect of power output leads on DC regulation, output impedance and transient response.

PHYSICAL DATA:

Mounting ..... Standard 19" Rack Mounting

Size

LA 50-03A, LA20-05A, LA 8-08A 3½" H x 19" W x 14¾"D
LA100-03A, LA40-05A, LA15-08A 7" H x 19" W x 14¾"D
LA200-03A, LA80-05A, LA30-08A 10½" H x 19" W x 16½"D

Weight

LA 50-03A, LA20-05A, LA 8-08A 55 lb Net 85 lb Ship. Wt.
LA100-03A, LA40-05A, LA15-08A 100 lb Net 130 lb Ship. Wt.
LA200-03A, LA80-05A, LA30-08A 140 lb Net 170 lb Ship. Wt.

Panel Finish ..... Black ripple enamel (standard). Special finishes available to customers' specifications at moderate surcharge. Quotation upon request.

LAMBDA ELECTRONICS CORP.
515 BROAD HOLLOW ROAD, HUNTINGTON, L. I., NEW YORK 516 MYRTLE 4-4200

Send for complete Lambda Catalog.

Impulse Counter 631

Readings in five-unit increments from a maximum reading of 995 to 000 are provided by model 11576 miniature impulse counter. Over-all size is less than 1-in. square by 3-in. long and weight is slightly more than 4 oz. Maximum speed of response is 1320 impulses per minute. The unit is designed for 80%-on-20%-off operation.

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

High-Purity Silver 376

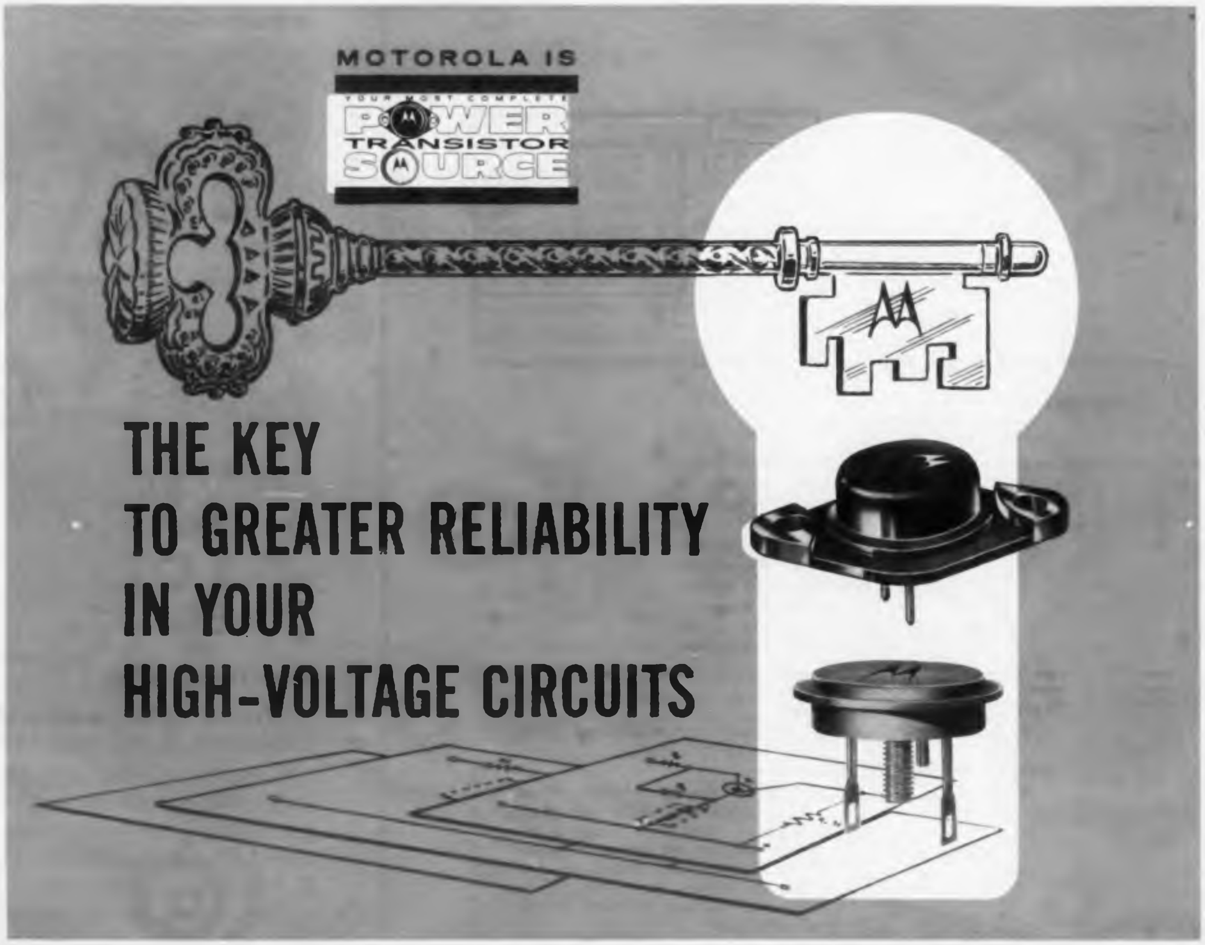
Silver 99.999+% pure is available in fine crystalline powder, vacuum-cast ingots, or rolled into strip or foil to user specifications. The only spectrographically detectable elements, Fe, Cu, Si, and Mn, amount to less than 1 ppm each.

High Purity Metals, Inc., Dept. ED. 340 Hudson St., Hackensack, N. J.

Coaxial Switches 628

High-power, coaxial switches, series 8000, are spdt units available in 1-5/8- and 3-1/8-in. coaxial sizes. Isolation is in excess of 75 db. High reliability is achieved by use of a direct-bearing flush-type mechanism. Standard models are manually operated with motor drives optional.

Bogart Manufacturing Corp., Dept. ED, 315 Siegel St., Brooklyn 6, N.Y.

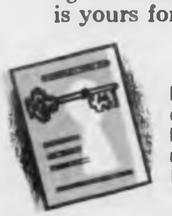


THE KEY TO GREATER RELIABILITY IN YOUR HIGH-VOLTAGE CIRCUITS

Motorola Power Transistor Applications Assistance

If you are working with high-voltage circuits you'll find a new report, prepared by Motorola applications engineers, of special interest.

It reviews the use of power transistors in high-voltage circuits and suggests application methods that could result in substantial cost reductions. In addition, the techniques outlined in this report can greatly improve circuit reliability and help simplify procurement problems. Titled "How to Design Economical High-Voltage Circuits," this applications brochure is yours for the asking.



For your copy simply contact your Motorola district office, Motorola distributor, or write: Motorola Semiconductor Products Inc., Technical Information Department, 5005 East McDowell Road, Phoenix 10, Arizona.

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Dayton / Detroit / Glenside, Pa / Hollywood / Minneapolis / Orlando, Fla
Silver Spring, Md / Syracuse / Toronto, Canada

MOTOROLA IS YOUR MOST COMPLETE POWER TRANSISTOR SOURCE

You can achieve marked improvement in *all* your circuits by utilizing the wide selection of field-proven power transistors available from Motorola. Whatever your specific requirements, you'll find a *standard* Motorola unit that meets your needs.

• Both TO-3 and TO-36 packages • 90 and 150 watts power dissipation • 0.8°C/W and 0.5°C/W maximum thermal resistance • 100°C continuous junction temperature • current ratings of 3, 5, 10, 15 and 25 amps • collector voltages to 120 volts • variety of gain/voltage combinations • 6 mil-types • "Meg-A-Life" mil-quality industrial units

For fast delivery in any quantity, call your nearby Motorola distributor or your Motorola district office.

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NEW PRODUCTS

Power Supplies 734

Voltage-regulated power supplies of SM 160 series deliver 0 to 160 v at 4, 2 or 1 amp. Line and load regulation is 0.1%. Stability is 0.1% or 6 mv, ripple less than 1 mv rms. Recovery time is 50 μsec, temperature coefficient less than 0.05% per deg C.

Kepco, Inc., Dept. ED, 131-38 Sanford Ave., Flushing 55, N.Y.

P&A: $525 to $925; 30 to 60 days.

Crystal Oscillator 738

Solid-state, voltage-controlled crystal oscillator 10M-WA can be directly frequency-modulated over a range of ±0.2% of F_o. Center frequency is 10.7 mc, deviation ±20 kc. Temperature drift is less than 1 kc from −40 to +65 C; linearity is ±200 cps. Output power is 5 mw, sensitivity 3 kc per v. Size is 3/4 x 2 x 2-1/2 in.

Itek Corp., Itek Electro-Products Co. Div., Dept. ED, Cambridge 42, Mass.

Electrical Tape 661

Acetate film insulation, glass filler and a solvent-resistant, thermosetting adhesive are combined in tape No. X-1131. The 7-mil tape has an electric strength of 5 kv, tensile strength of 130 lb/in. and an electrolytic corrosion factor of 1.00. It will not cause corrosion under prolonged exposure to humidity and stress.

Minnesota Mining and Manufacturing Co., Dept. W1-29, Dept. ED, 900 Bush Ave., St. Paul 6, Minn.

NEW PRODUCTS

Video Amplifier **728**

Broad-band, solid-state decade video amplifier VF1399 is designed for rack-panel mounting. For laboratory or system use, it covers frequency band of 50 kc to 50 mc ±2 db. Voltage gain is 80 db in 20-db steps, input impedance 50 ohms. Maximum output voltage is 3-v peak.

LEL, Inc., Dept. ED, 75 Akron St., Copiague, N.Y.

Power Supply **724**

Transistorized, regulated power supply TP-30 delivers 0 to 36 v dc at 30 amp. Line regulation is held to 10 mv max, load regulation 5 mv max, ripple 1.0 mv. Rack-mounting chassis has a panel height of 7 in.

Invar Electronics Corp., Sales Dept., Dept. ED, 323 W. Washington Blvd., Pasadena, Calif.

Audio Cable **727**

Double-channel audio cable No. 17555 is suitable for use with stereo and binaural systems, and any multiplex system. It is constructed of two tinned copper stranded conductors with color-coded insulation. Spirally wound shield serves as second conductor.

Lenz Electric Manufacturing Co., Dept. EI-2, Dept. ED, 1751 N. Western Ave., Chicago 47, Ill.

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Magnet Solder 720

Alnico magnets may be soldered to bare steel pole pieces with Orango Flux No. T-64-C. The nonresinous, water-based flux leaves no active residue after water rinsing. Adhesion is good whether metal is bare or plated.

London Chemical Co., Inc., Dept. EI-2, Dept. ED, 1535 N. 31st Ave., Melrose Park, Ill.

Sequence Relay 723

A bi-directional, 12-position sequence relay for remote control, No. 4175 operates in 40 msec min. Coil is rated at 5-K impedance, 0.003-amp drop-out current, and dc input current of 0.020 amp min. Contact rating is 1 amp, 24 v ac. A 117-v, 5-amp switch is provided at zero position. Size is 2.07 in. high x 2.69 in. wide x 2.00 in. deep.

The Lionel Corp., Electronics Div., Dept. ED, Hoffman Place, Hillside, N.J.

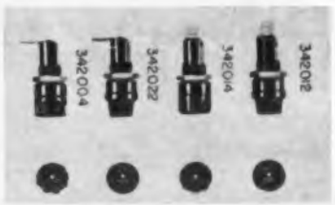
Laminated Circuits 721

Reduction of size and weight of electronic packages is possible with etched laminated circuits. Copper-backed glass epoxy is used in up to eight layers. Thickness varies with signal level to be carried. Inductance is lower than with wire harnesses. Capacitance is uniform ±10% throughout a circuit; typical rating is 7 pf per in. on a 30-mil line.

Litton Industries, Inc., U. S. Engineering Co. Div., Dept. ED, 336 N. Foothill Road, Beverly Hills, Calif.

NEW PRODUCTS

Fuse Posts 722



All 3AG miniature fuse applications are covered by a line of four fuse posts with two knobs and connecting terminal arrangements. Current rating is 15 amp max, voltage rating 250 v max. Models 342004 and 342022 require 1-1/64 in. behind panel, models 342014 and 342012 use 1-11/32 in. Posts meet military requirements and are UL-approved.

Littelfuse, Inc., Dept. ED, Des Plaines, Ill.

DC Motor 737

A 9-v, battery-powered motor, model 36-B has less than 2% variation in speed. Capable of 4,000 rpm, it has a 1,500-rpm governor that allows adjustments of 600 rpm. Power consumption is 25 ma in a neutral position.

Jonard International, Inc., Dept. ED, 624 Madison Ave., New York, N.Y.

Ultrasonic Cleaner 729

With tank capacity of 1-1/4 qt, the Maxson ultrasonic cleaner occupies a space 8 x 6 in. Power output is 45 w, operating frequency 70 to 80 kc. Power consumption is 140 w. The cleaner is guaranteed for one year.

L & R Manufacturing Co., Dept. ED, 577 Elm St., Kearny, N.J.

Sweeping Oscillator 735

Frequency range of 2 to 215 mc is covered in 12 bands by the 860-B sweeping oscillator. Sweep rate is continuously variable, 10 to 40 cps, or locked to line frequency; sweep width is up to 30 mc. Sweep output is regular sawtooth; rf output is 1.0 v rms.

Kay Electric Co., Dept. ED, Maple Ave., Pine Brook, N.J.

Heat Exchanger 717

All-aluminum, dip-brazed heat exchanger model INFSK 6.3.10-4-1/2 measures 6 x 4-3/4 x 3-1/2 in. Designed for oil-cooled electronic gear, the unit will dissipate about 1,000 w of heat with fluid temperatures around 80 C.

Lytron, Inc., Dept. ED, 42 Brookford St., Cambridge 40, Mass.

Control Meter 731

Operating without electrical contacts, model 2547 electronic control meter provides continuous output signal past control setting, with accurate, uninterrupted full-scale indication and automatic reset. A power input of 22-1/2 v dc at 10 ma is required for the switching circuit.

International Instruments, Inc., Dept. ED, P. O. Box 2954, New Haven 15, Conn.

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NEW PRODUCTS

Precision Potentiometer 736

Multigang, multitap precision potentiometers may be obtained in linear and nonlinear functions with up to six gangs. Power rating is 6 w for single, 5 w per gang in multigang units. Resistance values range from 1 K to 400 K. Body is stainless steel or blue anodized aluminum, OD 3 in. Conforming to military specifications, unit withstands acceleration to 30 g, with temperature range of −55 to +225 C. Life expectancy is 5 million revolutions. Resistance tolerance is ±5% standard, linearity ±0.1%.

Chicago Aerial Industries, Inc., Kintronic Div., Dept ED, 10134 Pacific Ave., Franklin Park, Ill.

Decade Counter 725

Directly coupled in-line readout in the LA-80 counter is provided by a true decade system with no binary conversion. Time base stability is one part in 10^8 per day; frequency range is 10 cps to 10 mc. With the LA-901B plug-in unit, time interval range is 1 μsec to 10 million sec. Other features are 0.1-μsec resolution, in-line eight-place readout, automatic reset, and automatic decimal point.

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

Accuracy Is Our Policy . . . .

The New Product description of a transistor socket made by Augat Bros., Inc., Attleboro, Mass, did not mention the maker of the mating transistor. The socket accepts units of the Clevite Corp. Spacesaver series. The item appeared in *ED*, March 1, p 123.

NEW PRODUCTS

Servo Tachometer 361

A size 11 servo motor tachometer, model BT1004MA is 1.250 in. long. Designed for transistor circuitry, the unit can be supplied with any gear train. Input to the motor is 115 v, 400 cps fixed phase, 20 v control phase. Tachometer input is 26 v; output is 0.24 v per 1,000 rpm. The 3.2-oz unit meets military requirements; standard operating temperature range is −55 to +125 C.

IMC Magnetics Corp., Dept. ED, Eastern Div., 570 Main St., Westbury, L. I., N. Y.

Resistance Wire 375

Iron-chromium-aluminum alloy 750 wire is intended for small appliances and other uses requiring low-cost elements for service to 2,050 F. Resistivity is 750 ohms per circular mil-ft; increase in resistance at operating temperature is said to be much greater than in similar alloys.

Hoskins Manufacturing Co., Dept. ED, 4445 Lawton Ave., Detroit 8, Mich.

Impedance Measuring System 353

Universal impedance measuring system model 291-A has a resistance accuracy of 0.05%. Inductance and

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capacitance accuracies are 0.1% at 1 kc. Measurement resolution is 120,005 dial divisions. The system includes ac and dc generators and detectors specifically designed for use with the bridge.

Electro Scientific Industries, Inc., Dept. ED, 7524 S.W. Macadam Ave., Portland 19, Ore.
***P&A:** $1,095; 30 days.*

Digital Readout 359

Characters 1-5/8 in. high are displayed by the series 160000 in-line digital readout. Multiple word messages may be displayed in black and white or color; color backgrounds may be used with any words or digits. The readout operates on a rear-projection principle, and measures 1-9/16 in. wide, 2-5/8 in. high, and 6-1/2 in. long.

Industrial Electronic Engineers, Inc., Dept. ED, 5528 Vineland Ave., North Hollywood, Calif.
***Price & Availability:** $18 ea; 30 days.*

Translation System 351

Shaft encoder translation system accepts the output of standard shaft encoders and automatically converts these data into 12-bit 8-4-2-1 binary-coded decimal form. These data are then prepared on punched paper tape, complete with parity checks.

Electronic Development Corp., Dept. ED, 423 W. Broadway, Boston 27, Mass.
***P&A:** $4,500; 45 days.*

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NEW PRODUCTS

Marking Machine 733

Teflon wire and tubing can be marked with the air-operated KW-7 marking machine. Wires are marked to an even depth regardless of variations in diameter, without damage to the dielectric. Dwell timer is adjustable in 1/10 sec increments. A dial-type indicating pyrometer shows type head temperature to 500 F and 260 C.

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

Impulse Counter 726

Counting speeds to 250 impulses per sec are attained by type 4TiF6EM counter. It consists of three stages: glow transfer tube, transistorized pulse shaper-amplifier, and totalizing counter. Suitable for flush mounting, unit measures 5-11/16 x 2-3/16 x 8-1/32 in. Power is 110 v, single phase, 16.5 w.

Landis & Gyr, Inc., Dept. ED, 45 W. 45th St., New York 36, N.Y.

Push-Button Switches 718

Compact, lighted push-button switches and pilot lights are available in modular design. With sub-panel, surface and matrix mounting,

contacts may be arranged up to 8pst. Actions include solenoid, momentary, alternate action, lockout and interlocking.

Luminator, Inc., Display-Control Div., Dept. ED, Costa Mesa, Calif.

Volt-Ohm-Milliammeter 555

Only one scale is visible at any one time, and all scales are direct-reading, on the V O Matic 360 automatic volt-ohm-milliameter. The meter is protected against extreme overload and burnout. Sensitivity is 20,000 ohms per volt dc, 5,000 ohms per volt ac; frequency response is 5 to 500,000 cps; accuracy is ±3% dc, ±5% ac.

B & K Manufacturing Co., Dept. ED, 1801 W. Belle Plaine Ave., Chicago 13, Ill.
Price: $59.95.

Tape Recorder 715

Voice and frequency program material is recorded simultaneously in up to 20 channels by the T-1000 magnetic tape recording and reproducing system. Speed is 1-7/8 or 15-16 in. per sec; frequency response is ±2 db, 300 to 4,000 cps at 1-7/8 in. per sec. Flutter is less than 0.5% rms at 1-7/8 in. per sec, harmonic distortion less than 3% at 500 cps.

Magnasync Corp., Dept. ED, 5546 Satsuma Ave., North Hollywood, Calif.

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NEW PRODUCTS

Miniature Relay 730

Shocks of 100 g and vibration of 40 g, 10 to 2,000 cps, do not affect operation of the Astro-relay series of 4pdt relays. Size is 0.875 x 0.800 x 0.400 in. Available for 6-, 12-, or 24-v operation, relay temperature range is −65 to +125 C. Pull-in power is 250 mw. Operate speed is 8 msec, drop-out 4 msec.

Kurman Electric Co., Dept. ED, 191 Newell St., Brooklyn 22, N.Y.

Magnetic Amplifier 719

Signal is ±80 mv dc at ±0 to 40 μa for model 1269, which combines magnetic amplifier, drive network, and motor in one package. Output is 10 w; excitation is 115 v ±5%, 400 cps ±10%. Linearity is ±5%, zero drift ±1%. Dynamic braking operates at 200 to 300 ma dc with zero input signal. Length is 5-5/8 in., OD 3-1/2 in. Weight is 4-1/2 lb including motor.

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

Tapped Delay Line 680

Utilizing magnetostrictive transducers, the ultrasonic torsional mode tapped delay line has taps at 345, 405, 408, 410, 427 and 438 μsec.

Specifications are: temperature range, —54 to +100 C; altitude, 100,000 ft; coil impedance, input, 100 ohms, output, 1 K; rise time, input, 0.2 μsec, output, 0.4 μsec; noise and spurious signals, less than 2 mv.

Curtiss-Wright Corp., Electronics Div., Dept. ED, Wood-Ridge, N.J.

Electro-Magnet **716**

Field intensity of 20,000 gauss over an area of 64 sq in. is provided by the 4 x 16 magnet assembly at 1-1/2 in. gap width. Pole face geometry is a 4 x 16 in. rectangle; faces are soft steel or Inconel. Magnet coils are wound from copper ribbon and insulated with Class B materials. A continuously variable power supply is used.

MHD Research, Inc., Dept. ED, P. O. Box 1815, Newport Beach, Calif.

AGC Amplifier **650**

Wide agc range of 250:1 is a feature of transistorized agc amplifier model 1020. When used with a variable gain servo, the 400-cps amplifier maintains constant loop gain. The 6.5-oz unit has an ambient temperature range of —55 to +125 C. Control voltage range is 0.1 to 26 v rms; maximum output voltage is 3 v rms. Input impedance is 10 K on error channel, 180 K on control channel.

Melcor Electronics Corp., Dept. ED, 48 Toledo St., South Farmingdale, L. I., N. Y.

Price & Availability: *$270 to $310; 30 days.*

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NEW PRODUCTS

Weatherproof Rectifier 360

Rated 2,500 amp at 225 v dc, the Unitron semiconductor rectifier is designed for outdoor installation. Disconnect switch, oil-cooled transformer, voltage regulator and rectifier section are integrated in a single unit. Area required is less than 80 sq ft.

I-T-E Circuit Breaker Co., Dept. ED, 1900 Hamilton St., Philadelphia 30, Pa.

Stabilized Power Supply 352

Stabilized output voltage within ±1% is delivered by model 200TV. The unit has an output capacity of 200 w at 118 v. Input power factor averages over 90% at related load.

Electromatic Industries, Dept. ED, Hollywood, Fla.

Noise Generator 739

Random voltage source, model 301 noise generator, has an ultra-

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stable spectral density of approximately 4.0 v^2/cps controlled to ±0.1 db from 0 to 40 cps. Gaussian amplitude distribution accuracy is better than 1%.

Elgenco, Inc., Dept. ED, 1555 14th St., Santa Monica, Calif.

Voltage Reference Source 740

Precision voltage reference source model VS-111 has a voltage range of −111.11 v dc to +111.11 v dc, selectable in 10-mv increments. Absolute accuracy is 0.025% and resolution is one part in 10,000. It is a four-decade, direct-reading instrument.

Electronic Development Corp., Dept. ED, 423 W. Broadway, Boston 27, Mass.

P&A: $795 fob Boston; from stock.

Digital Instruments 354

Three models of digital instruments include an ac-dc voltmeter, dc ammeter, and a multimeter. Typical accuracy is 1.0% of full scale for ac voltage measurement and 1.0% for current measurement.

Electro-Logic Corp., Dept. ED, 515 Boccaccio Ave., Venice, Calif.

P&A: From $360 to $440; 60 days.

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NEW PRODUCTS

Precision Parts 732

Tolerances of 0.0002 in. are possible on custom precision parts produced by chemical etching. No deburring is necessary. Metals include Hy-Mu 80 and 800, stainless steel, beryllium copper, phosphor bronze, silicon, nickel silver, and others.

Komak, Inc., Dept. ED, 2632 W. Cumberland St., Philadelphia 32, Pa.

Availability: *2 to 4 weeks.*

Power Supply 402

From one to four type 122 preamplifiers may be powered from the type 125 power supply. It provides three different regulated supplies to these preamplifiers through octal interconnecting cables. Output voltages include: +135 v dc at 0 to 20 ma ±3%; −90 v dc at 0 to 20 ma ±3%; −6 v dc at 0.7 to 4 amp ±5%.

Tektronix, Inc., Dept. ED, P.O. Box 500, Beaverton, Ore.

P&A: *$285; immediate.*

Vibration Table 407

Ultrasonic shake table model 160 provides vibrations of variable frequency and power from 20 to 100 kc with uniform amplitude of motion. Accelerations of 4,000 g can be obtained.

Ultrasonic Industries Inc., Dept. ED, Plainview, L.I., N.Y.

Price & Availability: *$750; stock.*

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Superior performance . . . greater reliability . . . extreme uniformity. . . . mil-quality! These are the dramatic design advantages you gain from Motorola Silicon Epitaxial Mesa transistors. Performance characteristics include: faster switching speeds, higher voltage breakdowns, reduced capacitance, increased power handling capabilities with reduced saturation resistance, and vastly improved VHF power gain performance. The result — outstanding switching and amplifying devices with a wide range of application potential.

MOTOROLA SILICON EPITAXIAL MESA TRANSISTORS

TYPE NO.	P_D mW	V_{CB} volts	V_{EB} volts	I_C mA	h_{FE} (typ) @I_C = 10 mA	f_T mc
2N706	300	25	3	200	40	450
2N706A	300	25	5	200	40	450
2N706B	300	25	5	200	40	450
2N707	300	56	4	200	12	450
2N707A	300	70	5	200	30	500
2N753	300	25	5	200	75	450
2N834	300	40	5	200	40	500
2N835	300	25	3	200	40	500

Immediate availability — All Motorola Silicon Epitaxial Mesa transistors are available "off the shelf" from your Motorola Semiconductor distributor.

For complete technical information on specific Motorola Silicon Epitaxial Mesa transistors, contact your Motorola district office, distributor, or write: Motorola Semiconductor Products Inc., Technical Information Department, 5005 East McDowell Road, Phoenix 10, Arizona.

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NEW PRODUCTS

Three-Pen Recorder 672

Solid-state three-pen recorder has encapsulated circuits to form rugged, replaceable modules. The pens travel the full width of the 4-in. chart. Input span of the potentiometer is continuously adjustable from 0 to 5 mv to 0 to 50 mv.

De Var Systems, Inc., Dept. ED, Glenbrook, Conn.

Terminal Strip 664

Produced in polyethylene and polypropylene plastic, these mounting strips are available in standard sizes. They adapt to automated production methods and contribute to the use of preassembled circuit modules or sub-chassis assemblies.

Electro-Glass Laboratory, Dept. ED, 4000 S.W. 114th St., Beaverton, Ore.

Multiturn Potentiometers 671

Unitized rotor design incorporated in the 3700 series multiturn potentiometer gives smoother operation while reducing the moment of inertia. Standard linearity tolerance is 0.1% in the 10-turn, and 0.2% in the three-turn unit. Glass-filled diallyl phthalate compounds are used in all molded parts for high insulation resistance.

Duncan Electronics, Inc., Dept. ED, 1305 Wakeham Ave., Santa Ana, Calif.

CIRCLE 86 ON READER-SERVICE CARD ▶

Accutron*...

new electronic timepiece uses ALLEN-BRADLEY Type TR Miniature Composition Resistors

With its miniature tuning fork and electronic circuit, Accutron introduces an entirely new principle to timekeeping—one which promises unprecedented wrist timepiece accuracy. Strapped to your wrist, it is guaranteed not to gain or lose more than one minute a month.

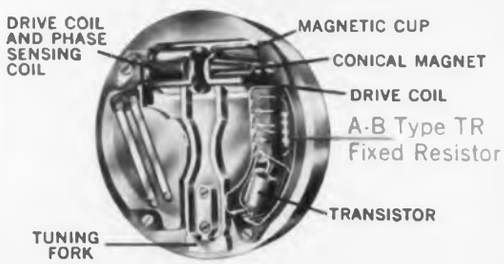
Allen-Bradley Type TR tiny resistors enabled Accutron designers to achieve the required circuit miniaturization for a wrist timepiece—*without sacrificing reliability*. This circuit controls the 360 pulses of power each second—31 million per day—that drive the tuning fork. Although incredibly small, these Type TR miniature composition resistors are made by Allen-Bradley's exclusive hot molding process that *guarantees complete freedom from catastrophic failures!* A-B Type TR resistors are conservatively rated 1/10 watt at 70°C.

There are also other Allen-Bradley space-saving potentiometers, capacitors, and h-f filters that can help solve your miniaturization problem. And you obtain the same reliability for which the larger Allen-Bradley components have earned a world-wide reputation. For full details, send for Publication 6024.

* TRADEMARK BULOVA WATCH CO. INC.

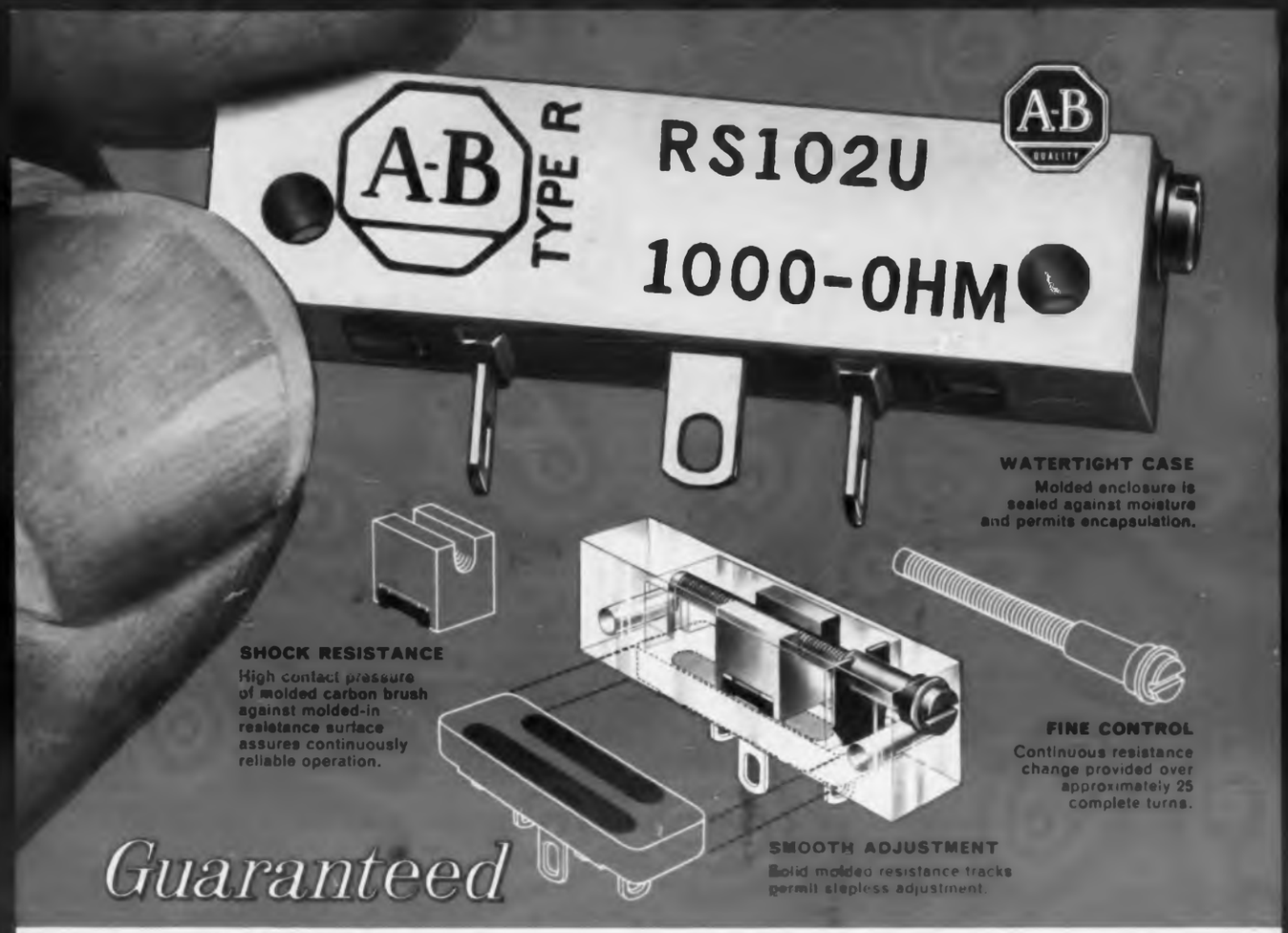
A-B HOT MOLDED COMPOSITION RESISTORS

DRAWING OF ACCUTRON SHOWS BASIC MECHANISM



ALLEN-BRADLEY Quality Electronic Components

Allen-Bradley Co., 222 West Greenfield Avenue, Milwaukee 4, Wisconsin • In Canada: Allen-Bradley Canada Ltd., Galt, Ontario



Guaranteed Reliable Performance and Stable Settings

UNDER EXTREME ENVIRONMENTAL CONDITIONS

In critical applications, Allen-Bradley Type R adjustable fixed resistors are *without equal*. For example, in recent tests* Type R resistors successfully withstood acceleration, shock, and vibration *five times* better than the latest MIL Spec requirements. Such wide margin of safety is your assurance of complete reliability. Virtual indestructibility is obtained through an *exclusive* Allen-Bradley process in which the solid resistance elements and the insulating mounting are hot molded into one integral unit. The moving element is self-locking for absolutely stable settings. Also, the Type R control allows "stepless" adjustment of its resistance.

