February 2, 1962

electronics

A McGraw-Hill Publication *75 Cents*

DOPED-OXIDE THERMAL DEVICE

generates high voltage in small volume, p 39

(photo below)

FIELD-EFFECT TRANSISTOR

shows negative resistance, p 48

MAGNETIC ROD MEMORY

large output and high speed, p 50

PIONEERS IN MINIATURIZATION

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W. W. MacDONALD, Editor

CERAMIC THERMOELECTRIC generator using mixed-valency oxides undergoes test at Army's Picatinny Arsenal. Generator puts out 100 v as electric furnace heats it to 2,400 F. *Army may use generator to convert waste heat of rocket exhaust to electricity. See p 39* COVER

MILITARY ELECTRONICS. Here's a sampling of technical news that will be made at next week's IRE National Winter Convention on Military Electronics. *Ground radar that senses space ship attitude, multicolor display and electronic intelligence system are reported* 20

MISSILE MISS-DISTANCE Is Indicated by Photon Counter. Compact, low-power system gives three-dimensional monitoring of small, tactical missile accuracy. *Advanced models to evaluate anti-ICBM missiles are underway* 21

OPTICAL CHARACTER READERS Use Memories for Increased Versatility. Equipment now in production backs up data processing equipment used by businessmen to cut paperwork. *Even skewed and mutilated type and variable fonts won't throw off the newer systems* 26

COUNTERMEASURES SIMULATOR Trains B-52 Crews. Preprogrammed to duplicate hostile r-f functions, it is the first of a new series for SAC. *Punched cards duplicate any antenna pattern* 28

100-MW AMPLIFIER Uses Microwave "Flywheel." Circular cavity steps up pulse output from 10 Mw to 100 Mw. *This is first of a series of superpower systems for plasma and radar research* 31

OXIDE THERMOELECTRIC GENERATOR With High Voltage Output. One side of alumina ceramic plate is sprayed with platinum by a plasma torch. Doped nickel oxide goes on other side. *Generator withstands high temperature, has high voltage output. However its resistivity is higher than intermetallic generators.* R. D. Fenity 39

BEAM-DEFLECTION TUBES Make a Telemetry Diversity Combiner. Control signals from receiver agc outputs are applied to deflection electrodes. Circuit offers wide frequency response and a rapid combining rate. *This system would be especially useful in a spinning, tumbling space ship traveling at many times the speed of sound.* V. A. Ratner 42

COMBINED OSCILLATOR-AMPLIFIERS for Tone Transceivers. A single transistor circuit can generate an audio tone during transmission and selectively amplify it during reception. Circuit is transformed by slight change in impedance level of an R-C time constant. *Math developed applies also to oscillators, Q multipliers, notch filters and selective amplifiers.* R. C. Carter 44

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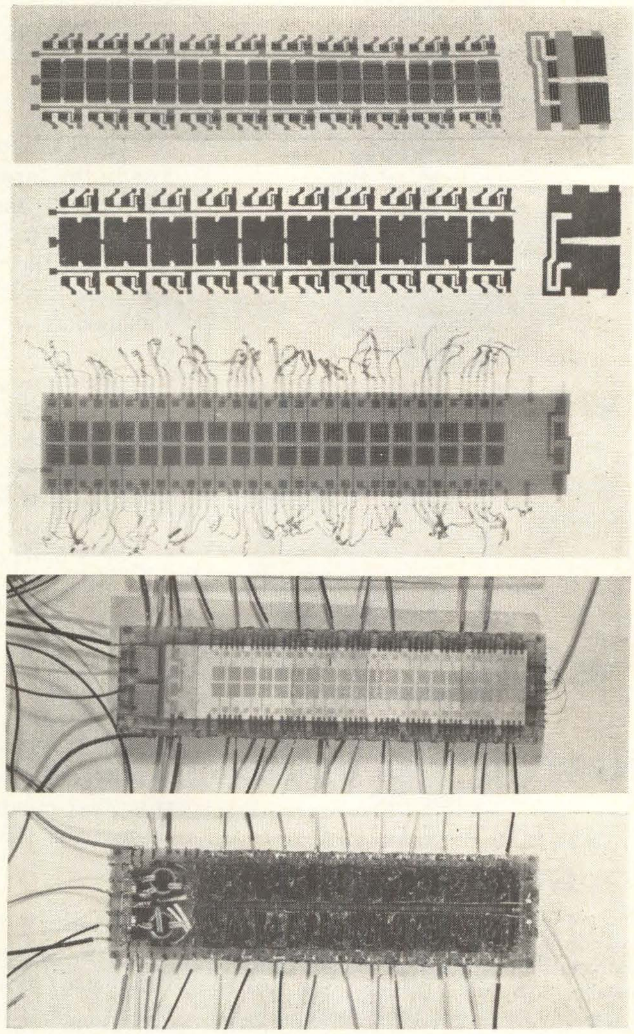
CROSSTALK

BIONICS AND ELECTRONICS. Next week we will publish the first of a series of articles on bionics, the study of functional units of life—or, more accurately, how living organisms function and why they function as they do. In some ways, this study is of direct interest to future developments in electronics. Other aspects are of tangential interest.

The intensive investigation of biological "machines" today stems from a need to improve existing manmade devices. Living creatures are highly efficient and are usually exquisitely designed and organized. Bionics pioneers feel that the operating principles of creatures may well be applied to nonliving systems.

In his first article, Assistant Editor Lindgren describes, for example, a prototype ground speed indicator based on the principles of a beetle's visual system. Another development, seen in the photographs, is an electronic neuron network, as assembled to test theories of actual neuron behavior. Real neurons, basic building blocks of the brain, are not yet fully understood because they are so complex. These analogs, developed under an Air Force contract by T. E. Bray, of General Electric's Syracuse Research Labs, grossly represent real neuron behavior. Interest in such devices is high because they can lead to development of artificial intelligence and, in turn, greater capabilities in such systems as computers and automatic control systems.

At first glance, the term *bionics* looks like a combination of biology and electronics. The actual origin is the Greek *bion*, meaning a life unit. Bionics embraces not only electronics, but mathematics, biophysics, biology, chemistry, medicine, applied physics and other fields. Unlike electronics, it has started as a melting pot of the sciences. Electronics (the word, by the way, was coined as a name for this magazine 33 years ago) in its early days was almost entirely concerned with what was known as the radio art. It has since broadened its scope until today it embraces virtually the entire range of applied physics and mathematics. Bionics will bring the life sciences more intimately into the fold.



SEMDECTRON. This term was coined by Andrzej Ambroziak, of the Polish Academy of Sciences, to describe a solid-state version of a cold-cathode counting tube. Operating principles will be reported next week. The article, incidentally, is one of the few we have accepted from a Communist country in recent years. Not that we haven't asked for more. We think engineering details on their aerospace equipment in particular would be instructive to Western engineers. But detailed information seems available only for innocuous developments.

COMMENT

Medical Electronics

Your series on medical electronics is excellent.

When one profession broadens its outlook to include the field of another profession, it is to be commended. The growth of the electronics field has been remarkable, and it will continue to be so.

Each individual in each laboratory tends to be specialized in his outlook for the problem. Workers in a field talk one language and are lost in the foreign elements of their neighbors' medical lingo. Your series allows a quick panoramic view into the work of different individuals as they progress along the uncharted courses of research or the clinical, diagnostic and therapeutic application of recent breakthroughs in medical discovery. Herein lies the importance in the worthwhileness of your series of articles.

WILLIAM H. HOVER, M.D.
Upper Montclair, New Jersey

The seven-part medical electronics series appeared on p 49, Jan. 20, 1961; p 46, Feb. 3; p 54, Feb. 24; p 43, June 23; p 63, July 21; p 65, Dec. 15; and p 47, Jan. 19, 1962. We will continue to keep abreast of new developments in this fast-moving field and report them from time to time.

