ELECTRONIC DESIGN

p 35

COVER: Tunnel diodes, represented by the "S-shape" curve, highlight this year's special Diode issue. Scores of diode types, shown within the "S" curve, are tabulated in the latest Department of Defense approved diode listing.

Selected Topics In This Issue

ELECTRONIC DESIGN · ONE DAY SERVICE

USE BEFORE JUNE 7th, 1961
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Name _______________ Title _______________

Company _______________

Company Address _______________ City _______________ Zone _______ State _______

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MEASURE RF POWER WITHOUT CONTINUAL ZERO-SETTING

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The new hp 431A Power Meter gives you 3% accuracy on all ranges, less than 2 μw/°C thermal drift

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New hp Thermistor Mounts assure hp 431A Therma

hp 478A Thermistor Mount

This wide-range, temperature compensated coaxial mount covers 10 MC to 10 GC, with no tuning required. Closely matched thermal environments for the two thermistor pairs for use with the dual bridge hp 431A assure excellent tracking, even under thermal shock. The hp 478A as used with the hp 431A provides high accuracy and virtually drift-free operation.

SPECIFICATIONS

Frequency Range:	10 MC to 10 GC
SWR:	Less than 1.5 (less than 1.3, 50 MC to 7 GC)
Power Range:	1μw to 10 mw (with hp 431A)
Elements:	Four 100-ohm, negative temperature coefficient thermistors permanently installed
Price:	$145.00

W
Th

X-Band Mount, 8.2 to 12.4 GC
perature tracking with the hp 4
ence of thermal shocks. No tu
usual freedom from drift is as
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ful matching of thermal envir
thermistors.

SPECIFICATION

Frequency Range:	8.2 to 12.4 GC
Power Range:	1μw to 10 mw
SWR:	Less than 1.5
Elements:	Two permanently inst coefficient thermistors
Waveguide Size:	1" x 1½"
Price:	$145.00

tability, 1 μw to 10 mw coverage, in owave power meter ever produced!

This new ϟ Power Meter makes continual zero-setting a thing of the past, even on the 10 μw range, with extreme temperature stability and a single zero-set covering all 7 ranges. You get a completely usable 10 db sensitivity premium over previously available equipment.

New, specially designed temperature compensated thermistor mounts are used with the ϟ 431A. The ϟ478A Coaxial Mount covers 10 MC to 10 GC, and the ϟ X486A Waveguide Mount covers X-Band.

A dual balanced bridge technique and careful design and construction keep dc power in one bridge equal to the unknown rf power in the other. The dc power is then metered. High heat conductivity materials and matched thermistors in close proximity in the 478A and 486A mounts provide extremely close thermal tracking. Thus ambient temperature effects are automatically balanced out and the meter remains zeroed, even in the presence of thermal shock.

These advantages combine to make the ϟ 431A unusually useful for instantaneous microwave power measurements. Microwave power standards measurements can be made to a high accuracy and resolution by using the dual bridge of the ϟ 431A as a transfer device. A dc calibration input jack permits precise dc calibration of the thermistor mount The grounded output jack will then drive an appropriate digital voltmeter for increased resolution. In addition, the grounded output jack, combined with the nearly drift free operation of the 431A, makes reliable long term recordings of microwave power.

The ϟ 431A also has an optional rechargeable battery pack which will give up to 24 hours of completely portable operation, as well as regular ac line operation while recharging.

SPECIFICATIONS

Power Range:	10 μw to 10 mw full scale in 7 ranges. Also calibrated from −30 to +10 dbm
Accuracy:	±3% of full scale on all ranges
Overall Thermal Drift:	Less than 2 μw/°C (includes meter and 478A/486A Mounts)
Operating Impedance:	100 or 200 ohms, negative, for operation with above Mounts
Recorder/Voltmeter Output:	Phone jack on rear with 1 ma into 2,000 ohms or less
Calibration Input:	Binding posts on rear for calibration of bridge with precise dc standards
Power:	1½ watts, 115/230 v ± 10%, 50-1000 cps
Dimensions:	7½" wide, 6½" high, 12½" deep. Weight 10 lbs.
Price:	$345.00

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ϟ 486A
Waveguide
Thermistor
Mount

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y installed 100-ohm negative
istors for each bridge

or perhaps your power measuring requirements can be met by these ϟ meters

ϟ 430C Microwave Power Meter — 0.02 to 10 mw

This laboratory-proven meter gives instantaneous rf power readings direct in dbm or mw, 10 MC to 40 GC with ϟ proven bolometer mounts available now. ϟ 430C operates with any bolometer operating at 100 or 200 ohms, positive or negative temperature coefficient. Fully adjustable biasing current to 16 ma available to bring bolometers to their operating range. Five power ranges are selected with a front-panel control, full scale readings of 0.1, 0.3, 1, 3 and 10 mw. Also continuous readings —20 to +10 dbm. Accuracy is ±5% of full scale reading. Dimensions, (cabinet) 7½" x 11½" x 14"; (rack mount) 19" x 7" x 13½" behind panel. Price, ϟ 430C $250.00 (cabinet); ϟ 430CR, $255.00 (rack mount).

ϟ 434A Calorimetric Power Meter — 10 mw to 10 w

Here's the fastest, easiest means yet devised to measure powers accurately from 10 mw to *10 w*, dc to 12.4 GC! No barretter, thermistor, external terminations or plumbing are required. Measurements are as simple as connecting to a 50 ohm type N front panel terminal and reading directly. Only two front panel controls (range and zero); seven meter ranges for full scale readings of 0.01, 0.03, 0.1, 0.3, 1.0, 3.0 and 10 w. Also provides continuous readings —30 to +10 dbw. Accuracy ±5% of full scale (includes dc calibration and rf termination efficiency but not mismatch loss). Greater accuracy can be achieved through appropriate techniques. Dimensions, (cabinet) 20½" x 12½" x 14¾"; (rack mount) 19" x 10½" x 13½". Price, ϟ 434A, $1600.00 (cabinet); ϟ 434AR, $1,585.00 (rack mount).

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CONTENTS FOR APRIL 26, 1961 VOL. 9 NUMBER 9

ELECTRONIC DESIGN Hayden Publishing Co., Inc., 830 Third Avenue, New York 22, N. Y.

$1,000 Waiting—Tell Us Who Gets It

The Ideas for Design in this issue are worth looking at. Each Idea is eligible for the $1,000 Idea of the Year award recently announced by ELECTRONIC DESIGN.

Tell us which Ideas are of greatest value to you—that is, which suggest a solution to a problem you may have, or stimulate your thinking, or which are just plain clever. That may apply to merely one of the Ideas or to two or more. Feel free to nominate as many Ideas as you wish for the grand award.

Each Idea is numbered. Vote by circling the corresponding numbers on the Reader-Service Card.

And after you've voted, why not send in some Ideas of your own?

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

Designers Shifting to Wide-Band Communications

Digital Time-Sharing and Continuous-Wave Approaches Are Being Explored To Penetrate Spectrum Congestion

Alan Corneretto
News Editor

BY CHALLENGING intuition, some designers are developing systems in which messages sent over broadband channels would get through congested environments better than those transmitted over narrow-band, exclusively assigned channels.

The apparently logical practice of using narrow-band signals of high power to push through interference is being questioned as not so logical for some types of communications. Two wide-band alternatives being explored are digital systems employing time sharing and continuous-wave systems in which power is distributed over a wide band at low density.

A number of companies, including Motorola, Inc., Martin Co., Radio Corp. of America, General Electric Co. and Philco Corp., have developed random-access, discrete-address digital systems. Users of these systems would time-share wide-band channels randomly and use various message-addressing techniques to lock transmitters to receivers.

A cw type of wide-band communication has been developed by General Electric. In the GE technique, a double-sideband channel several megacycles wide carries a low-powered coded signal to receivers designed to combine multi-path signals of very low signal-to-noise ratio.

Frequency-Division Sharing Of Spectrum Scrutinized

The renewed interest in wide-band communications is partly a result of information-theory developments that have clarified the relationship between spectrum capacity and various ways of sharing the space. Frequency-division sharing is being re-evaluated as the basic approach to using available space; it has been called a poor choice for many applications.

Much of the current effort in wide-band communications rests on the groundwork laid by Lincoln Laboratory's multi-path diversity RAKE system, built in 1957, and the Army Signal Corps' AN/MRC-66 system of several years ago.

Other spread-spectrum systems have been developed to solve specific technical problems, such as ranging in space applications.

In addition to Motorola and Martin, which have released information on their random-access, discrete-address systems, Collins Radio Co. and Philco Corp. report they are developing classified spread-spectrum systems. RCA has several such classified systems in design, including at least one discrete-address system, RADAC. Bell Telephone Laboratories says it has built and tested various types of wide-band equipment with complex modulation schemes.

The Signal Corps is reviewing a number of proposals for random-access, discrete-address systems that it has received in response to an invitation. The agency says the spectrum it anticipates in any warfare is so crowded that it doubts standard, assigned-frequency, narrow-band systems would be able to function. The Air Force is said to be considering a discrete-address system for ground use.

Wideband Emergency System Uses Delta Modulation

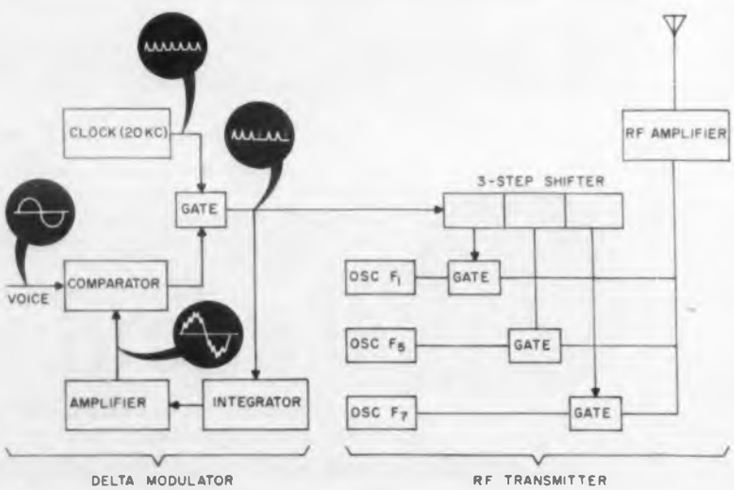
At the 1961 IRE Convention in New York, Henry Magnuski of Motorola, Chicago, described a proposed digital system in which a single wide-band channel could provide emergency, short-range communications in the vhf and uhf bands.

Although the system exists only on paper, some hardware is reported to have been built to test the feasibility of the method.

Delta modulation is used in the proposed system. In this technique, the slope of the voice curve is sampled to provide digital signals from which the original input can be reconstructed. In operation the Motorola system would transmit short pulse groups, each carrying modulation and an address.

To avoid a central control point, transmission of the pulses would not be synchronized. The channel therefore would be time-shared, and pulses from some senders would occasionally interfere with those of others. This interference could be minimized, Dr. Magnuski reports, either by reducing the duty cycle or by transmitting redundant information at the cost of additional transmitter power that would contribute no extra range.

The system is said to be able to accommodate about five talkers per megacycle at an interference level of 30 db.



Delta - modulation transmitter for proposed spread-spectrum communications system transmits discretely addressed digital signals. Feedback loop in Delta modulator integrates and amplifies pulses to reproduce a voice curve. Comparator subtracts reproduced curve from original curve. Positive and negative voltage differences from the comparator close and open the gate, so that pulses from clock will be stopped or passed. Result is that Delta modulation train is formed from clock pulses. Addressing of signal is added by three separate oscillators connected to a common rf amplifier through three gates.

Test model of Racep random-access, discrete-address communications system consists of encoder-decoder for addressing, left; transmitter, center, and receiver, right. System is said to be capable of supporting up to 700 users on 4 mc.

Martin's concept of a discrete-address, spread-spectrum system is called RACEP, for Random Access Communications with Extended Performance. It has been tested in a breadboard model, the company reports. The system is similar to Motorola's proposal but is believed to use a form of pulse-code modulation. Pcm is said to be less vulnerable to jamming than delta modulation.

Martin says that its system would support up to 700 users on one 4-mc channel in a typical 15-mile link at a use factor of 10 per cent. The modulation system used is said to permit either, or both, voice and data transmission with the same equipment, although the system is basically digital. It is intended for use at vhf and uhf.

The system has been discussed with the Federal Aviation Agency for use in air traffic control, Martin says, and has been proposed to military agencies for use in missile guidance and troposcatter communications.

Signals from GE's Phantom System Heard as Noise by Other Sets

General Electric calls its broadband communications system Phantom I. The company describes it as a double-sideband system for long-haul communications. Average transmitted power is spread over several hundred kilocycles, and the system is intentionally operated at a low data rate in relation to transmission bandwidth to minimize the effects of jamming. Signals are addressed by waveform coding.

Phantom I is operating as a test model in the Southwest, sending to a GE facility near Syracuse, N.Y. Although the company is evaluating the system under an Air Force contract, the Army and Navy are monitoring the tests. The system has been reported successful in first tests, and second-phase testing has begun.

Phantom I is classified, as are most of the broadband systems under development for the military. ■ ■

NEWS

Solar-Cell Sensing Used In Novel Accelerometer

Light Beam, Split by a Pendulum, Is Detected by Two Identical Sensors

A NEW accelerometer developed on the West Coast uses a light beam and a pair of identical solar cells for sensing. The beam is split by a pendulum that responds to any acceleration.

The solar cells are formed by scribing a line through the junction layer of a single cell. Changes in illumination on the two cells are detected and compared.

The pendulum is a quartz fiber rod. Illumination from above passes its edges and falls as two discrete beams on the cells. Movement of the pendulum with acceleration decreases the total light flux on one cell and increases it on the other.

In operation, the solar cells respond to the changes in light intensity in nonlinear fashion. However, the cells are used in a push-pull circuit that cancels out nonlinearities.

The accelerometer is the result of a joint effort by Electro Optical Systems, Pasadena, Calif., and Jet Propulsion Laboratory. Electro Optical developed the pickoff.

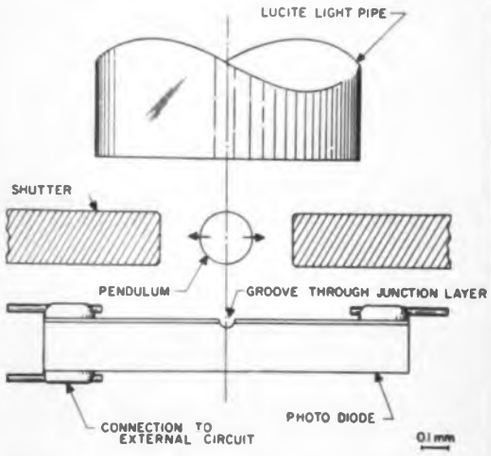
The accelerometer was developed for use in the high energy Vega vehicle, which has been canceled. In Vega it would have been used to sense accelerations useful in orienting the vehicle with respect to the earth.

Acceleration to 1 Part in 10,000 Measured by This Technique

According to JPL's Dr. Alan Johnson, the new accelerometers using this technique are successful; they can measure acceleration to one part in 10,000. Used as simple level detectors or level indicators, they can detect to 1/10 sec of arc.

The accelerometers are 1-in. cubes illuminated by tungsten lamps. They have a condensing lens 0.1 in. in diameter. When the pendulum is in the center position, each of the two slots left between the shutters and the pendulum measures 1 mm by 0.2 mm.

Miniature incandescent lamps obtained by Electro Optical during the development of the device came from Chicago Miniature Lamp Co. and American Cystoscope Makers, Inc. The Chicago Company's lamps were 0.1 in. in diameter, 0.187 in. long, with a 3-v, 60-ma filament rating. The threshold of the larger American Cystoscope No. 540-110 lamps and three of similar construc-



Scribe line splits silicon solar cell into two equal parts in the light-operated accelerometer. Quartz rod pendulum splits light beam into a pair of matched beams at null position. If acceleration is applied the pendulum moves and the change in light flux on the twin cells is compared to get an output proportional to the amount of acceleration.

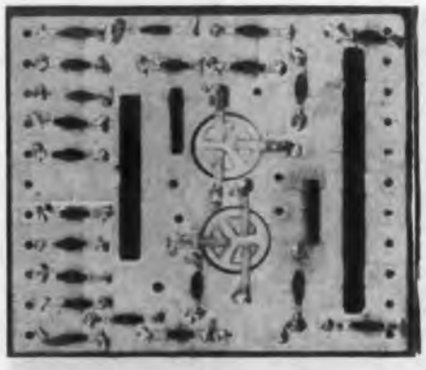
tion to the Chicago No. CM8-666 lamps but 25 per cent larger, were shaken at rated voltage to 36 g, 20- to 1,500-cycles noise without failure.

Used as a gyro pickoff, according to Electro Optical's manager of the Solid State Div., Irving Weiman, no pendulum would be necessary. A small spot of light would be directed from a mirror on the gyroscope to the scribed line on the solar cell. As the mirror drifted, the spot would move to one side or the other of the scribed line. This would result in unequal output from the two cells.

Some of the characteristics of the dual-cell pickoff were reported by Mr. Weiman. Sensitivity of the solar cell itself is given as 8 μa per cm² in tungsten light. Source impedance is 30 K. Senior research engineer William McClellan chose the doping of the silicon solar cells, so as to provide a 50 per cent greater output than standard solar cells—in terms of short-circuit output current. Symmetry, in terms of difference of output between the two cells on a single wafer, Mr. Weiman said, is 5 per cent over a two-to-one variation in light intensity. The temperature range is from 75 to 180 F.

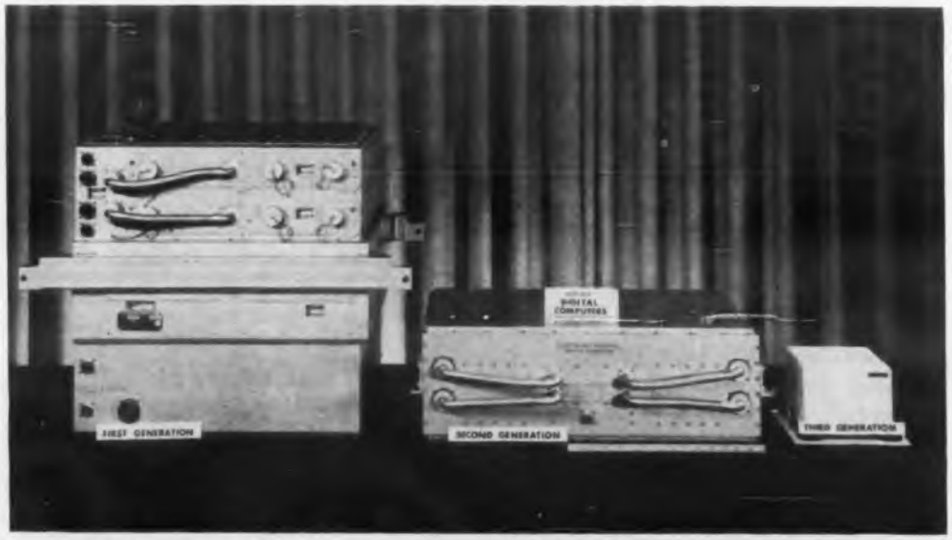
The pickoff has application anywhere a nonloading readout is required. According to Mr. Weiman, it could be used for high-density photo readouts, optical computers and A-to-D converters (by lining up several cells and constraining an analog-generated light beam to travel across them). The dual cell has been marketed in sample quantities by Electro Optical's manufacturing affiliate, Micro Systems, Inc., Pasadena, Calif. ■ ■

Microminiature Guidance Computer to Use 2-D Approach



2-D circuit, above, has Texas Instruments microtransistors, Pacific Semiconductor microdiodes, and deposited carbon resistors mounted on a 1-in. sq alumina wafer. Holes at the edges of the wafer are for wires used to connect it to a printed-circuit board. All joints are made with solder. Intraconnections on the wafer are made with silk-screened silver conductors. Below, deposited carbon resistors are put on a wafer using an injection printing process, giving good thickness control.

Microminiature guidance computer using 2-D circuits with microcomponents and deposited carbon resistors will weigh 15 lb and occupy 0.3 cu ft. The unit, being developed by American Bosch Arma Corp., will have a 1-mc clock rate and 2,300 words of multiaperture storage, provided by either a ferrite sheet or strips.



Three generations of guidance computers designed by Arma illustrate the progressive size reduction achieved. The first generation computer is the present Atlas ICBM inertial guidance computer. The second generation computer, not yet assigned to a specific project, uses circuitry embedded in foamed polyurethane. It was developed under Air Force contract. The third generation computer is the microminiature unit now in development.

Microcomponents to Be Combined With Deposited Elements in Logic

Robert Haavind
News Editor

A PROTOTYPE microminiature guidance computer, using a combination of ceramic wafer-mounted microcomponents and deposited elements in its logic, is scheduled for completion before the end of this year. A nondestructive multiaperture-type memory, using either ferrite sheets or strips, is planned for the experimental unit.

The techniques, being used by American Bosch Arma Corp., Garden City, L.I., N.Y., are derived from the 2-D packaging approach developed by Diamond Ordnance Fuze Laboratories, Washington (see "Guidelines to Microminiature Designs," *ED*, Nov. 9, 1960, p 61). Although the basic approach to the Arma computer has been decided, according to James P. Maguire, supervisor of the company's microminiaturization group, some design details are not yet settled. *(Continued on p 10)*

Arma Guidance Computer Specifications*

	First Generation (Operational)	Second Generation (Prototype)	Third Generation (Developmental)
Weight (lb)	200	60	15
Volume (cu ft)	8	2.5	0.3
Power Dissipation (w)	1,000	120	50
Memory size (words)	**	2,300	2,300
Bits per word	**	29	27
Clock Rate	**	250 kc	1 mc
Add time (μsec)	**	0.128	0.027
Multiply time (μsec)	**	0.896	0.135

*First generation is the present Atlas inertial guidance computer. Second generation uses circuits potted in polyurethane foam. Third generation will use 2-D circuits and a multiaperture memory.
**Classified information.

CIRCLE 9 ON READER-SERVICE CARD ➤

NEWS

(continued from p 9)

Six Basic Circuit Types On 1,000 Wafers To Be Solder-Mounted On Printed Boards

Six basic circuit types, mounted on about a thousand 1-in.-sq alumina wafers, will be used in the computer. Arma plans to join the wafers to printed circuit boards with a flow-solder process. Present test boards contain six wafers each, but a shift to nine wafers on a board is being considered, according to Mr. Maguire.

Conduction paths on the wafers are silk-screened, and resistors are added by injection printing. Silk-screening of resistors was evaluated, Mr. Maguire said, but the injection method was chosen because of better thickness control.

Microcomponents—transistors, diodes and capacitors—are then soldered in place. A fixture, for holding these components in place while the wafer is dipped into a solder pot, is now being designed by Arma for computer production.

Memory Operated in Saturated Mode Insensitive to B-H Loop Changes

Nondestructive read-out of data is the chief advantage of the multiaperture memory under development for the computer. Insensitivity to shifts in hysteresis loop characteristics, caused by temperature variations or other factors, is another advantage of this approach. This is possible because a coincident flux technique, with the ferrite material in saturation, is used by Arma for memory operation. Mr. Maguire declined to give details of the Arma technique.

Prototype memory units have used two-hole cores and conventional copper wiring. Arma is now working on ferrite sheet memories, which would be easier to produce and wire. If eddy currents prove a problem in the sheet approach, the sheet might be cut into multiaperture strips.

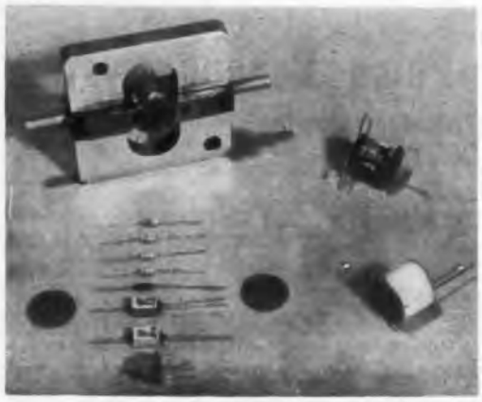
An extruded plastic method for mounting the sheet memory units to boards is being developed, and Arma is also considering the use of deposited conductors rather than wires for interconnecting apertures. The present core memories are mounted on boards in bakelite strips.

Each board in the memory will hold 22 words of stored data. Although the data will be primarily stored programs and constants, provision will be made for external loading from a remote source.

Signal-to-noise ratios of about 15:1 are expected, with drive current requirements of about 500 ma.

Assemblies Holding 8 to 10 Boards Have Slots to Permit Free Air Flow

The memory and logic boards will be fastened to slotted metal assembly frames using Elco Microminiature V-type connectors. Each assem-



Arma's "second generation" computer uses circuits potted in foamed polyurethane. Special jig, top, is used to hold components between pieces of printed circuit board as potting takes place. Circular plugs are then inserted in holes in foam plastic circuit holder. Computer configuration is shown below.

bly frame will hold 8 to 10 boards. A central duct in the computer will allow free air flow through the assembly frame slots and over the flat circuit surfaces, carrying away heat.

The use of corrugated cards between boards within each frame is being considered for better shock and vibration protection.

The initial estimated price for the computer is about $100,000. This is expected to drop as microcomponents become less expensive, and as the computer goes into production. The computer is being developed with company funds.

Second Generation Computer Uses Foam Plastic Circuits

Circuits potted in foamed polyurethane are used in a prototype miniature guidance computer already developed by Arma under Air Force contract. Arma terms this unit a "second generation" guidance computer.

Small cylindrical plugs containing up to 15 components embedded in foam plastic are fitted into machined holes in a foam plastic circuit holder. Printed boards on each side of these circuits are used for interconnections, using solder joints.

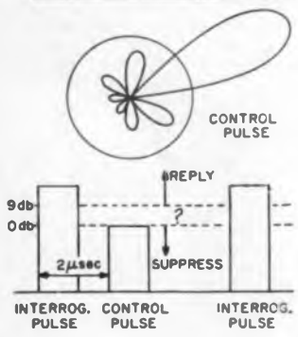
This all solid-state computer has not yet been assigned to any specific programs. ■ ■

NEWS

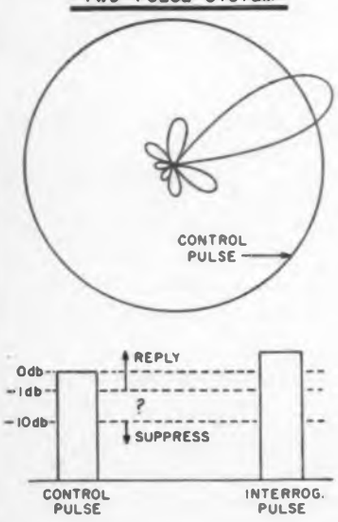
FAA Adopts Three-Pulse Beacon System

Symposium Told New Transponders Needed; Progress Slow in Anti-Collision Devices

THREE-PULSE SYSTEM



TWO-PULSE SYSTEM



Three-pulse side-lobe suppression path system adopted by FAA for use in U.S. differs from two-pulse beacon systems in use internationally in that an omnidirectional pulse is sent 2 μsec after first interrogation pulse and a specified time before second interrogation pulse. In standard two-pulse system, control pulse is sent simultaneously with interrogation pulse and with much greater power than side lobes. In both systems replies are suppressed if side lobes are received, but in three-pulse system less omnidirectional power is needed and timing is less critical.

A THREE-PULSE beacon system has been officially adopted by the Federal Aviation Agency for use by aircraft in the United States. The announcement touched off a competition among manufacturers of transponder equipment to supply the market guaranteed by the FAA's decision and by the major airlines' announced intention to equip their aircraft with transponders. These would be compatible with the secondary radar system being installed by the FAA at major air-traffic-control centers.

At least five companies have developed, or have almost developed, transponders capable of meeting the new standard. These are Radio Corp. of America, Bendix Corp., Collins Radio Co., Wilcox Electric Co., and at least one British firm. The RCA and Collins units, reportedly, are basically two-pulse systems that can be modified by adding a module. The Bendix transponder has both capabilities built in.

Announcement of the new standard was made at the First Annual International Aviation Research and Development Symposium held recently in Atlantic City. More than 500 aviation specialists from nearly 30 countries attended the week-long meeting at which the state of research in aviation was discussed. At the symposium, it was stated that:

- The air-height surveillance radar being tested at the National Aviation Facilities Experimental Center near Atlantic City is so far performing as expected. Twenty-beam segments of the 111-beam system are providing altitude readings accurate to ±200 ft.
- Development of collision-avoidance systems or pilot-warning indicators suitable for general use in aircraft is not probable in the near future, even though one of the three systems under test at NAFEC—the Bendix ground-bounce-ranging system—is meeting specifications. Also under test is a Motorola cooperative pilot-warning indicator and a Sperry system using a microwave antenna.
- Studies designed to aid integration of the Air Force's SAGE system with the FAA's air-traffic-control system are nearly complete and indicate that such integration is feasible.

The FAA's announcement of the three-pulse, side-lobe suppression standard was made during a discussion of the agency's entire radar-beacon program. L. E. Shoemaker, head of the beacon systems section of the FAA's Development Div., said that nearly 60 ground stations were now

equipped with secondary radar beacons and that the FAA planned to install such equipment at all stations that had primary radar. He reported all the major airlines had programs to install transponders in their aircraft, although only a third of the planes are now so equipped.

Besides installing additional equipment, the agency is extending the usefulness of the beacon system by increasing the number of codes that can be used, by adding altitude-reporting capability and by developing transponder equipment suitable for all aircraft other than airline and military. This would comprise about 70 per cent of the planes flying in the U. S.

The 64 codes now available will be increased by doubling the number of pulses in the reply train to form a supplementary set of 64 basic codes. These will provide a total of 4,096 codes. Most secondary radar equipment in development is being designed to operate with the additional codes and to process replies containing altitude information.

Automatic Altitude Reporting Planned in Beacon System

The FAA is confident that altitude reporting by means of beacon replies will prove feasible, according to Kenneth Wise of the agency's beacon section. In a paper at the meeting, he said that development of an automatic altitude-reporting subsystem for radar-beacon systems would reduce the load on aircraft-ground communications channels and give controllers an important third dimension to establish position of aircraft.

In reporting on the FAA's transponder program, Mr. Wise said the agency hoped to start testing by June, five different transponders now being developed for general aviation use. These are being designed by Hazeltine TDC Div., Indianapolis, and Wilcox Electric Co., Kansas City, Mo. The transponders will be lighter, cheaper and have less power drain than units in use on military and airline aircraft, Mr. Wise said.

These transponders will use only 64 codes and a single mode of interrogation, will have limited reply words and will not be as rugged as current types. They will reply only to the common air-traffic control code 3/A, which uses an 8-μsec separation between leading edges of pulses, and will have only three-pulse, side-lobe suppression. Their range, Mr. Wise said, will be 150 miles. Weight and power drain will be 14 lb and 35 to 60 w. The units are being designed to sell from $1,000 to $1,400. The FAA expects to complete testing the transponders by November, Mr. Wise reported.

The FAA representative revealed that the agency planned to develop an improved transponder antenna, with dual aperture and im-

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proved coverage, and was investigating for commercial application the data-transfer feature of an Air Force transponder that uses parity pulses for error checking.

Three-Pulse Suppression System Believed Better Than Two-Pulse

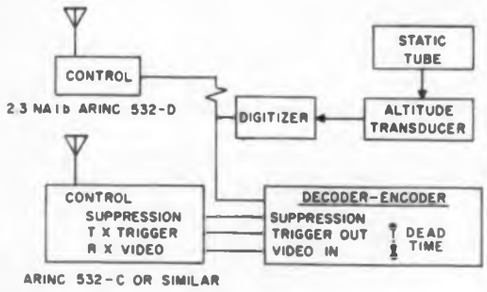
The adoption of side-lobe suppression during interrogation is part of the program to improve existing equipment, Mr. Shoemaker said. In the standardization of the three-pulse suppression technique, not only will beam paths of interrogating transmission be shaped to minimize interference but effective bandwidth will also not be lost as range increases. This point was made by J. E. Herrmann of the agency's beacon section, who delivered a paper on interrogation path side-lobe suppression.

In a two-pulse system, interrogation and control pulses are sent simultaneously–the control pulse omnidirectionally, the interrogation pulse directionally at slightly greater amplitude. The aircraft transponder compares the received pulse with the last one it received. If the new pulse is stronger than the last, it replies, because it is receiving an interrogation pulse. If amplitude is less, it is receiving a side-lobe and so suppresses its reply.

In the three-pulse system adopted by the FAA, an omnidirectional control pulse is transmitted 2 μsec after the first directionally transmitted interrogation pulse and is followed by the third pulse. The aircraft transponder compares the control pulse with the first interrogation pulse in delay-line circuitry and replies if the third pulse is at least 9 db greater than the control pulse. If the third pulse is less in amplitude than the control pulse, a reply is suppressed. The elapsed time between the control pulse and the second interrogation pulse determines which transponders will reply.

According to Albert Brown, chief of the Systems Engineering Div. of the FAA, the advantages of this three-pulse system over a two-pulse system are that it requires less omnidirectional power, gives better reflection suppression, is less dependent on timing and synchronization, is compatible with military systems and uses a simpler antenna.

The system was said to be originally developed by Mortimer Setrin of the Air Force. During the meeting D. G. Terrington of the British Ministry of Aviation, reported that Great Britain was still using a two-pulse, side-lobe suppression system, in accordance with an international agreement. It was learned at the meeting that a convincing demonstration of the effectiveness of the FAA three-pulse system has been made



Test setup for evaluating beacon transponding methods for reporting altitude from aircraft is installed at FAA's Atlantic City, N.J., facility. Transducer converts static pressure to an analog signal. In a simplified arrangement not requiring decoder-encoder, the digitizer connects directly with the control unit of the transponder. The receiver in a more complex version has if video, modified to include suppression of sidelobes, spikes, long pulses and echoes. In reply to proper interrogation, the decoder-encoder codes a reply corresponding to altitude, and uses it to modulate the transponder reply. The code is cyclic binary-coded decimal.

to the British and that they are considering adopting it.

Mr. Wise reported that the three-pulse system, already in test operation at Atlantic City, would be put into general civilian use starting in 1962. It is being recommended for inclusion in the IFF Mark X air traffic control radar-beacon standard, which is a preliminary to recommendation to NATO as a standard system.

In discussing the side-lobe suppression program of the FAA, Mr. Herrmann said that the agency was developing with the Army Signal Corps a traveling-wave-tube switch called a Beacotron for ground-station beacons. In this device the tube output is controlled by voltage applied to the tube's control grid, enabling the switch to control the shape of the beam being transmitted as the beacon antenna is rotated. This feature is particularly valuable, it was said, in areas where several beacons are operating. Output can be suppressed when it will interfere with adjacent beacons. Another high-speed switch being developed for the same purpose would use either diodes or a ferrite device. Both efforts are part of a program to develop a beacon interrogation system that would need only one interrogator to generate both the control and interrogation pulses. They represent adoption of monopulse radar techniques to provide sharpened beam widths of interrogation antennas.

Video Processor in Development Uses Monopulse Techniques

Monopulse techniques, Mr. Shoemaker reported, are being used in equipment about to be introduced to mark the true center of the

NEWS

target arc on the controller's display. This is done in the receiver, he said, by video processing in separate sum and difference channels, and by introduction of an adjusted threshold level. In manual tracking, the width of the displayed arc can be made to correspond to the width of the surveillance radar target, which is about 2 deg.

The video-processing unit that will do this is in development at Burroughs Corp., Paoli, Pa. It was described by W. A. Connolly, an FAA project engineer. It is a 10-channel unit contained in five racks and will be part of major air traffic control radar beacon systems. It will provide beacon tracking, positive identification, and selection and display filtering over a range of one-half to 200 nautical miles, he said. According to Mr. Connolly, this elaborate all-transistorized system will be able to function 10 ways. It will:

- Provide plan position display of replies from aircraft equipped with basic IFF Mark X transponders that answer mode 1, 2, or 3A interrogations. These displays will be blips.
- Provide ppi display of common-system transponders in mode 3 and change a blip display to a bar when the reply code is followed by identification pulses. The number of codes to be handled is expandable to 4,096. An emergency reply produces a double bar, an audible alarm and a display of the letter "E."
- Display as a single blip all aircraft responding to mode 3A and exclude responses from basic IFF Mark X transponders.
- Provide rapid readout and digital display of reply code.
- Provide digital decimal display of all information from planes equipped with mode-C altitude-reporting systems.
- Provide altitude zone filtering by either altitude reply codes or by analog height pulses from 3-D radars.
- Display center marks on each beacon video target equipped with suitable equipment.
- Accept three inputs: basic beacon, all C/S and selective aircraft replies, and analog altitude pulses.
- Control interrogation modes, video definition and display selection.
- Sense code-garble and have nondestructive readout.

Included in the unit will be a storage tube type of defruiter rather than a delay-line type. This subsystem will retain the response pattern of the first interrogation cycle, compare it with the next pattern, and filter out nonsynchronous replies, Mr. Shoemaker said. ■ ■

Advertisement

Burndy YD Tool Modified For Faster Operation

As a result of wide customer acceptance of BURNDY Omaton Division's YD-2, a new version of this semi-automatic, portable, pneumatic crimping tool has been developed. The new edition, the YD-2-3 is a bench-mounted, foot-operated tool with a magazine holding almost eight times (533 contacts) as many contacts as the original version (70 contacts).

The YD was originally designed as a magazine-fed hand-operated tool for work in and near electronic cabinets. The new version will produce a higher rate of contact installation, making it especially useful in harness wiring.

The bench-mounted, foot-activated increased-magazine-capacity features will allow the contact installation rate of the YD-2 to be greatly increased. The YD-2-3 retains the features of automatic pre-positioning, feeding, and crimping of BURNDY's HYFEN®, STAPIN®, and CRAB-LOK®-MODULOK® lines of contacts. It also features color coded die sets matched with the color of contact-carrying strips. The plastic carry strips are automatically ejected from the tool after the contacts have been used.

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Norwalk, Connecticut

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CIRCLE 18 ON READER-SERVICE CARD

NEWS

Bomber IR System Being Designed To Track Enemy While Scanning

A passive infrared surveillance system for bombers is being designed to track while scanning for interceptors or missiles.

Avco Electronics and Ordnance Div., Cincinnati, is developing the system under a $500,000 classified contract for the Air Force's Wright Air Development Div.

Signals from each target tracked by the system will be processed by separate receiving channels. A special-purpose digital computer, also in development at Avco, will compute tracking information from these signals for automatic injection into the bomber's control system. The display will be digital.

The proposed system is an outgrowth of the company's Avscan scanning system, an engineering model of which is being used as a design aid in the development program.

In operation, the Avscan IR scanner rides in the nose of a bomber and scans a rectangle in the aircraft's path. Its field of view is reported to be 60 deg azimuth and 40 deg elevation. Instantaneous field of view is said to be 0.1 by 1 deg, giving a resolution equivalent to 40 lines with a spin rate of 1,800 rpm. Range is believed to be up to 20 miles. The scanner operates in the 3-5-micron intermediate infrared region.

The detector cell used is an indium antimonide grown-junction type developed by Avco and cooled to liquid-nitrogen temperature by immersion in a stainless-steel Dewar flask.

The scanning head contains a refractive optical system consisting of four two-element arsenic

Engineering model of Avscan infrared scanning system, being used to aid in the development of an IR track-while-scan system that will warn bombers of interceptors and missiles. Avscan's scanning head contains four achromats that spin at 1,800 rpm while nodding 3 times per sec. Arsenic trisulphide dome is of 8.75-in. diam. Stainless-steel Dewar flask, at right, contains a special indium antimonide grown-junction cell that operates in the 3-5-micron region. The model shown here has an extra cylindrical section to house a switch for demonstration purposes. System was developed by Avco Electronics and Ordnance Div.

trisulphide and silicon achromats mounted on a rotating drum. The drum spins at 1,800 rpm while nodding 3 times per sec.

A different optical arrangement might be used in the track-while-scan system, it is reported. Broader scan coverage and probably a faster scan rate may be designed into the new system.

Avco is reported working toward designing a ranging capability into such an IR track-while-scan system. Ranging would be provided by a IR maser that generated coherent radiation.

Cryogenic Accelerometer And Delay Line Ordered

Two new applications of cryogenic technology are under way in separate programs sponsored by the National Aeronautics and Space Administration and the Air Force.

An accelerometer, expected to prove the feasibility of cryogenic techniques for sensing of acceleration, is being developed at General Electric Co., Schenectady, N.Y. The device is to be produced under a $119,000 NASA contract.

Martin Co. is designing a cryogenic delay line for the Rome (N.Y.) Air Development Center under a $90,000 Air Force contract.

Design objectives for the accelerometer, which will be an analog, are a threshold and bias of 1×10^{-6} g or less, and linearity and repeatability of one part per million or less, according to GE. The threshold goal is said to be about two orders of magnitude better than that of available analog types and about one order better than the latest digital types. The linearity of typical available accelerometers is about 25 ppm, the company says.

The GE program is related to development of a cryogenic gyroscope, which is proceeding under a previous contract at the company's engineering laboratories. An engineering model of the gyroscope unit has been built and a prototype for testing will be produced, the company states.

As in the gyroscope, the proof mass of the accelerometer will be suspended and rotated in a magnetic field acting on a superconducting surface. The whole structure, including a cryogenic preamplifier, will be enclosed in liquid-nitrogen environment. Data pickoff will be through the preamplifier.

The delay line being developed by Martin is designed for 15,000-ft transmission without energy loss. It is expected to fit in a 3-in. cube. The line will operate at 4.2 K in the microwave region between 4 and 15 Gc and will provide a delay of 20 μsec. It is to be used in a classified system now in development.

WASHINGTON REPORT

J. J. Christie
Washington Editor

RFI—THE HANDWRITING ON THE WALL

The Defense Department's Electromagnetic Compatibility Program, representing a long overdue effort to combat radio frequency interference from a military standpoint, is gaining momentum.

A big step forward in the program will come with the establishment of an RFI analysis center. This facility, which reportedly will be set up and administered by the Armour Research Foundation and located at Annapolis, Md., will be the focal point of efforts to develop techniques for measuring and predicting RFI environment and emission.

Meanwhile, DOD is collecting spectrum signatures on both new and existing equipments for experimental testing. It has let a few contracts and will award others this year to research measuring and predictive methods.

An example of the type of research required at this stage of the game is a project at Georgia Tech which seeks a short-cut means of measuring antenna field patterns. If efforts to measure far effects at close range are successful, Pentagon officials say the expense of such testing would be reduced by a factor of 10.

Once the nature of the data required for interference prediction and control can be ascertained and the best methods of obtaining it can be determined, it is expected that a considerable amount of R&D will be necessary to upgrade instrumentation capabilities.

As the program matures, manufacturers will be required to furnish spectrum signatures with breadboards and with prototypes. Eventually, DOD officials expect that spectrum signatures can be supplied with design proposals on the basis of circuit designs and components.

The Consequences for Industry of the RFI compatibility program eventually will be similar to those now resulting from the Pentagon's determined effort to impose quantitative reliability specifications.

Initially, as in the case of reliability, the impact of the RFI program will be felt primarily on the systems and equipment level—in the need for specialized personnel and the necessity for increased testing and inspection. But, it won't be long before new obligations permeate the components level. DOD experts believe that by 1963 designers of relays, tubes, transistors and other components will be dealing with RFI requirements. They also foresee a boom in filtering device developments.

A good indication of the growing awareness of the RFI problem is the expectation that some 600 engineers will attend the third national IRE symposium on the subject to be held in Washington June 12-13.

MILITARY COMMUNICATIONS DEFICIENCIES

The Kennedy Administration's re-evaluation of defense policy has resulted in strong emphasis on improving both strategic and tactical communications systems and command and control facilities.

In reference to the strategic requirements, the President told a recent

meeting of the NATO military committee: "In our studies we have found a serious need for a sensitive and flexible control of all arms, and especially of nuclear weapons."

He outlined in his defense budget message requirements for "invulnerable and continuous command posts and communications centers" to insure "controlled and properly authorized response. . . ."

Implementation of these goals involves development of airborne and seaborne command posts as well as mobile land units and underground installations. The plan envisions tying one or more mobile command posts into key communications centers such as the Strategic Air Command headquarters.

Under consideration for airborne centers are either the Lockheed C-130 transport plane or the KC-135 tanker version of the Boeing 707, both of which have the advantage of short runway requirement. The project may lead to new requirements for airborne computers, although it is noted that a good deal of the data processing could be performed on the ground and that the results would then be relayed to the flying command posts.

Underground installations will give added impetus to efforts to propagate low frequency and very low frequency signals through nonconductive rock strata. The program also puts further emphasis on the necessity for shock-resistant communications and for data-processing equipment.

Tactical Communications are under review as much from the point of view of procedures as from the standpoint of equipment. As one DOD communications official put it, "voice transmission is too wasteful of bandwidth to be relied upon under present-day battlefield conditions. We must go to code to the fullest extent possible and even in fairly rudimentary equipment."

Concern over spectrum congestion and both intentional and unintentional interference has Pentagon communications experts anxiously watching developmental work on various modulation schemes and on wideband systems such as random access, discrete address systems. (See story on p 4). However, they remain noncommittal on these developments, pending determination of cost, weight and complexity as compared to conventional narrow-band systems.

Military communications planners expect to put greater reliance on digital data links for tactical use and point to the need for further development work in this field.

Mobile tactical command posts also have high priority. One feature of these will be smaller versions of the trailer-housed MOBIDIC general purpose digital computer developed for use at Army headquarters level. Smaller versions will go into mobile units at corps and division levels, and perhaps at even lower command echelons.

McNAMARA'S TROMBONES

Drastic alterations in the Pentagon's procurement organization and procedures could result from studies that have been initiated by Defense Secretary Robert S. McNamara. Not only is single-service procurement under study but also the often proposed ministry of supply approach under which procurement for all the services would be unified.

Some 100 or more quick study projects, which have been dubbed "McNamara's Trombones," have been assigned by the Defense Secretary since taking office in January. They range from re-examination of top-level strategic doctrine by the Joint Chiefs of Staff to improved means of preventing classified information "leaks."

NEWS

Ten Navy Carriers to Get Automatic Landing Systems

Automatic landing systems will be installed aboard 10 Navy aircraft carriers, including the nuclear-powered Enterprise.

Twelve of the landing systems are being produced for the Navy Bureau of Ships by Bell Aerosystems Co., Buffalo, N. Y., under a $10-million contract. In addition to the 10 carrier installations, two systems will be employed as land-based training devices.

The Bell system electronically guides an approaching aircraft to a landing on the carrier deck without need for the pilot to touch pitch and bank controls or to make visual contact with the carrier.

