TUNNEL DIODES
For nanosecond logic, p 72
(photo below)

NUCLEAR RADIATION
Designing for high dosage, p 51

ISOLATED PARAMP
Circulators not required, p 58
AUTOSPEC from Raytheon...
Transformers quoted in 3 days
Delivered in 3 weeks

Raytheon announces the fastest, most efficient system yet devised for specifying, ordering and delivering power transformers and filter inductors to your requirements.

From now on, every engineer can have at his fingertips a set of tools that will enable him to automatically specify the size of the transformer that exactly meets his electrical requirements. Mounting, terminal location and style are quickly and easily determined from convenient charts. The new Raytheon "AUTOSPEC" system delivers high quality "specials" in quantities from 1 to 15 within 3 weeks.

With AUTOSPEC, Raytheon has discarded the classic trial-and-error approach to transformer design and has developed the first fully coordinated transformer data system for all required power, temperature rise, regulation and dimensional calculations.

A comprehensive brochure explains how you can employ AUTOSPEC to simplify your transformer design work and reduce component costs while cutting delivery time to the 2 to 3 weeks now associated with off-the-shelf items.
PUMPED TUNNEL DIODE-transistor logic processes data at 500-Mc rate in a circuit by GE. The transistor provides unidirectionality of information flow, the tunnel diode provides gain. Since the transistor need not provide gain it may be operated close to its cutoff frequency. See p 72

SEMICONDUCTOR RADIATION DETECTORS Demonstrate Their Practicality. Sensitive to low-energy particles, these detectors are being used in space experiments and reactor diagnostics. One estimate of next year's market: $41 million

LANDING SYSTEMS for Manned Spacecraft. Approaches range from aircraft type radar beacons to onboard adaptive controls and combinations of pilot and ground control. Maneuvering a powerless glider and overcoming communications blackouts are two of the major problems

HIGHER FREQUENCY OPERATION Is One Goal of French Tube Manufacturers. Paris parts show also includes brushless variable transformer, electrostatic relay. Missing from the show: implosion-proof tv picture tubes

KEIR CELL CAMERA Films in 5 Nsec. Six electronically-controlled shutters and film holders are arranged around central optics. This permits framing rate of 100 million a second

NUCLEAR RADIATION and How to Design Equipment to Live With It. The author considers high doses but low dose rate that may be encountered close to radioactive materials and tells how they affect metals, dielectrics and semiconductors. The article supplements one we ran Feb. 10, 1961 dealing with transient, or nuclear weapon, radiation. By P. Barratt

ISOLATED PARAMETRIC AMPLIFIER With Low Noise Figure. A big problem with parametric amplifiers is that they tend to be unstable. One way to cope with this instability is to use ferrite circulators to separate input and output. But circulators introduce losses. This amplifier uses two varactors 90 degrees out of phase and a 3-db directional coupler to achieve isolation. By L. D. Baldwin

BIONICS: Part IV—Applications and New Directions. The last article of a series deals in part with adaptive or learning networks that have been developed as analogies to biological systems. One signal network consists of threads built up by passing current through ferrous sulfate solution. The paths, like memory associations, dissolve unless used. By N. A. Lindgren
CONTENTS continued

VOLTAGE-CONTROLLED OSCILLATOR Uses Negative Feedback. It is used in an analog-to-digital converter that gives an output varying from 0 to 1,000 pulses per second as input varies from 0 to 10 mv. Negative feedback loop includes two pulse counting discriminators with inputs from voltage-controlled oscillator and a stable reference oscillator.

By N. W. Bell and V. Chiunti 64

COMPLEMENTARY COMPUND EMITTER FOLLOWER. Compares the advantages and disadvantages of cascade and complementary compound emitter followers for applications where the current gain of a single emitter follower is insufficient. Complementary circuit tends to limit power dissipation.

By T. K. Hemingway 66

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We’ve Just Not Been Trying

“DURING THE LAST FIVE YEARS . . . many new electronics firms have been started . . . almost none of which has failed. I believe something is wrong with a situation that perpetuates nearly every one.”

The words are those of Finn J. Larsen, Army Assistant Secretary for Research and Development. They could be taken literally. Or they might have been chosen for their dramatic effect. At any rate, the electronics industry, by its very nature, requires a large number of companies. The sum total of their contributions, large and small, makes up the vast technological complex that is so vital to our scientific program, our national defense, our commercial expansion and our present way of life.

Where such a large number of companies is involved, obviously not all contribute at the same rate. But the intricate demands of today’s technology often permits the smallest sub-subcontractor to play as vital a role as a major industry leader. Years ago a keen observer of the current scene gave us the words “For want of a nail, the shoe was lost . . .” and it is much like this in our field today.

Mr. Larsen’s comments on the few failures in the field of electronics, however he meant them, put us in mind of the tv comedian who read to his audience a fictitious report to the effect that national traffic accidents during the week had been 28 percent below predictions. He followed this statistic with the statement “Some of you out there are just not trying!”

OLIVES AND COMPUTERS—How would you build a machine that could be taught by reward and punishment to do things better? Or even a machine that could modify its own actions in the light of what it had learned?

A computer could be rewarded by adding appropriate logic for a correct answer, so it gave a similar answer more speedily next time. For punishment, circuits that yielded wrong answers or didn’t contribute to right ones could be pared away. Fit the computer with a robot armed with tools for adding or removing circuits—or with some electronic system that achieves the same result—and the reward-punishment process is automated.

But what if the nature of the problem changes? Suppose the computer is trained to recognize the letter E. What does it do when presented with an F? It’s likely the parts removed in the E recognition process are vital to F recognition. So they would have to be replaced and others removed as F is learned. This is hardly the best example of an automatic process.

In his concluding article on bionics this week, Assistant Editor Lindgren discusses some more reasonable approaches to apparatus that learns by reward and punishment. Their basic simplicity helps these devices adapt themselves to a change of problem without drastic alterations.

One approach looks like a jar of olives. Except the olives are small metal spheres and the vinegar is acid that attacks the spheres and develops a nonconducting layer between their points of contact.

Electric pulses break down the insulating layers between spheres. Since the jar is fitted with electrodes through its wall, these pulses can be applied to any of the outer layer of balls and detected at other chosen locations. The apparatus is rewarded by bonus pulses that maintain a useful conducting path when the desired response is detected. If it delivers the wrong output, it is punished by allowing the insulation layers to reform.

Coming In Our March 23 Issue

SYMBOGRAPHY. As promised a few months ago, we publish next week 500 graphical symbols and letter symbols for electronics diagrams. They will be arranged on one side of a 30 by 11⅛-inch foldout special section.

Another article tells how a tunnel diode working as an oscillator with a saturable reactor provides an excellent frequency-control device, by R. E. Morgan, of GE.

J. W. Martin and J. R. Cox, of Texas R&D Corp., in still another feature, describe uses of a solion tetrode in a chromatograph. An integrator using solion cells can drive a transistor, to operate control circuits.
**Stainless Steel ATTENUATORS by WEINSCHEL**

**Model 210**  
Range: 1 to 20 DB  
Connectors: Type N

The ruggedness and longer life of stainless steel connectors and metal parts make these attenuators exceptional—and only Weinschel makes them. The Model 210 has these additional **Exclusive Weinschel Features:**  
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Write for Weinschel Engineering Bulletin

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**COMMENT**

**The Cocktail Party Effect**

I'm glad to see all this high-level dissertation on the cocktail party effect (Crosstalk, p 3, Feb. 16). I had observed this phenomenon for years—particularly in Washington and New York press parties—but had made no scientific analysis of it.

I had attempted to discuss my observation with other party attendees on various occasions, but at this point in the party the ambient noise level was too high for intelligent conversation. (It's hard to be profound while shouting.)

I finally concluded that my auricle system S/N somehow diminished directly in proportion to either party duration or alcoholic saturation. Thanks for helping clear up this disturbing conclusion. I'm leaving now to pick up some earplugs and go to a cocktail party.  

HAL GETTINGS  
Dynatronics, Inc.  
Orlando, Florida

**Transmission-Line Charts**

In reading the December 1, 1961, issue, I noticed the article Logarithmic Transmission-Line charts (p 48), by H. F. Mathis: In this article, the author introduces the same logarithmic charts that I have published, as early as 1955, in the French periodical *L'Onde Electrique.*

**R. GUILLIEN**  
Director  
l'Ecole Nationale Superieure  
d'Electricite et de Mecanique  
University of Nancy, France

**Professor Mathis sent us a letter he received:**

A few days ago my attention was drawn to an article entitled Logarithmic Transmission-Line Charts. I wish to refer to Fig. 2 (p 50), the Logarithmic Z - 6 chart, which is basically similar to a chart published by the writer twenty-five years ago in the Marconi Review. It was still customary in those days to use hyps or nepers as units of attenuation, and the chart was plotted in those units. Between the chart published by you and the one by the writer there is a difference in origin of abscess coae of 90 degrees or one-quarter wavelength.

I enclose copy of a paper written by three notable Marconi engineers: C. S. Franklin, N. M. Rust and R. J. Witt, on the design and setting up of the feeders and aerials of the world's first television station, at Alexandra Palace, London. It was my job to devise the chart in question to facilitate the feeder and aerial calculations in 1936 for the Alexandra Palace project, and the paper provides examples of its use in that project.

H. CAFFERRAT
Marconi's Wireless  
Telegraph Company, Ltd.  
Chelmsford, Essex, England

Professor Mathis writes that he did not prepare a research paper but one intended to be a working tool, similar to others that had gone before, yet different in some details. He encloses a letter he wrote to Mr. Cafferata, which reads in part:

You may be interested in knowing that E. A. Kennelly published almost the same charts in 1914, in his very large book "Chart Atlas of Complex Hyperbolic Functions," which was published by the Harvard University Press. I did not know this until it was called to my attention by a friend.

H. F. MATHIS  
The Ohio State University  
Columbus, Ohio
**FEATURES**

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- Short Circuit Proof
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### LA SERIES

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<thead>
<tr>
<th>Voltage Range (VDC)</th>
<th>Current Range (AMP)</th>
<th>Price ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-34</td>
<td>0-5</td>
<td>510</td>
</tr>
<tr>
<td>20-105</td>
<td>0-10</td>
<td>560</td>
</tr>
<tr>
<td>75-330</td>
<td>0-15</td>
<td>600</td>
</tr>
</tbody>
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**Temperature Coefficient**

Less than 0.025%/°C.

(1) The DC output voltage for each model is completely covered by four selector switches plus vernier range.

(2) Center of vernier band may be set at any of 16 points throughout voltage range.

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  - LA 8-08B: $395
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Typical of the information in the catalog are discussions of swept frequency measuring techniques, methods for measuring SWR, and measurement of frequency, impedance, attenuation, power and noise figure.

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NASA Selects AT&T as Engineering Consultant

WASHINGTON—NASA is negotiating with AT&T on a contract to provide system engineering support for manned space flight programs, including Mercury, Gemini and Apollo. The Bell System is to provide analysis and fact-finding support, but not hardware.

The arrangement is reminiscent of Air Force contracts for missile and space programs (p 22, Aug. 25, 1961). Air Force first used Space Technology Labs, a profit-seeking organization, and then Aerospace Corp., a nonprofit firm. STL’s parent, Thompson Ramo-Wooldridge, was banned from selling hardware on STL project. Whether a similar ban will be placed on AT&T’s Western Electric will be determined at the negotiation meeting, it was reported.

Dollar amount and duration are also to be negotiated. Duration will probably be one year, subject to renewal. NASA hopes to build up sufficient in-house capability to eventually dispense with this type of contract altogether. An estimated 200 AT&T personnel will be responsible to Joseph Shea, NASA deputy director for manned space flight systems.

Fast-Searching Cryogenic Memory Associates Data

CRYOGENIC associative memory circuit has been developed by General Electric’s Heavy Military Electronics department and Research Laboratory. The device simultaneously compares all stored computer information, associating input data with any portion of related data in the memory. GE says it is the first operative circuit of its kind.

The memory circuit is composed of numerous lead and tin cryotrons, evaporated on a glass substrate. The circuit is kept in liquid helium, at a temperature of -452 F. Leads pass through the flask to room-temperature computing equipment.

GE says the memory’s small size, high capacity and high speed should result in applications in military and commercial computers, including air traffic control, missile detection and satellite monitoring and control.

The engineering model measures 3 by 6 by 1/2 in., contains 81 cryotrons and stores three 3-bit words. Density can be raised to 16 21-bit words. GE estimates that a comparison time of 50 μsec would be needed to locate the first association in a 300,000-bit memory.

West Ford Project Gets Go-Ahead for New Launch

BOSTON—Space Science Board is giving MIT Lincoln Laboratory approval for a second try at West Ford. A 40,000-mi-long orbiting belt of dipoles, 2,000-mi high, is to be used as reflector for intercontinental communications at 8 Gc.

The new payload has been extensively modified. The package launched Oct. 21, 1961, did not dispense its dipoles because the ejected package failed to spin, leaving the fibers clustered. Five or six clumps have been tracked for several months by Lincoln Lab’s Millstone Hill uhf radar equipment.

Besides mechanical redesign, a vhf beacon and telemetry have been added to indicate package position, spin and tumble rate, and dipole dispensing. To make room, the number of dipole fibers has been reduced from 350 million to 250 million, cutting weight to 50 lb.

Dipoles will be ejected on ground command only if the package goes into suitable orbit, to make sure dipoles have limited lifetime. During the wait for the second launch, high-capacity digital data transmission equipment has been tested with the moon as a substitute for the dipoles.

Commerce Department Sees Electronics Rise in 1962

WASHINGTON—Business and Defense Services Administration of the Department of Commerce sees 1962 as another growth year for electronics. More competition, however, will keep profits from rising at the same rate as factory value.

Here are the estimated increases: systems and equipment, $7.2 billion, up seven percent; components, $3.7 billion, up from $3.54 billion; consumer electronics, $1.9 billion, a gain of seven percent, with a rise of 50 to 100 percent anticipated for color tv.

Figures do not include R&D, business expenses and operating revenues. R&D may reach $2.8 billion in 1962. Among the few declining segments are receiving

Court Upholds Pay T.v Broadcasts in Hartford

WASHINGTON—U. S. Court of Appeals last week upheld the FCC’s authority to permit trial operation of pay tv systems. In dispute was the three-year license for RKO’s Phonevision Co. in Hartford, Conn.

Connecticut Committee Against Pay T.v and a group of theatre chains said the FCC could not authorize a broadcasting system which requires payment of fees by the public. The court said Congress gave FCC power to experiment and develop communications facilities.

Phonevision plans to present 40 hours a week of programs over station WHCT, charge from 25¢ to $3.50 a program. The system was developed by Zenith Radio Corp.
tubes, which are expected to drop $10 million, to $350 million. While semiconductor sales will rise $30 million, to $610 million, the profit increase will not be as large, BDSA says.

Ocean-Bottom Seismograph Detects Nuclear Blasts

DALLAS—Texas Instruments is reported to have developed a seismograph which will detect natural earth tremors and distant nuclear detonations when it is placed on the ocean floor at depths to 1,600 fathoms. The station is said to sense, gather and store seismic information automatically. Data is digitally recorded on magnetic tape for later recovery and interpretation. The system was developed as part of Project Vela Uniform.

Another Line of Large Computers on the Market

ANOTHER SERIES of computer systems, the 1800, was announced last week by Minneapolis-Honeywell's EDP division. One system is a central processor which performs more than 120,000 three-address operations a second and has a memory cycle of 2 μsec. A floating-point arithmetic unit operates at nanosecond speeds when used with the processor.

Developed for “very large business and scientific” uses, the two units combined sell for over $1 million. The arithmetic unit makes extensive use of tunnel-diode circuits. Equipment utilizes features of the Honeywell 800 systems and will work with peripheral equipment in the 800 line.

Plan Computers That Read and Make Parts

ROCHESTER, MINN. — Development programs in numerical machine control and also in character reading systems are underway at IBM's General Products division here.

A new laboratory is working on ways to integrate numerically controlled machines into moderately sized manufacturing operations. Aim is a data-processing system that will tie together parts design and manufacturing. Investigations will be made of mechanism synthesis by computer, parts selection and fitting and production techniques for selection and control of machines.

Object of the character recognition program is to develop equipment that is faster and more versatile than optical and magnetic readers now made by IBM. One aim is high-speed alphanumeric readers. Contextual reading, recognizing groups of letters and words, is one technique to be probed.

High-Accuracy Ranging System Contract Given

MOTOROLA'S Military Electronics division in Arizona has won the $3 million contract for R&D on the Goddard Range and Range Rate Tracking System. Using carrier and side-tone modulation measurements, the system is to track near-space and cislunar probes with position accuracy of a few feet and velocity within fractions of a foot per second. Stations are to be transportable, to accommodate different satellite orbits. Development of ground and airborne equipment for NASA will take about a year.

Apollo Will Use Fuel Cells as Power Source

NORTH AMERICAN AVIATION is awarding two competitive contracts for development of fuel cells for Apollo spacecraft. One contract will go to Pratt & Whitney and the other to Tapeo division of Thompson-Ramo-Wooldridge.

The cells, operating on oxygen and hydrogen are expected to provide a lightweight electrical power source, with potable water for the crew as a byproduct.

Ionics, Inc., of Cambridge, Mass., has teamed up with Tapeo. Ionics has developed a unit reported to deliver 250 w at 28 v. It uses a stack of 40 internally-manifolded dual membrane cells.

In Brief . . .

ARMED SERVICES Electro-Standards Agency (ASESA) will move this summer from Fort Monmouth to the new Defense Electronics Supply Center, Dayton, Ohio.

JAPAN'S electronics exports to the U. S. in the first nine months of 1961 were $78.4 million, up 24 percent over the 1960 period.

NASA launched its Orbiting Solar Observatory last week (p 8, March 2). The agency also announced it was establishing its Atlantic and Pacific Missile Ranges as independent field installations.

FORD MOTOR will include all-transistor ignition system as optional equipment on 1963 trucks.

BECKMAN INSTRUMENTS and Toshiba have formed a jointly-owned company, Beckman-Toshiba, in Tokyo. It will produce Beckman products in Japan.

DEFENSE DEPARTMENT patent policies were raped by the Joint Congressional Economic Committee. It wants the Pentagon to follow AEC policies for greater public use of inventions.

BENDIX announces its computer division will specialize in engineering and scientific computers for military and other uses.

R&D CONTRACTS include $200,000 to Electro Nuclear Systems in field of undersea warfare. Tasker Instruments will study analog-digital hybrid computer organization for Air Force.

ANTENNA contracts include $700,000 to Rohr for two more missile range tracking antennas, and $70,000 to Scientific-Atlanta for a tracking system for the Saturn booster.

MILITARY CONTRACTS include $2.4 million to Fairchild Camera & Instrument, tv systems for Talos missiles; $1 million to Kinetics Corp., switching devices for Titan; $800,000 to Manson Labs. for uhf tactical communications for Navy.
METAL FILM RESISTORS

OFFER 5 DISTINCT TEMPERATURE COEFFICIENTS TO MEET ALL CIRCUIT REQUIREMENTS

Providing close accuracy, reliability and stability with low controlled temperature coefficients, these molded case metal-film resistors outperform precision wirewound and carbon film resistors. Prime characteristics include minimum inherent noise level, negligible voltage coefficient of resistance and excellent long-time stability under rated load as well as under severe conditions of humidity.

Close tracking of resistance values of 2 or more resistors over a wide temperature range is another key performance characteristic of molded-case Filmistor Metal Film Resistor. This is especially important where they are used to make highly accurate ratio dividers.

Filmistor Metal Film Resistors, in 1/6, 1/4, 1/2 and 1 watt ratings, surpass stringent performance requirements of MIL-R-10509D, Characteristics C and E. Write for Engineering Bulletin No. 7025 to Technical Literature Section, Sprague Electric Co., 35 Marshall Street, North Adams, Mass.

For application engineering assistance write:
Resistor Division, Sprague Electric Co., Nashua, New Hampshire.

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Mincom Division 3M COMPANY
Los Angeles 25, California - Washington 4, D.C.
WASHINGTON OUTLOOK

A NEW POLITICAL RUMPUS is shaping up over the B-70 program. The House Armed Services Committee, in approving an aircraft, missiles and ships authorization bill for next year, added $320 million to the administration’s $171 million B-70 budget. In unprecedented language, the committee “directed, ordered, mandated, and required” the use of the extra funds.

The present B-70 schedule calls for three stripped-down prototype models of the Mach 3 plane for flight testing. The House committee put in the extra funds to resume development of the bomb-nav, communications, and other electronic subsystems and to expand the program to six prototypes (including one fully-equipped weapon system model).

The committee, in effect, is supporting the Air Force in its fight against Defense Secretary McNamara on the B-70. McNamara showed no sign of changing his adamant stand against a B-70 stepup. He has already refused to spend the extra $180 million voted by Congress for the B-70, is holding this year’s level of spending to $220 million. Odds are the Senate Armed Services Committee and the two appropriations committees will continue the pressure on McNamara.

Air Force has been unsuccessfully pushing for funds to reorient the program toward weapon system status, with eventual production of at least 35 operational-model aircraft. The plane has been redesignated the RS-70 (reconnaissance strike), would be crammed with missiles and reconnaissance apparatus and would no longer function as a conventional bomber with predetermined targets. Its mission would be to roam over enemy territory after an initial ICBM exchange, performing surveillance and selecting strategic targets.

ON ANOTHER CONTROVERSIAL defense project with considerable electronic implications—the Army’s Nike Zeus anti-ICBM—the House Armed Services Committee supported McNamara’s decision to withhold production.

Said the Committee: “These (terminal defense) systems would still not necessarily solve the problem of nuclear fallout from surface explosion outside the defended areas. There is a limit to the range of effectiveness of any terminal defense system.” (The Army reported that a Nike Zeus launched at Kwajalein Island last week intercepted a simulated target missile.)

COMMUNICATIONS SATELLITE CONTROVERSY continues, but Congress is now agreed on one point: it wants to settle the ownership issue this year. Senator Robert S. Kerr privately says he can send a bill to the Senate that will meet with administration approval. He wants to get a bill through the Senate in the next few weeks. The House must still hold hearings, so congressional agreement is likely to be a month or more away.

Predictions are that final legislation will bear the administration label, for political reasons, but with considerable alterations. The three bills now before Congress are the administration plan for public stock offerings, backed by the Department of Justice, but not FCC Chairman Newton N. Minow; Senator Estes Kefauver’s proposal for government ownership, and Kerr’s bill for ownership by domestic and international common carriers.

Big carriers like ITT and AT&T are backing Kerr, industry support is divided between the Kerr and administration plans. Opposition in Congress to the administration plan centers around the unwieldliness of the corporate structure it proposes. Participating communication companies, for example, would have limited control over decisions.