Electronic Versus Electronics

When, in 1930, I first began my R&D and patent developments of musical instruments utilizing electrical methods for generating and controlling musical tones, I was in a quandry of the same kind queried by Mr. Rohrer in the issue of Jan. 12 (*Comment*, p 4). This year, as I remember, was the same year that ELECTRONICS made its appearance. I soon became convinced that mere reinforcement, by public-address system methods, of sounds already produced, as in guitars, organs, pianos or the like, or by pipe organs with electrically-operated actions, should be classed differently than those in which incidental sound took no part, and where indeed that sound, more often than not, required suppression where it, uncontrollable in harmonic content, only blanketed the electrically-generated tones having such harmonic content control. Such tone generators as rotating, vibratory, vacuum-tube, etc., with either silent transducers or silent vacuum tubes providing the desired tones in electrical form, required differentiation from the purely acoustic types using a microphone, amplifier and loudspeaker.

The music trade papers constantly confused the two types, both in their news and the advertising content. My solution for this was to call the electrically-amplified acoustic instruments *electrical*, and the new types, *electronic*. This nomenclature gradually took hold in the music instrument industry and is almost uniform today, thirty years later. I say "almost uniform" because there are still a few manufacturers of such instruments as accordions and reed organs, with internal microphones and amplifier-speaker reproducers, who call their instruments *electronic*, where in fact electronics has nothing at all to do with tone *generation*, and only a little to do with control of tone quality.

BENJAMIN F. MIESSNER
Miessner Inventions, Inc.
Miami Shores, Florida

Hitachi, Not Hibachi

The company referred to in the second paragraph of the *Components and Materials* section of the Dec. 29 issue (p 58) is correctly spelled Hitachi.

Hibachi is the wastebasket-shaped utensil, now commonly made of ceramic, in which the Japanese place a few glowing embers for heating purposes. Not just anyone can be warmed by a hibachi: it takes practice, as the glow from the embers is not strong enough to warm the body, but only the soul. This need for practice, in which the young people of Japan today will not persevere, is one more reason that the hibachi is on its way out. Perhaps more important is that the price of charcoal has been steadily rising, the price of kerosene and gas heating appliances steadily decreasing.

Another English-language publication left off the H and wrote it Itachi. *Itachi,* the Japanese word for skunk, is an error in far worse taste.

CHARLES L. COHEN
Tokyo, Japan

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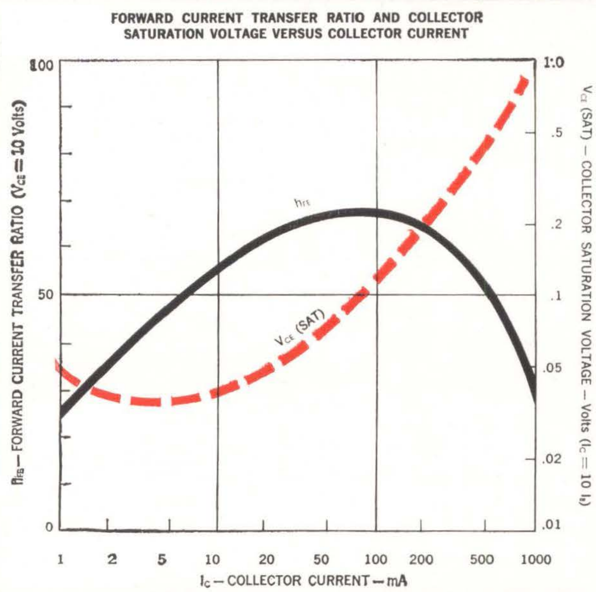

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h_{FE}	@ I_c = 1.0A V_{CE} = 10 volts	15 MIN
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V_{CE} (SAT)	@ I_c = 150mA I_b = 15mA	.2 volts MAX
V_{BE} (SAT)	@ I_c = 1 ampere I_B = 0.1 ampere	2 volts MAX
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ELECTRONICS NEWSLETTER

FAA Awards First Project Beacon Contracts

WORK HAS BEGUN on the Federal Aviation Agency's five-year, $500 million effort to develop a new air traffic control system. A presidential task force, Project Beacon, recommended late last year (ELECTRONICS, p 14, Nov. 17) that FAA work out a system using radar and altitude-reporting transponders to replace the present pilot reporting system.

FAA's design team is to submit by this summer a draft of a master plan for carrying out the task force's recommendation. A prototype is to begin operating 18 months later at FAA's experimental center in Atlantic City, N. J. A $2.7 million contract to test and evaluate certain concepts of the system has just gone to the nonprofit Mitre Corp.

Contracts, totaling $174,000 were awarded Hazeltine Corp. and Transco Products, Inc., for transponder development. They'll be called Slate (Small Lightweight Altitude Transmission Equipment). Hazeltine is to have a 10-lb airborne radar beacon ready in 10 months. Transco has a year to follow another approach expected to make a 5½-lb unit possible.

Transponders are to report altitude in 500-ft increments from 1,000 ft below sea level to 15,000 ft and have a range of 50 to 100 miles. They'll be used in planes weighing less than 12,500 lb. Longer-range equipment will be developed for airliners.

Magnetic Field Increases Diode Forward Resistance

LARGE INCREASES in forward resistance of indium-antimonide diodes at liquid nitrogen temperatures have been produced by changes of about five gauss in transverse magnetic fields. Reported by I. Melngailis, of MIT Lincoln Lab at the American Physical Society meeting in New York last week, magneto diodes are expected to be useful as four-terminal swiches and amplifiers.

H. Riemersma, of Westinghouse Electric, reported achieving a field of 68 kilogauss with a variable composition superconducting solenoid. Designed for 80-Kg field intensity, it has six concentric sections wound with niobium-zirconium wire. It has 25 percent zirconium on the outside and 50 percent on the inside.

Westinghouse scientists also reported they are researching thin films for magnets. Theoretically, critical current density would be increased by a factor of 10^4 over wire-wound magnets, permitting thinner windings or possibly higher magnetic fields.

Discrimination Radar for Nike Zeus Being Built

ARMY DISCLOSED at a press conference in Los Angeles that the first installation of the Nike Zeus discrimination radar is being made now at White Sands, N. M.

Gen. August Schomburg expressed Army confidence in the ability of this controversial link of the anti-ICBM system to perform its function. He told a somewhat skeptical press group that "no contest exists between Nike Zeus and the USAF's Atlas."

Sperry Gyroscope is building the radar. After brief testing of the initial equipment, it is expected a similar system will be installed on Kwajalein (ELECTRONICS, p 12, Jan. 12).

Schomburg said actual atmospheric testing of Nike Zeus's warhead won't be needed to prove its detonation capabilities.

(A Washington report said work on a discrimination radar at Kwajalein is well advanced and that it would be used during the firing of Atlas nose cones from California.)

FAA Buying $114 Million Airport Electronic Gear

FAA ANNOUNCED last week what air traffic control and navigation equipment it will buy with the $114 million Congress appropriated for fiscal 1962, which ends June 30. Here are major items:

Two long-range radars, $2.7 million each, for airports at Garden City, Kansas, and San Juan, Puerto Rico; three airport surveillance radars, $307,400 each; improvements in 16 existing long-range radars, $129,500 each.

Also, 50 vortac stations, $392,000 each; 15 radar beacon systems, $238,600 each; an air route traffic control center at San Juan, $2.1 million; equipment for seven new air traffic control towers, $160,000 each; 21 terminal vor stations, $115,900 each; 90 direction finders, $27,800 each.

Instrument landing systems at 18

Information Technology Rivals Farmer's Almanac

CROP FORECASTING, timber inventories, detecting timber diseases, surveying traffic and slums, measuring mountain snows to estimate water reserves—these are some of the fields opening up to information technology by peaceful applications of military aerial reconnaissance techniques and electronic interpretation of photographic data.

Some of these applications are underway in California. Fast and accurate forecasts of grape crop size and quality, for example, permits pacing deliveries to vintners for market and price stability.