The system assumes control of an aircraft when it is several miles from the carrier. Radar tracks the airplane and relays its position to a computer. The computer compares the aircraft's position with that of the carrier and generates control commands, which are radioed to the aircraft's automatic pilot.

In addition to the Enterprise, the Bell landing system, officially designated AN/SPN 10, will be installed on the Constellation, Kitty Hawk, Independence, Ranger, Saratoga, Forrestal, Roosevelt, Coral Seat, and Midway.

Components Parley to Consider 'Darnell Report' on Reliability

The expected impact of the "Darnell report" on new parts specifications for reliability should be a high point of the Electronic Components Conference which will be held in San Francisco, May 2-4.

The Darnell report was prepared by a 56-man military-industrial study group led by Paul S. Darnell, director of military reliability engineering at Bell Telephone Laboratories. The formal title of the study is "Parts Specifications Management for Reliability."

The effects of the Darnell report—including new parts reliability specifications by the Defense Dept.—will be discussed at the components conference by William H. von Alven of ARINC Research Corp., Washington, D.C.

Microwave components will be analyzed at the conference at an afternoon session May 3. The following topics will be discussed: "A Vacuum Coaxial Relay for High-Speed, High-Power RF Switching"; "The Output Window—A Critical Item in High-Power Microwave Electron Tubes"; "Solid-State, High-Power Modulator for

Pulsing Microwave Device"; "Microwave Filters Using Ghost-Mode Resonance," and "A Miniature-Package 2,200 Mc Parametric Amplifier Using a Varactor-Loaded Helix."

The keynote speaker will be James Bridges, Defense Dept. director of electronics, who will discuss "New Components and Their Impact on Our Future."

The conference, sponsored by the IRE, AIEE, EIA and Western Electronic Manufacturers Assoc., will be at the Jack Tar Hotel.

Standards for Luminance Available From NBS

A program to provide standards for luminance has been initiated by the National Bureau of Standards.

The program is in response to requests for precision evaluation of the brightness of aircraft instrument dials and panels.

Covering two components—a diaphragmed, flashed opal glass and an electric lamp—the standards are also being used for other standardizing purposes: for example, to achieve uniformity in measuring the brightness of cathode-ray tubes and TV sets, and to calibrate the luminance meters used by engineers.

Luminance standards are issued with a report of calibration containing instructions for their use. They are available at prices ranging from $63 to $72 (depending on the size of the lamp component), from the Photometry and Colorimetry Sections, National Bureau of Standards, Washington 25, D.C.

Over 100 Functions Monitored

Engineers test a new system that will check out the launching of this country's first Saturn booster later this year from Cape Canaveral, Fla. Monitoring more than 100 functions, the system will automatically stop the launch sequence in the event of any malfunction. It was developed by the Guidance and Control Div. of the National Aeronautics and Space Administration.

NEWS

Leipzig Fair Indicates Slow E. German Progress

Radio and TV Sets On Display Fail to Impress Western Visitors

Gustav Grenschow
ELECTRONIC DESIGN W. German Correspondent

WESTERN obesrvers at the Leipzig Spring Fair in Communist East Germany were largely unimpressed with the radio and television models on display. On the whole no important technical advances were evident.

Improvements in sound quality, ease of control and sensitivity appeared to have reached a peak last year. Some of the set cabinets this year were more contemporary in design, though, more in the direction of stylings in West Germany.

Production Emphasis Is Shifting to TV

A slow shift in production, from radio receivers to more television sets, is apparently under way in East Germany, where all plants are Government-owned or controlled. Manufacturing of home radios has been stopped at the Stassfurt plant, as has production of portable and auto radios at Funkwerk Halle. Both plants are now fully engaged in turning out television receivers.

Television production is concentrating on 15 set models, with list prices ranging from $410 to $900. Picture tubes for the receivers are standardized; only two types are available for all 15 receiver models. One of the tube types, a 17-in. variety, is being used in five models, and the other, 21 in., in 10 models.

In radio manufacturing, nine East German plants are building a total of 29 models of home receivers. Of the nine plants, two are concentrating on seven combination radio-phonograph consoles. Three manufacturers are building four portable radio models.

Three of the four portable radio models are transistorized.

Output of Semiconductors In Millions at Two Plants

East Germany has two producers of semiconductor devices, Werk Fuer Fernsehelektronik in Berlin-Obserschoeneweide and Halbleiterwerk Frankfurt in Frankfurt on Oder. Plans this year call for producing 3 million transistors and 5 million diodes and semiconductor rectifiers.

The Berlin-Oberschoeneweide plant is developing germanium and silicon diodes for small-

power applications, as well as Zener diodes of up to 250 mw. The Frankfurt plant, in the midst of a long-range expansion program, is making germanium transistors and diodes.

Some of the East German component production is being adapted to printed-circuit requirements, but this field seems in a first stage of development, according to what was shown at Leipzig. There is, however, an over-all plan for the gradual, widest-possible introduction of printed circuits in East Germany.

Satellites Appear to Lag In Radio-TV Styling

Czechoslovakia, Hungary, Poland and other satellite countries exhibited at the fair. Judging by the displays, though, some of these nations are several years behind in radio and television styling and circuitry compared with the West.

Transistorized portable radios were shown by Czech, Polish and Hungarian manufacturers. A Czech model, dubbed Universal, can be used as an auto radio or a normal portable.

A Soviet transistor radio of very small dimensions had an audio output of 800 mw. This model is designed as a home radio, not as a portable in the Western sense of the word.

Television sets from the Soviet Union and some from Czechoslovakia came the closest to Western standards of cabinet design. These sets were equipped with 17- or 21-in. tubes and were relatively flat. ■ ■

EIA Technical Data Service Offered to Microwave Users

Information to avoid possible interference with nearby microwave facilities will be available to microwave equipment manufacturers and users under a new Electronic Industries Association service.

The service, set up after consultation with the Federal Communications Commission, uses a standard form for compiling technical data on all U.S. private and commercial microwave facilities. These data include transmitting frequency and bandwidth; transmitter make, model, and rated power output; antenna type, input power and location; and compass points with which the station communicates.

Photocopies of these data forms are made and distributed weekly to subscribers. Assuming 100 per cent participation in the program, subscribers will have complete data on all microwave operations within a year, since the FCC requires licenses in this class to be renewed annually.

Information can be obtained from the EIA in Washington or from Seabrooke Printing Co., 514 Tenth St. N. W., Washington 4, D.C.

NEWS

U. S. Sends Clear Radio Signals To Venus and Back in 6½ Min

Strong, clear radio signals have been reflected back to earth from Venus. The round trip took about 6-1/2 min, the National Aeronautics and Space Administration announces.

The transmission was completed at the Jet Propulsion Laboratory's Goldstone tracking station in the Mojave Desert. It is the first announced success in a two-month experiment to unveil some of the mysteries of Venus.

The laboratory crew at Goldstone started months ago to prepare two 85-ft dish antennas for the experiment. The transmitting antenna, placed 7 miles from the receiving antenna to minimize interference, sent a 2,388-mc signal to Venus using about 10 kw of power. The signal was a conical beam only 0.4 deg wide.

The Goldstone receiver used both a maser and a parametric amplifier.

Other experiments have bounced signals off Venus, but this is the first time such signals have been immediately detectable without elaborate analysis and processing, NASA reports.

R&D in Chicago Region Under Study by 2 Groups

Electronic research and development in the Chicago region is being examined for quantity and quality by the National Electronics Conference, Inc., in cooperation with a group of engineering management personnel.

A study sponsored by the two groups is seeking to determine whether the region's R&D potential is being adequately realized.

The findings are expected to be available for presentation at the 1961 National Electronics Conference, to be held Oct. 9-11 at the International Amphitheatre in Chicago.

French Field-Effect Amplifier With High Impedance Offered

A new French field-effect amplifier reported to have an extremely high input impedance—0.5 to 5 meg, depending on type—is being offered in large quantities in France.

The semiconductor device, called Tecnetron, is made by Thomson-Houston Co. Designed principally for use in fm radios and TV sets, the amplifier has an upper frequency ceiling of 110 mc.

attention diode users: if someone has removed your copy of Hughes' informative new brochure on germanium diodes, just circle 248 on reader service card, or write

H

Hughes Semiconductor Division • Box 278 Newport Beach, California

Number two of a series

H

WHY ENGINEERS USE GERMANIUM DIODES

II

How to characterize specify and use germanium diodes today

attention diode users: if someone has removed your copy of Hughes' informative new brochure on germanium diodes, just circle 248 on reader service card, or write

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Hughes Semiconductor Division • Box 278 Newport Beach, California

Why engineers use germanium diodes

Of late, there has been much discussion as to exactly why, with the apparent superiority of the silicon diode, germanium diodes are being purchased and used at all. Especially today when the price gap between silicon and germanium has been appreciably lowered. To the device engineer, the following may appear "old hat"; but, for the engineer who utilizes semiconductor devices intermittently, changing semiconductor technology and market conditions should be constantly examined, summarized and recorded so that he will not lose sight of the exact purpose each component is designed for and where it fits in today's overall engineering picture. Hughes, pioneer of semiconductor devices[1], has attempted to achieve this with the following discussion of the germanium diode.

Price for today's semiconductor devices is a major design factor and should be examined first. Historically, the germanium diode has been less expensive than the silicon. In many instances, however, silicon diodes' costs have been reduced through improved manufacturing techniques so that they now equal those of germanium. But, where requirements call for the characteristics which originally made the germanium diode a valuable and popular device, price is still a most important factor. Where high recovery speed in the millivolt region combined with high conductance is a requirement, the silicon diode is still far more costly to manufacture and t
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October, 1953.

GERMANIUM DIODE FAMILIES AND TYPES

Essentially, germanium diodes can be classified into three basic performance groupings:

(a) general purpose (point contact)
(b) general purpose (gold bonded)
(c) ultra fast switching (gold alloy)

Figure 2 compares typical forward characteristics of the three germanium families listed above. Note the high forward conductance of the
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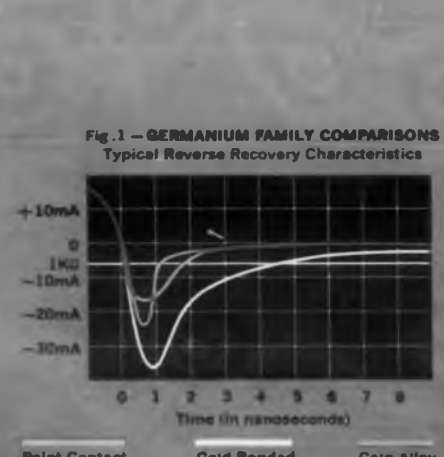
Fig. 1 — GERMANIUM FAMILY COMPARISONS
Typical Reverse Recovery Characteristics

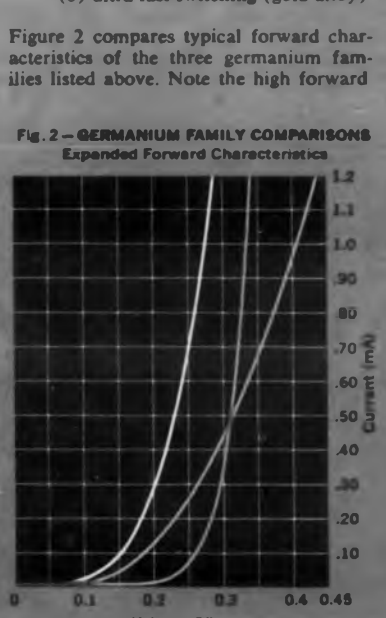


Point Contact | Gold Bonded | Gold Alloy

For measurements see: Recovery, under Ultra Fast Switching Diodes

Note: If special body markings or codings are required, allow additional .008" for outside body diameter.

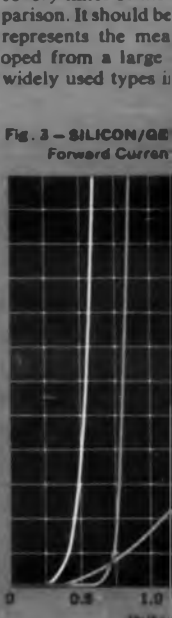
Fig. 2 — GERMANIUM FAMILY COMPARISONS
Expanded Forward Characteristics



Point Contact | Gold Bonded | Gold Alloy

NOTE: Detailed specifications on all Hughes® germanium diode types are available upon request — see back cover for address of Hughes representative nearest you.

Fig. 3 — SILICON/GE
Forward Curren



Ge Gold Bonded | Ge

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N/GERMANIUM COMPARISON
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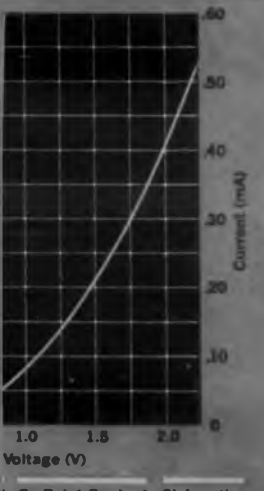


POINT CONTACT DIODES

PHYSICAL CHARACTERISTICS The original "point contact" diode is actually one in which the active junction is formed by a pressure contact between the whisker tip and the slice of germanium (i.e. the old crystal radio set with its cat whisker). The modern version of this device consists of a germanium N-type die which is soldered to one lead. The other lead is welded to a molybdenum S-shaped whisker whose tip has been indium plated. The tip is then fused to the germanium slice to form the active junction. Externally, they are fusion sealed in a subminiature glass package to ensure complete isolation of the active elements from damage or contamination. They will withstand severe physical shock and vibration.

ELECTRICAL CHARACTERISTICS Forward currents range from about 1 to 25 mA at one volt while reverse currents range from 15 to 500uA at 50 volts. Peak inverse voltages range from 50 to over 150 volts. The diode capacity is generally less than 1 pf. Frequency response is about 100 mc. The diode operates efficiently within the range from −55°C to +90°C.

APPLICATIONS The number of uses for these diodes is legion. Examples are tube and transistor driven logic circuits, RF mixers, clampers, modulators, bridge rectifiers, detectors, and instrument rectifiers.

HUGHES EIA TYPES — *JAN versions available

1N34A	1N66	1N70A	1N90	1N116	1N126A*	1N191	1N198B	1N297
1N38B	1N67A	1N81A	1N95	1N117	1N127A*	1N192	1N268	1N298
1N54A	1N68A	1N88	1N97	1N119	1N128*	1N198*	1N290	1N480
1N58A	1N69A	1N89	1N99	1N120	1N142	1N198A	1N294	1N636

GOLD BONDED DIODES

PHYSICAL CHARACTERISTICS The gold bonded germanium diodes are identical with the point contact types except that the molybdenum whisker is replaced by a gold-gallium doped wire. The forming process or "gold bonding," is a process in which a short pulse of current fuses the gold wire tip into the germanium and forms a small P-N junction, giving fast recovery and low shunt capacitance.

ELECTRICAL CHARACTERISTICS These popular Hughes® diodes represent a high conductance series. They have a range of forward currents from 25 to 600mA at one volt. Inherent in this series is a sharp voltage-current reverse characteristic, more like that which silicon displays. That is, the reverse current is linear with applied back voltage until a sharp breakdown region is reached. The reverse currents and peak inverse voltages, as well as the temperature ranges, are the same as those of the "point contact" series.

APPLICATIONS The applicability is also much the same as that of the point contact series except the gold bonded devices offer the advantage of higher forward conductance and higher reverse impedance. It should be noted that the alloy formed at the juncture of the crystal and the whisker (gold, gallium, and germanium) is somewhat more brittle than the corresponding alloy formed in the case of the "point contact" diode. Although considerable progress has been made in improving the mechanical ruggedness of these devices to the point where they are almost as rugged as the "point contact" types, careful consideration should be given to this factor when designing equipment which must withstand severe environmental conditions.

HUGHES EIA TYPES — *JAN versions available

1N96	1N98A	1N118	1N139	1N143	1N276*	1N279	1N287	1N291	1N770
1N96A	1N100	1N118A	1N140	1N270*	1N277*	1N281*	1N288	1N292	1N835
1N98	1N100A	1N133	1N141	1N273	1N278	1N283	1N289	1N500	

ULTRA FAST SWITCHING DIODES

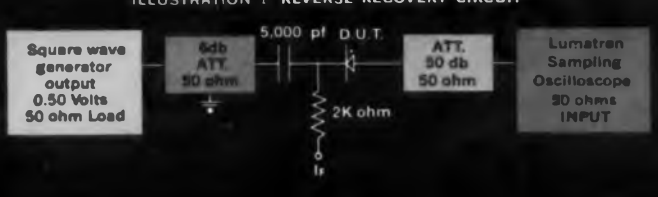
FEATURES These Hughes® diodes are a modification of the "gold bonded" process of diode manufacture. They combine fast recovery with low voltage drop. Devices in this series switch at nanosecond speeds and have rectification efficiencies ranging from 60 to 75% @ 100 mc. Their forward conductances are much higher than the "point contact" germanium types.

APPLICATIONS Designed especially for high speed computer logic, high-frequency transistor circuits, extremely fast reference switching...and, also, low-noise, low-level RF modulation and demodulation.

RECOVERY Measured with the Lumatron scope and attachments, see Illustration 1, when switching from 10mA to −6V, $R_L = 100$ ohms, they recover to 1K ohms in 2 to 5 nanoseconds. Typical capacitance @ 0 Volts = 0.8 to 4 pf (measured on Boonton's Model 75A-S8 capacitance bridge with applied signal voltage 50mV peak to peak). Forward switching speeds are too fast for detectable measurement on the presently available "traveling wave" or "sampling scope" equipment.

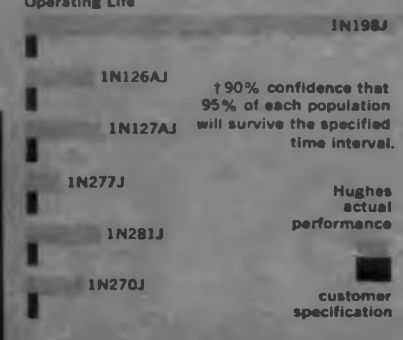
HUGHES TYPES Two Hughes house types are currently available, HD2963 and HD2967; and registration procedures for additional types are in process.

ILLUSTRATION 1 REVERSE RECOVERY CIRCUIT



Survival Reliability†

Specific reliability data must include a complete definition of test conditions, testing intervals, what constitutes a failure, applicable confidence levels, and many other pertinent facts in order to be at all meaningful. However, the following chart indicates examples of Hughes' actual reliability performance against customer specification for a few representative germanium diode types.



Purchasing Do's and Don'ts

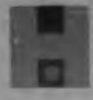
DON'T specify a device that does not exist for your circuits—although this will motivate research and development groups to design better products for the future...the immediate result is long delay in quantity delivery. Be sure you can wait if your requirement is exotic.

DON'T specify inferior products for economical purposes resulting in unreliable circuit performance. This practice creates a vicious reject and replacement cycle between manufacturer and user.

DON'T buy from manufacturers whose facilities are not adequate for testing to rigid military specifications and whose production quantity delivery is questionable.

DON'T attempt to buy reliability by specifying breakdown voltages far in excess of those required. There may be some exceptions, however, this is a very expensive practice. DO buy reliability—not reliability by safety factor!

DO make sure that the diodes you buy meet the manufacturer's advertised and registered specifications.



DO make sure your 1N diode type is "registered" with EIA, not "reserved." When using types with a "reserved" status, the manufacturer may alter his specifications at will.

DO make sure the leakage currents are measured at a reverse voltage as high as your present requirement demands.

DO remember that reliability has to be designed in the diode; it cannot be tested in. No amount of testing will undo poor design. However, it is important that the manufacturer have a sound quality assurance program to insure that the reliability is actually there.

DO make sure that a diode that is to be used as a switch meets your speed requirements by actual test in your circuit; this is the only true test. Manufacturers often show values for switch-speeds that are optimized.

DO be sure to get the leakage currents you actually need. Specify the measurements which match most closely your actual circuit requirements.

DON'T guess what the parameters will be if your circuit is for intended high temperature operation, but DO get the proper data from the manufacturer.

Germanium diode's future at Hughes

Obviously, device engineers *still* need and use germanium diodes and will continue to incorporate them in their circuits for years to come. Hughes also will continue to design and produce better and more efficient germanium devices for the industry. Listed below are some of the goals Hughes' engineers have outlined to achieve that end.

- Leakage current approaching micro-micro-amps
- Minimum parameter change with temperature
- Infinite life expectancy
- Completely defined reliability
- Microminiaturization
- Recovery times in the low nanosecond region

The foregoing information has been gathered from the Hughes Semiconductor Division's reports and records on the germanium diode, compiled with the cooperation of Hughes' staff of skilled engineers. A pioneer in the semiconductor field, Hughes has continued as a top developer and producer of the most advanced semiconductor devices. The Newport Beach plant, with its third of a million square feet of floor space, houses all of the facilities necessary for every phase of design, development and production of diodes, transistors, rectifiers, special devices and semiconductor materials. *For further information call or write your nearest Hughes Semiconductor Sales Office. Or write, Hughes Semiconductor Division, Marketing Dept., 500 Superior Ave., Newport Beach, California.*

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Wet-Blast Machine Cleans Component Leads Rapidly

Semiautomatic cleaning of component leads prior to circuit board soldering is being done at rates up to 4,000 components per hour with a wet-blast machine at Melpar, Inc., Falls Church, Va.

Other techniques evaluated by Melpar before choosing the automated wet-blast approach included brushing, chemical reaction, wiping, and glass erasing. The disadvantages of these methods included high cost, handling difficulties, and inability to clean all types of leads. The company sought a method that allowed uniform and complete cleaning, conveyor handling of components, and fast loading and unloading.

A modified wet-blast machine manufactured by Pressure Blast Manufacturing Co., Manchester, Conn., was chosen. In operation the machine adjutates an abrasive into a homogeneous water-grit mixture, which is forced out of a blast gun by compressed air.

Mighty Atom-Smasher Tube

Experimental model of 24-megawatt superpower klystrons, being developed by Sperry Gyroscope Co., Great Neck, N.Y., for a proposed two-mile-long atom smasher, is assembled by Sperry engineers. Energies of up to 10 to 20 billion electron volts are expected to be achieved by driving relatively lightweight electrons along a straight path. Six tubes will be delivered to Stanford University later this year. The accelerator of the atom smasher will require 240 of these klystrons.

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NEWS

Simulator for B-58 ECM Station Has Automatic Program Control

A complex simulator has been put in operation by the Air Force to train crewmen of the B-58 bomber who man the Mach-2 craft's electronic countermeasures station.

The simulator, which has passed its acceptance tests, according to the manufacturer, Reflectone Electronics Inc., Stamford, Conn., is an exact replica of the bomber's Defense System Operator Station (DSO). In the B-58, the pilot and navigator are too occupied to monitor for tracking, possible attack, and to take countermeasures. The DSO operator, protects the aircraft.

Flexible programing, designed around an automatic programed system, permits the instructor to run the mission manually, automatically by a punched-tape programer, or both manually and automatically. The programer has a repeatable capacity for controlling 50 discrete functions over a maximum operating time of 10 hours during a single mission, according to the manufacturer.

A typical mission might include takeoff, use of the craft's passive and active defense systems, and communications and othreer equipment.

Reactions Are Printed by 300-Channel Printing Recorder for Analysis

Students' reactions are recorded on paper tape; voice communications are recorded on magnetic tape. Fifty channels of a 300-input-channel printing recorder record events as they occur. The remaining channels record the status of student controls or trainer actions on command of the

Student and instructor compartments of simulator for operators of B-58 electronic countermeasures station houses equipment for simulating missions, which can be programed automatically. Three punched matrix cards feed program information into trainer from triple box-like device above and to left of instructor, who may change conditions or insert malfunctions.

instructor at specific times. Only student errors are recorded, to simplify analysis.

Reflectone reports that the trainer simulates two enemy ground radars and three radar-equipped airborne targets. When the operator gets within range of these transmitters and is tracked he gets a warning. He then selects the chaff or chaff technique he wants and observes the effects.

Airborne attacks can be simulated one, two or three at a time. Signal generators develop targets for display on radar-system indicators. All functions of monitoring, target selection, and use of armament must be performed to remove the target from the display.

Programing is provided by a Hickock Cardomatic switch into which punched Mylar cards are inserted. Reflectone reports that, for the most part, voltages proportional to the value of the particular parameter are picked off a voltage-dividing network by the switch.

The simulator uses an analog electro-mechanical computer system to produce pursuit or lead-collision attack courses, selection of which may be made by means of the punched cards. Angular quantities are generally indicated by mechanical shaft positions and scaler quantities by dc voltages.

Development of very accurate elevation signals is said not to be necessary because the only elevation indication in the radar system is the relative time sequence in which the several target signals flash on the scope indicator. This function is provided with initial elevation set in as a dc voltage.

The simulator is designed for retrofitting so that changes in configuration of the actual aircraft can be provided for in the simulator. ■ ■

Slide out rack construction is used for simulator's electronic subsystems. Computer for system is an analog-electromechanical unit.

NEWS

Versatile Computer Is Planned To Process World Messages

Plans are under way for a versatile computer system that would process messages from a variety of worldwide networks.

The system, to be developed by RCA Communications, Inc., of New York City, reportedly will employ many of the techniques and much of the equipment used in the RCA 601.

The special data processor will be designed to store information that will enable it to handle automatically and rapidly all messages sent into it from any channel of communications. The system will be built to handle traffic transmitted by wire lines, microwave, coaxial cable, high-frequency radio, tropospheric scatter propagation or satellite communications systems.

By recognizing the various code symbols preceding a message, the processor will identify the type of message, the country it is destined for, the major city to which it should be sent, the route it should follow, the relay points along the line, and even the priority the message warrants. The system will then send the message through normal transmission channels to its destination.

One of the features of the computer-controlled system will be an automatic check for accuracy.

Two identical systems, to assure reliable operation, will be installed in New York City. They will occupy 3,850 sq ft.

10,000-W Transmitter to Bounce Telephone Signals Off Satellite

A 10,000-w fm transmitting system is being developed for the Air Force to bounce telephone and teletype signals off an Echo satellite. The system will be used on a 2,000-mile experimental relay network between Floyd, N.Y., and Trinidad, West Indies Federation.

The equipment is being built by Radio Engineering Laboratories, Inc., Long Island City, N.Y., under a contract from Page Communications Engineers, Inc. It is designed to provide the reliability and clear-voice reception of wired telephone systems.

The new transmitter will beam its signals from Floyd at the satellite, which will reflect them downward. At Trinidad the highly attenuated signals will be picked up by powerful receiving systems, amplified and demodulated into their original voice, teletype or data messages.

The transmitting system includes a giant 10-kw power amplifier (1,700 to 2,400 mc) and a 10-w exciter, which will operate from an ultra-stable

"Atomicron" high-frequency generator.

Page is in over-all charge of the installation of communications equipment, under technical direction of the Rome (N.Y.) Air Development Center.

Watch Converted to Measure Heart Beat Automatically

An inexpensive wrist watch has been converted into an automatic, convenient device for measuring the heart beat.

The device, called a Heart Beat Totalizer, was developed by Lockheed's Missile and Space Div., Sunnyvale, Calif., for two San Francisco heart specialists. It measures a person's heart beat day and night while he continues his normal way of life.

The device employs two electrodes, about the size of a postage stamp, which are taped to the chest. Wires from each electrode connect to a battery-operated amplifier, which can be clipped to a wearer's undergarment.

Amplifier Increases Voltage of Human Heart Beat

Heart-beat voltage is increased by the amplifier and is transmitted by a thin double-wire to the wrist watch. A tiny electromagnet, taking the place of the watch's balance wheel, is powered by the heart-beat amplifier. The electromagnet operates the escapement mechanism of the watch, causing the second, minute and hour hands to move.

One hundred and fifty heart beats will move the second hand one full circle. For the minute hand to make a full circle, 9,000 heart beats are required.

Comparison of the heart watch with a conventional timepiece will tell how fast the heart is beating.

A patient wearing the Heart Beat Totalizer can determine the activities in his daily routine that produce increased strain on the heart.

Heart watch, looking like an ordinary timepiece, measures the heart beat.

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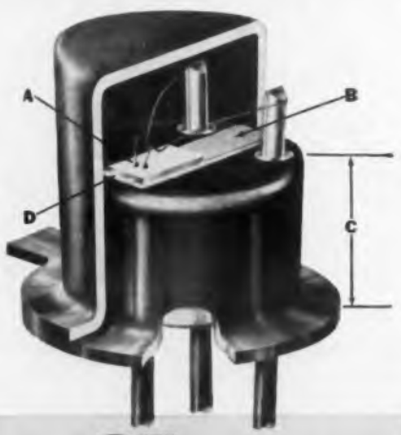

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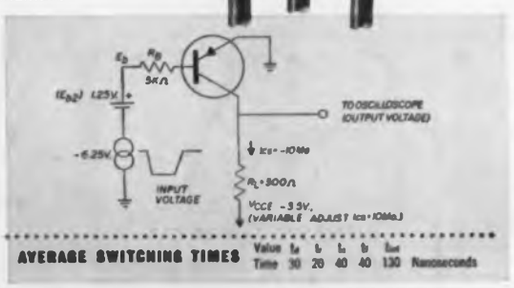

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Time	30	20	40	40	130	Nanoseconds

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EDITORIAL

Good Styling a Critical Factor

The majority of electronic instruments now on the market show some evidence of good styling. In walking along the more than two miles of exhibits at last month's IRE Show, one expected almost automatically to see something smart, neat, clean and modern. Only infrequently did some boxed monolith, with camouflaged knobs and markings all in gray or black, turn up to remind us of the day when electronic engineers laid out their own panels.

It's quite certain that any Show attendees who grimaced as they looked at these ghosts of the past did not warm to buying them, regardless of their technical features. If a similar product showed evidence of being well designed both from the inside and the outside, they picked the latter.

The moral is obvious: if you design a product for the marketplace, make sure it meets today's standards of smart appearance.

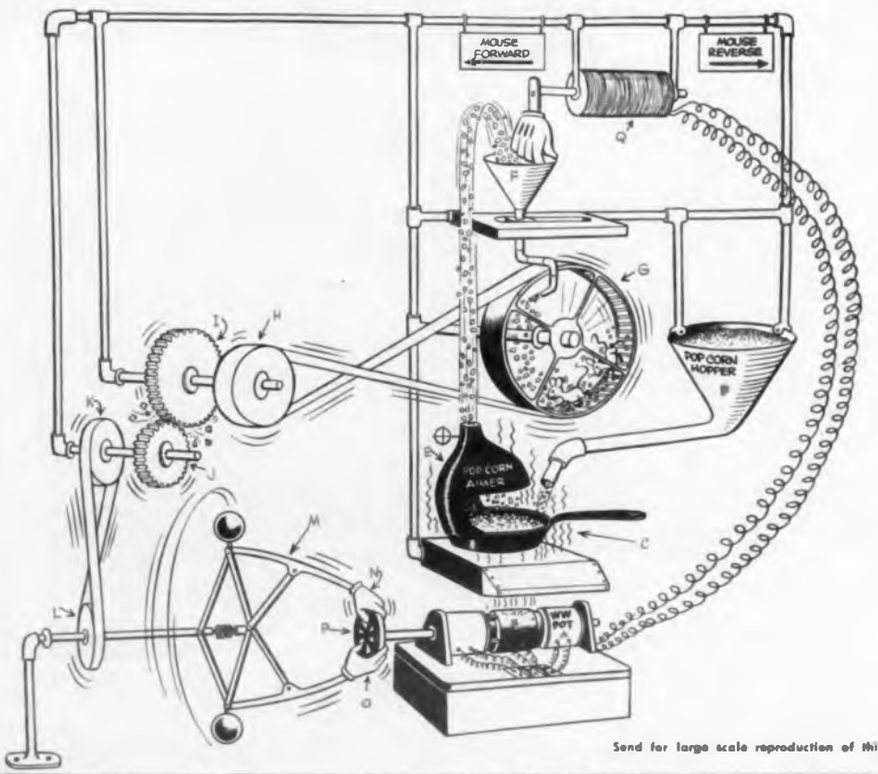
Obviously silk-screened panel markings, baked on flush lines, and ordinary engravings look cheap. Neither can smart design be achieved now—as in recent years—simply by using fancy panel meters and colored knobs. We have reached a higher standard. Nothing less than completely integrated instrument designs are called for today.

To be properly designed, the product's circuit must not only perform its role and the controls be human-engineered to facilitate operability; the product must fit harmoniously into the total environment, which includes other equipment, test benches, storage shelves and the like. One such total approach to the packaging design of instruments was displayed at the IRE Show. The handiwork of Hewlett-Packard's industrial designer Carl J. Clement showed a single integrated solution to the design problem of panels for both bench and rack mountings, servicing accessibility, and the carrying of small instruments.

Industrial designers try to tell us our unconscious is favorably influenced by impressive appearance. We do not know how much. We acknowledge that good styling may only be in the eye of the beholder. But what our eye sees pleases us, and this should be sufficient warning to those who ignore the outside of their "black boxes."

Jerry G. Kippke

How To Improve Response Speed of Servos Using Wire-Wound Pots...



Send for large scale reproduction of this unique system.

High starting torque Wire-Wound pot (**A**) stalls Servo Motor (**B**). Motor overheats. Frying Pan (**C**) becomes hot and proceeds to pop corn. (Note Popcorn Hopper (**D**) designed for slow, continuous flow of top quality corn.) As corn pops, Turbo Jet Popcorn Aimer (**E**) directs stream of popped corn to Funnel (**F**). Corn is then directed into Auxiliary Power Treadmill (**G**), causing popcorn-loving mice to start Power Treadmill revolving as they begin to chase falling popcorn. Revolving Power Treadmill then turns Pulley (**H**) which turns Gears (**I** & **J**), in turn revolving Pulleys (**K** & **L**). Pulley (**L**) spins Fly-Ball Governor-Grabber (**M**). As momentum is increased Governor-Grabber causes spinning Clutch-Hands (**N** & **O**) to engage Wheel (**P**), supplying the additional torque necessary to start servo rotating.

Reversing input signal flips Solenoid (**Q**) to reverse position, sliding Funnel (**F**) to Mouse-Reverse position. As popcorn is then directed into other side of Power Treadmill, the mice reverse their running action so as to continue catching falling popcorn. Periodic replacement with fresh mice and/or use of cheese-flavored popcorn can be used to increase efficiency of this system.

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	10K	± .5%
	50K	± .5%
7/8"	1K	± .5%
	10K	± .5%
	50K	± .5%
	1K	± .25%
	10K	± .25%
	50K	± .25%
1-3/32"	1K	± .5%
	10K	± .5%
	50K	± .5%
	1K	± .25%
	10K	± .25%
	50K	± .25%
2"	5K	± .25%
	20K	± .25%
	50K	± .25%
	5K	± .1%
	20K	± .1%
	50K	± .1%
3"	5K	± .1%
	20K	± .1%
	50K	± .1%
	5K	± .05%
	20K	± .05%
	50K	± .05%

SINE-COSINE SINGLE TURN FILM POTENTIOMETERS

Diameter	Resistance	Conformity
1-3/32"	10K	± .75%
	20K	± .75%
2"	10K	± .25%
	20K	± .25%
3"	10K	± .15%
	20K	± .15%

LINEAR MOTION FILM POTENTIOMETERS

Size	Resistance	Stroke	Linearity
1" Sq.	10K	1" Stroke	± .5%
	20K	1" Stroke	± .5%
	10K	2" Stroke	± .25%
	20K	2" Stroke	± .25%
	10K	3" Stroke	± .1%
	20K	3" Stroke	± .1%

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diodes 1961

Howard Bierman
Technical Editor

An Electronic Design Staff Report

At the recent 1961 Solid State Circuits Conference, a rather large number of empty chairs was evident at the evening panel discussion devoted to tunnel diodes. At the 1960 Conference, the turnout for the tunnel diode session was so great that attendees who were fortunate managed to get seated on chairs, stairways or suitcases—many others were forced to stand throughout the three-hour discussion.

Why the drastic drop in interest within the short space of a year? Perhaps too much was promised in terms of application possibilities with too few practical uses demonstrated. Perhaps too little emphasis was placed on the need for adequate time to solve problems imposed by the bilateral device. An interesting and amusing analogy has been drawn between the plot of voltage vs current and intensity of interest vs time for the tunnel diode. The V-I characteristic follows the now famous "S" form—starting from zero, rising sharply to a peak, reversing to a low and then rising rapidly again. In terms of relative interest, zero might be considered the period in 1958 preceding publication of Dr. Esaki's, "New Phenomenon in p-n Junctions" (Physical Review, Vol. 109)—interest soared until 1960, then dipped markedly as evidenced at the 1961 Conference. Will interest reverse its downward trend and demonstrate a sharp upswing? Experts at the Conference discussion predicted that new test equipment and computers will soon be released using tunnel diodes in conjunction with transistors. From these pioneer ventures, it is believed that design engineers will renew activity to incorporate the fast-switching, low-noise, radiation-resistant device into their new equipment.

In this year's special Diode report, Electronic Design has included four practical design articles directed toward application of the tunnel diode to amplifier, oscillator and switching circuits. In addition, the latest of the Department of Defense approved diodes are listed together with their specification number.

diodes 1961

Tunnel Diode Square Wave Generator

Although simple and compact, the circuit described is capable of producing square waves of less than 1 cps to over 2 mc with no sag and only slight overshoot.

James E. Dalley
Electrical Engineering Dept.
University of Utah
Salt Lake City, Utah

TWO TUNNEL DIODES, one coil, one resistor and one capacitor constitute the total component list for a stable square generator capable of operation from less than 1 cps to over 2 mc. The simple and compact circuit consists of a relaxation oscillator driving a bistable switching circuit; rise time of the square-wave output is less than 10 nsec. Although the design procedure outlined results in an approximate rather than exact solution, the method is straightforward and can be applied using commonly published data and circuit values.

Relaxation Oscillator Consists of A Tunnel Diode plus One Coil

The circuit for the relaxation oscillator is shown in Fig. 1a and the exact equivalent circuit is shown in Fig. 1b.

The inductance of the coil is given by L, R_L is the resistance of the coil, R_1 is any added resistance, L_S is the inductance of the tunnel-diode leads, R_S is the series resistance of the tunnel diode, R_D is the incremental resistance of the tunnel diode at a particular operating point and C is the shunt capacitance of the tunnel diode junction. V_1 is the dc voltage source which is assumed to have zero internal impedance for the present discussion. An inspection of Fig. 1b will reveal that a complicated expression would result if one attempted to write a transfer function. This can be avoided by comparing the output waveshape with the characteristic curve of the tunnel diode and choosing several regions of operation. Simplified equivalent circuits can be applied to some of these regions.

Fig. 2 shows a sketch of the output voltage of the relaxation oscillator with four periods of operating time defined. A sketch of a typical tunnel-diode characteristic curve is shown in Fig. 3 with key voltages and currents indicated.

The operation during period *1* follows the characteristic curve from the origin to the point (V_p, I_p). During period *2*, the current remains constant at a value of I_p and the voltage jumps to V_f. Throughout period *3*, the operating point follows the curve from the point (V_f, I_p) to the point (V_v, I_v). When the valley point (V_v, I_v) is reached, the operating point jumps again (period *4*) and starts the cycle over from point (V_o, I_v). The supply voltage must lie between the peak and valley voltages.

Period 1: Experimental results indicate that satisfactory design equations can be obtained if the inductance and capacitance of the tunnel diode are neglected. The simplified equivalent circuit is shown in Fig. 4.

The loop equation in the S-domain is

$$(LS+R_{t1})\, I\,(s) = V_1/S + I_o L \qquad (1)$$

where $R_{t1} = R + R_{D1}$

and R_{D1} is the increment diode resistance during period 1. Solving for the current,

$$I(s) = \frac{V_1/L}{S\left(S + \frac{R_{t1}}{L}\right)} + \frac{I_o}{\left(S + \frac{R_{t1}}{L}\right)} \qquad (2)$$

After the first cycle, I_o becomes I_v and the current in the time domain is

$$i(t) = \left(I_v - \frac{V_1}{R_{t1}}\right) e^{\frac{-R_{t1}\,T}{L}} + \frac{V_1}{R_{t1}} \qquad (3)$$

The output voltage is simply

$$V(t) = i\,(t)\, R_{D1}$$

$$= \left[\left(I_v - \frac{V_1}{R_{t1}}\right) e^{\frac{-R_{t1}\,T}{L}} + \frac{V_1}{R_{t1}}\right] R_{D1} \qquad (4)$$

The material covered by this paper is the result of independent research carried on by the author at the Sperry Utah Engineering Laboratory during the month of July 1960. Work on the relaxation oscillator was virtually completed before any published material on the subject was seen.[1] The design equations and approach used in this paper are original (unless otherwise noted) with the author to the best of his knowledge. The bistable switching circuit is based on information given in an article by Erich Gottlieb and T. P. Sylvan of General Electric Company.[2]

1. Dr. C. M. Barrack and M. C. Watkins, "Tunnel Diode Relaxation Oscillators," ELECTRONIC DESIGN, June 22, 1960.

2. Erich Gottlieb and T. P. Sylvan, "Tunnel Diodes as Amplifiers and Switches," Semiconductor Products Dept., General Electric Co., Syracuse, New York.

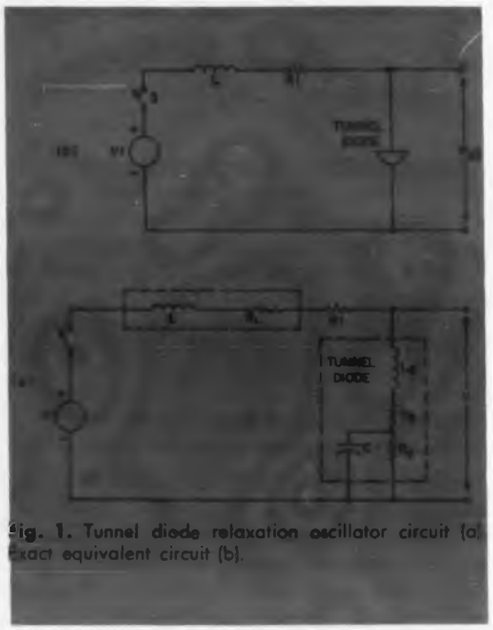

Fig. 1. Tunnel diode relaxation oscillator circuit (a). Exact equivalent circuit (b).

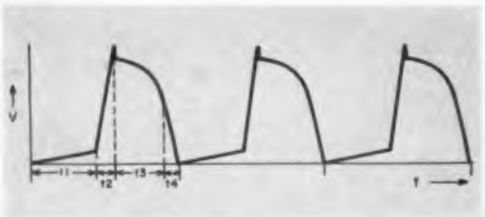

Fig. 2. Waveform of a relaxation oscillator output divided into four periods; periods t_2 and t_4 are deliberately expanded to permit inspection.

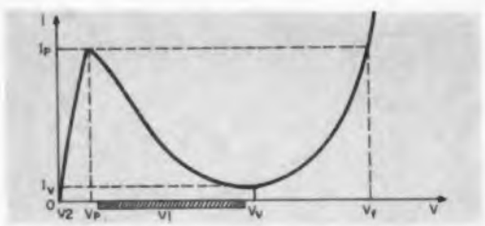

Fig. 3. Typical characteristic curve of a tunnel diode.

Fig. 4. Simplified equivalent circuit valid during period 1. $R = R_s + R_1$ and $R_{D1} = R_v + R_d$. Generator LI_0 inserts the initial conditions into the Laplace transform.

The length of period 1 can be found by setting $V_t = V_p$ and solving Eq. (4) for T. This gives

$$T_1 = \frac{L}{R_{t1}} \ln \frac{V_1 - I_v R_{t1}}{V_1 - \frac{V_p R_{t1}}{R_{D1}}} \qquad (5)$$

Now since $R_{D1} = \Delta V / \Delta I$ at any point on the characteristic curve between the origin and the point (V_p, I_p), it can be seen that R_{D1} is nonlinear and is a function of the operating point. Obviously some average value must be used for R_{D1} if T_1 is to be found in a straightforward manner. A simple solution to arrive at a correct average value for R_{D1} and reduce Eq. 5 to circuit constants and tunnel-diode parameters is to set

$$R_{D1} = \frac{V_p}{I_p} \qquad (6)$$

The above definition would be exact if the characteristic curve were a straight line passing through the origin and the point (V_p, I_p), a fair approximation in actual practice.

Eq. 5 then becomes

$$T_1 = \frac{L}{R_{t1}} \ln \frac{V_1 - I_v R_{t1}}{V_1 - I_p R_{t1}} \qquad (7)$$

where $$R_{t1} = R + \frac{V_p}{I_p}$$

Periods 2 and 4: When the operating point passes the point (V_p, I_p) on the curve, it enters the negative resistance portion of the curve which is unstable. An increase of voltage across the tunnel diode results in a decreased current and a decreased current through the inductance and series resistance results in a further increase of voltage across the tunnel diode. This action is cumulative and tends to reduce the current from I_p to I_v almost instantaneously. The current through an inductance cannot change instantaneously, so the operating point jumps from the point (V_p, I_p) to the point (V_f, I_p) which is on a positive resistance portion of the characteristic curve and stability is again restored. According to Gottlieb and Sylvan[3] the switching speed with constant current drive is

$$T_2 = \left(\frac{V_f - V_p}{I_p - I_v}\right) c \qquad (8)$$

Using the GE ZJ61-22 tunnel diode, the switching time should be approximately 1.2 nsec which is much faster than the 12-nsec rise time of the oscilloscopes used to observe the pattern.

3. Ibid p 17.

Since the tunnel-diode capacitance is a factor in Eq. 8, it cannot be neglected in the equivalent circuit.

The operation during period *4* is similar to that of period *2* and it is assumed that the switching time is comparable.

The slight amount of overshoot at the ends of periods *2* and *4* can probably be attributed to the series resonance of the inductor and the tunnel-diode shunt capacitance.

Period 3: During period *3*, the operating point moves along the characteristic curve from (V_f, I_p) to (V_v, I_v). Again there exists a problem of determining the value of a nonlinear resistance but the problem is complicated by the fact that a straight line to approximate the curve cannot be drawn through the origin. This can be remedied by drawing a straight line having a slope equal to the average slope of the curve and extending it until it intercepts the voltage axis. The effects of the curve in this region can then be approximately represented by a resistance having a value equal to the reciprocal of the slope of the line in series with a battery having a voltage equal to the voltage axis intercept.[4] To simplify the equations, remove guesswork in arriving at an average value, and allow a single

4. Martin, Thomas L. Jr., Electronics Circuits, Prentice Hall, Inc. Englewood Cliffs, N. J., 1955, pp 6-7.

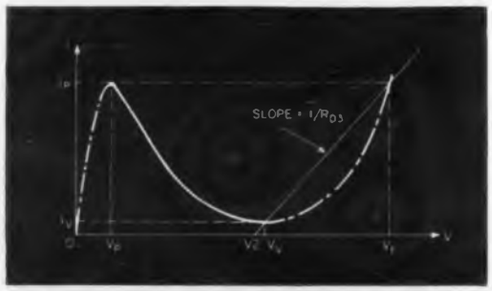

Fig. 5. Graphical representation of R_{D3} and V_2.