The molded case of the Type R control is watertight and dust-tight. Rated ¼ watt at 70°C, these Type R controls are available in values from 100 ohms to 2.5 megohms.

*Test Report #71801, Sept. 1960, United States Testing Co., Inc.

ALLEN-BRADLEY

Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

QUALITY ELECTRONIC COMPONENTS

Power Meter 663

Average reading power meter, model PM-5K, 5 kw full scale, 100 kc to 30 mc is completely self-contained. These absorption type meters are completely shielded and nonradiating. The coaxial load resistor consists of several fused pyrex resistors. The meters are available in 50- and 70-ohm types.

Electro Impulse Laboratory, Inc., Dept. ED, 208 River St., Red Bank, N.J.

Pulse Generator 669

Rise time is 10 nsec for the model 131 pulse generator. It delivers a 50-v pulse into 50 ohms. The unit is designed for laboratory and research applications as well as production line testing of components and solid-state devices.

E-H Research Laboratories, Inc., Dept. ED, Oakland, Calif.

P&A: $575 fob Oakland; 30 days.

DC Amplifier 665

Signal-conditioning dc amplifier, model 2-181, is designed to amplify the output from strain gages, thermocouples or similar low-impedance transducers. All signals and power are mutually dc isolated. Specifications are: long term stability, ±0.25% of full scale; nonlinearity, less than 1%; common mode rejection, greater than 100,000 to 1; input impedance, 100 K.

Electro Development Corp., Dept. ED, 3939 University Way, Seattle 5, Wash.

◀ CIRCLE 86 ON READER-SERVICE CARD

NEW PRODUCTS

Time Delay Relay 689

Reversible time delay relay meets all environmental tests for military use. A clutch mechanism allows instantaneous reset. An adjustable load pointer can be set between time limits for outside circuit control. Timer automatically shuts off on reaching zero or maximum time. It operates on 115 v ac and contains its own dc power supply.

McElroy Electronic Corp., Dept. ED, Littleton, Mass.

Meter Indicator 632

Model 470 meter-indicator is packaged complete with transistor amplifier, power supply, and wide-scale meter. It will provide continuous indication of pressure, torque, force, weight or flow when used with strain-gage transducers of the bonded or unbonded type. Standard scale is 0 to 100; proportional secondary output voltage is 0 to 1 v.

Bytrex Corp., Dept. ED, 50 Hunt St., Newton 58, Mass.

P&A: $490; from stock to 45 days.

Speed Control 692

Speed-sensing control switches of the KC-860 series are 1-3/4 in. high and 2-1/2 in. square. Weight is 15 oz. Flyweight-centrifugal force principle is used to control 1, 2 or 3 snap-action switches. Repeatability and differential can be held to 1%. All models have an AND 10285 pad on one end, a through shaft, and an AND 20005 pad on the other end. Military specifications are met.

Kahn and Co., Inc., Dept. ED, P. O. Box 516, Hartford 1, Conn.

Digital Computer 623

Lightweight, airborne digital computer system is used as an active, real-time element for navigation, guidance and control of drone aircraft. A general-purpose, two-address, serial binary data system, it uses a 12,000-rpm memory drum with a 2,048-word capacity. Clock speed of 260 kc permits 78-μsec multiplication.

Motorola, Inc., Military Electronics Div., Dept. ED, 8201 E. McDowell Road, Scottsdale, Ariz.

Wirewound Resistors 634

Precision wirewound power resistors, series SR, are sealed in silicone and are impervious to moisture and salt-spray. Ratings from 0.5 to 10 w are available in 15 types. Diameters are 3/32 to 3/8 in.; lengths are from 11/32 to 1-15/16 in. Resistance range is from 0.05 to 210,000 ohms. Insulation strength is 1-kv ac.

California Resistor Corp., Dept. ED, 1631 Colorado Ave., Santa Monica, Calif.

Tone System 579

Remote control of on-off functions is provided by transistorized audio tone channel systems. Both am and frequency shift are available; am channels are used for slow telemetry and simple functions, while frequency-shift channels are used for high-speed telemetry and control functions. Receivers and transmitters are housed in identical modules, which provide 10 channels in 5-1/4 in. of rack panel height. Power required is 110 v ac or 12 v dc.

Quindar Electronics, Inc., Dept. ED, 5 Lawrence St., Bldg. 9, Bloomfield, N.J.

◀ CIRCLE 88 ON READER-SERVICE CARD

NEW PRODUCTS

Transistor Transformers 675

Encased in drawn steel cans, these two miniaturized transistor transformers have nickel alloy leads on standard 0.1-in. spacings. The BUD configuration is 5/16-in. high and the MITE unit has a diameter of 3/8 in. A total of 42 designs can be supplied in either style.

Decco, Inc., Dept. ED, 2025 Farrington, Dallas, Tex.

Trimmer Potentiometer 677

Series 5000 trimmer potentiometer is a 25-turn unit with welded construction of all fixed connections. Rated at 1 w up to 70 C, it has an operating temperature of −65 to +150 C. Nine standard resistance values from 100 ohms to 50 K are available with a standard tolerance of 5%.

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

Cable Connectors 678

Coaxial cable connectors, with "crimp-on" construction, have a 50-lb cable pull min. They are provided with only three handling parts to afford convenience in assembly, post-assembly inspection and replacement of damaged connector bodies.

Dage Electric Co., Inc., Dept. ED, 67 N. Second St., Beech Grove, Ind.

LING ELECTRONICS

The design of the Model 300 Shaker is an extension of an environmental shaker concept pioneered by Ling. This revolutionary concept, using a closed-loop cooling system for direct cooling of the armature, field coils and for compensation conductors, has greatly improved the efficiency of shaker performance.

In Model 300, Ling hermetically seals the system—so the standard shaker can be used freely in an evacuated chamber without special shaker accessories. Model 300 is particularly suited for mounting with the piggy-back chamber—the technique in which the shaker body acts as one wall of the chamber, and only the table rides into the chamber.

In addition, Model 300 offers Ling's new velocity signal generator for displacement monitoring. Loop-type flexures offer maximum lateral restraint and linear spring constant.

SPECIFICATIONS FOR LING'S MODEL 300 SHAKER INCLUDE:

Force Rating; vector	5,000 lbs.
Frequency range	5-3,000 cps.
Stroke, continuous duty	1 inch, peak to peak
Flexure Stiffness	1,000 lbs. per inch
Table Diameter	13⅛ inches
Max. Acceleration	100 G
Stray Field	less than 6 gauss, 3 inches above the table

LING-TEMCO ELECTRONICS, INC.
LING ELECTRONICS DIVISION

HIGH POWER ELECTRONICS FOR VIBRATION TESTING • ACOUSTICS • SONAR
CIRCLE 90 ON READER-SERVICE CARD

Instrumented Power Supply 674

Rated 30 kv at 3 ma, model PSC 30-3-4 instrumented power supply has a ripple of 0.5% per ma. Regulation is 10% no-load to full-load. The unit has reversible polarity and a shielded, coaxial cable is provided for the output.

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

Ultrasonic Tester 681

For ultrasonic, nondestructive testing, model 424-D testing instrument has a variable pulse repetition rate. Metals and reasonably elastic materials such as glass, hard rubber and ceramics may be inspected with this unit. It has a built-in video delay circuit and recorder output circuits.

Curtiss-Wright Corp., Princeton Div., Dept. ED, P.O. Box 110, Princeton, N.J.

General Purpose Relays 676

Available with either 0.110- or 0.187-in. wide "push-on" terminals, type DM general purpose relays eliminate soldering from installation operations. Operating coils are 250 v ac or 130 v dc and the unit can also be supplied as a current-sensitive device with standard plate circuit value coils. Contacts are in any combination to 3pdt with 5- or 10-amp ratings.

Davis Electric Co., Dept. ED, Cape Girardeau, Mo.

NEW PRODUCTS

Carrier Amplifier 562

A 5-v, 3-kc excitation for bridge and differential transformer transducers is provided by the model SCAS-1008 carrier-amplifier system. The solid-state system has one crystal-controlled oscillator, one dc power supply, and four amplifier plug-in modules. Modulating frequency response is flat from dc to 500 cps within ±1.5%.

Plug-In Instruments, Inc., Dept. ED, 1416 Lebanon Road, Nashville 10, Tenn.

P&A: $1,750; 6-week delivery.

Square-Frame Motor 573

Ratings from 125 to 300 hp are available in the D-5000 series of square-frame ac motors. The design has large air intakes at each end of the motor and exhaust outlets at the sides. Class B insulation is standard; frames and louvers are cast iron. The motor is supplied with sleeve or ball bearings. Line voltage may be 220, 440, or 550 for 3,600, 1,800, 1,200, and 900 rpm operation.

Reliance Electric and Engineering Co., Dept. ED, 24701 Euclid Ave., Cleveland 17, Ohio.

Feed-Through Headers 611

Hermetic sealing from —325 to 1,200 F against high pressures and in radiation environments is claimed for the FT terminal feed-through headers. The parts are available in standard configurations of 1, 2, and 6 pins.

Physical Sciences Corp., Dept. ED, 389 N. Fair Oaks Ave., Pasadena, Calif.

BOURNS TRIMPOT®

Schweber

FOR IMMEDIATE LARGE QUANTITY DELIVERY AT FACTORY PRICES

Yes! Schweber can sell any model of BOURNS TRIMPOT® at factory prices. Sizeable quantities are available for immediate shipment from stock from Schweber's warehouse.

Schweber ELECTRONICS

60 HERRICKS ROAD, MINEOLA, L. I., N. Y.

PIONEER 6-6520. TWX G-CV-NY-560U

CIRCLE 93 ON READER-SERVICE CARD

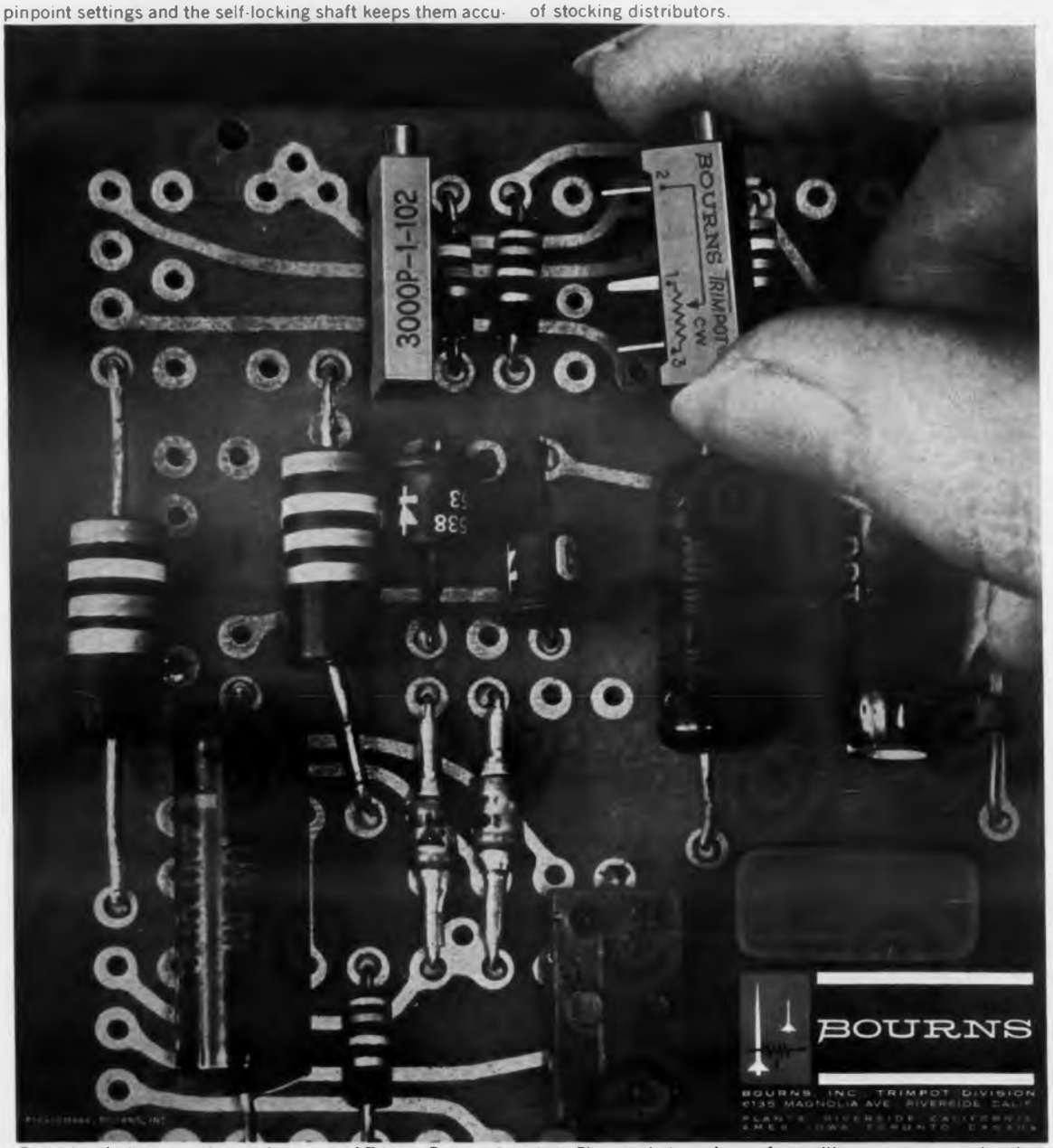
NUMBER 13—NEW PRODUCT SERIES

Now—an Even Smaller High-Temperature Trimpot® Potentiometer

Here, just ¾" in length, is a wirewound potentiometer that is completely humidity-proof and operates at 175°C! Ideal for your printed circuit applications, it withstands 30G vibration and 100G shock, dissipates 0.5 watt at 70°C (0.2 watt at 125°C), and has tapered pins for quick, easy mounting.

Sealed against humidity in a high-temperature plastic case, the Model 3000 exceeds the requirements of MIL-STD-202A, Method 106. The 15-turn screwdriver adjustment permits pinpoint settings and the self-locking shaft keeps them accurate. For maximum stability, the unit incorporates a ceramic mandrel. Reliability is outstanding. The exclusive Silverweld® bond between terminal and resistance wire is virtually indestructible under thermal or mechanical stress.

Available within 24 hours from factory and distributor stocks, the Model 3000 is stocked in resistances of 50 ohms to 20K. A Resiston* carbon version, Model 3001, is available with resistances of 20K to 1 Meg. Write for complete data and list of stocking distributors.



Exclusive designers and manufacturers of Trimpot® potentiometers. Pioneers in transducers for position, pressure, acceleration.

CIRCLE 94 ON READER-SERVICE CARD

NEW PRODUCTS

Cast Epoxy Rod 614

Formulated to meet MIL-R-93B specifications, the BMCO 2000 series of cast epoxy rod is available in standard colors and diameters. Volume resistivity is 0.19 x 10^{16} at 180 C. Resistor bobbins and thin-wall shells machined from this material have good dimensional stability.

Boonton Molding Co., Dept. ED, Boonton, N.J.

Vacuum System 635

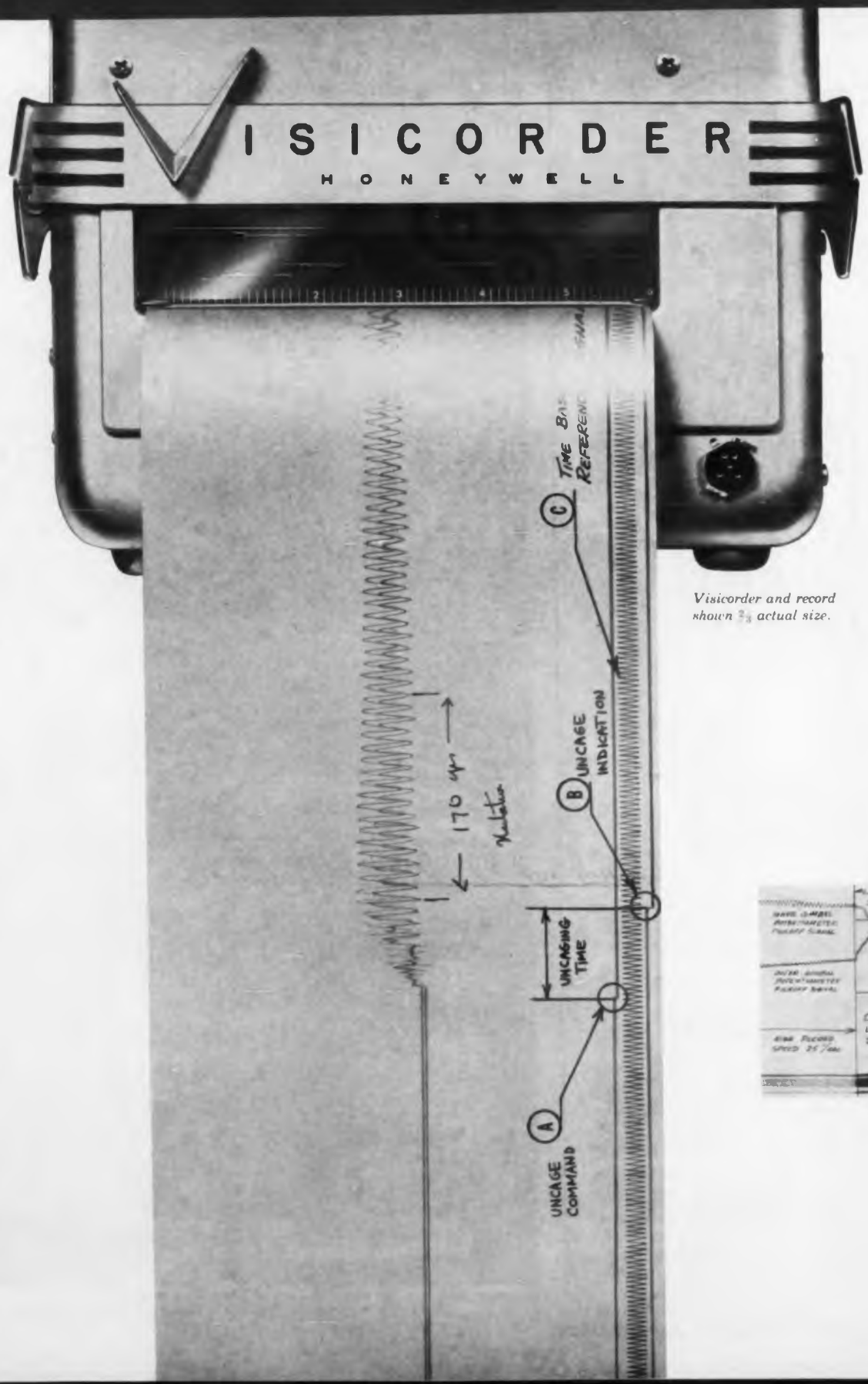
Designed for high-vacuum depositions of lightweight metals, this light-weight, compact vacuum system is for laboratory use. The 18-in. diam, aluminum bell jar can be evacuated in 5-min to 1 micron of mercury with an ultimate vacuum of 2 x 10^{-6} mm. A water-cooled baffle minimizes back-streaming from the diffusion pump.

Cenco Instruments Corp., Central Scientific Div., Dept. ED, 1700 Irving Park Road, Chicago 13, Ill.
Price: *$3,950.*

Tape Device 580

Accessory to pulse-height analyzers, model 52-26 magnetic tape input-output device provides for external storage or re-entry of digital data into the analyzer memory. Data may be transferred from the analyzer to the tape units at 1,000 decimal digits per sec. Multipliers of 10%, 1%, or 0.1% may be selected to operate on data being transferred.

Radiation Instrument Development Laboratory, Inc., Dept. ED, 61 E. North Ave., Northlake, Ill.



Visicorder and record shown ⅔ actual size.

How the Visicorder helps keep "spring" in a free gyro

by simultaneously recording several performance characteristics

How do you production-test a spring-wound miniature "free" gyro which has been designed for a limited number of firings without changing its characteristics due to excessive testing? Whether a gyro under actual conditions will reproduce test results depends to a large extent upon how many times it is "fired" before its short but important life begins. The multi-channel high-frequency Visicorder makes it possible for Whitaker Gyro Division of Telecomputing Corp. to test simultaneously all operating characteristics with only one firing of the gyro.

Five channels of a Honeywell 906 Series Visicorder are used in the test for *uncaging time* and *gimbal drift*.

For the uncaging time study, a squib is fired to release the gyro's spring motor. One trace indicates squib firing (A). When the gyro attains correct speed (and uncaged condition) a switch closes to record another trace (B). Between these traces, a 400 cps trace is a convenient time reference (C).

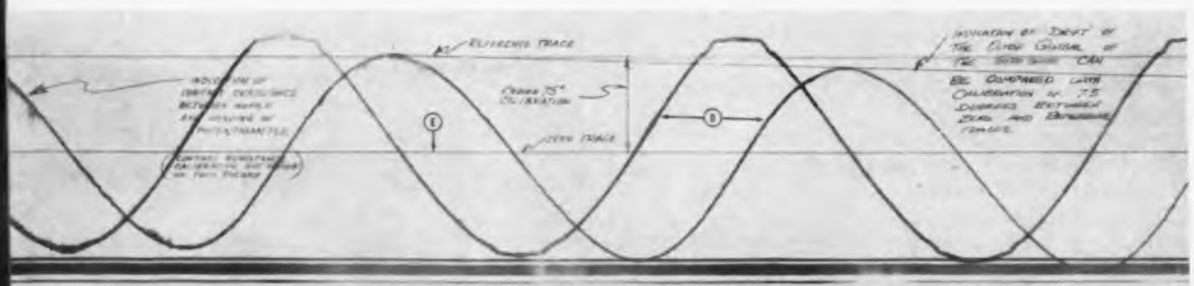
The gyro is mounted on a Scorsby table set to deflect the unit 7½ degrees from the perpendicular about two axes. Potentiometers sensing the gyro's deflection are directly connected to galvos which measure the position of the gyro gimbals as the unit is rotated on the fixture. The potentiometer outputs trace individual sine waves on the record (D) which are easily compared to a zero trace (E) to indicate gimbal drift.

The records shown here in two parts are actually one continuous record. Immediately after the uncaging time test, the record drive was switched to lower speed *without* stopping the record. The resulting traces are easy to compare and gimbal drift is measured immediately.

In this simple bench set-up, the 906 Visicorder is at right. Between it and the control panel is the Scorsby table on which the gyro is mounted, ready for test.

Four different models of the Honeywell Visicorder oscillograph provide immediate readout of analog data from DC to 5,000 cps, with 8, 14, 24 and 36 channel capacity. Prices are as low as $1845 for a 6-channel system with grid lines and built-in timer (Model 1406). Call your Industrial Sales Office soon for a demonstration of how the world's most versatile oscillograph can save you time and money in data acquisition.

Ask, also, for your free copy of the 36-page Visicorder Applications Manual, an engineering guide packed with problem-solving suggestions.



The record at left was made at a speed of 25" per second. The record above is a continuation, after record speed was changed to 1" per second without interrupting the test sequence.

Heiland Division, Minneapolis-Honeywell
5200 East Evans Avenue
Denver 22, Colorado

HONEYWELL INTERNATIONAL
Sales and Service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

Honeywell

Industrial Products Group

CIRCLE 95 ON READER-SERVICE CARD

Rate Gyro 592

Self-testing features of the GR-H4-T rate gyro provide indication that the spin motor is operating at synchronous speed and that the gimbal is free to rotate. Permanent magnets and pickup coils provide a readout signal in excess of 2.5 v peak-to-peak. The rugged gyro withstands extremes of environment, including shocks of 500 to 900 g.

Northrop Corp., Nortronics Div., Dept. ED, Northrop Bldg., Beverly Hills, Calif.

Tantalum Capacitors 593

Single-ended lead terminations can be supplied on TW (wire) and TS (slug) wet-electrolyte tantalum capacitors. Leads are properly coded for easy identification. Design enables fast assembly on modules and circuit boards.

Ohmite Manufacturing Co., Dept. ED, 3650 Howard St., Skokie, Ill.

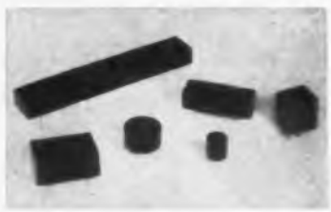
Constant-Voltage Transformers 588

Static-magnetic voltage-regulating transformers maintain output voltages within 1% at inputs from 95 to 130 v. Operating on ferroresonance principle, the units are made in capacities of 15, 30 and 50 va. Any step-up or step-down ratio is available. Single or multiple secondary windings with or without centertaps can be furnished as required.

Neshaminy Transformer Co., Dept. ED, Neshaminy, Pa.
P&A: $17.50 to $8.50; 2 weeks.

NEW PRODUCTS

Module Cases 610



Molded component cases are made in a wide range of shapes and sizes. Epoxy, phenolic or other materials may be used. Pin or terminal styles and layouts are made to customer order. The module cases allow the components to be assembled directly into the case.

Plastronic Engineering Co., Dept. ED, 721 Boston Post Road, Marlborough, Mass.

Coaxial Ignitron 587

Rated at 900 amp dc, the NL-1064 coaxial ignitron is a water-cooled mercury pool tube designed for resistance welder and similar ac control applications. Anode voltage is 250 to 600 v rms; maximum averaging time is 17.8 sec at 250 v and 8.9 sec at 500 v.

National Electronics, Inc., Dept. ED, Geneva, Ill.

Cable Clamps 594

Used with cables and hydraulic lines, nylon clamps are available in sizes ranging from 1/8 to 1-1/4 in. diameter. Design provides a true circle, and prevents wire pinching. The lightweight clamps are impervious to nearly all corrosive liquids and fuels.

Olympic Plastics Co., Inc., Dept. ED, 3471 S. La Cienega Blvd., Los Angeles 16, Calif.

CIRCLE 751 ON READER-SERVICE CARD

Servomotor 752

Smallest size 8 is 0.84-in. long

Said to be the smallest size 8, 115 v servomotor sold, the Model 8 SM 461 is 0.840-in. long, weighs 1.1 oz. A precision-control component, it has a rotor inertia of 0.18 gm-cm² coupled with a stall torque of 0.22 oz-in., providing acceleration at stall of 86,500 rad per sec²—three times greater than any equivalent unit, asserts the company. Using stainless-steel and Teflon as insulation throughout permits an ambient temperature rating of —55° to +130° C. Maximum unit operating temperature is 200° C.

Helipot Div. of Beckman Instruments, Dept. ED, Fullerton, Calif.

Precision Potentiometer 753

Has matching 7/8-in. turns-counting dial

Model 7216, 7/8-in. diam. precision pot has standard resistance of 10 to 125,000 ohms and ±0.5 per cent standard linearity. A 7/8-in. diam. 2600 series turns-counting dial is also offered for users desiring a precision pot-and-dial package, counts full turns and hundredths. The model 7216 is a ten-turn potentiometer with 1/4-in. diam. shaft and 3/8-32 bushing mount. It is rated at two w at 25° C with a minimum operating temperature of —55° C. The pot has a molded diallylpthalate housing, bronze front lid and stainless-steel shaft.

Helipot Div. of Beckman Instruments, Dept. ED, Fullerton, Calif.

Panel Meters 754

Built to MIL specs

Built to exact conformity with MIL-M-10304A, 4-1/2-in. round, sealed panel meters have plug-in terminal construction, easy disassembly and good linearity. All-metal construction and modern appearance make the 92 standard models suitable for a variety of applications. Available as volt-meters, ammeters, milliammeters and microammeters.

Helipot Div. of Beckman Instruments, Dept. ED, Fullerton, Calif.
Availability: 30 days.

CIRCLE 755 ON READER-SERVICE CARD

NEW PRODUCTS

DC Power Supplies **586**

Derated components are used in the Brute Force line of silicon dc power supplies. The current-regulated supplies have less than 1% rms ripple at any output voltage or current within rating. Ammeter and voltmeter with ±2% accuracy are standard. All units may be floated up to 500 v peak above ground; either terminal may be grounded.

NJE Corp., Dept. ED, 20 Boright Ave., Kenilworth, N.J.

Cartridge Rectifiers **603**

Rated at 1.5, 3, and 5 kv piv, military type silicon cartridge rectifiers 1N1731, 1N1733 and 1N1734 meet MIL-S/19500/142 (Sig C). They have higher current ratings, lower voltage drop and better reverse leakage characteristics than previously available types. Case is nonmetallic.

Pacific Semiconductors, Inc., Dept. ED, 12955 Chadron Ave., Hawthorne, Calif.

Temperature-Humidity Chamber **585**

Available in 2-, 4- and 8-cu ft sizes, chamber SUB-Z-H has temperature ranges of −100 to +400 F and humidity of 20 to 95%. Climatic conditions are controlled by wet and dry bulb indicating controllers. Even temperature is maintained by means of an 8-in. circulator with fin-coil evaporator.

Cincinnati Sub-Zero Products, Dept. ED, 3932 Reading Road, Cincinnati 29, Ohio.

Power Transformers 584

Rectifier power transformers, models P-8193 and P-8194, are designed for use in either full-wave bridge or half-wave rectifier circuits. They can be used with either selenium or silicon rectifiers. P-8193 has outputs from 7 v dc at 2.5 amp to 17 v dc at 4 amp. P-8194 has circuit outputs from 14 v dc at 2.5 amp to 28 v dc at 5.2 amp.

Chicago Standard Transformer Corp., Dept. ED, 3501 W. Addison St., Chicago 18, Ill.

Digital Resolver 615

Model DR-14 digital resolver provides high-speed conversion from Cartesian to polar coordinates or the reverse. Conversion is accomplished in 200 μsec or less. Completely transistorized and operating at a 1-mc clock rate, the unit accepts two 10-bit inputs representing Cartesian coordinates and converts them to two 10-bit numbers representing polar coordinates. It can provide conversion of 5 channels in less than 1 msec.

Computer Control Co., Inc., Dept. ED, 2251 Barry Ave., Los Angeles 64, Calif.

Digital Converter 591

Designed for on-line digital telemetering and control applications, the Digi-Tel analog to digital converter operates directly from process transducers. Output is coded for direct digital transmission, display, control and data logging. Input transducers are available for operation from standard variables. Output may be decimal, binary-coded decimal, or special code. Up to three simultaneous output circuits are provided.

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

NEW PRODUCTS

Thyratron Tubes 636

With milled-grid construction, thyratron tubes C1K, C3J and C6J are always constant in performance characteristics. Checks to select balanced sets are not necessary with these units. They meet all JAN MIL specifications.

Cetron Electronic Corp., Dept. ED, 717 Hamilton St., Geneva, Ill.

Amplitude-Distribution Analyzer 578

The amplitude-probability distribution of random signals is established by the model 317 analyzer. Voltage threshold is preset at front panel; noise levels exceeding that level are read in terms of percentage and time. The solid-state device operates from 5 cps to 500 kc. Amplitude ranges are 100%, 10%, and 1% full scale. Accuracy is ±3% of full scale. Size is 8-1/4 x 5 x 6-3/4 in.; weight is 5 lb.

Quan-Tech Laboratories, Inc., Dept. ED, 60 Parsippany Blvd., Boonton, N. J.

Infrared Detectors 627

Room temperature, indium antimonide, infrared detectors have a time constant of less than 1 μsec and peak at 6.8 microns. Specifications for a typical cell 1.5 x 6 mm are: black body response, 3 x 10^7 cm-cps^{½} per w; resistance, 20 ohms; time constant, less than 1 μsec; peak response, 6.8 microns.

Block Associates, Inc., Dept. ED, 385 Putnam Ave., Cambridge 39, Mass.