Meanwhile, the administration will meet Premier Khruzhchev’s recent bid for cooperation in space by offering the Soviets a share in a world-wide communications satellite system. This would not affect any U.S. ownership plan.
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TAUT-BAND MOVEMENT has no friction, no hysteresis...gives perfect repeatability. High-tensile band, low-mass suspension is non-destructible in normal use.

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Super-Calibration permits you to upgrade present meter performance, but it also permits you to reduce costs if you are using more complicated instruments now for this level of performance.

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Write for Bulletin 30.

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March 16, 1962
MEASURE VOLTAGE IN THE PRESENCE OF HIGH NOISE WITH NEW FLOATED AND GUARDED INTEGRATING DIGITAL VOLTOMETER

You can easily and accurately measure voltage down to millivolt level, despite large common mode and spurious noise superimposed on the measured signal—with the DY-2401A Integrating Digital Voltmeter. You can use the DY-2401A on a lab bench—or take advantage of complete programmability, BCD outputs, and compatibility with other instruments for systems use.

This totally new instrument provides 140 db effective common mode rejection at all frequencies, including dc, enabling 10 volts of common mode pickup to appear on the signal with less than 1 microvolt error in the DY-2401A reading.

Fully floated and guarded input circuitry blocks induced ac ground currents, or common mode signals, existing between voltmeter and signal source. Additionally, an active integration technique presents the average reading of the input voltage applied during a selected sample period, minimizing error due to noise unavoidably superimposed on the measured signal.

The DY-2401A is the most useful and versatile digital voltmeter available today. Here are some of the additional advantages you receive:

±300% OVERRANGING on the four most sensitive ranges provides additional accuracy and resolution on the commonly used 1-to-3 area.

ALL-ELECTRONIC CIRCUITRY assures maximum reliability, speed and noiseless operation.

BCD OUTPUT referenced to ground retains floating and guarded features when DY-2401A is used with output recorder.

±0.01% OR ±1 DIGIT STABILITY on the four highest ranges.

INTERNAL CALIBRATION SOURCE with ±0.01% per month stability.

10 CPS TO 300 KC frequency and frequency ratio measuring capability enables use as a solid state electronic counter with crystal-controlled time base.

FULL PROGRAMMABILITY with remote control lines referenced to chassis ground to allow system incorporation with complete retention of floating and guarding.

DYMEC
A Division of Hewlett-Packard Company

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DAvenport 6-1755 (Area Code 415) TWX-117-U
SPECIFICATIONS

2401A Digital Voltmeter

RANGE AND MEASUREMENT SPEED:
1-second sample period
99.999 mv, 999.99 mv, 9,999 v, 99,999 v, 999,999 v
0.1-second sample period
100.00 mv, 1,000.0 v, 10.000 v, 100.00 v, 1000.0 v
0.01-second sample period
0.0100 mv, 0.0100 v, 0.1000 v, 0.0100 v, 0.0100 v

±300% overranging on four most sensitive ranges; overload circuit, at approx. 310% of range, automatically switches to 1000 v range.

DISPLAY:
5-digit Nixie readout. Polarity, decimal point, measurement units and overload condition indicated automatically.

COMMON MODE NOISE REJECTION:
Overall rejection, better than 140 db at all frequencies, 160 db at dc, provided by floated and guarded input circuitry with 1000 Ω in low side of measurement pair.

LINEARITY: ±0.005% of full scale or ±1 digit.

STABILITY: ±0.01% or ±1 digit on 4 highest ranges.

INTERNAL CALIBRATION:
Provides stability of ±0.01% per month.

INPUT IMPEDANCE:
Precision 1 megohm, 1 volt range and above; 100 K ohms, 0.1 volt range only.

RECORDER OUTPUT: BCD output referenced to ground.
SIZE: 6½" x 19" x 18½", 48 lbs.
PRICE: $3,950.00.

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5 RANGES including high resolution 0.1 volt rms range.

300% OVERRANGING on the four most sensitive ranges provides additional accuracy and resolution in the commonly used 1-to-3 area.

For Resistance Measurements

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New Amplifier

The new \$465A Operational Amplifier can be used for analog computing functions, as a high impedance integrator, or as a dc amplifier. Features solid state circuitry, low noise photocathode chopper. May also be used as a normal dc amplifier. Two plug-in units are available to switch gain from 1 to 1,000 or to insert your own input and feedback networks for analog work. Open-loop dc gain is 10^6. The amplifier features low noise (3 \mu V rms) and low drift (6 \mu V/day referenced to input). \$425.00.

Amplifier Levels Broadband Power

New \$401A Leveler Amplifier, when used with a directional coupler and an \$431A Microwave Power Meter, modulates microwave signal generators and sweep oscillators so that they provide level output across their operating bands. System output is level \pm 0.1 db to 1.0 db across the band, with no fine grain discontinuities. Output power is constant regardless of load and may be instantly changed in 5 db steps by use of the power meter switch. A microwave amplifier may be inserted in the system ahead of the sampling point to provide 1 watt of level microwave power. \$290.00.

New Output to 5 coupler

In addition to having an internal pulse and square-wave generator with a repetition rate variable from 50 cps to 50 KC for modulating the rf, \$8714A can be driven by external pulses at rates to 1 MC. For pulse burst durations of less than 1 sec, repetition rate may be as high as 2 MC. Sync pulses in advance of the rf pulse and simultaneous with the rf pulse are also provided. \$850.00.

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easier to use instantaneous frequency selection, ideal for repetitive and production testing
easier to handle very compact, new \$ modular construction for bench, rack, or ready portability

$241A Push Button Oscillator

New Probes for hp 428A/B DC Current Meters

$352A Clip-On Current Probe. Has 2\% aperture for making measurements on large cables or waveguides. Provides readings 3 ma to 1 amp or 1 ma to 10 amps depending on whether used with $428A or 428B DC Current Meters. $352A, $300.00.

New Versatility for hp 185 Scopes

New Switching Time Tester

$186A Switching Time Tester plugs into 185 oscilloscopes, makes rapid measurements of transistor, diode and tunnel diode switching characteristics with nanosecond resolution. Also provides convenient means of testing pulse response of high speed circuits. $186A comprises a fast rise pulse generator, single channel vertical amplifier and two power supplies for biasing components under test. Four plug-in jigs are supplied for testing transistors, diodes, tunnel diodes and external networks. $186A, $1,500.00.

New Delay Line

$110A Delay Line (not pictured) permits you to view the leading edge of a signal used to trigger 185 oscilloscopes. A special load incorporated into the 110A compensates for frequency losses in the delay line. The delayed signal is virtually identical to the input signal. $500.00.

New Attenuators

New \$350C and 350D are 500, 600 ohm attenuators, adjustable in 1, 10 db steps to 110 db. Accuracy better than \pm 1 dB, 0 to 110 dB, dc to 1 MC. 5 watts continuous duty. $350C or 350D, \$110.00.

New \$35C and 35D are coaxial attenuators designed for operation from dc to 1 GC. $35C provides 12 db attenuation in 1 db steps; $35D provides 120 db attenuation in 10 db steps. $35C or 35D, \$125.00.

New Push 1 MC Oscillator

$241A, with push button frequency control, gives three digit resolution in selection of frequencies, yet provides utmost simplicity of operation. Ideal for situations where several preset frequencies are required quickly and accurately. Frequency coverage is 10 cps to 1 MC; frequency stability is better than \pm 0.03% from 0° to 55°C. $425.00.

hp 716A Klystron Power Supply

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See back page for new easy-to-use equipment from Boonton Radio, Dymec, Harrison Labs, F. L. Moseley, Sanborn at I.R.E.
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**hp 120B 450 KC Oscilloscope**

The new \$ 120B Oscilloscope combines more desirable features to give you more actual measuring help than any 450 KC scope ever produced. Not only are reading errors from parallax and distracting reflections eliminated, but you have a genuinely unique array of electrical and convenience features for measurements from dc to 450 KC.

Model 120B combines minimum controls with \$ automatic triggering for utmost speed and convenience. Horizontal amplifier dc to 300 KC, phase-shift between amplifiers less than 2°. Balanced input on most sensitive range for noise rejection at low levels. Times-5 sweep expander, all ranges. New modular design for rack or bench use. \$ 120B, \$475.00.
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March 16, 1962
Semiconductor Radiation Detectors

By HAROLD C. HOOD

LOS ANGELES—The nuclear semiconductor radiation detector is changing from a laboratory curiosity to a developmental manufactured device. One estimate of the potential market for semiconductor detectors next year is $3/4 million.

So far, the usefulness of the detectors has been demonstrated in space measurements, probing oil well survey holes, determining neutron spectrums as a function of position in nuclear reactors, and in many industrial process control instruments.

Basic principle upon which the solid-state detector operates is illustrated. In a device developed by Solid State Radiation, Inc., phosphorus is diffused into high-resistivity p-type silicon. An np junction results somewhat less than one micron below the surface and a p-type depletion area extends for several hundreds of microns below. As ionizing radiation crosses this depletion region it gives up energy in the formation of electron-hole pairs. The internal electric field separates the electron-hole pairs and an external circuit pulse, the rise time of which is typically in the nanosecond range, results.

Stephen S. Friedland, SSR president, says the quantity of charge generated within a semiconductor detector from a given nuclear source is 10 times that generated within a gas detector. Formation of an electron-ion pair in gas requires 32.5 electron volts while an electron-hole pair in a semiconductor detector results from 3.5 ev.

One-dimensional detector arrays have replaced photographic plates in space-borne beta-ray spectrometers. The instruments need not be recoverable, since data may be telemetered back to earth, and the spectrum is reported as a continuously changing function of vehicle height. Arrays of 10 elements each were flown aboard Discoverers 29 and 31. Spectrum range was 70 Kev to 1 Mev.

A proton spectrometer under development, using 16 side-by-side detectors for Van Allen belt measurements, will have a range from 10 Mev to approximately 200 Mev. Another, measuring up to 15 Mev, is orbiting in two Navy Transit satellites and reported to be sending back reliable data.

An epithermal neutron spectrometer, sandwiching a thin layer of Li metal between two semiconductor detectors, shows considerable promise in the field of neutron and reactor physics, according to Friedland. One is being used in the Advanced Epithermal Thorium Reactor Program being sponsored by Southwest Atomic Energy Associates at Atomics International. The spectrometer measures the neutron energy spectrum directly with a linear output in the range of 0.5 to 15 Mev. Alpha and triton particles from the lithium-hydrogen reaction deposit energy in the two
Demonstrate Their Practicality

detectors, the total shared energy is summed electronically and its amplitude is linearly related to incident neutron energy (see block diagram).

Other neutron detection devices use semiconductor detectors coated with suitable neutron-to-charge particle converter materials such as B³⁺, U²³⁵, H, and Np²³⁹.

Another two-dimensional array device developed at SSR is a beam profiler of pulsed beams from large particle accelerators. Presentation of the beam during each burst of particles is used to measure flux density near a nuclear reactor and for nuclear reactor emission diagnostics.

Three-dimensional arrays, the company says, may be feasible for cube-shaped cloud chambers. By feeding coordinates and pulse heights of triggered detectors into a computer, it may be possible to compute instantaneously the total energy and identify the particle. Under investigation is the possibility of substituting a continuous slab of semiconductor material in this application, to reduce the number of amplifiers and power supplies needed.

A spokesman for Jet Propulsion Laboratory is optimistic about space applications for both diffused junction and gold-silicon surface barrier types of semiconductor detectors. They are inherently small, rugged, fast, and have low power requirements. Reliability expectations will be studied since anticipated uses call for lifetimes of three months to several years.

Size depends only on requirements for attaching leads to the two sides of detectors and for mounting. JPL expects several of the interplanetary Mariner and Voyager probes to fly SSR units and points out that semiconductor detectors have little competition in measuring many parameters important in space work, such as charged particles. However, crystals like sodium iodide and cesium iodide, used with multiplier photo tubes, will remain the only practical devices for measuring gamma rays in near future, JPL says.

SSR adds that the future of the new detectors must be evaluated with caution. As yet, life characteristics of the device are unknown and some shelf deterioration has been reported. Some devices may exhibit excellent properties one day, be of questionable use the next and return to excellence the third day. A correlation of transistor production techniques with those of semiconductor detectors is expected shortly to give detectors the reliability shown by transistors. Also under investigation is the effect of nuclear radiation damage on the detectors. After large doses, some fast neutron damage has been noticed.

Exposure to comparable gamma ray fields produces similar deterioration.

Other companies actively engaged in nuclear semiconductor detector development include Ortec, RCA of Canada, and Hughes.

### Molecular Circuit Version of AN/ARC-63

Westinghouse Electric and the Air Force this month showed a molecular circuit version of the AN/ARC-63 emergency communications receiver. It weighs 2-lb, compared to 5 lb for the conventional set. The number of parts was reduced from 219 to 82, including nine functional blocks (mixer-oscillator, three 5-f and two a-f amplifiers, audio detector, differential and two-stage age d-c amplifiers).
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PROBLEMS AND PROPOSALS:

Manned Spacecraft Landing Systems

By ROY J. BRUUN
Assistant Editor

ONE OF THE KNOTTIEST problems now facing manned space system designers is how to bring the vehicle in safely through reentry to a controlled touchdown on land.

Several electronics companies are now designing landing systems. Approaches range from an instrument landing system incorporating available subsystems, proposed by GE, to an on-board adaptive control recommended by General Precision Labs. Raytheon leans toward an airborne guidance system with ground support equipment. Sperry takes a pilot-oriented approach.

The system under development at General Electric's Systems division would regulate the descent path from 500 miles out. The vehicle path would be controlled to dissipate the kinetic energy without overheating or overstressing the vehicle. Landings can be made under automatic control, or the pilot can use a display and perform designated control responses.

GE says over 100 landings have been simulated with the system, on an analog computer, and that it is ready for application to specific vehicles.

Subsystems include the AN/TPQ-10 radar being produced for use by the Marine Corps in close-support bombing operations, a GE 225 computer and airborne beacon and decoder (Mod III G). The latter is similar to units developed as part of a radio command guidance system for launching ICBMs and boosters. Airborne weight is 28 lb.

System operation is outlined in the block diagram. Radar data enables the computer to compute position and velocity and generate satisfactory flight paths. Flight commands go to the vehicle over the radar link until the vehicle comes in for a landing at its particular stalling speed. Accuracy is expected to be 1 to 2 fps.

GPL's report on its study program says that the complexity of landing a spacecraft may require an on-board adaptive control system. Adaptive systems respond instantly to operational conditions, not pilot or ground control. The adaptive system would back up ground-based regulator and servo-type systems.

An adaptive system, GPL feels, could cope with unpredictable operating variables. It could, for example, interrelate flight parameters to stall the vehicle the required few feet above the runway. Reasoning is that since vehicle, position and environmental parameters cannot be accurately foreseen, closed loop control is needed.

The regulator control system requires establishment of a reference trajectory and would act on deviations from that reference. The servo control system would control from existing position and conditions along a path estimated according to predicted future conditions. The adaptive backup system would make a "best estimate" of the effects of sudden changes in variables and controls.

Another argument in favor of including adaptive controls, GPL says, is the difficulty of maintaining air-ground communications through the ionized air that would sheath the reentering vehicle.

GPL stresses that the first consideration in manned vehicles is personnel safety. Provision should be made to monitor life-support equipment and operate emergency equipment. If retrorockets misfire, for example, the pilot should be able to transfer into an orbit transsecting the fringes of the atmosphere.

Raytheon has been studying and planning instrumentation for a recovery control to be established at the Air Force Flight Test Center, Edwards AFB, Calif.

A company spokesman says that
the weight penalty of maneuvering engines makes it likely that spacecraft will be gliders, creating severe terminal guidance problems. The trajectory of the approaching vehicle “may be viewed as a string whose slack may be oriented in many different ways” relative to the direct line between reentry and landing points.

The guidance system, he says, must enable the vehicle to fly a large number of “nominal trajectories which together encompass all the vehicle’s maneuver potential.” Raytheon says the system could compute trajectories or select them from storage. However, real-time computation is difficult to achieve. Large, rapid-access storage would be required since it is uncertain whether taped data could be searched in time. Even if a trajectory is found quickly enough, the problem of controlling the vehicle remains. A glider’s position and velocity cannot be forced to correspond to a trajectory.

Raytheon points out other guidance problems. Radar, the traditional ground-based instrument, gives only position and range rate information. Errors are introduced when vector velocity is computed. While inertial guidance systems measure velocity accurately, their position information is not reliable during the terminal portions of a flight. Inhibition of communications by the reentry plasma sheath would depend on vehicle characteristics and communications frequencies.

Raytheon feels that reliability problems favor basing the system’s principal components on the ground. But economics and versatility favor an entirely airborne system. With an airborne system, the vehicle could land at locations not equipped with ground-based equipment. The ultimate solution will probably be a combination of ground and airborne equipment, Raytheon says.

Further analysis of the problems and equipment requirements—particularly line-of-sight instrumentation, computers and terminal equipment—is needed, the company says.

Sperry engineers are developing a space vehicle landing system that consists of a control radar unit housed in a highway van and transponder equipment located in the spacecraft to receive and transmit coded radar signals. Called Man (Microwave - Aerospace - Navigation), it has been in development 1½ years. A company spokesman recently said that “it is possible that radar line-of-sight limitations will necessitate the use of an airborne-relay-mode of operation or the addition of an auxiliary ground station.”

Sperry engineers see earth-based recovery systems for manned vehicles as primarily a pilot aid. To determine this, Sperry conducted extensive investigations of re-entry recovery and landing of unmanned glider vehicles. This study is reflected in the illustrated system in which a “ground pilot” assumes pilot functions. Ground pilot controls the “transition (re-entry) maneuver and navigation to a high key point.” As the vehicle approaches flare-out and touchdown, phases during which time and computational factors become more critical, the automatic (computer-controlled) mode is used with the ground pilot monitoring the operation and overriding the control in the event of emergency (failure) conditions.
French Ready Implosion-Proof Tv Tubes

By ARTHUR ERIKSON
McGraw-Hill World News

PARIS—What wasn’t displayed had industry insiders buzzing at the Fifth International Electronics Components Show held here recently.

Implosion-proof tv picture tubes were whisked off the stands of two manufacturers as the show opened. The official explanation: French safety regulations require a protective glass in front of picture tubes, so the new versions won’t be released until this requirement is changed. But some informed showgoers felt the real reason was set makers’ worries that news of an important tube development for next year’s sets would keep hesitant prospective buyers out of the market for a while longer.

It’s an open secret that SOVIREL, a company that supplies the glass for French-made picture tubes, is producing tubes with a fused steel coating that extends about four inches back from the face. The fused steel checks the spread of fissures should the glass crack. La Radiotechnique by midyear will have on the market an implosion-proof tube, developed jointly with SOVIREL, with a tight polyester-glass sheath applied under pressure. The sheath extends about halfway back and there is a metal band around the edge behind the face.

Displays underlined a steady technological advance. CSF, for example, has an experimental O-type Carcinotron with 10-mw output at 0.7-mm wavelength. Thomson-Houston showed a high-power klystron with 25-Mw peak and 30-Kw average output over a frequency range of 2,700-3,100 Mc (with two tubes), up from 5-Mw peak and 10-Kw average last year.

French instrument makers are also climbing toward higher frequencies. Ribet-Desjardins, for one, displayed a sampling oscillograph with two identical channels having a passband of 0.5 nsec. Chauvin-Arnoux has a microvolt-ammeter, accurate to 3 percent, that can measure a-c currents to 1 amp at frequencies to 1 Mc. D-c component has no effect on the reading, made with a microclip transformer so the circuit doesn’t have to be disconnected.

A brushless variable transformer provoked considerable interest. In S.E.I.M.’s Variovolt, the lamination stack for the primary magnetic circuit is split along the line of zero flux and spring-loaded against a rotor carrying the secondary winding. This arrangement eliminates air gap between the primary and secondary, so losses are no more than in a fixed transformer. A nickel-stainless steel tube screens the secondary, which is completely isolated from the primary. Ratings run to 2 Kva. Output voltage varies steplessly from zero to 200, 300 or 500 volts, depending on the angle of the secondary winding.

S.T.A.R.E.C. showed a coaxial relay that switches within 10 ms either of two coaxial inputs to a single output. The unit handles up to 3 kw at 100 percent, modulation, has vswr less than 1.05 over a frequency range from zero to 400 Mc.

CSF’s electrostatic relay integrates low-level outputs from de-

TEMPTING MARKET

PARIS—Sales curves for the French electronics industry are moving up. The Federation Nationale des Industries Electroniques said 1961 sales topped $800 million, 21 per cent over 1960. Components accounted for more than a third of the total. A market like that tempts manufacturers from other countries and the show reflected the temptation. A full third of the 600-odd exhibitors were non-French. West Germany led the outsiders with 67 exhibitors followed by the U. S. with 57.
Digital Computer Will Run Red Lights in LA

Los Angeles is making a pilot installation this spring of a traffic control system run by a digital computer. In the initial installation, it will operate 26 lights along four miles of Sunset Boulevard and 10 lights on approach streets. Traffic flow data will be telephoned from automatic detectors to a Thompson Ramo Wooldridge RW-300 computer at City Hall.

West Germany May Join Private Satellite Net

Boston—It is likely that West Germany will build a ground station for Telstar, Bell Telephone Lab's communications satellite experiment (p 26, Feb. 16). The station would be in addition to one at Andover, Me., and those planned in England and France, John R. Pierce said at an MIT lecture.

Among other comments, Pierce expressed skepticism that the state-of-the-art is ready for the Army Advent Project to place a satellite in synchronous orbit. For communication satellite networks, he remarked, high-power, long-life equipment should be developed now, even before reliable boosters are ready. Among needs are masers not dependent on gas liquefaction and five-year attitude controls.

Pierce said that of satellites launched to date, only Vanguard I had anything like the lifetime needed. Telstar, he said, approaches the limits of today's art.

March 16, 1962
Kerr Cell Camera Films in 5 Nsec

Los Angeles—Complete photographic records of high-speed physical phenomena have been made possible by development of a framing camera with Kerr cell shutters, reports Electro-Optical Instruments, of Pasadena. The camera takes six frames at a rate of 100 million frames a second with exposure times as brief as 5 nsec.

Collected by an f/3.5 objective lens with a focal length of 10 in., light is split into six beams by a six-faced, silvered prism, allowing separate images of the same event, from the same aspect, to be seen through the same set of optics.

The control system includes six channels of regenerative and passive trigger delays, modular pulse generators and pulse-forming networks, and series or parallel synchronous selectors.

Interframe time is continuously variable from 5 to 700 nsec. Framing rate is independent of exposure time and optical resolution. The latter two can be selected arbitrarily to accommodate the available light and the rate of the event.

The camera is intended for studies of explosive hydrodynamic phenomena, classical explosive propagation, exploding wires, and hypervelocity impact. The high energy densities of these phenomena allow self-luminous photography at very brief exposure times. For rapid evaluation, photos can be made on Polaroid film.