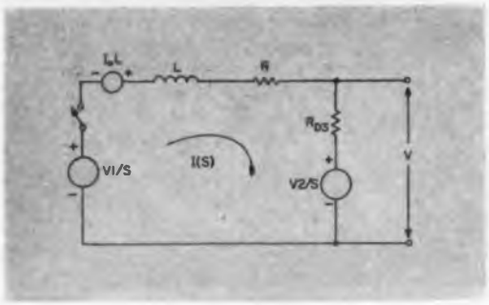

Fig. 6. Equivalent circuit valid during period 3.

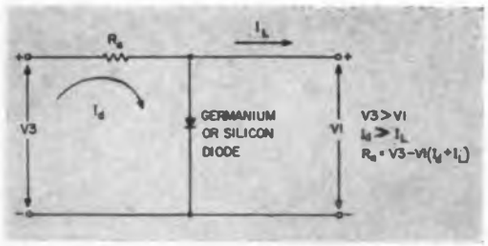

Fig. 7. Circuit for diode voltage regulator.

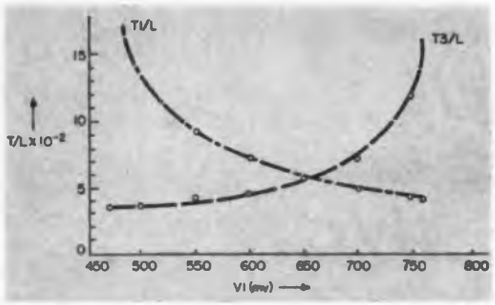

Fig. 8. Plot of $T1/L$ vs $T3/L$ vs supply voltage V_1.

approximation to be used, a definite rule will be established. If the straight line is drawn through the points (V_v, I_v) and (V_f, I_p), the tunnel-diode resistance in this region can be defined as

$$R_{D3} = \frac{V_f - V_v}{I_p - I_v} \tag{9}$$

and the required series voltage (V_s) is given by

$$V_2 = V_v - \frac{I_v (V_f - V_v)}{(I_p - I_v)} = V_v - I_v R_{D3} \tag{10}$$

This expression was derived by writing the equation for the line through points (V_v, I_v) and (V_f, I_p) using the slope intercept form where V_2 is the intercept of the voltage axis.

Thus

$$I = \frac{1}{R_{D3}} (V - V_2) = \frac{I_p - I_v}{V_f - V_v} (V - V_2) \tag{10a}$$

Now, set $I = I_v$ and $V = V_v$ and solve for V_s to arrive at Eq. 10. The graphical solutions for R_{D3} and V_2 are shown in Fig. 5.

Using this method to represent the curve in region 3, the simplified equivalent for the Laplace transform loop equation is shown in Fig. 6.

At the beginning of period 3, $I_o = I_p$. The loop equation is

$$(LS + Rt_3)I(s) = \frac{V_1 - V_2}{S} + I_p L \tag{11}$$

where $R_{t3} = R + R_{D3}$ and the current in the S-domain is

$$I(s) = \frac{\frac{V_1 - V_2}{L}}{S\left(S + \frac{R_{t3}}{L}\right)} + \frac{I_p}{\left(S + \frac{R_{t3}}{L}\right)} \tag{12}$$

In the time domain this becomes

$$i(t) = \left(I_p + \frac{V_2 - V_1}{R_{t3}}\right) e^{-\frac{R t_3 T}{L}} - \frac{V_2 - V_1}{R_{t3}} \tag{13}$$

The output voltage is

$$V(t) = i(t) R_{D3} + V_2$$
$$= R_{D3}\left[\left(I_p + \frac{V_2 - V_1}{R_{t3}}\right) e^{-\frac{R t_3 T}{L}} - \frac{V_2 - V_1}{R_{t3}}\right] + V_2 \tag{14}$$

Substituting V_v for $V(t)$ and solving for T

$$T_3 = \frac{L}{R t_3} \ln \frac{I_p + \frac{V_2 - V_1}{R_{t3}}}{\frac{V_v - V_2}{R_{D3}} + \frac{V_2 - V_1}{R_{t3}}} \tag{15}$$

Several assumptions and approximations were used in deriving the equations for T_1 (Eq. 7) and T_3. These equations can be solved without the need for characteristic curves by using the parameters given on the manufacturer's specification sheet. As will be shown later, the results are sufficiently accurate for a first approximation in practical situations and adjustments can be made to obtain the exact periods desired.

Power Supply Must Be Free Of Transients and Drift

It was assumed earlier that the power supply had perfect regulation. While this is desirable, power supplies having an internal impedance of 1 ohm or less will operate satisfactorily. If it is not feasible to use an electronically regulated power supply at the desired voltage, a higher voltage supply can be used with a forward biased germanium or silicon diode used as a regulator as shown in Fig. 7. A germanium 1N270 diode can be used to regulate satisfactorily over a range of 350 to 600 mv; a silicon 1N470 diode was used with satisfactory results for voltages between 730 and 830 mv. The diode current must be high enough to bias the diode beyond the knee of its curve. Capacitors are, in general, not satisfactory for bypassing the switching circuits used here.

It will be noted in Eqs. 7 and 15 that the pulse periods are dependent on the supply voltage. Thus the supply voltage must be free from drift also. As the supply voltage (V_1) is increased, the period T_1 decreased while the period T_3 increases. If the total period, or frequency, is of greater importance than the relative pulse widths, it may be possible to find a voltage at which T_1 and T_3 are changing by equal but opposite amounts with changes in V_1. This would make frequency independent of V_1 over a narrow operating range.

Fig. 3 indicates that V_1 must be somewhat greater than V_p and less than V_v. A method for determining the usable range of V_1 will now be presented. From Eq. 7 note that T_1 approaches infinity as V_1 approaches $I_p R_{t1}$.

$$V_1 > I_p R_{t1} \tag{16}$$

but $R_{t1} = R + R_{D1}$ and $R_{D1} = \frac{V_p}{I_p}$,

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$$V_1 > I_p R + V_p \qquad (16a)$$

Similarly, from Eq. 15 note that T_3 will increase without limit if

$$\frac{V_v - V_2}{R_{D_3}} + \frac{V_2 - V_1}{R_{t_3}} = 0 \qquad (17)$$

Solving for V_1 and substituting Eq. 10 for V_2, this reduces to

$$V_1 < I_v R + V_v \qquad (18)$$

Combining expressions 16a and 18

$$I_p R + V_p < V_1 < I_v R + V_v \qquad (19)$$

If R is reduced to zero, this expression becomes

$$V_p < V_1 < V_v \qquad (19a)$$

On the other hand, as R is increased, the lower limit of V_1 approaches the upper limit. When these two values are equal, it is impossible for V_1 to be between them and oscillation will cease. The maximum value for R is found by setting the limits equal to each other and solving for R. The result is

$$R < \frac{V_v - V_p}{I_p - I_v} \qquad (20)$$

This, incidentally, is the reciprocal of the slope of a line passing through the points (V_p, I_p) and (V_v, I_v) and could be considered as the "average" negative resistance of the tunnel diode.

Step-by-Step Design Procedure And Design Example

For a given tunnel diode, the designer can vary L, R, and V_1 to obtain the desired values of T_1 and T_3. All of these factors influence both T_1 and T_3, furthermore, R and V_1 are interwoven in the equations in such a way that it becomes almost impossible to solve for them explicitly. If both T_1 and T_3 are specified in the design requirements, the following six-step design procedure is recommended:

1. Choose the tunnel diode to be used and determine its parameters (I_p, I_v, V_p, etc.), or read them from the tunnel-diode data sheet. If an accurate characteristic curve is available, parametric values can be easily determined; the parameters can be determined experimentally without drawing the complete characteristic curve if necessary.
2. Choose a value of R consistent with the expected values of the inductance and supply voltage.
3. Determine the usable range of V_1 from Eq. 19.
4. Plot T_1/L (from Eq. 7) and T_3/L (Eq. 15) on the same set of coordinates with V_1 as the abscissa. Select V_1 from these curves to give the desired T_1/T_3 ratio. The power supply should be variable about this value.
5. Solve for L to give the desired values of T_1 and T_3. Design a variable inductance having this value of L in the center of its range and having the resistance R chosen in Step 2.
6. After the oscillator has been constructed, adjust V_1 for the exact T_1/T_3 ratio and adjust L for the desired frequency.

Example of Design Procedure: The first five steps of the design procedure will be illustrated by means of an example and then the predicted values will be checked against measured values in an experimental circuit. As was previously pointed out, desired values of T_1 and T_2 are usually specified; however, here several available fixed inductors will be used and the periods will be computed and measured for values of V_1 within the usable range.

1. The GE ZJ61-22 tunnel diode will be used. The parameters for the particular unit to be used, determined by direct measurement, are as follows:

$$I_p = 23 \text{ ma}$$
$$I_v = 2.0 \text{ ma}$$
$$V_p = 125 \text{ mv}$$
$$V_v = 730 \text{ mv}$$
$$V_f = 1{,}165 \text{ mv}$$

Other necesary parameters which may be calculated from the above are:

$$R_{D_1} = \frac{V_p}{I_p} = \frac{125}{23} = 5.44 \text{ ohms}$$

$$R_{D_3} = \frac{V_f - V_v}{I_p - I_v} = \frac{1{,}165 - 730}{23 - 2} = 20.7 \text{ ohms}$$

$$\max R = \frac{V_v - V_p}{I_p - I_v} = \frac{730 - 125}{23 - 2} = 28.8 \text{ ohms}$$

$$V_2 = V_v - I_v R_{D_3} = 730 - 2(20.7) = 688.6 \text{ mv}$$

2. Let $R = 15$ ohms. This is well below the maximum value, yet it is larger than the resistance of the coils to be used. Thus this value can be realized for all coils used.
3. The minimum value of V_1 is $V_1 > I_p R + V_p = 23(15) + 125 = 470$ mv and the maximum value is given by $V_1 < I_{vR} + V_v = 2(15) + 730 = 760$ mv.
4. The normalized periods are given by the following equations and tabulated for various values of V_1 in Table 1.

$$\frac{T_1}{L} = \frac{1}{R_{t_1}} \ln \frac{V_1 - I_v R_{t_1}}{V_1 - I_p R_{t_1}}$$

$$= \frac{1}{20.44} \ln \frac{V_1 - 2(20.44)}{V_1 - 23(20.44)}$$

$$= 4.89 \times 10^{-2} \ln \frac{V_1 - 41}{V_1 - 470}$$

Table 1. Normalized periods for given values of V.

V_1 (mv)	$\frac{T_1}{L} \times 10^{-2}$	$\frac{T_3}{L} \times 10^{-2}$
470	∞	3.56
500	13.3	3.79
550	9.0	4.24
600	7.09	4.86
650	5.94	5.74
700	5.14	7.25
750	4.54	12.0
760	4.41	∞

$$\frac{T_3}{L} = \frac{1}{R_{t_3}} \ln \frac{I_p + \frac{V_2 - V_1}{R_{t_3}}}{\frac{V_v - V_2}{R_{D_3}} + \frac{V_2 - V_1}{R_{t_3}}}$$

$$= \frac{1}{35.7} \ln \frac{23 + \frac{688.6 - V_1}{35.7}}{\frac{730 - 688.6}{20.7} + \frac{688.6 - V_1}{35.7}}$$

$$= 2.8 \times 10^{-2} \ln \frac{23 + \frac{689 - V_1}{35.7}}{2.0 + \frac{689 - V_1}{35.7}}$$

The data of Table 1 are plotted in Fig. 8. Usable values of V_1 can be selected that will give T_1/T_3 ratios of from 3.5:1 to 1:2.5.

5. This step will be worked backwards since only discrete values of inductance are available and it is not desirable to design and construct special coils for this example. Calculated and measured values of T_1 and T_3 are given in Table 2 for various values of V_1. The error was calculated using the following equation.

$$\%\ error = \left| \frac{Calculated\ value - measured\ value}{measured\ value} \right| \times 100 \qquad (21)$$

With the 330-μh coil, oscillations started at a supply voltage of 450 mv and stopped at 710 mv. When the 100-μh coil was used, the circuit operated over a supply voltage range of 482 to 710 mv.

Some of the predicted values given in Table 2 vary from the measured values by fairly high percentages. When one considers that several as-

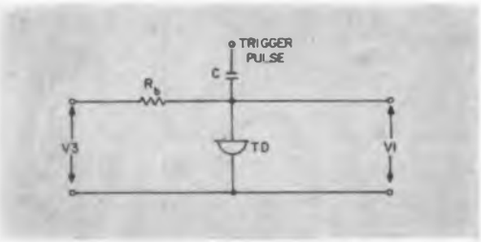

Fig. 9. Tunnel diode bistable switching circuit.

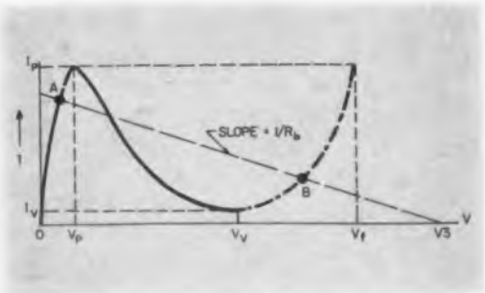

Fig. 10. Tunnel diode characteristic curve with high resistance load line; V_3 represents the power-supply voltage.

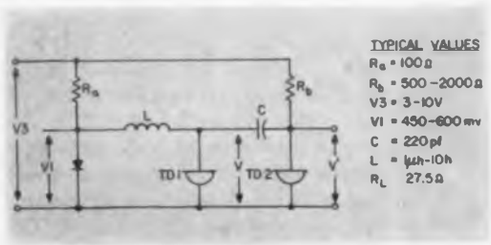

Fig. 11. Complete circuit of the square-wave generator using a single power supply.

sumptions and approximations were made in the derivation of the equations, the inductance had a 10 per cent tolerance, that meters and oscilloscopes are not perfectly accurate nor can they be read with perfect accuracy; and that a slide rule was used for all calculations, the results seem to be consistent with the method used. They are sufficiently accurate for practical design purposes if adjustable inductances and power supplies are used.

Operating Characteristics Of the Bistable Squaring Circuit

The simple bistable switching circuit suggested by Gottlieb and Sylvan[5] is shown in Fig. 9. The characteristic curve for a tunnel diode is shown in Fig. 10 with a high resistance load line. It can be observed from the figure that the load line intercepts the curve at two points of positive resistance (points *A* and *B*). These are quite stable states. If the operating point is at point A and a positive current pulse forces the current through the tunnel diode to a value equal to or greater than I_p, the operating point will switch to point *B*. The operating point will remain at point *B* until it is switched back to point *A* by a negative current pulse large enough to reduce the tunnel-diode current to a value equal to, or less than, I_v. The operating point will remain at point *A* until it is switched again to point *B*. Thus there is no sag in either the high or the low state regardless of the frequency.

If a higher load resistance than the one illustrated in Fig. 10 is used, the load line will become more nearly horizontal. Constant current operation is then approached. The value of this constant current is determined by the supply voltage and the load resistance. It should lie midway between I_p and I_v if the positive and negative trigger pulses have equal amplitude.

The coupling capacitor should have the smallest capacitance that will give satisfactory triggering. It passes only the leading and trailing edges of the relaxation oscillator waveform and allows the bistable switching circuit to have a waveform different from that of the oscillator between switching pulses.

Since the leading edge of the oscillator waveform has approximately twice the amplitude of the trailing edge, the positive trigger pulse will be about twice as large as the negative pulse; thus, the constant current load line should intersect the switching diode characteristic curve at about one third the difference between I_p and I_v. The rise time for this circuit can be calculated from Eq. 8. Since the rise time is in the order of a few nanoseconds, it can be considered as being negligible for frequencies up to several megacycles.

The output of the bistable switching circuit is an almost perfect square wave except for a small overshoot, probably due to the series inductance of the tunnel diode and the connecting leads plus the shunt capacitance of the tunnel diode.

A complete circuit of the square wave generator capable of operating from a single power supply is shown in Fig. 11. Resistor R_a and diode D_1 form a regulating voltage divider to supply the proper voltage, V_1, to the relaxation oscillator which consists of L and TD_1. R_b and TD_2 form the bistable switching circuit and C is the coupling capacitor between the oscillator and the switching circuit. R_a can be made adjustable over a limited range to provide some variation in the

5. Gottlieb and Sylvan, op. cit. pp 15-17.

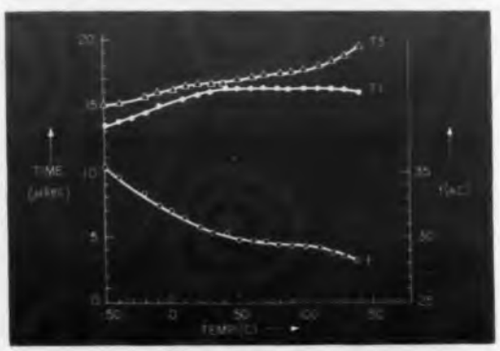

Fig. 12. Variation of period and frequency with temperature.

Table 2. Comparison of measured and calculated values for periods T_1 and T_3.

L	R	V_1 (mv)	Cal. T_1 (μsec)	Meas. T_1 (μsec)	Per cent Error	Cal. T_3 (μsec)	Meas. T_3 (μsec)	Per cent Error
330 μh	15.0 ohms	470	∞	39.0	∞	11.7	10.0	17
		500	44.0	32.0	37.5	12.5	10.1	23.8
		550	29.8	25.0	19.2	14.0	10.4	34.6
		600	23.4	21.0	11.4	16.1	12.5	19.2
		650	19.6	18.0	8.9	18.9	15.0	26.0
		700	17.0	16.0	6.25	23.9	18.0	32.8

pulse width due to variation of V_1. The inductance should be adjustable if frequency variations are desired. Typical values of circuit components for use with the ZJ61-22 tunnel diodes are given in the figure.

Effects of Temperature and Supply Voltage On Performance

The temperature characteristics of tunnel diodes are discussed by Gottlieb and Sylvan.[6] They point out that V_p, V_v and V_f decrease; I_v increases and I_p may increase, or increase up to a point, then decrease with increased temperature.

In order to check the temperature effects on the circuit as well as the tunnel diodes, the entire circuit of Fig. 11 (with the exception of R_c and D_1 which were omitted from the circuit in order to allow for independent control of V_1 and V_3) was placed in a temperature chamber. V_1 was set at 640 mv and V_3 at 6.4 v. A 330-μh inductance, having a resistance of 11 ohms, was used and R_b was a 2-K, 1/2-w carbon composition resistor. The relaxation oscillator operated satisfactorily with no adjustment from −50 C to +140 C. The periods T_1 and T_3 and the frequency are plotted as a function of temperature in Fig. 12. The oscillator became unstable at 143 C. When V_1 was adjusted to 630 mv, the oscillator operated satisfactorily to temperatures of +150 C and back down to 0 C without readjustment.

On the other hand, the supply voltage of the switching circuit (V_3) had to be readjusted upward about every 50 C rise in temperature and the circuit would not operate at temperatures above 130 C. This was probably due to the fact that the load line intersected the characteristic curve too near the valley current (I_v), the valley current increased appreciably at high temperatures, and a carbon composition resistor was used for the load resistance.

The amplitudes of the oscillator and the switching circuit both reduced about 0.1 v for temperatures above 70 C.

It is obvious from the results of the temperature tests that a controlled temperature oven will be required if good frequency stability is required throughout the entire temperature range of from −50 C to +150 C. This is not surprising; even quartz crystals are placed in temperature controlled ovens when accurate frequency control is required. If the temperature variation can be limited to the range between 20 C and 100 C, frequency variations on the order of 6 per cent can be expected and 2 per cent accuracy was obtained for the circuit tested in the temperature range from +50 C to +100 C. ■ ■

6. Gottlieb and Sylvan, ibid, pp 5-7.

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Practical Aspects Of Low-Frequency Tunnel Diode Amplifiers

A discussion of gain, stability and circuit behavior for a parallel-type amplifier. Factors such as bias requirements and stabilization as well as temperature behavior are analyzed.

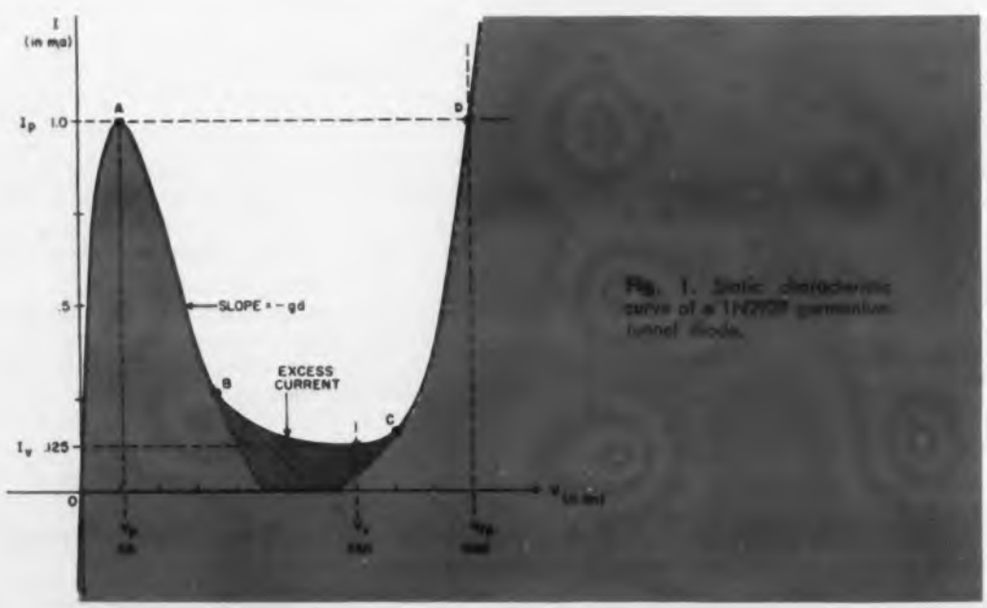

Fig. 1. Static characteristic curve of a 1N2939 germanium tunnel diode.

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TUNNEL-DIODE amplifiers, offering advantages of small size and simple circuitry, must be carefully designed in terms of layout and conductance matching in order to obtain optimum amplification with adequate stability. In addition, the dc bias must remain stable to avoid nonlinearities and variations in gain. Practical results obtained from a parallel-type amplifier, using a germanium 1N2939 diode, will illustrate the practical problems and design solutions involved in low-frequency applications.

Characteristics of the 1N2939 Germanium Tunnel Diode

The 1N2939 is a three-lead device, housed in the TO-18 package. Pins *1* and 2 are connected internally to reduce lead inductance and are the anode (positive electrode) leads, while pin 3 is the cathode lead and is electrically connected to the case. Having a −55 to +100 C operating junction temperature range, the 1N2939 has a peak current of 1.0 ma ±10 per cent and a min-

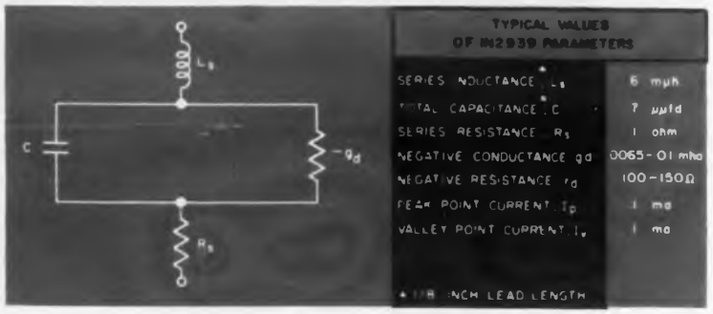

Fig. 2. Equivalent circuit and typical values of the 1N2939 biased in the negative conductance region.

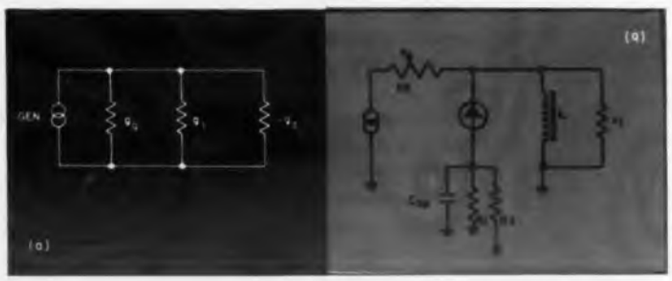

Fig. 3. (a) Low frequency equivalent circuit of a parallel-type negative resistance amplifier. (b) Practical amplifier circuit.

imum I_p/I_v ratio of 8:1, see Fig. 1. It is basically designed for high-speed, low-level switching as well as for small signal, high-frequency operation in communication circuitry. Its speed and frequency limitations are determined primarily by the inductance and capacitances inherent in this type of package. Having a typical total capacitance of 7 pf, of which 1.5 to 2.0 pf is in the header, and a typical inductance of 6 mμh (1/8-in. lead length) the device has a self-resonant frequency (f_{so}) of

$$f_{so} = \frac{1}{2\pi}\sqrt{\frac{1}{L_s C} - \left(\frac{g_d}{C}\right)^2} = 750 \text{ mc typical}$$

Its resistive cut-off frequency[1] (f_{ro}) is

$$f_{ro} = \frac{1}{2\pi}\,\frac{(g_d)}{C}\sqrt{\frac{1}{R_s\,(g_d)} - 1} = 2{,}300 \text{ mc typical}$$

Its other typical parameters are: a negative resistance $-r_d = 1/-g_d = -100$ to -150 ohms, a series resistance (R_s) of 1 ohm, typical peak point voltage (V_p) of 55 mv and a typical valley point voltage (V_v) of 350 mv. The equivalent circuit when biased in the negative conductance region can be seen in Fig. 2.

[1]The resistive cut-off frequency of the device is the frequency at which the real component of the negative impedance goes to zero, hence the device becomes passive at this point.

Negative Resistance Amplifier In the "Parallel" Connection

The basic low-frequency equivalent circuit of this connection can be seen in Fig. 3a. Essentially, it consists of a current source driving the parallel combination of the load conductance (g_l) and the negative diode conductance ($-g_d$) of the tunnel-diode characteristic. This latter can be seen between points *A* and *B* on the static current-voltage characteristics shown in Fig. 1.

When biased at about the center of the negative conductance region (120-125 mv), the slope (di/dv) of the diode is equal to a negative conductance ($-g_d$) of approximately 0.00714 mhos ($-r_d = 1/-g_d \approx 140$ ohms). To obtain maximum dynamic range, it is important to maintain this bias operating point in the center of the negative conductance characteristics.

An actual circuit which would closely satisfy the equivalent circuit of Fig. 3a can be seen in Fig. 3b. Here the tunnel diode is shown being forward biased by the bypassed voltage divider R_1 and R_2 while choke L acts as a low resistance dc return across the ac line without shunting the ac gain. Transformer coupling could, of course, be used in lieu of RC or direct coupling, thereby eliminating the need for the choke. The total dc loop resistance must be smaller than the negative resistance in order to serve as a constant voltage source. Therefore,

$$R_1 + R_{inductor} < \frac{1}{|g_d|}$$

preventing the device from switching. An extremely small value of total loop resistance might prompt the circuit to oscillate ($R_1 + R_{ind} < Lg_d/C$). Values found to permit stable amplification varied from 1/3 to 2/3 of $1/g_d$. The limit condition is that

$$\frac{L|g_d|}{C} < RT < \frac{1}{|-g_d|},$$

where $R_T = R_1 + R_{inductor}$

Power Gain Expressed as Function of Circuit Conductance

The expression of "available gain" (PG_{av}) for the equivalent circuit of Fig. 3a as rearranged in conductance terms is given by Eq. 1 where $g_g + g_l - g_d =$ the total circuit conductance g_t

$$PG_{av} = \frac{P_o}{P_{in_{av}}} = \frac{\left(\frac{\Delta i}{g_t}\right)^2 (g_l)}{\frac{(\Delta i)^2}{4\,g_g}} = \frac{(4)\ (g_g)\ (g_l)}{(g_t)^2}$$

$$PG_{av} = \frac{(4)\ (g_g)\ (g_l)}{(g_g + g_l - g_d)^2} \qquad (1)$$

A number of conclusions can be drawn from this expression:

1. The available power gain would be infinite if $g_t = 0$ (when $g_g + g_o = g_d$).
2. Practical values of power gain can be achieved by various combinations of g_g and g_l, assuming a fixed value of $-g_d$ (the latter depending on the geometric dimensions and current density of the device).

Case (a) $g_g << g_l = |g_d|$

Case (b) $g_l << g_g = |g_d|$

Case (c) $g_l = g_g = \frac{|g_d|}{2}$

Load Conductance Matches Negative Conductance, Generator Conductance Small

In this case, maximum power gain is obtained when $g_g = g_l + (-g_d)$. If $g_l = g_d$, then $g_l + (-g_d) = 0$ and therefore g_g is zero. This, of course, is the extreme case for infinite gain.

Fig. 4. Equivalent circuit of a tunnel diode plus external circuitry.

If g_t is almost equal to $-g_d$, practical values of circuit gain can be obtained. The degree of matching required to yield fixed values of gain is therefore of interest.

Gain versus degree of match: Starting with a 10 per cent mismatch, for example, with $-r_d = 100$ ohms and $r_t = 90$ ohms, the parallel resistance would be $-100 \times 90/-100 + 90 = 900$ ohms. If r_g is equal to 900 ohms, the available gain is

$$PG_{av} = \frac{4 \times \frac{1}{900} \times \frac{1}{90}}{\left(\frac{1}{900} + \frac{1}{90} - \frac{1}{100}\right)^2} = 10 = 10 \text{ db}$$

It is obvious that closer match is needed to obtain an increase in gain. Therefore, if $-r_d = 100$ ohms, but r_t is increased to 99 ohms (for a 1 per cent match), the resultant parallel impedance (Z_{in}) is equal to $-100 \times 99/-100 + 99 = 9{,}900$ ohms. Subsequently, if $r_g = 9{,}900$ ohms, the available power gain is increased to:

$$PG_{av} = \frac{4 \times \frac{1}{9{,}900} \times \frac{1}{99}}{\left(\frac{1}{9{,}900} + \frac{1}{99} - \frac{1}{100}\right)^2} = 100 = 20 \text{ db}$$

And, of course, if a 0.1 per cent match could be achieved, the resultant gain would be increased to 30 db. It becomes apparent that this degree of matching is quite critical, especially if higher gain is required; of course, this gain must be maintained reasonably constant over an acceptable range of supply voltages and ambient temperatures.

Stability criteria: Several conditions can be established to determine stability:

1. If the parallel combination of r_g and r_t is greater than the negative resistance of the tunnel diode, the resultant characteristic is a large value of negative resistance making the circuit unstable.

Or, if $g_g + g_t < |\, g_d \,|$, then g_t is negative.

2. If the total (dc loop) bias conductance is smaller than the negative conductance of the diode, the circuit will be bistable and tend to switch between the peak and valley point current extremes.

3. As long as the resonant frequency (f_o) of the circuit is below the resistive cut-off frequency (f_{ro}) of the circuit, the amplifier will tend to oscillate at f_o. This latter criteria may be particularly troublesome in the low-frequency range since it is not simple to design low-frequency amplifiers without the use of wiring and components having a great deal of stray inductances.

The circuit cut-off frequency is still given by

$$f_{ro} = \frac{1}{2\pi} \frac{|g_d|}{C} \sqrt{\frac{1}{R_s g_d} - 1}$$

but R_s is now the sum of R_s (internal) + R_s (external). Since R_s (external) is essentially the matched load resistance, the term under the radical becomes very small, thus reducing f_{ro}. The use of greater shunt capacity to reduce f_{ro} is not recommended since this would also lower the resonant frequency of the circuit (f_o).

Looking at the equivalent circuit of Fig. 4, it can be seen that the circuit resonant frequency

$$f_o = \frac{1}{2\pi} \sqrt{\frac{1}{L_s \times C} - \left(\frac{g_d}{C}\right)^2}$$

is determined largely by C and L_s, both of which are increased by the use of additional lumped constants.

4. To permit stable amplification*

$$\frac{1}{g_d} > R_T > \frac{L_{gd}}{C}$$

where R_T is the total positive circuit resistance, L and C are the total circuit inductance and capacitance.

The limit condition would be $1/g_d = R_T$ in which case $1/g_d > L_{gd}/C$. Assuming the distributed capacitance can be kept down to about 3 pf and the device capacitance is 7 pf, $C = 3 + 7 = 10$ pf,

$$L < \frac{C}{{g_d}^2} < \frac{10 \times 10^{-12}}{1 \times 10^{-4}} = 100 \text{ m}\mu\text{h}$$

This constitutes an additional stability criteria which is especially difficult to deal with at very low frequencies. It can be seen from this equation, however, that a high capacitance or low conductance diode (high $C/{g_d}^2$ ratio) would be easier to stabilize at low frequencies.

5. Since the negative resistance may be affected by dc bias and temperature variations, all above conditions must remain satisfied. In a 20-db stage having only a 1 per cent difference between $-r_d$ and r_t, this 1 per cent difference must be kept constant to maintain a fixed value of gain.

Generator Conductance (g_g) Matches Negative Conductance (g_d), Load Conductance g_t Small

Here the generator conductance must remain closely matched to the diode while reasonable variations in load conductance only affect gain slightly. If, for example,

$r_g = 109$ ohms ($g_g = 9.18 \times 10^{-3}$ mhos)
$r_t = 1{,}000$ ohms ($g_t = 1 \times 10^{-3}$ mhos)
$-r_d = 100$ ohms ($-g_d = 1 \times 10^{-2}$ mhos)

$$PG_{av} = \frac{4 \times 9.18 \times 10^{-6}}{(9.18 \times 10^{-3} + 1 \times 10^{-3} - 1 \times 10^{-2})^2}$$

$$= \frac{36.7 \times 10^{-6}}{3.25 \times 10^{-8}} = 1{,}130 = 30.54 \text{ db}$$

Now, if both r_g and $-r_d$ remain constant, but r_t varies by ±10 per cent, the following changes in gain would result:

(a) $r_t' = r_t - 10\%$

Thus $r_t' = 1{,}000 - 100 = 900$ ohms and $g_t = 1.11 \times 10^{-3}$

*U.S. Davidsohn, Y.C. Hwang, G.B. Ober, *"Designing with Tunnel Diode,"* Electronic Design, Feb. 3, 1960.

$$PG_{ar} = \frac{4 \times 9.18 \times 1.11 \times 10^{-6}}{[(9.18 + 1.11 - 10)\ 10^{-3}]_2} = \frac{40.4 \times 10^{-6}}{8.4 \times 10^{-8}}$$

$$= 481 = 26.8 \text{ db}$$

A loss of 3.74 db

(b) $r_t' = r_t + 10$ per cent

Thus $r_t'' = 1{,}000 + 100 = 1{,}100$ ohms and $g_t = 0.91 \times 10^{-3}$

$$PG_{ar} = \frac{4 \times 9.18 \times 0.91 \times 10^{-6}}{[(9.18 + 0.91 - 10)\ 10^{-3}]^2} = \frac{33.3 \times 10^{-6}}{.81 \times 10^{-8}}$$

$$= 4{,}120 = 36.2 \text{ db}$$

A gain increase of 5.66 db.

Since the gain has gone up in one case and down in the other, a total change of $5.66 + 3.74 = 9.4$ db must be considered.

Stability Criteria: In both cases previously discussed, the value of negative conductance is equally critical, since either g_g or g_t must remain very nearly equal to $|g_d|$ in order to sustain adequate stable gain. Otherwise, the same previously discussed stability criteria apply in both cases.

Load Conductance (g_t) Is Equal to the Generator Conductance g_g While $g_d = g_t + g_g$

In this instance, the generator and load conductances share the responsibility of matching the negative diode conductance thereby distributing the burden somewhat. Here, however, both g_g and g_t must remain extremely constant and all other stability criteria still apply.

Summary of Requirements To Achieve Stability

(1) Regardless of the operating frequency of the amplifier, the latter has to be built with extremely short leads and careful layout, as if it were a vhf stage, in order to keep f_{xo} above f_{ro} and $L < C/g_d^2$.

(2) For adequate amplification and stability, the sum of the load and generator conductances has to be very nearly equal to, but always greater than, the negative conductance of the diode.

$$G_t > -g_d$$

(3) The total dc loop conductance must be larger than the negative conductance. (Dc bias supply must be a voltage source.)

(4) All above requirements must remain satisfied over a range of supply voltages and temperature conditions.

Several Methods of Obtaining Stable DC Bias

There are two reasons why the dc operating point must remain stable. First, looking at Fig. 5, it is apparent that the maximum voltage

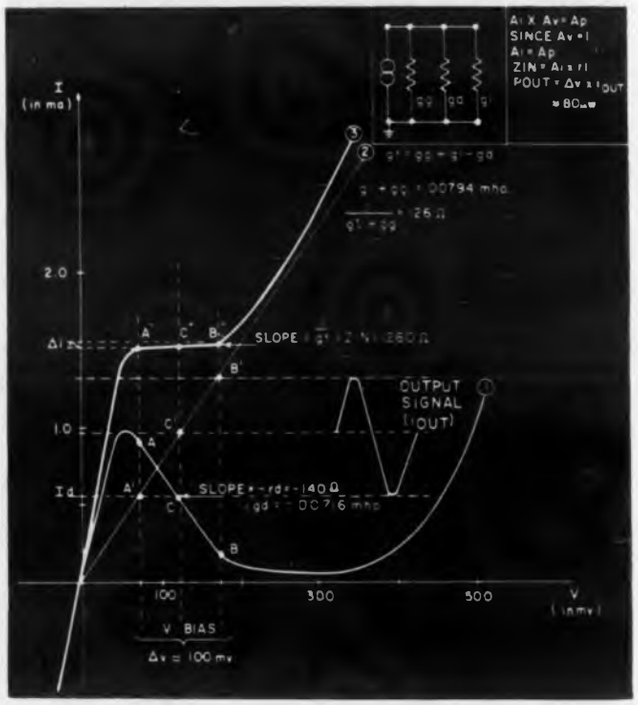

Fig. 5. Load line superimposed on the diode characteristic curve.

swing is limited to about 100 mv (peak-to-peak) by the nonlinearities occurring around points *A* and *B*. If point *C* is allowed to deviate from the center of the linear slope, the dynamic range would be greatly reduced and/or the distortion increased.

Second, even the slightest nonlinearities in the operating portion of the slope ($-g_d$), could create relatively large changes in gain due to the required match conditions. In Fig. 6 the results of such slight nonlinearity have been illustrated by the following test:

The circuit was set up at full supply voltage (6 v) properly biased (E_{diode} = 125 mv) and having the following parameters:

r_l = 140 ohms e_{in} = 4 mv
r_g = 1,000 ohms e_o = 3.6 mv
PG_{av} = 18.1 db

Subsequently, the supply voltage was reduced (simulating a lower battery voltage) in steps. The change of output voltage was recorded and the resultant loss in power gain calculated. The cause of the rapid gain fall-off is expected to be a nonlinear change in negative conductance versus bias voltage.

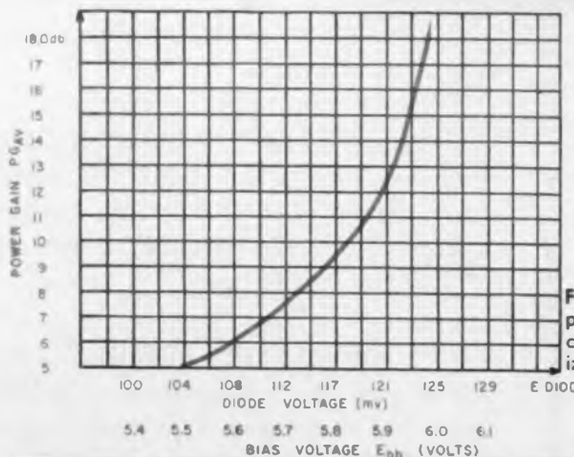

Fig. 6. Variation of power gain vs bias change in a nonstabilized amplifier circuit.

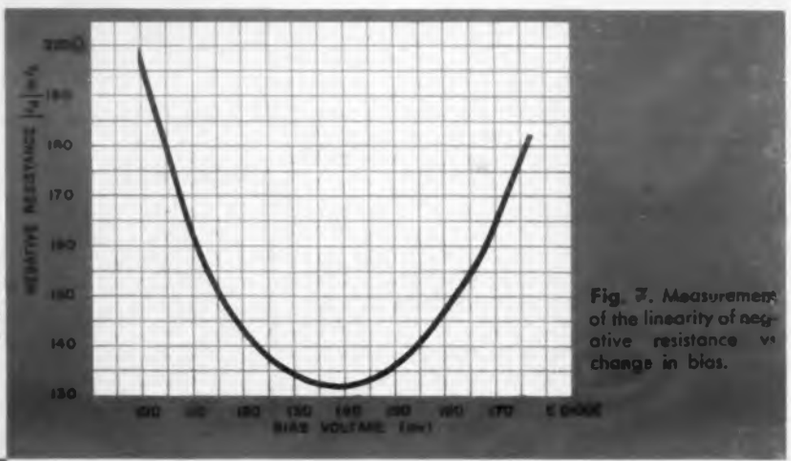

Fig. 7. Measurement of the linearity of negative resistance vs change in bias.

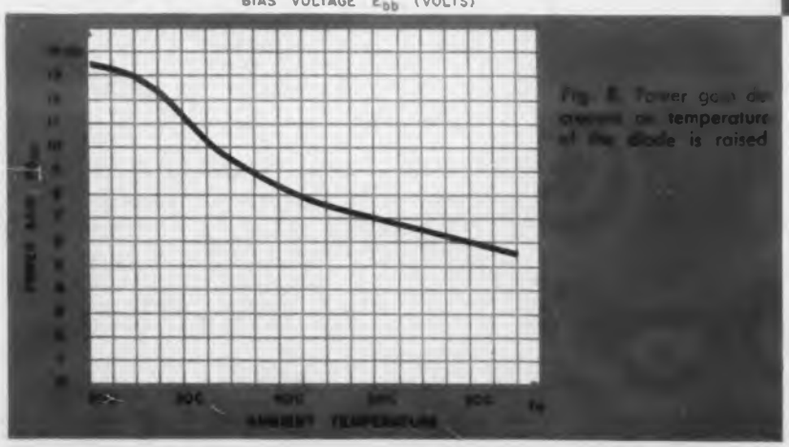

Fig. 8. Power gain decreases as temperature of the diode is raised

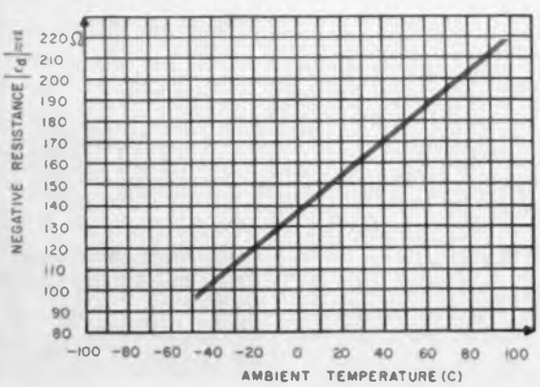

Fig. 9. A linear increase of negative resistance takes place as diode temperature is raised.

In order to get an idea of the magnitude of this change, the output signal voltage was maintained constant by readjusting the load resistance and thereby sustaining a reasonably constant match. The change in r_l can be considered equal to the change in $-r_d$, see Fig. 7.

Note the fact that the slope changes sign at about 140 mv. From Fig. 7, it is evident that a means to stabilize the bias voltage must be found. Three of the more obvious methods are:

(1) The use of a mercury cell (stable E_{bb}).

(2) The use of the relatively constant voltage drop across a forward biased diode.

(3) The use of breakdown (Zener) diodes as voltage regulators.

Experimental Check of the Temperature Dependence of Tunnel Diodes

An increase in ambient temperature has the following effect on the *V-I* characteristics of the tunnel diode: the peak current may increase or decrease, the valley current increases and the forward injection voltage (V_{fp}) decreases. The effect on the negative resistance region is to make the value of $-r_d$ temperature sensitive. To obtain a rough estimate of the sign and magnitude of this coefficient for the 1N2939, the following tests were performed:

(1) A circuit was set up having 13.3-db power gain at room temperature. In the first experiment, only the ambient temperature (t_a) was varied and the results can be seen in Fig. 8.

It became quickly apparent that an increase in temperature would result in (1) a change in diode bias voltage and (2) a change in gain which could be caused by the bias change, by a change in negative resistance or both.

In a test setup, with temperature varied from 10 to 50 C while maintaining a 145-ohm load resistance, the bias voltage changed 3 mv and gain decreased by 6.6 db. After readjusting the bias to its original value (131 mv), only a fraction of a db improvement was obtained (0.6 db). Obviously a change in negative resistance took place. By adjusting the load resistance (r_l) to obtain approximately the original value of power gain, the sign and magnitude of this change can be roughly estimated. From Fig. 9, an average change of 0.8 ohm/C has taken place which, when normalized to room temperature, gives approximately a 0.5 per cent/C "positive" temperature coefficient.

Subsequent work on representative production lots of these tunnel diodes have shown that a certain spread in the above coefficients is evident. Hence the above data, although reasonably accurate, are not necessarily typical for the 1N2939 diode. It is therefore recommended that for accurate design specifications, an up-to-date specification sheet be consulted. ■ ■

diodes
1961

Transistor-Tunnel Diode Combination

High-speed switching, at relatively high-voltage levels, is possible using a tunnel diode transistor combination.

Carl D. Todd
Senior Staff Engineer
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THE HIGH SPEED triggering capability of the tunnel diode may be combined with the higher useful voltage levels of a transistor to produce a composite negative resistance device having an N-type current stable characteristic. The peak voltage is relatively insensitive to temperature variations and transistor leakage current does not generally pose a problem.

Negative resistance devices can be grouped into two major classes, N-type or current stable and S-type or voltage stable. N-type negative resistance devices have a voltage-current plot with the basic shape illustrated in Fig. 1a.

For a range of voltage values between a peak voltage, V_P, and a valley voltage, V_V, three current values are possible for each value of applied voltage. If the current is specified, however, only one voltage may exist for that current. N-type characteristic devices are therefore considered current or open-circuit stable.