The state is working with Itek Laboratories' Palo Alto division. Techniques are like those for detecting underground nuclear blasts in ARPA's Project Vela. Multicamera reconnaissance and electronic data reduction measure changes in the earth's surface color and brightness near the test site airports, $163700 each; directional localizers for 12 instrument landing systems, $163,700 each; 40 visual glide slope lighting systems, $51,-100 each; high intensity approach lights, 45 airports at $183,400 each. Costs given are estimated averages.

Addresses—Literally—Operate This Computer

BRITISH Addressograph-Multigraph Co. has developed an addressing machine that used coded address plates as the input for a digital computer. It was designed to process stock dividend checks.

For each shareholder there's a plate on which his share holding is coded in binary form and his name and address are embossed.

As the plates feed into the machine, photoelectric cells detect the share holding. The computer figures gross and net dividends less taxes. Out comes addressed checks at a rate of 100 dividends a minute.

Air Force Wants Flyable Airport Traffic Controls

AIR FORCE has scheduled for operational use in 1963 an air-transportable, all-weather, emergency air traffic control system. They'll be designed for fast movement to sites without ground-to-air facilities, will be compatible with FAA systems.

Equipment will include search and precision approach radar, communications, Tacan, visual and instrument flight rules towers. Proposals, due Feb. 22, have been invited from 77 companies. A new office—482L—has been set up by the Electronic Systems Division, Hanscom Field, Mass., to manage the program.

Space Vehicles Will be Tracked with Transponders

HIGH-ACCURACY range and range rate measuring system for spacecraft will be developed for NASA by Motorola. The goal, according to NASA, is a system that can tell the position of a vehicle in near space within a few feet and its velocity within fractions of a foot per second. This can be done by placing single stations around the world under the expected orbit and by using three stations in a specific region for triangulation. Stations will be in vans so they can be transported by air to accommodate different orbits.

NASA indicated that carrier and side-tone modulation measurement techniques would be used. Motorola added later that transponders would be carried in the space vehicles.

Oxygen Sensor Provides Its Own Power Supply

FUEL CELL principles are used by General Electric in an experimental oxygen sensor that is its own power supply. It consists of an ion-exchange membrane between two catalytic-platinum electrodes. Hydrogen is supplied to one side and, depending on the amount of oxygen on the other side, oxygen level is read in milliamperes.

GE says an operational instrument, complete with hydrogen supply, for monitoring oxygen levels in spacecraft would weigh about seven ounces. By using oxygen instead of hydrogen as a gas supply, it would become a hydrogen sensor. The sensor could also be used in mines and submarines, GE believes.

Magnetometer to Forecast Solar Proton Showers

ZEEMAN EFFECT magnetometer is under construction at Air Force's Sacramento Peak Observatory in New Mexico to help predict periods of solar proton showers, perhaps the biggest hazard a space traveler will face. Solar proton radiation is intermittent, cannot easily be predicted over long periods. The observatory, operated by AFCRL, will try to extend the forecast period.

All proton showers so far recorded originated in sunspot groups of 100,000 to 200,000 Km diameter. A sunspot center with a complicated magnetic field averages five times as many flares as a center with a simple dipolar or unipolar field. The magnetometer under construction will permit complete mapping of the longitudinal magnetic field of an active center.

In Brief...

A-M STEREO broadcasting proposals will be studied by EIA's engineering department in New York City.

HOFFMAN ELECTRONICS has packed a 33⅓-45 rpm stereo phonograph, a-m and shortwave radio into a portable the size of a cigar box. It lists at $79.95.

IBM HAS INTRODUCED another large-scale, solid-state scientific computer, the 7094, an expanded 7090. It costs $3,134,500.

MARTIN MARIETTA has a $500,000 feasibility study contract for a new Army antitank guided missile called Tow. Hughes and McDonnell Aircraft have similar contracts. Hughes has a follow-on contract of $750,000 for continued development of guidance for Mauler air defense missile.

QUANTATRON has a Navy contract to apply advanced laser technology to missile guidance problems.

SPERRY GYRO has a $15 million Navy contract for navigation equipment for the 20th to 29th Polaris submarines. A $6 million-plus Navy contract to Magnavox covers classified systems including APQ 94 airborne radar systems.

OTHER MAJOR military contracts include $4 million to Budd Electronics for conversion of 86 Air Force AN/FPS-18 radar to AN/FPS-74; $1.2 million to Astronautics Corp. of America for jet aircraft horizon situation indicators; $1 million to Heldor Electronics for AN/TRC-24 Army radio set components; $1 million to National Company for communications equipment and development of a pocket-sized transceiver.

ISOTOPES Development Center has been set up at AEC's Oak Ridge National Laboratory to spur government and private R&D in radioisotope technology.

RCA ANNOUNCES a video recorder with tape speed of 7.5 and 15 ips, said to reduce tape costs. Recorded tracks are five mils wide instead of 10 mils.

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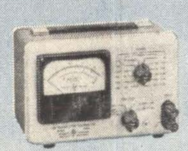
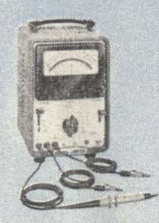
 hp 403A	Solid state ac voltmeter, battery-operated, portable. Fast, accurate, hum-free ac measurements.	1 cps to 1 MC	0.001 to 300 v 12 ranges	2 megohms 40 pf shunt, low ranges; 20 pf, mid ranges; 15 pf, high ranges	$275.00
 hp 400D	Wide range ac voltmeter. High sensitivity, 2% accuracy.	10 cps to 4 MC	0.001 to 300 v 12 ranges	10 megohms 15 pf shunt, high ranges; 25 pf, low ranges	$250.00
 hp 412A*	Precision VTVM. 1% accuracy; measures voltage, current, resistance; no zero set needed; 1 ohm to 100 megohm center scale for resistance meas., 60 db dc amplifier.	dc	1 mv to 1,000 v 1 μa to 1 amp	10 to 200 megohms, depending on range	$400.00
 hp 413A*	DC null meter, dc voltmeter, 60 db dc amplifier. 2% accuracy, floating input, 1 mv end scale sensitivity.	dc	1 mv to 1,000 v 13 ranges	10 to 200 megohms, depending on range	$350.00

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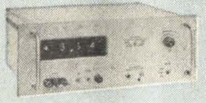
 400L	Logarithmic 400D. Accuracy ±2% constant percentage of reading. For log voltages, linear db measurements.	10 cps to 4 MC	0.001 to 300 v 12 ranges	10 megohms 15 pf shunt, high ranges; 25 pf, low ranges	$325.00
 410B	VTVM for audio, rf, VHF measurements; dc voltages, resistances. Minimizes circuit loading, low drift, one zero set all ranges.	dc; ac, 20 cps to 700 MC	dc, 1.0 to 1.000 v, 7 ranges; ac, 1.0 to 300 v, 6 ranges	dc, 122 megohms; ac, 10 megohms/ 1.5 pf shunt	$245.00
 405	Automatic digital VM. "Touch and read", direct dc voltage measurements, digital readout. Automatic range, polarity; readout available for printer, system.	dc	0.001 v to 1,000 v (accuracy ±0.2% of reading ±1 count)	11 megohms	$850.00
 425A*	Microvolt-ammeter reads μv, $\mu\mu$a; 100 db amplifier; measures dc voltages, current as in medical, biological, physical, chemical work.	dc	10 μv to 1 v 11 ranges; 10 $\mu\mu$a to 3 ma, 18 ranges	1 megohm ±3% (v) 1 megohm to 0.33 ohms (current)	$500.00
 428A	Clip-on dc milliammeter, eliminates direct connection, no circuit loading. Measures dc in presence of ac.	dc	3 ma to 1 amp 6 ranges		$500.00
 428B	Similar to 428A, wider range, recorder output for dc to 400 cps.	dc on meter, dc to 400 cps on recorder	1 ma to 10 amps 9 ranges		$550.00

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WASHINGTON OUTLOOK

TAX CREDIT FOR UTILITIES?

PURCHASES OF ELECTRONIC equipment by regulated communications utilities such as Western Union, the Bell System and independent telephone companies may be stimulated by a proposed four percent tax credit on investment in equipment.