Minnesota Sets Week Aside for Electronics

Minnesota last week celebrated its growth in electronics with exhibits in St. Paul and Minneapolis and the dedication of new graduate facilities at the University of Minnesota.

State officials now consider the industry a prime element in the state's economy. A spokesman for Gov. Elmer L. Anderson said new electronics plants reversed a downward trend in employment during 1959 and 1960.

In 1955, 26,135 Minnesotans were employed in electronics plants. By the end of 1961 there were 44,438 and another 1,500 jobs were anticipated in 1962. The number of companies increased from 89 in 1955 to 157 by 1962.

Growth of the industry has been aided by a gubernatorial committee set up by Orville Freeman, now U. S. Secretary of Agriculture (Electronics, p. 30, June 17, 1960).

Development of suburban industrial parks is being pushed. Last year in the New Hope region, for example, the Twin Cities Science Industry Center saw new plants for National Connector, Miniature Instruments, Electro Nuclear Systems and Nedmac.

A regional research institute is in the final planning stages, under direction of W. G. Sheperd, chairman of the gubernatorial committee and head of the university's department of electrical engineering.
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MEETINGS AHEAD

AUDIO ENGINEERING SPRING CONVENTION, AES; Ambassador Hotel, Los Angeles, Mar. 19-26.

IRE INTERNATIONAL CONVENTION, Coliseum & Waldorf Astoria Hotel, New York City, Mar. 26-29.

QUALITY CONTROL CLINIC, Rochester Society for Quality Control; University of Rochester, N.Y., Mar. 27.

ENGINEERING ASPECTS OF MAGNETOHYDRODYNAMICS, AIEE, IAS, IRE, University of Rochester; University of Rochester, N.Y., Mar. 28-29.

QUALITY CONTROL ADMINISTRATIVE APPLICATIONS CONFERENCE, American Society for Quality Control; University of Montreal, Canada, Mar. 29-30.

READ-ONLY DIGITAL COMPUTER MEMORIES DESIGN & APPLICATION DISCUSSION, Institution of Electrical Engineers (British); Savoy Pl., London, April 3.

ELECTRONIC & ELECTRICAL INDUSTRIAL-COMMERCIAL EQUIPMENT SHOW, Electrical Manufacturers Representatives Association; Artillery Armory, Detroit, April 4-6.

CHEMICAL & PETROLEUM INSTRUMENTATION SYMPOSIUM, Instrument Society of America; DuPont Country Club, Wilmington, Delaware, April 9-10.

NONDESTRUCTIVE TESTING CONFERENCE, SNT; Pick-Carter Hotel, Cleveland, Ohio, April 9-13.

BUSINESS EQUIPMENT EXPOSITION, Business Equipment Manufacturers Association; McCormick Place, Chicago, April 9-13.

PLASMA SHEATH SYMPOSIUM, AF Cambridge Research Labs; New England Mutual Hall, Boston, April 10-12.

SOUTHWEST IRE CONFERENCE AND SHOW; Rich Hotel, Houston, Texas, April 11-13.

JOINT COMPUTER CONFERENCE, IRE-PGEC, AIEE, ACM; Fairmont Hotel, San Francisco, Calif., May 1-3.

HUMAN FACTORS IN ELECTRONICS, IRE-PGEC; Lafayette Hotel, Long Beach, Calif., May 3-4.

ELECTRONIC COMPONENTS CONFERENCE, IRE-PGEC, AIEE, EIA; Marriott Twin Bridges Hotel, Washington, May 8-10.

AEROSPACE INSTRUMENTATION SYMPOSIUM, Instrument Soc. of America; Marriott Motor Hotel, Washington, D.C., May 21-23.

ELECTRONICS PARTS DISTRIBUTORS SHOW, Electronic Industry Show Corp.; Conrad Hilton Hotel, Chicago, May 21-24.

NATIONAL AEROSPACE ELECTRONICS CONFERENCE, IRE-PGEC; Biltmore Hotel, Dayton, Ohio, May 22-24.


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The instrument consists of a source, chopper, attenuator, monochromator and a power monitor.

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Designing Equipment for Nuclear Environments

How equipment and components are affected by radiation of high dosage, low dose rate and low rate of change of flux level radiation. Damage is illustrated with simple models of the structure of matter.

By P. BARRATT
Pte Ltd. Cambridge, England

A previous article in Electronics discussed the effects of transient radiation on electronic circuits.

Here, a different radiation environment, characterized by high doses but comparatively low dose rates and rates of change of flux levels is considered. Table I illustrates the differences between weapon explosion and reactor environments.

Electronic component behavior is only one aspect of the design problem: to it must be added: equipment activation; radiation heating; mode of equipment use and compatibility of the equipment with its environment, involving chemical and radiation properties.

Experimental data are still limited and theoretical predictions must frequently be qualitative rather than quantitative. For these reasons an approach is outlined which has proved valuable in this type of work. The aim is practical, that of building up background knowledge to help resolve design problems when there are no guides.

The starting point is the expression of the structure of matter in terms of simple models, followed by the study of radiation damage in relation to the models. These aspects are sufficient for the determination of significant radiation types and the assessment of the relative suitability of available components of a given type. Published data, with their uncertain...
ties as to the precise flux spectrum and irradiation temperature, need be used only to indicate the order of magnitude of significant doses or dose rates. In this work, too great reliance upon figures is inadvisable since the equipment is probably intended to work in an ill-defined environment. But, in some cases, radiation must be counted at least as important as such items as temperature and pressure.

Figure 1A shows the doses and dose rates encountered. Note that equipment within caves used for handling active material receives doses several decades greater than in the vicinity of a nuclear explosion. Television equipment used in shut-down reactors is regularly subjected to $10^4$ R hr$^{-1}$ of gamma radiation and receives total doses well in excess of $10^4$ R during its life. Gamma doses of $10^5$ R hr$^{-1}$ can occur in a working reactor.

There are a number of other situations in which moderate doses can be received, like near accelerators or active sources. These have been discussed already in more detail. 

The conditions requiring electronic parts and equipment to be exposed to radiation can be readily summarized. Humans can be exposed only to radiation levels which are low relative to those commonly used in nuclear technology, hence they cannot be used directly as a control or observing agent. This results in a demand for remote observation, control and transmission.

Knowledge of the basic structures of materials is essential in interpreting and predicting radiation effects. The important features may lie in nuclear or electronic properties, lattice arrangements, chemical bonding and molecular orientation. Often, the detail in which a material must be considered depends on the property.

Mechanical and some physical properties can often be explained in qualitative terms without considering finer scale detail than the molecular. Physical properties such as electrical resistivity are related more to the electronic configurations.

Consistent with these simplifications, only four classes of materials (metals, inorganics, organics and semiconductors) need be distinguished. Figures 1B, and 2 illustrate the following discussion.

Metals are represented as an assembly of ions with a large number of free electrons. Ionization effects, such as occur with gammas, are not expected to produce appreciable damage since the changes in electron concentration are relatively small. However, particles can dislodge atoms from lattice positions, giving changes in mechanical properties and small changes in electrical properties as electrons are obstructed by the disruption of the orderly lattice. There is a similarity with a simple picture of heat conduction, but radiation can give far higher local energy concentrations than occurs with thermal effects. When nuclear reactions occur their products are impurity atoms.

Inorganic materials are characterized by more marked chemical bonds than occur with metals. The covalent bond implies the presence of ions, and again there is comparative insensitivity to ionization. However, ionization sensitivity is greater than for metals.

Organic compounds are often complex assemblies of groups of atoms and are taken to include silicon-based as well as carbon-based materials. All types of radiation can cause considerable damage since ionization breaks the chemical bonds that determine the material properties. This sensitivity to radiation is in accord with the greater sensitivity to temperature increase that is found with the two previous groups. High melting point is frequently allied with resistance to radiation. Polymers—long chains of groups of atoms forming one, two or three-dimensional networks—are particularly important. Orientations and lengths of the chains are important in determining properties.

Semiconductors are only the borderland between metals and non-metals but their importance in electronics warrants specific treatment. The complexities of the semiconducting state are well known and radiation effects considered in detail are equally complex. Nevertheless, many effects can be explained using conventional ideas of charge carriers. The crucial point is the sensitivity of properties to small changes in charge carrier concentrations.
These four classes correspond to the classification of radiation damage effects and are convenient for grouping components of a given type. For example, capacitors may rely on organic or inorganic dielectrics.

Mention should be made of dislocations, a useful concept in considering solid-state behavior. They are imperfections in the structure and can give the material different properties to those it would have with a perfect lattice. They may represent weak points in the structure or sinks for other defects. This discussion cannot pretend to be even a survey of the useful models but, with the following section, it shows the value of a superficial approach to solid-state physics in the practical application of radiation damage concepts. Further information is available. Table II includes all types of radiation that may be encountered. The list can be reduced considerably: except in special cases, equipment containers or distance itself will remove all but neutrons and gammas. A possible exception lies in beta particles: viewing equipment may require the exposure of optical components to appreciable beta levels. Neutrons and gammas are most significant since the other particles show damage behavior similar to that of neutrons.

Before summarizing the most important mechanisms it is useful to define the threshold energies which radiation must possess to produce significant changes in material. There is considerable dependence on atomic weight but Table III, indicates the general situation. The values given assume that a lattice displacement requires an atom to be given 25 eV.

As the discussion of material structure indicates, the properties of matter depend either on how its constituent atoms are located spatially (the lattice) or how they are held together (bonding), or both. Radiation effects can be considered as displacement effects in which atoms are moved, with resulting disturbance of electrons, and ionization effects in which the atom remains in its lattice position but the local electron configuration is changed. Particulate radiation therefore produces both displacements and ionization while gammas show predominantly ionizing action. Displacement effects can be further broken down into vacancies and replacement collisions. Vacancies are created when an atom leaves its lattice site and comes to rest in interstitial positions of unstable equilibrium. Neutron reactions produce new nuclides which are then impurity atoms. Replacement collisions occur when one displaced atom ejects another from its lattice site, which it then occupies since it has insufficient energy to leave. Figure 3 illustrates a number of the damage mechanisms.

These concepts agree with the observed types of damage. Effects range from permanent damage, which can only be partially annealed out to temporary effects which disappear as soon as radiation is removed. Many materials show such limits of behavior, while others show both effects with widely varying relaxation times for partial recovery from the damage.

Figure 4A shows the characteristics symbolically, but the association of total dose effects with displacements, and of rate effects with ionization is not generally valid.

Materials classification and radiation effects can now be brought together:

Metals are virtually insensitive to gamma radiation (apart from heating effects) and fast neutron doses of at least 10⁵ n cm⁻² are necessary before displacement effects produce significant changes in properties, such as resistivity and density, that are important from the electronic viewpoint. Magnetic properties may be affected by doses that are a decade lower.

Inorganic materials show more sensitivity: optical properties are affected by both neutrons and gammas in, for instance, glasses. Displacement effects lead to significant density changes for doses of 10⁴ n cm⁻². As a working rule for insulators, a dose of 10⁵ n cm⁻² leads to expan-
sions of the order of 1 percent in insulating materials, and below this, expansion is linearly related to dose. Glasses may shatter for neutron doses in excess of about $10^6$ n/cm$^2$. Their optical transmission may be affected by gamma doses of only $10^3$ R or neutron doses of $10^4-10^5$ n/cm$^2$. Where comparison is appropriate, inorganic compounds are sensitive to doses a decade lower than those which are important with metals in the same application.

Organic materials may become effectively different materials for comparatively low doses. Changes in mechanical rather than electrical properties prevent their usage. The increase in conduction resulting from ionization can be considerable. Polymers are particularly susceptible. Figure 4B shows two of the important effects — cleavage and cross-linking — the breaking of chains and setting-up of bonds between chains. Processes such as this leave free radicals which enter into new chemical reactions. An important example is the evolution of gases within plastics, leading to clouding and swelling. In some cases gases may have a corrosive effect.

Generally, cross-linking produces a more rigid material while cleavage weakens it. Organic materials differ in their susceptibilities and it must be emphasized that the many variations within a particular type prevent generalizing as to the behavior of individual examples. For instance, fillers may modify radiation resistance considerably. Silicones in general show behavior similar to carbon-based materials. A total neutron dose of $10^3$ n/cm$^2$ represents the limit for virtually all plastics and some are useless by $10^4-10^5$ n/cm$^2$. The corresponding gamma doses are $10^4-10^5$ R, as lower and upper limits.

Semiconductors are extremely sensitive. Silicon and germanium show considerable property changes by $10^3$ n/cm$^2$ or about $10^4-10^5$ R of gamma. Again there are considerable variations from material to material and property to property, but the use of semiconductive materials in radiation fields should be avoided as far as possible.

With all four classes of material the degree of radiation damage depends not only upon the radiation but also upon previous history, irradiation temperature and impurities. With neutron fields, since the energy thresholds of gamma reactions are usually too high, components should be selected to minimize activity after irradiation. The possibility of contamination of the equipment by active material affects design of the equipment casing only; it is desirable to contain the electronics fully to avoid compatibility problems.

Assessment of the relative merits of two materials from the neutron activation aspect is complicated by the types of active nuclides which are produced in the parent material, irradiation time and decay time. It is necessary to define the period for which the equipment will be irradiated because this determines the nearness of approach to saturation activity. Decay time is important since the active nuclides will decay at different rates. Figure 4C summarizes the general cases while Table IV lists the active nuclides formed by irradiation of some commonly used materials.

Frequently only one nuclide is important and the problem can then be stated simply. Time $T_s$ is defined as the decay time at which samples of two materials that have received identical irradiations have equal activities. If handling is required before $T_s$ has elapsed, one material is used, if later than $T_s$, the other.

Two simple expressions apply for short and long irradiation times. If $t_s = \text{half-lives of active nuclides in elements } a \text{ and } b$, $A_s = \text{atomic weights of parent nuclei}$, $T_s = \text{irradiation time}$ and $\delta_s = \text{activation-cross sections of parent}$

---

**TABLE II — RADIATION**

<table>
<thead>
<tr>
<th>Name</th>
<th>Mass</th>
<th>Charge</th>
<th>Nature</th>
<th>Sources</th>
<th>Typical Shielding Materials</th>
<th>Ranges in Air (energy dependent)</th>
<th>Radiation Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutron</td>
<td>1</td>
<td>0</td>
<td>Basic particle; radioactive</td>
<td>Reactors, Nuclear reactions</td>
<td>Water, concrete, boron</td>
<td>Up to 100'000 of feet</td>
<td>Lack of charge gives high penetration; hence distributed damage. Displacements and ionization</td>
</tr>
<tr>
<td>Electron (e)</td>
<td>1.67</td>
<td>-1</td>
<td>Basic particle; stable</td>
<td>Accelerators, Reactors, Nuclear reactions, Active materials</td>
<td>Plastics</td>
<td>Few feet</td>
<td>Easily stopped; damage is a surface effect</td>
</tr>
<tr>
<td>or Beta (β)</td>
<td>1</td>
<td>-1</td>
<td>Basic particle; stable</td>
<td>Accelerators, Reactors, Nuclear reactions, Active materials</td>
<td>Most materials adequate</td>
<td>Inches or less</td>
<td>Charged; easily stopped; displacements and ionization</td>
</tr>
<tr>
<td>Proton (p)</td>
<td>1.67</td>
<td>+1</td>
<td>Proton + neutron; stable</td>
<td>Accelerators, Nuclear reactions</td>
<td>Most materials adequate</td>
<td>Inches or less</td>
<td>&quot;</td>
</tr>
<tr>
<td>Deuteron (d)</td>
<td>3.34</td>
<td>+1</td>
<td>Deuteron + neutron; stable</td>
<td>Accelerators, Nuclear reactions</td>
<td>Most materials adequate</td>
<td>Inches or less</td>
<td>&quot;</td>
</tr>
<tr>
<td>Alpha (α)</td>
<td>4.80</td>
<td>+2</td>
<td>Helium nucleus; 2n + 2p; Stable</td>
<td>Reactors, Nuclear reactions, &quot;Natural&quot; Radioactivity</td>
<td>Most materials adequate</td>
<td>Inches or less</td>
<td>&quot;</td>
</tr>
<tr>
<td>Fission Product (β/γ)</td>
<td>Variable</td>
<td></td>
<td>Remnants of atoms which have undergone fission, May be: U, Pu, Th</td>
<td>Nuclear fission of, Nuclear reactions, Reactors, Accelerators, Active materials</td>
<td>Most materials adequate</td>
<td>Inches or less</td>
<td>&quot;</td>
</tr>
<tr>
<td>Gamma (γ)</td>
<td>0</td>
<td>0</td>
<td>Electromagnetic radiation, wavelengths of $10^{-1}$ to $10^{-11}$ cm</td>
<td>Nuclear reactions, Reactors, Accelerators, Active materials</td>
<td>Load</td>
<td>Up to 100'000 of feet</td>
<td>Penetrating; distributed damage; ionization</td>
</tr>
</tbody>
</table>

---

electronics
nuclei; then the decay time is

\[ T_e = \frac{1.44 L_e}{L_e - L_r} [\ln (A_e/A_r) - \ln (A_r/A_b)] \]

for \( T_e > > t_e \), and

\[ T_e = \frac{1.44 L_e}{L_e - L_r} [\ln (A_e/A_r) + \ln (t_e/t_r)] \]

for \( T_e << t_e \).

These expressions apply to equal masses of the two elements; an equal volume basis yields different results.

Use of these limits can still give results of practical interest since they may not differ by a great amount. The general expression for \( T_e \) does not show any maxima or minima between the two limits, that is, \( T_e \) does not lie outside these limits for any intermediate irradiation time.

Comparison of equal masses of iron and aluminum gives \( T_e \) values of 57 m and 13.15 m for short and long irradiations; hence for immediate examination, iron is preferable; if a decay time of an hour or more is permissible then aluminum is the correct choice.

Correct selection can reduce component activities by factors of 100 or greater.

Energetic particles or photons are capable of giving considerable heating effects as they give up their energy. Except for a few elements with high thermal neutron absorption cross-sections, thermal neutrons (0.005—0.5 ev) produce negligible heating compared with fast neutrons (0.1—10 Mev) since the fluxes are usually comparable in thermal reactors—the only location in which neutron heating is likely to be important.

Thermal neutrons may, however, lead to activation and the subsequent emission of energetic particles, for example, 2.87 Mev betas from Al.

Gamma heating and fast neutron heating frequently have similar magnitudes and the effect is uniformly distributed throughout the material since both radiations are penetrating. Beta particles generally produce only surface heating.

In a reactor, gamma heating is usually due primarily to prompt fission and \( ^{235} \text{U} \) capture gammas, hence the heating rate is proportional to the reactor power or flux level.

Published data\textsuperscript{9, 10} agree with theoretical estimates in suggesting heating rates of the order of 0.5 watt gm\textsuperscript{-1} for gamma levels of 10—

10\textsuperscript{4} R/hr; taking 1 joule/gm deg C as a typical specific heat, this implies temperature rises of 30 deg C/min assuming no heat losses.

The heating problem can be minimized by: choice of material, provision of conduction paths to a heat sink such as a reactor coolant and designing for the anticipated temperature rises. The high thermal capacity gained by increasing the

---

**TABLE III—THRESHOLD RADIATION IN EV TO PRODUCE DISPLACEMENTS**

<table>
<thead>
<tr>
<th>Radiation</th>
<th>Atomic Weight of Material Atoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutron, Protons</td>
<td>10, 100, 200</td>
</tr>
<tr>
<td>Alpha Particles</td>
<td>75, 169, 325</td>
</tr>
<tr>
<td>Fission Fragments of Alpha</td>
<td>76, 23, 27</td>
</tr>
<tr>
<td>Atomic Weight 100</td>
<td>10</td>
</tr>
<tr>
<td>Gamma, Electrons</td>
<td>6.8x10\textsuperscript{-3} 1.1x10\textsuperscript{-1}</td>
</tr>
</tbody>
</table>

---

*March 16, 1962*
mass of material is no solution since the total heating rate is, to a first approximation, also proportional to mass. The provision of suitable sensing elements is desirable; thermistors are usable at fluxes of 10¹³ n/cm² sec and thermocouples are usually satisfactory.

Absorption mechanisms cannot be described within the scope of this article, for further details references 4 and 12 could be consulted; the constants necessary for calculations are readily available. It is most important to obtain a good representation of the radiation energy spectrum before attempting predictions.

Summaries of experimental results and bibliographies have already been published. These, with experience, form the basis of the summaries. Remember that pre- and postirradiation measurements will not necessarily indicate component performance under irradiation. Figure 5 relates electronic component damage to that of materials.

Some types of tubes may fail with neutron doses of about 10¹³ n/cm² but others are still satisfactory after doses in excess of 10¹⁴ n/cm². Envelope failure due to neutron damage is a common cause, particularly with boron-containing glasses. Gamma radiation colors the envelopes but is usually significant only in tubes such as thyatrons, multiplier phototubes, and vidicons which are ionization sensitive. Tubes may be used for neutron doses in excess of 10¹⁴ n/cm² and gamma doses of at least 10¹⁰—10¹¹ R.

Ceramic, glass, and mica dielectric capacitors are, as would be expected, most satisfactory, typically showing capacitance decreases of a few percent for 10¹⁴ n/cm² or more. For the same dose, plastic dielectrics can show variations of 10-20 percent, and paper capacitors up to approximately 80 percent. Plastic dielectrics will be affected far more drastically by gammas than the inorganic dielectrics. Boron-containing electrolytics may fail with 10¹⁴ n/cm², and oil-filled capacitors are prone to gas evolution.

Tantalum electrolytics have good resistance (a capacitance maximum for 10¹⁴—10¹⁵ n/cm² was noted in one type) and are rather better than plastic dielectric capacitors. Effects on power factor are small but appreciable changes in leakage current have been measured. Generally, capacitors can be chosen to match the performance of the tube.