S-type negative resistance devices, such as the tunnel diode, have a voltage-current plot as shown in Fig. 1b.

For a range of current values between a valley current, I_V, and a peak current, I_P, three voltages may exist. Specifying the voltage, however, defines the one value of current which may exist. S-type negative resistance devices are therefore considered voltage or short-circuit stable.

Monostable multivibrators and relaxation oscillators using N-type negative resistance devices normally use a capacitor as the energy storing element; S-type devices must use an inductor. Low-frequency oscillators using S-type negative resistance devices are therefore quite bulky and have considerable weight.

Straight-Line Analysis of the Tunnel-Diode-Transistor Combination

The circuit which may be used to convert the S-type, low-voltage characteristic of the tunnel diode into an N-type characteristic operating at much higher voltage levels is shown in its simplest form in Fig. 2.

The emitter-base diode characteristic may first be assumed to intersect the tunnel diode characteristic in the valley region as illustrated in the drawing of Fig. 3. Since the tunnel diode and the transistor input are directly in parallel, a composite characteristic of these two curves may be constructed as illustrated by adding the two currents for a given voltage value. This composite characteristic must operate along the load line whose slope is determined by the value of R_1 and whose voltage intercept is the terminal voltage, V_1.

Constructing the plot of the terminal current I_1, as a function of the terminal voltage, V_1, by graphical manipulations, the characteristic of Fig. 4a is obtained. While at first glance this does not look exactly like the basic shape shown in Fig. 1a, it will perform switching applications in a similar manner. The line $a'-b'$ is due mainly to resistor R_1 and, to a much lesser degree, to the initial slope of the tunnel diode. The emitter-base diode of the transistor has no effect since it has been assumed that conduction does not begin until a higher voltage level is reached. Since there is no base current, the collector current may, for most cases, be assumed negligible. In the construction of the curve, h_{FE} of the transistor has been assumed to be constant with collector voltage and collector current.

The line $b'-c'$ is due to the negative resistance region of the tunnel diode. Current through the tunnel diode is decreasing as the terminal voltage across the total circuit is decreased. Because the voltage drop across the tunnel diode is larger in the negative resistance region than for the initial positive slope, the value of I_1 produced by a given terminal voltage will be a small amount less. If the value of R_1 is high such that the firing voltage, V_P, is made large with respect to the voltage across the tunnel diode, line $b'-c'$ will fall very close to line $a'-b'$. It is assumed that the emitter-base diode does not conduct in this region and thus the only current flowing is that through the tunnel diode. Collector leakage currents have also been assumed negligible.

Line $c'-d'$ of Fig. 4a is produced as the operating point in Fig. 3 is moved along the constant current region in the valley of the tunnel diode. The emitter-base diode is still assumed to be nonconducting in this region.

As the terminal voltage V_1 is now increased slightly, the current flowing through the tunnel diode remains the same since the operating point is still in the valley region of the tunnel diode. Base current begins to flow as soon as the value of V_{BE} exceeds the value V_d. This current is multiplied by the current gain of transistor Q_1 thus producting the rapidly rising current described by line $d'-e'$ in Fig. 4a.

If the value of V_{BB} exceeds the voltage V_f, the tunnel diode current again rises and, under certain conditions, may cause a leveling off in the current I_1.

Perhaps the most important parameter in any negative resistance device used in a switching application is the firing point, described in the characteristic of Fig. 4 by V'_P which is equal to V_b. For the conditions assumed for this case, V'_P may be very easily computed from the simple relation

$$V'_P = I_P R_1 + V_P \cong I_P R_1 \qquad (1)$$

For nearly all cases, the value of V'_P is much larger than the peak voltage of the tunnel diode, V_P, and thus the approximation indicated above in Eq. 1 is very accurate. This means that the firing point is very stable since the peak current of a tunnel diode is not appreciably affected by changes in temperature.

The value of the voltage V'_c is given by:

$$V'_c = I_V R_1 + V_v \cong I_V R_1 \qquad (2)$$

V'_c is the valley voltage for the composite device for the exact conditions assumed. The value of I_V of the tunnel diode will be determined by the peak current and the peak-to-valley current ratio, H, of the tunnel diode used. The higher the value

of H for the tunnel diode, the lower the voltage V'_o and the more efficient the composite device becomes when used as a switch. Since the behavior of I_V of a tunnel diode as a function of temperature is not fully understood, it is not possible to accurately predict the variations in valley voltages for the composite.

The voltage differences between V'_c and V'_d has been greatly exaggerated in Fig. 4a. This voltage will actually be the difference between the values of V_o and V_d of the tunnel diode and hence, for most cases, will be negligible. The transistor will thus begin to conduct at a terminal voltage V_1, approximately equal to the product of I_V and R_1.

The terminal resistance for the "off" condition is very nearly equal to R_1 and the resistance for the "on" condition will approach the value of R_1 divided by the h_{fe} of the transistor. Any tendency of the current gain of the transistor to decrease with increasing current levels will result in an increase in the "on" resistance at those current levels.

The position of the emitter-base diode characteristic will vary with temperature at a rate of approximately 2.5 mv/C. As long as the knee of this curve falls within the valley region, the effect on the composite characteristic will be negligible.

It is of interest to study the case where base current begins to flow before the valley region of the tunnel diode is reached. For applications using germanium tunnel diodes with germanium transistors, this is the condition most of the time. By proper biasing, the emitter-base diode characteristic may be moved to any portion of the tunnel diode characteristic as will be seen later.

Assume the conditions depicted in Fig. 5. Again, the emitter-base diode is assumed to be nonconducting until a certain voltage, V_c, is reached. The composite characteristic curve shown in Fig. 4b is therefore identical to the one in Fig. 4a up to the point where base current commences. As soon as the voltage across the tunnel diode and the transistor input has reached the value V_c, base current flows. This current is multiplied by the h_{fe} of the transistor thus producing a very rapid rise in the current I_1 as before. There is no flat or constant current region in the characteristic curve representing the tunnel diode and the transistor in parallel, and thus there will be no constant current portion in the over-all composite characteristic curve of Fig. 4b. When conditions are such that the tunnel diode begins to operate in its valley region, however, there will be an increase in the rate of current increase since the effect of the negative resistance slope of the tunnel diode is no longer present.

The change in emitter-base diode characteristics with temperature which produced a very minor change in the over-all results for the first case described must now be considered in light of the conditions illustrated in Fig. 5. Whereas previously, shifts in the transistor characteristics did not change the valley current for the composite curve shown in Fig. 3, such is not the case in Fig. 5. If line c-d shifts downward by a value ΔV mv, I_c, the valley current for the composite, will shift upward by an amount equal to $\Delta V R_{bc}$ ma and the valley voltage for the over-all composite characteristic curve of Fig. 6 will shift upward by $R_1\ \Delta V/R_{bc}$ v. Since R_1 is normally much larger than the value of R_{bc}, the resulting change in the valley voltage of the over-all characteristic will be much larger than the value of ΔV and the amount of change for the curve of Fig. 4a.

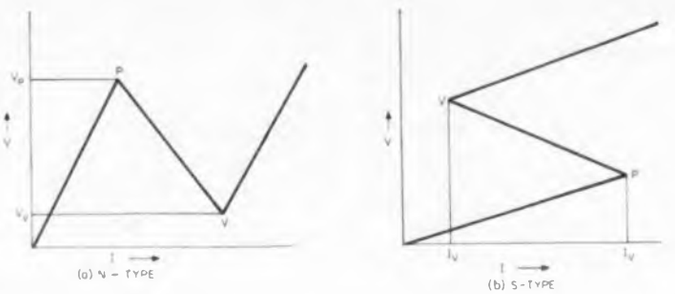


Fig. 1. V-I characteristic curves of negative resistance devices.

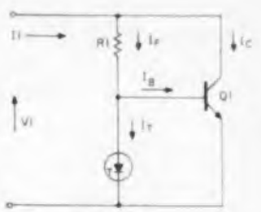


Fig. 2. Basic tunnel diode-transistor combination to convert "S" to "N" type characteristic.

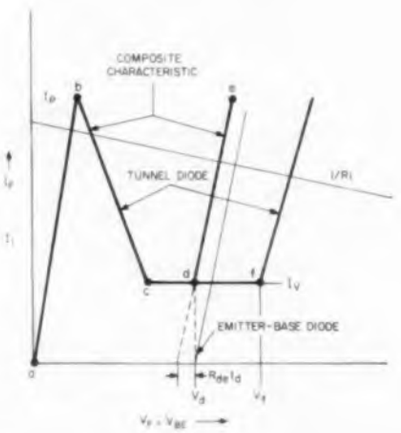


Fig. 3. Straight-line approximation of the composite device input characteristics where the emitter-base diode intersects the valley region of the tunnel diode.

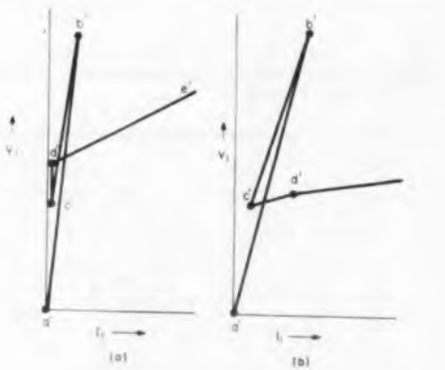


Fig. 4. Terminal voltage vs terminal current for conditions set in Fig. 3 is shown in (a) and for Fig. 4 is shown in (b).

Development of the Characteristic Curve for the Practical Case

In the preceding analysis, the emitter-base diode was assumed to remain nonconducting until a certain threshold voltage was reached. Beyond this voltage the characteristic was assumed to rise in a linear manner. Actually, the diode characteristic curve is a logarithmic function. This means that for the practical form of the conditions shown in Fig. 3, the line c'-d' will not be constant current but such that the current at any point d' may be much larger than that for point c'. All transitions will be more or less smooth curves rather than the very sharp ones indicated in the previously described straight-line analysis.

The peak voltage of a tunnel diode is low so the current flowing in the emitter-base diode at this level may be negligible as assumed. Triggering will actually occur when the load line of R_1 is tangent to the composite curve; for general considerations, this point will be very close to the peak point. Thus Eq. 1 still holds for the trigger voltage of the practical case and the "off" resistance will still be equal to R_1.

The slope of the over-all composite characteristic curve bears a definite relationship to the relative values of the magnitude of the tunnel diode resistance, r_d, the transistor input resistance, R_i, and the transistor common emitter current gain, h_{fe}.

(continued on p 50)

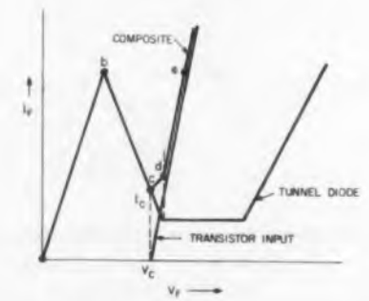


Fig. 5. Straight line representation of the input characteristic when base current flows before tunnel diode valley region is reached.

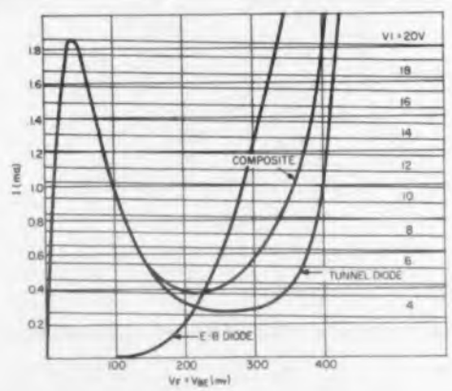


Fig. 7. Operating characteristic curve for a tunnel diode-transistor combination.

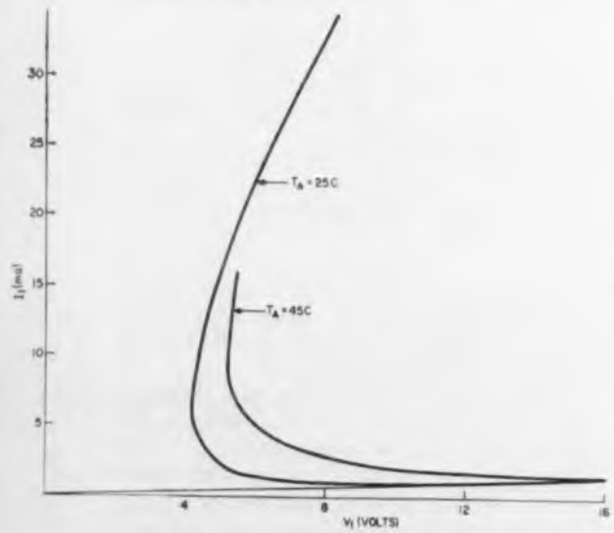
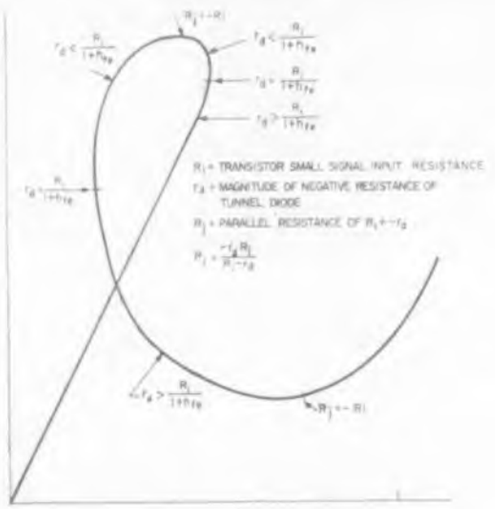
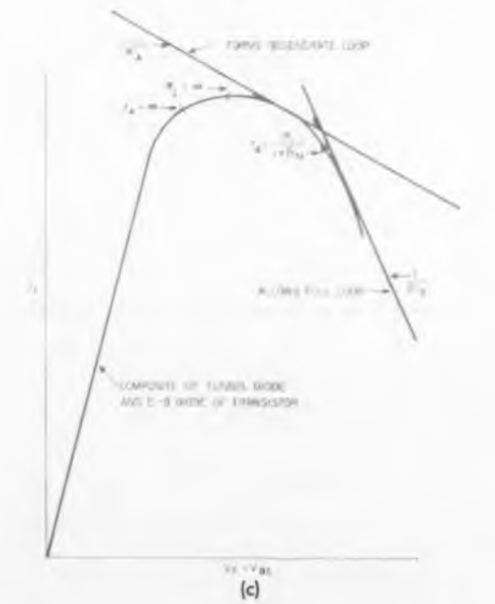


Fig. 8. Over-all characteristic developed from Fig. 7.



(a)



(c)

Fig. 6. Exaggerated input characteristics for a practical case. Full (a) or degenerate (b) loops will be formed depending on the load conditions (c).

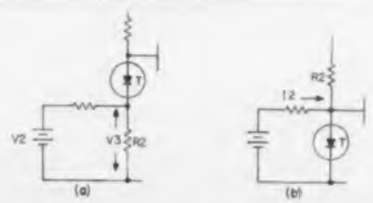
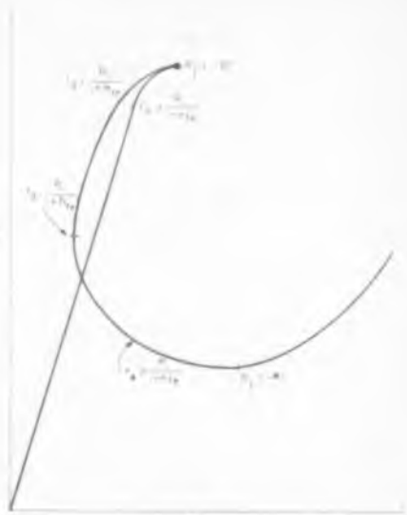


Fig. 9. Voltage bias (a) and current bias (b) used to shift the relative position of the tunnel diode and transistor input characteristics.



(b)

This relationship is given by Eq. 3 and is illustrated in Fig. 6a and b.

$$R_n = \frac{V_1}{I_1} = \left(\frac{R_1 + R_j}{R_j}\right)\left(\frac{1}{\frac{h_{fe}+1}{R_1} - \frac{1}{r_d}}\right) \quad (3)$$

The over-all composite characteristic curve obtained will be of the nature shown in Fig. 6a if the value of r_d may be equal to $R_1/(1 + h_{fe})$ near the peak point with $|R_j|$ greater than the value of R_1. If the voltage necessary to cause r_d to be equal to the value of $R_1/(1 + h_{fe})$ is greater than that necessary for $|R_j|$ to be equal to R_1, a degenerate loop will be formed as indicated in Fig. 6b. The load conditions necessary for each case is shown in Fig. 6c.

In most cases, the size of the loop is quite small, being most apparent for a low design value of trigger voltage or where the emitter-base diode has a higher conduction voltage. The conditions shown in Fig. 6 have been greatly exaggerated for clarity.

Graphical Example Of Transistor-Diode Combination

As a practical example, a tunnel diode of peak current equal to 1.85 ma was combined with an npn alloy germanium transistor having an h_{fe} of 70 over a wide current range. The characteristic curves for the tunnel diode, the emitter-base diode for the transistor, and the parallel composite for the two are shown in Fig. 7. For the curves including the transistor, the collector voltage was held constant at 1.5 v. In actual use, however, the collector voltage is varying and may be substantially higher than 1.5 v with correspondingly higher junction temperature. The various load line conditions are shown for ter-

minal voltage, V_1, values of 4 to 20 v.

The voltage-current characteristic obtained by graphical analysis is shown in Fig. 8. An additional curve included in Fig. 8 is the curve obtained at an elevated temperature of approximately 45 C.

The room temperature characteristic of Fig. 8 has a very sharp peak region which indicates a loop of very small area. As the temperature is increased, the size of the loop becomes smaller.

Addition of Bias To Shift Input Characteristic

Voltage Bias: Voltage bias may be used to shift the relative positions of the tunnel diode and the transistor input characteristic curves. A practical means of obtaining a large region of negative resistance is shown in Fig. 9a. Resistor R_2 should be small in comparison to the tunnel diode resistances. Supply voltage V_2 may be derived from the same source used to supply the entire circuit if point "B" is made common.

Some characteristic curves obtained for various voltage bias conditions are shown in Fig. 10. The dotted lines indicate an approximate condition. The trigger voltage will remain relatively constant and will normally change only by an amount equal to the bias voltage. The application of bias may be extended to use with silicon transistors or may be used to compensate for differences in transistors. By making the bias voltage vary at the same rate as the change in V_{BE} with temperature, the stability of the over-all circuit may be substantially improved.

Current Bias: For an ideal switch, it is desirable that the "off" current and the "on" voltage both be zero. For the basic circuit of Fig. 2, the "off" current is determined mainly by resistor R_1. The "on" voltage is a function of the relative shapes of the tunnel diode and the transistor input characteristics. From the composite curve shown in Fig. 8, the valley voltage may be determined as that value of V_1 which causes the load line of R_1 to be tangent to the valley region of the composite curve. Thus, the lower the composite valley current, the lower the value of valley voltage on the over-all characteristic of Fig. 8.

The composite curve of Fig. 7 may, in effect, be shifted downward by the application of a current source to the tunnel diode in the manner shown in Fig. 9b. The vertical shift will be equal to the bias current I_2. The peak current will also be decreased by an amount equal to I_2, and thus, for the same firing voltage, the value of R_1 must be increased; this will increase "off" resistance.

The three characteristic curves of Fig. 11 illustrate the effect of bias current applied in the manner described. Curve 2 represents a much more efficient switch than the condition with no bias current as shown by curve 1.

There is a limit as to how much bias current may be applied and hence how low the "on" voltage may be made. The current gain of the transistor falls off rapidly as the collector voltage is decreased below a few tenths of 1 v. Also, it is possible to cause a "locking" condition in which the switch may only be turned off upon the application of a reverse voltage pulse.

Characteristic curve number 3 of Fig. 11 shows the effect of applying a voltage bias and a current bias at the same time.

Circuit Predictability Improved by Collector Resistor

The presence of a resistor (R_2) in series with the collector allows the transistor to saturate very quickly thus allowing the "on" condition to be determined by the parallel combination of the two resistors, R_1 (Fig. 2) and R_2. In Fig. 12 note how closely the curves for the over-all characteristic follow the dotted line representing the parallel combination of the two resistors.

While the addition of R_2 does reduce the efficiency of the switch, it does make it much more predictable. By selecting an operating point in the "on" region which is substantially removed from the turning point, the circuit becomes relatively unaffected by changes in temperature or in changes in transistor parameters. The higher the trigger voltage for which the circuit is designed, the better will be the adherence to the straight-line function.

Composite Device Responds to Short Duration Pulses

Although the N-type negative resistance composite device may be triggered in the same manner as other two terminal negative resistance devices, a third terminal is often desirable.

The junction of the tunnel diode and the transistor base serves as an ideal point at which to apply a trigger. The effect of a momentary trigger is that described earlier. Upon the application of a positive trigger (assuming an npn transistor), the peak trigger voltage will be decreased momentarily. If the normal "off" voltage is larger than the momentary value of the peak voltage, the circuit will fire.

The tunnel diode is a very high speed device and hence it may respond to trigger pulses only a few nanoseconds in length. Thus while the operating speed of the over-all composite device will be greatly dependent upon the speed of the transistor, a trigger of extremely short duration applied directly to the tunnel diode will actuate the circuit. It may be desirable to insert a very small inductance in series with the tunnel diode and the base of the transistor to decrease the effect of the high input capacitance presented by the transistor. ■ ■

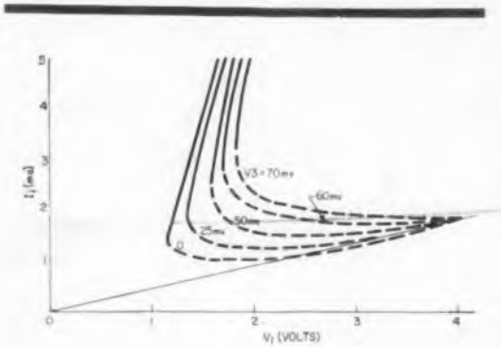


Fig. 10. Over-all input characteristic for various voltage bias conditions.

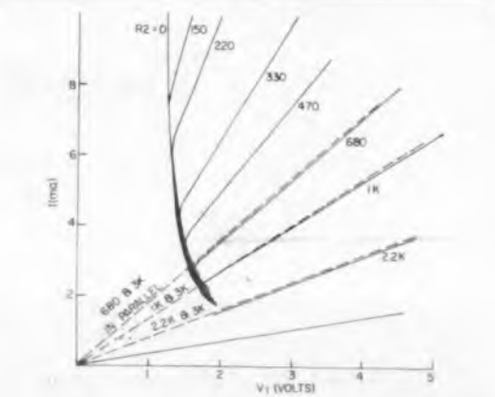


Fig. 11. Effect of current and voltage bias on over-all characteristic curve.

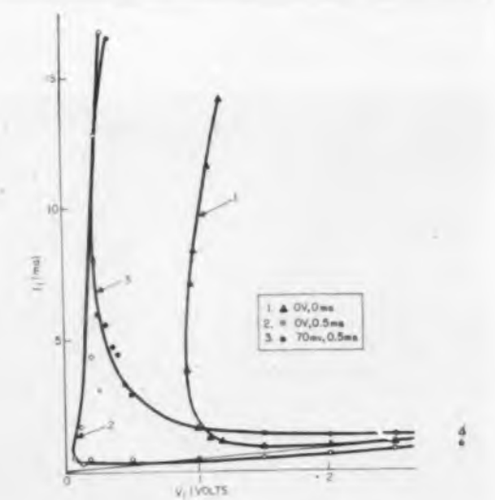


Fig. 12. Effect of series collector load resistor.

diodes
1961

Tunnel Diode Amplifier Calculator

A handy slide rule to reduce tedious calculations involved in the design of tunnel diode amplifier circuits.

Schematic diagram of a 100-mc tunnel diode amplifier in a series configuration.

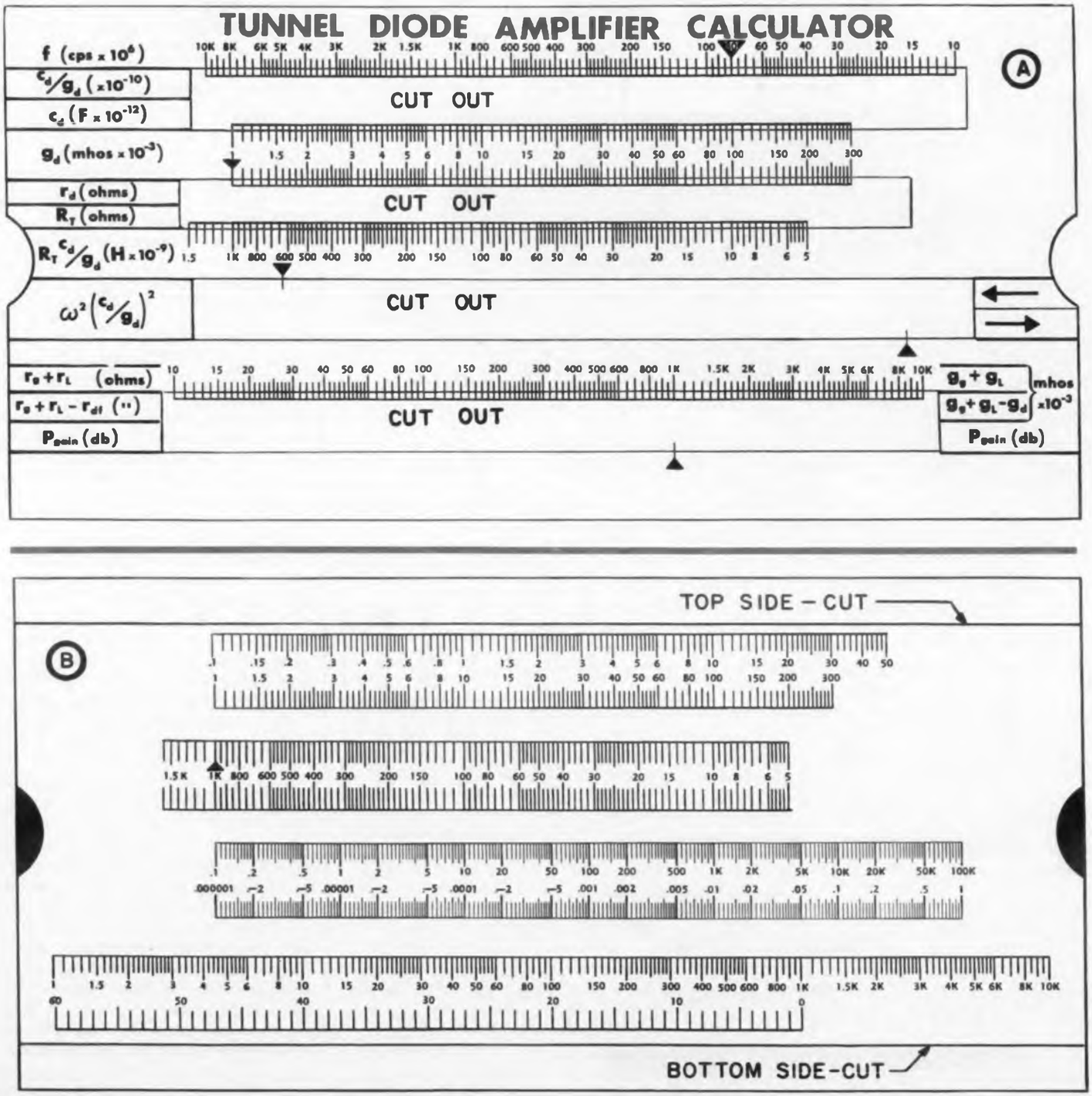
James R. McDermott
Electronics Consultant
McDermott Associates, Inc.
New York, N. Y.

DESIGN of tunnel diode amplifiers involves equations with time-consuming multiplication, division, and squaring of terms with large powers of 10. The Tunnel Diode Amplifier Calculator has been prepared to save substantial time and effort by reducing these calculations to simplified slide-rule operations.

The Tunnel Diode Amplifier Calculator scales can be cut out and easily assembled. The scales are glued onto thin, tough cardboard or bristol board. The *A* scale is the top, fix[illegible]ale while the *B* scale slides underneath. Cut the edge strips from the *B* scale and glue them to the back of the *A* scale. These strips serve as spacers between the front and a solid back sheet and also as guides for the center slide movement.

Design Procedure Using Slide-Rule Calculator

The value of the calculator is demonstrated by an example involving a 100-mc series-type amplifier, operating between two 50-ohm transmission lines, shown in the schematic diagram. An initial requirement is that the amplifier be stable, which is satisfied by meeting the following requirements: *(Continued on p 54)*



For those engineers who are too busy to cut and paste, a prefabricated Tunnel Diode Amplifier Calculator may be obtained for $2.00 from McDermott Associates, Inc., 1472 Broadway, New York 36, N.Y.

$$L_t(g_d/c_d) < R_t < \frac{1}{g_d}$$

or $$L_t < R_t\,(c_d/g_d)$$

In addition, it must be noted that in these amplifiers the resonant frequency is adjusted by variation of circuit resistance, while gain is controlled by adjustment of circuit inductance. With these factors in mind, proceed with amplifier design in accord with the following steps:

1. Circuit Resistance required for a given frequency is obtained from the following relations:

$$R_t = \frac{r_d}{1 + \omega^2\,(c_d^2/g_d^2)} \qquad (1)$$

Negative diode resistance r_d is obtained by aligning the arrow of the g scale with the arrow of the r_d scale, placing reciprocal values opposite each other. From the schematic, read, opposite 7 on the g_d scale, 143 for the value of r_d.

Next, solve for $\omega^2\,(c_d^2/g_d^2)$. Move 5 pf of the c_d scale opposite 7 millimhos of the g_d scale. Under the arrow at 80 on the f scale, read $c_d/g_d = 7.2\ (\times 10^{-10})$. (Note: The arrow coinciding with 80 has no numerical relation to the f scale.) Set 7.2 of the c_d/g_d scale opposite 100 mc on the f scale. The slide is extended to the right, therefore, read the answer on the lower $\omega^2\,(c_d^2/g_d^2)$ scale as 0.21. (Note: When the slide is extended to the left for this problem, read the answer on the upper scale, at the lefthand arrow.)

Total circuit resistance R_t is now found by simple pencil division of 143/1.21, in accord with Eq. 1, thus giving 118 ohms. But the circuit resistance of $r_g + r_s + r_L$ is only 102 ohms, which means an added 16 ohms (r_a) must be connected in series.

2. Amplifier Gain is controlled by the value of total circuit inductance L_t, which must be slightly smaller than $R_t\,(c_d/g_d)$ for maximum stable value. To find the value of $R_t\,(c_d/g_d)$, set the value of 7.2 on the c_d/g_d scale opposite the 80 arrow on the f scale. Then, read opposite 118 on the R_t scale, a value of 84.3 on the $R_t\,(c_d/g_d)$ scale, in millimicrohenries. L_t must therefore be somewhat less than this value.

In the schematic, series lead inductance L_s of 6 mμh is given, but in practice this may vary from 2 to 12 mμh. Consequently, L_s can fall between 72 and 82 mμh, and a 50- to 100-mμh variable inductance is connected in series to provide a wide range of gain adjustment.

3. Bias Considerations are few. The operation

of the diode is centered about an inflection point on its characteristic curve. For this example, it is 130 mv at 0.7 ma. The value of battery voltage and adjustable series dropping resistor are chosen so that the inflection point setting may be conveniently obtained. The rf bias decoupling choke has an inductance value which gives not less than 10 K at the operating frequency, in this case 15 μh.

4. Power Gain is determined, for tunnel diodes, in terms of insertion gain. For the series circuit in the example, insertion power gain is given by:

$$P_{gain} = \frac{(r_g + r_L)^2}{(r_g + r_L - r_{df})^2} \qquad (2)$$

In most literature, the $-r_{df}$ term is written as $-r_d$, implying the negative diode dc resistance can be used. However, this is incorrect (except for dc applications) since, in the series circuit, the *effective* negative resistance is governed at the frequency of interest by circuit inductance L_t. For this reason, the value of r_{df} is determined in accord with

$$r_{df} = L_t\,(g_d/c_d) \text{ ohms} \qquad (3)$$

To find (g_d/c_d) on the calculator, align the left hand ends of the c_d/g_d and f scales. Opposite the known value of c_d/g_d, read the numerical value of g_d/c_d on the f scale and raise that value by 10^7. For the example given, first align scales and then opposite 7.2 on the c_d/g_d scale read 140 on the f scale. Thus 140 by 10^7 or 1.4×10^9 is the value for g_d/c_d.

The solution of the power gain equation is simplified by the Tunnel Diode Amplifier Calculator because it eliminates handling squared terms. It is only necessary to add $r_g + r_L$ and $r_g + r_L - r_{df}$, place the latter term opposite the first on the slide rule and read the gain directly in decibels.

For the circuit given, the inductance L_a was adjusted to give an r_{df} of 103. Thus, $r_{df} = L\,(g_d/c_d) = 118$ ohms. Thus, $r_g + r_L = 100$, and $r_g + r_L - r_{df} = 3.16$ ohms, providing a power gain of 30 db. Increasing L_t sufficiently provided experimental gains up to 40 db. Much beyond this value, circuit instability becomes a problem.

For parallel-type tunnel diode circuits, the power gain is given by the same scales but the quantities are in terms of conductance in mhos $\times 10^{-3}$. Here, if the frequency of interest is much smaller than ω_s, the diode reactive frequency, the diode admittance is approximately equal to g_d and the dc value can be used.

For additional detailed information on tunnel diode amplifiers and factors affecting circuit gain, refer to "Designing with Tunnel Diodes" by U.S. Davidson et al., ELECTRONIC DESIGN, Feb. 3 and 16, 1960. ■ ■

diodes 1961

Latest Defense Department Diode List

The latest military listing of preferred and guidance type semiconductor diodes has recently been approved by the Department of Defense. Although the tabulation has not been officially blessed at the time of this writing, close sources involved in the preparation indicate the listing is complete and accurate.

Table 1. Small signal and power diodes.

V	50 ma	150 ma	250 ma	500 ma	1 A	5 A	12 A	20 A	35 A	50 A	70 A
50	1N483B	—	—	—	—	—	—	—	—	—	—
100	1N485B	—	—	—	—	—	—	1N249B	1N1184	1N2173	1N1397
200	1N486B	*1N645	*1N538	1N3189	*1N1124A	1N1614	1N1202	1N250B	1N1186	1N2174	1N1399
300	—	—	—	—	—	—	—	1N2135A	—	1N168	—
400	—	*1N647	*1N540	1N3190	*1N1126A	1N1615	1N1204	—	1N1188	—	1N1401
500	—	—	—	—	—	—	—	—	—	—	—
600	—	1N649	*1N547	1N3191	*1N1128A	1N1616	1N1206	—	1N1190	—	1N1403
800	—	—	1N560	—	—	—	—	—	—	—	—
1,000	—	—	1N561	—	—	—	—	—	—	—	—

Table 2. High voltage rectifiers.

V	45 ma @ 75 C	75 ma @ 100 C	100 ma @ 100 C	300 ma @ 25 C
1,500	—	—	*1N1731	*1N1130 *1N1131
3,000	—	—	*1N1733	—
5,000	—	*1N1734	—	—
12,000	1N1147	—	—	—
16,000	1N1149	—	—	—

Table 3. Germanium diodes.

V	30 ma	40 ma	75 ma
50	—	*1N276	—
80	1N933 1N198	— 1N270	—
100	—	—	*1N277

Table 4. Microwave diodes.

UHF		SHF			EHF
L Band	S Band	X Band	K Band		
390 mc	1,550 mc	5,200 mc	10,900 mc		
1,000 mc *1N25 1N25A	3,060 mc *1N21WE *1N32 1N32A	9,375 mc *1N23WE *1N31 1N31A	16,000 mc *1N78 1N78C	23,984 mc *1N26 1N26B	34,869 mc *1N53 1N53B

* preferred

Table 5. Silicon switching diodes.

V	10 ma	100 ma	400 ma
Slow Speed (0.8 μsec —0.3 μsec)			
75-100	—	—	1N691
Fast Speed (0.3 μsec — 10 mμsec)			
75-100	—	—	1N697
175-200	—	1N3070	—
Very Fast Speed (< 10 mμsec)			
20-50	1N3064	—	—
75-100	*1N914	—	—

Table 6. Voltage reference diodes.

V	TC 0.01%/C	0.005%/C	0.001%/C	0.0005%/C
6.2	1N821	1N823	1N827	—
8.4	1N3154	1N3155	1N3157	—
9.0	1N935B	—	1N938B	1N939B
11.7	1N941B	—	1N944B	1N945B

Table 7. Controlled rectifiers.

V	10 A	16 A @ 65 C	50 A
50	2N1771A	2N682	—
100	2N1772A	*2N683	—
200	2N1774A	*2N685	—
300	2N1776A	*2N687	—
400	2N1777A	2N688	—
500	—	2N689	—

* preferred

Table 8. Voltage regulator diodes.

E_z Nom. V dc	400 mw	1 w	10 w	50 w
3.3	*1N746A	—	—	—
3.6	*1N747A	—	—	—
3.9	*1N748A	—	—	—
4.3	*1N749A	—	—	—
4.7	*1N750A	—	—	—
5.1	*1N751A	—	—	—
5.6	*1N752A	—	—	—
6.2	*1N753A	—	—	—
6.8	*1N754A	1N3016B	1N2970B	1N2804B
7.5	*1N755A	1N3017B	1N2971B	1N2805B
8.2	*1N756A	1N3018B	1N2972B	1N2806B
9.1	*1N757A	1N3019B	1N2973B	1N2807B
10	*1N758A	1N3020B	1N2974B	1N2808B
11	1N962B	1N3021B	1N2975B	1N2809B
12	1N963B	1N3022B	1N2976B	1N2810B
13	1N964B	1N3023B	1N2977B	1N2811B
15	1N965B	1N3024B	1N2979B	1N2813B
16	1N966B	1N3025B	1N2980B	1N2814B
18	1N967B	1N3026B	1N2982B	1N2816B
20	1N968B	1N3027B	1N2984B	1N2818B
22	1N969B	1N3028B	1N2985B	1N2819B
24	1N970B	1N3029B	1N2986B	1N2820B
27	1N971B	1N3030B	1N2988B	1N2822B
30	1N972B	1N3031B	1N2989B	1N2823B
33	1N973B	1N3032B	1N2990B	1N2824B
36	1N974B	1N3033B	1N2991B	1N2825B
39	1N975B	1N3034B	1N2992B	1N2826B
43	1N976B	1N3035B	1N2993B	1N2827B
47	1N977B	1N3036B	1N2995B	1N2829B
51	1N978B	1N3037B	1N2997B	1N2831B
56	1N979B	1N3038B	1N2999B	1N2832B
62	1N980B	1N3039B	1N3000B	1N2833B
68	1N981B	1N3040B	1N3001B	1N2834B
75	1N982B	1N3041B	1N3002B	1N2835B
82	1N983B	1N3042B	1N3003B	1N2836B
91	1N984B	1N3043B	1N3004B	1N2837B
100	1N985B	1N3044B	1N3005B	1N2838B
110	1N986B	1N3045B	1N3007B	1N2840B
120	1N987B	1N3046B	1N3008B	1N2841B
130	1N988B	1N3047B	1N3009B	1N2842B
150	1N989B	1N3048B	1N3011B	1N2843B
160	1N990B	1N3049B	1N3012B	1N2844B
180	1N991B	1N3050B	1N3014B	1N2845B
200	1N992B	1N3051B	1N3015B	1N2846B

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Table 9. Specification numbers for approved diodes.

Type	Specification
1N21B	MIL-E-1/656
1N21C	MIL-E-1/657
1N21E	MIL-E-1/1155(USAF) Cancelled
1N21WE	MIL-E-1/1115
1N23B	MIL-E-1/618
1N23C	MIL-E-1/295B
1N23CR	MIL-E-1/550A
1N23E	MIL-E-1/1231(SigC)
1N23WE	MIL-E-1/1117A
1N25	MIL-E-1/658
1N26	MIL-E-1/659B
1N26B	MIL-S-19500/128(SigC)
1N28	MIL-E-1/660A (cancelled)
1N31	MIL-E-1/661A
1N32	MIL-E-1/27A
1N38B	MIL-E-1/492B
1N39	MIL-E-1/777B(NAVY)
1N44	MIL-E-1/377(NAVY)
1N48	MIL-E-1/378(NAVY) Cancelled
1N53	MIL-E-1/497B
1N55A	MIL-E-1/487A(NAVY)
1N55B	MIL-E-1/481A(NAVY)
1N56A	MIL-E-1/549A(NAVY)
1N63	MIL-E-1/376B(NAVY)
1N67A	MIL-E-1/508(NAVY) Cancelled
1N67A	MIL-E-1/508 Cancelled
1N69A	MIL-E-1/142D
1N70A	MIL-E-1/154D
1N72	MIL-E-1/780A(NAVY)
1N78	MIL-E-1/662A
1N78B	MIL-S-19500/129(SigC)
1N78C	MIL-S-19500/130(SigC)
1N81A	MIL-E-1/155D(SigC)
1N82A	MIL-E-1/1299(SigC)
1N93	MIL-E-1/895B(NAVY)
1N126A	MIL-E-1/156C
1N127A	MIL-E-1/157C
1N127B	MIL-E-1/1150(SigC) Cancelled
1N128	MIL-E-1/158B
1N145	MIL-E-1/811(NAVY)
1N198	MIL-E-1/700
1N212	MIL-E-1/932A(NAVY)
1N224	MIL-E-1/713
1N249B	MIL-S-19500/134(SigC)
1N250B	MIL-S-19500/134(SigC)
1N251	MIL-E-1/1023
1N253	MIL-E-1/1024A
1N254	MIL-E-1/989B
1N255	MIL-E-1/990B
1N256	MIL-E-1/991B
1N263	MIL-E-1/809B
1N269	MIL-E-1/808(SigC)
1N270	MIL-E-1/992A
1N276	MIL-E-1/1025
1N277	MIL-E-1/993A
1N281	MIL-E-1/961
1N315	MIL-E-1/1088(SigC)
1N411B	MIL-E-1/1196(SigC)
1N412B	MIL-E-1/1151(SigC)
1N413B	MIL-E-1/1194(SigC)
1N429	MIL-E-1/1134A(USAF)
1N430	MIL-S-19500/140(NAVY)
1N457	MIL-E-1/1026
1N458	MIL-E-1/1027
1N459	MIL-E-1/1028
1N483B, 1N485B, 1N486B	MIL-S-19500/118(NAVY)
1N538	MIL-E-1/1086 Cancelled
1N538	MIL-E-1/1084A
1N540	MIL-E-1/1087 Cancelled
1N540	MIL-E-1/1085A
1N547	MIL-E-1/1083A
1N548	MIL-S-19500/97(SigC)
1N549	MIL-S-19500/98(SigC)
1N560	MIL-S-19500/167(NAVY)
1N561	MIL-S-19500/167(NAVY)
1N570	MIL-E-1/1275(USAF)
1N592, 1N593, 1N594, 1N595	MIL-E-1/1109(USAF)
1N643, 1N645, 1N646	MIL-E-1/1171(SigC)
1N647, 1N648, 1N649	MIL-E-1/1143(USAF)
1N658	MIL-E-1/1160(SigC)
1N662	MIL-E-1/1139(SigC)
1N663	MIL-E-1/1140(SigC)
1N664 thru 1N672, 1N674, 1N675, 1N701	MIL-S-19500/150(SigC)
1N673 and 1N947	MIL-S-19500/149(SigC)
1N691	MIL-S-19500/132(NAVY)
1N696	MIL-S-19500/121(NAVY)
1N697	MIL-S-19500/141(NAVY)
1N709, 1N716, 1N718, 1N720, 1N722, 1N750	MIL-E-1/1238(SigC)
1N746A thru 1N759A	MIL-S-19500/127(NAVY)
1N821, 1N823, 1N827	MIL-S-19500/159(NAVY)
1N914	MIL-S-19500/116(NAVY)
1N933	MIL-S-19500/119(NAVY)
1N935B, 1N938B, 1N939B	MIL-S-19500/156(NAVY)
1N941B, 1N944B, 1N945B	MIL-S-19500/157(NAVY)
1N962B thru 1N992B	MIL-S-19500/117(NAVY)
1N1124A, 1N1126A, 1N1128A	MIL-S-19500/104(NAVY)
1N1130, 1N1131	MIL-E-1/1287(SigC)
1N1147	MIL-E-1/1305(SigC)
1N1149	MIL-E-1/1306(SigC)
1N1183 thru 1N1190	MIL-E-1/1135(USAF)
1N1199 thru 1N1206	MIL-E-1/1108(USAF)
1N1281 thru 1N1288	MIL-E-1/1136(USAF)
1N1324	MIL-E-1/1176(USAF)
1N1341	MIL-E-1/1186
1N1342	MIL-E-1/1187
1N1343	MIL-E-1/1188
1N1344	MIL-E-1/1189
1N1345	MIL-E-1/1190
1N1346	MIL-E-1/1191
1N1347	MIL-E-1/1192
1N1348	MIL-E-1/1193
1N1353, 1N1358, 1N1361	MIL-E-1/1236(SigC)
1N1396, 1N1397, 1N1399, 1N1400, 1N1401, 1N1402, 1N1403	MIL-E-1/1202(USAF)
1N1408	MIL-E-1/1172(SigC)
1N1413	MIL-E-1/1173(SigC)
1N1414	MIL-S-19500/148(SigC)
1N1415	MIL-S-19500/146(SigC)
1N1416 thru 1N1424, 1N1482, 1N1483, 1N1743	MIL-S-19500/147(SigC)
1N1425 thru 1N1483, 1N1484, 1N1485, 1N1744	MIL-S-19500/145(SigC)
1N1614	MIL-E-1/1240(SigC)
1N1615	MIL-E-1/1241(SigC)
1N1616	MIL-E-1/1242(SigC)
1N1682	MIL-E-1/1195
1N1731	MIL-S-19500/142(SigC)
1N1733	MIL-S-19500/142(SigC)
1N1734	MIL-S-19500/142(SigC)
1N1777, 1N1778, 1N1781, 1N1791, 1N1795	MIL-E-1/1235(SigC)
1N1804, 1N1807	MIL-E-1/1236(SigC)
1N1816A thru 1N1836A	MIL-E-1/1259(NAVY)
1N2052, 1N2053	MIL-E-1/1237(SigC)
1N2135A	MIL-S-19500/134(SigC)
1N2153	MIL-S-19500/91
1N2172	MIL-E-1/1196
1N2173	MIL-E-1/1151
1N2174	MIL-E-1/1194
1N2804B thru 1N2811B	MIL-S-19500/114(NAVY)

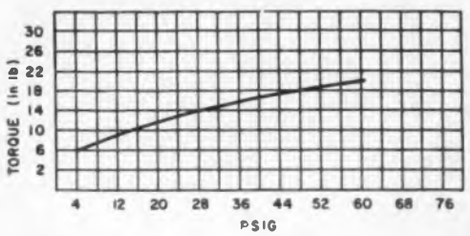
Type	Specification
1N2813B 1N2814B	
1N2816B 1N2818B 1N2819B 1N2820B 1N2822B thru 1N2827B 1N2829B 1N2831B thru 1N2838B 1N2840B thru 1N2846B	MIL-S-19500/114(NAVY)
1N2970B thru 1N2977B 1N2979 1N2980 1N2982 1N2984 1N2985 1N2986 1N2988 thru 1N2993 1N2995 1N2997 1N2999B thru 1N3005B 1N3007B 1N3008B 1N3009B 1N3011B 1N3012B 1N3014B 1N3015B	MIL-S-19500/124(SigC)
1N3016B thru 1N3051B	MIL-S-19500/115A(NAVY)
1N3189 1N3190 1N3191	MIL-S-19500/155(NAVY)
1N3154 1N3155 1N3157	MIL-S-19500/158(NAVY)
2N681 thru 2N688	MIL-S-19500/108(NAVY)
2N1771A 2N1772A 2N1774A 2N1776A 2N1777A	MIL-S-19500/108(NAVY)

CIRCLE 44 ON READER-SERVICE CARD ➤

Air Clutch Boosts Torque, Cuts Size

A NEW air clutch, in a 1-in. diam case, provides almost five times the torque available with conventional magnetic clutches of the same size. In a 1/2 in. size, the air clutch shows even more dramatic improvement over magnetic clutches—a factor of almost 14.