The tax credit plan has received a tentative nod from the House Ways and Means Committee. But help may be a long way off. The committee has a long history of reversing itself on tentative votes made in closed sessions. And besides, any tax bill is subject to many changes before it finally becomes law.

Here's some background: last fall the committee adopted a draft tax revision bill built around an eight-percent investment credit for business. It was designed to stimulate modernization of equipment, but left out utilities.

Now the committee is amending its draft and the utilities are cut in for a four percent credit. It means that utilities would be entitled to reduce their final tax bill for any year by four percent of what they spend on new equipment.

SPACE DETECTION MONEY

THE PENTAGON is less than candid in releasing budget figures about its planned electronics spending. And that's a gross understatement. For example: Defense Secretary McNamara allows as how increased funds have been set aside for the Space Detection and Tracking System (Spadats). He says next year's sum will exceed the "substantial funds" allocated last year.

The additional money will be spent on development of improved radar, other sensing devices, computers and operation of the system's two parts: the Navy's Space Surveillance System (Spasur) and the Air Force's Space-Track System.

NAVY'S BUDGET

ALSO IN THE "GUESSING GAME" category are the figures on Navy's electronics procurement program. That is, electronics buying not related to other weapons systems such as aircraft or missiles. There will be an increase of about nine percent over this year's level of contracting and 19 percent over last year's.

The Marine Corps will buy increased quantities of the AN/PRC-38 tactical radio. This will be initial procurement of the newly developed item. But according to Secretary McNamara it will fulfill "a substantial part of the objective."

ARMY'S BUDGET

ARMY GETS $296 MILLION for new electronics equipment procurement not associated with other weapons systems. This is slightly under Army's present rate of electronics buying.

Largest item, nearly $30 million, is for the new AN/VRC-12, a rugged and easily serviced vehicular radio set. Another important item is the AN/PRC-25, a man-portable radio to provide field communications for company-sized units. The budget earmarks $13 million for this item.

FLOATING COMMAND POSTS

AT LEAST TWO MORE floating command posts may provide additional high-command backup in case the Pentagon is wiped out in a nuclear attack. The Defense Department wants funds from Congress to convert at least two mothballed light carriers into command and control ships. They would be equipped for constant radio communications between joint command headquarters and strategic retaliatory, air defense and tactical warfare commands in the fields.

There are already at least two alternate high command posts. One is the mountain hideout along the Maryland-Pennsylvania border, the other is aboard the Navy's cruiser-command ship *USS Northampton*.

Type 161 TBS Portable Instrument—
11.2-inch scale

New, rugged Westinghouse portable instruments give long-term accuracy never before possible

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Westinghouse TBS portable instruments are available as a-c or d-c ammeters or voltmeters, with single or multi-range scales for practically any precision applications. Full-scale deflection as low as 1 microampere is available. Shatterproof glass window, high impact molded case and insulated retractable handle are standard features. Accuracy rating is ½% or ¼%. All Westinghouse portable instruments meet or exceed the requirements of ASA standard C-39.1. Write for complete specifications and a sample of Taut Band Suspension. Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania. *You can be sure . . . if it's Westinghouse.* J-40541

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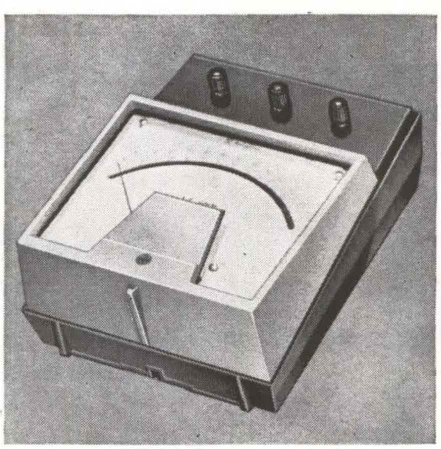

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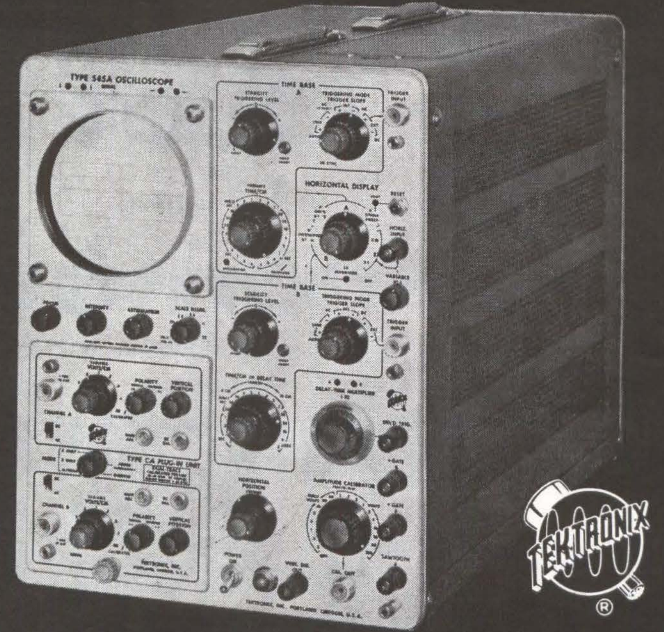

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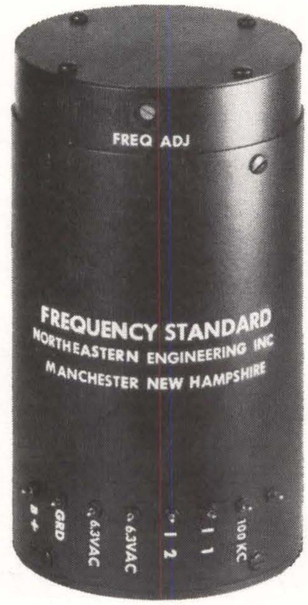

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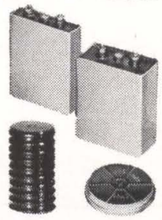

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CIRCLE 19 ON READER SERVICE CARD

Radar Will Measure Space Vehicle Attitudes

LOS ANGELES—IRE's National Winter Convention on Military Electronics has on its agenda for next week 91 papers, including 29 classified confidential. Among topics slated for a big play are antisubmarine warfare, lunar landing systems, radar, communications and reconnaissance systems.

Here is a sampling of some of the reports which the technical program committee, headed by Matthew Brady, lists as certain to attract considerable interest:

A. Reich, of RCA, will describe an attitude sensor for space vehicles which needs no optical system or electromechanical parts. Attitude is determined from measurements made with ground radar equipment, using phase modulation coding of radiation lobes transmitted from the vehicle.

Several radiator configurations will satisfy requirements, Reich feels. A circular wave guide will be used in initial prototypes. No particularly new techniques are needed to synthesize antenna patterns. System accuracy depends on signal-to-noise ratio and the functions describing the antenna pattern. A cosine-squared pattern makes the direction of cosines directly available at the receiver output without further computation.

Multicolor Display

A mock antisubmarine warfare battle will be fought at session III-D, as L. J. Hines and H. L. Djelland, of National Cash Register, describe their company's multicolor photochromatic display. A single light source provides all the energy needed for writing multiple tracks and alphanumerics, to illuminate cursors, and to project dynamic information and a static background grid on a rear-projection screen.

Tracks and characters are written in real time by multiple ultraviolet beams. Lens motion is controlled by x-y input signals. Reversible light-sensitive dyes are used on the screen. The film changes from a transparent to opaque state wherever the light beams strike, then is transparent again. Image persistency can be controlled by temperature variation and light control.

Applications include computer output in command and control systems and for real time display in antisubmarine warfare, air traffic control, missile range surveillance and other systems handling continually changing information. Production for a classified Navy torpedo weapon system will begin in mid-1962.