Instrument Pivots 691

Precision instrument pivots are made for electrical indicating instruments, velocity and pressure gages, and similar applications. They are manufactured to tolerances of 0.0001 in. and have a hardness of 65 on Rockwell C scale. Various point curvatures and nonmagnetic pivots are made.

Welton V. Johnson Engineering Co., Inc., Dept. ED, 95 Summit Ave., Summit, N.J.

Precision Relay 624

Only 0.2 x 0.4 x 0.6 n. in size, the "Dyna-Mite" precision relay weighs 0.1 oz. Sensitivity is 100 mw and current rating is 0.25 amp with a contact life of 100,000 cycles min at the rated resistive load of 28 v dc. The unit will operate without variation over the temperature range of −65 to +125 C at the max guaranteed pull-in current of 7 ma max for the 2-K coil, 18- to 30-v rating. Available in spdt, with resistances of 500, 1,000 and 2,000 ohms, and a voltage range of 12 v, 16 v, and 18 to 30 v.

Control Dynamics Corp., Dept. ED, North Hollywood, Calif.

Nuvistor Triode 581

High-mu nuvistor triode 7895 is useful in cascode circuits, rf and if stages, on-off controls, and resistance-coupled amplifier circuits. Transconductance is 9,400 μmhos at plate current of 7.0 ma, plate voltage of 110 v. Heater drain is 135 ma. at 6.3 v. Amplification factor is 64. The triode is 0.8 in. long and weighs 1/15 oz.

Radio Corp. of America, Electron Tube Div., Dept. ED, 415 S. 5th St., Harrison, N.J.

CIRCLE 99 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Frame-Grid Tubes 379

A pair of frame grid tubes are in production, with other types scheduled. The 6DJ8, a twin triode, is designed for industrial use; the 6GK5 triode is used as an rf amplifier in TV tuners. The design gives uniform tube characteristics.

Westinghouse Electric Corp., Dept. ED, Box 2278, Pittsburgh 30, Pa.

Precision Delay Lines 630

For use in IFF equipment, these high-performance delay lines have a total delay of 20.3 μsec ±0.05 μsec. Taps are available at every 1.45 μsec. Minimum delay-to-rise time is 100 to 1 and characteristic impedance is 470 ohms. Attenuation is less than 2 db and spurious signals are maintained below −20 db.

Richard D. Brew and Co., Inc., Dept. ED, 90 Airport Road, Concord, N.H.

Availability: *4 to 6 weeks.*

Miniature Demodulator 620

Solid-state demodulator model D 6004 is a plug-in assembly measuring 1 x 1 x 1.375 in. It converts suppressed carrier input signals to dc output with amplitude and polarity proportional to phase sense and amplitude of ac input. A signal of 5.0 v rms provides an output of ±5.0 v dc with input impedance of 40 K, output impedance 10 K and linearity better than 1%. Frequency may vary from 200 cps to 50 kc.

Natel Engineering Co., Inc., Dept. ED, 15922 Strathern St., Van Nuys, Calif.

Price & Availability: *$60 to $140; 2 weeks.*

High Precision Data Logger for $3,600

The RS2 Recording Digital Voltmeter — now in volume production at Non-Linear Systems, Inc. — scans up to 20 double-pole input channels . . . measures DC voltage from ±0.001 to ±999.9 with ±0.01% accuracy . . . and records input channel number and the 4-digit voltage measurement. Uses include research and development, quality control, environmental and reliability testing.

Plug-in stepping switches in the digital voltmeter section of the RS2 permit replacement of all switches and decade resistors in minutes instead of days. The plug-in feature allows almost instant trouble-shooting by the substitution method.

Volume production and simplified controls of the RS2 account for its low cost — half to a third less than custom-built units.

Note the compact, plug-in modular design of the scanner-printer section of the RS2.

NLS Reports on Low-Cost, Standard Data Logger

A low-cost automatic data logger built as an integrated scanning, measuring and printing system — the RS2 Recording Digital Voltmeter — is now in volume production at Non-Linear Systems, Inc.

This economy-priced NLS logger is designed for applications requiring high accuracy and low cost without need for the higher speed and greater input capacity of higher cost NLS systems. Simplified controls offer several automatic and manual modes of operation.

While utilizing many circuits field-tested for six years in thousands of NLS digital voltmeters, the RS2 has undergone extensive testing as a standard, complete system. It is delivered ready to use, without need for additional engineering or complex interconnections.

Call your NLS regional office or representative for a demonstration, or write NLS.

RS2 BRIEF SPECIFICATIONS

Visual Indication: 4-digit voltage reading with correct polarity and range. 2 digits for input channel identification.

Range-Polarity Indication: automatic

Functions: scanning up to 20-double-pole channels; measuring DC voltage from ±0.001 to ±999.9 in ranges of ±9.999/99.99/999.9, printing channel number, 4-digit reading, polarity and decimal point placement.

Accuracy: ±0.01% of full scale on each range.

Speed: 2 seconds average for each data point scanned, measured and recorded.

Scanner Operation Modes: AUTO CYCLE — system continually repeats automatic scanning cycle from channel 00 to 19. ONE CYCLE — system automatically stops after scanning channel 19. PRINT — one input is measured without advancing scanner. Scanner may be manually advanced one channel at a time by depressing front panel ADVANCE button.

AC Voltage: Use NLS AC/DC Converter.

Low-Level DC: Use NLS Model 140 Preamplifier.

Input Impedance: 10 megs on all ranges.

Size: 14" high, 15¾" deep for 19" rack.

Delivery: From stock, 30 days, maximum, should stocks become depleted.

Originator of the Digital Voltmeter

non-linear systems, inc.

DEL MAR, CALIFORNIA

CIRCLE 101 ON READER-SERVICE CARD

Battery Charger 668

Dual voltage, constant current, battery charger model T-8-16 is designed to charge nickel cadmium batteries without overheating or overcharging. A two-position switch sets voltage and current for 8- and 16-v batteries. Voltages from 1.4 to 24 v can be accommodated by an internal shunt change.

ELF Inc., Dept. ED, P.O. Box 302, Florissant, Mo.

Price: $49.95.

Linear Potentiometer 589

Linear-motion, conductive plastic potentiometer has a wirewound element with high resolution and a standard linearity of 0.05%, with closer linearity on order. Length is 2 to 24 in. Taps can be provided on request.

New England Instrument Co., Dept. ED, 1334 Main St., Waltham, Mass.

AC Test Set 607

With output to 150 kv rms, 0.1 amp, model K 150-15 dielectric test set may be supplied alone or with controls for dielectric and corona testing. Power required is 440 v, 60 cps, 1 phase, 27 amp. A scope calibrating unit is optional. Waveform distortion is below 5%; military testing standards are met.

Peschel Electronics, Inc., Dept. ED, Route 216, Towners, N.Y.

A
tLAS
HAWK
TITAN
DISCOVERER
SPARROW
THOR
SNARK
TIROS
FALCON
CORVUS
NIKE HERCULES
TALOS
PIONEER
SIDEWINDER

TIME TO TRAVEL... in a bird, or elsewhere, this A. W. Haydon timing motor is unique. We married our successful Vanguard II sub-miniature DC motor, for power, to a tiny new version of our well known (and patented) chronometric governor, for precision. Result: it will drive miniature tape recorders, printed circuit commutators, potentiometers, and such things... and hold its speed to within ± 0.1% of the speed you want, even if the shaft load, line voltage and ambient temperature vary widely. It weighs a mere two ounces and measures less than 1¾" x 15/16", yet delivers at least 30 ounce-inches of torque at 1 rpm. For full information on this #14600 motor, or any other sort of timing device, electronic or motor driven, just write.

THE AWH AYDON COMPANY

227 NORTH ELM STREET, WATERBURY, CONNECTICUT

CIRCLE 102 ON READER-SERVICE CARD

NEW PRODUCTS

Limit Stop Assembly **599**

Adjustable rotational limit control within an operational range of 30 to 4,530 deg is provided by this precision limit stop assembly. Contained in a size 18 case, the assembly has a 3/16-in. shaft with ball or bronze bearings.

PIC Design Corp., Dept. ED, 477 Atlantic Ave., East Rockaway, L.I., N.Y.
P&A: $45 to $75; 10 days.

Photoelectric Control **553**

Infrared light-actuated photoelectric control is designed for operation at distances up to 100 ft between the light source and the control. The lens of the control is shielded from normal light so that operation continues day or night, whether lights are on or off. Operation is from 115/230 v, 50 to 60 cps.

Autotron, Inc., Dept. ED, Box 722 HA, Danville, Ill.

Temperature Transducer **683**

For temperature ranges from −320 to +280 F, model Y-0218 temperature transducer will measure skin temperatures, the level of liquid nitrogen, as well as acting as the temperature compensation element for constant signal readout. Excitation is in the order of 2 ma. The unit is approximately 1-in. square, less than 0.040 in. thick and weighs less than 1 g. It will stand 100 g at 100 to 700 cps.

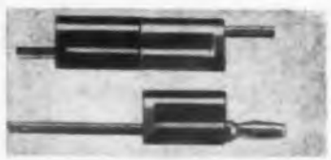
Crescent Engineering and Research Co., Dept. ED, 5440 N. Peck Road, El Monte, Calif.

Operational Amplifier **670**

Solid-state, high-gain, direct-coupled amplifier module model A-201 is for general purpose closed-loop use. Amplifier frequency response is flat from dc to 1 kc; open loop dc gain is over 1,000,000. Output is 14 v peak at 3 ma.

Dynamic System Electronics Corp., Dept. ED, 2001 N. Scottsdale Road, Scottsdale, Ariz.

Stacking Patch-Cord **564**



Endless extension couplings are possible with the model HB extension-stacking patch-cord. The part is available in 10 colors and standard cord lengths. Banana plugs are beryllium copper spring, fitting standard 0.166-in. jacks.

Pomona Electronics Co., Inc., Dept. ED, 1500 E. 9th St., Pomona, Calif.
Price: *$1.75 to $1.23 ea.*

Tuning Fork Oscillator **673**

Transistorized tuning fork oscillator, series DFO-80, is available in any frequency from 400 to 4,000 cps. Frequency tolerance is ±0.15% over the temperature range of 0 to 60 C. It will provide 3 v rms into a 10-K load nominal and a sine wave with less than 10% distortion or 12-v peak-to-peak square wave with a rise time of less than 10 μsec.

Delta-F, Inc., Dept. ED, 113 E. State St., Geneva, Ill.
P&A: *$66.25 to $45 depending on quantity; from stock.*

NEW PRODUCTS

Inertia Switch 357

Single pole, double throw model 6BC-189 is a unidirectional switch with a range of 2 to 30 g ±5%. Response time of the undamped switch is 0.015 sec; reset is automatic. Power rating is 2 amp at 28 v dc, temperature range —65 to +250 F. Two insulated terminals and case ground are provided. Switch meets requirements of MIL-E-5272.

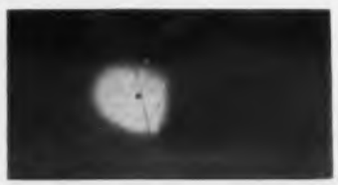
Inertia Switch, Inc., Dept. ED, 311 W. 43rd St., New York 36, N. Y.

Vacuum Chambers 577

Diameters from 18 in. to 12 ft with standard lengths to 20 ft are included in the Spacemaster series of vacuum chambers. The standard unit is for vacuum levels to 10 microns while the high-vacuum type, with stainless steel vessel, is for vacuum levels to 0.1 microns.

Bethlehem Foundry and Machine Co., Environmental Engineering Div., Dept. ED, 225 W. Second St., Bethlehem, Pa.

Tantalum Capacitors 626



Microminiature in size, these nonpolar solid tantalum capacitors measure 0.1 x 0.090 x 0.065 in. max. Models are available in a range of values from 0.001 to 0.0047 μf which operate at 50 v nonpolar and from 0.0068 to 0.047 μf at lower voltages. Temperature range at full-rated voltage is —55 to +85 C.

Components, Inc., Dept. ED, Biddeford, Me.

◀ CIRCLE 106 ON READER-SERVICE CARD

Deviation Voltmeter 358

Voltages to ±1,010 v dc are measured with accuracy of ±0.1% ±0.1 v. Circuit is floating; input impedance is greater than 100 meg. Standard cell referenced voltage is adjustable between 0 and 1,010 v. Deviation from reference is indicated on 10 v or 100 v scale. Size is 9-1/2 x 8 x 12 in.

Industrial Measurements Corp., Dept. ED, 250 N. Thomas, Pomona, Calif.
Price: $460.

Indicator and Controller 576

Designed for use in any bonded strain gage transducer system, type 110 Pointer Indicator and Indicating Controller is an automatic null-balance type instrument. It uses a servo-driven slide wire to balance an internal bridge circuit. Standard models are capable of over-all systems accuracies of ±0.5%.

Baldwin-Lima-Hamilton Corp., Dept. ED, 42 Fourth Ave., Waltham 54, Mass.

Mounting Hardware 633

Continuous mounting hardware permits the user to mount as many of the firm's standard lighted assemblies as necessary in a compact and orderly matrix fashion. The use of this device prevents accidental dual actuation of two switches.

Controls Co. of America, Control Switch Div., Dept. ED, Folcroft, Pa.

CIRCLE 107 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Variable Delay Lines 559

Series 8710 all-metal delay lines are continuously variable, distributed constant units that afford precise selection of extremely short time intervals. Delay times of 1 μsec to 0.1 μsec are provided, with rise times less than 10% of total delay time. Life expectancy is one million or more shaft revolutions.

Beckman Instruments, Inc., Helipot Div., Dept. ED, 2500 Fullerton Road, Fullerton, Calif.

Bar Switch-Light 604

A multipole, momentary-contact bar switch-light, series 34 is available in a variety of normally open or normally closed contact arrangements as 1, 2, or 3pdt and 2, 3, 4, or 6pst. Rated at 28 v dc, 2 amp resistive, mechanism has double-break silent action. Lens is available plain or engraved in four standard colors.

Pendar, Inc., Dept. ED, 14744 Arminta St., Van Nuys, Calif.

Telemetering Calibrator 568

All fm-fm subcarrier channels are automatically calibrated with the model C-005, a three-point telemetering calibrator. All signals derive from transistorized, plug-in crystal oscillators operating at the fundamental frequency. There are two automatic and one manual operating modes.

Probescope Co., Inc., Dept. ED, 8 Sagamore Hill Drive, Port Washington, N. Y.

4PDT Relay 565

Rated to 3 amp at 30 v dc or 115 v ac resistive, the KHP series of relays provides 4pdt in a package slightly larger than 1 cu in. Contact arrangements of four Form C and two Form Z are available. Coil operating voltages range from 6 to 110 v dc. Pull-in time is 15 msec, drop-out 5 msec max. Dust cover is translucent nylon.

Potter & Brumfield Div., American Machine & Foundry Co., Dept. ED, Princeton, Ind.

Compression Accelerometer 687

A true compression sensing device, model 706 accelerometer is designed for shock and vibration measurement. Sensitivity is 35 mv per g and frequency response is flat within ±5% from 0.2 cps to 10 kc. Resonant frequency is 60 kc. Acceleration range is from 0.2 to 40,000 g with an amplitude linearity of ±1%.

Columbia Research Laboratories, Dept. ED, McDade Blvd. and Bullens Lane, Woodlyn, Pa. *P&A: $160 ea in quantities of 1 to 5; two weeks.*

Signal Generator 556

With a 405- to 549.5-mc range, model BSG-9 signal generator displays generated frequencies in 5-digit direct readout form. It has continuous tuning across the frequency band. Accurate to ±0.005% the rf output signal can be modulated to ±300 kc. Output power is variable over the range of 1.0 to 100,000 μv.

Babcock Electronics Corp., Dept. ED, 1640 Monrovia Ave., Costa Mesa, Calif.

NEW PRODUCTS

Accelerometer 686

An ultraminiature sensing device, model 606-TX is designed for tri-axial use in shock and vibration testing of printed-circuit boards, electronic tubes and similar applications. Sensitivity is 2.0 mv per g; frequency response is flat from 0.5 cps to 8 kc within ±5%. Resonant frequency is 50 kc.

Columbia Research Laboratories, Dept. ED, McDade Blvd. and Bullens Lane, Woodlyn, Pa. *P&A: $675 ea in quantities of 1 to 5; two weeks.*

Light Flasher 563

Capable of switching 150 w through a long service life, the A-300-P static position light flasher is fully transistorized and potted. The device has automatic fail-safe, is explosion-proof, and resistant to contact with fuels. It fully meets specification MIL-F-26301.

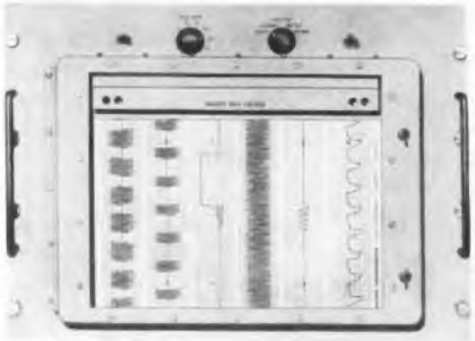
Joseph Pollak Corp., Dept. ED, 81 Freeport St., Boston 22, Mass.

Rotary Indicators 679

Microminiature rotary indicators, designed to use 100 mw or less, are available for any standard voltage to 30 v dc or ac at 400 cps. The smallest model measures 0.375 in. in diameter x 0.562 in. long, and weighs 3.7 g. Temperature range is −65 to +165 F.

Daco Instrument Co., Dept. ED, Tillary and Prince Sts., Brooklyn 1, N.Y.

CIRCLE 112 ON READER-SERVICE CARD ➤



in direct writing recording systems

only Brush designs specifically for mil specs

From every nut and bolt to the shipping crate, fully militarized Brush Direct Writing Recording Systems are *originally* built to meet military specifications.

That's why they are performing every imaginable task of data acquisition and recording at U. S. and NATO installations throughout the world. These electric writing systems have proved their unexcelled reliability . . . from the Operations Monitor that will record 120 separate operations at the instant they occur . . . to the Analog and Sequence Recorder that simultaneously records both analog data and sequential events. And, they are built for maximum performance in the hands of non-technical personnel.

Brush equipment is already at work putting evaluation data in writing for a whole new generation of weapons. When the weapons become operational, Brush MIL Recorders are a vital part of the system. This experience is unique in the industry. *Before* prototype design becomes a problem – call, write or wire Brush for complete details.

brush INSTRUMENTS

DIVISION OF CLEVITE CORPORATION

37TH AND PERKINS CLEVELAND 14, OHIO

Convert Your Counter to a 0.1% Digital Voltmeter...

Vidar 240 cabinet model shown in use with standard electronic frequency counter. Rack mounting also available.

with the New VIDAR 240 ALL SOLID STATE VOLTAGE TO FREQUENCY CONVERTER

Vidar transistorized voltage-to-frequency converters develop output pulses at a rate precisely proportional to dc input voltages. Because these instruments combine solid-state reliability with good linearity and high stability, they offer the ideal method of converting any electronic frequency counter into an 0.1% digital voltmeter.

Convert Your Counter to a Precise Integrator

Output pulses generated over any given period of time are directly proportional to the time integral of the input signal. By combining a Vidar 240 with a counter, analog input signals can be accurately integrated. This capability is particularly valuable where a steady or slowly changing signal is contaminated by noise or hum. The average value can be accurately recovered from the noise with ease.

Convert Your Preset Counter to a Go No-Go Test System

A Vidar 240 plus a preset counter provides a convenient, reliable, and economical method of accomplishing production checkout and quality control testing of electrical or electronic equipment and systems.

Use Vidar Converters in Telemetry Systems

FM telemetry systems of 0.1% accuracy can be assembled using Vidar voltage-to-frequency and frequency-to-voltage converters. For operation at center frequencies from 100 cps to several hundred kc, modified converters are available. Bandwidths to 25 kc can be provided with typical signal-to-noise ratios of 60 db.

In Fact Vidar solid state converters provide "state of the art" excellence wherever you want to interchange analog and digital signals.

KEY TECHNICAL FACTS ABOUT THE VIDAR 240

- Choice of 0-10 kc or 0-100 kc frequency outputs
- Automatic polarity indication
- Long term drift less than ±0.1% per week
- Full scale sensitivities from 0.1 v to 1000 v
- Priced at $700; no extra charge for rack, cabinet or modular version.

Also Available – Vidar offers the Series 2500 analog to frequency converters for conversion of ac-dc voltages and resistance to frequency.

More Information – *For complete technical information, a demonstration, or other data on the Vidar 240 or 2500, call your nearest Vidar engineering representative whose name and phone are listed below, or write directly to the factory.*

VIDAR CORPORATION

2296 Mora Drive
Mt. View, California
Phone: YOrkshire 8-6561

VIDAR ENGINEERING REPRESENTATIVES

ALABAMA, Huntsville, S. S. Lee Associates, Inc., JEfferson 6-0631 • **CALIFORNIA, Los Angeles (Beverly Hills),** Moxon Electronics Corp., BRadshaw 2-9311 • **CALIFORNIA, San Francisco (San Mateo),** Moxon Electronics Corp., Fireside 5-7961 • **CALIFORNIA, San Diego,** Moxon Electronics Corp., HUdson 8-2901 • **CONNECTICUT, Stratford,** Instrument Dynamics, Inc., DRexel 8-0435 • **FLORIDA, Orlando,** S. S. Lee Associates, Inc., CHerry 1-4445 • **ILLINOIS, Chicago,** Pivan Engineering Company, KE 9-4838 **INDIANA, Indianapolis,** Pivan Engineering Company, Victor 6-1532 • **MASSACHUSETTS, Boston (Wakefield),** Instrument Dynamics, Inc., CRystal 6-5100 • **NEW JERSEY, Ridgewood,** G. Curtis Engel & Assoc., GIlbert 4-1400 • **NEW YORK, Syracuse,** J. D. Ryerson Assoc., Gibson 6-1771 • **NEW YORK, New York City and Long Island,** G. Curtis Engel & Assoc., REctor 2-0001 • **NORTH CAROLINA, Winston-Salem,** S. S. Lee Associates, Inc., STate 8-0431 • **OHIO, Dayton,** Dayton Associates, BAldwin 3-9621 **PENNSYLVANIA, Philadelphia,** G. Curtis Engel & Assoc., WAlnut 2-3270 • **TEXAS, Houston,** Datronics • **WASHINGTON, Seattle,** Comptronics, MAin 4-5135 • **WASHINGTON, D.C. (Towson, Md.),** S. S. Lee Associates, Inc., LOckwood 5-3066

CIRCLE 113 ON READER-SERVICE CARD

Servomotor **558**

Size 5 servomotor, model 9005-1502-0, is 0.865 in. in length and weighs 0.6 oz. Torque-at-stall registers 0.1 oz-in. and rotor inertia is 0.18 gm-cm^2, providing an acceleration-at-stall of 39,000 rad per sec^2. No load speed is 10,000 rpm. It is powered by 26-v, 400-cps reference voltage.

Beckman Instruments, Inc., Helipot Div., Dept. ED, 2500 Fullerton Road, Fullerton, Calif.

Transistor Enclosure **684**

An all-glass enclosure for microtransistors, this unit consists of two parts, a case and a flat cover. Diameter is 150 mils and height, after sealing, is 60 mils; three coplanar, ribbon leads are an integral part of the case. A glaze, with low melting point, applied to the top rim of the case, allows a hermetic seal between case and cover. This eliminates the need for welding or soldering the final closure.

Corning Glass Works, Dept. ED, Corning, N.Y.
Availability: *From stock in small quantities.*

Circuit Boards **685**

A molded, recessed circuit board, this unit has electro-plated conductors in recessed grooves and contoured holes to insure fool-proof, two-sided circuitry. They can be molded of any number of plastic materials, depending on required specifications.

Combined Electronics, Inc., Dept. ED, Cicero, Ill.

NEW PRODUCTS

Low-Shrinkage Tape 373

A regular skived, Teflon tape with controlled low-shrinkage, this tape will change no more than 2% in any dimension when heated at 730 F for 15 min. Tensile strength at 0.003 in. is 4,000 psi min and elongation 300% min. Dielectric strength is 2,700 v per mil min.

Dixon Corp., Dept. ED, Bristol, R.I.

Pulse Group Generator 355

A variety of pulse trains useful in testing computers and data-handling equipment is provided by type 5101 pulse group generator. Groups are generated at a repetition frequency variable from 1 to 10,000 groups per sec. Group length is adjustable between 20 μsec and 0.2 sec; within each group, pulse rate is variable from 10 cps to 100 kc. Accuracy is ±5%. A positive gate output is provided; provision is made for single-group operation.

Instrument Corp. of America, Dept. ED, 516 Glenwood Ave., Baltimore 12, Md.

***Price & Availability:** $795; 1 month.*

Tapped Delay Lines 370

Completely encapsulated in epoxy resin, model TDL-2197 tapped delay line is 4.5 x 1.04 x 0.50 in. in size. Specifications are: delay time, 3.4 μsec ±5%; characteristic impedance, 500 ohms ±10%; input rise time, 0.1 μsec; output rise time, 0.25 μsec max; dielectric, 250 v dc; distortion, 10% max; attenuation, 1.0 db max.

Dresser Electronics, HST Div., Dept. ED, Northridge, Calif.

***Price:** $55.*

CIRCLE 115 ON READER-SERVICE CARD ➤

Binary Counter 364

Counts of any length can be made by cascaded binary counter modules. Model 1231 counters have outputs available at each of four stages through front-panel jack connections. An equivalent printed-circuit board module is made.

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

Price & Availability: *$197.50; delivery from stock.*

Thin Film Tester 372

Programable pulse generator, type 2104, is for rapid analysis, testing and programing of thin-film and cryogenic devices. Capable of running at a clock frequency higher than 4 mc, at levels having 25 nsec rise times and 50 nsec widths, it will deliver four separate trains of both logical levels and pulses. Each of the eight output trains is separately programable into eight time zones.

Digital Equipment Corp., Dept. ED, Maynard, Mass.

DC Amplifier 356

A solid-state dc amplifier for use with dc torquers, model 579.35 has 100-w output. In a hermetically sealed can measuring 2-1/2 x 3-3/16 x 2-1/2, the unit can provide 65 db power gain between a dc driver stage and a torque motor. Output current waveform has magnitude and polarity proportional to input signal; amplifier null and gain are stable and independent of temperature.

Inland Motor Corp., Dept. ED, Northampton, Mass.

NEW PRODUCTS

Triaxial Accelerometer 629

Model 620 triaxial accelerometer is designed to provide high-level signals proportional to component accelerations along the mutually perpendicular axes. Specifications are: dynamic error bands, to ±0.6%; resistance, from 1 to 10,000 ohms; cross axis acceleration error, 0.01 g per g max; size, 2 x 3 x 2-3/4 in.

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

Flexible Curing Agents 371

Used to control flexibility, viscosity, and exotherm in epoxy resins, these curing agents are low-viscosity, almost colorless liquids. They are described as amine-terminated aliphatics with controlled and limited functionality.

Dow Chemical Co., Dept. ED, Midland, Mich.

Price: X-3483.1, $0.605 in drum quantities; X-3483.2 and X-3843.3, $0.755 in drum quantities.

Elapsed-Time Indicator 366

Commercial elapsed-time indicator registers hours and tenths and minutes and tenths to 99999.9. Resettable and nonresettable models can be supplied with 3-1/2 in. diam round bezel or 3 x 3 in. square bezel. Terminals are screw type. Power is 120 or 240 v ac, 50 or 60 cps.

Haydon Div., General Time Corp., Dept. ED, Torrington, Conn.

Voltmeter 557

A range of 300 μv to 300 v at frequencies from 10 cps to 11 mc can be measured with model 317 voltmeter. It is useful as a null detector from 5 cps to 30 mc. As a calibrated amplifier it provides a stable gain up to 60 db with a frequency response ±1 db from 6 cps to 11 mc. Input impedance, with probe, is 10 meg shunted by 5 pf.

Ballantine Laboratories, Inc., Dept. ED, Boonton, N.J.

P&A: $445 for model 317, $50 for probe; March 1961.

Epoxy Laminate 616

Glass-fabric epoxy laminate is offered copper-surfaced as Di-Clad 614 or plain as Dilecto 614. Haloing and edge-lifting are virtually eliminated in fabrication. Extinguishing time after removal from flame is zero and NEMA specifications for G-10 are met.

Continental-Diamond Fibre Corp., Dept. ED, Newark, Del.

Primary Battery 666

A silver-zinc primary battery, model 70, will activate itself within a maximum of 15 sec. Designed to provide power for long-distance transmission, the 28-v battery will discharge for 12 min with a load of 5 amp. Voltage is regulated to limit fluctuation to ±5.4% of the 5-amp load. Weight is 4.2 lb.

Electric Storage Battery Co., Dept. ED, P.O. Box 11301, Raleigh, N.C.

NEW PRODUCTS

Power Supply 606

A multiple-output dc power supply, this unit is typical of militarized power supplies built to custom. The supply has outputs from +2.65 to −22 v at up to 20 amp.

Perkin Electronics Corp., Dept. ED, El Segundo, Calif.

Retaining Spring Clips 561

For socket-mounted transistors, these retaining spring clips comply with military requirements for retention of plug-in devices. Designated 3B-714-1 and 3B-714-2 they are designed for use with TO-5 and TO-9 cases. Material is beryllium copper with a silver plate finish.

The Birtcher Corp., Industrial Div., Dept. ED, 745 S. Monterey Pass Road, Monterey Park, Calif.

Decade Counter 560

Transistorized decade counting unit, model BEC-10 will count pulse rates up to 20,000 pulses per sec. It has been designed for use in industrial counting applications where in-line visual readout is required. The unit will drive a number 47 incandenscent bulb in the readout unit directly.

Binary Electronics Co., Dept. ED, Bldg. E, 824 E. Walnut Ave., Fullerton, Calif.

Vibration Analyzer 570

Model 41 vibration signal analyzer and portable balancer uses modular construction and transistor circuitry. The unit is adaptable to any type of transducer, and measures amplitude from 5 μin. to 0.1 in., peak to peak; frequency from 3 cps to 10 kc; and velocity from 50 μin. per sec to 100 in. per sec. Accuracy is ±2%. A continuously variable frequency filter system is provided. The set operates on 110 v ac or an internal battery pack.

RayData Corp., Dept. R2, Dept. ED, 1078 E. Granville Road, Columbus 24, Ohio.
P&A: $2,000; 30- day delivery.

Solid-State Multiplexer 619

For data acquisition and computing systems, the model EM-3 multiplexer can switch from 4 to 64 channels. Settling time is 20 μsec; 64 channels are scanned in 50 μsec. Input and output limits are ±10 v with no inversion; the unit will drive a stable load impedance of 25 K or greater. Internal noise is less than 1 mv. Supply is 115 v ±10%, 60 cps.

Packard Bell Computer Corp., Dept. ED, 1905 Armacost Ave., Los Angeles 25, Calif.

DC Power Supplies 569

Outputs from 0.2 to 0.5 amp at up to 32 v are provided by the 170 series of dc power supplies. Three configurations are available: bench model with calibrated voltage control, plug-in version with octal plug and screw-driver adjustments, and a terminal-strip version with screw-driver voltage adjustment. Regulation of all models is better than 3 mv, line or load; ripple is less than 250 μv rms. Case size of models 170 and 172 is 3 x 4 x 5 in., of models 171 and 173 is 3-1/2 x 5 x 5-1/2 in.

Quan-Tech Laboratories, Inc., Dept. ED, 60 Parsippany Blvd., Boonton, N.J.
Price: $98 to $129.

NEW PRODUCTS

Component Connectors 595

Insulated feed-through and stand-off component connectors offer high tie-point density. Height above board is 0.25 in.; OD is 0.190 in. Sockets accepting wires of 0.010 to 0.022 in. are spaced equally on a 0.120-in. circle. The devices allow simple insertion and changing of circuits and components.

Omega Precision, Inc., Dept. ED. 757 N. Coney Ave., Azusa, Calif.

Carrier Demodulator 600

Used with variable reluctance transducers, the model CD10 provides a dc output signal for recording and control in dc systems. Operating on 95 to 125 v, 60 cps, output is 1 ma into a 1-K load. Ambient temperature range is −65 to +165 F.

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

Cam Assemblies 598

For precision timing applications, these adjustable cam assemblies feature positive locking at any predetermined operational setting, within a range of 0 to 180 deg. Machined from No. 303 stainless steel, with clear passivated finish, they are stocked in 0.1248, 0.1873 and 0.2498 in. bore sizes, in pin or clamp hub styles.

PIC Design Corp., Dept. ED, 477 Atlantic Ave., East Rockaway, L.I., N.Y.