Resistances up to at least 10 megarons are insensitive to radiation damage. Observed resistance decreases may be due to ionization giving external conduction paths. Wire-wound and metal-film types will probably withstand at least 10¹⁴ n/cm² and have negligible sensitivity to large gamma doses. Possible weaknesses lie in the former and in the insulation. Typical re-

---

**FIG. 5—Radiation damage to materials and electronic components**

<table>
<thead>
<tr>
<th>MATERIALS</th>
<th>COMPONENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>10¹³</strong></td>
<td><strong>10²⁰</strong></td>
</tr>
<tr>
<td>10¹⁴</td>
<td>10²¹</td>
</tr>
<tr>
<td>10¹⁵</td>
<td><strong>10²²</strong></td>
</tr>
<tr>
<td>10¹⁶</td>
<td><strong>10²³</strong></td>
</tr>
<tr>
<td>10¹⁷</td>
<td><strong>10²⁴</strong></td>
</tr>
<tr>
<td>10¹⁸</td>
<td><strong>10²⁵</strong></td>
</tr>
<tr>
<td>10¹⁹</td>
<td><strong>10²⁶</strong></td>
</tr>
<tr>
<td>10²⁰</td>
<td><strong>10²⁷</strong></td>
</tr>
</tbody>
</table>

**MATERIALS**
- Metals and Ceramics Usable
- Aluminum Hardens
- Ceramics’ thermal conductivity reduced; density change

<table>
<thead>
<tr>
<th>RESISTIVITY AND CONDUCTIVITY OF METAL CHANGE</th>
<th>10²⁰</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon steels: yield strength doubles</td>
<td></td>
</tr>
<tr>
<td>Uranium grows</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LUBRICANTS GEL</th>
<th>10²⁰</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphite swelling significant</td>
<td></td>
</tr>
<tr>
<td>Plastics usable</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GLASS SHATTERS</th>
<th>10²⁰</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lubricants thicken</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RUBBER HARDENS</th>
<th>10²⁰</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water gases</td>
<td></td>
</tr>
<tr>
<td>Plastics affected but many usable</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PLEXIGLASS WEAKENS AND CLOUDS</th>
<th>10²⁰</th>
</tr>
</thead>
<tbody>
<tr>
<td>T.V. tubes – some become soft</td>
<td></td>
</tr>
<tr>
<td>Glass darkens decrease in dark current</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GLASS COLORS</th>
<th>10²⁰</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potting resins – significant changes in power factor and dielectric strength</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CERAMIC AND SILICON</th>
<th>10²⁰</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amplification loss</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE** – 10³ RADs ARE LETHAL TO MAN
TABLE IV—ACTIVITIES OF MATERIALS AFTER IRRADIATION.

<table>
<thead>
<tr>
<th>Element</th>
<th>Active Nuclides</th>
<th>Half-life</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese</td>
<td>Mn^54</td>
<td>2.6 h</td>
<td>390 mc gm^-1 (Saturated)</td>
</tr>
<tr>
<td>Tungsten</td>
<td>W^95</td>
<td>5.1 h</td>
<td>65 mc gm^-1 (Saturated)</td>
</tr>
<tr>
<td>Copper</td>
<td>Cu^63</td>
<td>12.8 h</td>
<td>60 mc gm^-1 (Saturated)</td>
</tr>
<tr>
<td>Tantalum</td>
<td>Ta^181</td>
<td>111 d</td>
<td>23 mc gm^-1 (Saturated)</td>
</tr>
<tr>
<td>Aluminum</td>
<td>Al^27</td>
<td>2.6 m</td>
<td>13 mc gm^-1 (Saturated)</td>
</tr>
<tr>
<td>Cobalt</td>
<td>Co^60</td>
<td>5.2 yr</td>
<td>8.3 mc gm^-1</td>
</tr>
<tr>
<td>Zinc</td>
<td>Zn^65</td>
<td>3.2 h</td>
<td>0.6 mc gm^-1</td>
</tr>
<tr>
<td>Silver</td>
<td>Ag^111</td>
<td>0.2 h</td>
<td>0.77 mc gm^-1</td>
</tr>
<tr>
<td>Silicon</td>
<td>Si^28</td>
<td>2.62 h</td>
<td>39 mc gm^-1 (Saturated)</td>
</tr>
<tr>
<td>Iron</td>
<td>Fe^55</td>
<td>45 d</td>
<td>25 mc gm^-1</td>
</tr>
<tr>
<td>Oxygen</td>
<td>O^16</td>
<td>2.05 sec</td>
<td>1.12 mc gm^-1</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>H^1</td>
<td>28.64 yr</td>
<td>91.1 pcc gm^-1</td>
</tr>
</tbody>
</table>

For 24 days irradiation at 10^9 n cm^-2 sec^-1 of gas of parent material. Total dose of 2 X 10^9 n cm^-2.

Neutron doses of 10^9 n cm^-2 or less can seriously affect the electrical properties of germanium and silicon, while 2 x 10^9 R/hr of gamma increases transistor noise levels by 25 db. Selenium withstands higher doses; it is an open question whether silicon or germanium is preferable. Individual diodes and transistors show better performances but tolerable dose levels must be set several orders of magnitude lower than for other components. The great sensitivity to gamma radiation is a considerable disadvantage.

Magnetic properties of materials are not seriously affected by doses of 10^9 to 10^10 n cm^-2 at least, hence many component types such as motors, relays, chokes and transformers must be judged in terms of their insulation. Leakage currents through plastic may change by a factor of 10 and mechanical breakdown can occur at neutron doses from 10^8 n cm^-2 upwards, or about 10^9 to 10^10 R of gamma depending on the material. Quartz crystals irradiated to about 16 n cm^-2 show frequency changes of less than 0.01 percent. Limit switches will generally be only as good as their housings. Dry cells show erratic behavior for neutron doses in the region of 10^7 n cm^-2. Encapsulating materials may give almost order-of-magnitude changes in power factor, loss factor and dielectric strength, with smaller changes in dielectric constant at doses of 10^8 n cm^-2.

There have been few attempts to irradiate and monitor working assemblies. Completely satisfactory performance has been found with units working at 1.2 x 10^9 thermal n cm^-2 sec with 10^9 to 10^10 R/hr gamma, and to doses of 10^9 thermal n cm^-2, 10^9 f n cm^-2, + 10 R gamma.

In equipment design, the circuit used in the high flux regions should be minimal. It is far better to have elaborate external, accessible equipment if necessary. This may require a compromise with the policy of making the overall functioning of the equipment as insensitive as possible to variations in the performance of individual components.

Where material choices exist, the preference should be for those with low activation and radiation heating characteristics. Replacing organic materials by inorganic can increase life by 100 x, and 1,000 x if metals can be used. In reactor work, the assembly should have a low overall neutron absorption cross-section. It is possible to design electronics that will serve as reliably as control rods. This is consistent with using as small quantities of material as possible to minimize total activity.

Structural members should be metal or ceramic, distance rather than insulators should be relied upon for insulation, and regard should be paid to the lower breakdown voltages between points at differing potentials.

It is essential to define the incident radiation as closely as possible and consider each component in detail in relation to the radiation. This involves the generally difficult task of establishing the true composition of materials used in the component.

There is a need to develop a general approach similar to that already suggested so that reasonable decisions can be made without too frequent recourse to expensive and time-consuming experiment. When experiments are necessary they should be fully instrumented so that equipment behavior can be understood under irradiation conditions.

There is generally little to be said for shielding unless, for special reasons, weight and dimensions are relatively unrestricted.

It is hoped that this article has helped to put radiation into perspective as an environmental factor. With meticulous attention to detail, there is no reason why electronic equipment should not withstand for higher radiation doses than are usually required or regard as realistic.

The author thanks the directors of Pye Ltd. for permission to publish this paper and to record that this article represents work carried out by a team drawn from Pye TVT Ltd., Cathodeon Ltd., and Pye Ltd.

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(3) W. C. Dashi, and A. G. Tweet, Observing Dislocations, Scientific American, 186, No. 4, p 107, Oct. 1956.


Isolated Parametric Amplifier Has Low Noise Figure

Input to this parametric amplifier is isolated from the output by using two time-varying reactances. Circulators are not needed, thereby reducing insertion loss and amplifier noise.

By L. DAVID BALDWIN
Senior Research Staff Member, Research Division, General Dynamics/Electronics, Rochester, N.Y.

Although parametric amplifiers can perform as low-noise amplifiers in the microwave range, their instability limits their practical use. Amplifier circuits that show the greatest promise are regenerative; that is, small changes in source or load impedances or changes in pump power level cause large changes in gain or produce oscillations. Using circulators with the amplifiers reduces instabilities, but circulators are not available at all frequencies. Furthermore, circulators introduce an insertion loss, which adversely affects the amplifier noise figure, and their use often restricts the frequency range.

Some data has been obtained on parametric amplifiers that do not require ferrite circulators. In a more advanced parametric amplifier circuit, the input is nearly isolated from the output. The use of two time-varying reactances pumped with a relative phase difference of 90 degrees, and two idler frequencies provides the nonreciprocal properties. The circuit constants can be adjusted so that the round-trip gain is less than unity, and oscillation is not possible for any combination of source and load impedances.

The isolated parametric amplifier is expected to have these advantages over the circulator amplifier:

1. Wide tunable bandwidth of the order of one octave.
2. Lower noise figure.
3. Stable operation at frequencies where circulators are not available.

Figure 1 shows the isolated parametric amplifier. Two time-varying capacitances, with a relative phase difference of 90 degrees, couple the two signal resonant circuits to common idler resonant circuits. The idler circuits are tuned to the difference frequency, \( \omega_i = \omega_p - \omega_s \), and to the sum frequency, \( \omega_s + \omega_p \). A 3-db directional coupler provides a power split and a 90-degree phase shift at the signal frequency.

Power incident at port 1 of the 3-db coupler leaves ports 2 and 3. The phase at port 3 leads that at port 2 by 90 degrees. In the absence of parametric action, this power is almost totally reflected into ports 2 and 3 where it recombines and leaves port 4. However, because of the time-varying capacitances, idler currents are generated at frequencies \( \omega_i \) and \( \omega_s \). The phasing reinforces the difference frequency currents from the two varactors and cancels the sum frequency currents in the idler resonant circuits.

Since power dissipation at the difference frequency causes regeneration at the signal frequency, amplification takes place at ports 2 and 3. The amplified power then recombines to leave port 4. Hence, there is a power gain between ports 1 and 4.

In the reverse direction, power incident at port 4 also splits and leaves ports 2 and 3, but the phase at port 2 leads that at port 3 by 90 degrees. The phasing causes reinforcement at the sum frequency and cancellation at the difference frequency. Since dissipation at the sum frequency requires an absorption of power at the signal frequency, there is a power loss at ports 2 and 3. Thus an attenuation is observed between ports 4 and 1.

A more quantitative analysis yields relationships for forward gain \( K_f \), reverse gain \( K_r \), and the

![FIG. 1—Power gain in this parametric amplifier circuit is from ports 1 to 4. In the reverse direction, gain is less than unity.](image)
March 16, 1962

Equations 1 and 2 show that the reverse gain is nearly the inverse of the forward gain. Under the simplifying assumptions that \( \omega_c \approx \omega_0 \); \( g_c \approx g_0 \); and the varactor losses at the signal frequency, \( g_0 \), is much less than \( g_c \) the round-trip gain, \( K_r \), is equal to unity. The term \( g_c \) adds attenuation in both directions.

If the loading at the idler frequencies is due entirely to varactor losses, then

\[
L_i = \frac{\omega_c}{\omega_0} C_i \left( 1 + j \frac{2Q \omega_c}{\omega_0} \left( \frac{\omega_0}{\omega_c} \right)^2 \right)
\]

The dual-resonant idler cavity is formed in the center waveguide section between two adjustable shorting plungers. The two pairs of varactors used in a balanced arrangement minimize both the pump coupling across the idler cavity and the coupling of the idler power to the pump waveguide.

The output of the pump source, an X-13 klystron, passes through an isolator and a flap attenuator to a waveguide 3-db coupler. The coupler splits the pump power into two parts with the required 90-degree relative phase shift. A tuning screw and an adjustable plunger are used in each of the two pump waveguides to match the pump power to the varactors.

The experimental model of the isolating parametric amplifier, Fig. 2, can be tuned to operate in the frequency range of 700-900 Mc. A pump frequency of 9000 Mc is used. The 3-db coupler for the signal circuit, shown at the left in Fig. 2, is connected to the signal circuit matching network by coaxial cables. The center conductors of the signal circuit matching networks pass through the pump circuit waveguides to the varactors located in the center waveguide. These conductors couple both signal and pump power to the varactors.

REFERENCE

Although the range of bionics investigations is wide and the promise great, the payoffs in hardware are not yet numerous. Directions being explored include evolutionary models and learning networks grown in liquid solution.
Already in the hardware stage is the Artron developed by Melpar. The maze runner delivered to ASD in January is based on 10 component switches or decision elements. Each Artron component is a statistical switch, or binary logical gating device, with 16 possible states. These elements can be wired up completely at random initially; then this original statistical freedom is gradually conditioned or weighted towards performing an intended goal by reinforcing states that trend towards the goal and punishing the states that tend away from the goal. Each statistical switch contains a counter that serves as memory. If part of the Artron circuit is destroyed, or the goals change (that is, the maze is changed) the Artron relearns the new maze, or works towards the new goal. Application of an Artron-type learning network could conceivably be made in an unmanned vehicle which is moving into an unknown environment—for example, a space ship approaching a planet with an unknown atmosphere and gravitational effects.

Learning in such cases would need to be rapid, of course, or facilitary, in the sense that the network might make fine corrections to a preprogrammed landing procedure.

Primarily, an Artron-type network could be used with equipment going into dangerous environments. It could be preconditioned on the ground to perform certain functions, to compensate for failures, and learn to deal with changes in environment. Melpar has been awarded another Air Force contract to study the feasibility of using Artron as a means of improving flight control reliability. A limitation with this type of network is its inability to deal adequately with noisy or rapidly changing (shifting) goals. An Air Force contract to study nonlinear problems, "Probability State Variable Devices", has gone to Adaptronics, Annandale, Va.

In England, Gordon Pask has been developing learning networks such as that in Fig. 2. The signal network consists of threads that build up out of a solution of ferrous sulphate as a result of current passed through the solution by the amplifiers. The amplifier electrodes are either sources or sinks of d-c, and the low-resistance metallic threads develop from the sinks along lines of maximum current. These threads tend to dissolve due to local acidity, but remain dynamically stable as long as they pass sufficient current. The distribution of this signal network depends on the goals of the system. Rewards consist of giving more energy or current to the network distribution that performs or interacts with the environment in a desired stable fashion. Using this kind of adaptive network, Pask has made a magnetic receptor and an ear that can discriminate between two frequencies, one 50 cps, the other 100 cps. This ear consists of a gap in thread structure with fibrils that resonate at the excitation frequency.

Another ASD contract deals with Myoelectric Servo Control. It was awarded to Space Labs, Inc., in Van Nuys, California. This concerns the
possibility of using body sensing and nontypical muscle reactions as control elements. This work might tie in with a projected contract called Tactual Perception of Visual Information. If, for example, a spacerman is oriented in a space-vehicle under high g, so that he is unable to use his arms or usual body motions to control his craft, or if he is unable to see his course, he could be fed orientation information to pressure-sensing nerves on the surface of his body. These nerves, though lacking the resolution of the other senses, such as the eyes or ears, nevertheless, might be trained to react characteristically to this input information. Thus, a diffuse sensation on a chest nerve might cause the space pilot to maneuver or tense his shoulder muscles just enough to control and guide his craft. Tensed muscles generate electrical potentials called muscle action potentials or electromyographic potentials, detectable with electrodes placed on the skin and can be converted or interpreted and used in a servo control. This is myoelectric servo control. Related but as yet uncontracted program of interest to the Air Force is a study and development of muscle substitutes.

At Litton Industries in California, considerable work has been done on an electromyographic (emg) open-loop control system. Muscle action potentials, whose spike repetition rate is proportional to muscle tension, activate a stepping motor. Each emg spike applied at the input, Fig. 3, results in a precise incremental shaft rotation at the output. More sophisticated emg control systems are now under development in the Medical Electronics and Bionics dept. of Litton Systems, Inc.

EMG control systems could also be used for power amplification of natural movements, as for example in the U.S. Army's servo-soldier concept.

The development of the optical maser, or laser, makes it probable that as man enters space he will need to transmit information over the astronomical distances at optical frequencies. In one research program at Armour Research Foundation, it has been discovered that chloroplast, extracted from plants, has a narrow frequency acceptance, somewhere near ir. ARF has grown and harvested this chloroplast, deposited it on plates, and formed rudimentary ir detectors. Such detectors might be made more sensitive; conceivably, a systematic search might reveal a spectrum of such narrow-band detectors in the near-optical region. Coupled with lasers, such devices could lead to a profitable exploitation of this frequency spectrum.

In yet another direction, ARF has worked with the olfactory sense, and is developing an artificial electrical nose that should be able to smell or recognize low concentrations of vapor in air.

Other devices near the hardware stage are ear analogs. One of these, under ASD contract Research on Speech Processing through Cochlear Matching, has been designed by the Sensory Systems group at the University of Arizona, headed by J. L. Stewart. Another bionics contract held by this university, in which the AF has a strong interest, is for an electronic simulation of the biological clock, a phenomenon exhibited by both plants and animals, that pace their functions in a cyclic fashion. Being considered, though not yet contracted, is another type of analog of the cochlea based on a nonuniform tapped, solid-state line. Possible recipient for this work is ITT, where much of the theoretical work has already been completed.

Another company involved in the development of a sophisticated speech processor based on neural networks is RCA. The network embodies many of the psychoacoustic phenomena known to operate in the human ear. The motion of the cochlea, the spiral receptor of the ear, is simulated by an RLC transmission line, which is a distributed low-pass structure. The outputs of these filters (f, f1, ..., f5, represent center frequencies) are fed into a neural network, Fig. 4, that pre-processes the frequency information. The first layer of electronic (transistor) neurons enhances small differences in signal amplitude in neighboring channels, the second layer selects the larger output of two neighboring neurons, and from this layer the local maxima, local minima, positive and negative slopes, and their local transitions are abstracted.

At GE's Advanced Electronics Center in Ithaca, N. Y., an elec-
tronic model of the eye of the limulus (horseshoe crab) relies on inhibitory interactions that have been found to exist in multi-faceted eyes. The device, which sharpens contrasts, could be used to accentuate edges in the pattern from an array of ir detectors, or to sharpen and refocus image edges and contours on a tv or radar system by operating on the video signal.\textsuperscript{10}

The operation of a simplified mutually inhibitory network, Fig. 5A, is like that of an edge detector (Part III), in which neighboring receptors modify each other's outputs. In the model, receptor units A, B, C, which correspond to single facets (ommatidia) of the limulus eye, are connected so that B and C inhibit A, but B and C cannot inhibit each other. In its model, GE has used 10 summing amplifiers, the outputs of which are changed in magnitude and sign, and fed back as inhibitory inputs to other amplifiers. Various weightings of inhibitory effects can be achieved by changing connections. So far, experiments have been conducted with a linear array of 10 units, but work is going on to develop a two-dimensional planar array of mutually inhibiting units. The photo shows how the edge of a band of light (bottom) has been sharpened (top).

Other studies of these inhibitory networks and of the resolving power of facet eyes have also been conducted by W. Reichardt in Germany. He has shown that lateral or mutual inhibition enables the multifaceted eye to portray perfectly the optical surroundings on the cross section of the optic nerves.\textsuperscript{11} This neural inhibition compensates for overlapping of visual fields and for diffraction effects. Figures 5B and 5C illustrate the difference between image formation by a lens and image formation in the multifaceted eye by lateral inhibition. In Fig. 5C, only neighboring operational amplifiers are shown inhibiting one another; in the actual eye, the output of each amplifier is connected to the inputs of all other amplifiers.

Other work in the GE Bionics Engineering section includes the Visilog (visual analog), a device that calculates slant angles to a textured surface, which might be useful in a recognition machine for normalizing figures in the third dimension.\textsuperscript{12} Conceivably, the device could be used for landed unmanned vehicles uprighth on another planet. Another device is an adaptive filter that can learn to recognize repetitive signals buried in noise.\textsuperscript{16} The device could be used in recognizing characteristic ir outputs from missiles and in recognizing various kinds of bioelectric signals.\textsuperscript{19}

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\end{enumerate}
Voltage-Controlled Oscillator

Uses Negative Feedback

Specially designed pulse-counting discriminator circuit in feedback loop gives voltage-controlled oscillator adequate linearity for computing applications

By N. W. BELL
V. CHIUNTI
Bell & Howell Research Center,
Pasadena, Calif.

VOLTAGE-CONTROLLED oscillator using negative feedback to provide good linearity and stability can be used with a totalizing counter to integrate slowly varying signals. With an events-per-unit-time meter, the oscillator can also be used as an analog-to-digital converter.

Oscillator output frequency varies between zero and 1 Kc as input voltage varies between zero and 10 mv. Linearity and stability are 0.1 percent at maximum frequency. The voltage-controlled oscillator is conventional except that negative feedback has been added. With high loop gain, operating characteristics depend only on the feedback element, which is a stable pulse-counting discriminator.

The feedback loop is shown in Fig. 1. With zero input feedback tends to make frequency equal to the frequency of the fixed 1.2 Kc oscillator. The difference frequency from the mixer is then zero. With maximum input of 10 mv, the negative feedback circuit shifts oscillator frequency toward 2.2 Kc so that the sum of the input and feedback voltages to the d-c amplifier again approaches zero. The difference frequency from the mixer is 2.2 Kc - 1.2 Kc = 1 Kc. Zero drifts in the discriminators tend to cancel, and the 1.2-Kc fixed oscillator need not be stable. Linearity depends on linearity of discriminator number 1, and d-c amplifier bandwidth can be much narrower than system bandwidth.

Performance depends primarily on the discriminators, which should be stable, linear and have equal
temperature characteristics. The pulse-counting discriminator in Fig. 2 provides linearity of better than 0.1 percent over an octave range. The input square wave is regulated by double-anode zener diode D, so that 5-percent variation in input amplitude produces less than 0.1-percent change in output.

Charging current for capacitor C, flows alternately through diodes D, and D,. Average charging current produces a voltage across R, and the 100-ohm potentiometer that is proportional to input frequency. The d-c output voltage is isolated from ground by capacitors. Charging capacitor C, must have low dielectric losses, and silvered mica was found to be satisfactory.

Resistors R, and R, improve linearity by removing the effects of varying diode resistance near the voltage origin of the diode curve. Temperature coefficient of the circuit depends primarily on regulating diode D,, and typical values are about 0.025 percent per degree Fahrenheit. The two discriminators are packaged together in a small plug-in unit to cancel the zero shifts caused by temperature changes.

The input filter in Fig. 2 attenuates interference and noise near the 60-cps chopping frequency. The chopped d-c is amplified and then demodulated by a phase-sensitive demodulator. After additional d-c amplification, the signal is used to control frequency of an astable multivibrator, and the square-wave multivibrator output is amplified and fed back to discriminator number 1. Another astable multivibrator operating at 1.2 Kc provides input to the other discriminator. The negative discriminator terminals are connected together and the positive outputs provide the feedback voltage. The negative feedback loop is completed through a filter that removes ripple.

The difference in frequency between the outputs of the variable-frequency and the 1.2-Kc multivibrators is produced in a balanced mixer using two diode rings. The diode rings act as shunt switches across the outputs of the phase inverter. Since one side of each switch is at ground potential and the phase-inverted signals are returned to ground, no isolation transformers are required.