Reconnaissance System

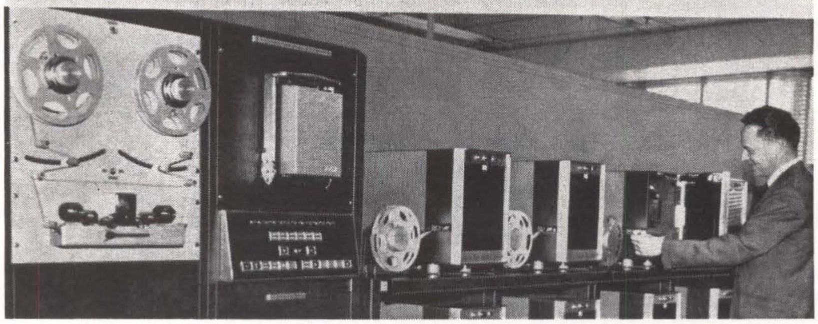
A heretofore unannounced reconnaissance system for electronic intelligence will be described in two papers by ITT Federal Labs personnel. It reportedly has demonstrated remarkable speed, accuracy and ability to detect unusual signals in actual flight tests.

Called Pirate, the system incorporates superheterodyne sensitivity with broad spectrum coverage without sweeping and a simple but all-encompassing form of logic which detects anomalous time- or frequency-domain behavior by signals.

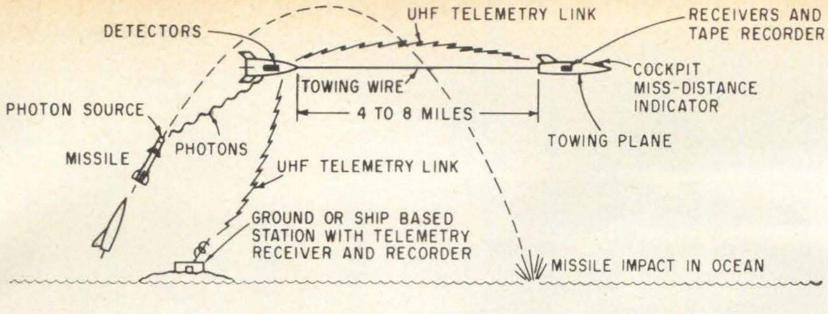
Multiple traveling-wave tubes are used in the polydigital receiver for high sensitivity. Several wide r-f bands are heterodyned into a wideband microwave i-f. Supposedly unique mix-based techniques for encoding received carrier frequencies into a three-digit code partially account for the high traffic capabilities reported. New methods for identifying input bands in both c-w and pulse sections are used.

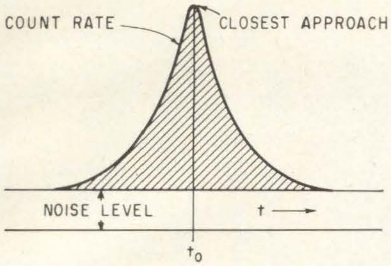
Video measurement and recording circuitry, the company claims, instantaneously detect, measure and store voltage analogs of pulse parameters such as carrier frequency pulse width, polarization, time of intercept, and signal strength. A direction finding system computes absolute bearing of received pulse signals.

Message Tape Cuts Government Red Tape



Social Security Administration is installing a data communications system between its computer center in Baltimore and 600 district offices. Processing of some three million claims annually will be speeded by eliminating typing, mailing and punched card preparation for computer input. Top photo shows Digitronics Corporation's Dial-O-Verter system magnetic and paper tape transmission units. At bottom, in one of six control centers, is equipment which sorts messages according to information concerned and routes them between computer center and offices. Bell Telephone's Data-Phone system is incorporated in the network

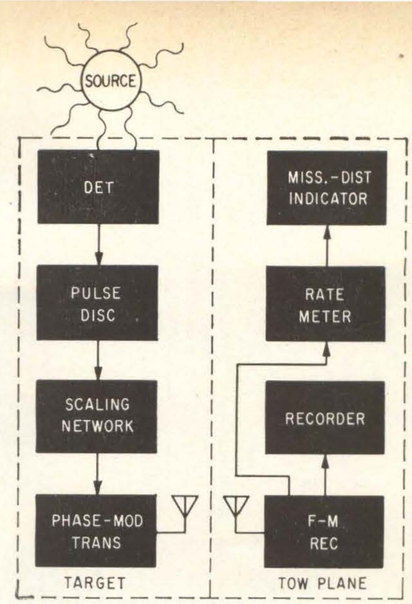




▲ *This is how prototype system evaluates small tactical missiles*

▶ *Impulse data from detector in target may also be telemetered to ground*

◀ *Count rate at detector as a function of time and approach distance*



Photon Count Tells Missile Miss-Distance

MISSILE MISS-DISTANCE indicator, allied in concept to the photon altimeter reported two weeks ago (ELECTRONICS, p 26, Jan. 19), has been developed by Giannini Controls Corp.

In the Photon Target Scoring System, the radioisotope source and the photon detector are two separate units. One is located in the intercepting missile and the other in the target. Miss-distance is calculated from the number of photons detected.

Prototype systems for evaluating such tactical missiles as Sidewinder and Sparrow are being used at the Pacific Missile Range. These systems typically require only about one-half watt of input power.

More sophisticated systems are underway, Giannini says, for evaluating anti-ICBM missiles. Among the reported advantages is that unlike r-f signals, radiation energy propagation is affected little by ionized shock waves which develop around missiles during reentry. Also, source units are physically small, don't alter missile characteristics, don't interfere with r-f apparatus and provide three-dimensional indication of miss-distance.

The source used on small tactical missiles is Ta 182, a high-energy gamma ray emitter, mounted in a ring configuration. If desirable, the source could be placed in the target and the detector in the interceptor.

The detector is a plastic scintillator coupled to a multiplier phototube. The tube amplifies impulses by a factor of one million or more.

Output pulses have a rise time on the order of 10 nsec. They are further amplified, shaped and passed through a pulse discriminating network. This network, essentially a bandpass filter in the energy spectrum, rejects most of the cosmic ray background.

A scaling network matches the pulse repetition rate of the detector to the limited bandwidth of the telemetry system. Pulses modulate the f-m—f-m carrier and are transmitted to the data processing subsystem.

Equipment in the towing aircraft converts the pulse data to display miss-distance in feet and also records the information. Data can also be recorded by a ground station. Future systems may improve accuracy by using digital computers and curve fitting techniques.

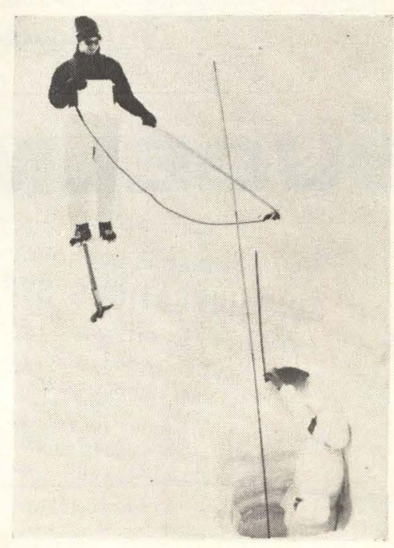
Magnetometer Finds Snow-Buried Skiers

NEXT WEEKEND, two members of the National Ski Patrol will be buried under a simulated avalanche at the Soda Springs ski area in northern California. They'll be testing a new way of finding lost skiers.

Each skier will carry a small permanent magnet. Searchers will use a Varian Associates M-49 portable magnetometer.

Boots fitted with heel magnets have been located in a few minutes. Tests have been made in Switzerland, where the technique was proposed by Harry Weaver and Attilio Melara, of Varian, and Franz Schaerer, a Swiss Army avalanche and rescue expert.

The two Americans, on a ski holiday, heard of a skier being lost 30 days under an avalanche as rescuers tried to find him using conventional probe rods. From 30 to 300 people are buried each year in Switzerland.