Price & Availability: $45 to $75; 10 days.

Advertisement

Power Transistors 583

Rated at 40 w, npn silicon mesa transistors 2N1768 and 2N1769 have an offset pedestal-and-stud mounting arrangement for positive heat-sink contact. The units are designed for use in dc-to-dc converters, inverters, choppers, voltage and current regulation, dc and servo amplifiers, and relay-actuation circuits. Saturation resistance is 1 ohm; thermal resistance is low. Temperature range is —65 to 200 C.

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

10-Turn Potentiometer 625

With an infinite-resolution film element, model 5010 potentiometer is available in resistances from 5 K to 500 K. Specifications are: mechanical rotation, 3,600 deg; temperature range, —55 to +150 C; power rating, 2 w to 75 C derated to 0 at 150 C; linearity, 0.05%. Life rating is 10 million revolutions per minute.

Computer Instruments Corp., Dept. ED, 92 Madison Ave., Hempstead, L.I., N.Y.

Germanium Transistor 574

With a maximum switching time of 110 nsec, type 2N781, an epitaxial mesa transistor, has a turn-on time of 60 nsec max and a turn-off time of 50 nsec max. Storage time has been reduced to 20 nsec max; saturation voltage is —0.16 v max. Absolute maximum ratings at 25 C are: collector-to-base voltage, —15 v; collector-to-emitter voltage, —15 v; collector current, 100 ma; power dissipation, free air, 150 mw.

Sylvania Electric Products Inc., Dept. ED, 730 Third Ave., New York 17, N.Y.

P&A: *$11.72 ea, 1 to 99; through distributors.*

TEMPERATURE TRANSDUCER 760

Small probe-type device for high and low temperature applications where high pressures and severe flow conditions are imposed. Precise liquid or gaseous measurements to 800°F. Tiny sensing element of deposited platinum film allows high base resistance, extreme linearity, wide range capability, and fast response. Approved for ICBM environments.

Microdot Inc., 220 Pasadena Avenue, South Pasadena, California.

WELDABLE STRAIN GAGE 761

Weldable-to-aluminum strain gage, less than 1-3/16" long by 1/4" wide, is capable of continuous operation at 700°F. Precise, rugged device consists of etched wire filament in swaged stainless steel tube, mounted on a special alloy welding flange. Installation is fast and permanent with stored energy welding equipment—no complicated bonding or curing processes necessary.

Microdot Inc., 220 Pasadena Avenue, South Pasadena, California.

AIRBORN DC AMPLIFIER 762

Solid state, direct-coupled, hermetically sealed instrument is less than 5 cu. in. in volume; weighs only 6 oz. DC gain is 200 to 1000 ±5 V into not less than 20K (single ended).

Microdot Inc., 220 Pasadena Avenue, South Pasadena, California.

CIRCLE 763 ON READER-SERVICE CARD ➤

VHF-UHF TRANSMITTERS

Proved in history's most demanding environmental laboratory — outer space — the custom designed unit shown above is typical of the development skill and production capability available from Microdot. The unit shown in miniaturized, pressurized, and features a solid state power supply that cannot be damaged by input/output overloads. Units are available in a complete range of modulation — CW, FM, Phase, and Pulse, with frequency coverage 100 to 5000 mc/s and output from 100 mw to 10 watts.

Telemetry Capabilities at Microdot have been dramatically expanded with the recent acquisition of Spectralab Instrument Company. The highly regarded development skill, production capability, and working experience of Spectralab in the field of VHF and UHF cavities and related instrumentation is available from Microdot's Instrumentation Division. This equipment, outstanding in its attention to miniaturization and ruggedness, is a vital part of such important projects as Pioneer V, Jupiter, Atlas, Pershing, Redstone and Echo I.

UHF Telemetry Transmitters, Models 2406 and 2409, use a unique, automatically stabilized circuit, with the output frequency referenced directly to a quartz crystal. This approach allows a greatly reduced size compared to the multiplier chain conventionally required to achieve crystal stability, as well as increased reliability due to a fewer number of parts.

The transmitters have their own solid state power supply designed to provide a high ratio of rf output power to total power input. The frequency modulation circuitry is sufficiently linear to introduce completely negligible distortion to the modulation signal. For further information, Call Microdot or write for catalog sheet TT-1.

SPECIFICATIONS	
Frequency Range:	
Model 2406	2200-2300 mc/s
Model 2409	1435-1535 mc/s
Frequency Stability:	±0.001%
Power Output:	10 watts
Power Output Stability:	1 db
Modulation:	PCM/FM, PAM/FM, FM/FM
Input Voltage:	28 vdc
Temperature Range:	—40°C to +70°C
Vibration:	10 g, 5-2000 cps
Size:	3⅜" x 7⅛" x 11"
Weight:	12 pounds

MICRODOT INC.

220 Pasadena Avenue, South Pasadena, Calif.

MUrray 2 3351 SYcamore 9 9171

NEW PRODUCTS

Display Storage Tube 552

Capable of high-speed, selective erasure, the Multi-Mode Tonotron storage tube has a simultaneous display of stored and nonstored information. Information may be written stored or nonstored or rapidly and selectively erased. The tube display has high-resolution light and dark trace displays. Displays are maintained at full brightness until erasure. Erasing takes place while the new trace is being written.

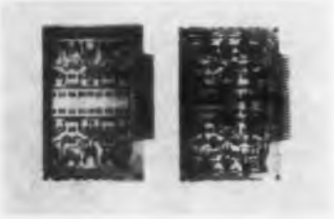
Hughes Aircraft Co., Dept. ED, Florence Ave. and Teale St., Culver City, Calif.

Tantalum Powder 621

Fabrication and performance of electrolytic capacitors is improved with SGP tantalum powder. The material is said to enable pellets to be pressed to lower green densities, lowering dissipation and increasing capacitance per gram. A low-capacitance powder, type SGL, is also in production.

National Research Corp., Dept. ED, 70 Memorial Drive, Cambridge 42, Mass.

Transistor Cards 688



An all-purpose card for transistors, E-Z Circuit cards are designed for the breadboarding of semiconductor circuits. A wide variety of analog and digital circuits may be developed by inserting active and passive components. The card will hold eight transistor circuits. It measures 4-1/2 x 6-1/2 in. with a standard 28-contact connector along one side.

Circuit Structures Laboratory, Dept. ED, P.O. Box 1194, Santa Ana, Calif.

This is the time of our annual subscription renewal; Return your card to us.

Power Supply 608

Outputs of plus and minus 15 v dc are provided at 200 ma by the 6033 power supply. The solid-state unit operates from 115 v ac; regulation against line and load variation is under 0.01%; ripple is less than 1/2 mv. Short-circuit overload protection is built in. The supply is available in bench and plug-in configurations.

George A. Philbrick Researches, Inc., Dept. ED, 127 Clarendon St., Boston 16, Mass.

Price & Availability: *About $285; delivery from stock.*

Pin Terminals 613

Designed for printed circuit use, pin terminals Nos. 2970 and 2971 have lengths of 0.3 and 0.15 in. respectively. The pins are machined of brass and finished in with hard gold over silver plate. They are for any 0.040 socket.

Cambridge Thermionic Corp., Dept ED, 45 Concord Ave., Cambridge 38, Mass.

P&A: *$19.53 per thousand in quantities of 5 thousand; from stock.*

Induction Heater 572

Constricted areas are easily reached by the model L6H-P induction heating machine. Suitable for brazing, soldering and heat-treating jobs, coil is mounted on a pistol-grip handle. The 2-1/2-kw generator has ac and dc overload circuit breakers and a timer. The flexible rf power cable is 10 ft long, with water-cooled conductors.

Reeve Electronics, Inc., Dept. ED, 609 W. Lake St., Chicago 6, Ill.

Price: *$2,200.*

NEW PRODUCTS

Sub-Carrier Oscillator 601

Up to 12 variable inductance transducers may be operated with the model CT10 telemetering subcarrier oscillator system. Any of the IRIG bands 4 through 18 or A through E may be used. Operating voltages range from 6 to 50 v dc at 48 ma. The 2-lb unit is 3 x 3 x 3-3/4 in. It will withstand shock and acceleration of 200 g, any axis, and vibration of 35 g, 50 to 2,000 cps.

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

Transistor Amplifier 612

Four-stage transistor amplifier, model TA-12-B, has a gain of 73 db at 1 kc. Nominal input impedance is 2,500 ohms; frequency response is ±5 db from 300 to 20,000 cps. Power is supplied by a 1.34-v mercury cell. Size is 0.531 in. in diam x 0.228 in. high.

Globe-Union Inc., Centralab Div., Dept. ED, 900 E. Keefe Ave., Milwaukee 1, Wis.

Power Tetrode 605

A 65-w power tetrode, PL-4-65A is suitable for use as an rf power amplifier and oscillator and as an af power amplifier and modulator. Small size and quick-heating filament make it useful in mobile equipment. It can be operated up to 150 mc.

Penta Laboratories, Inc., Dept. ED, Santa Barbara, Calif.

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DC Motor 596

A single package houses motor, gear train, governor and noise filter in this 1-1/4 in. permanent magnet or reversible motor. Built to meet MIL-M-8609 (ASG) requirements, the unit operates over an ambient temperature range from −65 to +200 F, producing 1/75 hp from 22 to 31 v dc. Current is 0.85 amp max, speed 18,500 rpm at 26 v.

Omega Precision, Inc., Electro-Actuators Div., Dept. ED, 757 N. Coney Ave., Azusa, Calif.
***Availability:** 4 to 6 weeks.*

Transistor Tester 609

In-circuit measurement of ac beta parameter is provided by the 219B transistor tester. Scales for beta are 1 to 4, 3 to 12, 10 to 40, and 30 to 120. There are also two collector current scales of 0 to 50 and 500 μa.

Sierra Electronic Corp. Div. of Philco Corp., Dept. ED, 3885 Bohannon Drive, Menlo Park, Calif.
***P&A:** Under $300 ea; Feb. 1961.*

Tape Reader 597

Chopped reflected light and ac-coupled amplifiers are used for stability in the model PTR-7 photoelectric tape reader. Speeds of 10, 30, 75 and 100 in. per sec may be selected, with up to 1,000 characters per sec reading rate. Stop to full speed requires 3 msec; tape stops in less than 1 msec. Output voltage level is 12 v negative. Complete controls are provided. The rack-mounted reader has a panel 5-1/4 in. high.

Omnitronics, Inc., Dept. ED, 511 N. Broad St., Philadelphia 23, Pa.

NEW PRODUCTS

Module Tester 602

Dynamic and dc test of digital modules is done with model MT1 module tester. The maker's 200 kc, 3 mc, and PB 250 modules are tested for parameters including input amplitude, duration, rise time, and repetition rate plus output resistive and capacitive load. The unit is self-testing.

Packard Bell Computer Corp., Dept. ED, 1905 Armacost Ave., Los Angeles 25, Calif.

Price & Availability: *$1,950; 60-day delivery.*

Coaxial Attenuators 551

For use from dc to 1 Gc, series AF type 2 fixed coaxial attenuators have a vswr of 1.10 max over their frequency range. They are bidirectional and unaffected by temperature or humidity changes. Specifications are: frequency range, dc to 1 Gc; attenuation, 1 to 40 db; power handling, 1-w, cw, 1-kw, peak; impedance, 50 ohms nominal; vswr, 1.10 max.

Maury and Associates, Dept. ED, 10373 Mills Ave., Montclair, Calif.

P&A: *$55 to $75; 2 to 4 weeks.*

Cabling Tape 618

Laminated aluminum foil and glass cloth are combined with a pressure-sensitive silicone adhesive in 6100 heat-reflective tape. Type 6101 is similar but nonadhesive. Type 4716 is a Mylar tape 1.2 mils thick, used to protect underwater cable. It has high dielectric strength, heat resistance, low moisture-vapor permeability and good elongation.

Permacel, Dept. ED, New Brunswick, N. J.

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Wirewound Potentiometer 642

Power rating of 12-1/2 w at 40 C ambient temperature is accomplished with special insulating materials in the MG wirewound control. Housed in 4-w case size, the control is derated to 0 w at 300 C. It is used in ground-support and aircraft applications.

P. R. Mallory & Co. Inc., Mallory Controls Co. Div., Dept. ED, Frankfort, Ind.

Power Supplies 644

From 50 kv to 120 kv in the 2-kw average power range is provided by a line of high-voltage power supplies. External polarity reversal is controlled by a lucite jack housed under an easily accessible cover. There are five models, all measuring 30 x 30 in. base x 4-1/2 ft high.

Manson Laboratories, Inc., Dept. ED, Stamford, Conn.

Remote Modulator 643

Remote-control monitoring can be done with this modulator at distances up to 1,000 ft. It can also be used as an integral unit. The modulator provides continuous tuning of a magnetron, and permits work from a tower.

Manson Laboratories, Inc., Dept. ED, Stamford, Conn.

NEW PRODUCTS

DC-to-DC Converter 656

Output of 1 kv dc at 25 μa is furnished by this dc-to-dc converter. A transistor blocking oscillator type, primary input is 3 v dc at 20 ma. It is supplied in hermetically sealed MIL-T-27A can or in open frame configuration. An epoxy-molded construction with pins or lugs is made on order.

Microtran Co., Inc., Dept. ED, 145 E. Mineola Ave., Valley Stream, N. Y.

P&A: $3.70 to $7.90 ea, 100 units; stock.

Circuit Modules 647

Designed for reliable operation in missile uses, a line of 20 modules includes multivibrators, Schmitt triggers, inverters, emitter followers, reset amplifiers, amplifiers, logic gates, etc. Modules occupy less than 0.09 cu in., weigh less than 1/10 oz. Operating temperature range is −55 to +125 C. The series F units withstand 20-g vibration from 47 cps to 5 kc.

Marshall Laboratories, Dept. ED, 2008 W. Carson St., Torrance, Calif.

Summing Amplifier 651

Fully transistorized model 1010 booster summing amplifier can drive a size 11, 400-cps resolver or several computing potentiometers. Up to five inputs may be summed; gain is unity ±0.005%. Phase shift is less than 5 min. Input impedance is 1 meg, signal level 30 v. The amplifier is encapsulated and sealed.

Melcor Electronics Corp., Dept. ED, 48 Toledo St., South Farmingdale, L. I., N. Y.

Differential Amplifier 648

Solid-state airborne dc amplifier, designed for severe environments, occupies 4.75 cu in. The direct-coupled, differential input amplifier has equivalent input drift of less than 100 μv for 8 hr. Input is 5 mv differential; gain is 200 to 1,000 ±0.75%. Output is ±5 v into not less than 20 K. Linearity is ±0.25%; gain variation is ±1% to 10 kc, 3 db down at 50 kc. Temperature range is −55 to +100 C, vibration 20 g to 2 kc.

Microdot Inc., Dept. ED, 220 Pasadena Ave., South Pasadena, Calif.

Silicon Diodes 654

No encapsulation is required for these silicon diodes, which measure 0.075 max x 0.030 max in. Rectifier types have ratings to 1 kv piv; computer diodes are rated to 2 nsec recovery time, 2 pf capacitance. A fast-recovery type and a general purpose diode are also made. Features include storage at temperatures to 300 C, thermal shock resistance over operating range of −65 to +200 C with no delay in transfer, and 300 mw dissipation.

MicroSemiconductor Corp., Dept. ED, 11250 Playa Court, Culver City, Calif.

Silicon Rectifier 640

Rated at 600 v maximum piv, type T rectifiers can be used at up to 420 v rms in resistive and inductive circuits, and up to 215 v rms on capacitive loads. It is rated at 750 ma continuous at 50 C ambient temperature, 500 ma at 85 C. Leakage current is 250 μa max.

P. R. Mallory & Co. Inc., Mallory Semiconductor Co. Div., Dept. ED, Du Quoin, Ill.

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NEW PRODUCTS

Crystal Filters 658

Wide band-pass crystal filters in the range of 0.5 to 30 mc have fractional bandwidths of 0.7 to 6.5%. Center frequencies of types NJ-1 and NJ-2 are held within 3 kc of a design center of 7.2 and 7.4 mc respectively, and 3-db bandwidths are held between 160 and 168 kc. The 40-db bandwidths are less than 300 kc. Package size is less than 1 cu in.

Midland Manufacturing Co., Dept. ED, Kansas City, Kan.

Frame-Grid Tubes 571

High transconductance and low noise are features of five miniature frame-grid tubes. Applications include use in rf amplifiers, if amplifiers, driver stages, cathode followers and cathode amplifiers. The tubes and their transconductances are the 6939, a double tetrode with 10,500 μmhos per section; 6688, pentode, 16,500 μmhos; 6922, twin diode, 12,500 μmhos per section, 5842, triode, 25,000 μmhos; and 5847, pentode, 13,000 μmhos.

Raytheon Co., Industrial Components Div., Dept. ED, 55 Chapel St., Newton 58, Mass.
Price: $2.95 to $7.90.

Cooling Fluid 622

Low viscosity allows pumping of Coolanol 35 at temperatures down to −85 F. The fluid is thermally stable at 400 F. Dielectric strength at 25 C is rated at 47 kv; viscosity at −65 F is less than 950 centistokes.

Monsanto Chemical Co., Dept. ED, 800 N. Lindbergh Blvd., St. Louis 66, Mo.

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Power Supplies 657

Transistorized power supplies are designed for incorporation into customer equipment. Outputs range from 12 v dc, 4 amp, to 40 v dc, 1.5 amp. Output is completely floating. Line and load regulation is 0.05%; ripple is less than 1 mv rms. Overshoot is less than 1%, recovery time less than 50 μsec. Gold anodized, extruded aluminum case measures 4-1/16 x 6-9/16 x 6-15/16 in. Octal plug and mounting studs facilitate installation.

Mid-Eastern Electronics, Inc., Dept. ED, 32 Commerce St., Springfield, N. J.

Price & Availability: *$149 ea; delivery from stock.*

Gallium Arsenide 639

Single-crystal GaAs, in doped and undoped form, is available with carrier concentrations ranging from 10^{16} carriers per cc to degenerate levels. Doping tolerance is ±50%; dopants are zinc, tin and tellurium. Ingots to 90 g and 1 in. diam have been made. Polycrystalline material is also available.

Merck & Co., Inc., Dept. ED, Rahway, N. J.

Price: $8 to $25 per g.

Ceramic Capacitors 667

Ultraminiature ceramic capacitors offer lower dissipation factors and improved temperature coefficient curves. The EA 12C capacitor is available in values from 39 pf to 560 pf; the EA 16C is in values of 680 through 1,200 pf. Miniature size in the 12-C line measures 0.098-in. in diameter x 0.250 length.

Electramics Corp., Dept. ED, Solana Beach, Calif.

Price: $0.55 to $1.12 ea depending on quantity.

NEW PRODUCTS

AC Panel Meters 660

Iron vane ac voltmeters, ammeters and milliammeters are available in Medalist and standard cases. Ranges are 1 to 800 v, 1 to 800 amp, and 10 to 800 ma. Moving iron vane mechanisms feature magnetic damping, impregnated field coils, and selected fixed and moving iron material for reliable operation. Cases are phenolic.

Precision Meter Div., Minneapolis-Honeywell, Dept. ED, Grenier Field, Manchester, N. H.

Data Communications System 638

Simultaneous data processing and communication with other computers is enabled by the H-880 and H-480 data communications control units. Data are transmitted over long-distance networks at the rate of 150 characters per sec. Provision for automatic verification and error correction is included.

Minneapolis-Honeywell Regulator Co., Dept. ED, 2747 Fourth Ave. S., Minneapolis 8, Minn.
Availability: *12 to 18 months.*

Lighted Push-Button 659

With single or two-color indication, the 302PB1-T switch measures 0.812 x 0.890 x 1.303 in. Switch is rated at 7 amp resistive and 25 amp inrush, 24 v dc; 7 amp resistive and 15 amp inrush at 115 or 230 v ac. There are five colors for display screen. Lamps are easily replaced.

Minneapolis-Honeywell, Micro Switch Div., Dept. ED, Freeport, Ill.
Price & Availability: *$16 to $13.85; stock.*

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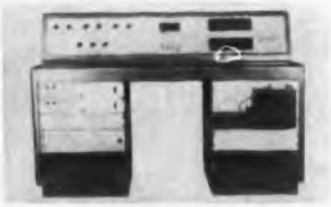
Data System 662



Automatic digital data acquisition and recording system performs digital recording of analog values at rates up to 10 four-character points per sec. Digital output is five-level punched paper tape suitable for printout or punched card conversion. Rotary switches provide for initial entry of fixed data.

Monitor Systems, Inc., Dept. 6, Dept. ED, Fort Washington Industrial Park, Fort Washington, Pa.

Low-Frequency Adapter 554

Ultrasonic inspection down to 200 kc is possible when this low-frequency adapter is used with standard pulse-echo ultrasonic equipment. Materials previously opaque to ultrasound can be penetrated. Over 24 in. of cast Iconel X has been successfully inspected with the use of this adapter.

Automation Industries, Inc., Dept. ED, 3613 Aviation Blvd., Manhattan Beach, Calif.

Fork Contacts 652

Printed circuit fork contacts of the 400 series have radiused contacting surfaces for smooth mating. Made from spring-tempered phosphor bronze, the gold-plated contacts come in upright, parallel and 45-deg styles.

Methods Manufacturing Corp., Dept. ED, 7447 W. Wilson Ave., Chicago 3, Ill.

NEW PRODUCTS

Gallium Arsenide 655

Single-crystal and polycrystalline GaAs is made in 3/4-in. diam semicircular ingot form. Mobility of N-type single-crystal material ranges from 3,500 to over 5,500 cm^2 per v-sec. High-purity and doped materials are available. Mobility and resistivity data are supplied with all single-crystal material.

Micro State Electronics Corp., Dept. ED, 152 Floral Ave., Murray Hill, N. J.

P&A: $7 to $30 per g; stock to 30 days.

Transistor Housing 637

Hermetically sealed transistor housings are made from 96% alumina ceramic, metalized with molybdenum manganese and braze-sealed to Kovar members. Seals withstand temperatures to 1,300 F. Body OD is 0.080, base 0.125 in. Housings may be designed to customer specifications.

Mitronics, Inc., Dept. ED, 1290 Central Ave., Hillside, N. J.

Static Relay 641

Solid-state static relay model SR1A-1 is designed for airborne and missile applications. Relay controls up to 4 amp at 115 v, 400 cps; turn-on time is 100 μsec max with a signal voltage of 5 to 28 v dc. The 0.4-lb unit measures 2 x 2 x 1-1/2 in. and meets requirements of MIL-E-5272B.

Magnetic Controls Co., Dept. ED, 6405 Cambridge St., Minneapolis 26, Minn.

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Miniature Filter 567

Occupying 0.25 cu in. the 75F series filter has the same electrical characteristics as larger units. Low-pass telemetering channels 1 through 18 and band-pass telemetering channels 8 through 18 are covered. Packaging is nonmagnetic metal, epoxy-potted.

Polyphase Instrument Co., Dept. ED, E. 4th St., Bridgeport, Pa.

Wirewound Trimmer 646

High-temperature trimmer 50-M48 is designed to meet requirements of MIL-R-27208. Temperature range of the sealed, wirewound potentiometer is −55 to +200 C; temperature coefficient is ±0.005% per deg C. Standard resistance values of the 1-w unit range from 25 ohms to 10 K. Hermetically sealed, it withstands moisture and salt spray. Vibration range is 10 to 2,000 cps, shock 50 g.

Maurey Instrument Corp., Dept. ED, 7917 S. Exchange Ave., Chicago 17, Ill.

Coaxial Connectors 649

Screw-type coaxial connectors in more than 100 standard types are available in 50-, 70- and 93-ohm impedances. Made in conformity to military specifications, they are universally interchangeable, shock and vibration resistant. Standard configurations are straight plugs, angle plugs, receptacles, bulkhead jacks and jacks. Minimum voltage breakdown test is 1.5 kv ac.

Electro-Physics Laboratories, Dept. ED, 1900 Walker Ave., Monrovia, Calif.

NEW PRODUCTS

Commutative Scanning System 682

Sequential monitoring of up to 40 channels is possible with model 540 commutative scanning system. Self-contained in a cabinet 48-5/8 in. high, the system consists of a scanner control unit, a zero and gain unit, a digital voltmeter and a printer.

Crescent Engineering and Research Co., Dept. ED, 5440 N. Peck Road, El Monte, Calif.

Controller Panels 590

Proportional power controller panels use magnetic amplifier and silicon-controlled rectifier circuitry to deliver 400, 1,200, and 4,000 w ac or dc to basic loads. The six units have high gain, low time delay, adjustable bias and gain control, multiple control windings, linear amplification, and standard input-output voltages. Supply is 115 v ac; output is 85 v dc or 95 v ac.

Norbatrol Electronics Corp., Dept. ED, 356 Collins Ave., Pittsburgh 6, Pa.

Delay Lines 566

Delays up to 5,000 μsec, with adjustment of ±5 μsec, are provided by the model 2370 magnetostrictive delay line. Temperature coefficient is 20 ppm per deg C standard, 4 ppm on request. Range is −55 to +70 C. Insertion loss is about 60 db; signal-to-noise ratio is better than 10:1. Carrier frequency is 250 kc to 1 mc. Transistorized drive and output circuitry can be supplied as integral part of package.

Power-Tronic Systems, Inc., Dept. ED, Pine Court, New Rochelle, N.Y.

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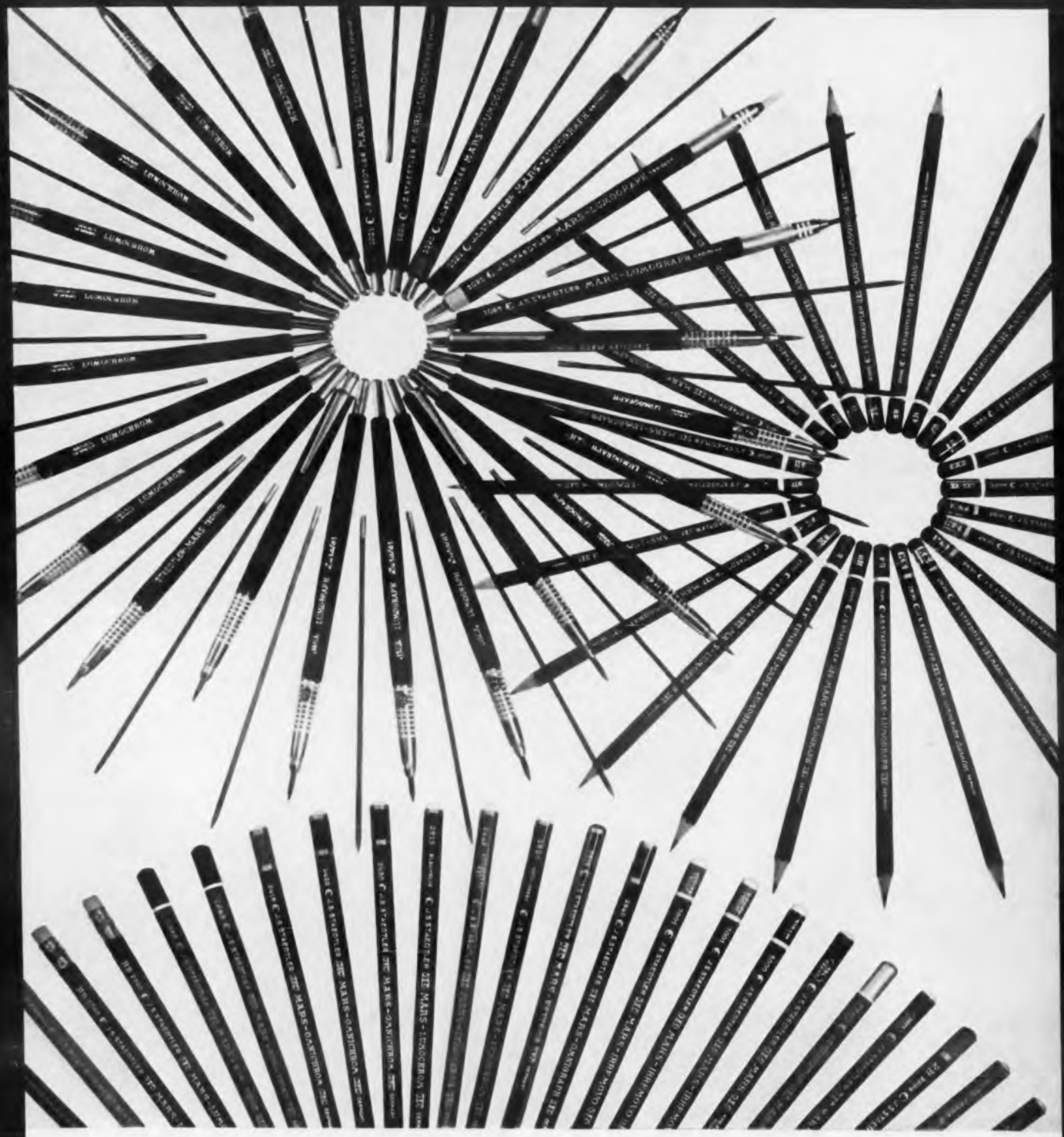

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Sequence of shield cans, punch press or spinning.

Complex configuration multi-lamina shield, hydroformed.

CRT shield illustrating combination of hand fabrication, spinning and sizing.

Backward wave tube shield assembly design, involving hand fabrication and hydroform or spinning.

Special purpose shield, hand fabrication (levitated gyro).

Tape preserver can be spun, hydroformed or punch press fabricated.

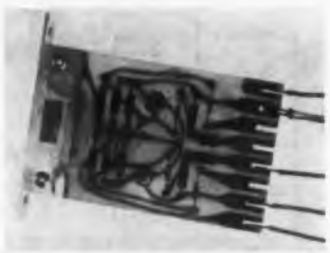
Data storage tube shield, hydroform or spinning, plus hand fabrication.

Large fabricated special structure (shaker table shield), approx. 60" dia. and 57" high.

Composite photo demonstrating that magnetic shielding qualities of NETIC alloy material are not affected by vibration, shock, (including dropping), etc.

CIRCLE 154 ON READER-SERVICE CARD

Digital Logic Packages 403



DigiBits, a series of digital logic packages, has a conservatively rated operating frequency of 10 kc (20 kc input frequency). They can be used over a 30- to 120-F temperature range. Packages available include flip-flops, diode "AND" and "OR" gates, rc gates and emitter followers.

Tech Serv, Inc., Dept. ED, 4911 College Ave., College Park, Md.

Ultrasonic Cleaner 384

Miniature parts and optics can be cleaned with lightweight, portable model US-100 ultrasonic cleaner. Useful in fast removal of solder flux, grinding and polishing compounds, oil, and other contaminants, unit accommodates parts up to 1-1/2 in. square. Transducer is magnetostrictive type.

Union Ultra-Sonics Corp., Dept. ED, Quincy, Mass.

Arbitrary Function Generator 401

Low frequency function generator, model 5846, can reproduce most arbitrary waveforms to requirements in addition to low frequency sine and triangle waveforms. Specifications are: frequency range, 0.001 to 10 cps in four ranges; accuracy, ±3% of set frequency; output voltage, 20 v peak-to-peak; hum, 45 db down from signal level.

Tensor Electric Development Co., Inc., Dept. ED, 1873 Eastern Parkway, Brooklyn 33, N.Y.

NEW PRODUCTS

Miniature Tap Switch 404

Molded, miniature tap switch, type 3A, is available with as many as eight decks; up to 12 positions per deck, single pole and six positions double pole; and adjustable stops if a lower number of steps is required. The basic unit is 1-1/4 in. in diameter and weighs 30 g. It has a rating of 1,200 v rms, 2,000 v dc, 5 amp, carrying. Insulating resistance is 100 meg min at 500 v dc.

Tech Laboratories, Inc., Dept. ED, Bergen and Edsel Blvds., Palisades Park, N.J.

Environmental Chamber 393

Walk-in style environmental chamber model WF-2100-125+300H provides temperatures from −125 F to +300 F and relative humidity from 20 to 95%. Usable inside space is 15 x 20 x 7 ft high. Thermal capacity is 56,000 BTU; air stratification is less than 1 deg. Interior is stainless steel, with frost-free viewing windows.

Webber Manufacturing Co., Inc., Dept. ED, P. O. Box 217, Indianapolis, Ind.

Pickup Coil 392

Electromagnetic pickup coil MA-3G has an integral transistor amplifier. Designed for use with turbine flow sensors, it can also be used as a magnetic motion pickup in tachometer applications. It is useful for impedance matching, and in applications where long transmission distances exist between pickup and readout.