The low-pass filter after the mixer removes high-frequency modulation products. A slicer circuit (Schmitt trigger) following the filter shapes output. Slicer hysteresis is made greater than filter p-p amplitude to avoid spurious outputs. Output is 20 v p-p, sufficient for most counters.

Discriminators 1 and 2 are adjusted for maximum and zero inputs, respectively. Loop gain is set for minimum response time by adjusting gain of the 60-cps amplifier. Response time is about 0.2 seconds. Calibration is maintained within 0.1 percent for several months.

March 16, 1962
Complementary Compound Emitter Follower

This circuit uses two complementary transistors to reduce power dissipation and increase power output at the lower frequencies

By T. K. HEMINGWAY and J. WILLIS* English Electric Aviation Ltd., Stevenage, Herts, England

IN APPLICATIONS where the current gain of a single emitter follower is inadequate, it is common practice to connect two transistors in cascade as shown at A in the figure. This is a convenient circuit for a class-A power output stage driving a reactive load where only a small phase shift between input and output voltages is permitted. The base current of power transistor Q1 is provided from the emitter of Q2 so the overall current gain is almost the product of the two grounded-emitter current gains. The circuit must be designed so that Q1 remains conducting under the worst conditions.

Emitter current of Q1 is given by

\[ I_{e1} = I_e + I_{e2}/(\beta + 1) - I_{em} \]

where the currents are as labeled in Fig. 1A. From this equation, if \( I_{em} \) exceeds the sum of the other two currents, \( I_e \) will cutoff and lose control over \( Q_2 \). This undesirable state can be avoided by choice of \( I_e \).

The worst condition occurs when the \( Q_2 \) junction attains maximum temperature simultaneously with the input voltage reaching its maximum positive value. At this point \( I_{e2} \) is maximum and \( I_e \) is minimum, so \( I_e \) must be large enough to make \( I_{e2} \) positive in the equation.

Since \( I_e \) has its minimum value for maximum positive input voltage, choice of an adequate value under these conditions may result in a high normal standing current through \( R \), and \( Q_2 \) resulting in large power dissipation in \( Q_2 \) as \( Q_2 \) is large. Then the dissipation in \( R \) will be high.

It may be preferable to use the complementary version shown at B. The current drive to \( Q_2 \) base is now limited to the standing current \( I_e \) through resistor \( R \), so the minimum value of \( I_e \) must be made large enough to turn \( Q_2 \) fully on under the worst conditions. That is, if zero \( I_e \) and minimum beta in \( Q_2 \). However, \( I_e \) in \( Q_1 \) will be drawn directly from the emitter of \( Q_2 \), turning \( Q_2 \) harder on so there is no danger of \( Q_2 \) cutting off at high temperatures. Further, \( Q_2 \) collector can now be returned to \( Q_1 \) emitter, with possibly the interpolation of diode \( D \) or a resistor to establish a minimum \( V_e \), of approximately 1 volt for \( Q_2 \). The collector voltage of \( Q_2 \) thus has a low and nearly constant value, independent of input voltage, and dissipation can be small. This combination may use a silicon low-power device for \( Q_1 \) and a germanium power transistor for \( Q_2 \).
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**PERFORMANCE TEST**

<table>
<thead>
<tr>
<th>LOAD LIFE @ 25°C, 1000 hours</th>
<th>LOAD LIFE @ 70°C, 1000 hours</th>
<th>SHELF LIFE</th>
<th>NOISE</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 volts, dc. .............</td>
<td>500 volts, dc. .............</td>
<td>Unlimited</td>
<td>3 to 8 millivolts, values below 500,000 ohms.</td>
</tr>
<tr>
<td>750 volts, dc. .............</td>
<td>750 volts, dc. .............</td>
<td>1/2 watt, Min.</td>
<td>8 to 12 millivolts, values above 500,000 ohms.</td>
</tr>
<tr>
<td>3/4 watt, Min.</td>
<td>1/2 watt, Min.</td>
<td>on value.</td>
<td>on value.</td>
</tr>
</tbody>
</table>

**Average Percent Resistance Change**

ZERO LOAD @ 100°C for 1000 hours
±4%, values to 100k; ±2%, values above 100k.

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March 16, 1962

CIRCLE 71 ON READER SERVICE CARD 71
Tunnel Diode-Transistor Provides Fast Logic

**THE FRONT COVER.** UHF shift register uses pumped tunnel diode-transistor logic elements, which are made in negative input-positive output and positive input-negative output types

**TUNNEL DIODE-TRANSISTOR** logic with a 500-Mc bit rate can perform four logical functions in 2 nsec. As faster tunnel diodes and transistors become available, the 2-Gc logic rate can be increased. In addition, the system requires substantially fewer circuit modules.

The logic system, developed by General Electric, is said to take advantage of the high speed of tunnel diodes while providing practical working margins. It was described at the 1962 International Solid State Circuits Conference at the University of Pennsylvania in a paper by W. Peil and R. Marolf (ELECTRONICS, p 7, Feb. 16).

A switching margin of 30 percent is provided by the pumped tunnel diode-transistor logic. Because logical functions are performed sequentially rather than in parallel, only one-tenth the usual number of circuit modules are required. This reduction and the simple six-component module contribute to reliability.

High speed of the logic system can enable real-time radar signal processing to be performed digitally. In high-resolution radar, it could distinguish among multiple targets and calculate velocity in real time. The system is also expected to be useful in high-speed counting and coincidence detection involving real-time control.

Basis of the logic system is a newly developed germanium tunnel diode. Commercially available as type STD606, it has typical switching speed of 50 nsec.

Speed of the system is attributed to the two-input NOR gate shown in the figure, which has a gain of 3 and consumes 50 mw. Because phase inversion occurs through the gate, positive input-negative output (PINO) and negative input-positive output elements are needed. The synchronous information signals are reclocked at each logic gate by pumping the tunnel diode with a 500-Mc sine wave. A single phase pump source is common to all circuit modules.

**Circuit Operation**

With no input signal, the tunnel diode in the NIPO element switches once every positive half cycle of the pump signal from its bias point below the peak voltage into the high-impedance region. A negative input at one or both inputs prevents diode switching, providing a NOR gate. A PINO element is provided simply by using an npn transistor and inverting tunnel diode polarity. Since each type element switches on opposite half cycles of the pump signal, two levels of logic can be performed during a full pump cycle and logic can be performed at a 1-Gc rate. A third element, an inverting transformer, is used where one element feeds another of the same type. Combinations of the three elements permit any complex logic to be performed.

Operating speed depends primarily on the tunnel diode, which provides gain and switching. The transistor provides isolation between input channels and unidirectional information flow. The isolation permits modules to be interconnected by matched microstrip transmission line, eliminating problems associated with reflections and permitting signal interconnections to be made over long distances. Line length is not critical because of the logic element reclocking. To ensure the same pump signal phase to all modules, a standing wave is generated on the stripline. Because no gain is required of the transistor, it can be operated near its cutoff frequency.

With constant bias and pump voltages, input signal phase error of ±60 degrees can be tolerated. Tolerances of components and of pump and bias voltages compare favorably with all-tunnel diode logic. A-c and d-c power supply tolerances of 20 to 25 percent are attributed to the 30 percent switching margin. Initial component variations are compensated by the variable capacitance in the pump feed.

To maintain the information in the system, the frequency band must extend from d-c to 500 Mc and a moderately controlled rolloff should exist to about 1.5 Gc.

A computer using the pumped tunnel diode-transistor logic system could be packaged in almost any form. Computers of 100,000 or more modules could be built without problems of heat dissipation.

**Designing Transistor Phase-Shift Oscillators**

By F. W. KEAR

The Lyle Corp., Albuquerque, N. M.

SINGLE-TRANSISTOR oscillator provides a sine-wave output using an R-C network to obtain phase shift and determine oscillator frequency. Adding a second transistor enables the oscillator to provide a square-
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wave output simultaneously.

The typical phase-shift oscillator in Fig. 1 uses a npn-transistor. In the common-emitter configuration, the signal is changed 180 degrees in phase between base and collector. The added 180-degree phase shift required to obtain positive feedback to the base is provided by C through C and R through R.

Current flow in the R-C circuit, which consists of resistance and capacitance in series, is determined by the series impedance of the components and the applied voltage, and it can be calculated using Ohm's law. Since reactance in an R-C network is capacitive, voltage lags current at a phase angle determined by the relative values of resistance and capacitance. Voltage drop across the resistance therefore loads applied voltage by this phase angle, and amplitude of the drop is determined by network current.

Obtaining Phase Shift

With a fixed capacitor, phase angle can be changed by varying resistance. As resistance approaches zero, phase angle between applied voltage and current can be varied up to 90 degrees. However, a phase shift network cannot have zero resistance since the only voltage across the capacitor would be applied voltage. With the minimum practical resistance in a phase-shift network, the phase angle will be slightly less than 90 degrees. At least three sections are required to produce the required 180 degrees phase shift to obtain positive feedback in the oscillator. Resistors should generally be chosen so that each section produces about 60 degrees phase shift. Power factor of the capacitor must also be considered because capacitor resistance affects losses and phase shift. Better performance can be obtained by using more than three sections.

Resistors R, R and R provide base and collector bias. Capacitor C provides a-c bypass for emitter resistor R. Oscillations are initiated by any random noise, such as transistor noise or switch noise as power is applied.

Oscillator output is nearly sinusoidal and frequency is constant except for minor fluctuations caused by voltage and temperature changes. Phase is shifted 180 degrees at only one frequency. As either resistance or capacitance is varied, the frequency at which the correct phase shift occurs also changes. Since most applications of phase-shift oscillators require that frequency be variable, resistance in the phase-shift networks is usually made variable.

If a three-section phase-shift network is used, considerable gain is required from the transistor because of the losses incurred in the network. As the amount of phase shift required of each section is increased, losses in the section also increase because of the increased voltage drop through the resistor and the resistance of the capacitor. It is therefore desirable to use more sections with less phase shift required from each section.

The phase-shift oscillator in Fig. 2 can provide a sine-wave signal and a square-wave signal at the same time. Oscillator frequency is changed by and width of the square wave is varied by . Square-wave width is limited only by oscillator frequency. Four sections are used in the phase-shift circuit.
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High speed signal circuits as well as solid state power supply circuits can be improved and simplified by the use of SAGE non-inductively wound resistors. Such parts are currently supplied in values from 1 ohm through several thousand ohms. This valuable circuit feature can be provided on any SAGE or MIL wattage size.

No compromise is made with other superior performance features long associated with SAGE precision power resistors, such as:

- High temperature operation to 275°C...
- Temperature coefficient less than 20 ppm/°C
- Typical 1000 hour load life change less than .5%
- Fully insulated, 1000 volt rms test on axial lead units
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Specify SAGE for your NON-INDUCTIVE Power Resistor Requirements

<table>
<thead>
<tr>
<th>NS Styles</th>
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*Sink mounted
Test samples available on request

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electronics
Ten thousand EL-MENCO high reliability dipped mica capacitors were put on life test at 85°C with 225% of the rated DC voltage applied—After 26,500,000 actual test unit-hours no failures of any type occurred.

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Assuming no temperature acceleration factor and assuming the voltage acceleration exponent is such as to yield an acceleration factor as low as 100, we have nevertheless verified a failure rate of less than 0.0001% per 1000 hours.

Assuming no temperature acceleration factor and assuming the voltage acceleration factor is on the order of 250 (test results are available to confirm this) we have accumulated sufficient unit-hours to verify a failure rate of less than 0.00004% per 1000 hours!

Note that all the above failure rates are calculated at a 90% confidence level.

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Life tests have proved that El-Menko Mylar-Paper Dipped Capacitors — tested at 105°C with rated voltage applied—have yielded a failure rate of only 1 per 1,433,600 unit-hours for 1.0 MFD. Since the number of unit-hours of these capacitors is inversely proportional to the capacitance, 0.1 MFD El-Menko Mylar-Paper Dipped Capacitors will yield ONLY 1 FAILURE IN 14,336,000 UNIT-HOURS.

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March 16, 1962

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If you are the man with the talent and drive and technical proficiency demanded by programs like ours, we urge your inquiry. It will be treated in strictest confidence, of course, and will incur no obligation. Read the details on the next page. If they command your interest, mail the attached Professional Placement Inquiry. We'll do the rest, including arranging an interview in your area. If you prefer to submit a detailed resume, please address it to Mr. R. M. Smith, Manager of Industrial Relations Administration-Engineering, Dept. 130-90, General Dynamics Astronautics, 5731 Kearny Villa Road, San Diego 12, California.
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March 16, 1962
Potentiometer Senses Moving Light Source

By CLAUS HAAKE
GUIDO GALLI
Giannini Controls Corp.,
Duarte, California

AN ELECTRO-OPTICAL potentiometer, now in production, uses a tiny light beam as its wiper arm. Primarily a position-measuring device, the unit functions exactly like an electromechanical potentiometer. However, the Photopot weighs less, is smaller, completely frictionless, has no contact wear, no inertia, and no hysteresis. The device has an infinite life, a very high sweep speed and no resonance frequency.

In the past year, the development of this light-actuated potentiometer has reached a stage of development where it is presently undergoing a severe testing program. Initial results indicate that the properties of the device will be most satisfactory.

The element of this device consists of a resistive film and an adjacent conducting strip which is separated from the resistive strip by a photoconductive crystal. The photoconductive material acts as an insulator when it is in the dark, and as a conductor when illuminated by the light beam. The device is independent of light intensity within wide limits.

One method of using the unit employs a non-movable shield that covers all but a narrow opening to the photoconductive crystal at a small distance from the crystal. When the light source moves, an angle is sensed.

A second method for operating the device involves a light source, fixed with respect to the unit, and a movable shield with its slit. In this way, mechanical movement can be sensed and translated into voltage without friction.

Output of the device is a linear function of the light beam displacement on the crystal. However, functional output can be obtained for special applications.

Although its applications are numerous, the optical pot is best suited for direct light-position measurements. Angular displacements down to only tens of arc-seconds can be clearly resolved.

Sensitivity of the solid-state potentiometer is defined as the ratio of crystal resistance between conditions of light and dark. If CdSe is used as the photoconductor, typical sensitivity ratios of $10^4$ at 1,000 microwatts per cm$^2$ of radiation between 7000 and 7400 Angstroms are observed.

The speed of response, is determined by either the rise or decay of the photoconduction process. The rise time is defined as the time measured from initial dark conditions to $1/e$ of the final light values. The decay time is defined as...
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Dielectric Constant | Between 2 and 3 with ±0.05 tolerance Must be homogeneous and isotropic | 2.55 ± 0.01 Meets requirement
Thickness Variation | ±.002" to ±.004" | Meets requirement
Coefficient of Thermal Expansion | As close to that of copper as possible | Slight warpage after processing, but with no adverse effects
Bond Strength | Must bond well to copper. 5# min; 8-10# average | Meets requirement
Solder Resistance | Withstand 440-450°F for 10 seconds | Meets requirement
Mechanical Strength | Rigid, with high mechanical strength | Meets requirement
Deformation | Must not permanently deform under loads up to 2000 psi at temperatures up to 200°C | Meets requirement
Processibility | Ability to be photo-etched by standard techniques. Easily machined (milled, ground, drilled, tapped) to close tolerances | Meets requirement
Radiation Resistance | Ability to withstand radiation with minimum change in operating characteristics | Meets requirement
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March 16, 1962
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For more details see Chemical Engineering Catalog, Electronic Engineers Master or write for 32 page catalog and Spectrosil bulletin.

Basic circuit of photopelt

range of 10 to 90 percent of full voltage.

Ultimate power dissipation of the device must be noticeably low to preserve the instrument-like qualities built in. Low power consumption would definitely be an asset in most applications.

Temperature dependence rests on the thermal sensitivity of the light-detecting crystal. Thus, temperature influences the output voltage and its linearity. However, if the load resistance in the output circuit is considerably larger than the impedance of the light path, the temperature range of operation is rather wide. Practical temperature limits, assuming not more than 1 percent variation from calibration, will include the range between −54°C and 71°C for a 1 megohm load. Photoconductive materials have been prepared which promise a higher temperature limit.

Evaluations of the deterioration

Rugged Crt For Outer Space

A cathode ray tube that can take the shock of thrust into outer space has been developed by the Electronic Tube and Instrument Division of General Atomics Corporation. The 5-inch single gun, tight tolerance tube can take vibration of 1,000 cycles per second at 0.10 in double amplitude, and impacts as high as 15 G with a time duration of 11 milliseconds, peak value occurring at about 5.5 milliseconds.
of materials indicate that single crystals are far superior to sintered layer units. The superiority of single crystals have been further substantiated by applying conventional methods for protecting the crystals.

Among the most intriguing applications for the optically-activated potentiometer is the analog conversion of information. The device can translate a linear motion into a programmed non-linear output and vice versa. The data program to be followed is easily built into the optics.

Other applications suggested are stellar-body position indicator; blast detection system; pickoff for pressure transducer, accelerometer, gyro, torque-angle meter, or mercury manometer; and linear position sensor.

The light intensity from even a 20 KT bomb is adequate to operate the device at a considerable distance. It is not a seismic indicator and could not be fooled by an earthquake. A photometric device coupled with a Photopot could act as a remote station which could give information as to position and yield of a nuclear blast.

Glass Laser Operates
In Near Infrared

A laser using trivalent neodymium doped, barium crown glass, as the active material—rather than a gas or crystal as in previous lasers—has been operated.

Output is in near infrared 1.06 micron region, with a wavelength interval of some 30 angstroms. The glass material is in the form of clad rods, three inches long. Various diameters, including 0.012 inches were tried.

The new laser, developed at American Optical Co., Southbridge, Mass., has been operated with various flash tubes and provides pulsed output. With different levels of pumping power the wavelength interval is variable, from about 5 to 70 angstroms. It is believed that single lines in the output may prove to be as narrow as other lasers.

An advantage of using a glass laser material is the ease in which it can be formed into various shapes. This allows large surface areas for efficient cooling with a minimum of equipment.

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BORG EQUIPMENT DIVISION
Amphenol-Borg Electronics Corporation, Janesville, Wisconsin.
Rolled Joints Reduce Waveguide Costs

By ROBERT A. ELMIGER*
Venetia, Pa.

WAVEGUIDE RUNS are the veins and arteries of the radio guidance and tracking system used to direct the Atlas ICBM to its target. Many of these waveguide runs are several thousand feet long and must be assembled in the field.

Flanged waveguide, whether rectangular or circular, must be prefabricated at the factory in various lengths. Special provisions must be made for shipment and storage to prevent denting or other damage to the waveguide, often at considerable expense. On the site, the sections are assembled by bolts or clamps with O rings for pressure seals at each joint.

Welded waveguide eliminates pre-fabricating sections. Waveguide material is shipped to the site, where welding is done by specially trained field service personnel. Rectangular waveguide is welded manually; for circular waveguide, an automatic helium-arc welder was developed for field use. The depth of weld penetration, starting dwell time, and speed of torch are automatically controlled and adjustable.

The method being used presently is a mechanical connection, uses circular waveguide and is essentially a rolled joint. Sections of waveguide are buttied together inside a stainless steel coupling sleeve. The joint is then rolled and expanded slightly from the inside by a special tool, and a strong, reliable leaktight joint, is formed by cold flow of waveguide metal into small ridges in the coupling. Tooling and procedures are similar to those in rolling tubes into boiler tube sheets. The pressure produced by rolling also helps align the butted sections of waveguide.

Raw waveguide, which is used in all methods, has dimensional tolerances that causes some mis-match. But mis-match is eliminated by the rolling and each joint is essentially a smooth transition between sections. No special experience is required to operate the equipment, and personnel can be trained to use it in 10 to 15 minutes. The rolling tool was developed for General Electric by G. Wiedeke Co.; connections can be made for straight runs only, but this is the bulk of the installation.

First the sections to be joined are faced and deburred with a facing tool similar to that used for preparing waveguide for welding. The pieces are then butted in the center of a machined coupling and the tool, with a 20 foot adjustable extension, is inserted. The tool is then operated either manually or by motor until a pre-set torque is reached, at which time it is automatically stopped. The motor is then reversed and the tool withdrawn. Depending on the torque used, the material, and wall thickness of the coupling, it is sometimes necessary to use a restraining vise around the cou-
A power supply control knob is a detail. We love details and give them the importance we feel is their due. For an electronic instrument, as well as a work of art, is the sum of all details. Technical details, electronic details, human factor details.

The fine voltage adjust control of our model 5015A is a case in point. We human-engineered this anodized aluminum knob for durability, appearance, torque/diameter ratio, panel protection against fingernail scratches, and just downright "feel." Nor did we stop here. We inspect every instrument we ship to make certain this "feel" is just right.

Turn this knob and you will find another detail: smooth mechanical control translated into smooth electrical control. There is no need to twiddle to find the right voltage. You won't find parallax on the main voltage control. It has been eliminated by a unique mechanical linkage between the variable autotransformer and its tracking potentiometer.

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Sealing compound is applied to waveguide sections prior to assembly in grooved stainless steel coupling

Rolling tool with extension is being inserted into waveguide section

pling to prevent excessive increase in diameter. The resulting joint is so smooth that the butting surfaces can hardly be seen. Upon completion of the run, a pressure drop test is made for leak tightness.

Circular waveguide is superior to rectangular in electrical loss characteristics and was used in these installations. The material is commercially hard drawn copper tubing; for welded waveguide, the copper must also be certified oxygen free. To compare physical strength, samples of each type of joint were pull-tested. At about 5,000 pounds pull on both flanged and welded samples, distortion began to occur at the annealed areas of the joints. Actual mechanical failure occurred at from 4,000 to 9,000 pounds for welded samples, and from about 8,000 to 10,000 pounds for flanged joints. Failures of rolled joints occurred between 14,000 and 18,000 pounds pull. These failures were in the waveguide itself where it was gripped in the pull machine. Where the waveguide did not break, failure of the rolled joint was considered to occur when it slipped in the coupling. At this failure point the guide is still intact, with a slight separation between the butted surfaces in the coupling. Electrical tests have shown that several such joints in a run have only a slight effect on attenuation.

In bend tests, in which the free end of a run is lifted several feet, and in jump tests, in which a man jumps on a coupling at the center of a 12 foot section supported at the ends, rolled joints did not fail but welded and flanged joints did. Field tests on welded and rolled joints showed no pressure loss over several weeks when checked at 10 psi. Experience has shown that with flanged joints, considerable leakage occurs, especially when the coupling is exposed to low temperatures that affect the O rings. Electrical checks showed that each method met specifications. Data taken for the rolled waveguide gave an average attenuation that approached theoretical values.

In actual field installation practice some useful comparisons can be made. Flanged joints provide relatively simple assembly but a good pressure seal requires considerable work and checking. Flanged joints also can be easily replaced.