Hole in snow was location of ski boot found by magnetometer

Designed for

Application

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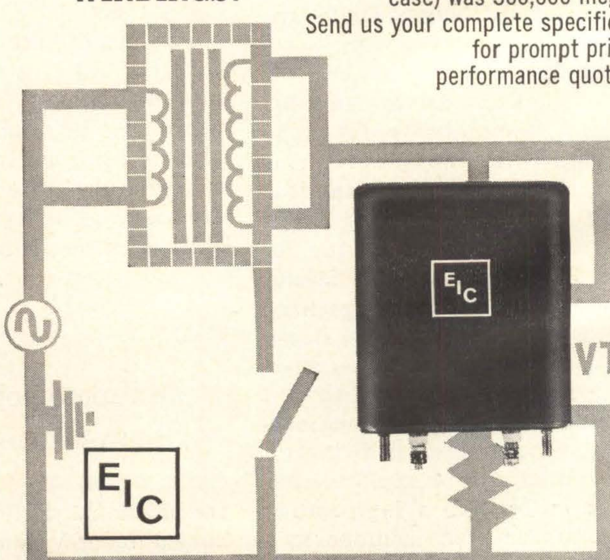

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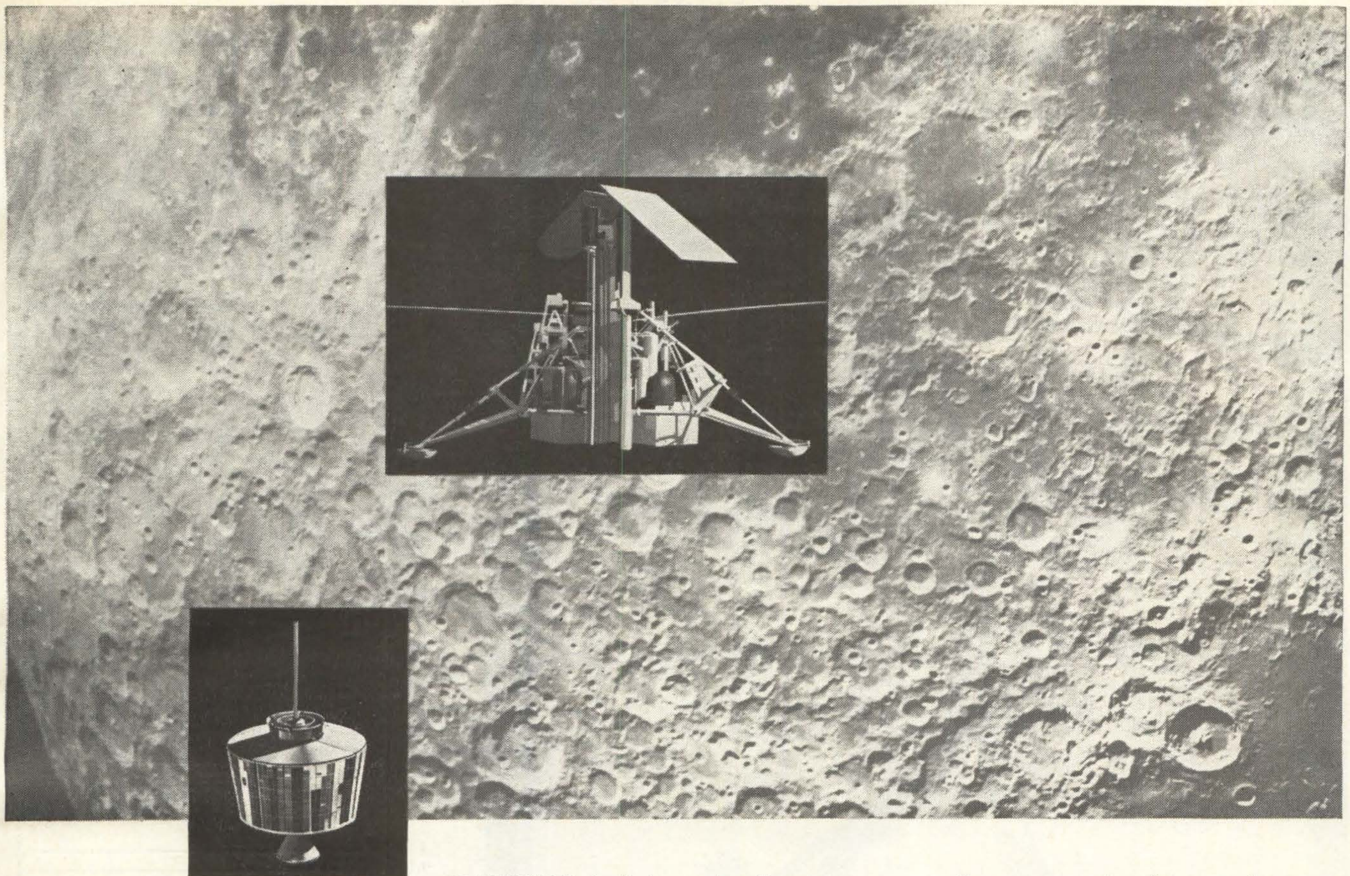

systems analysts:

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SURVEYOR (soft lunar landing spacecraft), SYNCOM (synchronous communications satellites), ARPAT (terminal anti-ballistic missile defense system), BAMBI (anti-ballistic missile defense feasibility study). These are a few of the many important and complex projects under design, development and study at Hughes.

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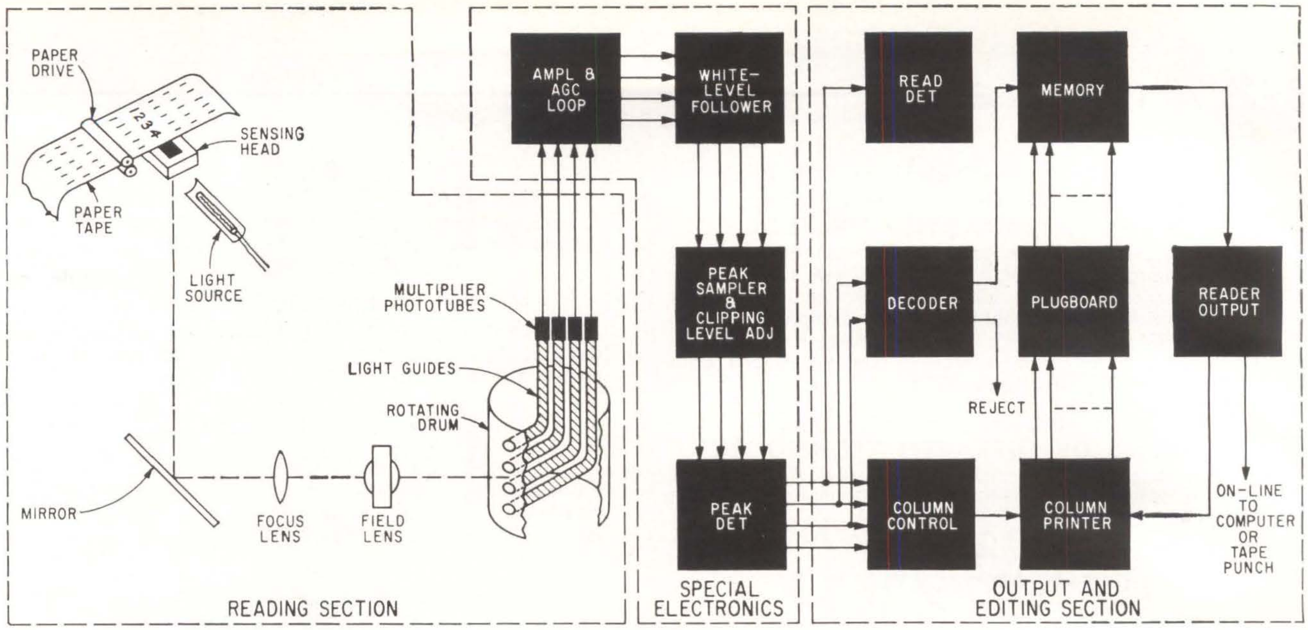


Reading section of NCR's 420 optical reader moves next line into place after line being read is accepted

Optical Character Readers Use Memory Drums, Matrices to Increase Versatility

By WILLIAM E. BUSHOR
Senior Associate Editor

WASHINGTON — Businessmen confronted with ever-mounting stacks of paperwork can take heart from availability of optical reading machines able to swiftly feed printed information into data processing systems. Some recent systems are selective in what they read, tolerant of faulty printing and able to read varying type styles.