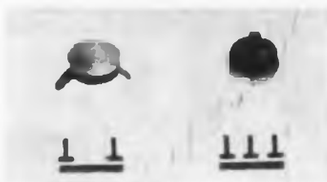
Waugh Engineering Co., Dept. ED, 7842 Burnet Ave., Van Nuys, Calif.

Cable Clamps 462

Nylon cable clamps accommodate cables from 1/16 in. to 1-3/4 in. in diameter. Flat clamps, molded half-clips and snap clips are made. Clamps are useful from −60 to +275 F under load, and are unaffected by oil to 300 F. Military requirements are met.

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

Thermostat 398



Model SA-5000 thermostat can be used as is or enclosed in various metal housings. It will handle currents to 20 amp, voltage to 240 ac. Bimetal snap-acting disk is open or closed type, 1/2-in. in size. Various types of terminals are available.

Thermostats, Inc., Dept. ED, P.O. Box 303, Chartley, Mass.

RF Tone Generator 396

Distortion testing and adjustment of single sideband receivers can be done with the TTG-5 dual rf tone generator. Used with any af spectrum analyzer, the set provides visual analysis of distortion and hum sidebands over a 60-db dynamic range. Five pairs of crystal-controlled rf signals are furnished in the 3- to 30-mc range. Output level is 0.1 v rms for each tone at 50 ohms, with 0 to 100 db attenuation in 1-db steps. Panel height is 5-1/4 in.

Panoramic Radio Products Inc., Dept. ED, 520 S. Fulton Ave., Mount Vernon, N.Y.

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NEW PRODUCTS

Variable Inductors 395

For printed circuit or breadboard uses, series 387 variable inductors cover a range of 1.5 μh to 3 mh. Both electrostatically and magnetically shielded, the high-Q units have distributed capacitances ranging from 3 pf to 16 pf in the 3-mh size. A kit of 10 inductors is offered. Military-grade units are made, as well as custom designs to 72 mh. Size is 1/2 in. square and 5/8 in. high.

Wells Electronics Co., Dept. ED, 1701 Main St., South Bend 23, Ind.

Price & Availability: *$1.80 to $1.90; stock.*

Load Cell 385

Made of 100% stainless steel, load cell type PR-35 uses a calibration-quality proving ring coupled inductively to a differential transformer. Output is over 500 mv with 10 v, 60 cps input, more than 1 v with 10 v, 400 cps input. Unit measures static and dynamic forces, tension or compression, in ranges from 25 to 4,000 lb, at temperatures from —115 to +500 F.

United Aero Products Corp., Dept. ED, Columbus Road, Burlington, N.J.

Rectifier Tester 408

Forward and reverse testing of diodes at 100 amp and 2 kv is done with model E-1 dynamic rectifier tester. Used with an X-Y oscilloscope, the tester has independently adjustable forward and reverse voltages. Calibrated resistor is used in forward current test, 0.5% resistors in reverse leakage test. A polarity-reversing unit is also made.

Instrument Development Corp., Dept. ED, 139 Delaney Drive, Pittsburgh 35, Pa.

Price & Availability: *$495; 6 to 8 weeks.*

Glass Diodes 400

Microminiature glass diodes, types TI-2 and TI-6, are computer diodes for use in diode gates, transistor-diode logic circuits and high speed switching applications. A package diameter of 0.040 in., a length of 0.060 in. and round leads provide a reduction in volume of 50 to 1 over conventional diodes with similar characteristics. They have reverse recovery times of 10 and 100 nsec respectively.

Texas Instruments Inc., Dept. ED, P.O. Box 5012, Dallas 22, Tex.

Ultrasonic Cleaner 397

Solid-state ultrasonic cleaning equipment is simpler, smaller and lighter, as shown by a 1-kw unit and the tube model it replaces. The new design uses less input power and requires no tuning or warm-up. Ratings range from 125 to 1,000 w, with a 2.5-kw unit scheduled. The 1-kw generator is 8-1/2 in. high, 17 in. wide, and 14 in. deep.

Electronic Equipment Dept., Westinghouse Electric Corp., Dept. ED, 2519 Wilkens Ave., Baltimore 3, Md.
Availability: *3rd quarter 1961.*

Piezoelectric Ceramics 411

Three ceramic bodies, models C43B, C43C and C45, have been added to the firm's line of piezoelectric ceramics. Characteristics of the C43B are: dielectric constant at 1 kc, 1,100; planar coupling coefficient, 45%; max operating temperature, 250 C; dissipation factor at 1 kc, 1%.

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

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NEW PRODUCTS

Clock Movement 391

Transistor electronic clock movement, for use in appliances, is accurate to within a few seconds per month. Input is 4.5, 6, 9 or 12 v; power consumption is about 0.30 ma. Movement is self-starting, insensitive to position, and shock-proofed. Size is 2-1/8 x 1-3/4 x 1-1/16 in.

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

Logic Circuits 390

Encapsulated, transistorized logic circuits, in 9-pin miniature plug-in form, are encapsulated in hard epoxy resin. Included are AND gates, OR gates, emitter followers and inverters, in single and dual units, with pnp, npn or complementary symmetry circuits. Rates are 250 kc to 1 mc.

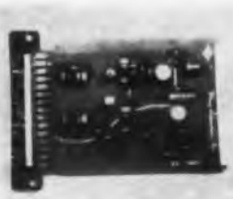
Walkirt, Dept. ED, 141 W. Hazel St., Inglewood 3, Calif.

Glow Lamps 380

Starting time is less than 1 msec for these glow lamps, in darkness as well as in light. Breakdown and maintaining dc voltages for type LT2-27-IR are 104 to 112 and 64 to 74 respectively; for type T2-27-IR100, 66 to 74 and 52 to 59; for type T2-27-1WR760, 170 to 200 and 70 to 75.

Signalite, Inc., Dept. ED, Neptune, N.J.

Digital Modules 386



Operating at 5 mc, the series 5000 line of digital modules is compatible with 200-kc modules. Circuits include flip-flops, multivibrators, nors, and gates. Logical 1 voltage is −6 to −8 v dc; logical 0 voltage is 0±0.5 v dc. Regulated power is not required. Card size is 2-11/16 x 3-1/2 in.

Wang Laboratories, Inc., Dept. ED, 12 Huron Drive, Natick, Mass.

Availability: *delivery from stock.*

High-Voltage Power Supplies 382

General purpose high-voltage power supplies are available in three models. Model 125 has a voltage output of 2 to 3 kv dc at up to 2 ma; model 126 has an output of 1 to 3 kv at 2 ma; model 127 has an output of 0.5 to 3 kv at 2 ma. Available in negative or positive polarity, all models have provision for internally reversing polarity.

Smith-Florence, Inc., Dept. ED, 4228 23d W., Seattle, Wash.

P&A: *From $330 to $365; 30 days.*

Enclosed Rack 389

Steel or aluminum electronic enclosure is made for heavy military or commercial uses. Panels are removable from the outside; enclosure may be made dust-free. Available in standard or custom sizes.

Vent-Rak, Dept. ED, 525 S. Webster, Indianapolis 19, Ind.

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NEW PRODUCTS

Power Supply 388

Continuous overloads or shorts cause no additional internal heat dissipation in the model RB-40V10SS power supply. Continuously variable current-limiting circuit holds maximum current to any selected level between 1.0 and 10.5 amp. Load regulation is 0.01%, transient recovery 50 mv max within 50 μsec. Provision is made for parallel and series operation, remote error sensing and programing. Panel height is 5-1/4 in., weight 35 lb.

Valor Instruments, Inc., Dept. ED, 13214 Crenshaw Blvd., Gardena, Calif.

Germanium Power Transistor 383

The "pancake" series of germanium power transistors have a dissipation of 150 w, and a guaranteed 0.5 C per w max thermal resistance. Designed for use in computers, converters and regulators, the series includes types 2N1099, 2N173, 2N278, 2N277, 2N441, 2N442 and 2N443. Junction temperature is 100 C and guaranteed h_{FB} ranges are from 20 to 70.

Texas Instruments Inc., Dept. ED, P.O. Box 5012, Dallas 22, Tex.

Power Transistors 381

Diffused-junction, npn silicon transistors types 2N389A and 2N424A have saturation resistance that is less than 0.75 ohm. Designed for high-power switching and amplifier applications their temperature range is —65 to +200 C. Maximum ratings are: collector current, 3 amp; emitter to

base voltage, 10 v; power dissipation, at case temperature of 25 C, 85 w, at case temperature of 100 C, 45 w.

Silicon Transistor Corp., Dept. ED, 150 Glen Cove Road, Carle Place, L.I., N.Y.

Clock Pulse Generator 399

Solid state clock pulse generators include a 3- to 25-mc and a 25- to 100-mc unit with overlap to provide continuous pulse sources from 3 to 100 mc. Design permits external drive input to provide repetition rates below 3 mc and to permit the operation of several clock pulse generators controlled by a master source. Specifications include: rise/fall times, less than 4 nsec; pulse width, less than 8 nsec at 1/2 pulse height; amplitude, 0 to 4 v; output impedance, 93 ohms.

Texas Instruments Inc., P.O. Box 6027, Houston 6, Tex.

Solenoid Valve 387

Radioactive, corrosive chemical solutions can be handled by this solenoid valve. The valve will operate in radiation fields to 25 million radians, and is usable with nitric and sulfuric acids, ammonium and sodium hydroxide, and hydrogen peroxide. It is supplied normally open or closed in standard ac and dc voltages, in 1/4-in. or larger pipe sizes.

Valcor Engineering Corp., Dept. ED, 365 Carnegie Ave., Kenilworth, N.J.

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NEW PRODUCTS

Digital Voltmeter 425

Voltages from 100 μv to 1.5 kv dc are presented as a four-digit display in decimal form with polarity discrimination in model LM 902.2 digital voltmeter. Voltage measurements are covered in 5 ranges; long term accuracy is ±0.1% of maximum reading on each scale. Readout time is 280 msec regardless of voltage input.

Solartron Laboratory Instruments Ltd., Dept. ED, Cox Lane, Chessington, Surrey, England.

Memory Unit 417

A single magnetic disk memory unit, model 31B has total memory capacity of nearly 10,000,000 bits with 400,000 bits available on a fast access basis comparable to magnetic drum performance. It provides over 9 million bits of random access storage capacity with an average access time of 147 msec. The 31-in. disk has two recording surfaces and incorporates eight movable data heads, 16 fixed data heads and eight fixed control heads.

Telex, Inc., Dept. ED, St. Paul, Minn.

Servo System 426

Solid state servo amplifier model 6102 has a sensitivity of 1 mv. It is completely transistorized with two dc signal inputs and one ac input. No warm-up time is required. The system occupies 1/4 the space of conventional systems and provides up to 400 in.-lb response.

Solar Electronics Co., Dept. ED, 5909 Melrose Ave., Hollywood 38, Calif.

P&A: Amplifier, $124.50; motor, $50; 2 weeks.

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Constant Voltage Transformers 427

Standard sinusoidal constant voltage transformers are completely automatic with continuous regulation. Response time is 25 msec at 60 cps. Standard items are available in 29 different primary-secondary voltage combinations from 60 to 7,500 v amp.

Sola Electric Co., Dept. ED, Elk Grove, Ill.

Power Amplifier 377

Fluoro-chemical cooling of the HC-105 high-frequency linear power amplifier allows delivery of 1 kw with case size of 7-1/2 x 7-1/2 x 6-1/2 in. The amplifier accepts am and single-sideband voice, digital data link, or any modulated signal in the 2- to 36-mc frequency range.

Hughes Aircraft Co., Communications Div., Marketing Dept., Dept. ED, P. O. Box 90-902, Los Angeles 45, Calif.

Core-Transistor Counters 422

Counting to speeds of 10 kc, series 73Z core-transistor counters utilize rectangular hysteresis loop magnetic cores. Type 73Z1 decade counter provides an output signal for every 10 input pulses, then resets in preparation for the next cycle. For higher counting two or more counters may be cascaded.

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

Counter Tubes 414

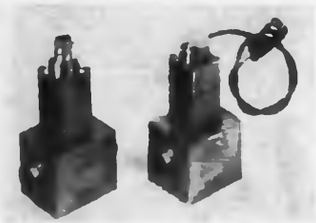
Decade counter tubes type CT4251 are dome-shaped, 13-pin, T-9 units with 10 output cathodes. They are for use in compact counting equipment in the zero- to 50-kc frequency range.

Sylvania Electric Inc., Dept. ED, 730 Third Ave., New York 17, N.Y.

P&A: $11.10, 1 to 24; immediate.

NEW PRODUCTS

Flow Transducers 421



Designed for missiles using thrust vector control, series SF2 flow transducers have ranges of 0 to 0.5 gal per sec through 0 to 200 gal per min. A signal-conditioning amplifier can be incorporated in the transducer which will provide a 5-v full scale output. Sensitivity is 4 mv per v; linearity is 2% of full scale; repeatability is less than 0.25%; flow is unidirectional. Infinite resolution permits sensing down to zero flow.

Standard Controls, Inc., Dept. ED, 1130 Poplar Place, Seattle 44, Wash.

Reed Relays 420

Encapsulated reed relays have electrostatic shields completely surrounding their glass switching elements. This isolates the reed contacts from stray electrical noise or random pickup of unwanted signals. They are available in 1, 2, 4, 12, and 20 pole types.

Struthers-Dunn, Inc., Dept. ED, Pitman, N.J.

Miniature Gyro 423

Floated, integrating, miniature gyro SYG-1000 weighs less than 1 lb and is less than 3-in. in length. Drift sensitivity is less than 0.005 deg per hr/g² under vibration tests of 20 g. Random drift cogging tests show standard deviations of 0.007 deg per hr in azimuth position and 0.005 deg per hr in vertical position.

Sperry Gyroscope Co., Dept. ED, Great Neck, N.Y.

Flat Ribbon Cable **424**

Multicolored, multiconductor flat ribbon cable is designed for ease of handling, full visibility of color-coding, and control of inter-conductor capacitance. Insulation is P.V.C. plastic; gages are from 10 to 30 AWG. Shielded leads, coaxial or thermocouples can be included.

Spectra-Strip Wire and Cable Corp., Dept. ED, P.O. Box 415, Garden Grove, Calif.

Special Purpose Motor **419**

Limited duty cycle, dc motor is a special purpose unit designed specifically for missile environments. Weighing only 6.7 lb the motor produces 3.25 hp at 13,700 rpm using 30 v dc. Over-all efficiency is 75%. Use of lightweight radio-noise filters is permitted by improved commutation and attendant low noise level.

Task Corp., Dept. ED, 1009 E. Vermont Ave., Anaheim, Calif.

Germanium Alloy Transistors **413**

General purpose npn and pnp germanium alloy transistors types 2N358A, 2N428, 2N526 and 2N396A meet the mechanical and environmental requirements of MIL-S-19500. The hermetically sealed devices are designed for both amplifier and switching applications in the audio frequency range. They use a TO-5 package.

Sylvania Electric Products Inc., Dept. ED, 730 Third Ave., New York 17, N.Y.
Price: From $1.50 to $6.51.

Crimp Connector **463**

Heavy-gauge wire is accepted by UL-approved crimp connector No. 412. It will handle combinations from one No. 14 with one No. 16 up to one No. 6 with two No. 8 wires. Sleeve is cadmium-plated steel, crimped with a standard tool. Locking, wrap-around insulator is polyvinyl chloride.

Ideal Industries, Inc., Dept. ED, 5098 Park Ave., Sycamore, Ill.

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THE SPARE PARTS PROBLEM

The Electronics Business may not be the most tranquil enterprise for anyone to get into — either as a buyer or seller — as evidenced by one of the problems currently plaguing both component makers and their customers. In a nutshell, the trouble is "equivalent" parts, made by a low bidder, failing to behave as the originals did. The explanation, while not as simple as this, seems to boil down to the fact that specs and descriptive data alone aren't enough for anyone to duplicate the *performance* of somebody else's original part. It could be a matter of the inability of the blueprint and the mimeograph machine to be a satisfactory substitute for the original manufacturer's experience, engineering skill, assembly methods and quality control.

No one can argue the merits of saving money, and a good part at the lowest possible cost is a commendable achievement. But when "low quote" means failure of critical equipment and personal hazard, there's not much to be said for economy. On the other hand, if the low man *does* get all the information he needs to build an exact replacement of the original part (assuming he can build it), he is automatically getting the benefit of a great deal of work done and paid for by the original manufacturer. The polite term is usually "proprietary data." Understandably, this arouses the "unfair competition" ogre.

We don't like to give away proprietary information any more than the next person. Neither do we like to see unreliable components endangering life and limb. We think part of the answer may be to give the second man the same *problem* you gave the original supplier—not the blueprinted solution to imitate. Then test his result as carefully as you did the original successful one. This way, the odds are strongly in favor of your getting something that *will* work — and perhaps work even better.

What do you think the answer is?

* *E. W. Schrader, Western Editor of DESIGN NEWS, made some good observations on this whole subject. see pp. 6-7, Jan. 16 issue.*

NEW PRODUCTS

Rear Projection Indicator 418

Model 12-R rear projection indicators contain 12 individual projectors, each centered on a single front screen. The unit measures 3/4 x 1-1/8 x 3-3/4 in. with a viewing screen 0.5 in. high x 0.4 in. wide.

Tasker Instructions Corp., Dept. ED, 7838 Orion Ave., Van Nuys, Calif.

Telemetry Receiver 405

For fm, am, and cw signals in the 30 to 260 mc model 1907 telemetry receiver is compact and lightweight. An am noise limiter is adjustable from the panel; a carrier-operated relay is provided. A bandswitch-controlled coaxial relay switches antenna inputs. Panel control selects if bandwidth and mode. Rack-mounting set is 3-1/2 in. high and weighs 25 lb.

Vitro Electronics Div., Vitro Corp. of America, Dept. ED, 919 Jesup-Blair Drive, Silver Spring, Md.

Analog Memory 412

Drift free analog memory model DAM 18-A makes and stores a digital conversion of an analog voltage. Incidental capabilities of each channel include digital to analog conversion rates up to 100 kc and analog to digital conversion at rates up to 6 kc. One standard rack mounts 18 channels with power supply.

Stony Brook Laboratories, Inc., Dept. ED, 55 State Road, Princeton, N.J.
P&A: $17,900; 90 days.

Trimming Potentiometer 415

The high-temperature plastic case of this trimming potentiometer eliminates insulation problems. Specifications are: resistance range, 10 ohms to 35 K; power rating, 3/4 w at 50 C; dielectric strength, 500 v ac, 1 min.

Techno Components Corp., Dept. ED, 18232 Parthenia St., Northridge, Calif.

Immersion Gold 416

Neutral immersion gold offers a fast means of depositing thin plates of 24 carat gold directly on copper, brass, nickel, iron, lead and solder plates without the use of anodes or currents. Direct deposits of 70 millionths of an inch in 30 min are possible over solder.

Technic, Inc., Dept. ED, P.O. Box 965, Providence, R.I.

Price: From $42 to $48 per Troy oz.

Vacuum-Coated Metals 406

Refractory metals such as tungsten and molybdenum can be supplied with a vacuum coating diffused into the base metal. Coatings include noble metals, aluminum, nickel, alloys and dielectrics. Selective and patterned coatings are possible. Thickness ranges from a few molecules up to 0.005 in. or more.

Vacuum Technology, Inc., Dept. ED, 7933 Gloria Ave., Van Nuys, Calif.

Rack Devices 409

Rack-mounted chassis capability is improved with a series of packaging devices. Connector drive handles permit disengagement or reconnection of slide-mounted chassis with fixed rear connections. A cable carrier is made to eliminate sagging, binding and twisting. Thin-line chassis slides of 1/2-in. width max carry up to 200 lb.

Jonathan Manufacturing Co., Dept. ED, 720 E. Walnut Ave., Fullerton, Calif.

Silicon Rectifiers 410

Miniature, hermetically sealed, silicon rectifiers, the Trimline series, are designed to replace the top hat type. Current ranges are up to 1,000 ma at piv ratings up to 2,200 v.

Slater Electric and Manufacturing Co., Dept. ED, 241 Sunrise Highway, Rockville Centre, N.Y.

Epoxy Laminate 459

Is flame-retardant. Epoxy resin laminate G-10-839 is a glass-base, flame-retardant material designed for ease of fabrication. It is available in sheets of 40 x 48 in. with thicknesses from 1/32 to 1 in. The 1/16-in. thickness can be sheared and punched with minimum heating. The laminate meets requirements of MIL-P-13949, and can be furnished copper-clad.

Spaulding Fibre Co., Inc., Dept. ED, 310 Wheeler St., Tonawanda, N.Y.

NEW PRODUCTS

Subcarrier Oscillators 460

Are highly stable. Operating on all standard IRIG subcarrier frequencies, these subcarrier oscillators show stable properties over a wide range of temperatures. The TEX-3000 oscillator has a sensitivity of 5 v peak-to-peak for 100% deviation. Deviation is ±7.5% in channels 1 through 18 and ±15% on channels A to E. The TEX-3100 oscillator has a sensitivity of 0 to 20 mv or ±10 mv for 100% deviation for channels 1 through 18 and ±20 mv for channels A through E.

Sonex, Inc., Dept. ED, 20 E. Herman St., Philadelphia 44, Pa.

Receiving Tubes 461

With 26.5-v heaters. Subminiature receiving tubes with 26.5-v heaters are available in three models. Type 7887, a medium-mu double triode for oscillator, amplifier and low-power servo circuits, replaces type 6111. Type 7888, a high-g_m, medium-mu triode for uhf oscillator and low-frequency oscillator and amplifier applications, corresponds to type 5718. Type 7889 is a high-mu double triode similar to type 6112, used in low-level audio circuits.

Sylvania Electric Products Inc., Dept. ED, 730 Third Ave., New York 17, N.Y.

Parametric Amplifiers 454

For 2,190 to 2,300 mc. Miniature microwave parametric amplifiers make use of a set of variable-capacitance diodes distributively coupled to a helix. Prototype SS-1000 delivers 1 mw with 15-db minimum gain and noise factor of 7.5 db max from 2,200 to 2,300 mc. Variant SS-1000V1 delivers 1 mw with 17-db minimum gain and 6-db noise max from 2,190 to 2,210 mc. Both have excellent stability, do not require a circulator, and are contained in miniature packages without tuning stubs. Pump source frequency is 30% above signal frequency; pump power is 300 to 400 mw. Variants of the amplifier range from 1,750 to 3,000 mc, with bandwidths to 100 mc.

Radio Corp. of America, Electron Tube Div., Dept. ED, Harrison, N.J.

Accuracy Is Our Policy . . .

The New Product description of power supply model 890A, made by Harrison Laboratories Inc., 45 Industrial Road, Berkeley Heights, N.J., gave power rating as 0 to 6 amp. The correct rating is 0 to 320 v dc at 0 to 0.6 amp. The item appeared on p 179 of the March 1 issue.

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MICROWAVES

MICROWAVES

Shoring Up Microwave Gains

Microwave technology has moved so far so fast, that like a rapidly advancing army, it has outrun its supply lines. One vital area where some backing and filling must now occur is in microwave calibration standards. As the report on the facing page reveals, money spent on standards now is money saved both in the long and the short run.

Another example of how designers can fill in the chinks as the technology matures is the article in this issue describing an elegantly simple concept for electronically scanned antennas.

R&D continues to extend the state of the art, but we can expect considerable achievement in the more prosaic area of following up the breakthroughs with good, sound design.

The damaging lack of microwave standards and joint industry-NBS attempts to solve the problems are described in

Hybrid couplers form the basis of a new scanning matrix that drastically reduces the number of components required in corporate structure antennas. For details and performance, read

Eliminating RFI and harmonics in microwave testing often calls for nonstandard filters. These can be readily designed and fabricated in-plant from available materials as described in

An 18-Gc backward-wave oscillator and a small traveling-wave tube delivering up to 28 w cw from 5 to 11 Gc are featured in

Closing the Gap in Microwave Standards

A GRADUAL attack on glaring deficiencies in microwave standards is under way, thanks to joint action by industry and the National Bureau of Standards. However, a lack of adequate standards will continue to plague industry and hamper the growth of microwave technology unless the pace of research and financing is greatly accelerated.

The vehicle for this industry-NBS teamwork is a continuing series of Measurement Research Conference meetings organized by the quality control committee of the Aerospace Industries Association. These meetings, and an industry survey of measurement needs, were undertaken at the request of the Air Force, with the Sperry Gyroscope Co. serving as project sponsor.

At almost half of the meetings held or scheduled to date microwave standards have been either the sole or principal topic of discussion. The most recently concluded meetings, in late January, dealt with pulse voltage, rf voltage, field strength, rf peak power and noise—all in the microwave spectrum. Earlier meetings in 1960 covered microwave power and attenuation. Forthcoming meetings will discuss impedance (June), material measurements (November), and frequency calibration (early 1962).

At these meetings industry can explain its particular measurement problems to NBS and recommend how the bureau may invest its limited R&D budget most effectively. Bureau scientists, on the other hand, counter with suggestions of how industry might reduce the work load imposed on NBS.

Snarl in Standards Costs Industry Money and More

With frankness on both sides, some rather grim instances have been revealed of the price industry is paying for inadequate standards.

- A company scheduled to deliver an order of 400 parametric amplifiers last year delivered only 50 and is producing the balance at half the scheduled rate. Lack of proper noise measurement standards has delayed design, production and testing of these $10,000 amplifiers.
- Test equipment worth $250,000 is shuttling between vendor and client. They cannot agree on peak power performance of the units because of differently calibrated inspection equipment.
- A large organization has three engineers permanently assigned to resolving discrepancies between its own test instruments and those of the company's suppliers. They've been on the job three years now and look forward to continued employment.
- Another company spent $25,000 for radio-frequency-interference measuring equipment and then had no confidence in the indicated results.
- Radars have been closed down because of uncertainty as to their radiation hazard to personnel.
- Almost a million dollars was wasted in the design of a radome because of a lack of attenuation calibration services in Ku band accurate to a few tenths of a decibel in a 60-80 db range.

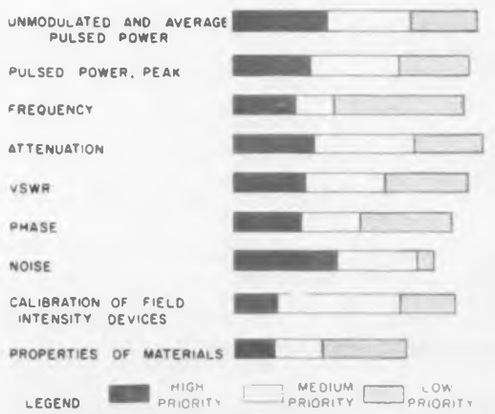
Overdesigning Among Evils Spawned by Uncertainty

Repeated instances have been cited where equipment was overdesigned to compensate for the uncertainty of test measurements. Often microwave tubes contain built-in adjustors that would be unnecessary if performance could be measured accurately in the first place. Weight, size and cost increases for equipment, caused by uncertainty of calibration, were continuously reported by conference participants.

For its part, NBS complained about the type of equipment sometimes submitted for calibration, unusual calibration requests, and imperfect knowledge of the equipment on the part of those who submit it. For example:

- One of the better known makes of attenua-

Rotary-vane broadband attenuator on table stirs discussion among Sperry Gyroscope engineers (left to right) Allan James, Lloyd Wilson and John Korewick.



Priorities of microwave calibration needs, according to a 40-company survey by Aerospace Industries Association. Highest priority needs are for power, attenuation and noise standards.

tors was found to be position-sensitive. The device exhibited substantially different attenuations when oriented vertically and horizontally.

- Attenuators can be thrown out of adjustment by the torque exerted on the unit by poorly mated waveguides. The guides should be carefully fitted to the attenuator.
- Many of the standards submitted for calibration are not designed for interlaboratory transfer. They travel poorly and are difficult to adjust.
- Much of the equipment submitted is of test-bench quality and does not have the inherent accuracy to warrant calibration against a primary standard.
- Requests are received for calibration at non-standard frequencies and power levels. The bureau can process most efficiently calibrations that have been reduced to routine.
- Defective equipment is occasionally submitted. Often adjustment and scale dials have excessive backlash, which destroys whatever calibration accuracy the bureau would specify.

Power, Attenuation and Noise Standards Needed Urgently

Industry spokesmen, on the other hand, complain that NBS is too conservative in specifying calibration accuracies, takes too long to perform calibrations, and offers only a limited range of microwave services.

The most urgent microwave standards requirements are for power, attenuation and noise, according to an AIA survey of 40 microwave companies. Generally these standards should extend beyond X-band and should cover extreme high and low limits of performance.

"The newness and rapid growth of microwave technology has resulted in a serious lack of standards that is costing industry millions of dollars each year," declares Lloyd Wilson, chief of Sperry's primary standards laboratory and a member of the AIA measurements project team. He adds that because of this gap, companies are establishing their own standards, whose compatibility with standards of other companies and the military is questionable.

The present jam-up at NBS is essentially one of too much work and too little money (see Editorial, "A Fair Week's Work for a Fair Day's Pay," Aug. 17, 1960, ELECTRONIC DESIGN). Bureau funds were cut during the 1950's and personnel has only now returned to the level of ten years ago.

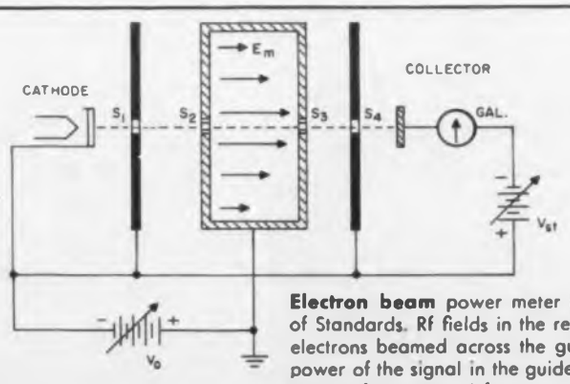
Microwave instruments are submitted for calibration in large quantities. During the latter half of 1960, the NBS radio standards division at Boulder, Colo., calibrated 156 microwave standards for industry. The time expended was approximately 1,500 man-hours.

Microwave calibration services now available include:

- Attenuation—300 mc to 18 Gc, 0 to 50 db, directional couplers.
- Frequency—300 mc to 75 Gc, cavity meters.
- Power—8.2 to 12.4 Gc, 0.1 to 10 mw, bolometer mounts, and 10 to 100 mw, dry calorimeter.
- Impedance—8.2 to 14 Gc, vswr 1.01 to 1.5, waveguide reflector.

Stringent Budget Slowing Microwave R&D Progress

To expand this range of services, NBS has a budget of only $300,000 for microwave R&D for



Electron beam power meter being developed by the National Bureau of Standards. Rf fields in the rectangular waveguide affect transit time of electrons beamed across the guide. Beam intensity is proportional to the power of the signal in the guide. The device is thought usable over a wide range of power and frequency with accuracy of 1 per cent.

this fiscal year. In response to military and industrial requirements, the bureau is advancing development of several new microwave standards for future introduction. However, Robert Beatty, chief of the microwave circuits section at Boulder, notes that the shortage of funds and personnel restricts development and that some of these new standards may be a year or more removed from operation.

The most likely candidate for early application is a noise standard to operate at several frequencies in X band. The device will calibrate gas-discharge tubes against a hot load. Calibration is expected to cover an excess noise ratio of about 15 db with an accuracy of ±0.03 db. NBS hopes to make this service available before the end of 1961.

Also on the way is a field-strength standard that will calibrate the gain of microwave horns at X band. Horns will be calibrated over a range of 10 to 20 db gain, accurate to 0.1 db. Introduction of this standard is stalled for lack of a microwave dark room to perform tests.

A new type of microwave power standard employing electron beams is also being developed at NBS. The technique consists of accelerating an electron beam transversely through an evacuated section of waveguide. Intersection between the fields in the guide and the beam makes the transit time of the electrons vary according to the rf power in the guide.

An X-band standard is being built along these lines to measure peak or average power from 100 w to 100 kw. The technique could be extended to cover a wide range of frequencies and powers. Accuracy should be about 1 per cent.

Another novel technique in development at NBS is a two-channel modulated sub-carrier means to measure phase shift but that can also be applied to a variety of other microwave measurements. The channel containing the device under test is audio-frequency modulated. This channel is mixed with an unmodulated channel and fed to a crystal detector. Thus the microwave measurement is essentially performed at a lower frequency, where a variety of accurate standards are already available. When completed, the two-channel phase-shift standard will operate in X band with an accuracy of 0.1 deg.