The 1-in. (size 10) clutch is part of a line developed by Elm Instrument Corp., 30 Chasner St., Hempstead, L.I., N.Y., that now includes a size 5 and a size 10 and will include a size 18 in six weeks. Each clutch has two concentric, stainless-steel shafts extending from one end of the housing. The outer shaft has a 1/4 in. OD while the inner one, extending for a 1/2 in. beyond the end of the outer one, has an OD of 1/8 in. These shafts can be driven independently of each other, or they can be driven simultaneously. They can be driven in the same direction at different speeds or in opposite directions.



Breakaway torque vs inlet-air pressure for a size 10 air clutch.

The units come in green, anodized-aluminum housings. A hose adapter is provided which allows a clutch to be connected to any convenient air supply. The units can easily be driven by a low-cost, fish-tank, air pump.

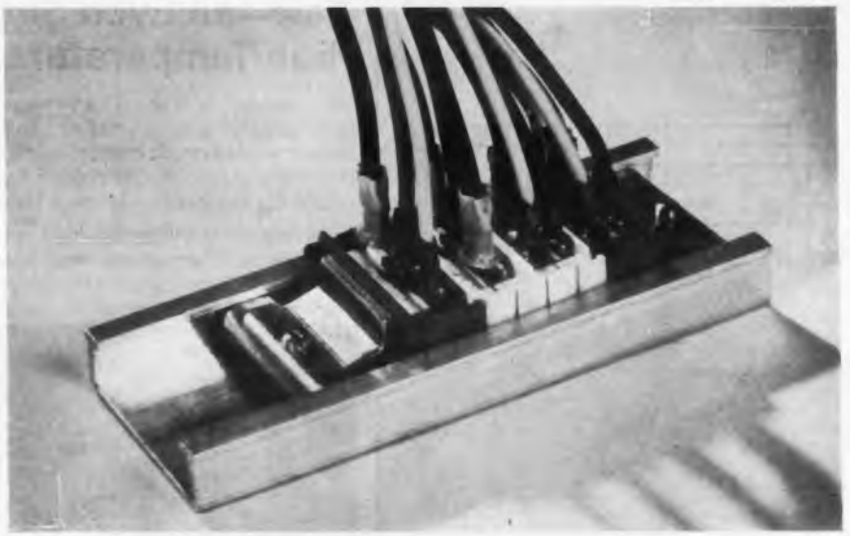
The size 10 air clutch develops a torque differential, of 320 in.-oz (at 60 psi inlet pressure) compared with the 72 in.-oz avaliable with magnetic clutches. At 2 psi, the size 10 air clutch delivers a torque differential of 96 in.-oz. In the size 5, the torque differential at 60 psi is 48 in.-oz compared with 3.5 in.-oz for magnetic clutches.

The clutches are powered by air pressure delivered through a 3/16 in. ID tube. Their response times are less than 4 msec.

Using ABEC Class 5 bearings the air clutches can operate in a temperature range from −5 F to +400 F. They are also available with oil-impregnated bronze bearings at lower cost. The air clutches are all designed to pass the severe environmental specifications in MIL-T-5422.

Unit price for the size 10 clutch is $138.69 for quantities of 1 to 10. The price drops to $134.53 for 11 to 25 units, to $131.76 for 26 to 50 units, to $128.29 for 51 to 100 units, to $124.82 for 101 to 500 units, and finally, to $110.95 for more than 500 units. Prices are about 10 per cent lower for the size 5. The clutches are available for immediate delivery.

For more information on these small, high-torque, air clutches, turn to the Reader-Service Card and circle **251.**



Assembled terminal block stack is locked into aluminum track.

Modular Terminal Panel Wiring Block

Tab terminals lock into modular cage assembly without use of tools.

VERSATILE power control circuiting for switchboards, control panels, and industrial instrumentation is provided by a newly designed modular terminal block. The modular technique allows rapid, simple change of stack configurations to suit the many variations of wiring logic.

Manufactured by AMP Inc., Eisenhower, Blvd., Harrisburg, Pa., the Termi-Blok uses modular 3-circuit common and 6-circuit common insulated cage assemblies which fit into an extruded aluminum track. The cages are made of tin-plated brass, and are housed in nylon insulators. Within each of the cage assemblies, a slotted, stainless steel spring member accepts tab terminals without necessity of any mechanical adjustment. No tools are needed for insertion or withdrawal. Individual cages can be added anywhere in the stack.

The heavy-duty terminal block is rated at 35-amp continuous current, or maximum wire temperature of 105 C. Voltage drop of the cage assembly, measured

between the end terminals of a 3-way cage, is 10.0 mv maximum at 12 amp. The block has a 125 per cent current-cycling overload capacity; insulation resistance is 1,500 v dc at sea level. Components withstand vibration, corrosion and humidity tests in accordance with military specifications.

The insulated cage assembly is available in two styles: series 3, accommodating 3 circuits per linear inch of track, and series 4, with 4 circuits per inch. One size of track width will accept both series. Series 3 has a higher, thicker nylon insulator to permit an increased creepage distance of 5/8 in. minimum with a 1/4-in. strike distance, for high-current applications or use where heat dissipation is important.

The high density afforded by this cage design, 0.275 in. center-to-center lineal spacing for series 4 and 0.333 in. for series 3, is further complemented by the front-loading feature of the modules.

Tab terminals are joined to circuit wires by a manual or automatic compression crimp. The 0.031-in. thick tab will accommodate wire sizes from 14 to 22 AWG. Insertion force is 2 lb min to 15 lb max; withdrawel force is 5 to 15 lb. The 0.040-in. thick terminal accepts wire sizes from 10 to 12 AWG; withdrawal force is slightly heavier than in the thinner tab. Pre-insulated terminals are color-coded by wire size.

Cage assemblies are available in 10 colors of nylon insulators for color coding of circuitry. An end-barrier nylon insulator, one per stack length, is used to enclose the last cage in the stack.

The extruded aluminum track is supplied either plain or coated with polyvinylchloride. Desired length is cut with a hacksaw from the standard 6-ft section. The 0.200-in. lip on either side of the track permits use of adhesive marking tape for identification of circuits.

A coaxial cable support bracket, to be available on special order, will hold a connector in the track to accommodate 2 coaxial conductors.

Price of the modules is less than $0.10 per circuit in large quantities, $0.15 each in small quantities. Standard items are available from stock; special orders are filled in 4 to 6 weeks.

For more information on these modular power control terminal blocks, turn to the Reader-Service Card and circle 252.

Digital Clock Times Long Periods — 676

Designed to serve as a long-duration data timer or as date-time source for data-processing equipment, digital clock provides a binary-coded output of day, hour and minute. Output is contact closure; a visual readout is also provided. With no tubes or transistors, the design gives trouble-free service.

Electro-Logic Corp., Dept. ED, 515 Boccaccio Ave., Venice, Calif.
P&A: $895; 30 days.

NEW PRODUCTS

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

Silicon Power Varactors Available in 55 Models — 675

Silicon varactor diodes MA-4351A-G through MA-4358A-F offer a wide variety of piv ratings from 6 to 120 v, and junction capacitance values (measured at breakdown voltage) ranging from 0.1 to 50 pf. The 55 models provide high-efficiency harmonic generation from 1 to 40,000 mc. The pill case has axial prongs, one of which may be removed for mounting on tapped posts. Junction series resistance values range from 1.1 to 21 ohms. The diodes are hermetically sealed and meet military environmental tests. The two large units in the photo show construction of the varactors, four of which are arrayed below the postage stamp.

Microwave Associates, Inc., Dept. ED, Burlington, Mass.
Availability: Sample quantities

Thermoelectric Junctions In Arrays and Modules — 674

Spot cooling of power transistors and other components is provided by the TA-20 array and TA-20M module, both containing a group of smaller junctions. The rigidly constructed module, measuring 1-1/2 x 1-1/2 x 1/2 in., can pump more than 20 w or typically attain a temperature differential in excess of 80 C. With 1/16-in. aluminum plates on top and bottom, the module is ready for use as a complete thermoelectric unit.

Ohio Semiconductors, Dept. ED, 1205 Chesapeake Ave., Columbus 12, Ohio.
Price: TA-20, $85.19 to $56.79; TA-20M, $91.06 to $60.71.

Capacitance Bridge For Electrolytic Capacitors — 677

Model 1W1 capacitance and dissipation factor bridge is for the measurement of both tantalum and aluminum electrolytic capacitors. It has provisions for 2-, 3- and 4-terminal measurements. An optional 0 to 600 v dc polarizing power supply is available. Specifications for capacitance are: range, 0 to 120,000 uf; accuracy, ±1% +10 pf; sensitivity, ±0.1% +10 pf. Specifications for dissipation factor are: range, 1 to 120%; accuracy, ±(2% +0.1% dissipation factor); sensitivity, ±(0.2% +0.05% dissipation factor).

Sprague Electric Co., Dept. ED, North Adams, Mass.

P&A: $845; May 1, 1961.

678

For Solid-State Scalers

All solid-state preset timer model 855-6 is designed for use with any transistorized scaler. Two interchangeable time bases, 10-kc crystal controlled oscillator and 60-cps line, are easily changed by inserting plug-in cards. A five-digit neon readout expresses elaspsed time in multiples of tenths of a sec for the 60-cps time base and multiples of one hundred thousandths of a minute for the 10-kc time base. Preset circuitry operates on any single digit. Any digit may be preset in any decade, one decade at a time. All other decades are preset to zero automatically.

Eldorado Electronics, Dept. ED, 2821 Tenth St., Berkeley, Calif.

P&A: $1,600 with 10-kc oscillator, $1,460 without; 60 days.

NEW PRODUCTS

Acoustic Transducer 650

An acoustic transducer, named the Oyster, is designed to operate under water. Able to tolerate water pressure up to 60 psi, the device has a frequency range from 10 cps to 10 kc. Below resonance, it has a nondirectional, flat, −82 db response referred to 1 v per microbar.

Clevite Ordance Div. of Clevite Corp., Dept. ED. 540 E. 105 St., Cleveland, Ohio.

Porcelain Capacitor 657

In radial design. End radial porcelain capacitor model VY is available is reduced size. Standard thickness of 5/32 ±1/32 in. and width of 9/32 ±1/32 in. provides more stable mounting on printed-circuit boards. The unit is available in capacitance values from 10 pf to 1,000 pf.

Vitramon, Inc., Dept. ED, Box 544, Bridgeport 1, Conn.

DC Voltage Standard 649

New dc voltage standard and null voltmeter, model 302, provides short-term stability better than 25 ppm and 30-day stability better than 50 ppm. Output voltages can be set from 1.000 to 502.110 v in 1-mv increments. Instrument can deliver 20 ma. Output impedance is less than 0.01 ohm for dc, less than 0.2 ohm at 1 kc.

Kin Tel Div. of Cohu Electronics, Inc., Dept. ED, 5725 Kearny Villa Road, Box 623, San Diego 12, Calif. *Availability: 30 days.*

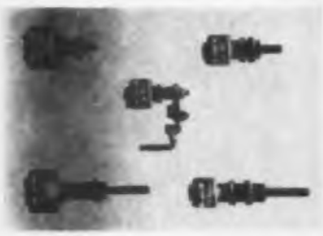
◀ CIRCLE 50 ON READER-SERVICE CARD

Accelerometer 651

Model 58SC accelerometer includes provision for self calibration even after installation. Acceleration range is from 0.02 g to 40,000 g with maximum cross sensitivity of 5%. Temperature range is −65 to +350 F for standard units and −65 to +500 F for high-temperature units.

Columbia Research Laboratories, Dept. ED, MacDade Blvd. and Bullens Lane, Woodlyn, Pa.
Price: $295 for 1 to 5 units.

Hermetic Switches 653



A line of hermetically sealed, rugged, control switches includes spdt, dpdt, and 4pdt switches. The 28-vdc switches carry 5 amp for resistive loads, 2.5 amp for inductive loads, 4 amp for motor loads, or 2.4 amp for lamp loads. Ambient temperature range is from −65 to +250 F.

Controls Co. of America, Dept. ED, Control Switch Div., 1420 Delmar Drive, Folcroft, Pa.

Servo Actuator 662

Is self-contained. Model 410 contains a servo amplifier, servo valve and hydraulic cylinder. It can be furnished with any stroke length from 1 to 6 in. and cylinder diameter from 1-1/4 to 2-1/2 in. Power supply is built in and command can be by potentiometer or external signal. Speeds are up to 40-in. per sec and frequency response is to 40 cps with 90 deg lag.

American Measurement and Control Inc., CompuDyne Corp., Dept. ED, Hatboro, Pa.

CIRCLE 51 ON READER-SERVICE CARD ▶

NEW PRODUCTS

Commutator Simulator 654

Two solid-state telemetry checkout instruments, a commutator simulator and a decommutator feature portability and 1 per cent accuracy. The simulator generates repetitive pulse frames for either pam or pdm. It can frame any number of pulses to operate at any repetition rate. The decommutator receives pam or pdm pulses and provides the analog of the information in any desired pulse. Both instruments are available with 30, 45, 60, or 90 channels. They each weigh 7 lb.

Crestmont Consolidated Corp., Dept. ED, Crestmont Electronics Div., 2201 W. Burbank Blvd., Burbank, Calif.

P&A: $1,200 per unit; 3 weeks.

Miniature Relay 660

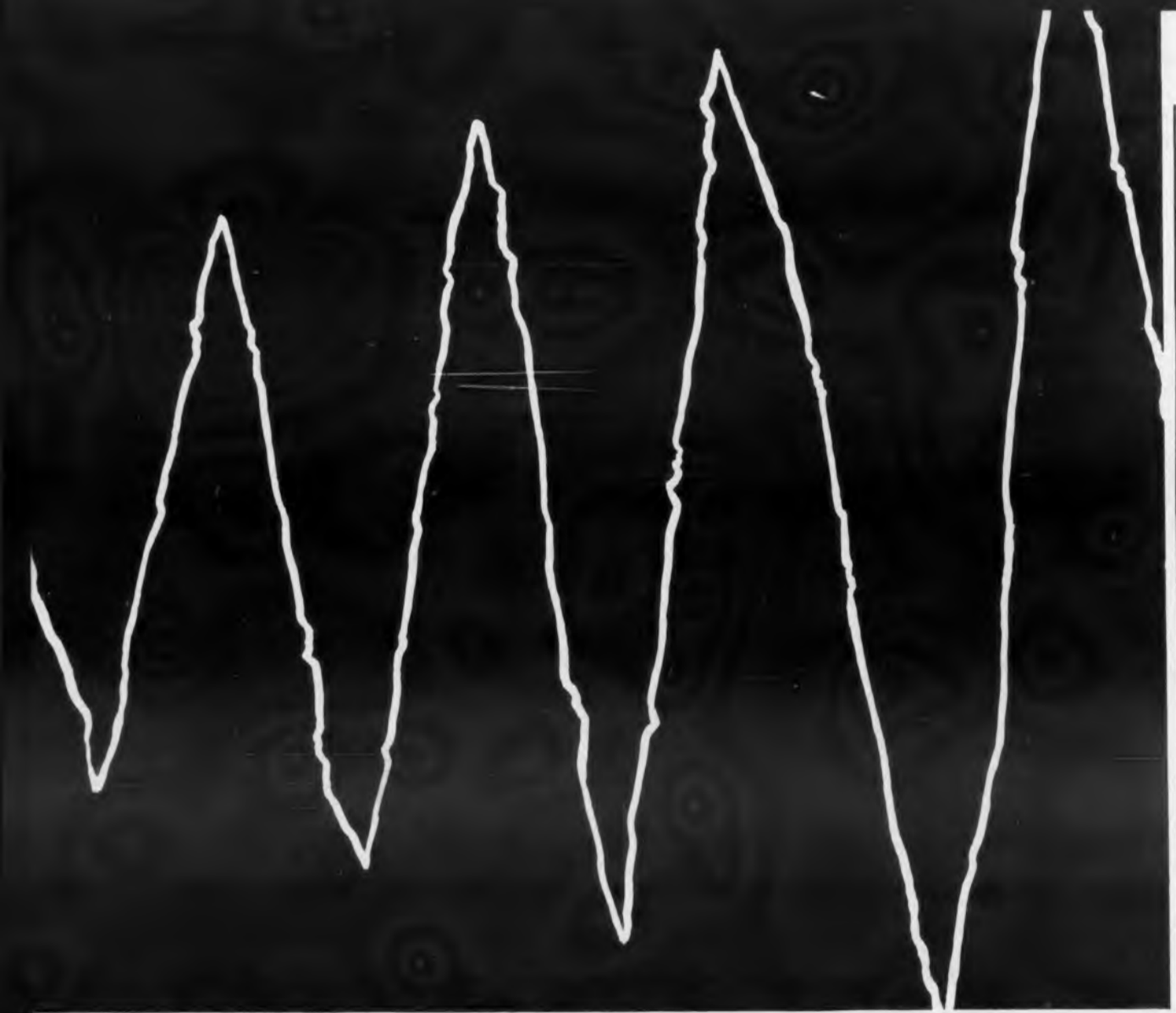
Has glass-to-metal hermetic seal. The relay, called the centipede, has eight terminals and four mounting pins which fit on 0.200-in. centers for standard printed-circuit grid mountings. Glass-to-metal sealing and recessed leads set in epoxy are used. A dpdt type, it is available in voltage and current sensitive models with coil resistances from 0.1 to 11,600 ohms. It measures 0.4 x 0.8 x 0.875 in.

Control Dynamics Corp., Dept. ED, 7420 Fulton Ave., North Hollywood, Calif.

Push Button Switch 659

Has quadrant lighting. A cellularized module and associated push rod allows any quadrant of the Quadlite push button switch to be lighted individually. It has a spdt switch rated at 5 amp at 125/250 v ac, 4 amp at 30 v dc, resistive, or 2.5 amp at 30 v dc inductive.

Controls Co. Of America, Control Switch Div., Dept. ED, 1420 Delmar Drive, Folcroft, Pa.



1000 AT 2 amps!

Prototype quantities now available. Order from these Westinghouse Distributors.

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ELECTRONIC WHOLESALERS, INC.
Melbourne, Florida/PA 3-1441

GENERAL RADIO SUPPLY CO., INC.
Camden, N.J./WO 4-8560

GENESEE RADIO PARTS CO.
Buffalo, N.Y./DE 9661

KANN-ELLERT ELECTRONICS, INC.
Baltimore, Md./TU 9-4242

MILGRAY ELECTRONICS
New York, N.Y./RE 2-4400

RADIO & ELECTRONICS PARTS CORP.
Cleveland, Ohio/UT 1-6060

SCHWEBER ELECTRONICS
Long Island, N.Y./PI 6-6520
Silver Spring, Md./JU 5-7023

MIDWESTERN

ELECTRONIC COMPONENTS FOR INDUSTRY CO.
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HALLMARK INSTRUMENTS CORP.
Dallas, Texas/RI 7-9385

INTER-STATE RADIO & SUPPLY CO.
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LENERT CO. Houston, Texas/CA 4-2663

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SEMICONDUCTOR SPECIALISTS, INC.
Chicago, Ill./NA 2-8860

S. STERLING CO.
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UNITED RADIO, INC.
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PIONEER 6-6520.
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CIRCLE 52 ON READER-SERVICE CARD

◀ CIRCLE 53 ON READER-SERVICE CARD

NEW PRODUCTS

Panoramic Receiver 632

Range 100 to 150 mc. Model Pan 1F panoramic receiver has no moving parts and features an electronic sweep and inertialess tuning. The highly sensitive receiver scans from 100 to 150 mc at 22 sweeps per sec and furnishes a visual display of all signals through the range. Frequency measurement accuracy is 0.2%; dynamic range is 60 db. Expanded sweep displays 1-, 5- or 10-mc sections. Power requirement is 117 v, 400 cps. The 3-chassis set weighs a total of 60 lb.

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

Antenna Multicoupler 633

Is transistorized. Model 7 wideband antenna multicoupler operates from 2 to 32 mc, providing outputs for 8 receivers from a single antenna. The solid-state unit has input and output impedance of 75 ohms. Insertion gain is 2 db, noise figure less than 8 db. Input vswr is 1.7:1, output vswr 1.14:1. Unit weighs about 10 lb.

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

Switching Deck 628

With narrow switches. Any desired number of switches can be stacked in the series SD101 switching deck. Individual switches measure 7/16 in. wide. Switch depth behind panel is 1-3/4 in., height 1-5/8 in. Number of switching sequences per switch is 1 to 10. The units meet military specifications.

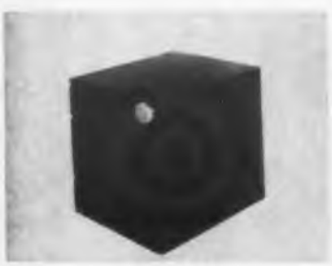
Valor Instruments, Inc., Dept. ED, 13214 Crenshaw Blvd., Gardena, Calif.

Modular Solderer 652

An automatic soldering system for production-line soldering of pc boards and in-line terminals is made of a number of independent modules. Modules are available for soldering, fluxing, preheating, cleaning, drying, scrubbing, and cooling. Solder temperature and contact time can be varied. Wave soldering can be used or jet soldering.

Compo Shoe Machinery Corp., Dept. ED, Special Products Div., 125 Roberts Road, Waltham 54, Mass.

Static Inverter 655



Solid-state static inverter Model SI-2 converts 22 to 28 v dc to an output of 115 v ±10%, single phase, 60 cps. Sinusoidal output waveform has less than 5% total harmonic distortion. Output power is 350 va. Size is 9 x 10 x 11 in. over-all. The inverter meets environmental requirements.

Kidde Aero-Space Div., Walter Kidde & Co., Inc., Dept. ED, 9 Brighton Road, Clifton, N.J.

Electromagnet 663

Has 51,500 gauss field. Model 18A-LI-HI electromagnet has high field, large gap and high homogeneity. The 1-1/2-in. diam pole tips. Maximum power of the magnet is 200 kw for low impedance coils and 12 kw for high impedance coils.

Pacific Electric Motor Co., Dept. ED, 1009 66th Ave., Oakland, Calif.

CIRCLE 56 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Predetermining Counters 627

Register 1,500 counts per min. Series 1801 predetermining counters use rotary preset switches for convenience. Reset time is 150 msec; up to 1,500 counts per min can be registered. Models are available for original equipment makers and existing equipment users. Units have 1 or 2 rows of preset dials, with 4 or 6 decades.

Electronic Controls Div., Veeder-Root Inc., Dept. ED, Danvers, Mass.

DC Motor 629

Has low rf noise. Low-cost, long-life dc motor series 317 uses a transistor inverter. The unit operates without brushes or governor, for increased reliability and elimination of radio interference.

Bristol Motors Div., Vocaline Co. of America, Inc., Dept. ED, Old Saybrook, Conn.

Heat Sink 642

Requires small volume. Semiconductor cooler model NC-401 is said to require half the space of other standard natural convection units. Thermal resistance is 2.8 to 0.8 C per w for natural convection, and down to 0.25 C per w with forced cooling.

Wakefield Engineering, Inc., Dept. ED, 414 Main St., Wakefield, Mass.

Availability: *Stock.*

ELECTRONIC GARAGE DOOR OPERATOR made by H. W. Crane Co. transmits a radio signal to operate garage door from inside car. The compact, transistorized control is powered by Mallory Mercury Batteries. These tiny cells deliver long, dependable service with a constant voltage output.

CONVERTING CURRENT TO VOLTAGE, the new Hewlett-Packard AC current probe simplifies measurements of alternating current. Two Mallory Mercury Batteries provide the instrument's low impedance power supply, with fade-free service of approximately 400 hours.

PLOTTING THE EARTH'S MAGNETIC FIELD is one of the many uses for this portable Gaussmeter from F. W. Bell, Inc. Power source for this sensitive, transistorized instrument, Mallory Mercury Batteries assure good voltage stability over long periods of time and a very high capacity per unit volume.

Vacuum Oven 631

Operates at 800 C. Commercial vacuum oven can operate at temperatures to 800 C and pressures as low as 0.000001 mm. Temperature uniformity is ±3 from 0 to 800 C. Heating and control elements are in the vacuum chamber to afford even temperatures and precise readings of temperature and vacuum.

Tri Metal Works, Inc., Dept. ED, Riverton, N. J.

Line Monitor 640

In portable case. The 400-cycle line monitor of the Shop-Lab series of precision portable instruments uses two expanded-scale meters. Frequency meter accuracy is 0.05%, voltmeter accuracy 0.5%. The rugged instrument is lightweight and compact.

Voltron Products, Inc., Dept. ED, 1020 S. Arroyo Parkway, Pasadena, Calif.

Price & Availability: *$375; 30 days.*

Rectifier Cooler 641

Has low thermal resistance. Rectifier cooler model NC-423 offers low thermal resistance per unit volume: 0.8 C per w with natural convection, down to 0.3 C per w with forced air. Special units for high-power rectifier stack designs are available with natural-convection thermal resistance as low as 0.5 C per w.

Wakefield Engineering, Inc., Dept. ED, 414 Main St., Wakefield, Mass.

CIRCLE 57 ON READER-SERVICE CARD

NEW PRODUCTS

Miniature Relay 644

Rated at 10 amp. Designed for space environment, series 200 relay is hermetically sealed and resists moisture and temperature extremes. It withstands shock and acceleration of 50 g, and vibration of 30 g up to 2 kc. Life exceeds 150,000 operations at 10 amp, 26.5 v dc or 115 v ac, at 125 C. The 2.5-oz relay measures 1 x 0.6 x 1.25 in.

Wheelock Signals, Inc., Dept. ED, 273 Branchport Ave., Long Branch, N.J.

Price: *About $8 ea.*

Coaxial Connector 639

Meets military requirements. Seven-pin coaxial connector has snap-in contacts that may be removed with an extraction tool. A clamping mechanism retains cable jacketing and braid with a minimum of 15-lb force. Cables retained are RG/58U, RG/187U, RG/188U, and RG/159U. Contacts are copper alloy, rhodium plated; inner insulation material is Teflon.

Viking Industries, Inc., Dept. ED, 21343 Roscoe Blvd., Canoga Park, Calif.

Bearing Counter 626

With clear readout. Integral illumination provides uniform day and night readout in 360-deg bearing counter. Translucent figures 0.187 in. high give high contrast ratio with low gloss and spillage. Counter registers 000.0 to 359.9 and repeat at rate of 600 deg per min. Torque is 1 oz-in. from 67 to 180 F. Weight is 6 oz.

Veeder-Root Inc., Dept. ED, 70 Sargeant St., Hartford 2, Conn.

CIRCLE 909 ON CAREER INQUIRY FORM, PAGE 163 ➤

ELECTRONIC ENGINEERS

AZUSA MARK II

A new precision electronics system — the Azusa Mark II — is now in operation at the Air Force Missile Test Center, Cape Canaveral, Florida. Designed and built by Convair/Astronautics, this remarkable system performs a variety of tasks with exceptional reliability. To the range safety officer, it provides a constant prediction of the impact point of any missile should its engines fail in flight. Engineers can determine exactly the speed and location of the missile at any time during the flight by studying data recorded by the Mark II. It can also be used to calculate satellite rendezvous points in space, track orbiting space vehicles, or determine interception points for satellite-to-satellite test and recovery missions.

Experienced electronic engineers are needed now to continue the refinement of this and similar systems and to develop them for future space missions.

You'll find more complete information, plus details of specific positions now available, on the next page.

If the inquiry card has been removed, or if you wish to furnish or request more detailed information, please write to Mr. R. M. Smith, Industrial Relations Administrator-Engineering, Mail Zone 130-90, Convair/Astronautics, 5666 Kearny Villa Road, San Diego 12, California. (If you live in the New York area, please contact Mr. T. Cozine, manager of our New York placement office, c/o General Dynamics, 1 Rockefeller Plaza, New York City; telephone CIrcle 5-5034.)

This convenient inquiry card may be the start of a new career for you — a new way of life for your family. Why not mail it today?

PERSONAL AND CONFIDENTIAL
ATTENTION: MR. R. M. SMITH
MAIL ZONE 130-90

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CONVAIR/ASTRONAUTICS

CONVAIR DIVISION OF GENERAL DYNAMICS

This battery of precision radar antennas—part of the Mark II system—permit the Air Force to track missiles with incredible accuracy. The system tracks a missile by transmitting radio signals to a small airborne transponder which beams a continuous signal back to earth. This signal is captured by these parabolic receiving antennas and sped into a computing system which translates the missile's flight progress on a large plotting board. Azusa Mark II was designed and built by Convair/Astronautics.

ELECTRONIC ENGINEERS: Specialists are needed now to apply creative solutions to design problems of advanced missile and space vehicle launch and tracking systems.

LAUNCH CONTROL CIRCUIT DESIGN
These are relay and transistorized open loop, and sequential switching circuits for the automatic control of the countdown process for the Atlas missile.

TELEMETERING DESIGN
Communications, modulation and data sampling techniques for telemetering and data aquisition systems.

TRACKING SYSTEMS DESIGN
Communications, pulse and phase shift techniques for the design of ultra-precise missile and satellite tracking systems.

TEST EQUIPMENT DESIGN
Switching and analogue circuitry for automatic test and checkout equipment. Assignments are of a project nature — from conception to production.

OPENINGS ALSO EXIST FOR ENGINEERS AND SCIENTISTS IN THESE AND OTHER AREAS:

RELIABILITY
Reliability analysis and test, in San Diego and at off-site bases. BS in EE, AE or ME required.

BASE ACTIVATION
Liaison or design support on launch control equipment, propulsion systems, automatic programming, and missile checkout equipment operations. A degree in ME or EE, plus experience in electrical or mechanical systems required.

FIELD SERVICE
Technical representation to the Air Force at various Atlas bases. Engineering degree plus field service, flight test, or test engineering required.

MECHANICAL DESIGN
For pneumatic, hydraulic and fluid systems design and test, and missile GSE and missile structures design. BS in ME or AE is required.

PERSONNEL SYSTEMS (Man/Machine Analysis)
To evaluate the personnel function from a *system* standpoint. Requires analytical approach to applying manpower to an existing system at the customer level. Broad technical systems background with emphasis on human relations essential. Assignments involve analysis of manpower requirements and applications for a weapon system, including equipment, procedures, time studies, logistics, and training. Degree required, preferably in industrial engineering, business administration, or industrial psychology.

Technical openings also exist in many other specialties. Write to Mr. R. M. Smith, Industrial Relations Administrator-Engineering, Department 130-90, Convair/Astronautics, 5666 Kearny Villa Road, San Diego 12, California. (If you live in the New York area, please contact Mr. T. Cozine, manager of our New York placement office, CIrcle 5-5034.)

CONVAIR/ASTRONAUTICS

CONVAIR DIVISION OF GENERAL DYNAMICS

ENGINEERING PLACEMENT INQUIRY

This card may be folded and sealed or stapled and mailed in complete confidence. It will enable the professional staff at Convair/Astronautics to make a preliminary evaluation of your background. A personal interview can be arranged in your city by appointment. Every completed inquiry will be acknowledged.

NAME _____

STREET ADDRESS _____

CITY & STATE _____ TELEPHONE _____

NEAREST MAJOR CITY (IF APPLICABLE) _____

COLLEGE GRADUATE: YES ☐ NO ☐ DEGREE: BS ☐ MS ☐ PhD ☐

YR ____ YR ____ YR ____

FOLD

MAJOR SUBJECT:

AERONAUTICAL ENGINEERING	☐	MECHANICAL ENGINEERING	☐
ELECTRICAL ENGINEERING	☐	MATHEMATICS	☐
ELECTRONIC ENGINEERING	☐		
CIVIL ENGINEERING	☐	PHYSICS	☐

OTHER _____

EXPERIENCE:

PRIMARY SPECIALTY _____ YRS _____

SECONDARY SPECIALTY _____ YRS _____

ADDITIONAL COMMENTS, IF ANY, CONCERNING YOUR JOB INTERESTS

PLEASE SEND CONVAIR/ASTRONAUTICS RECRUITMENT BROCHURE ED-4 ☐

Frame-Grid Tubes 362

Subminiature frame-grid tubes CK 7994 and CK 7995 are housed in T-3 button envelopes with nominal outside dimensions of 0.375 by 1.25 in. The CK 7994 is a high-frequency, grounded-grid triode, designed for use in wide-band amplifier stages and grounded-grid amplifier applications. With a ratio of 15 ma plate current to 18,000 μmhos g_m, the tube has a plate-to-cathode and heater capacitance of 0.25 pf.

The CK 7995 is designed for use as a wide-band rf or if amplifier, especially in equipment with a low plate supply voltage. It has 8-ma plate current, g_m of 13,000 μmhos, and a grid-to-plate capacitance of 0.03 pf. Tubes operate in environments to 220 C.

Industrial Components Div., Raytheon Co., Dept. ED, 55 Chapel St., Newton 58, Mass.
P&A: $8.50 ea; sample quantities.

Switching Transistors 352

Germanium pnp mesa transistors 2N705, 2N710 and 2N711 are designed for use in military and commercial data-processing equipment. The diffused-base units meet requirements of MIL-S-19500B. Combined turn-on, storage, and turn-off time is 275 nsec for 2N705 and 2N710, and 450 nsec for 2N711. Power dissipation is 150 mw max at 25 C; minimum beta is 25, alpha cut-off frequency 300 mc. Package is TO-18.

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

Scanner Unit 405

All-solid-state scanner unit produces two 17-bit modified time-of-day codes in the Atlantic Missile Range format, and a 1-ppm pulse rate output. The unit fits 19-in. rack mounting, and measures 7 x 17 in. The weight is 27 lb, and the power requirement is 117 v, 50 to 400 cps at 70 w.

Electronic Engineering Co. of California, Dept. ED, 1601 E. Chestnut Ave., Santa Ana, Calif.
P&A: $5,775; 60 to 90 days.

◀ CIRCLE 909 ON CAREER INQUIRY FORM, PAGE 163

NEW PRODUCTS

Mylar Tubing 357

A wide range of inside diameters, from 0.040 in. to 8 in., is available in a new line of Mylar tubing. Wall thicknesses range from 0.001 to 0.050 in. in relationship to diameter. Dielectric strength is 2,500 v per mil. Tubing withstands 300 F continuously and is rated Class B (130 C). Material is impervious to common solvents and resists corrosion and fungus.

Resinite Corp., Dept. EI-2, Dept. ED, 6984 N. Central Park Ave., Chicago 45, Ill.

Time Code Generator 404

Time code generator model 804 supplies time code with a frequency stability of three parts in 10^8. Three additional auxiliary pulse rates are provided: 20-bit, 24-hour binary coded decimal (BCD) code; 1 mc differentiated square wave; and 1-pps pulse. This all-solid-state unit requires 65 w, 100 to 130 v at 50 to 400 cps. The generator measures 7 x 19 x 17 in.

Electronic Engineering Co. of California, Dept. ED, 1601 E. Chestnut Ave., Santa Ana, Calif.
P&A: $7,925; 60 to 90 days.

Proximity Limit Switch 399

Sensitive to ferrous and nonferrous metals, the proximity switch includes completely transistorized control and pick-up unit. Contaminants that collect on the pick-up do not affect the operation, and the pick-up will not attract metal chips.

Electronic Signals, Inc., Dept. ED, P. O. Box 3811 Cleveland 10, Ohio.
Price: $72.00 and up.

FOR TECHNICAL ASSISTANCE AND SERVICE CONTACT THE TRANSITRON FIELD OFFICE NEAREST YOU AS LISTED BELOW.

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2319 Maryland Ave.....CHesapeake 3-3220

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CHICAGO, Illinois
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Oak Park, Ill.....VIllage 8-5556

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14625 Detroit Ave.
Lakewood, Ohio.....ACademy 1-9191

DALLAS, Texas
511 Braniff Airways Bldg.
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First National Bank Bldg.
621 Seventeenth St.....AComa 2-1686

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2842 West Grand Blvd.....TRinity 5-2440

KANSAS CITY, Missouri
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31st and Troost Sts.....VAlentine 1-1819

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Hollywood 28, Calif.....HOllywood 2-2381

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1060 Broad St.....MArket 3-3151

ORLANDO, Florida
#10 Jacklind Bldg.
205 E. Jackson St.....CHerry 1-4526

PHOENIX, Arizona
2727 North Central Ave.....CRestwood 7-3366

ST. PAUL, Minnesota
Griggs-Midway Bldg.
1821 University Ave.....MIdway 6-1891

SAN DIEGO, California
3620 30th St.....CYpress 7-3708

SAN FRANCISCO, California
535 Middlefield Rd.
Palo Alto, Calif.....DAvenport 1-2064

SEATTLE, Washington
3466 East Marginal Way.....MAin 4-0783

SYRACUSE, New York
2360 James St.....HOward 3-4502

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Nissen Building
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electronic corporation
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Sales offices in principal cities throughout the U.S.A. & Europe
cable address: Trelco

CIRCLE 62 ON READER-SERVICE CARD

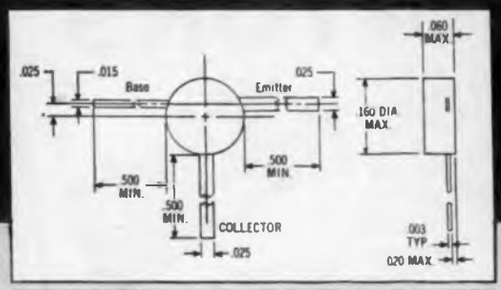
CIRCLE 63 ON READER-SERVICE CARD ➤

NEW FROM

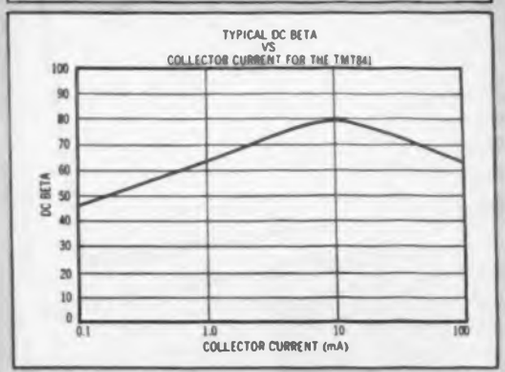
Transitron

micro-T

(A MESA MICRO-TRANSISTOR)



- SILICON DIFFUSED
- HERMETICALLY-SEALED
- ALL-GLASS PACKAGE



AMPLIFIER TYPES					
Type	Maximum Collector Voltage (Volts)	Minimum AC Beta (h_{fe})	Typical Gain-Bandwidth Product (Mc)	Maximum Collector Leakage Current at 25°C (μA)	Maximum Power Dissipation at 25°C Ambient (mW)
TMT 839	45	20	45	1	150
TMT 840	45	40	45	1	150
TMT 841	45	80	65	1	150
SWITCHING TYPES					
Type	Maximum Collector Voltage (Volts)	Minimum DC Beta (h_{FE})	Typical Gain-Bandwidth Product (Mc)	Maximum Saturation Resistance (Ohms)	Maximum Power Dissipation at 25°C Ambient (mW)
TMT 842	45	20	45	120	150
TMT 843	45	45	65	120	150

INTRODUCING THE FIRST SERIES IN A COMPLETE LINE OF MICRO-TRANSISTORS

Development of the **MICRO-T** — first silicon diffused mesa micro-transistor in an hermetically sealed all-glass package — represents a major step forward in microminiaturization. As compared with conventional "metal can" configurations, the **MICRO-T's** hard glass packaging embodies a significant improvement in the hermetic seal between leads and package. Reliability is substantially increased; possibility of leakage is sharply reduced.

This new series of 45-volt micro-transistors is the first designed for small-signal low-level applications, with current operating range from 50 microamps to 20 milliamps. Other electrical characteristics include an Rcs of 100 to 200 ohms; minimum Betas from 20 to 80; cut-off frequencies of over 50 megacycles. Perfectly compatible with present circuitry, **MICRO-T's** will facilitate microminiaturizing in such critical areas as airborne, space vehicle and missile application. They are 1/20th the size of the TO-5, and 1/5th that of the TO-18.

The first five types of **MICRO-T's** are available now. For full information, write for Bulletins No. PB-78, (Amplifier types) and PB-79, (Switching types).

Transitron T.
electronic corporation
wakefield, melrose, boston, mass.
SALES OFFICES IN PRINCIPAL CITIES THROUGHOUT THE U.S.A. AND EUROPE · CABLE ADDRESS TRELCO

NEW PRODUCTS

Mark II Relay 402

The spdt relay features operation which produces a self-cleaning or brushing action. The relay has a minimum life of 100,000 cycles at rated load. The solenoid for nominal 26.5 v dc operation; other voltages can be supplied. Type 1000 relay meets specifications MIL-R-5757 and MIL-R-25018, Class C, Type II, Grade 3. The unit weighs 4.7 oz.

Electro-Tec Corp., Dept. ED, 10 Romanelli Ave., South Hackensack, N.J.

Thermoelectric Cell 398

Usable thermoelectricity is produced by this power package measuring 6 x 1-1/2 x 3/8. Specifications are: power output 2.5 mw, and current of 5 ma into a 100-ohm load. Its resistance is 100 ohms, and it generates 1 v at 200 F differential. The Seejen weighs 1-1/2 oz.

Harco Laboratories, Inc., New Haven, Conn.
P&A: $4.95; 14 days.

Linear Amplifier 401

Double delay line, nonoverloading, linear amplifier is based on Oak Ridge National Labs A-8 design. Type N-308 amplifier has a gain of 7,000, adjustable by coarse and fine crystals, stability of 0.25% per day, rise time of about 0.2 μsec, and integral linearity of 0.1%, 3 to 100 v into 10-K load. The unit is available with integral or differential discriminator. An optional pick-off circuit is for coincidence work in the 50-nsec range.

Hamner Electronics Co., Inc., Dept. ED, Princeton, N.J.
***Availability:** From stock.*

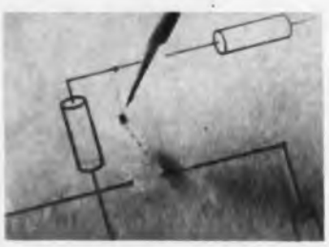
Photoflash Trigger Tube 403

High altitude, subminiature, cold-cathode trigger tube designed for high altitude operation requires an input of 0.25 w and a trigger voltage of 250 v. Type WC-18 requires trigger current of 10 μa, and a keep-alive current of 30 μa. The tube is rated at 700 v, and can operate at max ratings to 65,000 ft.

Electronic Industries Inc., Dept. ED, South Norwalk, Conn.

Availability: *from stock.*

Double-Ended Transistors 361



Subminiature silicon npn transistors are available in double-ended configuration. Capable of dissipating 400 mw at 25 C, the types 2N902 through 2N908 are electrically equivalent to the single-ended subminiature 2N789 through 2N793, 2N745 and 2N746, and to the TO-5 units 2N332 through 2N338. Size is 0.130 x 0.160 in. Ambient temperature range is −65 to +175 C. Military specifications are met.

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

Price & Availability: *$8 to $30; immediate.*

Electronic Relay 356

No dc power supply is needed for the operation of model 120 solid-state electronic relay. Output is 25 v, 150 ma dc; input is dc or 60-cy ac. Turn-on point is adjustable from 3 to 150 v. An independent hysteresis control determines turn-off point. A dual phase-sensitive detector input provides coherent detection of 60-cps input signals and reduces noise. Size is 8 x 4 x 4 in.

K-F Products, Inc., Dept. ED, 3100 E. 43rd Ave., Denver 16, Colo.

NEW PRODUCTS

Time Delay Standard 385

Variable, wide-band time delay standard has a constant delay from dc to 2 Gc. The time delay is continuously variable up to 3 nsec. Accuracy is better than 1% at any given point, readability better than 50 nsec. Attenuation is 0.017 db at 100 mc and 0.85 db at 1.5 Gc.

Ad-Yu Electronics Laboratory, Inc., Dept. ED, 249-259 Terhune Ave., Passaic. N.J.

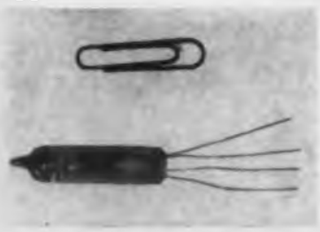
Availability: 1 to 2 weeks.

Sensitive Magnetometer 381

Magnetic anomalies of 0.1 gamma or less are detected and relayed in digital or analog form by this instrument. The continuous output is sufficient to drive telemetry systems or recorders. The unit is 7 in. long x 3 in. in diameter. Power consumption is 0.8 w at 200 ma.

Arnoux Corp., Dept. ED, 11924 W. Washington Blvd., Los Angeles 66, Calif.

Trigger Tube 384



Subminiature, low-impedance cold-cathode trigger tube model 7711/Z71U is for use as an inertialess switch and counter in automatic telephone exchanges. The tube has two positive-voltage operated starters. Starter transfer current of 40 μa makes it suitable for use with diodes and transistors.