Several such systems were described here at a symposium sponsored late last month by the Office of Naval Research and National Bureau of Standards.

Business machine journal tape characters can be recognized by National Cash Register's Bi-code system even if they are skewed 7.5 degrees. The system also has a memory and can be instructed to edit and rearrange data read.

Top and bottom sections of characters are each assigned five zones. Vertical stroke in a zone produces a binary ONE; absence, a binary TWO. A 10-bit binary word represents stroke location.

As the tape moves over the reading head, the print image is periodically reflected through optics (see figure) so it periodically coincides with one of 18 four-aperture sets around the rotating drum. The sampled image is ducted by light guides to multiplier phototubes. Tube output corresponds linearly to white level, delineating ink strokes.

An amplifier and agc loop take care of variations in lamp intensity, paper reflectivity, aperture area and power supply voltage. "White level" circuits allow only ink stroke waveforms into peak sampling and clipping level circuits. Feedback from the peak detector establishes a new clipping level for subsequent peaks.

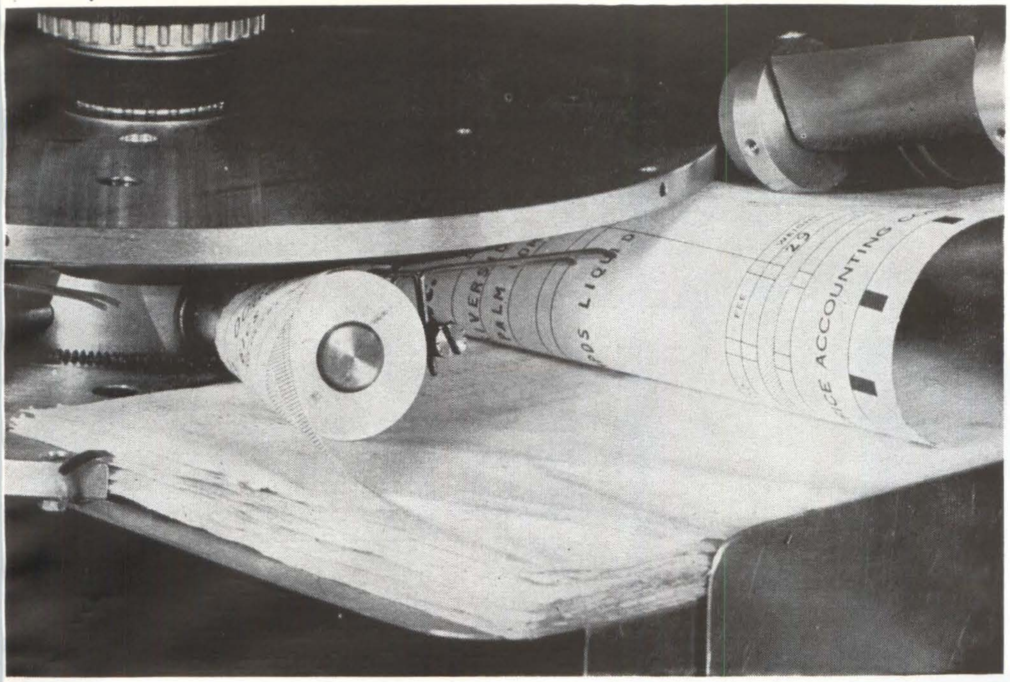
The peak detector's shaped pulse output goes to a column counter that steps with the right-hand edge of each character. One memory position is assigned each character. Plugboard wiring determines which column is stored in which memory position. The lower reading phototube and the memory control the decoder.

Farrington Electronics showed its Selected Data Page Scanner, which can be instructed what to read on such documents as invoices. Instruction selectors are interchangeable panels that can be wired to any reading mode and to arrange data as desired. Switches, counters and an individually addressable 32-position accumulator can also be used to control the data.

A reader that will tolerate some print mutilation and up to a 10-degree character tilt was developed for the Signal Corps by Control Instrument division, Burroughs Control Corp. It reads pages of double-spaced elite type at a rate of 75 characters a second.

An automatic handling system moves the document about a rotating drum. A flying spot scanner generates a signal whose level is proportional to reflected light. Each character is read as a particular pattern of 96 black or white points, which are compared with a stored library of patterns.

To compare, the serially-generated video data is converted to parallel form so signals for a character are all presented at one time. This is done by passing video signals through delay lines with 96 parallel output taps. Each tap has twin



Cycloid paper pickup developed by Rabinow handles flimsy papers

leads for black and white points.

Each lead connects to a magnetic core, which is set to a ONE state by a pulse from the lead. Wires are threaded through the cores in a character recognition pattern. The pulse generated in each wire is proportional to the number of switched cores through which it is threaded. This voltage is matched against reference voltages representing each character and the one with least mismatch is read out as a five-unit teletype code.

Rabinow Engineering made three developments public: two experimental readers and a cycloid paper pickup mechanism.

One machine uses a full retina of photocells to examine characters, identifying them by correlation matrices. The second uses multiple curve tracing to examine such characters as handwritten numerals. As long as line quality and size are kept within reasonable limits, numbers can be read even though written without restraint.

The paper pickup handles flimsy paper at rates up to 20 documents a second, reportedly more than double previous speeds. This narrows the gap between input feed rates and scanning speed, which at present is up to 25 times faster.

A timing gear rotates a disk carrying 12 to 15 cone shaped vacuum pickups. As a cone whirls around, it picks up a corner of a document, rolls it to the disk and releases the vacuum. Rollers then pull the document along in the usual way.

Among feasibility models reported was an RCA multifont machine for automatic language translation or autoabstracting. One approach is to use a photographic matrix mask for memory and recognition by optical correlation. A second technique is electronic page scan with automatic line and character location.

Faraway Weather Data Gathered by Photometer

OZONE DISTRIBUTION in Arctic regions has been measured at the Naval Ordnance Test Station in China Lake, Calif. UCLA and Navy researchers made the readings with a two-color photoelectric photometer, using the Echo satellite as a sunlight reflector. The photometer measures the ratio of light intensity, in blue and orange, as Echo enters the earth's shadow.

The technique could provide weather information from other inaccessible regions. Daily variation of ozone content indicates atmospheric movements. Ozone distribution at altitudes above 30 Km may provide clues on the relationship of solar radiation and surface weather. An installation similar to that at China Lake is being planned to cover the Antarctic. It will probably be in Chile.

Exhaust Probes Monitor Helicopter Rotor Icing

SOLID-STATE aircraft deicing control system developed by Cook Electric is reported to be small enough for private planes and helicopters.

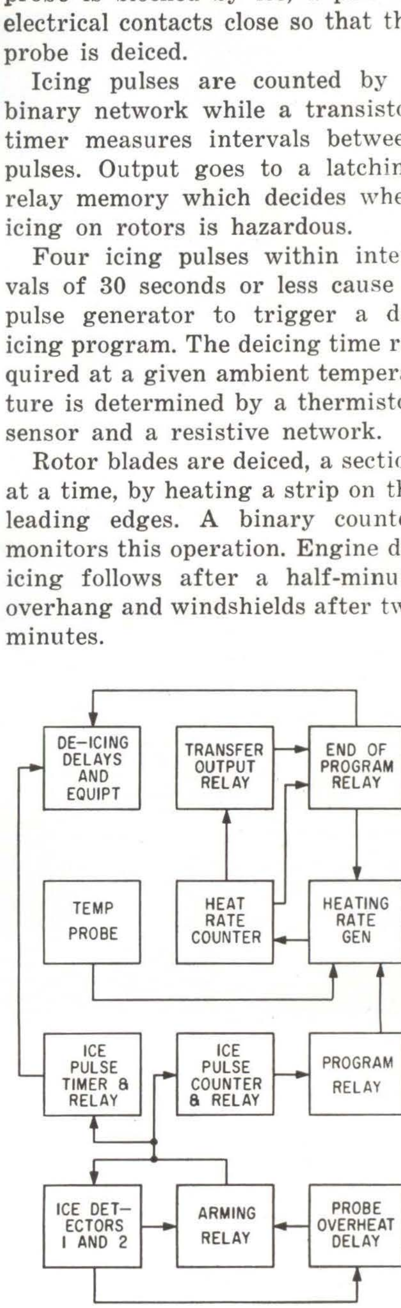
It weighs only 12 pounds, occupies about one-sixth the volume of electromechanical systems and improves deicing reliability, says Daniel Shevelenko, executive engineer.