Also being readied by NBS is a high-power adiabadic calorimeter to measure average power from 1 w to 100 w at X band. The projected accuracy is 1 per cent. ■ ■

MICROWAVES

Beam-Forming Matrix Simplifies Design of Electronically Scanned Antennas

A drastic reduction of components in electronically scanned arrays is achieved by using a matrix of hybrid dividers in place of the usual three-port dividers. A 64 x 64 array would require less than 25,000 hybrids as compared to almost one-half million three-port dividers needed in a conventional design. Authors Jesse Butler (left) and Ralph Lowe also describe an auxiliary combining network to form cosine order beams which require only a few additional hybrids.

Jesse Butler,* Ralph Lowe
Sanders Associates,
Nashua, N. H.

ELECTRONIC scanning of corporate structure antennas ordinarily requires a separate power dividing and phasing matrix for every beam formed. Thus, the number of components needed for large, fully steerable arrays can reach astronomical proportions.

To form a single beam in a conventionally designed 64-element linear array requires 63 power dividers. In the Sanders beam-forming matrix, however, a network of 192 hybrids forms 64 independent beams from the same 64-element array. Each beam has the full gain corresponding to the projected aperture of the array. Beams overlapping at the $2/\pi$ voltage levels essentially cover a full hemisphere of space.

This performance is achieved by utilizing the phase shifts occurring in hybrid dividers.

The basic unit of the system is a 3-db directional coupler combined with a fixed phase shifter or differential length of transmission line (see Fig. 1). A signal fed to one of the four ports is divided into two equal outputs. One output remains in relative phase with the input, while the other is shifted in relative phase by 90 deg. (In Fig. 1 and throughout this article, the 90-deg phase shift occurs between diagonally opposite ports.)

Conversely, two signals 90-deg out of phase applied to different ports are coupled into one of two mutually isolated ports. Isolation between ports exceeds 20 db. This signal-combining mode occurs when the array functions as a receiving antenna. In a transmitting array, the hybrids operate as signal dividers.

To form a multiple-beam array, the phase of each radiating element is assigned by the following rule:

> In a linear array of 2^m equispaced elements, the phase difference between any two elements 2^{m-1} apart increases (or decreases) 90 deg when the antenna pattern axis is rotated by slightly more than 1/2 of the 1/2-power beamwidth.

Hybrid phase shifter "building blocks" are combined accordingly.

An eight-element, eight-beam array designed in this manner is shown in Fig. 2. Note the separate input terminals corresponding to each beam. All elements radiate regardless of the beam that is being formed, but their phase relationships are varied for each beam by the passage of the signal through the matrix.

To illustrate, signal flow for the "2 Right" beam is shown in color in Fig. 2. Phase shifts are expressed in units of $\pi/16$. Signals traversing a hybrid *diagonally* are shifted 90 deg (eight units). Fixed phase shifters, represented by circles, impose additional phase shift denoted by the number within the circle. Phase shifts at various internal points in the matrix are indicated, as

Table 1. Radiating element phases for eight-beam array

		Radiating Element							
Beam	Phase Diff.	A	B	C	D	E	F	G	H
		Relative Phase							
4L	$14\pi/16$ rad	16	30	12	26	8	22	4	18
3L	$10\pi/16$ "	12	22	0	10	20	30	8	18
2L	$6\pi/16$ "	10	16	22	28	2	8	14	20
1L	$2\pi/16$ "	10	12	14	16	18	20	22	24
1R	$-2\pi/16$ "	24	22	20	18	16	14	12	10
2R	$-6\pi/16$ "	20	14	8	2	28	22	16	10
3R	$-10\pi/16$ "	18	8	30	20	10	0	22	12
4R	$-14\pi/16$ "	18	4	22	8	26	12	30	16

Note: Phase is expressed in units of $\pi/16$ radians

*Now with Advanced Development Laboratories Nashua, N.H.

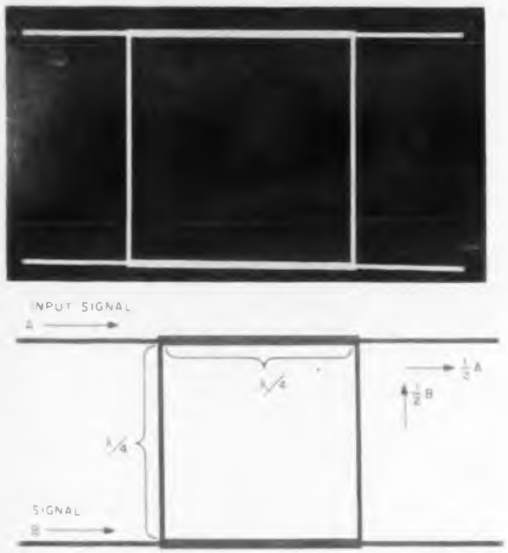


Fig. 1. Hybrid divider printed on Tri-Plate. Relative phases and amplitudes of output signals are shown.

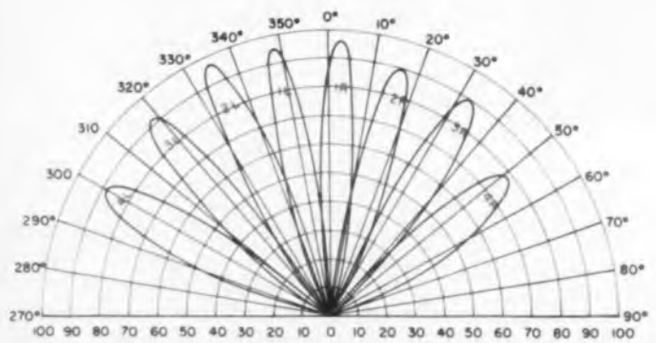


Fig. 3. Eight-beam radiation pattern formed by Sanders matrix. Beams overlap at the —4-db points. Radiating elements are spaced at half-wavelength intervals. Beams are amplitude-tapered.

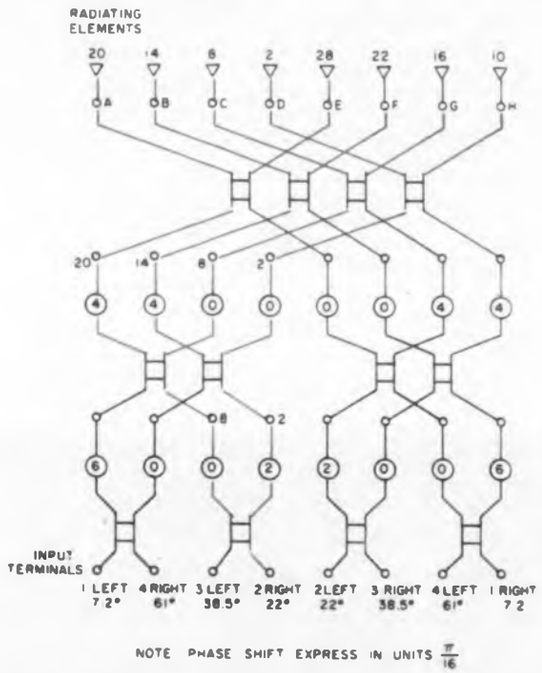


Fig. 2. Eight-element, eight-beam matrix. Signal path for the "2 Right" beam is shown in color. Squares denote the hybrid couplers used in the matrix; circles denote fixed phase shifters. Numbers within the circles indicate the amount of phase shift applied. Relative phase shifts of signals are shown at various points in their passage from the input terminal to the radiating elements. Note that signals crossing a hybrid diagonally are shifted eight units (90 deg).

are the final shifts at the radiating elements with respect to the input.

Output phases for each of the eight beams are listed in Table 1. The phase differences between adjacent radiators are uniform for any given beam, but vary from beam to beam as shown.

In this array, $2^{m-1} = 4$. As required by the previously stated rule, the phase difference between radiators so spaced changes 90 deg when the beam is shifted. For example, the phase difference between elements *A* and *E* is −8 units for the "4 Left" beam. This relationship also holds between elements *B* and *G*, elements *C* and *H*, etc.

The eight patterns formed by this array overlap at the −4 db points. Elements are spaced

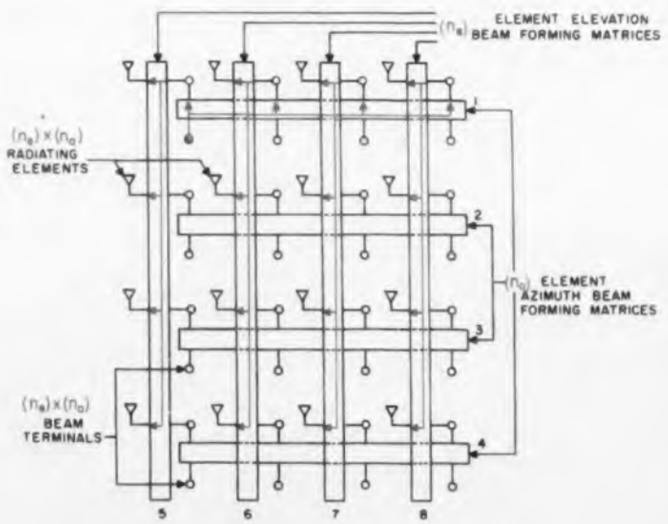


Fig. 4. Two-dimensional, 4 x 4 hybrid matrix. Signal flow for one beam is shown in color. The azimuth-directive pattern formed by one set of matrices is superimposed on elevation-directive pattern formed by second set of matrices. Result is a choice of 16 pencil beams. ventional design would require Unit employs 32 hybrids; con- 96 three-port dividers.

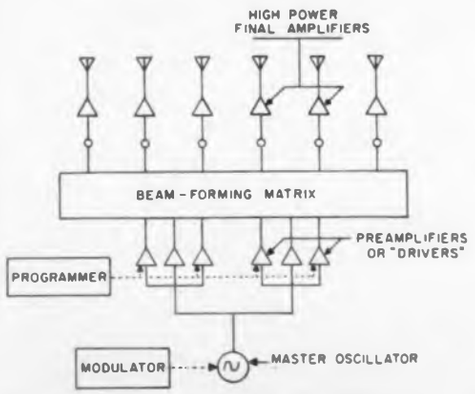


Fig. 5. System diagram for high-power steerable array transmitter employing beam-forming matrix. Input terminals are scanned by programer controlling the drivers. Master oscillator can be modulated for communications purposes, and individual amplifiers for each radiator result in high-power system.

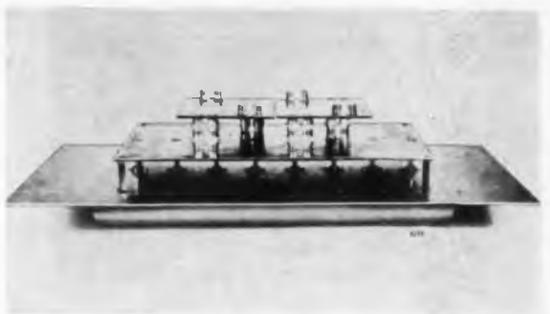


Fig. 7. Eight-element beam-forming matrix built for Jet Propulsion Laboratory. Operating frequency is about 2.1 Gc, bandwidth about 50 mc. Radiators are housed within the cylinder at bottom of unit. Entire assembly is about 40 in. long.

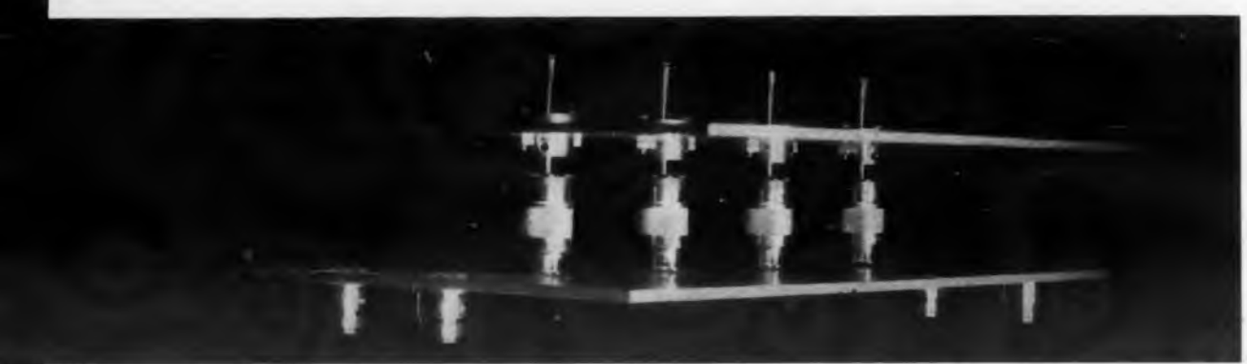


Fig. 6. Four-element beam-forming matrix built on Sanders Tri-Plate. Coax-fed dipole radiators are cut for 3 Gc. Operating bandwidth of unit is about 50 mc.

at half-wavelength intervals and the eight patterns cover almost 180 deg (see Fig. 3).

A 16-element array can be designed by paralleling the matrix of Fig. 2 with an identical network and adding a set of cross-connections through hybrids at the radiating elements.

The extension of this technique to a two-dimensional array is shown in Fig. 4. This simple 4 x 4 array requires eight matrices and a total of 32 hybrids.

Azimuth scanning is controlled by the four horizontal matrices (Nos. 1-4); elevation is controlled by the four vertical matrices (Nos. 5-8). Note that all similar output elements of the horizontal matrices are tied into one vertical matrix. For example, the extreme left-hand outputs of the horizontal matrices are connected to vertical matrix No. 5, while the extreme right-hand outputs are connected to vertical matrix No. 8. Conversely, four identical inputs to the vertical matrices are driven by the same horizontal matrix.

This interconnection scheme permits the vertical matrices to superimpose an elevation-directive phase pattern onto the azimuth-directive phase pattern developed by one horizontal matrix. The result is a choice of 16 pencil beams in two-dimensional space.

The number of hybrid building blocks required to form n beams in either a linear or two-dimensional array of n elements is $n/2 \log_2 n$. Thus, a 64 x 64 array capable of forming 4,096 pencil beams requires 24,576 hybrids. Conventional designs of this capability would require almost 1/2 million power dividers.

The Sanders beam-forming matrix can be considered as a black box with n input terminals and n radiating element terminals. The array could be scanned by a system such as shown in Fig. 5. Medium-power drivers excited by a master oscillator are used as control switches to excite one or more input ports for beam steering. A separate, final amplifier at each element would result in an extremely high power system. In addition, the master oscillator could be modulated for communications purposes. The same black box could also be used in scanning a receiving array with equally flexible applications in radar, countermeasures and communications.

Both the hybrids and fixed phase-shifters can easily be designed for efficient operation over a 50 per cent bandwidth. As the frequency increases, element spacing becomes greater than 1/2 wavelength and the beams narrow and shift toward the broadside axis. However, the same —4-db crossover level between adjacent beams is maintained.

Any two beams in the system couple at only one level in the matrix, so that isolation between any two input terminals or two output terminals is greater than the isolation of a single hybrid. Isolations of 25 to 40 db are easily attainable.

The hybrids can be waveguide top-wall or side-wall couplers, or branch-line and parallel-line couplers in waveguide, coax cable or strip-transmission line.

Several experimental arrays have been built to test this design concept. The unit shown in Fig. 6 is a four-element array for 3-kmc operation using directional couplers printed on Sanders Tri-Plate® components. Coaxially fed dipoles serve as radiating elements. A larger, 2.1-kmc array with eight radiating elements was built for the Jet Propulsion Laboratory. (See Fig. 7.) Both of these models were designed for bandwidths of only 50 mc.

Typical beam patterns obtained with the eight-element array are shown in Fig 8.

The largest matrix built to date is a 16-element unit delivered to Lincoln laboratory. This model operates at 900 mc over a 30 per cent bandwidth.

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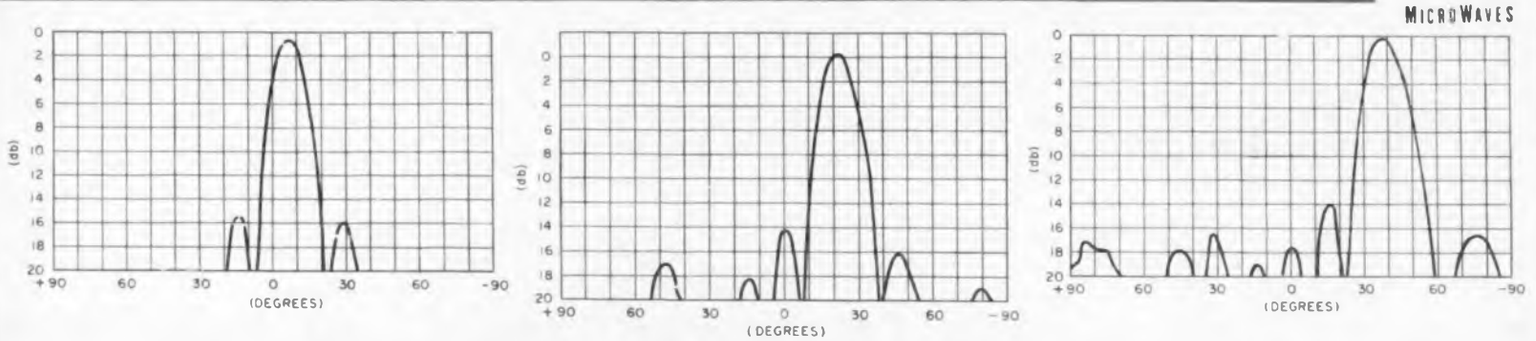


Fig. 8. Three typical beam patterns of unit delivered to JPL. (See Fig. 7.) From left to right: the "1 Right," "2 Right" and "3 Right" beams. Increase in number of sidelobes as beam moves off center is due to reduced projected aperture of the array. Measurements were made at about 2.1 Gc with amplitude tapered illumination. Cosine order beams with reduced sidelobes are discussed in latter half of this article.

Again considering the matrix as a black box, additional hybrid networks can combine adjacent or overlapping beams to form cosine order beams. As contrasted to the —13-db sidelobes for uniform illumination, cosine taper sidelobes are —23 db, while cosine squared taper sidelobes are —32 db.

Two adjacent beams can be combined with an appropriate phase shifter to form a cosine tapered beam as shown in Fig. 9. The phase shifter adjusts the phase center of one beam to coincide the phase center of the second beam. Isolation between beams is provided by the hybrid coupler, whose unused ports are terminated in a load that matches line impedance.

Several adjacent cosine beams can be formed as shown in Fig. 10. The combining network imposes a 3-db insertion loss, as the power in the matrix beams must be divided between the adjacent beams formed by the network. This power loss is partially compensated by the tapered illumination of the cosine beam.

Individual and adjacent cosine squared beams, which combine three matrix beams, are formed in similar fashion, as illustrated in Figs. 11 and 12, respectively. Again, hybrids provide inter-beam isolation.

In general, the number of adjacent higher order cosine beams that can be formed by an n-beam matrix is n-y, where y is the order of the cosine function.

Preliminary study has shown that dissipation losses in the beam-combining network are less than would result from loss tapering the amplitude of each antenna element in the array.

As the order of the cosine function increases, network losses are proportionately reduced as compared to the losses suffered in tapering the individual antenna elements.

In cosine taper illumination, however, network and antenna amplitude tapering losses are approximately equal. ■ ■

Fig. 9. Hybrid connected to form cosine taper illumination beam. Phase shifter adjusts the phase center of one matrix beam to coincide with the phase center of the second matrix beam.

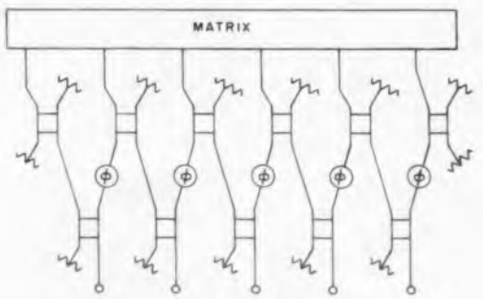


Fig. 10. Several adjacent cosine tapered beams are formed by this pairing of matrix beams. Anyone of five cosine beams can be generated by this network.

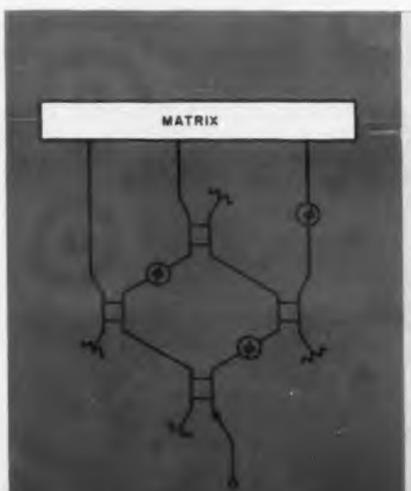


Fig. 11. Three matrix beams are combined by this network to form a cosine squared tapered beam. Unused ports are terminated in loads matching the transmission line

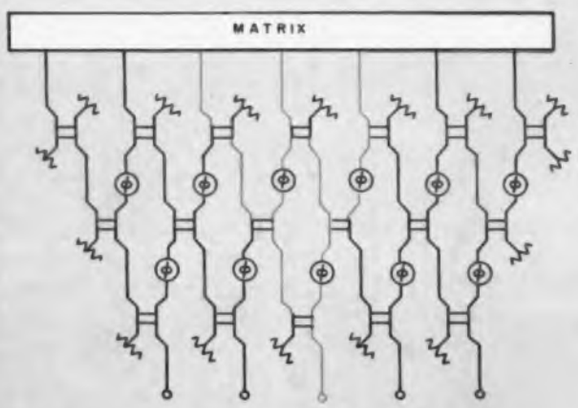


Fig. 12. Matrix beams are combined three at a time by this network to form adjacent cosine squared taper beams. Signal flow for one of the cosine squared beams shown in color.

MICROWAVES

Rapid Design of Coaxial Low-Pass Filters

A convenient method of designing nonstandard, low-pass coaxial filters with pass bands in the 1- to 8-kmc range. Author Bostick has designed more than 25 such units to eliminate RFI and harmonics in field and laboratory testing of radar gear. The filters are readily assembled from stock materials.

Glyn Bostick
Chief Engineer
Radar Design Corp.
Syracuse, N. Y.

THE "varying impedance" type filter can be readily tailored for a desired cut-off frequency in the 1 to 8 kmc frequency range and machined from stock tubing, rod and connectors.

The filter (See Fig. 1) derives its periodic changed characteristic impedance from periodic changes in center conductor diameter. The unit is assembled within a tube chosen to match the diameter of connectors employed in the rest of the system. Impedance matching sections at each end provide sharp cut-off.

The following design procedure yields the number, thickness and spacing of the filter discs and of the end sections. Insulation is assumed to be Rexolite, styrene, or other suitable plastic with a dielectric constant of about 2.50.

Equations are given for quick computation of average and peak power. Charts of insertion loss and vswr are included to indicate "safe" operating specifications.

The pertinent design specifications are:

- F_c—Cut-off frequency (the frequency for 3-db attenuation)
- A_1—Attenuation (in db at a specified frequency $F_1 > F_c$)
- Power handling (average and peak)

Once the above are specified and a tube of diameter *(D)* compatible with the required line size and connectors is chosen, all filter dimensions can be computed from Table 1.

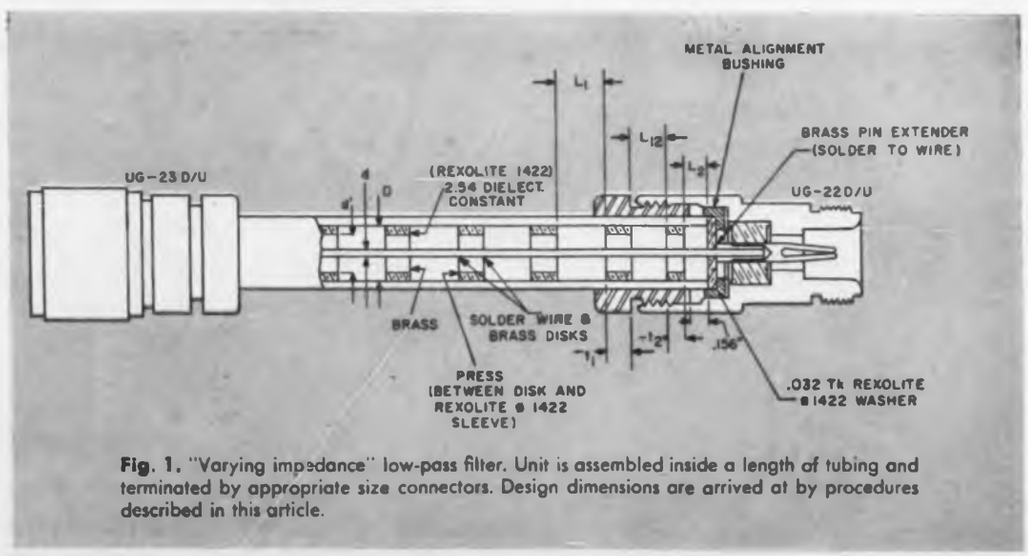


Fig. 1. "Varying impedance" low-pass filter. Unit is assembled inside a length of tubing and terminated by appropriate size connectors. Design dimensions are arrived at by procedures described in this article.

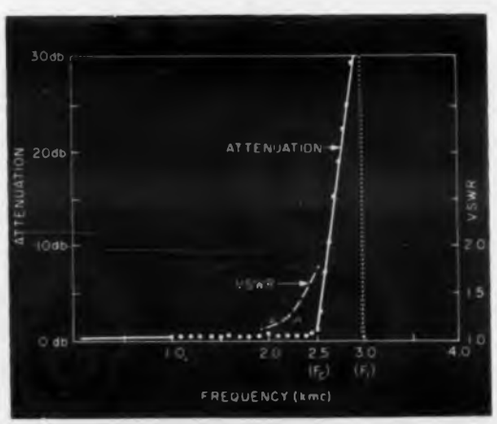


Fig. 2. Performance curves of low pass filter. Unit was designed for cut-off frequency (F_c) of 2.5 kmc, and for 30 db attenuation at 3 kmc. Design exceeds performance specifications.

Table 1. Design data for "varying impedance" low-pass filters

Dimension	Value
D/d'	1.42
D/d	8.5
θ_2 (radians)	$= 2\ \mathrm{Tan}^{-1}(\mathrm{Tan}\ 15° - 4.2\ DF_c \times 10^{-6})$
θ_1 (radians)	$= 2\ \mathrm{Tan}^{-1}(\mathrm{Tan}\ 15° - 3.2\ DF_c \times 10^{-6})$
t_2	$\frac{\theta_2 \lambda_c}{13.1}$
t_1	$\frac{\theta_1 \lambda_c}{10}$
L_{12}	$\frac{\lambda_c}{9.09}$
L_2	$\frac{\lambda_c}{21}$
L_1	$\frac{\lambda_c}{8}$

NOTE: physical dimensions in inches
angles in radians
frequency in Mcps

Note that the inside diameter of the tube determines the diameters of the center conductor and of the filter disks.

The designer next computes θ_1 and θ_2—the effective electrical lengths between filter disks and between the filter and end disks. These dimensions, together with the cut-off wavelength, determine the thicknesses of the disks.

The spacing between each pair of filter disks is L_1; the spacing between end disks and filter disks is L_{12}; and spacing between end disks and the end of the filter is L_2. Each of these spacings is a fraction of the cut-off wavelength as indicated in the table.

The total number of filter disks (N) is given by:

$$N = \frac{A_1}{35\left[\frac{F_1}{F_c} - 1\right]} \quad \text{(Rounded up to the next higher integer)} \qquad (1)$$

Where:

F_1 = attenuation frequency
A_1 = attenuation in db at F_1
F_c = cut-off frequency

All frequencies are expressed in megacycles.

Average power rating is established as that power which can be handled without filter tem-

perature exceeding 70 deg C at 25 deg C ambient. The appropriate equation is:

$$P_{ave} \cong \frac{\pi \lambda_c D}{60} (65N + 100) \text{ w} \qquad (2)$$

The cut-off wavelength (λ_c) and D are expressed in inches.

Peak power, at which arcing will probably occur, is:

$$P_p \cong \frac{d^2}{4} \times 10^6 \text{ w} \qquad (3)$$

Again, d is expressed in inches.

Procedure Demonstrated By Design of Typical Filter

As an illustration of this method, we can consider the design of a filter to the following specifications:

F_c = 2,500 mc
F_1 = 3,000 mc
A_1 = 30 db minimum

Connectors = Type N (3/8-in. line)

P_{ave} = 10 w
P_p = 15 kw

A convenient size tube, requiring little alteration of the type N connectors is 7/16-in. OD (0.312-in. ID) brass tubing.

Next compute the number of filter sections (N) according to Eq. 1.

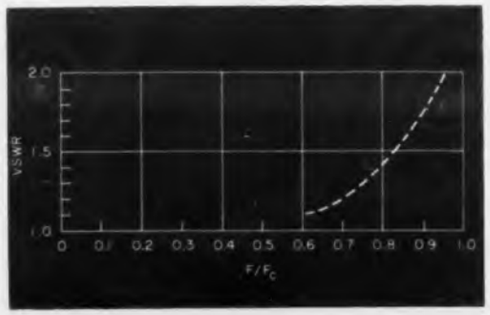


Fig. 3. VSWR characteristic of "varying impedance" filters. Ratio increases sharply as operating frequency approaches cut-off frequency.

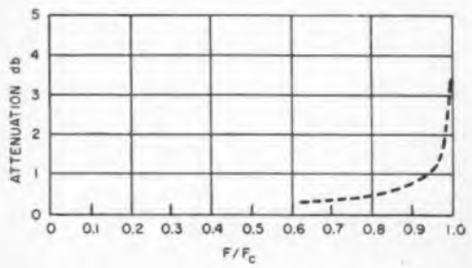


Fig. 4. Insertion loss characteristic of filter. As in Fig. 3, curve shows advantage of operating well below the cut-off frequency.

$$N = \frac{A_1}{35\left[\frac{F_1}{F_c} - 1\right]} = \frac{30}{35\left[\frac{3{,}000}{2{,}500} - 1\right]} = 4.3 \text{ (5 rounded up)}$$

Next check the power rating of the filter by use of Eqs. 2 and 3.

$$P_{ave} = \frac{\pi \lambda_c D}{60}(65N+100) = \frac{\pi \times 4.72 \times 0.312}{60}[(65\times 5)+100] = 32.8 \text{ w}$$

For the peak power calculation, the design table shows $D/d = 8.5$, and $d = 0.0367$ in.

$$P_p = \frac{d^2}{4} \times 10^3 = \frac{(0.037)^2}{4} \times 10^3 = 34.2 \text{ kw}$$

Ratings exceed requirements by a wide margin.

If ratings are too low a larger tube diameter is required. Physical dimensions specified in the table are:

$$L_2 = 0.224 \text{ in.}$$
$$L_{12} = 0.520 \text{ in.}$$
$$L_1 = 0.590 \text{ in.}$$
$$t_1 = 0.225 \text{ in.}$$
$$t_2 = 0.167 \text{ in.}$$

Performance of this filter is illustrated in Fig. 2. Attenuation at 3 kmc (F_1) is well above the required 30 db. The vswr is minimal over most of the passband.

The designer can minimize filter insertion loss and vswr for a given frequency range in the pass band by choosing a sufficiently high cut-off frequency as determined from Figs. 3 and 4. ■ ■

MICROWAVES

MICROWAVE PRODUCTS

Backward-Wave Oscillator 693

Range is 12.4 to 18 Gc

Model OD 12-18 backward-wave oscillator delivers 10 mw min power output from 12.4 to 18 Gc. With uniform power over the range, it is suitable for swept signal generators and similar uses. The helix-type tube is made of hard glass and metal. It is enclosed in a protective metal capsule, with an RG91/U output connector on RG55U coaxial cable.

Stewart Engineering Corp., Dept. ED, Santa Cruz, Calif.
Price: *$1,000.*

Slide-Screw Tuner 695

Cancels small reflections

Precision slide-screw tuner adjusts to very small values of return loss or vswr. Micrometer and dial gage indicators allow precision measurement of phase and amplitude positions. Models 732 through 739 cover frequency spans between 2.60 and 18.0 Gc. The device will tune a 25:1 vswr to near unity, and provides at least one guide wavelength linear travel of probe at each frequency range.

Omega Laboratories, Inc., Dept. ED, Rowley, Mass.
P&A: *$250 to $375; 2 weeks.*

Waveguide Switch 694

For RG-51/U systems

MA-1064 is a spdt waveguide switch for use in RG-51/U waveguide systems over 7.05 to 10.0 Gc range. Switch is rated at 300 kw peak power unpressurized, and 500 kw peak power when pressurized to 2 atmospheres. Insertion loss is 0.15 db, vswr 1.10 max; isolation exceeds 35 db. Holding current is 150 ma; switch may be operated at ambient temperatures to 125 C. A 28-v rotary solenoid provides high operating torque. Switch body is a cube of 1-7/8 in. Switching time is 55 msec max.

Waveguide Systems Div., Microwave Associates, Inc., Dept. ED, Burlington, Mass.

P&A: $395; stock to 30 days.