Amperex Electronic Corp., Semiconductor Div., Dept. ED, 230 Duffy Ave., Hicksville, L.I., N.Y.

CIRCLE 66 ON READER-SERVICE CARD ➤

See it in Action . . .

For a demonstration of the new V60 millivoltmeter or any digital measuring instrument, call any of the following NLS offices or sales representatives. If you prefer, please contact NLS for additional information.

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OX 7-0810 (Montreal)
Aeromotive Engineering Products, Ltd.
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Toronto, Ontario
RU 3-4288

Export, Excluding Canada
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San Francisco, Calif.
EXbrook 2-5112

Originator of the Digital Voltmeter
non-linear systems, inc.
DEL MAR, CALIFORNIA

CIRCLE 67 ON READER-SERVICE CARD

AC-DC Supply 395

Portable power supply model 4372 offers dial selection of voltages from 0 to 125 v dc, or 0 to 140 v ac at 2.5 or 3.0 amp respectively. The bridge rectifier is overload protected, and a special accessory filters the output for a max ripple of 0.075 v at full load. The unit measures 5 x 5 x 7-1/2 in. weighs 7-1/2 lb.

Edler Engineering Co. Inc., Dept. ED, 1568 S. First St., Milwaukee 4, Wisc.
P&A: $49.50; from the stock.

Counter Indicator 400

Variable radix counter indicator model C-100 is a transistorized counter operating at rates up to 110 kc. Complete "G" Series also includes Preset Counter and Counter Indicator; Set/Reset Indicator; Plus/-Minus Indicator.

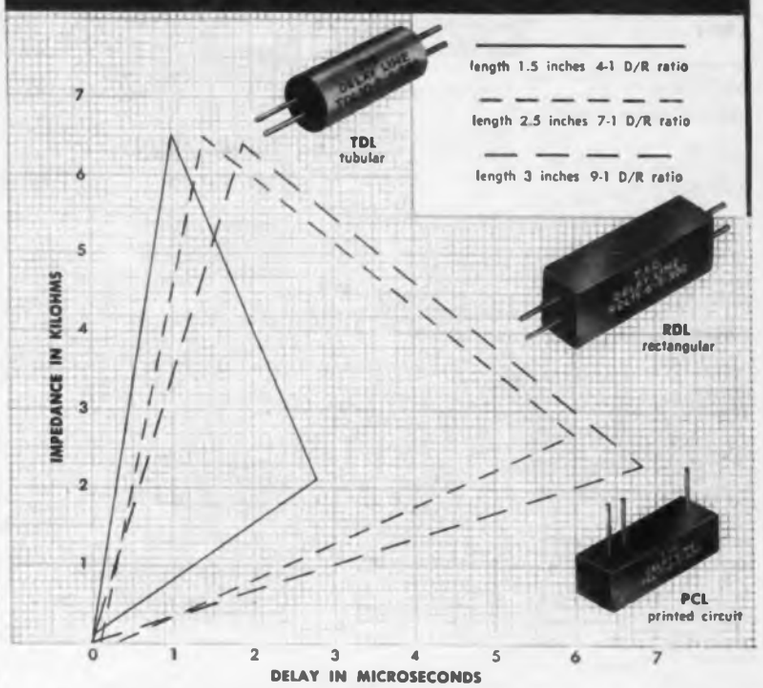
Electronic Control Products, Dept. ED, P. O. Box 286, Dunellen, N.J.
Price: $98 to 122.50

Capacitance Measuring System 397

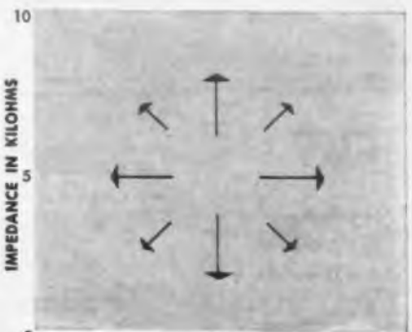
Model 700 measures 2- or 3-terminal capacitors in the range of 0 to 0.12 μf with a resolution of 0.0001 pf on the lowest range. The system provides five ranges of capacitance readings with 120,000 dial divisions of resolution on any range. Accuracy relative to the standard capacitor is ±0.01% plus one dial division, on the three intermediate ranges; ±0.002% plus one dial division on the highest and lowest range. The unit measures 19 x 10-1/2 x 8 in.

Electro Scientific Industries, Dept. ED, 7524 S.W. Macadam Ave., Portland 19, Ore.

Plot your lumped constant delay line needs on these charts! *



* If your requirements fall within any one of the triangles then the TIC standard type in any configuration is your answer. For other specifications PDL type provides Delay time to 500 microseconds, Impedance 25 to 10,000 ohms, Delay to Rise ratios to 150-1.



TIC OF CALIFORNIA

DELAY LINES

FEATURE:
- **HIGHER RELIABILITY**
- **LOWER ATTENUATION**

TIC's lumped constant delay lines are available in three standard configurations, TDL (tubular), RDL (rectangular), PCL (printed circuit), PDL series (are made to customer specifications). They feature a higher delay to rise time ratio per cubic inch than is available with conventional techniques. Every TIC Delay Line is hermetically sealed and complies with applicable MIL specs. TIC Delay Lines are M derived, phase and frequency compensated with excellent pulse response characteristics and exceptionally low attenuation. Standard lead lengths of RDL and TDL units is 2". The PCL lead length is ¾".

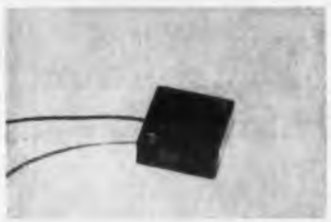
Prompt delivery. Write, wire or call.

TECHNOLOGY INSTRUMENT CORP. OF CALIFORNIA
850 LAWRENCE DRIVE, NEWBURY PARK, CALIFORNIA • HUdson 5-2165
Western Sales Offices • BEVERLY HILLS, CALIFORNIA • OLeander 5-7861

CIRCLE 68 ON READER-SERVICE CARD

NEW PRODUCTS

Subminiature Trimmer 390



A high-temperature, precision trimming potentiometer model 355 measures 1/2 x 1/2 x 0.2 in. It is available in values from 10 ohms to 50 K over an operating temperature range from −55 C to 220 C. Resolution, at 50-K, is 0.0086%. Worm-gear adjusting device provides friction loading and eliminates backlash. Wire leads are 4 in. in length, 30 awg, and Teflon insulated.

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

Thermocouple Hotbox 358

All types of thermocouple wire are joined directly to copper in the universal TC hotbox. No external junctions are used, eliminating the need for wire-matching plugs. Junction temperature of 150 F is maintained; 51 pairs of wires can be accommodated.

Research, Inc., Dept. ED, Box 6164, Minneapolis 24, Minn.

Pulse Modulator 365

Peak power of 1.2 megawatts is provided by pulsed-power signal-source modulator model 344M. Trigger generator, pulser, high-voltage power supply and filament supply are contained in a 7-ft cabinet. Pulse width is 0.1 to 5.0 μsec, continuously variable; maximum duty cycle is 0.002. Rise time is less than 0.2 μsec min at maximum pulse voltage and current into a linear load.

Radiation At Stanford, Dept. ED, Palo Alto, Calif.

Push-Button Actuator 389

Model A4-195/EF-136 is a spdt actuator which is rated at 5 amp, 125/250 v ac, 2.5 amp at 30 v dc. The unit features 0.250 in. min overtravel, 4-oz min release force, and a movement differential of 0.004 in. max.

Control Switch Div., Dept. ED, 1420 Delmar Drive, Folcroft, Pa.

Insertion-Loss Scanner 355

Measurement of insertion loss as a function of frequency in the range of 50 kc to 8 mc is provided by the PTC 1206 insertion loss scanner. System consists of sender and receiver units with power supply. Dual-trace crt displays insertion loss versus frequency characteristic of system under test. Recorder output is available.

Pye Telecommunications Ltd., Dept. ED, Cambridge, England.

Low Power Recorder 387

Miniature strip chart recorder requires 400 μw for full response within 0.6 sec. Model A+ Recorder is available in 0 to 1 ma range with moving coil resistances of 140, 350, 1,500, or 5,500 ohms, and a 4,500-gauss flux. Ink pen, hot wire, or Teledeltos writing systems with standard chart speeds can be specified. Panel space required is 5-1/2 x 7-1/3 in. and portable housing is available.

Atkins Technical Inc., Dept. ED, 1276 W. Third St., Cleveland 13, Ohio.

Cooling Unit 393

Operation from −65 to +125 F and altitude from sea-level to 10,000 ft is possible with the RS-100-102 cooling unit. It is rated at 800 w at 125 F condenser temperature and power requirements are 416 v, 3-phase, 400 cps. Weight is 85 lb; size is 16 x 10 x 19 in.

Eastern Industries Inc., Dept. ED, 100 Skiff St., Hamden 14, Conn.

NEW PRODUCTS

Shielded Transformers 386

Power transformers in five design styles cover the range from 100 w to 50 kva, 120 v input, 120 v output. These transformers are code requirement class I division 1, for use in locations where hazardous concentrations of flammable gasses or vapors exist.

Acme Electric Corp., Dept. ED, Cuba, N.Y.

Miniature Attenuators 383

Printed circuits provide up to 20 steps of attenuation in ladder or potentiometer configuration. Composition or wirewound 1/2-w resistors are available in these units. The attenuators meet standard type specifications.

Cinema Engineering Div. of Aerovox Corp., Dept. ED, 1100 Chestnut St., Burbank, Calif.

Instrument Switches 382

Type CVS switches have up to 32 adjustable positions and 360-deg rotation. Stop positions can be selected without removing the switch from the panel. Contacts, commutator rings and brush blades are of solid nickel-silver. Terminals accommodate wire up to 18 awg.

Aerovox Corp., Cinema Engineering Div., Dept. ED, 1100 Chestnut St., Burbank, Calif.

◀ CIRCLE 71 ON READER-SERVICE CARD

Diode Test Set 369

Four-terminal measurements of forward voltage drop can be made with model 1808 diode test set. Ranges are 1, 3 and 10 v. Adjustable reverse voltage is metered from 0.5 to 2,000 v. Reverse current can be read directly from less than 1 na to 3 ma.

Dynatran Electronics Corp., Dept. ED, 187 Herricks Road, Mineola, N.Y. *P&A: $1,250; 30 to 60 days.*

Stem and Wafer Machine 374

Small production runs on all types of button stems up to 1 1/4 in. diam may be made on this machine. Model 105-BST1 is equipped with gas-air-oxygen or hydrogen-oxygen burners to handle all types of glass parts.

Eisler Engineering Co., Inc., Dept. ED, 750 S. 13th St., Newark 3, N.J.

High-Temperature Furnace 366

Capable of reaching 2,600 C at vacuum of 10^{-6} mm Hg, the furnace has heating area 6 in. in diameter by 7 in. high. Heating is accomplished by passing 3,000 amp through a circular tungsten element surrounded by tantalum foil. Vacuum apparatus for the chamber consists of 46-cfm roughing pump and a 6-in. oil diffusion pump. The 10^{-6} mm Hg pressure can be reached in approximately 4-min pumping time.

Electro-Optical Systems, Inc., Dept. ED, 125 N. Vinedo Ave., Pasadena, Calif.

Miniature Capacitors 377

High voltage capacitors are available in sizes from 1 5/8 x 1 13/16 x 1 1/6 in. Designated as HI-VAR, these units exceed MIL-C-25C requirements, and range in value from 0.1 μf to 15.0 μf, in voltages from 400 to 12,500 v dc.

Dearborn Electronic Laboratories, Inc., Dept. ED, P.O. Box 3400, Orlando, Fla.

Module Racks 371

Standard S-Block racks can accommodate either 19 or 28 3C-PAC series S plug-in modules. A choice of taper or solder pin type connectors is available, and power and ground busses are factory prewired. Power connections +12-, −6- and −18-v terminals are quick disconnect type. The units are of welded steel construction and measure 19 x 5 1/2 x 9 1/2 in.

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

Cable Tester 532

One-man checkout of interconnecting and power cables is possible with this portable cable test set. Cables are checked for crossed wires, shorts and opens; power cables are checked for proper ac and dc voltages and correct phase rotation. Standard model has a go/no-go meter and handles up to 35 conductors. Set weighs 21 lb and operates from 115-v, 60 to 400 cps, or from internal batteries. Unit can be packaged for commercial or military use.

The Hallicrafters Co., Dept. ED, 4401 W. Fifth Ave., Chicago 24, Ill.

Planetary Lappers 379

Semiconductor crystal processors are capable of lapping both faces of a slice simultaneously, with parallelism in the order of 0.000005 in. Model PL-2875-B features a 2-7/8 in. track and ten carriers, and will lap 10 slices up to a max size of 1-3/4 in. in diameter. Model PL-1875-B has a 1-7/8 in. track and 17 carriers, each holding from one to three slices. This unit can lap 17 slices up to 1 in. in diameter.

Dallons Labs., Inc., Dept. ED., 5066 Santa Monica Blvd., Los Angeles 29, Calif.

Tunable Filter 380

Narrow bandpass, tunable filter model 100 is for use in the 118 to 136 mc range. It has tuning accuracy to within 25 kc. Power rating is 50 w am at 100% modulation and useful bandpass is 100 kc. Type N female connectors are used.

Adams-Russell Co., Inc., Dept. ED, 200 Sixth St., Cambridge 42, Mass. *P&A: $1,175; 30 days.*

Card Reader 533

Automatic control of program, formula, position, etc., is provided at low cost with clip cards and reader. Vinyl cards may be cut with scissors; finger length is in direct proportion to command signal. Life is over 1 million readings; accuracy can be 1 part per 30,000. No relays or stepping switches are used. The flush-mounting reader can be supplied to handle cards with up to 40 fingers.

Jordan Controls, Inc., Dept. ED, 3235 W. Hampton Ave., Milwaukee 9, Wis.

Glass Cloth 376

Material for insulating boards withstands soldering temperatures of 450 to 500 F, and is made of silicone-glass laminate. This laminate is applicable in environments of −40 to 160 F; withstands shocks of 30 g for 11 msec.

Dow Corning Corp., Dept. ED, Midland, Mich.

Sealed T-Switch 367

The H-16-200 is a spdt switch which meets MIL-S-6743 electrical ratings. It has a pretravel of 0.012 in., is 0.787 in. in length and weighs 7 g. Operating force is 550 g min.

Controls Company of America, Control Switch Div., Dept. ED, 1420 Delmar Drive, Folcroft, Pa.

◀ CIRCLE 73 ON READER-SERVICE CARD

NEW PRODUCTS

DC Motor 360

A **permanent-magnet** dc motor, model PM-1 is suitable for military and commercial uses. With efficiencies to 54% through high-flux utilization, the motor requires very low current at full load. Weight is less than 2 oz; length is 2 in., OD 7/8 in. Motor operates from −55 to +100 C, under vibration, shock and acceleration satisfying military specifications. Voltage range is 3 to 30 v dc.

Reflectone Corp., Dept. ED, Stamford, Conn.

P&A: $14.50 ea in quantity; stock.

Memory Systems 354

Magnetic-core memory systems are available wired, assembled, and tested. Capacity ranges from 256 to 4,096 words of 8 to 32 bits. Read-write cycle time is 5 to 12 μsec. Systems are built to operate under broad variations in power and temperature. Complete information retention is provided, even in case of full power loss. Standard and custom types are made.

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

Power Transistors 353

Drift-field germanium pnp power transistors 2N1905 and 2N1906 have linear characteristics and a wide frequency response. They are useful as high-power, high-speed switches, ultrasonic oscillators, and wide-band linear amplifiers. Power dissipation is 50 w at 25 C. Rise and fall times are less than 1 μsec. Minimum beta is 50 for 2N1905, 75 for 2N1906. Typical gain-bandwidth product is 7.5 mc.

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

Digital Ohmmeter 396

Transistorized, five-digit, ohmmeter featuring a three-position readout with Super-Nixie indicators is accurate up to 0.01%. Model 3500AO indicates the

range of 0.01 ohm to 9.9999 meg. The average reading time is 2 sec, and the test currents meet MIL specifications. Plug-in boards and military-type connectors are used throughout, and printers can be operated directly.

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

Neon Distribution Amplifier 391

Three pulse width modulated signals can be applied simultaneously to EECO 860 neon distribution amplifier. The unit supplies a 12-channel output for transmission over two-wire cables for distances up to several miles. The output levels are sufficient to drive camera neon lines to remotely located instrumentation cameras. The all solid-state unit measures 7 x 16 x 19 in.

Electronic Engineering Company of California, Dept. ED, 1601 Chestnut Ave., Santa Ana, Calif. *P&A: $2,500; 60 to 90 days.*

Cooling Unit 394

Laboratory cooling unit has a rating of 18 kw at 80 F. Temperature can be controlled manually or a servo system permits remote control of the unit. Operating conditions are from 32 to 110 F, and from sea level to 5,000 ft altitude. The unit weighs 200 lb, and measures 21-3/8 x 29-3/16 x 34-1/2 in. Power requirements are 440 v, 3-phase, 60 cps.

Eastern Industries Inc., Dept. ED, 100 Skiff St., Hamden 14, Conn.

Power Transistors 351

Stud-mounted silicon power transistors use standard stud-mounted rectifier hardware. Increased thermal conductivity allows operation in ambient temperature range of −65 to +200 C. The five stud-mounted types are the 2N1894 through 2N1898, electrically equal respectively to the 2N389, 2N424, 2N1660, 2N1661 and 2N1662.

Raytheon Co., Semiconductor Div., Dept. ED, 200 First Ave., Needham, Mass.
P&A: $24 to $60, 100 to 999; immediate.

NEW PRODUCTS

Pulsed X-Ray System 406

With 1-μsec pulse duration. Model 5660 pulsed X-ray system is expected to have widespread use in shock and vibration studies, radiation effects, rocketry, medical radiology, ballistics, and crystallography. The long-life tube is pulsed with a square-wave voltage of up to 150 kv; rate of application is 1 to 30 pulses per sec. Resulting X-rays have an effective spot size of 1 x 2 mm, and at 1 in. from the target have an intensity of 10 million roentgens per sec. A Rauland image intensifier tube provides an image suitable for direct viewing or photography.

Zenith Radio Corp., Dept. ED, 6001 W. Dickens Ave., Chicago 39, Ill.

Automatic Tape Spooler 375

Bidirectional-winding, automatic tape spooler TS-400 can be used with any tape reader. The unit uses standard reels up to 8 in. in diameter, and handles paper or Mylar tape. The unit has a 1,000 ft tape capacity and winds at 15 ips.

Electronic Engineering Company of California, Dept. ED, 1601 E. Chestnut Ave., Santa Ana, Calif.

P&A: $495; 6 to 8 weeks.

PDM Multicoder 370

All-transistor, 48-channel, PDM multicoder has 3-pole, 16-channel subcommutator. It is of modular plug-in design. Silicon semiconductors are used throughout. Unipolar or bipolar models are available with common or insulated ground.

Applied Electronics Corporation of N.J., Dept. ED, 22 Center Street, Metuchen, N.J.

Automatic Solderer 526

Compact, automatic, soldering machine for pc boards can be adjusted quickly for pc boards measuring from 2 x 3 in. to 8 x 12 in. A two-wave solder pot with automatic fluxing can hold 300 lb of solder. The machine handles from 180 to 720 boards per hr.

Devcon Inc., Dept. ED, P. O. Box 616, Westfield, N. J.

◀ CIRCLE 78 ON READER-SERVICE CARD

Conductive Inks 368

Printed circuit conductive inks which can be sprayed, roller coated or screened have an approximate resistance of 400 ohms per sq in., when screened through 8XX mesh. Formulation EL-787 is prepared for porous boards, while formulation EL-796 is for thermo-plastic applications. The inks are black in color, and will air dry in 35 min.

Advance Process Supply Co., Inc. Dept. ED, 2315 West Huron Street, Chicago 12, Ill.
Price: $35 to $39 per gal.

Telemetry Display 373

Model TDU-1 telemetry display unit has sensitivity of 2 μv for full deflection. Image rejection is 60 db and gain control range is 80 db. It operates at 30 mc input frequency, and has a continuously adjustable sweep from 0 to 3 mc. This is a companion unit to TMR-1 telemetry receiver.

Defense Electronics, Inc., Dept. ED, 5451-B Randolph Road, Rockville, Md.
P&A: $685; 30 to 60 days.

Wide-Band Transformer 378

Rf transformer model RFT-130, covers the range of 1 to 30 mc and matches a 50-ohm unbalanced source to a 1,200-ohm balanced load. It has a frequency response of 0 to 3 db in the indicated range. Flat loss is approximately 1 db. The unit is potted in epoxy resin, measures 1-7/16 in. cu, and mounts with two 6-32 x 1/4 in. spade bolts.

Columbia Technical Corp., Dept. ED, 24-30 Brooklyn-Queens Expressway W., Woodside 77, N.Y.

Data Converter 372

A radiosonde balloon data converter accepts analog synchro voltages representing radiosonde elevation and azimuth in degrees. The unit senses and records contact closures, and measures elapsed time in increments of 0.01 min. Completely transistorized, the data converter conforms to MIL requirements, and was designed to operate with existing tracking antennas and recorders.

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

CIRCLE 79 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Alkaline Batteries 364

For radio and photoflash service, four alkaline batteries provide long life in continuous or intermittent service. Included are the VS1073, a 1.5-v N cell; the VS1334, a 1.5-v penlight cell; VS1149 a 4.5-v unit for portable radios, and the VS1335, a 1.5-v C cell.

Radio Corp. of America, Dept. ED, 30 Rockefeller Plaza, New York 20, N. Y.
Availability: *from distributors.*

Indicator Lights 363

Welded indicator light modules for instrument and computer use are made in eight types, WM-2000 through WM-2007. Self-contained units need only external power supplies and trigger signals. Configurations include transistor amplifier with incandescent and glow lamps, positive and negative logic, turn-on and turn-off types.

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

Variable-Speed Drive 359

A static-powered drive for wide range, variable speeds from in-plant ac circuits, the Statatron is available in ratings from 1 to 200 hp. Silicon diodes are used in conjunction with a transistorized power exciter.

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

Terminal Assemblies 527

A high degree of reliability is claimed for "Cerameterms" ceramic-metal terminal assemblies. They are for use with transistors, relays and condenser banks.

Bendix Corp., Dept. ED. Eatontown, N.J.

Audio Chokes 528

Rated at 350 h at 5 dc ma, audio choke C-2345 has a dc resistance of 5,600 ohms. Type C-2346 is rated at 35 h at 15 ma dc and has a dc resistance of 1,800 ohms. Both units have an insulation breakdown rating of 2,500 v rms.

Chicago Standard Transformer Corp., Dept. ED, 3501 W. Addison St., Chicago 18, Ill.

Price: *$5.11 for C-2345; $2.87 for C-2346.*

Filament Transformers 529

Filament transformer P-6432 has a 5-v center tap, a 21-amp secondary and an insulation breakdown of 2,500 v rms. P-6433 has a 5-v center tap, 15-amp secondary and an insulation breakdown of 2,000 v rms.

Chicago Standard Transformer Corp., Dept. ED, 3501 W. Addison St., Chicago 18, Ill.

Price: *From $11.56 to $13.89.*

Power Transformers 530

Industrial power transformer P-6358 is rated at 300-0-300 v ac at 65 ma. Model PM-8423 is rated at 300-0-300 v ac at 90 ma. Primaries of both units are 117 v 60 cps.

Chicago Standard Transformer Corp., Dept. ED, 3501 W. Addison St., Chicago 18, Ill.

Price: *$9.93, P-6358; $13.55, PM-8423.*

Test Console 531

Universal storage and crt console model 300B is for test of storage tubes having up to two writing guns and one flood gun. Characteristics are: accelerating voltages, screen potential of 20 kv max; positioning voltages, +250 to −250 v; sawtooth frequency ranges, 20 to 16,000 cps; synchronized sweeps, 60 to 15,750 pps.

Automation Laboratories, Inc., Dept. ED, 179 Liberty Ave., Mineola, L.I., N. Y.

CIRCLE 82 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Transmitter Arrestor **388**

Lightning arrestor Type LA-4 features a high-temperature series capacitor, and a low loss magnetic type spark gap that permits the unit to exceed MIL-A-9094C specification. The arrestor has a mounting flange that may be fitted into an antenna coupler.

Dale Electronics, Inc., Dept. ED., Columbus, Neb. *Availability: 70 days.*

Motor-Generator **536**

Brushless motor-generators have ratings from 3 to 150 kw. The synchronous motor-powered devices are claimed to have 1% voltage regulation with optional regulation up to 1/2%. Frequency is "exactly" 400 cps. Standard harmonic content is less than 2% with closer tolerances available.

American Electronics, Inc., Dept. ED, Precision Power Div., 1598 E. Ross Ave., Fullerton, Calif.

Potentiometer **537**

Wirewound potentiometer series 57-EM is a 2-w unit available in resistances up to 100 K. Glass-sealed terminals permit this high-reliability unit to operate at temperatures up to 150 C.

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

Stepping Switch 538

Solenoid operated, rotary stepping switch model 100619 has 104 contacts in each deck. Decks may be stacked. Operating voltage is 24-v dc with other voltage coils available. Contact carrying capacity is 2 amp; working voltage between contacts is 3,000 v dc and resistance drop through contacts and slip-rings is 0.05 ohm.

Astral Electronics Inc., Dept. ED, 14620 Arminta St., Van Nuys, Calif.

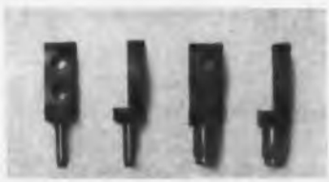
P&A: From $604.42 ea; 30 to 60 days.

Spaghetti Tubing 539

Greater thermal stability, low-temperature toughness and superior dielectric strength is offered by Teflon spaghetti tubing. Designated Chenflour, it is available in 11 colors. Sizes range from AWG 30 to AWG 0.

Chemplast, Inc., Dept. ED, 3 Central Ave., Newark, N.J.

Printed Circuit Hardware 540



Miniature plug and jack assembly is for printed circuit applications and measures 1/8 x 1/8 in. at max cross section. Both plug 2654 and jack 2655 are brass, finished in silver plate with a gold flash.

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

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

NEW PRODUCTS

Tape Reader 392

Up to 80 bits of information can be read simultaneously by means of TP 401 tape reader. The unit reads 10 lines and 8 levels across at a time at 6 tests per sec. Special search speed runs at 12 ips. A frame counter indicates the number of frames the tape has advanced from a selected point. TP 401 measures 10-1/2 x 13 x 19 in.

Electronic Engineering Company of California, Dept. ED, 1601 Chestnut Ave., Santa Ana, Calif. *P&A: $1,620; 6 weeks.*

Push-Button Switch 534

Rated to 50 w, the S6 series molded push-button switch is 1-7/16-in. long, with OD of 11/16 in. It is available normally open or normally closed, spst or spdt. Maximum working voltage is 115 v. Carter Parts Co., Dept. ED, 3401 Madison St., Skokie, Ill.

Battery Holders 535

Designed to retain C cell mercury batteries under severe shock, No. 2880 holders are of phosphor bronze, with beryllium copper spring washers. They measure 2-3/8 at the base. Cambridge Thermionic Corp., Dept. ED, 445 Concord Ave., Cambridge 38, Mass.

Price: *$0.78 ea, 100 to 249.*

Availability: *From stock.*

Coil Form 541

Vertically mounted ceramic coil form No. 2501 is for printed circuit work. The grade L-5 ceramic form is silicone-impregnated and is internally threaded for tuning cores. It is available with four different powdered-iron tuning cores having overlapping frequency ranges from 0.2 to 150 mc. Dimensions are 0.255 in. for the form OD and 0.625 in. for mounted height.

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

Converter 548

Designed for use with "Nixie" indicator tubes, models VC 12-170 and VC 28-170 have an output of 170 v dc from 12 and 28 v dc respectively. Full load current is 30 ma for each, enough to power 10 "Nixies."

Burroughs Corp., Electronic Tube Div., Dept. ED. P. O. Box 1226, Plainfield, N.J.
***Price:** $48.50 in small quantities.*

Ferrite Antenna Coil 549

Broadcast band antenna coil RTC 9252 is for small receivers where no external antenna or large internal loop antenna is desired. The inductance can be screw-driver adjusted from 43 μh at 2.5 mc ("Q" of 100) to 270 μh at 790 kc ("Q" of 300).

Chicago Standard Transformer Corp., Dept. ED, 3501 W. Addison St., Chicago 18, Ill.

NEW PRODUCTS

Modulator 542

An electro-optical system is used to perform the modulation in the "Autoverter" microvolt modulator. A power source capable of 200 v dc delivering 200 ma is the only requirement to drive the unit. Two 5-v square wave outputs have less than 2-μv rms noise level with 2-μv zero offset. Weight is less than 3.3 oz.

Apollo Electronics Inc., Dept. ED, 301 S. Harbor Blvd., Fullerton, Calif.

Impulse Counter 543

Push-button actuated impulse counter has an automatic reset which counts at a rate up to 500 counts per minute. The start button is integral with the count-setting knob. Four standard counting ranges are available: 1 to 120; 2 to 240; 4 to 480, and 8 to 960.

Automatic Timing & Controls, Dept. ED, King of Prussia, Pa.
Price: *$45.*

Modular Connector 544

For miniaturized packaging, these connectors will provide 100 connections in 2-1/2 in. of length. Top and side feed nylon modules may be interlocked on a rigid plastic track which may be cut to any length.

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

CIRCLE 87 ON READER-SERVICE CARD ▶

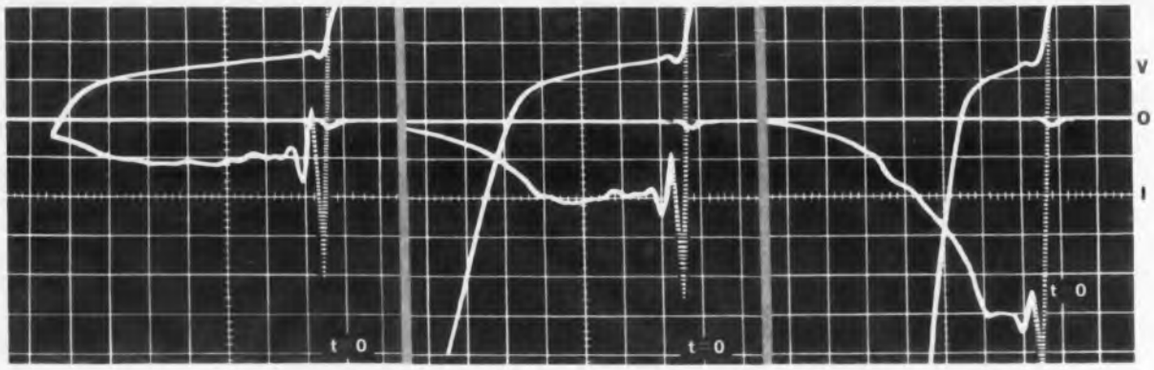


Figure 1 — 1ma., 10nsec., 185mv./div.

The usefulness of diode stored charge measurements

by DAVID E. HUMEZ
Technical Advisor to the Manager of Operations
Clevite Transistor, Waltham, Mass.

Because driving signals usually are of fixed amplitude and duration in a given circuit, it would be desirable to express the transient behavior of diodes in terms of the charge which must be removed during switching. It would be even more desirable if a simple method of measuring stored charge under a given set of circuit conditions could predict the diode behavior under different conditions.

Measurements of the charge represented by the product of reverse current (I_r) and the time (t_r) required for the diode junction voltage to drop to zero have been disappointing. For the same forward current (and therefore the same total stored charge) the charge measured varies widely with changes in the reverse current. Table 1 lists a series of measurements on a single, moderately-fast, diode. Note particularly that the measurement made from 10ma. to 18ma. shows a smaller ratio of t_r to τ, the effective total charge lifetime, than all the other measurements and yet does not show a maximum normalized value of t_rI_r. Very small values of t_r/τ do not give more understandable results.

Table 1

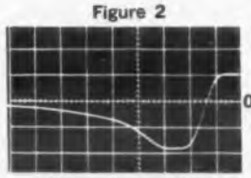
I_f ma	I_r ma	t_r nsec	t_rI_r $\mu\mu$coul	τ nsec	τI_f $\mu\mu$coul
5	2	18	36	31.7	158.5
20	2.0	42	84	33.2	664.0
20	1.0	62	62	31.6	632.0
20	0.5	86	43	33.8	676.0
20	0.1	134	13.4	34.0	680.0
10	18	3.1	55.8	33	330.0
20	1.0	73	73	37.2	
20	2.0	48	96	33.6	
20	5.0	26	130	31.6	

The use of the popular expression $Q = \tau I_r (e^{t_r/\tau} - 1)$ at all, and particularly when $t_r << \tau$, gives rise to large errors because the derivation of the expression makes use of a fundamentally false assumption: viz., that at the time, t_r, the charge contained in the diode will have dropped to zero. Both theory and measurement show that the fraction of the total charge removed during this time is never larger than about one fourth, that it varies widely with the ratio of I_f/I_r and that it reaches a maximum at I_f/I_r of approximately 1.5 corresponding to $t_r/\tau = 0.35$ approximately.

The current and voltage traces displayed in figure 1 illustrate the variation in the fraction of charge removed during the time, t_r. The diode behavior shown is that of the diode of Table 1. The last three lines of Table 1 were derived from the photographs, whereas the first five lines were obtained with different equipment. Experimental difficulties in achieving simultaneous traces of current and voltage have given rise to small errors.

A general solution of the diffusion equation for a diode whose base is thick compared to a diffusion length (W > L) yields the expression, $\text{erf}\sqrt{t_r/\tau} = I_f/(I_f + I_r)$. By the use of this simple expression, values of τ and τI_f (the total stored charge) have been calculated in the last two columns of Table 1. For a wide range of values for I_f/I_r, remarkably uniform values of τ result. From the value of τ can be calculated t_r for any value of I_f/I_r. Assuming a value of τ = 33 nsec t_r was calculated for I_f/I_r = 0.55. The result predicts that the constant current phase of recovery should be over in 3.1 nsec. Figure 2 illustrates this same diode performing under these conditions. The diode is being switched from 10ma forward to 3 volts and approximately 100 ohms external loop impedance. Note that with such a low voltage and loop impedance the voltage drop across the diode itself is not negligible. The reverse current is not 3/100 amperes but rather .018 approximately. Also at this speed the rise time of the generator and CRO are important. It is, none the less, encouraging that a measurement made at 134 nsec and an I_f/I_r of 200 to 1 should predict so well the behavior at 3.1 nsec and an I_f/I_r of 1 to 1.8.

Figure 2



10ma., 1nsec/div.

Table 2

I_f ma	I_r ma	t_{r1} nsec	t_{r2} nsec
20	2.0	42	140
10	1.0	42	200
5	0.5	42	260
2	0.2	42	330
1	0.1	40	380

Table 2 illustrates a simple test for the condition W > L. The diode yielding the results listed as t_{r1} satisfies the condition, the other diode does not.

Stored charge measurements can, then, be made at conveniently long times for a large group of moderately to very fast diodes intended for use in the low nanosecond range. A single set of test conditions could well be adopted as standard for a very wide range of end use conditions.

Detailed information on this subject is available. When writing please ask for Applications Bulletin 3.

Splice Cap 545

Wire twisting for splicing is eliminated by splice cap 2008S. The steel cap has eight equally spaced flutes to position it in the crimping tool as the connection is made.

Buchanan Electrical Products Corp., Dept. ED, Hillside, N.J.

Lanyard-Operated Switch 546

A 4pdt lanyard-operated switch, type M-479-1 withstands high-level sinusoidal and random noise vibration tests in both axes, in normally open and closed positions, without contact movement. Switch has passed vibration test of 92 g at 2 kc. Contacts are rated at 10 amp dc. Weight is 0.5 lb, length 2.7 in. Life exceeds 5,000 cycles per min.

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

Vibration Tables 547

Lightweight vibration tables are made for electronic reliability testing programs. Model RH-5220, for horizontal vibration, produces 3.2 g; RV-5340, for vertical vibration, will produce 3.6 g. Frequency range is 25 ±5 cps; test load capacity is 500 lb.

L. A. B. Corp., Dept. ED, 700 Onondaga St., Skaneateles, N. Y.

Price: $4,000 to $7000.

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NEW PRODUCTS

Cable Clamps 439

Adjustable cable clamps and cable ties are completely flexible from −65 to +225 F. Unaffected by moisture, the Lok-Strap clamps withstand extreme flexure and vibration. They do not become brittle at low temperatures and do not stretch at high temperatures. Wire harnesses from 1/8 to 2 in. in diameter are accommodated.

Panduit Corp., Dept. EI-2, Dept. ED, 17301 Ridgeland Ave., Tinley Park, Ill.

Cryogenic Pumps 436

Flooded electric motors are used in line-mounted cryogenic pumps. Operating temperature range is −290 to −420 F. Motors range in size from fractional to 50 hp, for 60 or 400 cps power. The 50-hp motor uses 3-phase, 400-cps power, measures 6.50 in. in diameter by 7 in. long and weighs 30 lb. At normal speed of 24,000 rpm, efficiency is 90%. Pumps are made for pipe sizes of 1 to 8 in., flange-mounted or welded.

Pesco Products Div., Borg-Warner Corp., Dept. ED, 24700 N. Miles Road, Bedford, Ohio.

Thermostat Module 434

Miniature, liquid-in-glass thermostat offers direct switching of 1, 4.7, and 10 amp or larger loads without external relays or amplifiers. Unit handles output voltages to 400 v at frequencies from 25 to 1,000 cps. Setting accuracies to 0.1 C and differential of 0.05 C can be provided. Package is 0.4 in. in diameter by 1-1/2 in. long for ac, slightly larger for dc.

Precision Thermometer & Instrument Co., Dept. ED, 1434 Brandywine St., Philadelphia 30, Pa.

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NEW PRODUCTS

Crystal Filter 453

With A 2.0-cps bandwidth at 100 kc f_o, model BP-104D crystal bandpass filter is designed for vibration-analyzing equipment. The crystal is housed in a thermostatically controlled oven to maintain 135 C. Specifications are: insertion loss, 22 db; impedance, output and input, 1.2 K; size, 4 in. in diameter x 5 in.; maximum drift, 0.0005% of f_o over operating temperature range.

Electronic Laboratories Corp., Dept. ED, 4221 Spencer St., Torrance, Calif.

Rotary-Actuated Switch 433

High-temperature, hermetically sealed switch uses a rotary linkage actuator for positive operation regardless of dust or ice conditions. Lever can be adjusted through 360 deg. Rating is 2 amp inductive, 28 v dc and 1 amp inductive, 115 v, 60 or 400 cps. Temperature range is −65 to 600 F.

Minneapolis-Honeywell Regulator Co., Micro Switch Div., Dept. ED, Freeport, Ill.

Price & Availability: *$130 ea; stock.*

Data Recorder 432

Analog data tape recording and reproducing system 102A is designed for general industrial and re-

search use. Accuracy is 0.2% from 0 to 400 cps. The system may be used for time scale contraction and expansion, dynamic simulation, programing and computer read-in and read-out. The portable, two-channel unit has three tape speeds, wide dynamic range, independent record and reproduce channels, low noise and low crosstalk.

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

Silicon Rectifier 431

Low cost of the MR322 diffused-junction silicon rectifier enables wide application. Rated at 18 amp, unit operates at case temperatures from −65 to +175 C. Welded case of 3/8-in. OD is designed for press-fit mounting.

Motorola Semiconductor Products Inc., Technical Information Center, Dept. ED, 5005 E. McDowell Road, Phoenix, Ariz.

Price: *$0.58 ea, 10,000 quantity.*

Frequency Converter 435

A frequency-to-voltage converter, the HP Magacycler produces an output voltage or current directly proportional to input frequency or pulse rate. Full scale outputs range to 10 v with accuracy of ±1/2%. Standard units cover the audio range from 5 cps to 12 kc, with up to 100 kc on request. Internal impedance is low. The converter meets military requirements. Can size is 3-1/8 x 2-5/16 x 2-5/16 in.

Pioneer Magnetics Inc., Dept. ED, 850 Pico Blvd., Santa Monica, Calif.

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NEW PRODUCTS

Capacitance Measuring System 450

Accuracy is ±0.01% plus one dial division on the three intermediate ranges of model 700 capacitance measuring system; ±0.02% plus one dial division on the highest and lowest ranges. Two- or three-terminal capacitors from 0 to 0.12 μf can be measured with a resolution of 0.0001 pf on the lowest range. Five ranges with 120,000 dial divisions of resolution on any range are provided.

Electro Scientific Industries Inc., Dept. ED, 7524 S. W. Macadam Ave., Portland 19, Ore.

Temperature Controls 454

Series 7000 electronic temperature controls are available in ranges from −300 to +2,000 F. Standard range is 0 to 800 F. A special plug-in "anticipator" actuates the relay by anticipating, on a proportional basis, the actual set-point, either high or low. The control circuit is encapsulated in epoxy.

Electronic Processes Corp., Dept. ED, 436 Bryant St., San Francisco, Calif.

Laminar Diodes 440

A multi-layer construction is used in silicon laminar diodes. Type IN3257 has greater than 30 ma forward current at 1 v, reverse recovery time of less than 3 nsec, and rectification efficiency of 45% at 100 mc. Type IN3258 has more than 100 ma forward current at 1 v, reverse recovery in less than 4 nsec, and rectification efficiency of 40% at 100 mc. Both types have saturation voltage greater than 100 v at 25 C. Core driver types are also available in laminar construction.

Pacific Semiconductors, Inc., Dept. ED, 12955 Chadron Ave., Hawthorne, Calif.

P&A: $4.35 and $5.00 ea, 100 to 999; immediate delivery.

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Diode Test Set 478

Forward and reverse dc characteristics of diodes and rectifiers are measured by model 1808 diode test set. The forward current supply is metered and adjustable from 50 μa to 3 amp. The forward voltage is measured in three ranges of 1, 3, and 10 v full scale. Reverse voltage is metered and adjustable from 0.5 to 2,000 v. Reverse currents from less than 1 na to 3 ma are read directly.

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

Servo Motor 442

Size 5 precision servo motor type 5351-01 is 1 in. long, weighs 0.7 oz. and has 0.12 oz-in. torque at stall. Operating temperature range is −55 to +125 C. Motor has 47,000 rads per sec² torque-to-inertia ratio. No-load speed is 9,500 rpm min. Power required is 26 v at 400 cps, 1.7 w at stall.

John Oster Manufacturing Co., Avionic Div., Dept. ED, Racine, Wis.

Miniature Relays 477

Rotary and time-delay relays are available in volume of less than 1/3 cu in. The solid-state time-delay relay TD-181 operates on 21 to 30 v dc; delays range from 100 msec to 10 sec, with accuracy to ±10%. Single-pole, normally open contacts are rated at 150 ma, 30 v. The M200 rotary unit has 2pdt contacts rated at 2 amp resistive, 1 amp inductive, 26.5 v dc or 115 v, 400 cps. Operate time is 0.005 sec max. Weight is 0.6 oz. The two units combine to form a 2pdt timing relay. Environmental tests are met.

Leach Corp., Controls Div., Dept. ED, Azusa, Calif.
Availability: 4 weeks.

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NEW PRODUCTS

1-W Resistor 446

Vitreous-enameled, wirebound 1-w resistors are made in axial-lead configuration. Length is 9/16 in. max, diameter 1/8 in. max. The resistor shows stability under constant full load, low noise, long life and good overload capability. Resistance range is 1 to 6,000 ohms, tolerance ±5%.

Ohmite Manufacturing Co., Dept. ED, 3657 Howard St., Skokie, Ill.

Coaxial Latching Relay 445

Magnetic latch assembly and a balanced rotary armature provide positive latching action in a compact coaxial latching relay. Size is 2-1/8 x 1-1/2 x 0.86 in., weight 5.5 oz. Environmental specifications are met. The pulse-operated relay has a low standing-wave ratio. Armature travel is 0.040 in.

Electro-Actuators Div., Omega Precision, Inc., Dept. ED, 757 N. Coney Ave., Azusa, Calif.

P&A: On request; 6 to 8 weeks.

Voltage-To-Frequency Converter 472

Solid-state voltage-to-frequency converter develops output frequency pro-

◀ CIRCLE 97 ON READER-SERVICE CARD

portional to the input voltage. Used with a standard frequency counter, the device measures dc voltage to 0.1% accuracy. Four-decade voltage ranges cover 0 to 1 kv dc, positive or negative. Sawtooth output wave amplitude is 3 v rms.

Lome Electronics, Inc., Dept. ED, 8526 N. New Braunfels, San Antonio 9, Tex.
Price: $395.

Radiation Instruments 447

Four chassis comprise the Logic 801 system for measuring radioactivity. Preamplifier accepts pulses from Geiger, scintillation, or proportional detectors and provides gain of 1 or 20. High-voltage supply is continuously variable, with positive output from 350 to 5,000 v and negative output from 350 to 1,500 v. The 6-digit scaler has a resolution of 1 μsec. Timer chassis records duration of count or provides preset stop; drift is 1 ppm per week max.

Nuclear-Chicago Corp., Dept. ED, 359 E. Howard Ave., Des Plaines, Ill.

Magnetic Tester 471

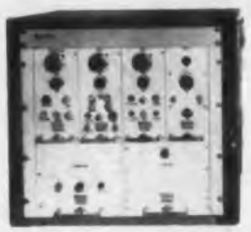
Automatic tracing of flux density vs magnetic force curves is done by the Ferrotracer. Used with an X-Y recorder, the unit makes a permanent record of the core under test in less than 60 sec. Magnetic values can be read directly in kilogauss and oersteds. The solid-state tester has over-all accuracies of ±2%.

Lumen, Inc., Dept. ED, P. O. Box 905, Joliet, Ill.
P&A: $1,575, 60 cps; $2,300, 400 cps; 14 weeks.

CIRCLE 98 ON READER-SERVICE CARD ▶

NEW PRODUCTS

Pulse Generators 428



Modular subsystems are combined as required to form pulse- and time-delay generating equipment. A wide range of repetition rates, delays, and pulse widths are possible through use of rate, delay, width, pulse-forming, and power supply packages. The model B-9 systems use accurate, largely transistorized circuitry.

Rutherford Electronics Co., Dept. ED, 8944 Lindblade St., Culver City, Calif.

Four-Terminal Clips 449

Designed for rapid, low-resistance, high-accuracy measurements using four-terminal techniques, model ESI Kelvin Klips are constructed of beryllium copper with gold plating. The units may be used with any bridge employing Kelvin circuits and the four-terminal method.