In automatic welding, external
conditions of temperature, wind, dust, and moisture have varying effect on the equipment. Prior to operation, test welds are required. After welding it is difficult to determine weld quality. In addition, only oxygen-free copper tubing, at extra cost, gives satisfactory results. To repair the run, a section is cut out and a new piece welded in. Installation equipment for rolled joints is basically simple and little difficulty is experienced in field assembly. Up to now, no joint has failed pressure test and consequently pressure testing has not been a problem. To repair the run, the affected section must be cut out. Special flanged sections are rolled on if the repair is in the middle of the run, and the remainder of the section is assembled in the normal manner. Test repairs have been made in ½ hour.

Costs of field labor for each method of installation are comparable but overall costs of various installations differ widely. Material costs for welded and rolled installations are almost the same and the major cost difference is in the equipment required.

A complete welder costs approximately $16,000; comparable rolling equipment can be obtained for about $1,500. Figures comparing the rolling method with flanged guide show a saving of about $2.00 per foot of installation for the rolling technique. Waveguide assembled using the rolled method also can be buried underground but flanged and welded joints do not have sufficient strength for the stresses caused by temperature cycles. By burying the waveguide in the ground instead of running it in a trench on rollers as is now done, an estimated $5.00 per foot of run can be saved. Thus, both using rolling and burial, a substantial cost reduction is accomplished.

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March 16, 1962

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- Three calibrated amplitude scales: linear, 40 db log, and power (square law).
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- I.F. attenuation adjustable 0.41 db in 1 db steps plus 20 db smooth attenuation.
- 0.01% accuracy frequency markers check entire SPA-10 tuning range to 43 kmc (optional).

Panoramic's New Model SPA-10 is a compact, easy-to-use instrument for reliable visual analysis of AM, FM and pulsed signals, oscillator stability, detection of parasites, harmonic output and other r-f and noise characteristics in Radar, Microwave and Communications devices.

A Panoramic engineer will be happy to discuss specific application to your project:

CALL COLLECT

PANORAMIC ELECTRONICS, INC.
530 South Fulton Avenue
Mt. Vernon, N. Y.
Phone 914 Owens 9-4600
TWX: MT-V-NY 5229
CABLE: Panoramic

Mt. Vernon, New York State

see
SPA-10 "in action"
at I.R.E. show booth 3301-3303

Whether you're designing a complex communication system, a new idea in computers, or a simple electronic device, you can depend on this kind of versatility to save you time and money.

- Knowledgeable recommendations relative to insulation materials and the ability to supply these materials.
- The capability to produce a wide range of constructions through diversified striping, braiding, shielding and cabling equipment.
- Brain power at your call to translate your preliminary designs or limiting parameters into functional wire and cable with the required performance and size characteristics.
- The ability to produce the product you need, military or commercial, and to meet all applicable U.L. or military specifications.
- Completely integrated facilities are nearby under one roof. This means production speed that meets delivery dates...scientific quality control to insure reliability...prices that are competitive.

Whether you require prototype quantities or millions of feet, call or write Brand-Rex.
Power surveys by Nergaard, *plotting average power output as a function of frequency for tubes of varying powers, predicted that maximum wattage available in X-band would be less than 10 kW CW.*

Varian research indicates this figure to be extremely conservative. Varian's recent introduction of the VA-849 amplifier klystron provided the industry with a tube capable of developing 20 kW CW power at 7.125-8.5 Gc. A modified VA-849 developed 51.5 kW power in the laboratory, and is now available as the VA-849G, conservatively rated at 25 kW CW. Varian accomplishments do not stop there. The company is now developing an X-band tube rated at a minimum of 50 kW CW.

*If your microwave project calls for such out-ahead capability in power tube development, write Tube Division.* - L. S. Nergaard, RCA Review, Dec., 1960

From the house of RF Specialists . . . a completely new VHF receiver for AM, FM, CW reception is now available. Covering the frequency range of 30 to 300 mc, this precision receiving unit is compact (3½" panel height) and employs solid state and vacuum devices.

**Frequency range**
- 30 to 300 mc (band 1: 30 to 60 mc)  
- 300 kc and 20 kc

**IF Bandwidths**
- 300 kc bandwidth
- 20 kc bandwidth

**Sensitivity**
- 300 mc bandwidth
- 20 kc bandwidth

**Power input**
- 115 volts, 50/60/400 cps
- Less than 40 watts
- 18 lbs. (approximately)

<table>
<thead>
<tr>
<th>Power consumption</th>
<th>Weight</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>19&quot; x 3½&quot; x 14½&quot;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Performance**
- AM-2 uv produces at least 14 db S/N for 50% modulation
- FM-4 uv produces at least 21 db S/N for 100 kc deviation at a 1 kc rate
- AM-2 uv produces at least 17 db S/N for 50% modulation
- FM-2 uv produces at least 20 db S/N for 7 kc deviation at 1 kc rate

**Specifications**
- For complete specifications write:

Communication Electronics, Inc.
4900 Hampden Lane
BETHESDA, MARYLAND

CIRCLE 206 ON READER SERVICE CARD
BULLETIN:

SOLA ANNOUNCES A NEW CONCEPT IN LINE VOLTAGE REGULATION IN THE KVA RANGE . . .

- No moving parts, eliminating maintenance problems.
- Up to 10 times faster than mechanical regulators.
- Lower cost per KVA.

FOR THE FULL STORY ON THIS COMPLETELY NEW CONCEPT IN LINE VOLTAGE REGULATION MAIL COUPON BELOW.

SOLAR ELECTRIC CO.
1717 Busse Road
Elk Grove Village, Ill.
HEmpstead 9-2800
IN CANADA, Solas-Basic Products Ltd., 377 Evans Ave., Toronto 18, Ontario

Send me all the facts on this new Sola line voltage regulator.

Name .................................................................
Company ............................................................
Title .................................................................
Address ..............................................................
City .................................................. State ........

CIRCLE 95 ON READER SERVICE CARD
NEED 65-80 db ISOLATION BETWEEN TRANSFORMER WINDINGS?

You do if your project involves very low signal levels. This was the case recently when a major transistor manufacturer specified EIC custom transformers with 65 db isolation between windings from 60 cycles to 10 kc. (We can give you 80 db if required.) Insulation resistance specified (winding to winding and winding to case) was 300,000 megohms.

Send us your complete specifications for prompt price and performance quotations.

ELECTRODYNAMIC INSTRUMENT CORPORATION
Subsidiary of Reed Roller Bit Company
JA 6-3761 • 1841 Old Spanish Trail • Houston 25, Texas
CIRCLE 207 ON READER SERVICE CARD

COSTS DOWN! WIRE FORMS PRECISION UP!

BY ARTWIRE

Art Wire's high speed, automatic machines and production economies mean BIG SAVINGS for you...with guaranteed precision from the first to the millionth unit. Widest variety of wire components, made for today's automatic production lines, delivered on schedule to assure uninterrupted work flow.

Send a Sample or Blueprint for Estimates

ART WIRE AND STAMPING CO.
18 Boyden Place, Newark 2, N.J.

CIRCLE 208 ON READER SERVICE CARD

How to grow a beard...

Sit back and wait for your copy on that routing list. Okay if you like beards. Otherwise, look in this issue for the Reader Service Card. Fill in the "for subscriptions" section. Mail. Only 7½ cents a week.

electronics

A McGraw-Hill Publication, 330 West 42nd St., N. Y. 36
If you find it increasingly difficult to get the up-to-date, expert information you need when you need it—here is important news from McGraw-Hill. A new professional encyclopedia has been developed that gives you latest available information in the scientific and engineering disciplines, and keeps you abreast of the whole spectrum of today's exploding technology.

Short-Cut to Basic Information on Every Aspect of Every Field: For help with everyday problems met in your work—as an instrument to help you bridge the gap between your specialty and other fields into which your work leads you—as a backstop and "refresher" in your own and related areas—there is no substitute for this new ready-reference tool in encyclopedia-form. McGraw-Hill enlisted the support of 2,000 contributors, including Nobel Prize winners and leaders of research and industry, for this unprecedented and widely-acclaimed undertaking.

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331 West 41st Street, New York 36, New York
NEW PRODUCTS

DESIGN AND APPLICATION

Distributed Constant R-F Module
150 WATTS IN 12 CUBIC INCHES
MICRODOT Inc., 220 Pasadena Avenue, South Pasadena, California, manufactures the Microdot power tetrode module averaging 12 cubic inches with power outputs up to 150 watts. The module features distributed-constant circuit components, weighs less than one pound and covers frequencies from 215 to 1,000 Mc. Special circuit layout effects rapid heat transfer to mounting surface. They can be used as power amplifiers or, frequency multipliers and are available either grounded-grid or grounded cathode.

CIRCLE 301 ON READER SERVICE CARD

Laser Calorimeter
5-PERCENT ACCURACY
ANNOUNCED by Trion Instruments, Inc., 1200 North Main Street, Ann Arbor, Michigan, is the model M1-1 Calorimeter measuring total energy output as a black-body calorimeter and peak power with a photocell. The useful power range is 0.1 to 30 joules with the calorimeter and 0 to 20 Kw with the photocell. Accuracy is better than 5 percent and time resolution of the photocell is approximately $10^{-4}$ second. The nominal output is 10 $\mu$V per joule calorimeter and 100 $\mu$V per kilowatt photocell, the input aperture is 0.75 inch and the input range of wavelengths is 0.3 to 3.0 microns. The unit was designed to provide accurate pulsed laser output data and the low-level outputs may be read directly or recorded on strip charts.

CIRCLE 302 ON READER SERVICE CARD

Two-Cavity Oscillator
PUMPS 10 AMPLIFIERS
OPERATING between 18 and 26.5 Gc, the new SOK family two-cavity oscillator made by Sperry Electronic Tube Division, Sperry Rand Corp., Gainsville, Florida, provides from 200 to 600 mw of power with a flat-top output curve. This oscillator will pump 10 or more parametric amplifiers such as used in phased array radar systems. The tubes are metal-ceramic construction and use electrostatic focusing. Cooling is by forced air and the weight is less than 8 oz. The two-cavity oscillator has lower beam voltage, higher output power, higher efficiency and lower a-m and f-m noise than a reflex tube. There is no reflector element and spurious shock modulation and vibration is reduced. Because of the flat-top output, variations in beam voltage produce negligible variation in output power. In many cases, pump levellers and a-f circuits can be eliminated. The first member of the SOK family is the SOK-292 operating at 25 Gc, 600 mw output at beam voltage of 1,000 v, current of 35 ma, flat-top bandwidth (minimum) of 20 Mc and a modulation sensitivity (minimum) of 200 Kc per volt.

CIRCLE 303 ON READER SERVICE CARD

Digital Voltmeter
USES CLAMP AND HOLD
RECENTLY introduced by Non-Linear Systems Inc., P. O. Box 728, Del Mar, California is their NLS CH2 clamp and hold digital voltmeter that makes four digit measurements in ranges of $\pm 9.999/99.99/999.9$ v to an accuracy of

CIRCLE 101 ON READER SERVICE CARD
**NOW... a Tracemaster System to meet your recording problem!**

AO Tracemaster presents three outstanding direct-writing recorder systems to help you acquire more meaningful low-frequency data.

**Series 250** — Ideal for test installations requiring a multi-channel record of diverse signal inputs on a common time base.

**Series 260** — Economical recording of simpler, medium sensitivity inputs requiring many identical channels.

**Series 290** — Single-, 2- or 3-channel portable Tracemasters; ruggedness and performance reliability in a compact package for those on-the-spot recordings in the lab, field or plant.

... And they all feature the advanced Tracemaster Pen Motor and the exclusive direct-carbon-transfer writing method ... assuring a clean, uniform, high-contrast, fine-line trace that is two to three times finer than any other direct-writing technique.

The important specifications above give only some of the many reasons why each system has established new standards of performance for direct-writing recorders in its class and price range. The complete story is yours for the asking ... just write for the catalog!

---

<table>
<thead>
<tr>
<th>SERIES 250 TRACEMASTER</th>
<th>SERIES 260 TRACEMASTER</th>
<th>SERIES 290 TRACEMASTER</th>
</tr>
</thead>
</table>
| 8-channel, Rack Cabinet on casters | 8-channel, Rack Cabinet on casters | Model 291
Single-channel, Portable |
| Model 293
3-channel, Portable |
| FREQUENCY RESPONSE | FREQUENCY RESPONSE | FREQUENCY RESPONSE |
| DC to 110 cps. ± 1% at 40 mm. peak to peak. Down 3 db at 140 cps. | DC to 100 cps. ± 1% at 40 mm. peak to peak. Down 3 db at 125 cps. | DC to 90 cps. ± 5% at 30 mm. peak to peak. Down 3 db at 125 cps. |
| BAND AMPLITUDE PRODUCT | BAND AMPLITUDE PRODUCT | BAND AMPLITUDE PRODUCT |
| 5600 (i.e. 40 mm. x 140 cps.) | 5000 (i.e. 40 mm. x 125 cps.) | 3750 (i.e. 30 mm. x 125 cps.) |
| SENSITIVITY RANGE | SENSITIVITY RANGE | SENSITIVITY RANGE |
| 10 Microvolts to 100 v/cm | 100 mv/cm to 20 v/cm | 50 mv/cm to 50 v/cm |
| CHART SPEEDS | CHART SPEEDS | CHART SPEEDS |
| 0.2 to 500 mm/sec. | 1 to 250 mm/sec. | 1 to 100 mm/sec. |
| CHART CAPACITY | CHART CAPACITY | CHART CAPACITY |
| 1000 ft. roll | 1000 ft. roll | 200 ft. roll |
| WEIGHT | WEIGHT | WEIGHT |
| 18 lbs. | 18 lbs. | 18 lbs. |

---

**American Optical Company**

INSTRUMENT DIVISION, BUFFALO 15, NEW YORK

See a complete demonstration at the IRE... AO Booth 3939.
Electro Development Corporation, Seattle, Wash., uses a Model 1108 Honeywell Visicorder Oscillograph to prove the linearity and resolution of signal conditioner-event markers which they supply to the Boeing Company.

A missile telemetering system samples each channel only once every 30 milliseconds, but missile engineers want to know when some events occur to an accuracy of better than one millisecond.

The event marker (the small cube atop the Visicorder) produces a highly-linear ramp output that starts exactly when the marker is triggered by the event in question. This ramp continues for about 100 milliseconds... enough time so that the telemeter system can sample the ramp at least three times. A straight line drawn through these points will accurately determine the occurrence of the event.

To check event marker linearity, the ramp is recorded at the very high record speed of 80"/sec. It's this high speed, the .01-second timing lines, the ease of operation, and the wide deflection capabilities of Honeywell galvanometers (approx. 7" in this application) that caused the Electro Development Corporation to select the Model 1108 Honeywell Visicorder.

Honeywell

First in Control
±0.01 percent ±1 digit. When making single readings as an analog-to-digital converter, it has 0.01-percent accuracy, constant 10-megohm impedance, ±0.001 v to ±999.9 v range, 1 μsec maximum read trigger lag and infinitely high measurement speed. The sketch shows the influence of slewing rate when digitizing a voltage waveform. At point A, the input is connected to the voltage source and the device slews at 2,000 v/sec until it reaches B. It then tracks the waveform faithfully since the waveform rate is less than 2,000 v/sec. At point C, a read trigger is issued and within 1 μsec (disconnect time), the unit disconnects from the waveform and measures the voltage at C in 5 ms. At point D, the unit again slews at 2,000 v/sec, until point E. It again tracks the waveform until point F where another read trigger is issued. The read triggers are initiated by the user.

**Capacitance Bridge**

0.00002 PF RESOLUTION

RECENTLY announced by Boonton Electronics Corp., 738 Speedwell Avenue, Morris Plains, New Jersey is the 75B capacitance bridge having a capacitance range from 0.00002 to 1,000 pF and a conductance range, calibrated in both conductance and parallel resistance, covering 0.01 to 1,000 µhos and 1,000 ohms to 100 megohms. The unit also features a built-in d-c bias supply adjustable between 0 and -5 v and 0 to +125 v permitting measurements of component capacitance and conductance in the presence of d-c bias. Applications requiring use of bias include semiconductor junction capacitance and conductance, performance of voltage-variable capacitors and determination of voltage coefficient of capacitors. The circuit (shown in the sketch) is a modified Schering bridge. Coaxial connectors give access to both arms of the bridge allowing for differential measurements. Lowest range has 0.1 pF at full scale spread over 5,000 dial divisions. Bridge output transformer is tuned to 1 Mc to present lowest possible shunt loading of the output signal.

**Coax Attenuators**

TWO STANDARD VALUES

RC ELECTRONICS, INC., 25 Martin Place, Port Chester, N. Y., offers variable coaxial attenuators with minimum insertion loss of zero db. Attenuation is essentially constant as a function of frequency with the required value selected by a linear dial movement. They are made in two standard values with direct reading settings in the AV-25 and linear settings in the AV-35. Units operate from 500 Mc to 11.0 Gc. Low vswr of 1.5 max is maintained by precision coaxial fabrication. Power rating, 2 w average; 2 Kw peak.

**Digital Computer**

MULTIPURPOSE

MNEMOTRON CORP., 45 S. Main St., Pearl River, N. Y. CAT400 is a portable, multipurpose digital computer for the study of biological and other variables. In addition to...
HUNDREDS OF WIDTHS, DEPTHS AND HEIGHTS

...with EMCOR Enclosures

Tailor-make a console, equipment bank or control center from the hundreds of standard enclosure widths, depths, and heights of the EMCOR Modular Enclosure System. Custom costly enclosure design time and modification is eliminated. Literally thousands of electrical, electronic or electro-mechanical equipment housing assemblies are available with EMCOR Standard Enclosures. With EMCOR, you get greater depth of line...the ultimate in flexibility and advanced design that defies obsolescence. Contact your local Ingersoll Products Sales Engineering Representative or write for full details.

A condensed version of Catalog 106 available at your request.

EMCOR-The Original Modular Enclosure System By
INGERSOLL PRODUCTS
Division of Borg-Warner Corporation
1000 W. 120th ST. • DEPT. 1242 • CHICAGO 43, ILL.

Most Ingersoll Products Sales Engineers also represent McLean Blowers for enclosures

averaging four different variables simultaneously, it serves a whole range of computing functions, such as: analog to digital conversion, recording fast wave forms, automatic plotting of digital data, statistical distribution of analog and events, and function generation.  

CIRCLE 307 ON READER SERVICE CARD

Delay Lines
MAGNETOSTRICTIVE

DELTIME INC., 608 Fayette Ave., Mamaroneck, N.Y. New magnetostriective delay lines can be used as precise quantitative storage elements in memory systems. Units offer from 20 sec to 10 milliseconds delay times, and 5 milliseconds delay to 1 Mc with return-to-zero. They are housed in steel cases, providing protection against stray magnetic fields and ambient humidity, resulting in long-term stability. Advances in design and materials have reduced delay drift due to temperature changes.  

CIRCLE 308 ON READER SERVICE CARD

RFI Meter
EXTENDED RANGE

EMPIRE DEVICES, INC., Amsterdam, N.Y. Frequency range of noise and field intensity meter NF-112 has been extended to 15 Ge with the addition of new plug-in tuner model T-5/NF-112. The entire range from 1.0 to 15.0 Ge is now covered in a single instrument by means of

electronics
five plug-in tuning units, thus avoiding costly repetition of circuitry and components common to all frequency ranges. Tuning units can be interchanged in seconds.

CIRCLE 309 ON READER SERVICE CARD

Slides
FOR MINIATURIZATION
GRANT PULLEY & HARDWARE CORP., High St., West Nyack, N. Y., offers a slide designed in keeping with trends toward miniaturizing and compressing equipment. The Micro-Slide features: 6 in. side space, load capacity of 100 lb, continuous ball bearing action, quick-disconnect, full extension of supported unit.

CIRCLE 310 ON READER SERVICE CARD

Tantalum Capacitor
SOLID, POLARIZED
GOOD-ALL ELECTRIC MFG. CO., Omaha, Neb. Type 501 solid, polarized tantalum capacitor features superior leakage characteristic. Range: 0.0047 μF to 0.330 μF in 0.10, 0.15, 0.20 and 0.35 μF d-c. Case: 4 subminiature sizes per MIL-C-26655-A.

CIRCLE 311 ON READER SERVICE CARD

Logic Modules
PLUG-IN UNITS
HARMAN-KARDON, INC., Plainview, N. Y., announces Facilog digital logic modules designed for simple and economical systems interwiring. Each module is separately housed in a plug-in case, approximately 1½ in. by 1½ in. by 3 in. deep and contains up to 4 separate logical functions, depending upon the complex-

No Strain; no sweat
As any printed-circuit assembler knows, you've got to treat transistors with respect. Transipads do just that.

Transipads protect transistors from inadvertent abuse. They prevent lead strain and breakage. They provide a built-in air space to dissipate the heat of soldering. They allow easy removal of solder flux and permit unobstructed inspection of solder joints and fillets.

They produce a neater finished job, too, by providing uniform above-the-board spacing. And a more reliable assembly, as well. Transipad mountings anchor transistors so securely that even under conditions of shock and vibration, leads won't short together and cases won't short against p-c conductors or adjacent component leads.

What's more, you can realize all of these benefits for a remarkably modest cost—a matter of pennies in fact.

Fifty Transipad styles cover all of the most common TO case types. Included in the line-up are a number of converter styles that increase pin circles and widen lead spacing. All can be furnished in dialyl phthlate, alkyd, or nylon—with color coding, if you wish. Call or drop us a line for drawings and samples.

THE MILTON ROSS COMPANY
238 Jacksonville Road, Hatboro, Pa. 18045 Crenshaw Blvd., Torrance, Calif.

Phone: Osborne 2-0551  Phone: Davis 3-7161

CIRCLE 105 ON READER SERVICE CARD
Program Switch

Programmed Switches

That can be altered for specific applications!!

Provides compact method for combining up to 28 inputs or outputs with up to 24 different circuit configurations. Speeds up circuit grouping or testing in complex circuitry. Offers alterable programming without disassembly. Single-source test signals can be channeled to as many as 648 circuit combinations. For complete specifications on this switch series, mark reader service card or request Shallcross 111-S-DS.

Punched Tape Reader

High Speed

Rheem MFG Co., 5200 W. 104th St., Los Angeles, Calif. Model RR-1000 is nominally a 1,000 character per sec unit, and features completely transistorized circuits, photovoltaic sensing cells and rugged two-speed motor drives. The unidirectional model is priced at $1,450; bidirectional model, $1,500. Standard model includes 2:1 speed ratio selectable with low level input, and 5, 7, and 8 level tape selection.

Sealed Connectors

Stainless Steel

Hermetic Seal Corp., Rosemead, Calif. Series SS nonmagnetic hermetically sealed connectors meet all applicable military specifications. They have leak rates in production as low as 1 x 10^-7 cc/sec, with even tighter leak rates possible for special requirements.