Traveling-Wave Tube 696

Produces 28 w cw

Up to 28 w of continuous power has been produced over a range of 5 to 11 Gc by the STX-182 traveling-wave tube, with 40 w expected. Using a column of permanent magnet rings as the focusing structure, the tube is 9 in. long and weighs 1 lb. Gain is 32 db. Tube life of more than 2 years under continuous operation in space environment is expected.

Sperry Rand Corp., Sperry Gyroscope Co. Div., Electronic Tube Div., Dept. ED, Great Neck, N. Y.

P&A: Depends on user specifications; 6 months.

MICROWAVES PRODUCTS

Ferrite Modulator 428

Range is 8.2 to 10 Gc

The X-band ferrite modulator model XL400 has a frequency range of 8.2 to 10 Gc and an attenuation range of 40 db min. The vswr is 1.25:1, max; insertion loss is 0.6 db, max. The modulation frequency is 100 kc; solenoid field is 0 to 50 gauss. Similar units are available in frequency ranges from S-band to Ku-band.

Micromega Corp., Dept. ED, Venice, Calif.
Availability: *30 to 90 days.*

Nuvistor Preamplifier 528

The IF71 preamplifier, using nuvistor tubes, is small, light, and requires minimal power. Bandwidth is 8 mc, gain 30 db, noise figure 1.5 db. Intended for use with microwave mixers, input operates from a 300-ohm, 22-pf source.

LEL, Inc., Dept. ED, 75 Akron St., Copiague, N.Y.

C-Band Oscillator 429

Output is 1 kw

A C-band pulsed triode oscillator, the model 301C has an output of 1 kw. Frequency is adjustable from 5,400 mc to 5,900 mc. There is no mode skipping; pushing figure is less than 1 mc, and no special pulse shaping is required. Temperature drift is 20 kc per deg C. The unit will withstand 20-g vibration, 20 to 2,000 cps, ±1 mc fm, and 100-g shock for 6 msec in all planes.

John Gombos Co., Inc., Dept. ED, Webro Road, Clifton, N.J.

Decade Attenuator 500

For dc to 1,250 mc

Model TAD-50 attenuator is designed for rf signals in the range of dc to 1,250 mc. The unit contains three separate turret attenuators, two covering 0 to 50 db in 10-db steps and one for 0 to 10 db in 1-db increments. Internally connected in series, the three provide a total of 110-db attenuation, adjustable in 1-db steps. Power rating is 1 w. Input and output impedance is 50 ohms. The rabbet-box construction used provides for an insertion loss of 0.1 db in the 0-0-0 position at 300 mc, 0.3-db at 500 mc and 0.6 db at 900 mc.

Telonic Industries, Inc., Dept. ED, Beech Grove, Ind.

Price: $325.

Availability: *Immediate, in production quantities.*

Power Supply 430

For klystron pumps

Designed to provide stable klystron pump oscillator voltages for parametric amplifier applications, the MA-2S power supply gives 0.1% regulation despite line voltage changes of ±10 v and frequency changes from 58 to 62 cps. Beam supply is −200 to −400 v at up to 50 ma, with ripple less than 2 mv. Load regulation is 1% max. Reflector supply is 0 to −400 v at 100 μamp max; ripple is less than 1 mv. Heater supply of 6.3 v, up to 2 amp. is provided. The 30-lb unit measures 10-3/16 x 10-13/16 x 14-3/4 in. deep.

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

MICROWAVES PRODUCTS

Strip-Line Devices 703

A 3-db coupler for L and S bands provides isolation greater than 25 db, with coupling of 3 db to ±0.1 db. The directional strip-line device can be also used for a broadband matched power divider, a duplexer or a 90-deg phase shifter. The vswr is less than 1.20. A four-port ferrite circulator, for C and X bands, is also made. Over a 6% band, the 4-oz strip-line device shows less than 0.4 db insertion loss, with input vswr less than 1.3:1. Arm 1 isolation is greater than 20 db, arm 2 isolation greater than 40 db.

Hycon Manufacturing Co., Dept. ED, 1030 S. Arroyo Parkway, Pasadena, Calif.

Coaxial Tuner 701

Model 872A coaxial slide-screw tuner simplifies balancing out small reflections in coaxial systems. It operates over the frequency range of 0.5 to 4 Gc, and can correct a vswr of 5 from 0.5 to 1 Gc and up to 10 from 1 to 4 Gc. Probe insertion is varied with a micrometer drive; position along the line may be read directly on a recessed scale. Probe travel is at least 1/2 wavelength at 0.5 Gc so that any phase reflection may be easily compensated.

Hewlett-Packard Co., Dept. ED, 1501 Page Mill Road, Palo Alto, Calif.

Price: $525.

CIRCLE 199 ON READER-SERVICE CARD

Antenna Amplifier 711

Wide-band antenna amplifier models 780 through 785 provide gain from 19 to 29 db with noise figures from 3.2 to 5.0 db. Five models have pass bands in ranges between 200 and 500 mc; band widths are 40 to 140 mc. Designed for outdoor use, the unit is normally mounted 3 to 5 ft from the antenna. It can be operated continuously at temperatures between −30 and 180 F, with a service expectancy of 10,000 hr or more.

Resdel Engineering Corp., Dept. ED, 330 S. Fair Oaks Ave., Pasadena, Calif.

Price & Availability: *$1,250 to $1,485; 15 days.*

Bandpass Filter 709

For 2.2 to 2.3 Gc frequency band, model FS-205 bandpass filter has insertion loss of 0.25 db in passband and 50 db in stopband. Designed for space environments, the filter withstands 20 g from 25 to 3,000 cps. The vswr is less than 1.2:1; filter can handle 15 w cw at any altitude. Size is about 6 x 2 x 2, weight 14 oz.

Rantec Corp., Dept. ED, Calabasas, Calif.

P&A: *$250 to $400 ea; 30-day delivery.*

CIRCLE 200 ON READER-SERVICE CARD ➤

MICROWAVES PRODUCTS

RF Wavemeter 531

Insertion length is 2-1/4 in.

Model 3170T1000 rf wavemeter, designed as a system component, has an insertion length of only 2-1/4 in. The device will tune to 0.25 cycle per mc per deg F, for any frequency between 5,929 and 7,125 mc over a temperature range of −5 to 140 F. Crystal detector delivers a minimum crystal current of 20 μa to a 3-K load with 100 mw floating in the main line. The vswr is 1.08:1 max; unit weighs 4 lb. The main line is RG-50/U waveguide, terminated in UG-344/U cover flanges.

Telerad Div., The Lionel Corp., Dept. ED, Flemington, N.J.

Price & Availability: *$250 ea; 6 to 8 weeks.*

Waveguide Duplexers 431

Rated at 2 megawatts

Using two atr tubes and one tr tube, these waveguide duplexers minimize incoming signal loss and eliminate the need for a critical transmitter line length. The L-band duplexer, for 1.25 to 1.35 Gc, is rated at 2 megawatts max, average power 4 kw max. The vswr is 1.6 max, and duplexer loss is 0.7 db. Weight is 49 lb. Similar units are available for V, Ka, K, C, S, and P bands.

Bomac Laboratories, Inc., Dept. ED, Salem Road, Beverly, Mass.

Broadband Antennas 512

Provide bandwidth of 10 to 1

Vertical, horizontal, left-circular and right-circular polarizations are provided in bandwidths of 10 to 1 or greater by this line of broadband antennas. Model 12E1-10 has a frequency range of 100 to 1,000 mc with a gain of 8 ±1 db and a vswr of 2.0 to 1 max. Model 13E1-5 has a range of 1 to 5 Gc with a gain of 7 ±1 db and a max vswr of 2.2 to 1.

Litton Systems, Inc., Maryland Div., Dept. ED, 4900 Calvert Road, College Park, Md.

Microwave Absorber 524

Is flexible

Flexible microwave absorber material, type RS, in the form of thin sheets of plastic can be supplied with resonance at any frequency between K- and S-bands. Performance is better than 25 db at resonance. Weight is 0.5 to 2 lb per sq ft depending on frequency. Positive adhesive mounting from −60 to 400 F.

B. F. Goodrich, Dept. ED, Shelton, Conn.

Parametric Amplifiers 513

For L-, S-, C- and X-bands

Environmentally qualified parametric amplifiers for L-, S-, C- and X-bands are designed to utilize a number of varactor diodes now commercially available. An S-band nondegenerate model has a noise figure of less than 3 db, including circulator loss, from −10 to +70 C. A transistorized pump power supply is available as optional equipment.

Hughes Aircraft Co., Dept. ED, Culver City, Calif.

MICROWAVES *PRODUCTS*

Diplexer 504

For 755 to 985 mc

Model 77-001 diplexer is designed for use from 755 to 985 mc. The vswr is less than 1.03; pass band insertion loss is less than 0.1 db and reject attenuation is greater than 75 db.

Antenna Systems, Inc., Dept. ED, Hingham, Mass.

Microwave System 527

For duplex service

Duplex, multichannel service for point-to-point communications of voice, control and data transmission applications is provided by this 6-Gc microwave system. Systems can be installed initially with a few carrier channels and expanded as necessary by adding more channeling equipment.

Lynch Communication Systems Inc., Dept. ED, 695 Bryant St., San Francisco 7, Calif.

Delay Lines 509

Insertion loss is 3 db

Lightweight band-pass delay lines for systems requiring time delay in the vicinity of a fixed center frequency are available in various combinations of operating frequencies and time delays. Typical time delay values of 0.22 μsec at an operating frequency of 60 mc and a bandwidth of 10 mc are available in a unit measuring 1 x 2 x 10 in. Standard 50-ohm cables are terminated in BNC-type connectors.

PCA Electronics, Inc., Dept. ED, 16799 Schoenborn St., Sepulveda, Calif.

Oscillator Assembly 503

Plate voltage is 185 v

X-band cw oscillator assembly has a minimum of 3 mw over a 1% tuning range from 8.5 to 9.6 Gc. Vernier tuning is the only adjustment. Requiring a plate voltage of 185 v and 6.3 v filament, the unit weighs 8 oz.

John Gosbos Co., Inc., Dept. ED, Clifton, N.J.

Waveguide Windows 519

Are solderable

Solderable waveguide pressure windows provide an air-tight seal within waveguide systems and are transparent to microwave energy. Designed for use with EIA sizes WR-90, WR-112, WR-187, and WR-284, all windows are silver plated to reduce rf loss.

Microwave Development Laboratories, Inc., Dept. ED, 92 Broad St., Babson Park 57, Wellesley, Mass.

Directional Coupler 497

Peak power is 5 megawatts

S-band directional coupler, model 45,000, will handle a peak power of 5.0 megawatts at a pressurization of 15 psig. The unit utilizes strip-line techniques and weighs approximately 4 lb. Coupling is −54 db ±1 db, flat to ±1 db. Directivity is 20 db min; vswr is 1.10 to 1 on main waveguide over a 15% bandwidth and 1.35 on auxiliary line.

Transco Products, Inc., Dept. ED, Los Angeles, Calif.

MICROWAVES PRODUCTS

Cavity Amplifiers 444

For L- and S-band use

Four miniature, continuous wave cavity amplifiers, series 30, operate in the frequency range of 215 through 2,325 mc. The units are precision fabricated from light metal alloys and completely gold-plated. Specifications for model P-30 are: low power gain, 16 db; low power output, 2.5 w; high power gain, 10 db; high power output, 25 w; plate power requirements, 600 v at 0.090 amp.

Resdel Engineering Corp., Dept. ED, 330 S. Fair Oaks Ave., Pasadena, Calif.

CW Amplifier 516

For X-band use

Model 30TWA1 cw X-band amplifier produces a nominal output power of 1 kw over a 5% band with a drive power of 50 to 100 w. A bandwidth of 2% is obtained at a fixed voltage and a 5% tuning range is available by varying the beam voltage.

Elliot Bros., Ltd., Dept. ED, 34 Portland Place, London, England.

Bi-Directional Coupler 432

Adjustable from 5 to 70 db

This broadband, precision calibrated variable directional coupler is adjustable from 5 to 70 db. The Delta Coupler may also be used as a variable attenuator. Accuracy is to within ±1 db. A direct-reading dial is provided. Maximum power handling capability is 200 w. The coupler is

available in frequency ranges from 0.5 to 1 Gc through 4 to 8 Gc.

General Precision, Inc., Kearfott Div., Microwave Branch, Dept. ED, 14844 Oxnard St., Van Nuys, Calif.

Mixer Preamplifiers 433

Range is from 1 to 36 Gc

Two series of coaxial and waveguide mixer-preamplifiers, one fully solid-state, the other employing nuvistor tubes, cover the range from 1 to 36 Gc. Both series have an if output of 30, 60 or 70 mc, a bandwidth of 8 mc and gain of 20 db. Typical noise figures for the transistor type are 10.5 db; for the nuvistor types, 7.5 db.

LEL, Inc., Dept. ED, 75 Akron St., Copiague, N.Y.

Planar Triode 550

Range to 3 Gc

Designed for use as an oscillator, frequency multiplier or power amplifier, the ML-7698 is a high-mu, planar triode with a frequency range up to 3,000 mc. With low inter-electrode capacitance, high transconductance and high mechanical strength, the tube has a metal and ceramic coaxial construction suiting it for use in line-type circuits and cavity resonators. The cathode is an indirectly-heated, oxide-coated disk; the anode is cooled by conduction and convection.

Raytheon Co., The Machlett Laboratories, Inc., Dept. ED, Springdale, Conn.

Price: *$100.*

Availability: *60 days.*

MICROWAVES *PRODUCTS*

Parametric Preamplifier 434

Gain is 25 db

Built as a weatherproofed, sealed unit for antenna mount use, the RA-1 parametric preamplifier is suited for distant range tracking, troposcatter links, or radio astronomy applications. Passband is 225 to 260 mc; gain is 25 db. Noise figure is less than 2 db. Input and output impedances are 50 ohms.

LEL, Inc., Dept. ED, 75 Akron St., Copiague, N.Y.

Varactor Diodes 523

Gallium arsenide type

Six varactor diodes, series AP-1, range in cutoff frequencies from 60 to 150 Gc min at an operating bias of −2 v measured at 10 Gc. Power dissipation rating is 150 mw at 25 C measured at 10 Gc. Breakdown voltage rating is 6 v for a reverse current of 10 μa at 25 C.

Tyco Semiconductor Corp., Dept. ED, Hickory Lane, Bear Hill, Waltham, Mass.

Reflex Klystron 442

Has single-screw tuning

Reflex klystron model VA-250 is a compact unit designed for applications requiring good frequency stability in severe environments. It has single-screw tuning and waveguide output. Electrical characteristics are: frequency, 68 to 74 Gc;

power output, 10 mw min, 20 mw avg; bandwidth, 100 mc avg.

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

Rotary Joint 435

For X-band

A dual-channel microwave rotary joint, model RJXD-1C, operating in the X-band, consists of sections of waveguide, waveguide to coaxial transitions, and a coaxial, noncontacting choke joint. The entire joint employs ball bearings and is sealed for pressurization. The high-power channel operates in a frequency range of 8.5 to 9.6 Gc; power rating is 250 kw, and vswr is 1.2. Insertion loss is 0.4, vswr wow is 0.04 db. Flanges are UG-137A/U.

Canoga Corp., Dept. ED, P. O. Box 550, Van Nuys, Calif.

Price: $1,800 ea.

Availability: 60-day delivery.

Coaxial Couplers 436

Have high directivity

Dual coaxial couplers models 3020 and 3022 are designed for use in coaxial reflectometer setups and have high directivity and a four-to-one frequency range. Directivity of these couplers is 35 to 30 db respectively. Model 3020 covers the 250-mc to 1-Gc range and model 3022 covers the 1- to 4-Gc range. Coupling of each arm is held to 20 db ±1 db over the frequency range and the coupling of the forward and reverse arms track each other within 0.3 db total.

Narda Microwave Corp., Dept. ED, 118-160 Herricks Road, Mineola, N.Y.

P&A: Model 3020, $160; model 3022, $150; from stock.

D-C AMPLIFIER EVALUATION *number 1 in a series*

AMPLIFIER NOISE

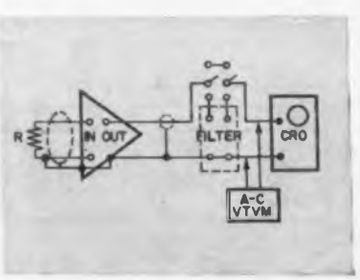
Accuracy is the basic objective in amplifier selection. When evaluating amplifiers for specific applications all errors must be considered. One such error, the noise level, determines the ultimate accuracy of the amplifier since the smallest observable signal cannot be less than the noise level. However, noise outside the frequency response range of the amplifier load can be filtered out or ignored with such read-out devices as galvanometer oscillographs.

Noise in an amplifier is any voltage component appearing at the output that has no counterpart in the input signal. Usually only the a-c component of the output is termed noise. The d-c component is called zero drift and its evaluation will be covered in another of this series.

Internally generated a-c components must be evaluated as to amplitude and frequency range. Noise may be divided into two general classes and measured as described below. (a) *Random voltages* of a broad band nature arising from thermal agitation in resistors and random tube or transistor noise . . . measurements on a peak-to-peak basis are often 10 times or more larger than the measured rms value over the same frequency band. (b) *Narrow band voltages* induced within the amplifier by line voltage or chopper excitation . . . these voltages are generally sinusoidal so that peak-to-peak values are only about 2.8 times larger than the measured rms values.

Testing amplifiers for noise

If the input signal is zero, any voltage components detected at the



amplifier output can be identified as noise. A standard technique for measuring noise is shown.

The oscilloscope measures the peak-to-peak values, the VTVM in rms values. Equivalent input noise (eq. in) is the measured noise divided by the amplifier gain. For details write for Bulletin BE AN121.

Noise less than 0.04%

With a full scale input signal of 10 mv, Honeywell's AccuData III Amplifier has a wide band (0-100 kc) noise specification of 4 μv (eq. in) and a peak-to-peak noise over a 0-10 cps band of 4 μv (eq. in) . . . less than 0.04% of full scale!

The AccuData III, a wide band differential input d-c amplifier with all transistor design, is especially useful for driving analog-to-digital converters, f-m magnetic tape systems and high speed oscillographs where low level signals such as thermocouple, strain gage and similar transducer outputs are to be accurately measured. Write for Bulletin BS-DISA-3 to Minneapolis-Honeywell, Boston Division, Dept. 5, 40 Life Street, Boston 35, Mass.

Honeywell
First in Control
SINCE 1885

CIRCLE 216 ON READER-SERVICE CARD

MICROWAVES PRODUCTS

Amplitude Modulators 498

With low drive power

At a given frequency in the specified band, this series of Faraday rotation amplitude modulators will produce an attenuation range of 0.5 db max to 25.0 db min. High modulation frequencies with low drive power are a feature of the units. Seven models ranging from the MS-100 for 2.6 to 3.5 Gc to the MKU-101 for 14.0 to 18.0 Gc are available.

Rantec Corp., Dept. ED, Calabasas, Calif.

Klystron Oscillators 517

Life is 500 hr

Four klystron oscillators in the 4-, 6-, and 12-mm bands are designed to produce output signals exceptionally free from thermal drift and hysteresis. The 4 FK1 is capable of a power output greater than 100 mw at a fixed frequency of 75 Gc. Average life expectancy is 500 hr min.

Elliot Bros, Ltd., Dept. ED, 34 Portland Place, London, England.

UHF Antenna 496

Range is 375 to 1,000 mc

Broadband bow-tie antenna model 91597 is an aid in rapid frequency scanning over the range of 375 to 1,000 mc. It has a sensitivity similar to that of a tuned dipole and does not require tuning adjustments. Matching devices are not

required; a matched balun provides a characteristic impedance of 50 ohms and is an integral part of the assembly.

Stoddard Aircraft Radio Co., Inc., Dept. ED, 6644 Santa Monica Blvd., Hollywood 38, Calif
P&A: $135; from stock.

Variable Attenuator 506

For S-band use

Flat, continuously variable, S-band attenuator model 4664-20A is capable of being remotely controlled. Electrical characteristics are: attenuation vs frequency, ±1 db from 2.5 to 4.0 Gc; frequency range, 2.5 to 4.0 Gc; attenuation range, 0 to 20 db; vswr, 1.50 max; insertion loss, 0.5 db max; power capacity, 10 w avg, 5 kw peak.

Antenna and Radome Research Associates, Dept. ED, 27 Bond St., Westbury, N.Y.
P&A: $450; 4 to 6 weeks.

Pattern Simulator 394

For monopulse circuitry

This monopulse antenna pattern simulator, in the 5.4- to 5.9-Gc range, performs checkouts and system analysis on monopulse circuitry. It simulates signals normally derived from sum and difference circuitry, and provides adjustable electrical line lengths in both signal and local oscillator branches.

Rantec Corp., Dept. ED, Calabasas, Calif.

IDEAS FOR DESIGN

The Most Valuable Ideas Need Your Votes

Be sure to vote for the Ideas which you think deserve the $50 Most Valuable of Issue Award. You may vote for one or more by circling the corresponding number on the Reader-Service card. Choose the Ideas which suggest a solution to a problem of your own, or which stimulate your thinking. The Most Valuable of Issue Ideas will be eligible for the $1,000 Idea of the Year Award, with each idea published receiving a $20 honorarium.

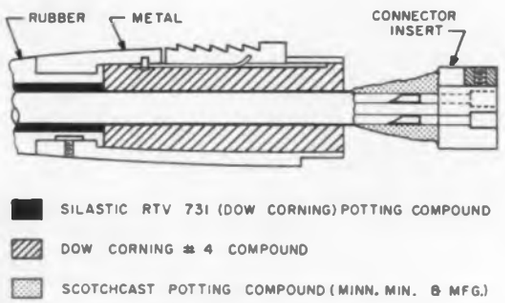
Microphone Connector Is Potted In Three Sections For Easy Disconnect 743

A conventional microphone connector, used on precision instrumentation buried in the snow of Northern Greenland, had to be potted so that changes in humidity and the presence of snow and ice would not change its insulation resistance. Further, the potting had to be such that the connector, an Amphenol Type 91-857, could be readily disconnected with a heavily gloved hand. This disconnecting feature ruled out conventional potting. Instead, a combination of three potting materials, molded into different sections on the connector, was used.

After the wire leads were securely soldered, a temporary, cone-shaped mold, tapering away from the connector, was formed by wrapping masking tape around the wire-to-connector junction area. Small quantities of Scotchcast Resin No. 4, made by Minnesota Mining and Manufacturing, were thoroughly mixed and poured into the cone with the connector mounted vertically in a clamp support. The poured "cone" of potting compound was cured for about one hour at room temperature. When the tape support was removed, the potted cone section was quite plastic and could be hand molded to any desired shape.

The connector body was then slipped over the cone in proper mounting position. With the insert section held at about 1/8 in. from "home," Dow Corning's No. 4 (high-dielectric grease) was injected into the central section of the connector as indicated in the drawing. Then, as the insert section was slipped into the shell, grease was forced into all voids of the moving parts of the connector yielding a potted, but flexible, central section. The set screw for locating and securing the insert was next placed in position.

This cable strain relief section was potted by injecting Dow Corning Silastic RTV-731 into the strain relief from the cord side of the connector.



Amphenol Type 91-857 microphone connector was potted by applying three insulating compounds at the darkened sections. Despite potting protection, connector could still be rapidly disconnected.

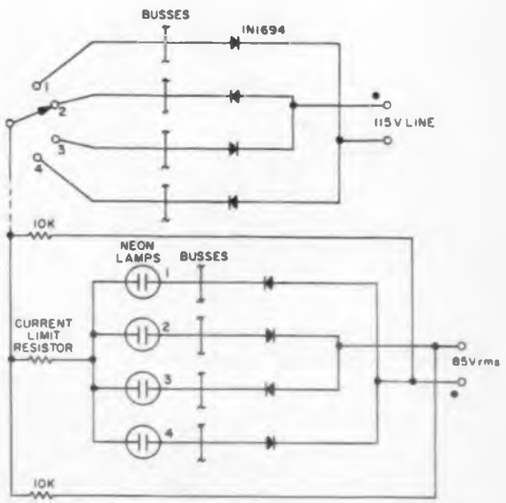
A room temperature curing rubber, this material forms very well and bonds readily to the connector rubber. However, contact must be avoided with the skin because it can be a severe irritant. Hands must be thoroughly washed immediately after it is used.

Edward J. Kolb, Physicist, U. S. Army Snow, Ice and Permafrost Research Establishment, Wilmette, Ill.

Separate Lamps Controlled Over Single Line 749

Four separate lamp circuits can be remotely activated over a single control wire by using the rectifier arrangement shown in the figure. The circuit uses the four possible combinations of phase and polarity that can be obtained by half-wave rectification of the ac line. Relative polarity of the 115-v source and the "remote" 85-v lines are indicated by the plus and minus signs.

The desired bulb can be lighted by connecting the control wire to the corresponding switch position. Firing of more than one lamp is prevented by reducing the remote ac voltage to about 85 v rms. The 10-K, 2-w resistors connected from the control wire to the 85-v supply help to minimize the effect of stray control line capacity which could cause improper lamp firing.



Four (or more) remotely located lamps can be controlled over a single interconnecting line.

It is possible to extend the circuit so that more than four lamps can be controlled. One control wire is required for every four lamps, with the same eight diodes sufficient for all lamps. Also, relays can be substituted for the neon lamps.

Note that, with appropriate switching, several lamps may be energized simultaneously. Thus, a binary coding may be employed, with decoding accomplished by using diode AND circuits, relays, etc. In this way, 15 functions may be switched over a single control line.

K. C. Herrick, System Engineer, Reflectone Electronics Corp., Stamford, Conn.

Reprinted from ED, Feb. 15, p. 218.

How You Can Participate

Rules For Awards

Here's how you can participate in Ideas for Design's Seventh Anniversary Awards:

All engineer readers of ELECTRONIC DESIGN are eligible.

Entries must be accompanied by filled-out Official Entry Blank or facsimile. Ideas submitted must be original with the author, and must not have been previously published (publication in internal company magazines and literature excepted).

Ideas suitable for publication should deal with:

1. new circuits or circuit modifications
2. new design techniques
3. designs for new production methods
4. clever use of new materials or new components in design
5. design or drafting aids
6. new methods of packaging
7. design short cuts
8. cost saving tips

Awards:

1. Each Idea published will receive an honorarium of $20.
2. Ideas judged Most Valuable of Issue will receive $50.
3. The Idea judged to be Idea of the Year will receive the Grand Prize of $1,000 in cash.

The Idea of the Year will be selected from amongst those judged to be Most Valuable of Issue.

Most Valuable of Issue and Idea of the Year will be selected by the readers of ELECTRONIC DESIGN. Votes will be cast by circling keyed numbers on Reader-Service Cards. Payment will be made eight weeks after Ideas are published.

Exclusive publishing rights for all Ideas will remain with the Hayden Publishing Co.

Note to Previous Contributors

Ideas already submitted to the Ideas for Design department, but not yet published, will be eligible for the Seventh Anniversary Awards.

For Additional Entry Blanks, circle **750** on Reader-Service Card.

SEVENTH ANNIVERSARY AWARDS

IDEAS-FOR-DESIGN

Entry Blank

To: Ideas-for-Design Editor
ELECTRONIC DESIGN
830 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)

Here is my Idea for Design for possible publication in ELECTRONIC DESIGN. I understand that 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.
Hayden Publishing Company, Inc. shall have the exclusive publication rights to these Ideas for Design selected for publication in ELECTRONIC DESIGN. This right extends to the subsequent use of the Idea for Design by Hayden in any of its other publications. Honorariums, if any, for subsequent publication shall be solely in the discretion of Hayden Publishing Company, Inc.

Name _____ **Title** _____

Company Name _____

Address _____

IDEAS FOR DESIGN

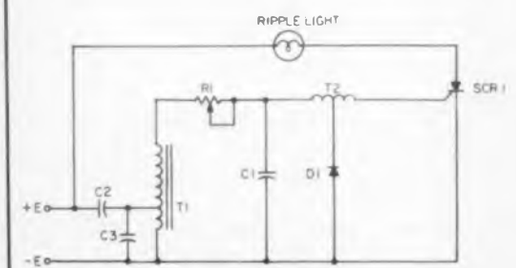
Signal Light Indicates Out-of-Bounds Ripple 747

We needed a circuit, on a transistorized power supply, to detect and indicate rises of ripple voltage above the allowable 10 mv.

The circuit shown was chosen because we found it to be simple, reliable, and accurate.

The supply to be monitored is connected to the detector with the proper polarity. Capacitor C_2 isolates the ripple signal from the direct current. The signal is then stepped up by transformer *T1* which is tuned to the ripple frequency by capacitor *C3*.

When the peak ripple signal causes the current through the tunnel diode, *D1*, to exceed its full value, the diode will switch to a higher voltage. The autotransformer action of *T2* creates a larger voltage pulse on the gate of the silicon controlled rectifier, *SCR1*. This pulse turns both the controlled rectifier and the ripple light on. The value of ripple voltage at which this occurs is determined by the turns ratio of *T1* and the value of *R1*.



Amplified ripple voltage triggers silicon controlled rectifier which lights indicating light.

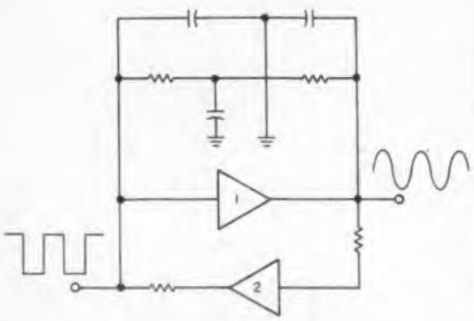
Capacitor *C1* is included to provide a low source impedance for the firing pulse to the controlled rectifier. Tuning *T1* with *C3* and including the *R1-C1* combination filters out and delays transient voltage pulses which could trip the *SCR*. If desired, a reset switch can be placed in series with the light.

Bruce Hicks, Development Engineer, Universal Match Corp., St. Louis, Mo.

Feedback Around Filter Provides 741 Sine and Square Wave Outputs

Sine and square wave outputs of equal frequency were produced by providing positive feedback around an active, twin-T filter.

The twin-T, RC network and amplifier *1* of the figure form a bandpass amplifier with gain



Sine waves at *1* and square waves at 2 are produced by feeding back around the active filter network.

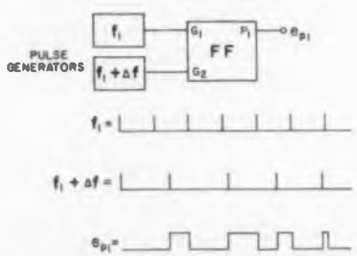
and narrow bandwidth. Amplifier *2* is of three direct-coupled stages, with an over-all gain of 65 to 90 db. It can be overdriven with but a small input signal and produces a constant-amplitude square wave at its output. This signal feeds back positively to amplifier *1* and the circuit oscillates. Thus, both sine and square waves are produced at the points indicated. The oscillating frequency depends only on the parameters of the twin-T network and can be varied over a wide range.

Wilbur Du Vall, Chief Engineer, Datrax Div., W. W. Henry Co., Maywood, Calif.

A Random Pulse Generator 742

To check coupling and clamping circuits, a quick and inexpensive random pulse generator was needed which would vary its pulse width at u random rate.

The problem was simply solved with the cir-



cuit shown. It is an arrangement that has been accidentally connected many times before.

Any variation in the output can be obtain by varying the frequency of $f_1 + \Delta f$.

Irving Bayer, Budd Electronics, Long Island City. N.Y.

Reprinted from ED, Feb. 15, p 218.

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IDEAS FOR DESIGN

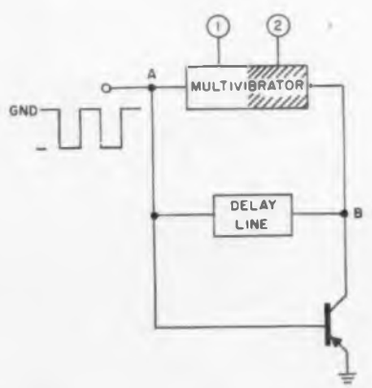
Constant Output Signal Maintained by Continuous Pulse Train 748

Certain logic circuits require that the presence of pulses at a given point be detected and indicated by a constant signal level. The multivibrator and delay line combination shown provides this constant (negative) level at point *1* as long as periodic input pulses are present at point *A*. If a pulse in the train is missing, the output at *1* will be triggered to zero.

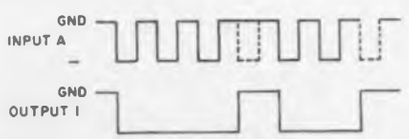
The circuit is designed so that point *A* rests at ground potential. If a negative-going pulse train is present, the first pulse will both trigger the multi and start a negative pulse propagating down the delay line. The total delay time of the line is equal to the period of the train.