Electro Scientific Industries, Inc., Dept. ED, 7524 S. W. Macadam Ave., Portland 19, Ore.

Encapsulated Inductances 464

For printed wiring applications, the J302 series of miniature encapsulated inductances range in value from 10 mh to 22 μh with ±5% tolerance. Maximum dc current rating is 60 ma to 1.21 amp. The units are wound with high-temperature wire and encapsulated in epoxy for −55 to +125 C ambient temperature operation. Lead spacing is 0.2 in.

James Millen Manufacturing Co., Inc., Dept. ED, Malden, Mass.

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Thermosetting Tape 430

Pressure-sensitive, thermosetting resin adhesive in glass cloth tape No. 7020 cures in 1/2 hour at 350 F. Tape operates at Class B temperatures. Other features are high tack, high initial adhesion, and excellent resistance to solvents, abrasion, aging, and chemicals.

Mystik Adhesive Products, Inc., Dept. ED. 2635 N. Kildare Ave., Chicago 39, Ill.

P&A: *$7.94 to $6.35 per roll, 1 in. x 60 yd; stock.*

Data Plotter 452

For analog as well as digital inputs, series 3100 dataplotter provides accuracies up to 0.175% of full scale on 11 x 17 in. plots. Plotting speeds are up to 80 points per min. It is equipped with transistorized control circuitry, provisions for "off-board" origin, and is able to accept punched card, tape or keyboard input.

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

Operational Amplifier 455

Octal-base, plug-in, operational dc amplifier model C/100/B is for analog computer and instrument applications. Specifications are: gain, 30,000 dc open loop; output, 3 ma over ±100 v dc; bandwidth, over 400 kc with 0.6-μsec risetime as unity inverter.

Embree Electronics Corp., Dept. ED, 993 Farmington Ave., West Hartford 7, Conn.

P&A: *$25 in 1 to 5 quantities; 10 days.*

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NEW PRODUCTS

Digital Converter 469

Used with pointer instruments, digital converter provides input data for digital computers or control systems. Photoelectric scanner operates at up to 10 scans per sec. An electronic unit houses circuitry and display. Typical accuracy is 0.1 ±1 count, resolution 1 part per 1,000.

MacLeod Instrument Corp., Dept. ED, 4250 N.W. 10th Ave., Fort Lauderdale, Fla.

DC Amplifier 448

A chopper-stabilized vacuum tube type, type 98 dc amplifier completely isolates the recorder from the signal source. Designed for use with the firm's 1MA or 100-μa recorders, it will increase sensitivity up to 10 times. Input resistance is 1 megohm; accuracy and linearity are 0.1%; drift is less than 0.5%.

Rustrak Instrument Co., Inc., Dept. ED, 130 Silver St., Manchester, N. H. *Price: $109.50.*

Static Converters 441

Rated at 100 w, dc-to-dc static converters type CN are designed to withstand shock and vibration. Input is 6, 12, 18, 24, or 28 v dc with an allowable variation of ±20%. Output voltages are 600, 300, 150 and 100 v dc at 100 w. Ripple is less than 0.5% rms. Units are potted in MIL-T-27A transformer cans; transistors are accessible for service.

PRL Electronics, Inc., Dept. ED, 232 Westcott Drive, Rahway, N. J. *P&A: $70.00 to $81.25; delivery from stock.*

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Rack Blower 470

Two-speed blower for electronic racks is designed to provide greater air turbulence over the entire rack interior. Output of the 19-in. unit is 500 cfm. Various rack depths are available. Washable filter can be serviced without removing the blower.

McLean Engineering Laboratories, Dept. ED, Princeton, N. J.

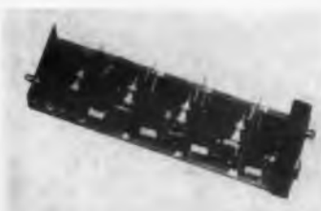
Soldering Instrument 443

Twin heating elements in this tweezer soldering instrument develop 572 F temperature at the 1/32 in. tips. Used with low-temperature solders, the instrument weighs 1 oz, is 8 in. long, and operates on 6 v dc.

Oryx Co., Dept. ED, 13804 Ventura Blvd., Sherman Oaks, Calif.

Price & Availability: *$14.95; immediate.*

Post-IF Amplifiers 444



Military requirements of temperature and service life are met by post-if amplifiers A 106-108. The silicon-transistor units have center frequencies of 30, 45, or 60 mc. Gain is 60 db, bandwidth 9 mc. The amplifiers are capable of −125 C operation, with storage to +150 C.

Orion Electronic Corp., Dept. ED, 108 Columbus Ave., Tuckahoe, N. Y.

P&A: *$550 ea, 1 to 9; 2 to 4 weeks.*

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NEW PRODUCTS

Microminiature Connectors 457

Hermetically sealed connectors type EHMM will mate with all standard corresponding plastic connectors having socket contacts. Bodies and pins are sealed with glass for reliability which meets or exceeds MIL-C-8384. Current rating is 3 amp; voltage breakdown is 1,200 v rms at sea level.

Escon, Inc., Dept. ED, 735 Branch Ave., Providence, R.I.

Metallized Glass 451

A metallized surface for soldering makes this glass suitable for applications in hermetically sealed units where it is desired to view the operation of components. Details of the process for assembly and design of suitable apertures are available.

Electro-Seal Corp., Dept. ED, 946-A North Ave., Des Plaines, Ill.

Bobbin Resistor 429

Mechanical strength is said to be greatly increased in precision resistors through strain-free bobbin construction. Made in sizes 1/4 x 1/4 x 1/8 in. (No. 20 lead wire) and 3/16 x 3/16 x 1/8 in. (No. 22 lead wire), the units operate in temperatures from −65 to +125 C. Environmental specifications are met. Rating is 150 v, 1/8 w.

National Resistance Corp., Dept. ED, Pearl River, N. Y.

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Circuit Module 480

A quadruple unit, for memory or data storage functions in pulse logic systems, this flip-flop circuit module has an operating frequency of 9 to 250 kc. Specifications are: input, 6 to 9 v; rise time for input, 0.1 to 1.0 μsec; rise time for output, 0.2 to 1.0 μsec. Two modes of operation are possible: reset-set and trigger.

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

P&A: $65 for 1 to 100 quantities; two weeks.

Rack Cabinet 458

Designed for maximum flexibility, model FT-192-A standardized electronic rack cabinet has adjustable channels to facilitate mounting slides or chassis. It has a completely adjustable ventilating system for cooling electronic equipment. Height is 77 in., depth and width are 24 in.

Falstrom Co., Dept. ED, 185 Falstrom Court, Passaic, N.J.

Tantalum Capacitors 459

Designed for polar operation, in low-voltage transistorized circuits, the Faratan series is a tantalum solid-electrolyte type. Each unit undergoes a 250-hr life test at rated voltage at 85 C. They are available in two sizes: case A, 0.125 in. diam x 0.250 in. length; case B, 0.175 in. in diameter x 0.438 in. length.

Faradyne Electronics Corp., Dept. ED, 471 Courtlandt St., Belleville, N.J.

NEW PRODUCTS

Force Gage 456

Three force transducers are incorporated in the same plane in the model 2106 force gage to accurately simulate point force loading. Sensitivity of 7 peak mv per peak lb is obtained. The entire top and bottom surfaces are load-bearing members with stiffness of 2 x 10⁷ lb per in.

Endevco Corp., Dept. ED, 161 E. California Blvd., Pasadena, Calif.
Price: $425.

Switch Light 467

Rebuilding and modification of the Twist Lite may be done without special tools. Switches include 2pdt and 4pdt momentary action, 2pdt alternate action, and magnetic holding. Display area may be split horizontally or vertically. Unit accepts 4 bulbs at 28, 12 or 6 v. Designed for military or commercial application, the unit meets military requirements.

Master Specialties Co., Dept. ED, 956 E. 108th St., Los Angeles 59, Calif.

Film Capacitors 460

Designed for rapid insertion in printed-circuit boards, series F207 capacitors have right-angle leads. These double-dipped, Mylar film capacitors are available in capacities of 0.01 through 1.0 μf, with ratings of 200, 400 and 600 v dc.

John E. Fast and Co., Dept. ED, 3598 N. Elston Ave., Chicago 18, Ill.

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Crystal Oven 468

A wide range of crystals is accommodated by the RD-135 mercury thermal switch crystal oven. Useful in low-frequency applications, oven takes crystals up to 1-3/8 in. long. Temperature control is ±0.005 C at fixed room ambient, and ±0.025 C from 0 to 60 C. Weight is 7 oz, size 5-3/16 by 1-3/4 in. OD. Unit meets military shock and vibration tests.

Manson Laboratories, Inc., Dept. ED, Stamford, Conn.

Foot Switch 476

Positive control of reversible operations is provided by the Clipper twin foot switch. Each of the switches has momentary contact for spdt circuits rated at 20 amp, 125-250 v ac, and 1 hp, 115-230 v ac. Only one external power cable is used. Variations include maintained contact or dpdt in momentary or maintained contact, one or both sides.

Linemaster Switch Corp., Dept. ED, 432 Woodstock Terrace, Woodstock, Conn.

Magnetic Drum 474

Contact read/write heads in magnetic storage drums provide large-capacity, nonambiguous storage of digital data. Surface air movement separates the heads from drum surface at operating speed. Write current is low, with 300-mv signal amplitude. A 1-v read signal is obtainable.

Computer Systems Laboratory, Litton Systems Inc., Dept. ED, 5500 Canoga Ave., Woodland Hills, Calif.

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NEW PRODUCTS

Power Rheostat 463

Enclosed, dustproof power rheostat is readily adaptable to any linkage for either manual or automatic operation. Design allows operation at full power rating with as little as 25% of the winding in use. The unit is available with standard or tapered windings in ratings of 100, 200 and 300 w. Center tap is optional.

Milwaukee Resistor Co., Dept. ED, 700 W. Virginia St., Milwaukee 4, Wis.

Thermistor Probe 461

Made of stainless steel, this 27-gage hypodermic needle will accommodate a variety of thermistors and is useful as a fast time-constant temperature probe. It has a diameter of 0.022 in.

Fenwal Electronics, Inc., Dept. ED, 51 Mellen St., Framingham, Mass.

Ratiometer 479

A five-digit dc/dc digital ratiometer, type 3500 CR has a ratio range of 0.00000 to 0.99999. Average balance time is 2 sec. An 80-db input filter allows the instrument to operate in the presence of a 10,000 to 1 noise-to-signal ratio. The unit consists of a power module and a switch module.

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

Epoxy Resins 437

Class H, single-component epoxy resins sustain continuous temperatures of 180 C. Made for impreg-

nating, potting and casting, the resins have long pot life and low viscosity during cure. Type ER 4251 is clear and unfilled, ER 4287 is opaque and filled. Flexibility allows thermal cycling.

Permacel, Dept. ED. New Brunswick, N. J.

Servo Amplifier 465

In a volume of 1 cu in., the model 1035 servo amplifier can drive a 40-v, 2-phase servo motor up to 3-1/2 w input. The amplifier weighs 1 oz, uses silicon transistors, and operates at 400 cps. Temperature range is −55 to +125 C.

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

P&A: $190 to $200, sample quantities; 30 days.

Tachometer Pickup 466

Explosionproof magnetic tachometer pickup model 2040 produces high-amplitude, low-modulation sine wave signals proportional to speed. Standard frequencies are 60 or 120 impulses per revolution, adaptable to a range of 1 to 240 impulses per revolution. Speed range is 75 to 10,000 rpm; output is more than 1 v rms at 100 rpm. Weight is 2-1/2 lb.

Electronic Div., Meriam Instrument Co., Dept. ED, 10920 Madison Ave., Cleveland 2, Ohio.

Regenerative Divider 462

A 100-kc output signal is provided from 1-mc input by the RD-126 regenerative divider. Output signal stability of the transistor unit is equal to that of the input. Amplitude of output is 1 v rms, impedance 50 ohms. Power required is 24 v dc ±5% at 30 ma. The 6-oz chassis measures 5-3/8 in. high, 4-1/4 in. wide, and 2-3/4 in. deep.

Manson Laboratories, Inc., Dept. ED, Stamford, Conn.

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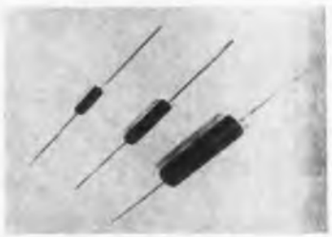
NEW PRODUCTS

Tantalum AC Capacitors 507



Continuous duty, solid-slug tantalum ac capacitors are made for military and industrial applications. Ambient temperature range is −80 to +125 C. Case sizes range from 0.155 in. diameter and 0.600 in. length to 0.350 in. diameter and 1.600 in. length. Capacitance range is 1.2 μf to 170 μf. The hermetically sealed units operate at up to 35 v peak, 60 cps.

General Instrument Corp., Micamold Div., Dept. ED, 65 Gouverneur St., Newark, N.J.
Price: $1.70 to $5.00.

Solenoid Valve 505

Service to 200 psi is provided by solenoid valve for use in fluid control. Available in standard ac and dc voltages, the valve operates in any position with a maximum rate of 1,000 cycles per min at 100 psi. Temperature range is −65 to +350 F. The 5-oz valve measures 2-5/8 in. long with a diameter of 1-3/8 in. Inlet connection is 1/2 in., outlet 1/8 in.

General Magnetics, Inc., Dept. ED, 2641 S. Louisiana Ave., Minneapolis 26, Minn.

Hydrogen Thyratron 509

Peak power of 48 megawatts is provided by the GL-7890 hydrogen thyratron. The tube operates at an anode dissipation factor over 55 x 10^9 with forced air or other coolants. Peak forward anode voltage is 40 kv, peak current 2,400 amp. Average current capability is 4.0 amp, average power over 70 kw. Hold-off capability is over 35 kv dc.

General Electric Co., Power Tube Dept., Dept. ED, Schenectady 5, N.Y.
Availability: immediate.

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Induction Motor 504

Totally enclosed induction motor B-5-1, designed for blower applications, provides 1/100 hp at 5,200 rpm. The 7.55-oz motor is powered by 208 v, 400 cps, 3 phases. Full-load torque is 1.87 oz-in. Starting torque is 214%, pull-out torque 222%.

General Precision, Inc., Kearfott Div., Dept. ED, Little Falls, N.J.

Power Supplies 503

Voltage-regulated power supplies SM 75-5M and SM 75-2M provide 0 to 75 v dc at 5 and 2 amp respectively. Ripple is less than 1 mv rms, regulation and stability 0.1%. Input power is 105 to 125 v, 60 ±1/2 cps. Unmetered models and units with 0.01% regulation are also available.

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

P&A: SM 75-5M, $670; SM 75-2M, $505; 30 to 60 days.

Tape Recorder/Reproducer 623

Wideband, magnetic tape recorder/reproducer VR-2600 has frequency response to 500 kc on direct record, 40 kc on fm, and 1,000 bits per in. parallel recording with pcm techniques. Six selectable speeds are in two ranges from 1-7/8 to 120 ips. The unit has all solid-state modular construction.

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

NEW PRODUCTS

Core Memories 473

Destructive and nondestructive magnetic core memories are available for airborne applications. Random access, linear select techniques, coupled with advanced circuitry, provide 2-μsec read-write cycles. Current variation of ±10% and temperature change of ±30 C without external compensation is allowable. The memories meet military specifications.

Litton Systems Inc., Dept. ED, Woodland Hills, Calif.

Storage Tube 515

Target assembly design in the E710 bistable, direct-view storage tube reduces risk of damage from high-beam current. The tube will store information indefinitely and allow continuous or intermittent display. Two or more signals can be stored and simultaneously displayed or instantly erased.

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

Level Switch 475

Ultrasonic liquid level switch uses a dual-crystal design. The light, rugged unit has low power requirements and accuracy within ±1/64 in. It may be used with any type of liquid for level warning and control, flow monitoring, and other operations. Probe and control unit may be separate or combined. Response time is 0 to 10 sec; probe temperature range is −195 to +250 C.

The Liquidometer Corp., Dept. ED, Long Island, N.Y.

◀ CIRCLE 119 ON READER-SERVICE CARD

Instruction Memories 511

Magnetic core instruction memories are made in several standard sizes. Units operate at 1 mc, with access time of 0.4 μsec, using nondestructive readout. The BIAX systems are available in 2 standard sizes, 128 and 512 words, with 24 bits per word. Other sizes up to 1,024 words and 36 bits per word can be built. Standard input is punched paper tape. Semiconductors are used throughout; ambient operating temperature is 0 to 50 C.

Computer Products Operations, Aeronutronic Div., Ford Motor Co., Dept. ED, Ford Road, Newport Beach, Calif.

Resistance Bridges 522

Accuracy of synchros or resolvers is measured by the proportional voltage method with these resistance bridges. Stable, dependable units have accuracy of ±2 arc-sec. Synchro bridge KT 427775-2A and resolver bridge KT 427771-2A can each be indexed to any multiple of 5 deg throughout a range of 0 to 360 deg by light, fingertip control. Standard frequency is 400 cps.

Kearfott Div., General Precision, Inc., Dept. ED, Little Falls, N.J.

Soldering Iron 510

Midget soldering iron offers improved performance, a new handle design and redesigned tip and heater assembly. Irons are available in 1/8 to 1/4 in. tip sizes with 6-v supply, 18 to 35 w.

General Electric Co., Dept. ED, Schenectady 5, N.Y.
Availability: May 1.

CIRCLE 120 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Capacitor Test Set 635

Fully automatic capacitor test set type 61 is for low voltage measurement of tantalum capacitors. Capacitance range at 120 cps is 1 to 11,000 μf in four ranges. Test voltage is 0.7 v rms; accuracy is ±1% over entire range.

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

Flat Cable Connector 481

Flat conductor cable can be connected to printed-circuit boards or to flexible etched circuitry by means of POS-E-CON connector. A continuous one-piece spring locks the cable into the connector and produces direct contact without solder. It provides a pressure point at each conductor contact.

The Thomas & Betts Co., Dept. ED, Elizabeth, N.J.

Converter 485

A four-decimal digit, solid-state, voltage-to-digital converter, the Transicon Datrac has both automatic and programed ranging. It is fully transistorized and meets MIL specifications. Specifications are: signal input, 0 to 0.9999, 0 to ±99.99, 0 to 9.999; conversion speed, 10 μsec per bit; accuracy, ±0.015% of full scale ±1 significant digit.

Epsco, Inc., Dept. ED, 275 Massachusetts Ave., Cambridge, Mass.

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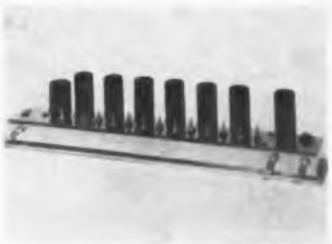
Wide-Band Oscilloscope 483

Bandwidth of dc to 70 mc is provided by the LA-270 oscilloscope. Designed to military specifications, unit has 6-cm vertical deflection. Display size is 6 x 10 cm. Single and dual channel plug-in vertical pre-amplifiers aand plug-in sweep delays are used. Horizontal sweep circuitry has 24 calibrated ranges with 10X magnifier extending the fastest sweep to 0.01 μsec per cm.

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

IF Amplifier 484



Wide-band if amplifier model IF301 has a detector and a cathode follower for video output. Typical noise figure at 30 mc is 1.5 db, input vswr less than 2:1. Standard 30 or 60 mc models have 90-db gain, 10-mc bandwidth, and 50-ohm input.

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

Limit Switch 498

Snap action limit switch is designed to bridge the gap between the very small and larger, enclosed limit switches. Ratings are as follows: ac, 40-amp make, 15-amp break; dc, 2-amp make and break on single throw forms with 0.040-in. gap.

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

NEW PRODUCTS

Torque Transducer 636

Variable inductance transducers, series C-B4, measure angular twist proportional to torque. Electrical measurement of a torsional strain and a mechanical assembly for producing the strain are provided. Speeds are to 20,000 rpm and torque ranges from 0 to 50 in.-lb through 0 to 12,000 in.-lb full scale.

B & F Instruments, Inc., Dept. ED, 3644 N. Lawrence St., Philadelphia, Pa.

Terminal Boards 497

Miniature terminal boards on 0.100 grid patterns, in any shape, are available with glass-filled epoxy, melamine or silicone insulation. The terminals are brass, phosphor bronze or beryllium copper and are silver or silver and gold plated. Terminals measure 0.062-in. OD x 0.026-in. ID; height above board is 0.156 in. and they are bifurcated with slots 0.025-in. wide x 0.068-in. deep.

Accurate Electronics Corp., Dept. ED, 169 S. Abbe Road, Elyria, Ohio.

Power Supplies 494

Solid-state, convection-cooled, 12-v power supplies, models ZA-723, -724, -725 and -727 have less than 0.001-v rms ripple. Ratings are from 12-v, 100 ma to 12-v, 3-amp. All units have an operating range of −20 to +65 C.

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

Tube Socket Preservers 489

Designed to prevent permanently wired sockets from wearing out under constant use, the Thinline socket preservers plug directly into existing sockets. The low silhouette makes them especially suited for portable equipment where space is at a premium.

Forway Industries, Inc., Dept. ED, 122 Green Ave., Woodbury, N.J.

P&A: $2.20 to $2.80 in 1 to 9 quantities; from stock.

Motor Control 487

Fractional horsepower motor control relays type CR120E are rated at 600 v. They are available with coils from 6 to 550 v, 60 or 50 cps. They may be used for power devices such as horns, buzzers and lights, solenoids and valves.

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

Amplifier Modules 490

Three-transistor, RC-coupled, printed-circuit modules type APC weigh only 0.148 oz. They measure 0.858 x 0.413 x 0.728, including case. Output is 9 mw into a 300-ohm inductive load at over-all distortion of 10% max. Gains are up to 93 db with a frequency response flat within 3 db from 100 cps to 10 kc at signal to noise ratios of −48 db.

Fidelity Electronics, Ltd., Dept. ED, 4120 W. Lawrence Ave., Chicago 30, Ill.

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NEW PRODUCTS

Synchro Transmitter 493

This positive-indexing synchro transmitter has 48 positive detents at 72 deg intervals on the input shaft. The transmitter is electrically zeroed on the 5th detent. The package is 1-17/64 in. sq x 2-1/2 in. long; it weighs 3-1/2 oz.

Clifton Precision Products Co., Dept. ED, 5050 State Road, Drexel Hill, Pa.

Test Set 492

Five-megawatt positive grid region test set is for design, development and production quality control testing of high-power triodes and tetrodes. Peak grid pulse is 10 kv, 500 amp at 2 μsec; prf is adjustable from "one shot" to 60 pps. All supplies are controllable from the front panel.

FXR, Inc., Dept. ED, 25-26 50th St., Woodside 77, N.Y.

Pressure Transducer 491

Absolute, gage or differential pressures of corrosive or noncorrosive gases or liquids in the 0 to 5 and 0 to 500 psi full-scale range can be measured by pressure transducer TP-200. Standard performance data includes the ability to withstand shock of 75 g; a static error band, including independent linearity, hysteresis, repeatability, resolution and friction, of ±2.5% in the 0 to 5 to 0 to 10 psi range and ±1.5% in the 0 to 15 to 0 to 100 psi range.

Fairchild Controls Corp., Dept. ED, 225 Park Ave., Hicksville, N.Y.

Power Supply 501

Packaged indicator power supply model 913 provides 4 kv dc at 500 μa with an input of 115 v, 400 cps. Measuring 5-3/8 x 2-1/2 x 2-1/4 in., supply has an operating temperature range of −55 to +100 C. Other units at 60 or 400 cps inputs are available with outputs from 1 kv to 20 kv, 50 μa to 1 ma.

Burmac Electronics Co. Inc., Dept. ED, 142 S. Long Beach Road, Rockville Centre, L.I., N.Y.

Shaft Coupling 488

Designed for light duty electromechanical applications, these zero backlash flexible couplings employ torsion spring elements to cushion starting and braking loads. Shaft to shaft misalignment may be up to 5 deg angular and 1/32-in. parallel offset.

Fourdee, Inc., Dept. ED, P.O. Box 6006, Orlando, Fla.

Price: $1.90 ea.

Delay Lines 482

Encased in a 13/32-in. diam tube, these distributed constant delay lines have an impedance of 500 ohms. Delay times are 0.05 to 1.0 μsec, with rise times from 50 to 120 nsec. Operating temperature is from −55 to +125 C.

Richard D. Brew and Co., Dept. ED, 90 Airport Road, Concord, N.H.

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NEW PRODUCTS

Deviation Calibrator 496

Fm-monitor deviation calibrator, "Monocal 500", provides better than 0.5% deviation accuracy. It combines the functions of five instruments previously needed to determine the peak deviation of an fm signal by the carrier drop-out method. It can be used directly with any fm monitor tuning to 12 mc. Deviation ranges are: 10-, 30-, 100-, and 300-kc peak.

Advanced Measurement Instruments, Inc., Dept. ED, 109 Dover St., Somerville 44, Mass.

Crystal Oven 495

Thermostatically controlled oven, model 1206, has internal temperature stability of ±0.5 C at 70 C over an ambient range from 0 to 50 C. It is for housing crystals, filters and other circuitry requiring temperature stabilization. Specifications are: power supply, 24 v dc; external dimensions, 2-in. sq x 3-1/2 in.; weight, 7 oz.

Airtronics, Inc., Dept. ED, 5522 Dorsey Lane, Washington 16, D.C.

High-Beta Thermistors 508

Beta of 3,000 K is a feature of a new series of thermistors. Units are made in rod form at 200 to 1,000 ohms, 25 C, with 0.050, 0.112, and 0.173 in. in diameter, and in disk form at 1 and 2.5 ohms at 25 C, with 3/4 and 1 in. in diameter. Beta tolerance is ±5%. Maximum standard thermistor temperature rating is 150 C, with higher ratings available on request.

General Electric Co., Specialty Resistor Project, Dept. ED, 7842 S. Neff Ave., Edmore, Mich.

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Analog-To-Digital Converter 500

With a conversion rate of 0.5 μsec, analog-to-digital converter model 101 has accuracy of ±0.5%, ±1/2 least significant digit. Input amplitude is 10 v at impedance of 250 ohms. Visual display is 2 binary-coded decimals. Size is 6-1/2 x 3-1/2 x 6-1/4 in.

General Data Corp., Dept. ED, 11602 Ninth St., Garden Grove, Calif.

Price & Availability: *$750; 4 to 6 weeks.*

Image Intensifier 514

High-gain image intensifier tube provides a photon gain of 100,000 to 200,000. It has an input photocathode, five secondary emitting dynodes, and an output fluorescent screen. Dynode usable diameter is 1 in.

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

Plug-Socket Set 499

Subminiature plug and socket combinations for low-current circuits are molded of low-loss, mica-filled phenolic. They may be swaged into metal chassis, cemented to bakelite chassis, mounted with retaining ring, or potted. Units are available with glass-filled diallyl phthalate insulators. Made with 3 to 7 contacts, sets have EIA standard electrical ratings.

Cinch Manufacturing Co., Dept. ED, 1026 S. Homan Ave., Chicago 24, Ill.

Angle Position Indicator 502

Angular displacement of any remote rotational device to which a synchro or resolver transmitter can be coupled is measured and indicated by the KT 427566 angle position indicator. Accuracy is ±6 min, resolution 1.0 min, and repeatability is 2 min. Indicator operates from 115 v, 400 cps power.

Kearfott Div., General Precision, Inc., Dept. ED, Little Falls, N.J.

High-Voltage Rectifier 506

Ratings up to 636,000 piv are available in a variety of rectifier stacks. A typical assembly is capable of delivering 600 kv at 20 ma dc. Air-cooled units are combined as required.

Selenium Div., Radio Receptor Co., Inc., Dept. ED, 240 Wythe Ave., Brooklyn 11, N.Y.

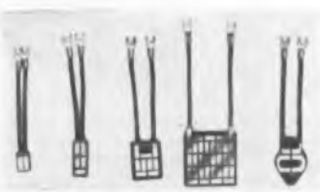
NEW PRODUCTS

Balun Transformers 519

Broad-band balun transformers match 50 to 75-ohm coaxial lines to 600-ohm balanced transmission lines over the hf range. Devices operate from 2 to 30 mc and display essentially flat input impedance vs frequency curves. Model 517 is designed to pass 10 kw cw, and may be pole-mounted. Model 532, a receiving type, passes 500 w.

Granger Associates, Dept. ED, 974 Commercial St., Palo Alto, Calif.

Cooling Modules 518



Thermoelectric solid-state cooling modules are made for military and industrial use. The F1, F4, F8 and F32 Frigistors, designated by a number corresponding to the number of thermocouples in the module, are available in quantity. Heat pumping capacity is about 1 w per couple. The devices, made from Neelium, are capable of producing a no-load temperature difference as high as 80 C. The series operates with currents of 10 to 15 amp. Couples are connected in series, each requires 0.1 to 0.3 v.

General Thermoelectric Corp., Dept. ED, Princeton, N.J.

Silicon Diode Assemblies 486

High-voltage, silicon diode assemblies designed for use as clippers, holding diodes, or power supplies are available with inverse voltage ratings of 1 to 50 kv. Current ratings range from 1 to 750 ma. Units are epoxy cast and hermetically sealed, and measure 3 x 1 x 1-5/8 in. approximately.

Burmac Electronics Co., Inc., Dept. ED, 142 S. Long Beach Road, Rockville Centre, L.I., N.Y.

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Push-Pull Switch 520

Normally open, spdt push-on, pull-off switch No. 30-16 has a positive detent action. Life expectancy is over 100,000 cycles. Contact rating is 1 amp, 115 v resistive, contact resistance 0.010 ohm. Base and button are molded phenolic.

Grayhill, Inc., Dept. ED, 561 Hillgrove Ave., LaGrange, Ill.

Price: $1.15.

Bridging Amplifier 516

For trunkline installation behind repeater amplifiers, bridging amplifier model BA-4C has 4 isolated distribution line outputs, each providing 3-db gain at channel 2. Bandwidth is 54 to 88 mc, impedance 75 ohms, vswr 1.2:1. Power is 115 v, 60 cps, 25 w.

Entron, Inc., Dept. ED, Box 287, Bladensburg, Md.

Insulating Rod 512

A Class H insulating rod stock, Vitac combines fiber-glass reinforcement with a high-temperature resin system. Properties are said to equal or exceed those of silicone-glass rod, at 25% less cost.

The Glastic Corp., Dept. ED, 4321 Glenridge Road, Cleveland 21, Ohio.

Servo Motor 521

Size 5 servo motor J126-06 is 1/2 in. in diameter by 0.968 in. long and weighs 0.68 oz. Phase 1 voltage is 26 v, phase 2, 36 v, at 400 cps. No-load speed is 9,500 rpm, stall torque 0.12 oz-in. Operating temperature range is −54 to +125 C.

General Precision, Inc., Kearfott Div., Dept. ED, Little Falls, N.J.

Nuvistor Sockets 517

Phenolic sockets for nuvistor tubes are supplied with solder washer for solder fastening or tabs for mechanical mounting. Fastened sockets will resist a pressure of 20 lb. Contacts are copper alloy with cadmium plating.

Cinch Manufacturing Co., Dept. ED, 1026 S. Homan Ave., Chicago 24, Ill.

Teflon-Lined Tubing 438

Neoprene rubber tubing with Teflon liner combines the best features of both materials. Size ranges from 1/8 to 1 in. inside diameter, with 1/8-in. coating of Neoprene or other elastomer. Tubing withstands service temperature of 200 F.

Pennsylvania Fluorocarbon Co., Inc., Dept. ED, 1115 N. 38th St., Philadelphia 4, Pa.

NEW PRODUCTS

Photoconductive Cells 596

Similar to the human eye in its sensitivity variation with the color temperature of light sources, this cell measures light accurately, whether the light is tungsten or daylight or whether the color temperature is 2,700 or 6,500 K. A footcandle meter incorporating the cell needs no correction filter.

Clairex Corp., Dept. ED, 22 E. 17th St., New York 3, N.Y.

Thermistor 620

This positive-temperature-coefficient unit can be used for temperature compensation, sensing and control in many applications including motors, transistorized circuitry and crystal ovens. Diameters range from 0.82 to 0.2 in., thicknesses from 0.12 to 0.06 in. and resistances at 37.8 C from 150 to 1,200 ohms.

The Carborundum Co., Refractories Div., Dept. ED, Perth Amboy, N.J.

Cable Breakout Boxes 602

Designed for operating circuit tests, these devices connect in series between existing cables and operating equipment, making test points available at each wire for voltage and waveform checks. Hi-pot, continuity, dielectric or resistance tests can be made.

Angler Industries, Dept. ED, Metuchen, N.J.

P&A: $16.50 to $110; 2 weeks.

Silicon-Glass Diodes 679

Forward current is 200 ma. For general-purpose use, types 1N456A through 1N464A also have surge capability. They are compact and can be used in severe environments.

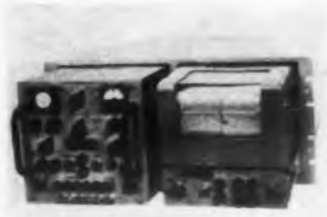
Princeton Electronics Corp., Dept. ED, P. O. Box 127, Princeton, N.J.

Rotary Switches 600

Modular-constructed types C-25 and C-40 are for power switching and motor control. Type C-25 is for 25 hp at 600 v, three-phase; type C-40 is for 40 hp. Each stage has two isolated double-break, silver alloy contacts, up to 24 contacts can be provided.

American Solenoid Co., Dept. ED, Union, N.J.
P&A: 5 to 10 days.

Frequency-Deviation Meter 597



One part in 10^{10} is measured by BTK-36A meter. It consists of two units, having a recorder to pilot the difference in frequency between the primary and secondary standards. Except for a crt, it is completely transistorized.

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

Scale Corrector 603

In-line data linearizers operate on binary or bcd data and translate the data into engineering units. Applications are with multiplexers, digitizers, timers and programmers creating advanced data-acquisition and handling systems.

Applied Development Corp., Dept. ED, 12838 Weber Way, Hawthorne, Calif.
P&A: From $1,200, 6 weeks.

Frequency Meters 680

Ranges are 3.95 to 40 kmc in these full-waveguide-band units 532 through 538, with each unit covering one waveguide bandwidth. Accuracies are to 0.08%. A 100-in. helical scale is provided.

PRD Electronics, Inc., Dept. ED, 202 Tillary St., Brooklyn 1, N.Y.

NEW PRODUCTS

Absorptivity Recorder 601

An auxiliary unit, model 2015 is for use with Cary spectrophotometers to record extinction coefficient on a logarithmic scale. It provides spectra with shape unaffected by sample concentration or path-length. Uses are sample identification and qualitative multi-component analysis.

Applied Physics Corp., Dept. ED, 2724 S. Peck Road, Monrovia, Calif.

Meter-Relays 575

Having a taut band movement, these relays can be used with accuracy in the range of 50 μa. They are particularly suitable for control applications with full-scale sensitivities of 0 to 5 μa or 0 to 2 mv.

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

Stepper Motors 599

With increments of 15 and 7.5 deg and rates of 200 to 550 steps per sec, these motors work in conjunction with a logic circuit which controls rate, sequence and direction. They may be driven by electromechanical or electronic logic.

American Electronics, Inc., Instrument Div., Dept. ED, 9503 W. Jefferson Blvd., Culver City, Calif.

Jack-to-Plug Adapter 681

Nickel-plated, completely shielded, with straight-through connections, no. 370 is for connecting cord ends with a phono plug. It has an output 9/64 in. in diameter and 9/16 in. long for the phono-jack input.

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

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Selective Decommutator 598

For PAM or PDM standard IRIG and nonstandard inputs, type 3201 operates with pulse repetition frequencies of 75 to 2,700 pps. It has automatic drift and gain correction. Fingertip selection of 10 from up to 99 channels is possible.

American Bosch Arma Corp., Dept. ED, 5000 Parkside Ave., Philadelphia 31, Pa.

Spectrograph Equipment 576

A complete line of mod ular units, including model 29000 direct-reading spectrometer is offered. Chemical analysis can be made on nearly every material; up to 48 elements can be analyzed simultaneously. It is suited to industrial quality control.

Applied Research Laboratories, Inc., Dept. ED, P. O. Box 1710, Glendale 5, Calif.

Repetitive Scan Accessory 577

For use with spectrophotometers made by Cary, this unit permits the spectrophotometer to operate unattended over a preselected wavelength span. It is suited for kinetic or other time-base studies or for scanning a series of similar samples.

Applied Physics Corp., Dept. ED, 2724 S. Peck Road, Monrovia, Calif.

Servomotor-Generator 608

Weighing 1.1 oz, this size 5 unit is contained in a single housing. Excitation voltage is 26 v at 400 cps. Torque at stall is 0.1 oz-in., acceleration at stall is 37,000 radians per sec^2 and no-load speed is 10,000 rpm. Generator output is 0.2 v per 1,000 rpm.

Beckman Instruments, Inc., Helipot Div., Dept. ED, 2500 Fullerton Road, Fullerton, Calif.

Silicon Monocrystals 682

Supplied to customer specs, types P and N have boron and phosphorous doping, respectively. Resistivity is 0.05 to 100 ohm-cm. Standard diameter is 3/4 in. Length is up to 6 in.

Solid State Materials Corp., Dept. ED, 5 Erie Drive, East Natick, Mass.

P&A: $1 up per g; 5 to 10 days.

NEW PRODUCTS

Generator 604

Triple-function type LRG 051 produces these synchronously initiated output waveforms: positive 100-v sawtooth, positive 10-v pulse and positive 10-v pulse delayable within the duration of the sawtooth. Operation can be triggered or gated from an external waveform.

Argonaut Associates Inc., Dept. ED, P. O. Box 273, Beaverton, Ore.

P&A: $200; 4 weeks.

Magnetic Amplifier 579

For controlling heater power, model FAP-T-601 amplifier meets MIL-E-5272A. Temperature accuracy is ±0.05 F using a 760-ohm sensor with a temperature coefficient of 0.0025 ohms per deg. Efficiency is 75 per cent at full output. Input is 115 ±6 v, 60 ±3 cps.

American Research and Manufacturing Corp., Dept. ED, 920 Halpine Ave., Rockville, Md.

Adapter for Scope Camera 607

For the firm's Oscillotron, this adapter permits the camera to accept holders for standard 4 x 5 films. It also permits ground-glass focusing and can be interchanged with the Polaroid back.

Beattie-Coleman, Inc., Dept. ED, 1006 N. Olive St., Anaheim, Calif.

Frequency Meter 683

Range is 2.4 to 3.7 in the 583-D calibrated precision unit. Accuracy is ±0.3% at room temperature and ±0.8% from −40 to 50 C. Connectors are type N jack. Insertion length is 3-23/32 in.

PRD Electronics, Inc., Dept. ED, 202 Tillary St., Brooklyn 1, N.Y.

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Strain Gage 606

Having a built-in computer to solve strain-to-stress equations automatically, the SR-4 gage provides electrical responses proportional to stress or strain by using two independent, axial strain-sensing elements oriented 90 deg apart.

Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div., Dept. ED, 42 Fourth Ave., Waltham 54, Mass.

Miniature Fittings 580

For use at 10 to 25 kv at low currents, these fittings are for power supplies, infrared detectors, test equipment and instrumentation. Temperature range is −65 to +150 F, they can be exposed to 100% relative humidity and contour tolerance is ±0.002 in.

American Research and Manufacturing Corp., Dept. ED, 920 Halpine Ave., Rockville, Md.

Motor Generator 581

Brushless, synchronous and with ratings of 3 to 150 kw, series 32 has a voltage regulation of 1%. Closer regulation is possible. Frequency is held to 400 cps. Standard harmonic content is 2 per cent. Little maintenance is needed.

American Electronics, Inc., Dept. ED, 1598 E. Ross Ave., Fullerton, Calif.

Precision Potentiometers 618

With 10-turn design and a diameter of 7/8 in., series 59M14-10 units have resistance values of 1,000 to 100,000 ohms in linear functions. Standard resistance tolerance is ±3 per cent; independent linearity is ±0.25 per cent. Power rating is 4.5 w at 40 C.

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

Transistor Tester 684

For testing 3,600 units per hour, the Vast I is a 20-parameter, go/no-go test unit. Information is recorded on a 2,000-bit program card and is assimilated by card-reader circuits and transposed into circuit adjustments. Two operators are usually needed.

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

NEW PRODUCTS

Indicator Tubes 611

New design of Nixie tubes provides flattened tube face and cutaway anode to permit higher positioning of the cathode numerals. Viewing angle is increased from 90 to 160 deg. Life is 200,000 hr. Type B5092 replaces B5031; type B6091 replaces B6033. A completely new large tube is also offered.

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

Recorder-Reproducer 582

A two-speed, magnetic-tape unit, model R168-C is for mobile use. It accepts 1/4-in. tape on reels to 10-1/2 in. Speeds are 7-1/2 and 15 ips. Signal-to-noise ratio is 40 db or better. Bias frequency is 125 kc. A number of configurations can be furnished.

American Concertone, Inc., Dept. ED, 9449 W. Jefferson Blvd., Culver City, Calif.

Epoxy Pencil 614

A no-mix, single unit, this epoxy pencil can be used in bonding, cementing, sealing and insulating. The epoxy requires no special storage and provides a permanent, waterproof bond that cures in 7 min at 400 F. The pencil comes in an aluminum, collet-type holder.

Cetron Electronic Corp., Plastics Div., Dept. ED, 2265 E. Foothill Blvd., Pasadena, Calif.

Power Transistors 638

Provide fast switching. The 2N1907 high-frequency/high-current germanium power transistors can switch 5 amp at a typical time of 2.5 μsec. Guaranteed min h_{fe} is 50 at 5 amp and 10 at 15 amp, making possible reduced input drive current.

Texas Instruments, Incorporated, Dept. ED, Dallas 22, Tex.

Mobile Antenna 578

This 30-ft, scanner antenna is designed for easy transport and is erected by a winch or a hydraulic lifting device. It is operable under normal wind conditions without guys and comes with a mesh or a solid surface. Designation is model 111.

Antenna Systems, Inc., Dept. ED, Hingham, Mass.

Planar Acceleration Switch 583

From 0.25 to 100 g is the range of sensitivity for this device. Accuracy is ±5 per cent. The switch closes a circuit upon the application of a predetermined vector acceleration. Units are produced with almost any vector diagram.

Aerodyne Controls Corp., 90 Gazza Blvd., Farmingdale, N. Y.

Pressure Transducers 613

Having ranges of 20 to 10,000 psig, these units can be over-pressured by a factor of 10 without needing calibration. Nominal output resistance is 350 ohms; power needed is 28 v max. Bonded silicon, strain-gage construction is used. Units are called 750.

Century Electronics & Instruments, Inc., Dept. ED, 1333 N. Utica Ave., Tulsa 10, Okla.

Phase Meters 584

With ranges of 500 kc to 1 cps, the 405 series phase meters provide direct indication of phase angle. Symmetrical waveforms of any shape can be accepted. Drift is less than 0.001 deg for 10 hr of operation. Relative accuracy is ±0.25 per cent; absolute accuracy is ±2 per cent at most frequencies.

AD-YU Electronics Lab., Inc., Dept. ED, 249 Terhune Ave., Passaic, N. J.

P&A: $548 to $595; 1 to 2 weeks.

Ganged Capacitors 686

For precision tracking, these units come in close tolerances. Made to customer specifications, they permit tracking in both directions of rotation. The entire assembly is shielded. Terminations may be solder or screw type or coaxial.

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

NEW PRODUCTS

Wirewound Resistor 612

Preset and variable, type INS-110 has a mounting plate to insulate the control. It is for hot-chassis or other potentiometer uses and can be furnished with a molded shaft. Diameter is 3/4 in. Rating is 1-1/4 w at 40 C, derated to no load at 105 C.

CTS Corp., Dept. ED, Elkhart, Ind.

Pressure Switch 587

With settings of 5 to 5,000 psi, absolute or gage, this switch has a temperature range of 65 to 250 F. It has metal-welded construction and needs no synthetic seals. It can be used in severe environments. Designation is P/N series 58520.

Century Geophysical Corp., Dept. ED, 515 S. Main, Tulsa, Okla.

Revolution Counter 605

Offered in 11 standard ranges, series 312 shaft-driven counter has a repeat-count accuracy of 0.25 per cent of the dial range. The shaft requires an operating drive torque of 1-1/4 oz-in. Applications include process, batch system and automatic flow control.

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

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

Isolation Transformers 595

Electrostatically shielded. Designed to closely approach battery performance in freeing laboratory instruments from stray pick-up, these isolation transformers are available in three ranges: 50 va; 150 va; and 500 va. Units are hermetically sealed and meet the requirements of MIL-T-27A.

Newport Scientific Co., Dept. ED, 638 W. 17th St., Costa Mesa, Calif.

P&A: $33 for the 50 va model; from stock.

Monitor-Receiver 617

Fm-crystal controlled, this unit comes in model RA-52 for low band with a sensitivity of less than 0.5 μv for 20-db quieting and high-band model RA-150 with less than 0.75-μv sensitivity for 20-db quieting. Both have a selectivity of ±30 kc greater than −40 db.

Checker Electronics Corp., Dept. ED, P. O. Box 251, Grayslake, Ill.

Environmental Chamber 588

Capacity is 0.5 cu ft; standard low temperature range is −10 to −60 F. A high temperature range to +500 F can be furnished. Called PENGUIN/5, the unit is suited for transistor testing, miniature bearing manufacture and other uses where space is at a premium.

Cincinnati Sub Zero Products, Dept. ED, 3932 Reading Road, Cincinnati 29, Ohio.

Hermetic Feed-Through Seals 593

Able to operate at 900 C, these seals are for electronic components in high-altitude, military aircraft equipment. Shock limit is 10,000 g. Composed of a threaded ceramic, a flange and a solid feed-through, the units are 1 in. long and 1/2 in. in diameter or 1-3/16 in. long and 3/4 in. in diameter.

Ceramics International Corp., Dept. ED, 39 Siding Place, Mahwah, N. J.

P&A: $2 in lots of 2,000; 8 to 14 days.

Computer Diodes 687

Diffused silicon mesa types 1N914 and 1N916 operate at 75-ma rectified forward current. Maximum recovery time is 4 nsec; capacitance is low. Internal construction meets military specifications.

Princeton Electronics Corp., Dept. ED, Princeton, N.J.