D-C Power Supply

And Battery Charger

Christie Electric Corp., 3410 W. 67th St., Los Angeles 43, Calif., introduces a line of wide-range d-c
power supplies for laboratory, automatic battery charging or general purpose use. Six models offer a continuous voltage adjustment range of 1 to 145 V d-c and up to 50 amp. Standard a-c supply source required is 115 V, single phase, 60 cycle.

CIRCLE 315 ON READER SERVICE CARD

Packaged Circuits

CORNELL-DUBILIER ELECTRONICS, 50 Paris St., Newark, N. J. Line of low-cost digital computer packaged circuits has operating frequency range of d-c to 1 Mc with 0.2 μsec rise and fall time.

CIRCLE 316 ON READER SERVICE CARD

Swept Oscillators

ALFRED ELECTRONICS, 3176 Porter Drive, Palo Alto, Calif., offers a series of swept microwave oscillators featuring built-in levelers which hold power output constant to approximately ±0.75 db over the entire frequency range and nominally to ±0.1 over any 100 Mc interval. The 620 B sweepers offer a frequency range from 1 to 26 Gc.

CIRCLE 317 ON READER SERVICE CARD

Capacitors

TANTALUM FOIL

INTERNATIONAL ELECTRONIC INDUSTRIES DIV., Standard Pressed Steel Co., Box 9036, Nashville, Tenn. New Super Series etched tantalum
foil capacitors possesses twice the capacity values, case size for case size, of MIL-C-3965/2 units. They are designed to operate over a temperature range of -55 C to 85 C. Voltage range is from 15 through 150 vdc. Capacitance range from 30 µf to 1160 µf.

CIRCLE 318 ON READER SERVICE CARD

Tape Recorder

RUGGED UNIT

LEACH CORP., 18435 Susana Rd., Compton, Calif. Tape recorder features precision gear drive (photo above) and silicon rubber capstan (below) as mover for 75 ft of 1 mil Mylar tape. Temperature range (limitation is imposed by tape, not recorder) is -112F (-80 C) and +180 F (+82 C).

CIRCLE 319 ON READER SERVICE CARD

Scribe Coat Film

FOR P-C LAYOUTS

KEUFFEL & ESSER CO., Third and Adams Sts., Hoboken, N. J. New scribe coat film eliminates the necessity of using light tables in the scribing of printed circuit lay-
Transistors
HIGH POWER
SILICON TRANSISTOR CORP., Carle Place, N. Y., announces four diffused junction silicon transistors—npn high power devices suitable for applications in power converters, power supply regulators, relay replacements and controls, and d-c and servo amplifiers. They are 150 w. single-end stud types, featuring low leakage currents, high temperature stability, and low thermal resistance.
CIRCLE 321 ON READER SERVICE CARD

Frequency Standard
MELPAR, INC., Falls Church, Va. Miniature tuning fork frequency standard gives sine waves and square waves with crystal precision.
CIRCLE 322 ON READER SERVICE CARD

Data Recorder
BATTERY OPERATED
SONY CORP. OF AMERICA, 514 Broadway, New York 12, N. Y. Model PPW-22 spring powered two-chan-

HIGH-ACCURACY PRECISE ANGLE INDICATOR
NEW KEARFOTT UNIT ACCURATE TO ±6 MINUTES

The new CO 2721011 Precise Angle Indicator features an accuracy of ±6 minutes. Latest addition to the Kearfott line of standard test equipment, the unit is designed to meet a wide range of applications. Typical Applications:
- Indication of gyro angle of pitch, roll, or yaw and relaying of signal to any preselected impedance or voltage level.
- Indication of shaft position of remote synchro or resolver, and transmission of this information to any impedance or voltage level.
- Display of difference between two shafts when driven by transmitter and differential synchos.

In addition to high accuracy the instrument combines a number of other prominent advantages: it requires only a single power source; it has good sensitivity; it is designed for modular application; and it offers direct automatic readout. The unit is of extremely compact construction and is built for maximal ease of maintenance.

The low-cost CO 2721011 Precise Angle Indicator is available with a single sensor, auxiliary dual-input sensor, or an auxiliary retransmitter. For additional information on this new test instrument, write for the brochure which describes its operation and capabilities in detail.

SPECIFICATIONS

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repeatability</td>
<td>±1.2 min</td>
</tr>
<tr>
<td>Readability</td>
<td>0.5 min</td>
</tr>
<tr>
<td>Input Power</td>
<td>30 va</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>1.0 min</td>
</tr>
<tr>
<td>Slewing Speed</td>
<td>7 sec/180°</td>
</tr>
<tr>
<td>Power (single source)</td>
<td>115 v, 1Φ, 400 cps</td>
</tr>
<tr>
<td>Size</td>
<td>1½ x 9½ x 9½ in.</td>
</tr>
<tr>
<td>Weight</td>
<td>4 lbs.</td>
</tr>
</tbody>
</table>

Write for complete data
KEARFOTT DIVISION
GENERAL PRECISION, INC.
Little Falls, New Jersey

March 16, 1962
20 to 200 D.P.
Send your prints for quotations

- SPURS
- HELICALS
- WORM AND WORM GEARS
- STRAIGHT BEVELS
- LEAD SCREWS
- RATCHETS
- CLUSTER GEARS
- RACKS
- INTERNALS
- ODD SHAPES

Quadrants and spindles with fine-pitch teeth are cut to close limits in our modern shop. Tell us your needs.

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Members $1.00. Non-members $3.00. Age limit: over 18

Audio Voltage Standard
PRECISION UNIT
HOLT INSTRUMENT LABORATORIES
Oconto, Wisc. Model 323 provides fully variable voltage from 10 mv to 1,000 v at 5 internal frequencies up to 10 Kc. Using an external oscillator 20 Kc may be obtained at...
any voltage setting. Unit will calibrate instruments at any load from 0 to 30 w through its full frequency and voltage range. Short term stability 0.01 percent; long term stability 0.03 percent per month.

-- permits shifting of phase between 2 self-generated voltages to any desired angle, with accuracy better than ±.05°

Precise generation of voltage vectors. The Gertsch VPS-1 generates 2 signals differing in phase by any angle from 0° to 360°, as determined by front-panel controls. The reference signal has a fixed amplitude of 50V rms. The vector output, which may be displaced in phase, has a maximum amplitude of 50V rms, and can be attenuated in steps of 50 mv within a range of 0-50V rms.

Operation at any 3 frequencies within a range of 150-3000 cps is provided by a front panel selector switch. Fine adjust control permits varying the frequencies ±5% max.

Completely self-contained unit requires no accessories for operation. Case or rack mounted. Send for literature VPS-1.
Bristol choppers help U.S. Astronaut maneuver

Friendship 7 spacecraft

Four Bristol Syncroverter* choppers formed a vital part of the infrared horizon sensors manufactured by Barnes Engineering Company, Stamford, Conn., and carried aloft in NASA's FRIENDSHIP 7 spacecraft by the first U.S. astronaut to orbit the earth.

The Bristol choppers function as sensitive phase detectors in the sensors as they establish a horizontal reference plane for the vehicle.

Infrared Horizon Sensor undergoes rigorous optical, mechanical, and electrical checks at Barnes Engineering Co. One Bristol chopper is located in foreground, in front of gear.

Bristol Syncroverter* choppers, noted for low noise, long life and high reliability, are finding a vital place in more and more missile guidance systems, as well as in analog computers, d-c amplifiers, and test equipment for industrial applications. More than 200 models available. Write for complete details.

The Bristol Company, Aircraft Equipment Division, 150 Bristol Road, Waterbury 20, Conn.
A Subsidiary of American Chain & Cable Company, Inc.


BRISTOL... engineers for precision, builds for reliability

250 ma resistive or inductive on normally open. Temperature -65 C to +125 C; vibration 20 g to 2,000 cps; shock 60 g for 11 ± 1 millisecond; life 1 million operations minimum.

CIRCLE 327 ON READER SERVICE CARD

X-Y Recorder
BUILT-IN TIME BASE
HOUSTON INSTRUMENT CORP., P.O. Box 22234, Houston 27, Texas. Model HR-95T features high performance servos, interchangeable plug-in control modules, built-in time base on X axis and standard Zener reference supplies. Recorder utilizes conventional vacuum system for holding standard 8½ in. by 11 in. graph paper to platen. New snap-in pen design utilizes standard recorder ink cartridges to eliminate ink filling problems. D-C accuracy is greater than 0.25 percent full scale.

CIRCLE 328 ON READER SERVICE CARD

Low Noise Amplifier
TRANSISTORIZED
MILLIVAC INSTRUMENTS, INC., 1100 Altamont Ave., Schenectady, N. Y. New input configuration provides 50 meg, 50 pf input impedance in this battery-operated amplifier. Noise, with 50 meg input open or shorted, less than 3 µv with a bandwidth of 10 Kc. Unit has other input impedances of 10,000 to 100,000.
Acoustical Components of Superior Quality

JAPAN PIEZO supplies 80% of Japan's crystal product requirements.

March 16, 1962

for use with lower source resistances. Upper and lower bandpass filters effectively reduce noise on unused band portions.

CIRCLE 329 ON READER SERVICE CARD

High-Energy Systems

YARDNEY ELECTRIC CORP., 40-50 Leonard St., New York 13, N. Y., announces high-energy electrochemical systems with a wide range of design possibilities—capacity ranging from 0.1 amp hr to 30,000 amp hr.

CIRCLE 330 ON READER SERVICE CARD

Power Supply

PROGRAMMABLE

ELECTRONIC RESEARCH ASSOCIATES, INC., 67 Factory Place, Cedar Grove, N. J. Model TR60-2 occupies a panel height of 3½ in. with a ½ rack 8½ in. panel length, yet provides highly regulated continuously adjustable output over the range 0-60 v d-c at 0-2 amp. Input is 105-125 v a-c, 60-1,000 cps; line or load regulation less than 0.005 percent, ripple less than 250 μv; temperature coefficient less than 0.01 percent per deg C; transient response better than 50 μsec.

CIRCLE 331 ON READER SERVICE CARD

Alumina Ceramics

INJECTION MOLDED

DIAMONITE PRODUCTS MFG. CO., Shreve, Ohio. Injection mold proc-
Airpax electro-magnetic circuit breakers add less than 0.5% to an equipment's base price while adding years of maintenance free, fail-safe performance. These circuit breakers have a versatility of application not available with other circuit protectors. They incorporate the protective features of fuses, thermal units and overload relays without their inherent disadvantages.

Series 500, Military Type
hermetically sealed, withstands 75 G shock

Series C-300, Industrial Type
positive protection at lowest cost

Series 500-R, Remote Indicating Type
auxiliary contacts for remote indication

Ratings from 50 MA to 15 amps
DC, 60 and 400 CPS types
No temperature derating
Instantaneous or delay types

Gang assemblies available
Series, shunt and relay circuit use
-55 C to +100 C temperature range
Trip free

Airpax Electronics
Cambridge Division • Cambridge, Maryland

RFI Gasket
AND FLUID SEAL

Technical Wire Products, Inc., 129
Dermody St., Cranford, N. J. Teckstik is a strip of Monel or aluminum knitted wire mesh integral with a fluid seal of neoprene or silicone, which is backed by pressure-sensitive adhesive material. Resilient and conductive, Teckstik is effective for re-establishing electrical continuity at the joints in all types of rfi shields, while sealing them off from fluids.

Insulation Tester
GOVERNORLESS

Yokogawa Electric Works, Inc., 40
Worth St., New York 13, N. Y. Model L-5B is a 2 Kv/5000 megohm tester with no power source or carrying-cart required. In place of the mechanical control of rotation by the governor, the Zener character-
istics of silicon diodes is utilized. This makes reverse rotation possible, eliminates mechanical breakdown of governor and provides constant voltage. Ruggedized pivot-jeweled movement is sandwiched between silicon rubber beds. Entire moving part floats on neoprene shock absorbers. Price is $245.

CIRCLE 334 ON READER SERVICE CARD

Gear Clamps
Tech-Ohm Electronics, Inc., 36-11 33rd St., Long Island City 6, N. Y., introduces a line of standard stock miniature precision single and two piece balanced gear clamps.

CIRCLE 335 ON READER SERVICE CARD

Potentiometers
Precision Trimmers
Mechatrol, a division of Servo mechanisms/Inc., 1200 Prospect Ave., Westbury, L. I., N. Y. For use in electrical circuits as a lead screw actuated two or three terminal variable resistance network, the new deposited metal film precision trimmer potentiometers feature a low temperature coefficient of resistance with infinite resolution available at competitive prices.

CIRCLE 336 ON READER SERVICE CARD

Telemetering Filter
Ulraminiature
Polyphase Instrument Co., East Fourth St., Bridgeport, Pa. All standard IRIG telemetering channels are covered by a new 1 5/8 in. by

March 16, 1962

without change in contact resistance

That’s the performance record of this new, solid-front .025" jack. And the unique construction of the caged beryllium copper spring in a housing with a blind hole permits dip soldering or encapsulation. What’s more, after 68,000 cycles, there was no significant increase in contact resistance...and no physical deterioration.

In addition to this new jack, there are 35 other basic types of Cambion Miniature Plugs and Jacks — and a wide choice of finishes and insulation, too — to meet your individual requirements for both conventional and printed circuits. They’re carefully processed from the highest quality materials to meet all applicable MIL specifications. And like all Cambion electronic components — the broad line includes more than 10,000 different items — they are unconditionally guaranteed in any quantity.

Wherever good contact is essential, insist on Cambion plugs and jacks. For information on deliveries and prices, and a copy of PLUG AND JACK CATALOG No. 70, write to Cambridge Thermionic Corporation, 437 Concord Avenue, Cambridge 38, Massachusetts.

Cambion
The guaranteed electronic components

CIRCLE 117 ON READER SERVICE CARD
Positive performance as proved by high customer acceptance characterizes Tele-Dynamics' 1270A voltage controlled oscillator. Exceptional electrical and environmental specifications, unique in off-the-shelf components at the right price, are representative of Tele-Dynamics' creative efforts in the complete telemetry field. Write for technical bulletins and a new capabilities brochure.

TECHNICAL CHARACTERISTICS
Input—0 to 5 volts or ±2.5 volts
Linearity—±0.25% BSL
Power Requirements—28 volts at 9 ma max.
Distortion—1%
Amplitude Modulation—10%

ENVIRONMENTAL CHARACTERISTICS
Thermal Stability—–20°C to +85°C ±1.5% DBW
Altitude—Unlimited
Vibration—30G random
Acceleration—100G
Shock—100G

R-F Wattmeter
PORTABLE UNIT
BIRD ELECTRONIC CORP., 30303 Aurora Rd., Cleveland 39, O. Model 6150 TermaLINE r-f wattmeter is a termination type absorption instrument having selectable dual power ranges of 0-30, 0-150 w. Power values are read directly over the frequency range of 30-500 Mc. VSWR is 1.1 max. Input connector is female type N. Price, $225.

Cable Ties
SAVE TIME, LABOR
PANDUIT CORP., 17301 Ridgeland Ave., Tinley Park, Ill., introduces a new concept in permanent cable ties—the Sta-Strap. The line combines self-locking Nylon cable ties and clamps with a tensioning tool that automatically cuts off excess strap at a pre-set tension. The result is a big reduction in cabling time and labor with controlled, uniform tie tension.
Use the 
POLAROID®
10,000 SPEED 
Land Film

in the new 
BEATTIE-COLEMAN 
MARK II 
OSCILLOTRON

Records in 
ANY RATIO 
from 1:1 to 1:0.5

Here's the most versatile oscilloscope camera ever made. Especially designed for new 10,000 speed Polaroid Land Type 410 film that records pulses of extremely short duration. Prints in 10 secs. Easily change ratios from 1:1 to 1:0.5 without extra lenses. External focusing. Flat field lens. Electric shutter eliminates cable release. Direct viewing port or hood. Records up to 13 traces on one frame. Dark slide on Polaroid Land Camera back. Records written data on film. Fits any 5" scope. Attractively priced. Send for catalogs on all B-C Oscillotron models now.

"Polaroid®" by Polaroid Corporation

CIRCLE 213 ON READER SERVICE CARD
March 16, 1962

PRODUCT BRIEFS

ALUMINUM SOLDER corrosion resistant material. Scientific Products, Inc., 521 Marilyn Ave., State College, Pa. (340)


CLUTCH DEVICES 1 in. diameter. Fair Instrument Corp., 16 Norden Lane, Huntington, L. I., N. Y. (342)

X-BAND MAGNETRON low voltage. Avnet Instrument Corp., 70 State St., Westbury, N. Y. (343)

VOLTAGE REFERENCE 0.025 percent accurate. Electronic Development Corp., 423 W. Broadway, Boston 27, Mass. (344)

FREQUENCY STANDARD 4.999600 Kc. Reeves-Hoffman Division, Cherry and North St., Carlisle, Pa. (345)

DATA TRANSMISSION SYSTEM no multiplexing. Security Devices Laboratory, Rochester 21, N. Y. (346)

SENSITIVE MICROPHONE 0.025-1 cps. The Geotechnical Corp., 3401 Shiloh Road, Garland, Texas. (347)

TRANSISTORS hermetically sealed. Hermetic Seal Corp., Rosemead, Calif. (348)

MICROWAVE SWITCH 0.88:1. Waveguide, Inc., 851 W. 18th, Costa Mesa, Calif. (349)

RFI FILTER for airborne cameras. Astron Corp., 255 Grant Ave., East Newark, N. J. (350)

P-C PLUGS meet MIL-C-21007. Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif. (351)

FOLLOWER INVERTER d-c to sine wave. Arnold Magnetics Corp., 6060 W. Jefferson Blvd., Los Angeles 16, Calif. (352)


DELAY LINES ultrafast rise time. Ad-Yu Electronics Lab, Inc., 249 Terhune Ave., Passaic, N. J. (355)

PRINTED CIRCUIT THUMBWHEEL SWITCH SOLVES UNIQUE OR COMPLEX SWITCHING PROBLEMS

Readily adaptable to wide range of custom applications in which printed board construction is required for unique or complex switching.

1. Compact modules for individual mounting.
2. Multiple decks may be integrally housed.
3. Typical binary printed wafer.

For complete specifications on this switch series, mark reader service card or request Shallcross 112-S-DS.

CIRCLE 119 ON READER SERVICE CARD

119
HOLE

EECO PUNCHED-TAPE READERS DIGEST "BLOCKS" OF DATA FOR AUTOMATIC PROGRAMMING

Machine tool control and automatic checkout and tests are just two of many applications of EEKO block readers, which offer complete test per block, identification of data function by position in block, elimination of data storage records and address decoding circuits. Straightforward programming by blocks. Standard units read 80, 96, 120, 160 bit blocks, in standard 19" rack mounting units or modular units. Takes 1", 8-level paper or mylar tape punched on 0.1" centers. Reader head designed for either forward or reverse reading. Most models are bi-directional. Write for data sheets.

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<tr>
<th>MODEL</th>
<th>401</th>
<th>402</th>
<th>414</th>
<th>417</th>
<th>422</th>
<th>450*</th>
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<td>CONTINUOUS ANDREW SPEED (ips)</td>
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<td>11</td>
<td>10</td>
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<td>12</td>
<td>11</td>
<td>10</td>
<td>9⅓</td>
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<tr>
<td>FRAME LENGTH (inches)</td>
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<td>1.5</td>
<td>2.0</td>
<td>1.0</td>
<td>1.2</td>
<td>1.5</td>
<td>2.0</td>
<td>1.0</td>
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<td>INPUT POWER</td>
<td>115 Vac 60 c/s 150 watts.</td>
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<td>FORWARD AND REVERSE</td>
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*Modular unit

** CIRCLE 120 ON READER SERVICE CARD

Literature of

FILTERS Kenyon Transformer Co., 1057 Summit Ave., Jersey City, N.J. Catalog P-621 fully describes the company's standard lines of telemetering, tone channel, and interstage filters. (356)

WIREWOUND RESISTORS Kelvin Electric Co., 5907 Noble Ave., Van Nuys, Calif. Catalog P-1 describes encapsulated precision resistors for p-c high density packaging. (357)

DIGITAL TRANSDUCERS Diginamics Corp., 2525 E. Franklin Ave., Minneapolis 6, Minn. An 8-page pamphlet of application notes is entitled "What? Why? How? Digital Transducers." (358)

TIMERS Logitek, Inc., 54 Rome St., Farmingdale, L.I., N. Y., offers a 4-page brochure on static time delays and time delay relay modules. (359)

D-C VOLTAGE REGULATORS Taber Instrument Corp., 107 Goundry St., North Tonawanda, N. Y., has available bulletin on miniature d-c voltage regulators. (360)

METALLIZED CERAMIC BASES Advanced Vacuum Products, Inc., 440 Fairfield Ave., Stamford, Conn., has issued a bulletin on high-temperature ceramic-to-metal bases for semiconductors. (361)


PHYSIOLOGICAL STIMULATOR Theratron Corp., 1821 University Ave., St. Paul 4, Minn. Brochure illustrates and describes the Theratron physiological stimulator for nerve identification in surgery. (363)

CRYSTAL CAN RELAYS C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Ill. Type F subminiature crystal can relay is described in a 12-page booklet. (364)

ENERGY DATA BOOK Yardney Electric Corp., 40-50 Leonard St., New York 13, N. Y., has available a special energy data book for design engineers. (365)

POWER TETRODES Calvert Electronics, Inc., 220 E. 23rd St., New York 10, N. Y., has available a
the Week

catalog containing data on two high frequency power tetrodes. (366)

WIREWOUND RESISTORS General Instrument Semiconductor Division, 96 Mill St., Woosocket, R. I. Bulletin GR-40 describes and illustrates bobbinless precision wire-wound resistors. (367)

INDICATOR TRIODE Tung-Sol Electric Inc., One Summer Ave., Newark 4, N.J., offers an information guide on the type 6977 indicator triode. (368)

ULTRASONIC MACHINING Raytheon Co., 225 Crescent St., Waltham 54, Mass., has published a brochure on ultrasonic machining. (369)

CORE MEMORY UNIT Ampex Computer Products Co., 9937 Jefferson Blvd., Culver City, Calif. Eight-page brochure describes the RQL core memory unit. (370)

RESISTORS Film Resistors Inc., 242 Ridgedale Ave., Morristown, N. J. Bulletin 12A covers a line of coaxial termination type carbon and metal film resistors. (371)


CLUTCHES AND BRAKES Vibrac Corp., 281 Hilleria Rd., Chelmsford, Mass., offers a catalog on a line of magnetic dry particle clutches and brakes. (373)

TRANSMISSION LINE SYSTEMS Procelin, Inc., Hightstown, N. J. Bulletin describes methods for pressurizing coaxial transmission line systems. (374)

SEALED CELLS Sonotone Corp., Elmsford, N. Y. Technical data catalog covers a line of miniature sintered-plate, nickel-cadmium sealed cells. (375)

HARMONIC GENERATORS PRD Electronics, Inc., 202 Tillary St., Brooklyn 1, N. Y. Technical data sheet discusses varactor harmonic generators. (376)

MOLDING COMPOUNDS Dow Corning Corp., Midland, Mich. A 4-page data sheet lists characteristics of 12 different silicone molding components. (377)

REALLY STACKED

In more ways than one. Stacked reels, a 3-stacked recording head, and an economy of size which would enable you to stack more than forty of these miniature tape recorders into a cubic foot of space. □ Using less than 1 watt of power, the Precision Model PS-301M records an hour of voice frequency data on a single reel of tape. It operates quietly, weighs just a few ounces, incorporates a 8-transistor, 2-diode electronics circuit. □ The space-saving reel design is the same used in PI instrumentation magnetic tape recorders. It is one of the many advanced features which enable all PI instruments to offer full-size performance in a fraction of the space. Write for our new short-form catalog for details.
Beau Electronics Opens New Plant

BEAU ELECTRONICS, INC., of Waterbury, Conn., has occupied a new, two-story plant, tripling manufacturing facilities.