If an adjacent pulse is present the transistor remains forward biased and point *B* remains at ground potential. Thus, the multi will not be triggered by the propagated pulse and the level at *1* remains constant. If an adjacent pulse is missing the delayed pulse will trigger the multi and the output level at *1* will change.

For a negative-going-to-ground pulse train the circuit merely requires an npn transistor for the gate. Also, the multi has to be designed to trigger on a positive pulse.



(a) Output at point *1* will be at constant level only if continuous train of input pulses is present at point *A*.



(b) Pulse train at point *A* and corresponding output at point *1* show that output "flips" when input pulse is missing.

Joseph F. Martin, Design Engineer, Stromberg-Carlson Div., Rochester, N.Y.

Z-Axis Blanking Helps Determine Lag or Lead

744

Oscilloscopes of even modest caliber provide reasonably accurate measurements of sinusoidal phase angles by means of Lissajous patterns. This technique falls short in determining whether the unknown voltage or current vector leads or lags the reference vector.

By simply applying a blanking pulse to the Z axis, one can easily determine leading or lagging conditions.

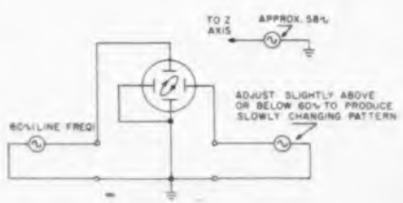
Assume an unknown voltage vector lags the reference voltage vector anywhere between 0 and 180 deg. Connect the reference vector to the *Y* axis, the unknown to the *X* axis. Though not apparent to the eye, except at very low frequencies, the resultant Lissajous pattern is formed by the electron beam moving in a clockwise path. This path remains clockwise for phase shifts anywhere between 0 and 180 deg.

If the unknown voltage vector leads the reference voltage vector anywhere between 0 and 180 deg, the electron beam will move in a counterclockwise path.

The time required for the beam to complete one revolution is the same as the period of the applied frequency.

It follows that a blanking pulse (practically any wave shape) applied to the Z axis, with a frequency equal to that present at the *X* and *Y* axis, will tend to blank out a portion of the Lissajous pattern. The blanked out portion will appear stationary. Decreasing the blanking frequency slightly forces the blanked portion to move in the direction of beam rotation; clockwise for lagging phase shifts, counter clockwise for leading phase shifts.

The foregoing applies to oscilloscopes that display a 0-deg phase shift in the first and third quadrants.



Slowly changing Lissajous pattern illustrates direction of beam rotation for leading and lagging phase shifts from 0 to 180 deg.

Michael Rakochy, Bell Telephone Labs., Allentown, Pa.

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IDEAS FOR DESIGN

Low-Cost Scope Traces Transistor Characteristic Curves 745

Transistor characteristic curves can be easily traced by using the low-cost oscilloscope attachment shown in Fig. 1. It can be connected to any oscilloscope having calibrated horizontal and vertical sweeps. A 400-cps power supply is required. However, the use of this frequency led to a reduction in circuit complexity and, hence, like reductions in size, weight and cost.

Transistors can be tested only in the common emitter configuration. Other user requirements could be met with additional switching. The 4-pole polarity switch reverses the collector supply, bias current, and meter connections as required for pnp or npn transistors. The collector has a half-wave sinusoidal voltage sweep, set with a variable transformer, which is supplied through an isolation transformer. The transformers are selected with combined ratios that yield a peak output of the maximum desired collector voltage, and with a power rating that will accommodate the largest transistors to be tested.

Base bias current is supplied from a 24-v transformer secondary with a filtered, full wave rectifier. This source is controlled by the dropping resistance of a 3-gang potentiometer. This limits the maximum base bias to 100 ma as read on the panel meter. Three current ranges (0-1, 1-10, 10-100 ma) are selected by a 2-pole switch that also changes the meter shunts. The shunts must be experimentally wound to match the impedance

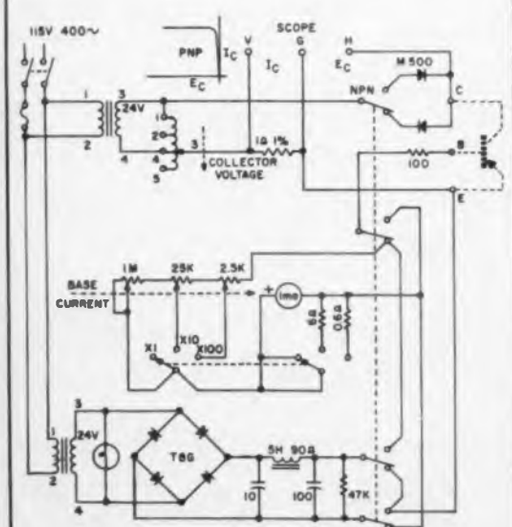


Fig. 1. Transistor curve tracing attachment can be used with almost any oscilloscope.

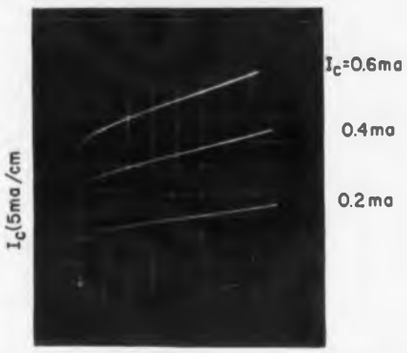


Fig. 2. Characteristic curves for 2N188 pnp transistor are obtained by taking multiple exposure photos for different base current values.

of the 1-ma meter by using a series calibrating meter.

The characteristic curves are presented on an oscilloscope connected to the terminals marked *H* and *V* respectively, and to *G*. A sensitive scope with directly calibrated control knobs (such as a Hewlett-Packard 130A) is particularly convenient for changing scale-factors during the test procedure. The collector current is sampled across a ohm ±1 per cent shunt, giving a one-to-one correspondence between current and vertical scope deflection. The sinusoidal collector-to-emitter voltage produces the horizontal sweep.

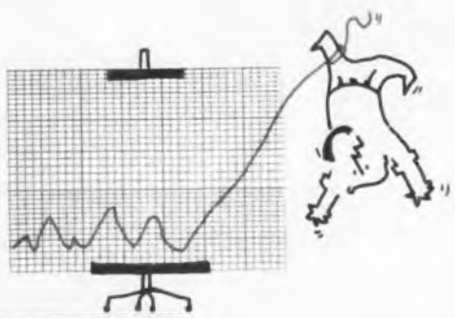
The power is turned on, and the "Collector Voltage" and "Bias Current" controls are turned to the full counterclockwise position. With the polarity switch and "Base Current" switch properly set, the transistor is inserted into the socket, or if more convenient, the *C*, *B* and *E* 5-way terminals are used. The characteristic curve will be presented on the scope as a second or fourth quadrant display for pnp or npn transistors respectively. This form of display gives the correct relative sense to the collector voltage deflection while connecting the common emitter to the common ground terminal found on most scope inputs.

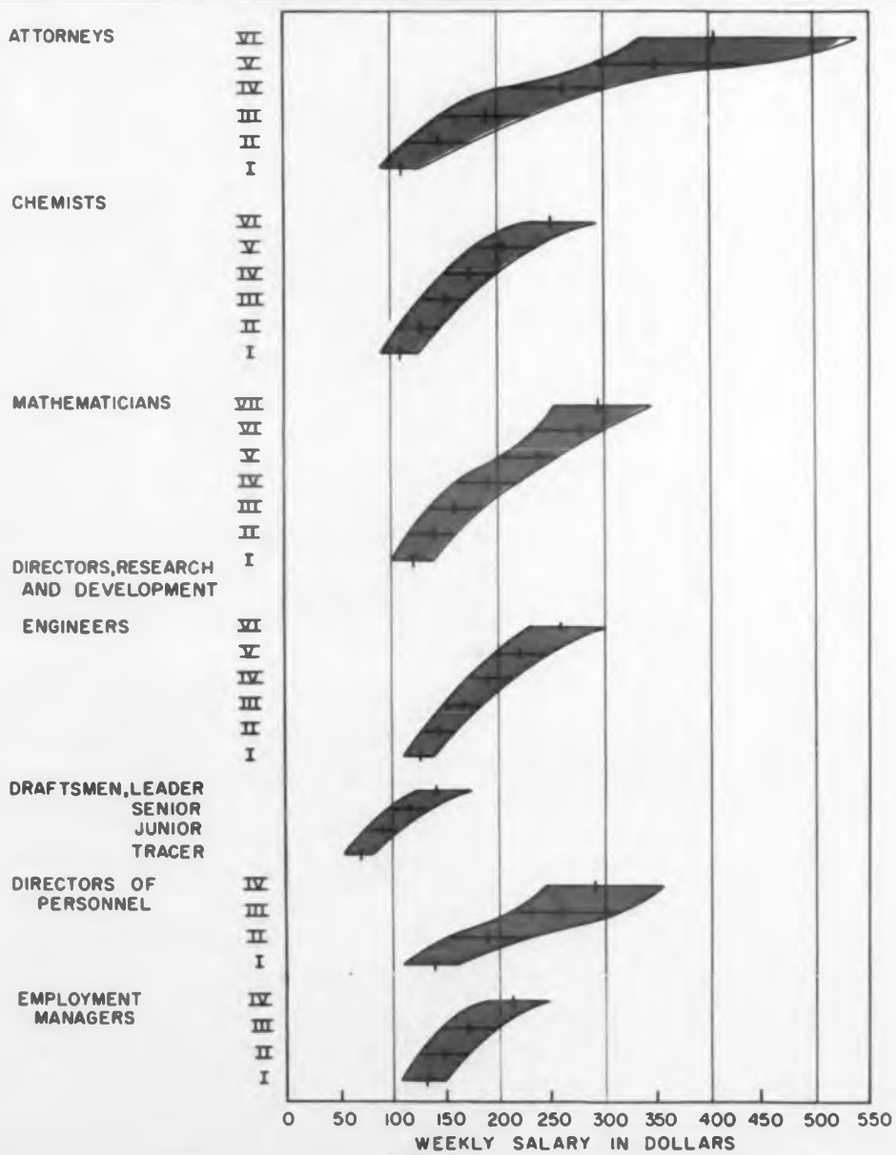
Next, the collector voltage is brought up to the desired operating value The collector current is varied through desired values by adjusting the base bias current. While this is done it is necessary to avoid exceeding transistor ratings. Families of curves are conveniently obtained by resetting the bias control. Multiple exposure photographs can be taken for a permanent record. Shown in Fig. 2 is a family taken for a 2N188 pnp transistor with three different values of bias current.

Chester B. Shapero, Research Engineer, Cupertino, Calif.

Reprinted from ED, Jan. 18, p 160.

Engineer's Salaries Still Start High, End Low But Some EE's Are Breaking Out of the Mold





Weekly salary ranges for various professional occupations indicate to what extent engineers start ahead but end behind. Bars indicate spread of middle range while mark in middle of bar indicates median.

A GOVERNMENT survey of salaries for engineering and similar occupations last year indicates that engineers still start with higher salaries than most other college graduates—and end up mostly with lower salaries. However, a more recent sampling of EE salaries by ELECTRONIC DESIGN shows that some electronic engineers are now doing as well as men in any profession.

The Government survey was made by the Dept. of Labor during January to June, 1960, and was published in October in the department's Bulletin No. 1286. A chart from the survey, Fig. 1, has been redrawn by *ED* to include only information on occupations whose status is comparable to that of engineers. Included are weekly salary bars for attorneys, chemists, mathematicians, draftsmen and directors of R&D. Also included are directors of personnel and employment managers, to provide some indication of what other white-collar persons in industry are receiving.

The engineers' median starting weekly wage was found by the survey to be $123, compared with $110 for mathematicians, $105 for chemists, and $106 for attorneys.

However, at the highest classification (VI), the median weekly salary for the engineers ($264) was found to be only slightly better than that for the chemists ($249) and actually less than that for the mathematicians ($269).

But the real difference was between engineers and attorneys. For while the engineer starts out earning $17 a week more than an attorney, the lawyer, in his profession's top classification, ends up earning $139 per week more than an engineer in the top engineering classification.

However, there are definite signs that some electronic engineers are breaking out of this mold. For whereas the survey showed that the top-middle-range salary for an engineer in class VI did not exceed $17,000 per year, *ED* has confirmed that top EE's are now able to earn more than $20,000 a year. These men would still be within the survey's VI classification; they would be working as engineers, not as managers. Thus competitive pressure for top EE's, particularly

Legend For Chart

As an aid to evaluating the chart on weekly salary distribution, the end values of the middle range are given for each engineering classification along with a brief job description of that classification:

1—$115-$130. Works under close supervision of superior. Typically receives formal classroom or on-the-job instruction.

2—$127-$150. Supervisor screens assignments to eliminate difficulty problems and select procedure to be followed.

3—$146-$176. Works independently on conventional projects but jointly with supervisor on unusual problems.

4—$170-$206. Performs engineering work requiring originality and judgment, though in areas generally covered by precedent. Characteristically supervises small group of engineers and technicians.

5—$197-$245. Both supervisory and nonsupervisory: Supervisory positions include coordination and review of small staff of engineers and technicians. Nonsupervisory positions involve carrying out novel or complex research pertaining to new or improved techniques.

6—$235-$302. Programs, plans and coordinates a number of large and important projects in either supervisory or nonsupervisory capacity.

creative computer circuit designers, has finally brought about engineering salaries comparable to the $21,000 median for top attorneys.

This happy state of affairs in the electronic engineering profession will probably not show up on across-the-board surveys of the whole engineering profession, such as this Government survey, for some time. As yet, these "over $20,000" EE's are only a fraction of the total picture. But for the man who loves engineering and does not want to be forced into management for money considerations, this "lifting" of the traditional ceiling on engineers' salaries should be a cheering phenomenon. ■ ■

YOUR CAREER

NEWS AND NOTES

High salaries for nonsupervisors, the dream of the creative engineer, have become a reality. The concept of the individual contributor who can earn more than his boss is being achieved in practice, according to Harry L. Brisk of the Accredited Employment Agency, Philadelphia. Mr. Brisk says he knows of many engineers who earn from $12,000 to $23,000 a year, though they supervise no one. These enviable positions usually are in special departments of the larger companies, Mr. Brisk says, and result from realization that a "creative engineering type," unhampered by supervisory chores, can be vital to the company's future earnings.

• • •

10 Ways to Create New Ideas

Looking for a fresh idea? Pinpoint a need. In terms of your own job or business, answer these questions:

- **What made me mad today?**
- **What took too long?**
- **What was the cause of a complaint?**
- **What was misunderstood?**
- **What cost too much?**
- **What did we waste?**
- **What was too complicated?**
- **What is just plain silly?**
- **What job took too many people?**
- **What job involved too many motions?**

The answers will almost certainly give you a long list of needs. Once you have them, look for ways to fill them. And there you are: ideas!

• • •

Higher earning power is always available to the engineer who keeps pace with technological advances.

In agreement with this statement, Ned Boggs of Boland & Boyce, Inc., N.Y., says he continually must turn down engineers he would only be too glad to hire at much higher salaries than they are now earning, because they have not kept up with changing trends in engineering. Along with many electronics employers, Mr. Boggs is looking hardest for and willing to pay most for solid-state digital circuit men. He says many of the men he has to turn down would be eligible if they had only started educating themselves in digital circuitry techniques a few years earlier. Then they would at least be able to get started in the digital field today. Once started, they can rapidly build up their abilities for the higher salaries available in this growing specialty area.

Advancement Your Goal?

Use CONFIDENTIAL Action Form

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 MAY 24, 1961

(8)

After completing, mail career form to *ELECTRONIC DESIGN*, 830 Third Avenue, New York. N. Y. Our Reader Service Department will forward copies to the companies you select below.

(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

CAREER NEWS

What are the "job shops" paying? Hourly rates for job-shopping electronic engineers range from $4.50 to $9. The men at the lowest level, $4.50 to $5 an hour, are recent EE graduates. They are not too much in demand, however. Men with a year to a year and a half experience command $6 to $7.50 an hour. Those in most demand—men with five years of experience and up, particularly men with backgrounds in solid-state digital logic circuitry—command $8 to $8.50 an hour. The very top rates of $9 an hour are for men with 10 years' computer circuitry experience. In addition to the hourly rate, if the man is away from home, he receives the usual $8 to $9 per diem expense allowance. The spokesman for a New York "job shop" who gave ELECTRONIC DESIGN these figures says that although the demand has softened somewhat in the last six months, he expects an upswing in the next few months.

• • •

Energy Boosters

The "gift" of abnormal energy that some people seem to have is regarded longingly by others. Actually, health factors being equal, it is not a gift but a conscious (or unconscious) knack these men possess for stimulating normal supplies of energy into a rushing geyser. They increase personal productivity by developing attitudes and creating situations that quicken their energy supply. You can too, if you:

Vary your tasks. **Plugging at the same job interminably saps energy. Varying your chores stimulates you, provides the change that rests your mind. Been calculating circuit stabilities? Try listing possible solutions for your next project. Been at your desk all day? Get on your feet for a while. Visit the laboratory to see how your projects are coming along.**

Motivate yourself. **Before you achieve, stick your neck out by announcing your goals to people whose esteem you value. You'll surpass your own expectations, because you've made a definite commitment. (However don't at the same time dream of the honors you will receive, or you will spend your time dreaming instead of producing.)**

Associate with enthusiastic people. **Enthusiasm is contagious. By mixing with men who are excited about their work, you will "catch" their zestful spirit and be inspired to do your very best.**

For the ambitious technician: International Correspondence school's new general catalogue 1125N describing over 250 standard home-study courses. Included are 25 technician-level electronics courses, of which 11 are new in 1961. They range from a short course on electronic fundamentals to electrical engineering with special electronics optional section. New 1961 courses cover the fields of radio-electronic telemetry, electronic computers, ultrasonics, mono and hi-fi, special sound systems, communications technology, industrial electronics technology, 1st and 2nd class FCC radiotelephone licenses and semiconductor transistor circuits. Write to ICS, Scranton, Pa.

• • •

Emotional fireworks in electronics are covered in a new novel about the inner problems of humans in an electronics company. "The Annals of Logan," by Robert Graham, is a series of verse monologues describing individual reactions when members of the company's advertising department plot to have one man fired.

The engineers, for the most part, escape Mr. Graham's analysis. There is, however, a brief mention of a visit by one member of the advertising department to the plant laboratory. The visitor is "revolted" by the professional pride of the engineers in a "cute, lovely, little fuzing device for thermonuclear warheads."

Author Graham was formerly a member of the sales promotion staff of Ford Instrument Div., Sperry-Rand Corp., N.Y.

• • •

How do you develop underdeveloped countries? British author M. Zvegintzov, in the Unesco publication "Impact," says:

"The technical problem [in underdeveloped countries] is not so much to install complicated machinery, then find personnel to operate and maintain it, but to think out modern production problems in terms of breaking them down into the simplest and most foolproof component jobs, which could then safely be entrusted to unskilled personnel with no industrial tradition."

In explaining why Russia has been so successful in industrializing backward areas, Mr. Zvegintzov writes:

"In general the principle of make-do-and-mend is sound: to establish in which fields half a loaf is better than no bread and build accordingly on what human resources and materials can be made available. This principle has been consistently adopted by Russia—even before the 1917 revolution—and is one of the reasons for its great recent successes and the ease in its dealings with underdeveloped territories."

CAREER NEWS

Engineering doctoral degrees in certain southern universities will be strengthened by a recent $3 million Ford Foundation grant. Georgia Institute of Technology was given $680,000; University of Florida, $695,000; North Carolina State College, $760,000, and the University of Texas $975,000. The funds will be used to hire new faculty members with the academic stature to conduct graduate courses and supervise graduate theses as well as to strengthen the present graduate staffs by further education.

• • •

Paper Call: Awards for essays on that hard-to-get-rid-of phenomenon, gravity, have been announced by Roger Babson's Gravity Research Foundation, New Boston, N.H.

The five awards, from $100 to $1,000, will be for the best 1,500-word essays on the possibilities of discovering:

- Some partial insulator, reflector or absorber of gravity.
- Some alloy, or other substance, the atoms of which can be agitated or rearranged by gravity to throw off heat.
- Some other reasonable method of harnessing, controlling or neutralizing gravity.

"Only one essay will be accepted from anyone who is seriously interested in the application of gravity . . . for the benefit of humanity." (Kibitzers can send in as many as they like.)

The deadline is April 15.

PAPER DEADLINES

Convention Program Chairmen have issued the following deadlines to authors wishing to have their papers considered for presentation.

April 15: Deadline for papers for **1961 annual NEREM** (Northeast Electronics Research and Engineering Meeting) which will be held **Nov. 14-16 in the Commonwealth Armory and Somerset Hotel, Boston.** Papers should describe R&D aspects of original developments. New feature of this year's meeting will be the invited state-of-the-art tutorial sessions and discussion panels which will be held in addition to the contributed papers. Send either complete papers or 400-500 word abstracts in triplicate, plus 50-word summaries for advance program mailings, to F. K. Willenbrock, Pierce Hall, Harvard University, Cambridge 38, Mass.

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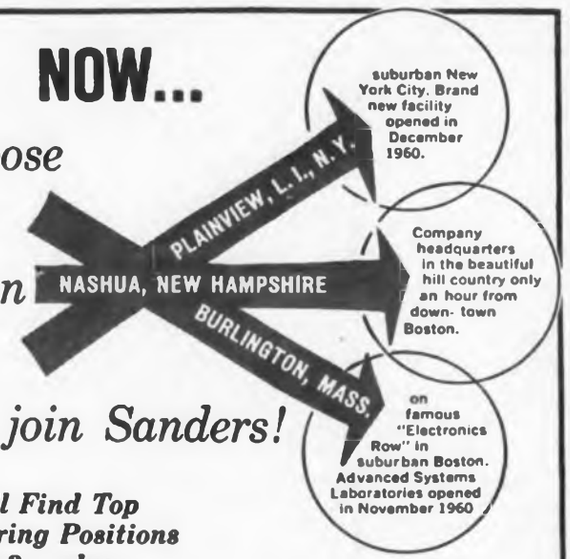
choose your location when you join Sanders!



suburban New York City. Brand new facility opened in December 1960.

Company headquarters in the beautiful hill country only an hour from down- town Boston.

on famous "Electronics Row" in suburban Boston. Advanced Systems Laboratories opened in November 1960

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This history of success was built through creation of *original technical concepts* resulting in unusual achievements—most of which are classified—including FLEXPRINT® flexible printed circuits, PANAR® radar and TRI-PLATE® microwave components and techniques—in high demand now and destined for a big future in next generation computers.

Pioneering programs are being continued in phased arrays, radar, pulse doppler radar systems, space radar and communication systems, providing stimulating assignments in space technology, missiles and radar systems.

To arrange a convenient interview appointment, send resume in confidence to R. W. McCarthy.

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To provide technical guidance at the Corporate level on a wide variety of transistor circuit design problems. Requires ability to design detailed circuits rapidly.

POSITIONS AVAILABLE AT ALL LOCATIONS FOR:

SENIOR SYSTEMS ENGINEERS

To contribute to advanced techniques in the general field of military electronic systems. Applicable experience includes systems analysis, synthesis and integration, with extensive background in circuit design augmented by hardware implementation.

CIRCUIT DESIGN ENGINEERS

EE or Physics graduates with 2 to 8 years experience and familiarity with tubes and transistors and their utilization in all types of circuits, as well as the integration of circuits into subsystems.

TRANSMITTER DESIGN ENGINEERS

2 to 8 years experience. For work up to and including microwaves.

PRODUCT DESIGN ENGINEERS

ME with heavy experience in feasibility studies coupled with experience in taking developed systems into production, monitoring mechanical design and overall packaging concepts of ECM or other airborne systems.

POSITIONS IN PLAINVIEW, LONG ISLAND

GROUND SUPPORT EQUIPMENT ENGINEERS

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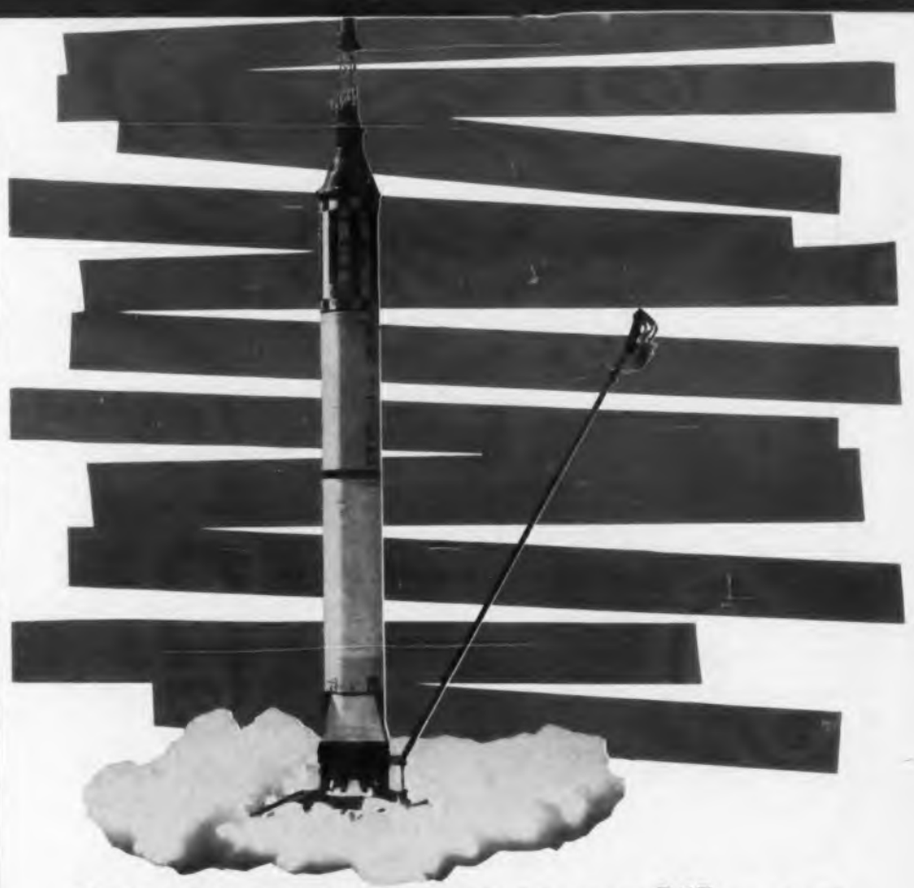

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CIRCLE 909 ON READER-SERVICE CARD

ADVERTISERS' INDEX

April 12, 1961

**Manufacturers' catalog appears in 1960-1961 ELECTRONIC DESIGNERS' CATALOG*

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GE

DEFENSE SYSTEMS DEPARTMENT

PROFESSIONAL EMPLOYMENT BULLETIN *APRIL, 1961*

On a regular basis, General Electric's Defense Systems Department publishes opportunities of special importance to experienced Systems Engineers and/or degree Engineers interested in developing their skills to the point of Systems Engineering in its broadest sense.

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To analyse acoustic wave propagation, particularly as applied to problems of detecting submarines. Competence with methods of calculating signal strengths as functions of water composition, distance and frequency is required, together with knowledge of anomalous conditions which may enhance or degrade sonic reception. Familiarity with electroacoustic tranaducers and the general fields of marine sonic equipment is desirable.

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Your response to this Bulletin will be expedited to the appropriate technical managers at DSD for prompt, personal attention and a confidential reply, generally within one week. Address: Mr. E. A. Smith, Box 4-C

DSD DEFENSE SYSTEMS DEPARTMENT
A Department of the Defense Electronics Division

GENERAL ELECTRIC

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1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161	171	181	191	201	211	221	231	241	251	261	271	281	291
2	12	22	32	42	52	62	72	82	92	102	112	122	132	142	152	162	172	182	192	202	212	222	232	242	252	262	272	282	292
3	13	23	33	43	53	63	73	83	93	103	113	123	133	143	153	163	173	183	193	203	213	223	233	243	253	263	273	283	293
4	14	24	34	44	54	64	74	84	94	104	114	124	134	144	154	164	174	184	194	204	214	224	234	244	254	264	274	284	294
5	15	25	35	45	55	65	75	85	95	105	115	125	135	145	155	165	175	185	195	205	215	225	235	245	255	265	275	285	295
6	16	26	36	46	56	66	76	86	96	106	116	126	136	146	156	166	176	186	196	206	216	226	236	246	256	266	276	286	296
7	17	27	37	47	57	67	77	87	97	107	117	127	137	147	157	167	177	187	197	207	217	227	237	247	257	267	277	287	297
8	18	28	38	48	58	68	78	88	98	108	118	128	138	148	158	168	178	188	198	208	218	228	238	248	258	268	278	288	298
9	19	29	39	49	59	69	79	89	99	109	119	129	139	149	159	169	179	189	199	209	219	229	239	249	259	269	279	289	299
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	303	313	323	333	343	353	363	373	383	393	403	413	423	433	443	453	463	473	483	493	503	513	523	533	543	553	563	573	583	593
	304	314	324	334	344	354	364	374	384	394	404	414	424	434	444	454	464	474	484	494	504	514	524	534	544	554	564	574	584	594
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RCA CERMOLOX TUBES...

a new concept in Beam Power Tube technology

To meet the increasing demand for dependable UHF power, RCA has developed Cermolox Tubes, a wide line of coaxial, ceramic-metal beam power tubes with precision-aligned grids. These Cermolox tubes are especially well suited to the requirements of aircraft, missile and guidance applications in CW, Pulse, and Hard-Tube-Modulator service.

Already they have set an enviable record of performance in such exacting applications. In Pioneer V, for instance, Cermolox tubes were used in the guidance systems, and in the satellite's high-power transmitter.

Some outstanding features of RCA Cermolox tubes which contribute to long life and reliability are:

- Precise alignment of grids for outstanding efficiency.
- Coaxial-electrode structure adaptable for use either in coaxial-cylinder or parallel-line circuits.
- Exceptionally sturdy structure.
- Low rf-loss ceramic insulation.
- High temperature operation.
- Brazed construction involves no spot welding and assures low rf losses and low internal stresses.
- Compact, ceramic-metal construction.
- Flexibility of cooling techniques: conduction, liquid, and forced air (with RCA's high-efficiency radiator).

The family of RCA Cermolox tubes is shown in the adjacent table. For more information, contact the RCA Field Office nearest you.

The Most Trusted Name in Electronics
RADIO CORPORATION OF AMERICA

RCA CERMOLOX BEAM POWER TUBES

Type	Max. Plate Input Watts	Max. Freq. at Max. Ratings	Max. Plate Diss. Watts	Heater Volts/Amperes
CW APPLICATION				
7870 Conduction Cooled	52.5	3,000	25	6.3/1
7801 Conduction Cooled	52.5	3,000	25	12.6/.5
6816 Forced-Air Cooled	180	1,215	115	6.3/2.1
7844 Conduction Cooled	180	1,215	115	6.3/2.1
7842 Ruggedized Conduction Cooled	180	1,215	115	6.3/3.0
7457 Ruggedized Forced-Air Cooled	180	1,215	115	6.3/3.0
7843 Conduction Cooled	180	1,215	115	26.5/.52
6884 Forced-Air Cooled	180	1,215	115	26.5/.52
7650 Ruggedized Forced-Air Cooled	1,250	1,215	600	6.3/7.5
A-2663* Conduction Cooled	1,250	1,215	600	6.3/7.5
7213 Forced-Air Cooled	2,500	1,215	1,500	5.5/17.5
A-2545-A* Forced-Air Cooled	28,000	400	10,000	8/88
PULSED RF APPLICATION				
A-2587-A* Conduction Cooled	3,750	3,000	25	12.6/.41
7649 Ruggedized Forced-Air Cooled	9,000	1,215	115	6.3/3.0
7651 Ruggedized Forced-Air Cooled	72,000	1,215	600	6.3/7.5
7214 Forced-Air Cooled	180,000	1,215	1,500	5.5/17.5
A-2581-A* Forced-Air Cooled	2,000,000	600	10,000	18/12
HARD-TUBE-MODULATOR APPLICATION				
A-2638* Ruggedized Forced-Air Cooled	8,000	–	115	6.3/3.0
A-2624* Ruggedized Forced-Air Cooled	60,000	–	600	6.3/7.5
A-2627-A* Ruggedized Conduction Cooled	300,000	–	1,500	5.5/17.5
A-2625* Conduction Cooled	1,500,000	–	10,000	18/12

The chart shown above includes all RCA Cermolox Tube types available as of February 4, 1961.

*Development Type–Available on Sampling Basis

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