NEW PRODUCTS

Angle-Beam Transducers 609

Offered in a variety of types, these transducers are for use with ultrasonic flaw-detection equipment. Type ZSL, for example, can be used to produce angles of 45 to 90 deg, as specified. Its operating frequencies are 1, 2.5 and 5 mc.

Branson Instruments, Inc., Dept. ED, 40 Brown House Road, Stamford, Conn.

Punched-Tape Reader 615

Having a readout speed of almost 8,000 bits per min, this reader provides 132 parallel, form A contacts rated at 28 v and 150 ma. Forward or reverse operation is possible. Reliability is 99.99997 per cent. It uses 70-mm Mylar tape.

Chalco Engineering Corp., Dept. ED, 15126 S. Broadway, Gardena, Calif.

Vector Analyzer 585

With a range of 20 cps to 100 kc at an accuracy of 2 per cent or 0.02 deg, type 202 measures very small phase angles, phase error between an unknown component and a standard component, voltage across two points both above ground potential and vector relations to 500 mc.

AD-YU Electronics Lab., Inc., Dept. ED, 249 Terhune Ave., Passaic, N.J.

P&A: $588; 1 to 2 weeks.

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Crystal Unit 594

Size is intermediate, between JAN HC-6/u and HC-18/u. The range of 250 to 800 kc is covered with DT or CT cuts and the range of 1 to 150 mc, with AT-cut quartz crystals. Principal applications are filters, discriminators and oscillators.

Clark Crystal Co., Inc., Dept. ED, Marlboro, Mass.

Fused Meters 610

Heavy-duty, multi-range meters in this series stand an overload of 10 times greater than normal for 1 hr. Included are the 410 triple-range ac voltmeter, the 420 dual-range ac ammeter, the 430 triple-range dc voltmeter, the 440 triple-range dc ammeter (shown) and the 450 galvanometer.

Buck Engineering Co., Dept. ED, 41 Marcy St., Freehold, N. J.

P&A: $36 to $42.

Digital Clocks 592

Up to three independent outputs can be provided by model 2600 or 2700. Outputs are parallel, decimal contact closure patterns based on 12- or 24-hr time. Seconds and tenths of minutes outputs are obtained with a rotary switch.

Chrono-Log Corp., Dept. ED, Box 4587, Philadelphia 31, Pa.

P&A: $490 to $640.

Measuring Device 590

For surface finishes of 1 to 1,000 μin. on metals, plastics, ceramics, and organic materials, model MS 1000 Surfindicator can be used at any point in a production line or inspection area. It is transistorized and uses two 9-v batteries.

Brush Instruments, Div. of Clevite Corp., Dept. ED, 37th & Perkins, Cleveland 14, Ohio.

P&A: $920; 30 days.

Thin-Film Systems 688

For microcircuits, EB-101 equipment offers standard tolerances and high reliability. This equipment is for the production of complex circuits composed of thin-film conductors and multiple resistors.

GVC Electron Heating Corp., Dept. ED, 81 Hicks Ave., Medford, Mass.

CIRCUIT IDEA FILE

NEW PRODUCTS

Variable-Speed Drive 554

Two new 5-hp electronic drive systems, models 1P11-20 and 1P81-20, are available to vary the speed of a 440-v, 60-cps motor. Either system, complete with motor, provides 2% speed regulation from 60 to 2,400 rpm from no load to full load.

Electro-Devices, Inc., Dept. ED, P. O. Box 2308, Paterson, N. J.

Servo Analyzer 616

Modulation rates are 0.005 to 1,000 cps, provided in sinusoidal, step and ramp functions, directly or in suppressed carrier form. Carrier frequencies of 50 to 10,000 cps may be used. Designated model 101, this unit measures phase and gain response on servo systems, amplifiers and other equipment.

Chance Vought Corp., Dept. ED, Dallas, Tex.
P&A: $2,952; 60 to 90 days.

High-Gain Preamplifier 586

Sensitivity is 10 μv per chart line in direct-writing recorder use. Input impedance is 10,000 ohms and is floating and guarded. Response to a step input is 90 per cent in 2 msec. In-phase rejection to a differential input is 120 db at dc, 60 and 400 cps. Linearity is 0.2 per cent. The unit is designated RD 4215 20; model RD 4215 00 has 100-μv sensitivity.

Brush Instruments, Div. of Clevite Corp., Dept. ED, 37th & Perkins, Cleveland 14, Ohio.
P&A: $550; from stock.

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Digital Clock 591

Requiring 3.5 in. of panel space, model 2500 is a time source for data loggers, computers and other applications where a parallel, decimal contact closure pattern representing 24-hr time is required. Up to three independent outputs can be provided in one clock.

Chrono-Log Corp., Dept. ED, Box 4587, Philadelphia 31, Pa.

Pass-Through Oven 550

Model 1408-M pass-through oven, with lift-sliding doors, can heat large loads of components continuously at 600 F. A 550-cfm blower insures rapid heat transfer and maintains uniform temperatures throughout the 32-in. wide, 25-in. deep, 30-in. high chamber despite frequent loading and unloading. Standard controls include indicating-controlling thermostat, pilot light, three-heat selector, and main switch. Other models are available with chamber volumes up to 60-in. wide, 30-in. deep, and 40-in. high.

Electric Hotpack Co., Inc., Dept. ED, Cottman Ave. at Melrose St., Philadelphia 35, Pa.

P&A: Varies with temperature range; 45 to 60 days.

Thermal-Shock Chambers 589

Accuracy is ±0.5 F. Model 600 has a range of −100 to +500 F, with 5-min pulldown and 30-min warmup. Model 800 has a range of −320 to +500 F. Designed for bench-top use, the units have inside dimensions of 16 x 8 x 8 in. The door is removable.

Cincinnati Sub Zero Products, Dept. ED, 3932 Reading Road, Cincinnati 29, Ohio.

Analog Controller 689

Is accurate and stable. Analog computer-controller CM-3 provides real time control for petro-chemical processes, simulation, or operator guidance. Stability and over-all accuracy may reach 1/2%. Solid-state system provides 1 to 3 outputs from 5 to 10 inputs.

Dresser Electronics, Dept. ED, 10201 Westheimer Road, Houston 42, Tex.

P&A: $5,000 to $10,000; 60 days.

NEW PRODUCTS

Photometers 622

Double-beam, ratio-recording Spectro-photometers DK-1A and DK-2A have a wavelength range of 185 to 3,500 mμ and a resolution of 2 Å at 220 mμ. The DK-2A is for bench-top use. A unit for far ultraviolet applications is also offered.

Beckman Instruments, Scientific and Process Instruments Div., Dept. ED, 2500 Fullerton Rd., Fullerton, Calif.

Size 8 Synchro 619

A sector switch provides a closed circuit when the position of the synchro exceeds ±70 deg from EZ. Adding 0.5 in. to the over-all synchro length, the unit can be used wherever switching is required in conjunction with synchro angular positions.

Clifton Precision Products Co., Dept. ED, 5050 State Road, Drexel Hill, Pa.

P&A: 4 to 6 weeks.

Magnetic-Tape Plotter 621

Producing an X-Y plot of digital data, model 570 plots calculated electron ballistics, reliability analyses and other computer outputs. The transport reads tapes with a linear density of 200 bits per in. The recorder uses a bi-directional, rotary step motor.

California Computer Products, Inc., Dept. ED, 8714 Cleta St., Downey, Calif.

P&A: $24,500; 90 days.

Porous Alumina 513

Used in high-power arc applications, porous alumina offers high impact strength and heat resistance. Material helps dissipate arc energy through outgassing and by providing a rough surface. Uses include circuit breakers, lightning arresters, arc diffusion systems, and other insulation applications.

Electronic Mechanics, Inc., Dept. ED, 101 Clifton Blvd., Clifton, N.J.

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Telemetering Transmitter 524

Accurate, stable cw signal for tracking of missiles or vehicles is provided by the TT-1001 Mod 7 uhf telemetering transmitter. Frequency is 225 to 245 mc. Accuracy and stability are better than 0.01%; power output is 260 mw. Silicon transistors are used throughout. Weight is 17 oz with battery, 6.5 oz without. Battery life is 1 hour min.

Frontier Electronics Co., Dept. ED, 4600 Memphis Ave., Cleveland 9, Ohio.

Tape Reader 523

Reading speed of 300 characters per sec is achieved by type 271 tape reader. Fully synchronous operation is possible up to 220 characters per sec. Fast advance and rewind speed is 1,000 characters per sec. The militarized reader is designed for slide or conventional mounting within a special console or standard rack.

Ferranti Electric, Inc., Dept. ED, Industrial Park No. 1, Plainview, N.Y. *P&A: quote on request; 120-day delivery.*

Life-Test Oven 525

Up to 2,500 test stations are provided by a life-test oven for semiconductors. Design ensures exact exposure and balanced air velocity over all areas. Temperature range is 400 C; oven is equipped with temperature limiting and air flow alarm. Through ports are provided for connections.

Forma Scientific, Inc., Dept. ED, Box 649, Marietta, Ohio.

CIRCLE 177 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Timing Relay 561

Solid-state timing relay, for pulse or squib applications, can turn on a 50-amp load within 10 μsec of the application of a short, low-energy, voltage trigger having an amplitude of +17 ±11 v. The relay, model TR-12-50-.050, operating from a 12 v dc source, shuts off the load after 50 msec.

Curtiss-Wright Corp., Dept. ED, Inter Mountain Instruments Branch, P. O. Box 8324, Albuquerque, N. M.

Shorting Switch 560

Progressive shorting-type switches have separate collector-ring connection for complete or continuous programing. Switches, which can be ganged, come in a 1-3/4 in. sq for 20 and 24 positions, and in a 2-1/4 in. sq for 24 and 32 positions.

Daven Co., Dept. ED, Livingston, N. J.

Magnetic Shifters 558

Two-way magnetic shift elements, type CTR 2W-100-P-12, provide outputs in response to shift pulses on either of two shift lines at rates from 0 to

100 kc. The elements can be used in arrays having two different information paths; hence, they can be used for bidirectional shift registers for reversible ring counters or for matrix registers.

Dian Controls, Inc., Dept. ED, 40 Leon St., Boston 15, Mass.

Price: Approx. $34 in small quantities.

Availability: From stock to 30 days.

Induction Motor 557

New line of 400-cps induction motors, available in frame sizes up to NEMA 215, uses aluminum construction for frame and end shields to cut weight by as much as 75 per cent. Unit pictured is a 12.5-hp motor with 7,300-rpm full-load speed. It weighs less than 25 lb and has a 6-1/2-in. frame diameter.

Doerr Electric Corp., Dept. ED, 507 N. Fourth Ave., Cedarburg, Wis.

Battery Substitute 556

Constant voltage supply, model BS(TC)-2 can substitute for dry and wet cells for use with precision laboratory potentiometers such as the L&N types K2 and K3 and the Rubicon types B and S. Voltage stability is better than 0.01 per cent for 10 per cent variations in 117 v line. Over 15 C to 35 C temperature range, stability is 0.001 per cent per deg C.

Dynage, Inc., Dept. ED, 75 Laurel St., Hartford, Conn.

P&A: $95.00; from stock.

CIRCLE 184 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Trimmer Potentiometer 559

Model 356 trimming potentiometer provides resistance values from 10 ohms to 50 K in a 1/2 x 1/2 x 0.195 in. package. The unit can operate from −55 to +200 C. Circular mandrel design provides 0.086% resolution at 50 K. The trimmer can dissipate 1 w up to 50 C.

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

Availability: *From stock.*

Tachometer Indicators 553

Complete tachometer indicator systems use permanent-magnet, instrument-type, dc generators with precision indicating meters to show speed of motor rotation. Various circuit arrangements are available to provide for expanded or suppressed speed scales and automatic selection of speed scale for either direction of rotation.

Electro-Devices, Inc., Dept. ED, P.O. Box 2308, Paterson, N. J.

Transient Protection 562

The FS-101 switch is a fail-safe, solid-state device that protects sensitive components from transients. It will disconnect the power source from the device under test within 1 μsec after safe current limit is exceeded. The device is for incoming inspection of electronic modules and transistors, for development laboratories, and for training classes.

Alpha-Tronics Corp., 1033 Engracia Ave., Torrance, Calif.

"DRESSES-UP" your panels, switchboards, other products.

BIG LOOK panel meters

MODERN DESIGN IMPROVES END PRODUCT APPEARANCE

Now, General Electric's BIG LOOK panel meter styling can help improve the appearance of your switchboards, panels and other equipment. BIG LOOK *styling* is the result of careful planning, development and field testing. It represents more than 28 years of General Electric leadership in creative panel meter design.

Now, BIG LOOK panel meters are available in your choice of seven attractive color windows to complement the appearance of your products or equipment.

For the complete AC and DC BIG LOOK panel meter story just contact your nearby General Electric Apparatus Sales Office or distributor; or write for bulletin GEA-7034 direct to General Electric Company, Section 597-04, Schenectady, New York.

INSTRUMENT DEPARTMENT

GENERAL ELECTRIC

CIRCLE 187 ON READER-SERVICE CARD

Low-Cost Magnet 555

A 5-lb horseshoe magnet, rated at 2,000 gauss, can lift more than 125 lb. The magnet features a high strength-to-weight-to-cost ratio.

Edmund Scientific Co., Dept. ED, Barrington, N. J.

P&A: $9.95; from stock.

Airborne Cooling Pack 552

New heat-transfer system, type E/HT-200-214, can dissipate 3,400 w. Intended for equipment miniaturized to the point where neither convection cooling nor fan cooling is adequate, the 25-lb system maintains the coolant (ethylene glycol and water) between 150 and 170 F. The unit operates from −55 C to +55 C and from sea level to 50,000 ft. It requires 208-v, 3-phase, 400-cps power.

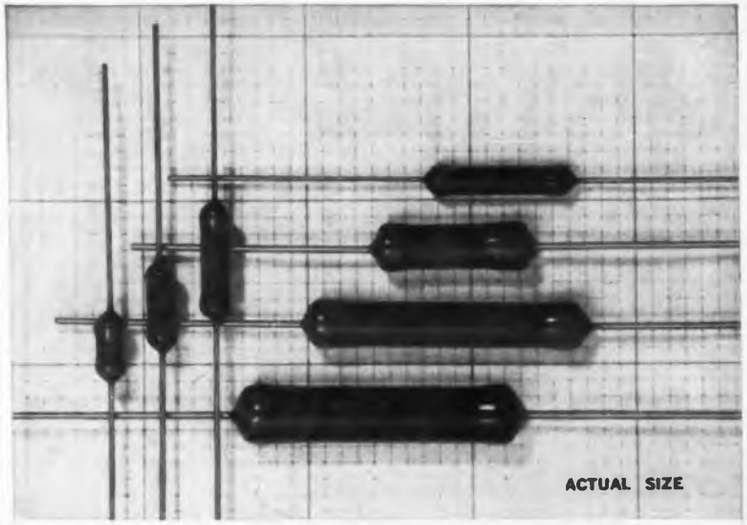
Eastern Industries, Inc., Dept. ED, 100 Skiff St., Hamden 14, Conn.

Current Integrator 551

Model A309A current indicator and integrator displays the integral of a wide range of input currents as well as the amplitude and polarity of these currents. For current amplitude, 12 switch settings provide full-scale meter deflections from 3×10^{-9} through 1×10^{-3} amp on a 4-1/2-in. panel meter. A five-digit counter shows the current integral (charge), with a 2-1/2-in. panel meter serving for interpolation between successive least significant digits on the counter.

Elcor, Inc., Dept. ED, 1225 W. Broad St., Falls Church, Va.

Price: $1,674 plus $32 for cabinet.



THESE "WIRE-WOUNDS" ARE CIRCUIT SHRINKERS . . . . . *newly*

expanded line lets AXIOHM® power resistors go into smaller circuits!

Ward Leonard AXIOHM power resistors are now available in *seven* sizes—down to 2 watts, up to 12.5.

They're ideal for miniaturization in printed-circuits, industrial instrumentation and automation circuitry. But they're recommended for *any* electrical or electronic application where the highest stability and maximum overload capacity are required.

The seven AXIOHM sizes come in a complete range of resistance values (see table) from 0.1 to as high as 75,000 ohms. Naturally, they feature the qualities Ward Leonard has made famous in power resistors:

Vitrohm vitreous enamel; Ward Leonard's specially made ceramic core; specially selected and matched resistance wire; and strong, permanent, low-resistance, spot-welded, lead-to-end-cap junctions.

SIZES AND RATINGS

Rating (in watts)	Type	Resistances (ohms)		Dimensions (inches)	
		Min.	Max.	Length*	Diam.
2	2X	0.1	5,000	3/8	3/16
3	3X	0.1	10,000	1/2	3/16
4	4X	0.1	15,000	11/16	3/16
5	5XM	0.1	20,000	15/16	3/16
7	7X	0.1	25,000	1	3/16
10	10XM	0.1	50,000	1 3/4	5/16
12.5	12.5X	0.1	75,000	1 3/4	3/8

*Less leads.

Get complete details in Supplement C to Catalog 15. Write for your copy and a list of stocking distributors today. Ward Leonard Electric Co., 77 South Street, Mount Vernon, New York. (In Canada: Ward Leonard of Canada, Ltd., Toronto.)

RESULT-ENGINEERED CONTROLS SINCE 1892

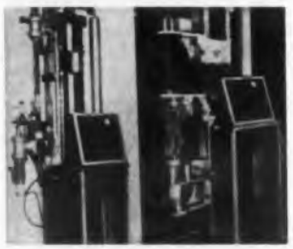
WARD LEONARD ELECTRIC CO. MOUNT VERNON NEW YORK

RESISTORS • RHEOSTATS • RELAYS • CONTROLS • DIMMERS

CIRCLE 188 ON READER-SERVICE CARD

PRODUCTION PRODUCTS

Dual-Purpose Fixture 563



Crystal pulling and floating zone attachments used with model HCP-D dual-purpose unit can be changed from one application to the other with a minimum of time and effort. Model consists of the basic unit with traverse mechanism and controls for operation of the induction heating generator. The same basic support, programing and control unit is used in each adaptation.

Lepel High Frequency Laboratories, Inc., Dept. ED, Woodside, N.Y.

Cartridge Spindle 564

Thinner, smaller diamond wheels usable with the type 2 cartridge spindle are said to speed production and reduce kerf loss. An accessory for automatic wafering machines, the device allows 40 to 100% more slices to be cut from a 1-in. crystal, with kerf losses reduced by 28 to 47%.

Micromech Manufacturing Corp., Dept. ED, 1020 Commerce Ave., Union, N.J.

Marking Machine 565

Compound concave or convex surfaces on molded plastic parts can be imprinted with trademarks and other information at production

speeds by the model 25AE marking machine. A direct ink-marking method is used with conforming plates. The imprint can be quickly changed. Specialized inks are available.

Markem Machine Co., Dept. ED, Congress St., Keene, N.H.

Wire Bonder 566

Thermocompression wire bonder model 402 is capable of bonding a wire 0.0002 in. in diameter to a transistor stripe measuring 0.001 x 0.003 in. Developed for making mesa transistors, the bonder can be used in the production of other transistors and diodes. Precision controls allow manual positioning accuracy of 10 to 15 millionths of an inch.

Kulicke and Soffa Manufacturing Co., Inc., Dept. ED, 401 N. Broad St., Philadelphia 8, Pa.

Resistor Grinder 567

Fully automatic. A completely automatic spiral grinding machine for carbon and metal film resistors, model SMA holds tolerance to ±0.05%. It will grind diameters from 1/16 to 3/8 in., lengths from 5/16 to 2 in. It will produce a resistor with 15 ground spirals at the rate of 2,500 units per day. Machine size is 24 x 12 x 14 in. over-all. A voltage-control unit and resistance bridge are furnished.

Associated American Winding Machinery, Inc., Dept. ED, 750 St. Ann's Ave., New York 56, N.Y.

Sealing Machine 568

Tube-to-wire. Hermetic sealing of tube to wire is done without heat, soldering, or welding by this automatic machine. It may be operated by unskilled labor, with an output as high as 2,000 parts per hour. The standard model will seal terminals up to 0.10 in. OD, with larger capacities feasible. First use of the machine has been in the sealing of top-hat diodes.

Micromat Co., Dept. ED, 548 Piermont Ave., Hillsdale, N.J.
Price: About $2,600.

PRODUCTION PRODUCTS

Soldering Machine 569

For fuse ends

This machine soft-solders the ends of caps to fuse links at the rate of 3,000 fuses per hour. After soldering by induction heating, fuses are sized to uniform length and tested for continuity. A circuit is provided to feed all fuses on the belt after shut-off, so that no unsoldered fuses will leave the machine.

Induction Heating Corp., Dept. ED, 181 Wythe Ave., Brooklyn 11, N.Y.

Commutator-Fusing Machine 570

Eliminates soldering operation

This machine, for fusing commutators on fractional hp motors, eliminates the soldering operation. It is said to provide better quality work with savings in time and labor. Of the models available, 2 are automatic. All sizes of motor armatures can be accommodated. As many as 550 units per day may be produced.

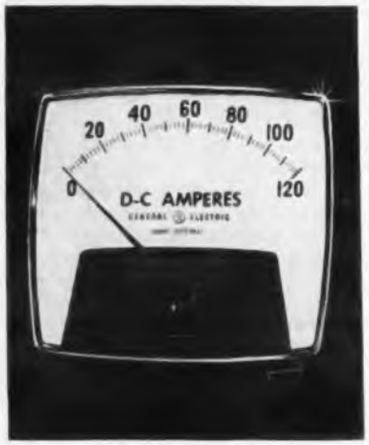
Joyal Products, Inc., Warner Equipment Co., Dept. ED, 250 McWhorter St., Newark 5, N.J.

Soldering Machine 571

Partially or fully automatic

Semi-automatic or completely automatic soldering may be done on a variety of components with the SD-4 model 1 soldering machine. Used with Solderforms, the machine passes parts through a heating chamber for a preset period, then cools and ejects them for flux removal. Speed and temperature are adjustable.

Kester Solder Co., Dept. ED, 4201 Wrightwood Ave., Chicago 31, Ill.



EASY-TO-READ panel meter scale is nearly 4 inches long.

BIG LOOK panel meters

NOW INCLUDE NEW 4½-INCH DESIGN

Designed with modern BIG LOOK styling, this new General Electric 4½-inch panel meter features a snap-on, snap-off cover for easy access to the scale face.

Improved readability, even at extreme distances, results from its expanded scale length . . . *ideal* for multi-scale applications on portable test instruments and panelboards. DC models of this new meter feature the same self-shielded mechanism available on 2½- and 3½-inch designs.

For the complete AC and DC BIG LOOK panel meter story just contact your nearby General Electric Apparatus Sales Office or distributor; or write for bulletin GEA-7034 direct to General Electric Company, Section 597-10, Schenectady 5, New York.

INSTRUMENT DEPARTMENT

GENERAL ELECTRIC

CIRCLE 195 ON READER-SERVICE CARD

For axial-lead parts

Magazine Loader 572

An accessory for the HD-3 remote spray coater, model ML-1 stacks 40 loaded trays of axial-lead components in a portable magazine, after the parts have passed through the painting station. The loader is 57-in. high and requires a floor space of 14 x 19 in.

Conforming Matrix Corp., Dept. ED, 841 New York Ave., Toledo 11, Ohio.

Automatic Tray Loader 573

For axial-lead components

Model TL-1 tray loader facilitates handling of axial-lead components. The unit automatically takes empty trays from a magazine, a hopper feeds them with straightened components, and stacks the loaded trays into another magazine. Each tray holds 20 to 50 components and each magazine holds 40 trays, thus handling 800 to 2,000 components as a complete unit.

Conforming Matrix Corp., Dept. ED, 476 Toledo Factories Bldg., Toledo 2, Ohio.

Price: *$3,995 ea.*

Availability: *2 to 3 weeks.*

Lead Trimmer 574

For axial-lead parts

The model H 101 interchangeably cuts, forms, or cuts and forms lead wires of axial-lead components. It has a processing rate of up to 11,000 pieces per hour, a set-up time of 30 sec, and can be run by unskilled personnel. Settings for lead length, bend length, and body size are made with micrometer-type lead screws. Right-angle bend is standard; special dies may be added.

Heller Industries, Inc., Dept. ED, 70 S. Munn Ave., East Orange, N.J.

what's so different about these time/delay/relays?

(and how these **AGASTAT** differences benefit you!)

AGASTATs are electrically actuated, but are *pneumatically* timed, so their accuracy and reliability are unaffected by voltage variations, and recycling is instantaneous. Adjustment is simple and stepless over l-o-n-g time ranges. With moving parts held to a minimum, the life span of a typical unit is measured in millions of cycles.

Industrial models (left) are dial-adjusted for delays of .05 sec. to 15 min. in five ranges. Needle valve models are also available, covering the full range (.15 sec. to 5 min.) in one unit. The Miniature Agastat on the right weighs as little as 15 oz. Hermetically sealed or unsealed types for MIL Spec or other demanding applications. Saves weight, saves space.

Timing accuracy and reliability are what you would expect from AGASTAT, pioneers in the development of time delay instrumentation. Single- or double-pole versions, in all standard AC and DC coil voltages. Types to provide delay on pull-in or drop-out. Want complete specs, or further information? Just write Dept. 11-44.

ESNA

ELASTIC STOP NUT CORPORATION OF AMERICA

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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.

Ungrounded Shield Reduces Effective Cable Capacitance 749

Often it is inconvenient to locate a cathode follower stage near the high impedance circuit which drives it. But, if a shielded connecting cable is used with its shield grounded, the cable's

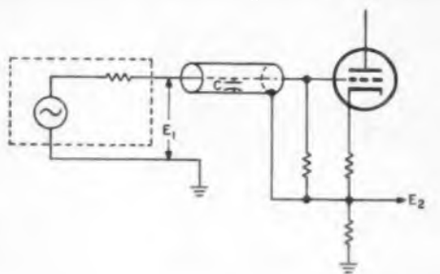

Fig. 1. Effective cable-input capacitance can be reduced by connecting shield to the cathode follower input.

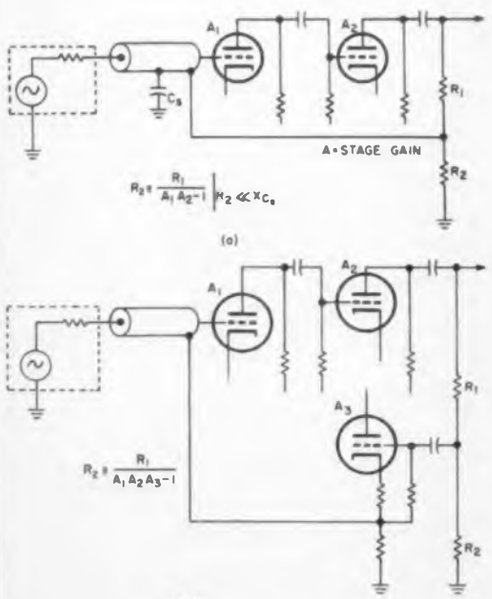

Fig. 2. Similar cable connections can be made for amplifiers of two or more stages.

input capacitance can affect the circuit frequency response.

This equivalent input capacitance, and the effect on frequency response, can be reduced by tying the cable shield to the cathode follower input, Fig. 1, instead of to ground. Very little voltage difference then exists between the inner and outer conductors. Reactive current is reduced to a small value.

If phase shift in the cathode-follower is negligible, the voltage E_1 on the inner conductor is in phase with the voltage E_2 on the shield. Reactive current I_x is equal to the difference between these voltages divided by the capacitive reactance of the cable X_c:

$$\text{Reactive current, } I_x = \frac{E_1 - E_2}{X_c}.$$

$$\text{Equivalent input reactance, } X_e = \frac{E_1}{I_x};$$

$$\text{Cathode-follower gain, } A = \frac{E_2}{E_1}.$$

These terms are substituted to yield the expression for the equivalent input capacitance, C_e.

$$\frac{E_1}{X_e} = \frac{E_1 - AE_1}{X_c} = \frac{E_1(1 - A)}{X_c};$$

$$\frac{X_e}{X_c} = \frac{C_c}{C} = \frac{E_1(1 - A)}{E_1} = 1 - A$$

$$C_e = C(1 - A).$$

Figs. 2a and 2b show similar arrangements for amplifiers of two or more states. Resistance R_2 is selected so that the voltage applied to the cable shield is equal to the voltage on the inner conductor.

H. W. McCord, Electron Tube Div., Radio Corporation of America, Harrison, N.J.

Short Trigger Pulse Turns On SCR, Fires Flash Bulb 744

A photoflash lamp had to be activated by a trigger pulse whose width was only 2 μsec—too narrow to fire the lamp directly. To effectively lengthen it, the pulse was applied to the gate of a silicon controlled rectifier as shown in the figure.

With no signal at the transistor input, the rectifier does not conduct. When the trigger pulse is applied, the rectifier's gate lead falls toward ground, and the rectifier fires. It remains "on"

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IDEAS FOR DESIGN

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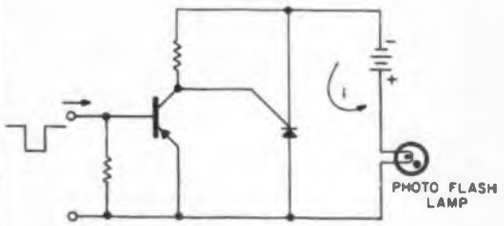


Narrow 2-μsec trigger pulse fires silicon controlled rectifier which stays "on" long enough to fire flash bulb.

even after the 2-μsec input pulse has been terminated.

In less than a millisecond, the photoflash bulb is fired by the current *i*, and its filament opens. The current i is now zero and the silicon controlled rectifier is reset for the next cycle.

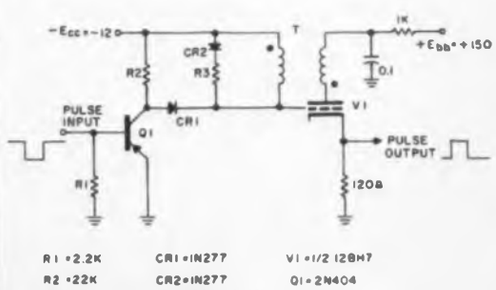
Note that when the bulb filament is opened, the battery voltage is removed from the transistor as well as from the rectifier. When a new bulb is inserted, the rectifier will remain "off" until the next trigger pulse.

Alfred W. Zinn, Engineer, Farrand Optical Co., Inc., New York, N.Y.

Transistor Trigger Pulses Fire Tube & Blocking Oscillator 747

Trigger sources of limited voltage swing and current capabilities are often regenerated by blocking oscillators. A vacuum-tube blocking oscillator can be triggered by a transistor as shown in the circuit diagram.

Transistor Q_1 is turned on by negative pulses applied to its base. Collector voltage rises from $-E_{cc}$ to ground potential. The grid of V_1 follows through CR_1. The tube is soon driven from cut-off into conduction and regeneration occurs through



Pulses applied to the transistor stage trigger the vacuum-tube blocking oscillator.

the action of T. As the grid potential of V_1 rises above ground, Q_1 is disconnected by CR_1. R_3 and CR_2 provide a load for the backswing of T. Resistor R_3 is selected so that the collector potential of Q_1 does not exceed its rating. Resistor R_2 provides a return for CR_1 and the collector of Q_1. Typical values for the circuit are given in the figure.

Karl Springer, Member Technical Staff, Hughes Aircraft Co., Culver City, Calif.

Standard Joints Used In Improved Dual-Channel Antenna 742

Dual-channel conical scanning antennas have two major weaknesses. One channel is invariably a low power channel, while the other has a high vswr or a high phase shift which cycles with each rotation of the scanner. Consequently, the dual transmitter or dual receiver channels found in monopulse systems, cannot be accommodated.

These difficulties may be overcome by using standard commercial components in the antenna shown in the figure. The dual-channel scanner consists of a parabolic reflector and two rotary joints. One of the rotary joints is a standard type, while the other is an "in line" or L-type joint.

The standard rotary joint, located near the focal plane of the antenna, is fed by a transmission line in an outboard fashion. The L-type rotary joint, mounted in the center of the dish, is fed near the optical axis of the parabolic system. Each joint has a radiating element in the focal plane of the dish and is mechanically joined near the radiating elements.

A drive motor and gear arrangement on the L-type joint causes both radiating elements to rotate about the optical axis of the antenna. This produces two conical scanning beams. The outboard feed line provides good mechanical stabilization for the outboard rotary joint, thus minimizing dynamic unbalance affects.

X-Band Antena Has 35 Db Decoupling 900-Mc Bandwidth

For best decoupling the radiating elements are placed on opposite sides of the optical axis. An X-band antenna has been constructed that had a decoupling figure in excess of 35 db over a 900-mc bandwidth. The vswr of each channel was less than 1.2:1 over the same band. Because the rotary joints are conventional, the power handling capabilities of the scanner depend upon

(*Continued on page 160*)

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IDEAS FOR DESIGN

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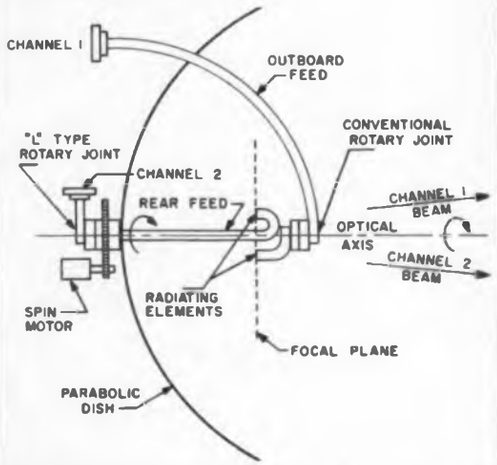


Standard rotary and L-type rotary joints are used in dual-channel conical scanning antenna.

the design of the radiating elements. However, it is not difficult to achieve a 200-kw handling capability at X-band.

An open waveguide provides an excellent radiating element from the point of view of dish illumination, power handling and simplicity. The outboard waveguide and rotary joint produces very little shadowing if the diameter at the dish is more than 10 times the diameter of the rotary joint.

Made with conventional rotary joints, the dual channel scanner can be rotated at speeds up to 3,000 rpm. It can provide either broadband single or dual frequency operation for either transmitters or receivers, or both.

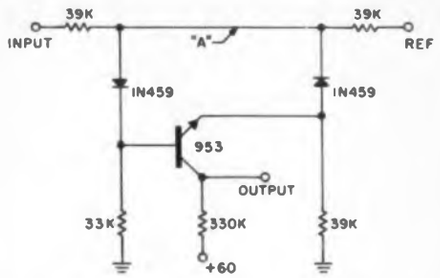
Robert B. MacAskill, Project Engineer, The Hallicrafters Co., Chicago, Ill.

Predetermined Input Level 741 Cuts Off Transistor, Sets Output

A simple circuit was required that would recognize a predetermined voltage level. An ordinary cathode-coupled binary could not be used because a positive output signal was desired during the time the chosen level existed, while at any other level the output had to be nearly zero. The circuit shown accomplishes this easily.

The reference is the negative of the level to be recognized. Thus the voltage at *A* becomes zero when the input and reference are equal. When these voltages are unequal, the line is either positive or negative.

A net positive voltage causes the transistor



When input voltage is at the reference level, voltage at A is at zero, transistor is cut off and output rises to the supply voltage level.

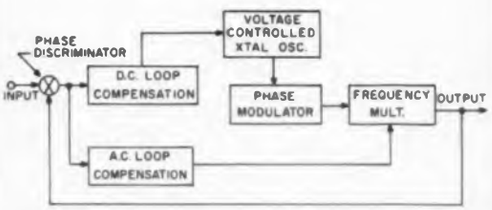
to conduct by raising the base voltage. A net negative voltage lowers the emitter voltage so that the output voltage is nearly zero. When input is at the reference level, the transistor is cut off, and the output voltage rises to the desired positive voltage level.

Lloyd E. Weberg, Senior Engineer, Military Electronics Div., Motorola, Inc., Phoenix, Ariz.

Servo Loop Frequency Modulates 746 Oscillator Outside Deviation Range

A cross-correlation servo loop using a high-stability crystal-controlled oscillator, had to be designed to allow frequency modulation outside the range of maximum oscillator deviation.

The technique employed used a "dc loop" to keep the crystal oscillator phase-locked to the incoming signal. An "ac loop" was used to phase modulate the oscillator output. The phase modulator can provide a modulation index of about 1.0 for virtually any modulating frequency. However, it does not affect the crystal oscillator stability. A frequency multiplier follows the phase modulator only when it is desired to obtain a modulation index greater than 1.0.



Ac loop phase modulates crystal frequency outside of its deviation range, but does not affect oscillator stability.

J. A. Webb, Aircraft Development Engineer Specialist, Lockheed Aircraft Corp., Marietta, Ga.

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Paper Tape Puzzler: Start It, Read It, Check It, Stop It— At 1800 Characters Per Second!

Paper tape skims through National's transistorized 360 photoelectric reader at the unprecedented speed of 15 feet per second. Starting and stopping instantaneously at this rate without tearing the tape was an electromechanical problem of the first order.

In solving it, NCR Electronics Division engineers developed a unique direct drive which has independent "bang-bang" servo motors for feed and take up reels. Conventional clutching is eliminated. A 3-foot section of tape remains slack for safe, low-inertia starts, and a photoelectric system reads and checks data at high speed. Once the last character in the desired record is sensed, the sapphire-hard Sanfordized aluminum brake stops the tape without permitting overshoot to the next character.

To create advanced digital systems, NCR scientists and engineers probe every promising area of technology. If you can make imaginative contributions in any of the pertinent fields, it may well be to your advantage to investigate the expanding opportunities at The National Cash Register Company Electronics Division now.

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Experienced graduate E.E.'s with 3 to 5 years in logic design and transistorized circuit design of digital equipment. Assignments will entail logic and circuit design of buffer storage units and digital peripheral equipment.

SENIOR PRODUCT DESIGN ENGINEER

Expanding commercial program offers excellent opportunity to apply advanced techniques in miniaturization. Applicant should have ME degree and substantial experience in packaging techniques for core-type memories and complex digital systems. Should also be capable of product design analysis and technical liaison to develop a producible product.

PRODUCT ENGINEERS
Seniors & Intermediates

Assignments entail design analysis and technical liaison to develop a producible product; establishment of design requirements from a standpoint of cost, product ability and standardization; recommendation of changes for ease of manufacture. Positions require substantial knowledge of manufacturing methods, practices, shop equipment and facilities; solid background in electronic design of digital equipment; E.E. degree.

SYSTEMS ENGINEER

Experience required in formulating functional design specifications for digital computer systems (buffer storage, punch card, paper tape, magnetic tape, random access devices, system organizations, command structures). Training in logical design, data-handling methods and programming techniques desirable. Assignments entail formulating functional specifications for business computers.

SYSTEMS TEST ENGINEERS

A responsible position entailing coordination of scheduling and utilization of both unit and systems test programs. Originate and analyze test requirements, supervise testing and analyses; recommend changes in design specifications and requirements. Determine validity of test data. Requires E.E. degree plus good knowledge of mechanical engineering, instrumentation, and design engineering.

SENIOR SOLID STATE DEVICE ENGINEER

An important position entailing investigation of semiconductor devices for purpose of establishing mathematical models and design parameters used in circuit design. Requires minimum of three years' experience and some background in computer circuitry, transistors, diodes, resistors, and transient phenomena. Should be familiar with characteristics, analysis, and mathematical models of various semiconductors, such as alloy transistors, diffused-base transistors, mesa transistors, and diodes.

Confidential interviews at the Western Joint Computer Conference in Los Angeles, May 9-11. Please send your resume immediately to Norval E. Powell, Personnel Manager, at the address below.

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YOUR CAREER

NEWS AND NOTES

Get an advanced Degree and marry a home economics major. This is the advice given to June graduates by Lon D. Barton of the employment counselling firm, Cadillac Associates, Inc., Chicago. Mr. Barton believes that within five years the BA or BS degree will become as common as a high school diploma was 35 years ago.

On marriage, Mr. Barton says he has seen more problems among young men attributable to a wife making more money in a competitive-type job. He also advises delaying marriage for a while so as not to be restrained in job mobility at the start of one's career.

• • •

Key to Persuasion

Next time you have to sell somebody on an idea, remember: spotlight the benefits.

Why? Because people don't buy an idea. They buy what an idea will do for them. They buy enjoyment, satisfaction, pleasure, solutions to problems, advantages—in short, benefits. People never accept an idea just because it is new or different. They accept it for what it will do for them.

Want your boss to install a new computer? Don't describe the operation of the special commands. Explain how the computer will eliminate errors, speed up projects, boost engineering department output.

Want a technician to be more workmanlike on your breadboards? Don't tell him how poor breadboard appearance can ruin the impression "your" project makes on your supervisors. Explain how "his" workmanship will create a good reputation for "him."

A reminder: people are most interested in profits (money, time, energy), safety, prestige and approval. Put your ideas in terms of any of these basic areas of self-interest and watch your powers of persuasion grow!

• • •

Company matching of employe gifts to colleges has been announced by Whirlpool Corp., St. Joseph, Mich. Whirlpool said it will match all gifts in cash or securities from $10-$1,000 a year made by its employees to colleges of their choice.

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

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!

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USE BEFORE JUNE 7, 1961

(9)

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Position Desired _____

Educational History

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Recent Special Training _____

Employment History

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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

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CAREER NEWS

Revision of the Taft-Hartley Act through adoption of a "Freedom-of-Association" bill is supported by the National Society of Professional Engineers. At present, the society says, engineering-management informal sounding-board conferences violate the labor law restrictions on nonbargaining discussions.

In fact, says Paul H. Robbins, executive director of the 54,000-member society, which has many engineers in supervisory positions, any informal management-engineer meeting violates the Taft-Hartley Act. The problem, he says, lies in the vagueness of the Taft-Hartley definition of a "labor organization."

The freedom-of-association bill, H.R. 412, which has already been proposed five times by Representative Carroll D. Kearns (R-Pa.), would distinguish engineers and professional groups from labor groups.

• • •

The Gentle Art of Criticism

There is a definite art to criticizing others. If you want your criticism to yield positive results, observe these rules:

Get all the facts. **Only then are you prepared to appraise the situation fairly. The best way to get a man to give you the facts is to ask, "What happened?" It boils down the whole issue to *what* went wrong rather than *who* is to blame.**

Stay calm. **You'll create a climate of "let's-find-the-solution-together," in which you ally yourself with the other fellow against the common enemy—a mistake. He'll respond in kind.**

Criticize in private. **Test after test has proved this gets better results than criticism in public.**

Commend before you criticize. **That way you take the sting out of what is to follow. You provide assurances that you still have great regard for the person you are criticizing. And you subtly suggest that you recognize his error as merely a departure from the norm—his customary high-calibre performance. In short, you help him "save face."**

Keep your criticism constructive. **The purpose of criticism is to "teach better ways." Collaborate with the other fellow to discover "what happened" and indicate ways to prevent the mistake from happening again. That's positive, purposeful, criticism—the only kind that gets lasting results.**

PAPER DEADLINES

Convention Program Chairmen have issued the following deadlines to authors wishing to have their papers considered for presentation.

May 1: Deadline for 100-200 word abstracts and 500-1,000 word summaries for the **1961 WESCON show, Aug. 22-25, San Francisco.** In addition to regular IRE professional group topics, special sessions on radio astronomy and coherent and infrared electromagnetic radiation are planned. Send papers to *E. W. Herold, WESCON Northern California Office, 701 Welch Road, Palo Alto, Calif.*

May 1: Deadline for papers for **17th National Electronics Conference,** to be held **Oct. 9, 10, 11** at the **International Amphitheatre,** Chicago, Ill. Papers covering any subject in the entire range of interests of electronic engineers will be considered. Submit 12 copies of a 150-word abstract, and send two copies of either the completed paper, or a 500-700 word summary to *W. L. Firestone, Motorola, Inc., 4501 W. Augusta Blvd., Chicago 51, Ill.*

July 1: Deadline for 100-word abstract and 500-word informal summary on "Kilomegacycle Computing Systems" for presentation at the AIEE 1962 Winter General Meeting, New York, **Jan. 28-Feb. 2.**

The papers should be oriented toward the entire system but may deal specifically with such system aspects as:

1. Applications for kmc computing systems; replacement of several machines by one ultra-fast machine; attacks on entirely new classes of problems.
1. Components for kmc computing systems, and effects of their particular characteristics on configuration of the system.
3. Over-all systems aspects; problems of information rate mismatch with external equipment and with people; hierarchies of memories; use of complex programing technique to replace hardware (fixed wiring).
4. Methods of fabricating ultra-fast systems; problems of reliability, circuit modules and interconnections, propagation delays; description of complete computer designs.

Deadline for full text is Oct. 30 for those papers that will also appear in the transactions and Nov. 25 for papers which will only appear as conference reprints. Address papers to *C. E. Day, Assistant Secretary for Technical Papers, AIEE, 33 W. 39th St., New York 18, N.Y.* Other correspondence should be addressed to J. H. Wright, papers chairman, Div. 12, U.S. National Bureau of Standards, Wash. 25, D.C.

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- Aircraft Flight and Electronic Systems—Largest supplier of airborne centralized flight data systems; also working with other electronic controls and instruments including missile and submarine applications.
- Missile Systems—Largest supplier of accessory power units, AiResearch is also working with hydraulic, hot gas and hydrogen systems for missiles, liquid and gas cryogenic valves and controls for ground support.
- Gas Turbine Engines—World's largest producer of small gas turbine engines, with more than 9000 delivered in the 30—850 hp class. Studies include industrial and nuclear applications.

Excellent positions are available for qualified men with M.S., Ph. D. and Sc. D. degrees for work in these areas.

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Send resume to: Mr. R. K. Richardsor

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ADVERTISERS' INDEX

April 26, 1961

•Manufacturers' catalog appears in 1960-1961 Electronic Designers' Catalog

looking for a special potentiometer?

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Your copy of EDC lists 157 different types of potentiometers in its PRODUCT LOCATOR. 27 categories from "AC" to "Wirewound" are included. Each sub-listing such as "Clutch," "Linear Motion," "Microminiature," "Precision," or "Self-trimming" gives manufacturers' name and thumbnail specs to aid in rapid selection. 52 items are further described by special literature bound in sections 2 or 3 of EDC.

This is only one example of the more than 7,000 products from 2,212 companies which are displayed.

Handy Inquiry Cards or Application Data Forms are bound in to make it easier for you to obtain additional data — and manufacturers' reps are also listed if you wish to phone for quick price and delivery information.

Electronic Designers' Catalog is one more service provided by the publishers of *Electronic Design.*

•Manufacturers' catalog appears in 1960-1961 Electronic Designers' Catalog

*Manufacturers' catalog appears in 1960-1961 ELECTRONIC DESIGNERS' CATALOG

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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
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