Sections of the first floor will be used for winding, grinding and varnishing operations, assembly of mass production items, precision testing and storage of finished and raw stock. Individual locations are designed to streamline production flow.

The second floor will contain air-conditioned offices for management, purchasing, sales, accounting and engineering.

Richard J. Beaulieu, president, said the new plant was needed to meet a rapidly increasing sales backlog. The company, which started in 1958 with two employees, makes hysteresis motors, precision recorders, and instrument and data process controls.

R&D activities will also be expanded. Beau recently developed a tape deck transport designed to use its motors. Flutter at 7.5 ips is 0.07 percent, the company says. The motors have a rotor outside the stator. The motor ring acts as a permanent magnet and the poles shift as frequency varies. The company claims improved torque and stability, due to increased moment of inertia.

Granger Associates Promotes Phelps

JOHN M. PHELPS, Captain USN (Ret.) has been named vice president-operations of Granger Associates, Palo Alto, Calif., with overall responsibility for manufacturing, supply, quality assurance and field services.

Phelps joined the communications equipment firm last November as assistant to the president, John V. N. Granger.

Custom Components Elects Olerud

ROY A. OLERUD has been elected president of Custom Components, Inc., of Caldwell, N. J. Company supplies ferrite and powdered iron magnetic materials to the electronic and electrical industries.

Olerud, who formerly held executive positions with ITT Corp. and Allen B. DuMont Laboratories, replaces Harold I. Danziger, founder of the firm. Danziger will continue as chief executive officer, directing the growth and expansion activities of the corporation.

Potter Instrument Hires Landman

BERNARD S. LANDMAN has joined Potter Instrument Co., Inc., Plainview, L.I., N.Y., as project engineer for the systems department.

He comes to Potter from PRD Electronics, Inc., Brooklyn, N.Y.

Sprague Names Korli Inet Division Head

WILLIAM D. KORLI has been appointed vice president and general manager of Sprague Engineering Corp.'s newly acquired Inet Division in Compton, Calif.

Korli was formerly Pacific Division manager of Kurs & Root Co., Inc., Appleton, Wis.

Thompson Joins Microtech

MICROTECH, INC., Cheshire, Conn., announces the appointment of George Thompson as vice president and general manager of the com-
Problem for you:

Soft land this vehicle on the moon

This spacecraft is SURVEYOR, one of the many important projects now under way at Hughes. It will "soft" land on the moon sometime in 1963. Its mission: to pierce and analyze the moon's surface; to transmit back to earth high quality television pictures; and to measure the moon's magnetic and radiation characteristics. To accomplish these demanding objectives, Project Surveyor requires the talents of many imaginative junior and senior engineers and physicists to augment its outstanding staff. A degree from an accredited university and U.S. citizenship are required. Experience in Aerospace Vehicles is preferred but not necessary. A few of the openings include:

CONTROLS ENGINEERS. Concerns airborne computers and other controls related areas for: missiles and space vehicles, satellites, radar tracking, control circuitry, control systems, control techniques, transistorized equalization networks and control servomechanisms.

CIRCUIT DESIGNERS. Involves analysis and synthesis of systems for: telemetering and command circuits for space vehicles, high efficiency power supplies for airborne and space electronic systems, space command, space television, guidance and control systems, and many others.

INFRARED SPECIALISTS. To perform systems analysis and preliminary design in infrared activities for satellite detection and identification, air-to-air missiles, AICBM, infrared range measurement, air-to-air detection search sets, optical systems, detection cryogenics and others.

SYSTEMS ANALYSTS. To consider such basic problems as: requirements of manned space flight; automatic target recognition requirements for unmanned satellites or high speed strike reconnaissance systems; IR systems requirements for ballistic missile defense. Inquire today. Please airmail your resume to: Mr. Robert A. Martin, Supervisor of Scientific Employment, Hughes Aerospace Divisions, 11940 W. Jefferson Blvd., Culver City 87, California. We promise a reply within one week.

Hughes Aircraft Company
Aerospace Divisions
An equal opportunity employer.

March 16, 1962
**ADFAK ADAPTER DEVELOPED BY RIXON FOR SECURE FAX TRANSMISSION**

![Diagram of FAX transmitter, ADFAX, and Encrypter with 2 or 4 WIRE LINE]

**BEFORE**

**The Problem:** Facsimile machines are used extensively by the various branches of government to make copies of documents for transmission to other locations. Since a large segment of these documents are of a secret nature, security is of the utmost importance. Modern security systems employ digital transmission. Thus the problem was to convert the FAX signal to a synchronous digital data stream without destroying the usefulness of the transmitted picture.

**The Solution:** By demodulating, slicing and time sampling the transmitter output, a two-level digital signal is produced. Either 1200 or 2400 bits per second may be used with the latter providing the maximum resolution. At the receiver a carrier is modulated directly by the decoded digital signal and fed to the FAX machine in a normal manner. Thus black and white FAX transmission with resolution almost indistinguishable from the analog original is provided over secure data circuits by the ADFAX unit.

**RIXON PROVES ITS CAPABILITIES ADAPT TO MEET ANY NEED**

See our new digital data line at the IRE Show Booth 3034.

**Coto-Coils For Contact Capsules**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>DC-V</th>
<th>Nom. Watts</th>
<th>Nom. Amp/Turns</th>
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<tr>
<td>S</td>
<td>5 1224</td>
<td>100 360 1400</td>
<td>.40 250</td>
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<tr>
<td>M</td>
<td>6 1224</td>
<td>50 17 820</td>
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<td>6 1224</td>
<td>100 400 1600</td>
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<tr>
<td>U</td>
<td>6 1224</td>
<td>150 500 2500</td>
<td>.24 125</td>
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Coil Windings
WIRE SIZES #6 to #56
CLASSES A, B, F and H
Write for Bulletin and Prices

Since 1917 Coto-Coil has wound all types of coils for every application. Complete design and engineering service is available.

**Brayshaw Announces New Company**

BRAYSHAW ELECTRONICS, INC., recently opened offices and plant at Olivia Street, McKees Rocks, Pa. The new corporation will manufacture selenium rectifiers, silicon rectifiers and other semiconductors and components.

President of the firm is Stanier E. Brayshaw who formerly was manager, semiconductor products R&D at Syntron Corp.

**Dickson Electronics Appoints Jones**

ROBERT L. JONES has been named production manager for Dickson Electronics Corp., Scottsdale, Ariz. Dickson Electronics manufactures a line of Zener diodes, reference diodes, and high voltage rectifiers for the electronics industry.

Immediately prior to joining the company, Jones was production manager for silicon alloy and mesa
Wilson Assumes
U. S. Sonics Post


Prior to this appointment, Wilson was manager of research and development administration for the Raytheon Co. and before this, was manager of the advanced development laboratory of the Raytheon Industrial Components division.

PEOPLE IN BRIEF


Transistors at Hughes Semiconductor Division.

Approaches laboratory standard precision under severe environmental conditions

TODAY'S MOST STABLE PLUG-IN FREQUENCY AND TIME BASE

JKTO-43 TRANSISTORIZED FREQUENCY STANDARD

A rugged plug-in oscillator engineered for use in precision type equipment operating under severe environmental conditions. An AGC type, low constant crystal drive oscillator employing silicon transistors, precision glass-enclosed crystal having a "Q" in excess of one million, followed by a silicon transistor output stage results in a high order of stability. A silicon zener diode is used to regulate the voltage supply to the oscillator and buffer. The crystal and oscillator are enclosed in a modern thermally balanced oven cavity where the average temperature can be held less than 1/4 °C, over an ambient temperature range of minus 55°C to plus 80°C, by means of a high gain silicon transistor DC type proportional temperature controller oven circuit.

Special features include precision vernier trimmer capacitor located within the temperature controlled enclosure, accessible externally; output of 250 microwatts operating into a high or low impedance load at oscillator frequency with excellent short term stability.

Optional features include multiplication of oscillator frequency by two to eight or division by two to sixteen, voltage control of frequency by means of a varicap diode, and variation in power output where additional can be used.

SPECIFICATIONS

## Weekly Qualification Form for Positions Available

**ATTENTION:**

**ENGINEERS, SCIENTISTS, PHYSICISTS**

This Qualification Form is designed to help you advance in the electronics industry. It is unique and compact. Designed with the assistance of professional personnel management, it isolates specific experience in electronics and deals only in essential background information.

The advertisers listed here are seeking professional experience. Fill in the Qualification Form below.

**STRICTLY CONFIDENTIAL**

Your Qualification form will be handled as "Strictly Confidential" by ELECTRONICS. Our processing system is such that your form will be forwarded within 24 hours to the proper executives in the companies you select. You will be contacted by your home by the interested companies.

**WHAT TO DO**

1. Review the positions in the advertisements.
2. Select those for which you qualify.
3. Notice the key numbers.
4. Circle the corresponding key number below the Qualification Form.
5. Fill out the form completely. Please print clearly.

---

### Fields of Experience (Please Check)

- [ ] Aerospace
- [ ] Antennas
- [ ] ASW
- [ ] Circuits
- [ ] Communications
- [ ] Components
- [ ] Computers
- [ ] ECM
- [ ] Electron Tubes
- [ ] Engineering Writing
- [ ] Fire Control
- [ ] Human Factors
- [ ] Infrared
- [ ] Instrumentation
- [ ] Medicine
- [ ] Microwave
- [ ] Navigation
- [ ] Operations Research
- [ ] Optics
- [ ] Packaging
- [ ] Radar
- [ ] Radio—TV
- [ ] Simulators
- [ ] Solid State
- [ ] Telemetry
- [ ] Transformers
- [ ] Other

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### Category of Specialization

Please indicate number of months experience on proper lines.

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### Employers

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TO ENGINEERS AND SCIENTISTS
LOOKING FOR GREATEST PERSONAL
INVOLVEMENT IN MAJOR SYSTEMS FOR SPACE:

COMMON SENSE SAYS, "LOOK TO THE HEAVENS"... OR DOES IT?

All of the glamour that surrounds hardware in orbit often obscures one very meaningful fact. As much as 80% of a complete space system is, and remains, on the ground.

Here's another fact. Within General Electric, technical competence for the ground-based portion of space programs concentrates here in Syracuse, New York.

For instance, the highly reliable radio-inertial guidance system our engineers developed for ATLAS (now operational with the USAF) is the same system that has been used for booster guidance on 75% of America's space shots.

Another system, utilizing an entirely different set of engineering concepts, is MISTRAM*. Its current function is to introduce a revolutionary magnitude of precision into ICBM trajectory measurement. Important future ramifications lie in extending the system to global ranges, satellite tracking, space guidance and hypersonic traffic control.

Still other programs such as GEESE (General Electric Electronic System Evaluator), the vast-scale Air Weapons Control System 412-L. Theoretical and Applied Space Physics, Radiation Effects Research, and many more, provide rugged exercises in technical ingenuity.

*MISTRAM's basic system concept involves a geometric arrangement of 5 ground radio receiving stations. Missile position, trajectory and velocities are continuously calculated with great accuracy from phase differences in a beacon signal received from the missile. Radar is used only to orient the radio receiving antennas in the general direction of the missile.

AN ADDED THOUGHT
This much diversity in one organization generates a uniquely flexible type of career environment. You can plot and re-plot your best avenue of advancement, without having to leave the company in order to do so.

IMMEDIATE OPPORTUNITIES
IN THESE AREAS:

For a prompt reply, mail us a copy of your resume (or an informal outline of your education and experience) in full confidence. Address to Mr. P. W. Christos, Div. 69-WK.

An Equal Opportunity Employer

DEFENSE SYSTEMS DEPARTMENT
A Department of the Defense Electronics Division

GENERAL ELECTRIC
Northern Lights Office Bldg., Syracuse, New York.

March 16, 1962
New, highly responsible opportunities created by vigorous growth of both military and commercial communication systems contracts—

COMMUNICATION SYSTEMS ENGINEERS

QUALIFICATIONS—

- A minimum of 10 years’ experience in the communications engineering field, 5 of which should have been directed toward communication systems involving microwave, telephone and teletype switching centers & data transmission.

- OR

- A significant level of experience in design of complete, 2-way radio systems involving mobile and station packaging, and control by local and remote means.

ALSO IMMEDIATE OPENINGS FOR THE FOLLOWING:

- Antenna Design Engineers (UHF/VHF)
- Test Equipment Design Engineers (EE)
- Subsystem Design Engineers (EE)
- Transistor Circuit Design Engineers (EE)
- Transmitter Engineers (EE)
- Receiver Engineers (EE)
- Electromechanical Engineers (EE or ME)
- Component Evaluation Engineer (EE)

Position Vacant

Community Has Cash To Help Locate Industry in western Kentucky lake area. No gimmick! Plenty of water, labor, sites, gas, power, 100% plant financing. For more details call or write, West Hopkins Industries, Box 245, Dawson Springs, Ky.

EMPLOYMENT OPPORTUNITIES

The advertisements in this section include all employment opportunities—executive, management, technical, sales, office, skilled, manual, etc. Look in the forward section of the magazine for additional Employment Opportunities advertising.

- RATES -

DISPLAYED: The advertising rate is $9.11 per inch for all advertising appearing on other than a contract basis. Insertion rates quoted on request.

An advertising inch is measured 1/2 vertically on a column—3 inches—6 inches to a point.

Percent to Agency Commission.

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- BOX NUMBERS—COUNT AS 1 LINE.

Discount of 10% if full payment is made in advance for consecutive insertions.

Not subject to Agency Commission.

ADDRESS BOX NO. REPLY TO: BOX NO.
Clayton Ave. Div. of this publication.
St. Louis, Mo. 63105.
NEW YORK C3: P. O. Box 2607.
CHICAGO 11: 512 S. Michigan Ave.
SAN FRANCISCO 11: 23 California St.

POSITION VACANT

WANTED: Experienced Electronic Control Engineers for automatic scale weighing applications. Must be fully versed in design and able to handle development. Good position for the right party. Our employees know of this ad. P-822. Electronics.

SELLING OPPORTUNITY WANTED

Sales Engineers—New Group Engineers to represent equipment manufacturer. Territory—Texas, Kansas, Oklahoma, Missouri—retailer or commission. RA-8391. Electronics.

NEW INDUSTRY WANTED

Community Has Cash To Help Locate Industry in western Kentucky lake area. No gimmick! Plenty of water, labor, sites, gas, power, 100% plant financing. For more details call or write, West Hopkins Industries, Box 245, Dawson Springs, Ky.

ELECTRONIC DEVELOPMENT ENGINEERS

Immediate openings for EEs experienced in original semiconductor circuit and component design. Positions require problem definition, system design and prototype evaluation. Salary open.

Send resume to Mr. J. E. McMullen UNION SWITCH & SIGNAL Division of WARCO Pittsburgh 18, Pa.

EXPENSE PAID TRIP . . . TO IRE SHOW

NEW YORK CITY, MAR. 26-29

SCOPE, Professional Placement Center, New England’s most progressive agency specializing in the electronics industry, will prearrange client company all-expense sponsored trips and will schedule a number of selected interviews from its National roster of client companies to save you time.

Exceptional job opportunities are available in Research-Design-Development and Sales-Marketing-Application. Better your professional stature now—no obligation on your part. BS, MS and/or PhD degree required.

For full details, write or call collect today: Twinbrook 9-8250.

SCOPE Professional Placement Center
1227 MAIN ST.
WALTHAM, MASS.

electronics

WEEKLY QUALIFICATIONS FORM FOR POSITIONS AVAILABLE

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Pittsburgh, Pennsylvania

* These advertisements appeared in the 3/9/62 issue.
You can be sure to play an important part in the exploration of space ... when you join NASA

A factual statement on career opportunities for scientists and engineers from James E. Webb, head of NASA

The exploration of space, for peaceful purposes and the benefit of all mankind, is the most challenging assignment ever given to the American scientific and engineering community.

To the men of NASA, the space program has many objectives: broad scale, rapid advancement of scientific knowledge of space, the moon and planets... the creation of a worldwide operational network of weather satellites... the establishment of a global satellite system of communications... prompt feedback of space technology into our economy... and many others. Technological advances through our space effort will bring total benefits exceeding those of any other undertaking in history.

The scientists and engineers who are directly involved in NASA's space program are faced with formidable research and development problems. NASA needs—and seeks—the best creative scientific and engineering talent our nation has to offer.

We will provide the professional men who join NASA with the tools they need: a truly intellectual atmosphere, a framework for easy communication with colleagues in universities as well as government and industry laboratories, the most advanced equipment available, and the technical and clerical support to let you concentrate on the important aspects of your work.

Still, the greatest personal satisfaction may be found in the scope of the individual assignment and in the end product of the work—breaking out from the world we know into an entire new world and uncovering a flood of new benefits not only for ourselves, but for all mankind.

To scientists and engineers in all disciplines, at all levels:

The dynamic expansion of NASA has created outstanding career positions and opportunities for rapid advancement. Career appointments are available in ten different locales: Washington, D.C.; Greenbelt, Maryland; Mountain View and Edwards, California; Hampton and Wallops Island, Virginia; Cleveland, Ohio; Huntsville, Alabama; Cape Canaveral, Florida; and Houston, Texas.

Find out how you may contribute to the American space effort. You need send only one resume—it will be reproduced and distributed to all NASA facilities for evaluation.

Write to: Director, Professional Staffing, NASA Headquarters, Washington 25, D. C.

AN EQUAL OPPORTUNITY EMPLOYER. POSITIONS ARE FILLED IN ACCORDANCE WITH AEROSPACE TECHNOLOGY ANNOUNCEMENT 252B.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

March 16, 1962
ENGINES, EE:

Looking for more responsibility immediately... and a starting salary that reflects it?

General Electric's Light Military Electronics Department is seeking highly competent engineers to fill immediate technical leadership and consulting openings in the following program areas:

- Space Vehicle Guidance Systems
- Missile & Satellite Computers
- Microelectronics
- Space Detection & Surveillance Systems
- Navigation & Communication Systems
- Silicon Crystal Circuit Development

Command Guidance & Instrumentation
A.E.W. & Control
Electronic Countermeasures
Space Communications & Telemetry
- Undersea Warfare Systems
- Thin Films
- Automated Test Equipment

THESE ARE SAMPLES OF THE IMMEDIATE OPENINGS:

- TRANSISTOR CIRCUIT DESIGN... on computers utilized in airborne early warning system.
- LEAD EE... to integrate logic and circuit design efforts on space vehicle guidance equipment.
- CIRCUIT DEVELOPMENT AND APPLICATION ENGINEER... should be capable of doing work in the following areas: a) Paper design & synthesis of complex circuitry such as is found in airborne electronics; b) Analysis of complete systems to determine and design those portions capable of being micro-minimized; c) Advise and consult with product line electronic design engineers; d) Prepare proposals.
- DATA PROCESSING CONSULTING ENGINEER... involves computer design, including logic and logic organization, basic computer circuit design, memory storage circuits and devices, overall computer systems synthesis. Also includes direct leadership of D/A projects for advance design techniques, consultation with design engineers on product line design problems, assistance in preparation of technical proposals, participation as panel member in design reviews, leadership of technical seminars in your design field.
- SYSTEMS ANALYST... includes missile flight test and analysis regarding guidance systems and computations; orbital trajectory analyses; overall system, sub-system and error analysis.
- COMMUNICATION ENGINEER... for design studies and analyses regarding command control systems for space applications.
- SPACE NAVIGATION OR GUIDANCE ENGINEER... to conduct systems studies regarding integrating hardware, e.g., developing stellar, radio or inertial navigation or guidance systems to perform specific missile function.
- STATISTICAL ANALYSIS ENGINEER... to perform analysis of statistical nature, e.g., correlation, error and probability of success analysis.

For a careful review of your qualifications, and a prompt reply, forward your resume today in strictest confidence. Address: Mr. R. Zukenski, Div. 65-WK, Light Military Electronics Dept., General Electric, P.O. Box 12, Utica, N. Y. 13501.

An Equal Opportunity Employer

LIFESCHULTZ
FAST FREIGHT

PIGGYBACK TO BOTH COASTS
TRUCKLOAD RATES TO BOTH COASTS
*We welcome your inquiry.

FASTEST TO BOTH COASTS!

CIRCLE 460 ON READER SERVICE CARD

FOR RESEARCH—DEVELOPMENT & EXPERIMENTAL WORK
Over 10,000 different electronic parts: waveguide, radar components and parts, test sets, pulsed, oscillators, pulse xmitte, magnetrons, IF and pulse amplifiers, dynamos, 400 cycle xmitte, 564 ant., pedestals, etc. PRICES AT A FRACTION OF ORIGINAL COST!

COMMUNICATIONS EQUIP CO.
343 CANAL ST., N. Y. 13, N. Y.
(formerly at 131 Liberty St.)
CHAS. KÖHEN, W.Orth 3-4055

CIRCLE 461 ON READER SERVICE CARD

Watch—the Searchlight Section for Equipment Opportunities

MANUFACTURERS' REPRESENTATIVES
IN THE ELECTRONIC INDUSTRY

SAMUEL K. MACDONALD, INC.
manufacturers representatives over 25 years
151 SPRUCE STREET, PHILA. 2, PA.

Territories:
Pennsylvania • New Jersey
Delaware • Maryland
Virginia • West Virginia
District of Columbia

OTHER OFFICES:
Pittsburgh • Baltimore
Washington, D.C.

MFRS. REPS:

DID YOU KNOW THAT . . .

when you advertise in the electronics BUYERS' GUIDE we reprint your advertising and mail it to over 3,500 Sales Managers of electronic equipment manufacturing companies?

THIS IS COVERAGE BEYOND OUR BUYER'S GUIDE SUBSCRIBERS . . . ADVERTISE IN THE 1962 EBG AND GET THIS EXTRA COVERAGE

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