In a typical two-engine helicopter installation, one differential air pressure probe is placed in each engine duct, providing redundancy should one engine fail. When the probe is blocked by ice, a pair of electrical contacts close so that the probe is deiced.

Icing pulses are counted by a binary network while a transistor timer measures intervals between pulses. Output goes to a latching relay memory which decides when icing on rotors is hazardous.

Four icing pulses within intervals of 30 seconds or less cause a pulse generator to trigger a deicing program. The deicing time required at a given ambient temperature is determined by a thermistor sensor and a resistive network.

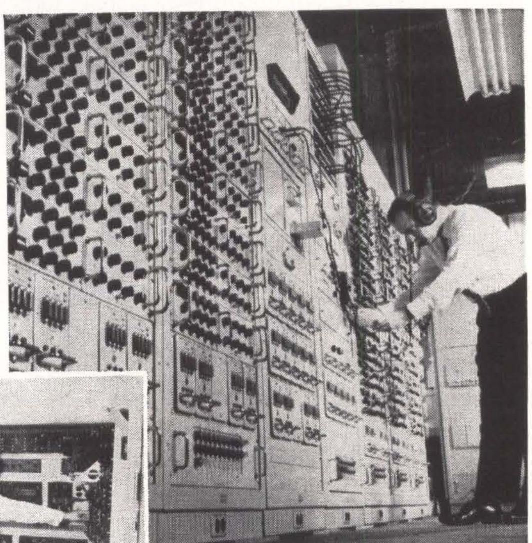
Rotor blades are deiced, a section at a time, by heating a strip on the leading edges. A binary counter monitors this operation. Engine deicing follows after a half-minute overhang and windshields after two minutes.



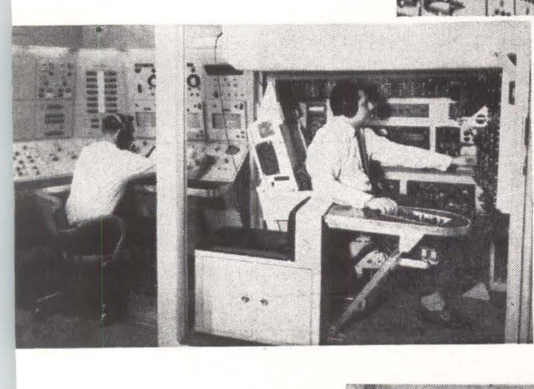
Simplified diagram of deicer

System Simulates B-52 Countermeasures

Ecm simulator provides electronic warfare officer all equipment found in the B-52 for detecting and taking action against hostile signal transmission



Instructor inserts punch card in signal generation section to simulate radar signal from enemy station



Instructor (left) monitors student electronic warfare officer's technique in coping with enemy signal transmission

B-58 ecm simulator, already in operation over a year, provides space for instructor not available in airborne training

By JOHN F. MASON
Associate Editor

ELECTRONIC COUNTERMEASURES simulator delivered to the Air Force can duplicate existing or predicted r-f environments that a bomber flying over enemy territory might encounter.

Although bought by USAF to train electronic warfare officers of B-52 bombers, the simulator, designated T-4, can be adapted for ecm training on other current or projected aircraft.

The T-4 is the first of a new series of electronic mission training systems being built for the Strategic Air Command by Reflectone Electronics, Inc., a subsidiary of Universal Match Corp. The $11.8 million contract was awarded by the Aeronautical Systems Division of the Air Force Systems Command, Wright-Patterson AFB, Ohio. The simulator was developed under the engineering cognizance of ASD's Bombing, Navigation and Ecm Branch, Director of Aerospace Ground Equipment Engineering Deputy for Engineers.

The new system differs from Reflectone's B-58 Defense Systems Operator simulator (ELECTRONICS, p 26, Apr. 7, 1961) in that the B-52 training device simulates only ecm. The older plane undoubtedly requires more sophisticated ecm gear than the newer B-58 since it is slower and will spend more time over enemy territory in a jamming, enemy radar, missile-attacking environment.

T-4 provides all countermeasures equipment an electronic warfare officer (EWO) must operate to detect and take action against hostile signal transmission. It can duplicate practically all types of signals in the r-f spectrum over a very wide range.

The T-4 includes a signal generation section of nine cabinets, a systems simulation section with seven cabinets (providing signals to simulate operation of student station equipment), an instructor's station and a student's station. The latter is essentially a physical duplication of the operational EWO portion of the B-52. The trainer fits into an area 30 ft by 28 ft.

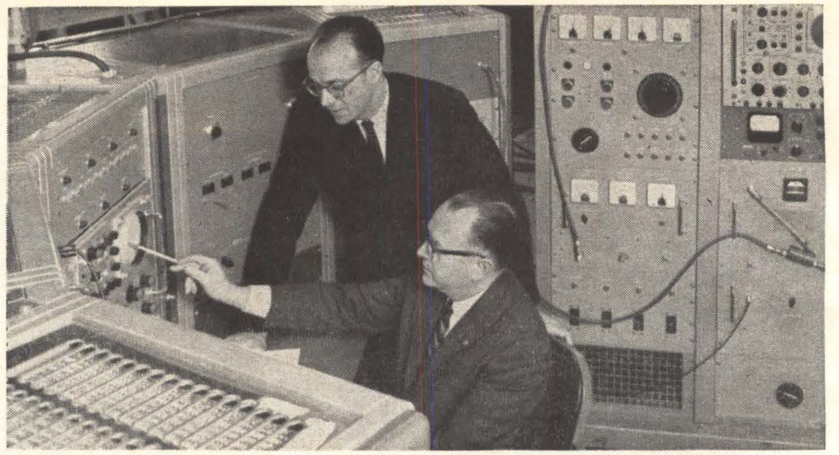
A large number of radar or communication stations can be simulated simultaneously. New stations can be introduced by leap-frogging back to use those no longer in the mission problem.

The simulator duplicates r-f transmission by preprogramming 19 functions. These include such signal characteristics as frequency, pulse repetition frequency (prf), pulse width, polarization and pulse mode. Other parameters include radar range, detection range, geographic position and the particular action an enemy station takes when it detects the B-52 and when the B-52 jams it. After detecting a target, the enemy radar may change from a search mode to a tracking mode. It may for a time go off the air. Back-up radars may come on when the target is fully in range. To counter jamming, a radar station may slide or jump to a different frequency. It may also change, for example, from a fixed frequency to varying modulation.

Any antenna pattern can be duplicated. The resulting signal is recorded on one channel of a continuous-loop, 50-channel tape recorder, which preprograms up to 50 different antenna signal characteristics. A semi-automatic punch card system selects the desired antenna characteristic and combines it with the appropriate video-audio signal to provide complete simulation of any radar or other r-f signal.

Project Engineer, Major P. Fasules, estimates that the cost of airborne training that can be accomplished in the simulator during one four-month period equals the cost of the simulator.

The B-58 ecm trainer has been in operation at SAC's Carswell AFB, Texas, for about a year. In one training period, 30 students averaged about 27 hr each, "flying" 497 missions totaling some 800,000 miles.



Amplifier is big enough to fill three-room apartment. This is control display

"Flywheel" Pumps Pulse Power

MICROWAVE POWER amplifier, capable of attaining a peak pulse power of 100 Mw at a frequency of 5.5 Gc, went into operation late last month at the Polytechnic Institute of Brooklyn's Long Island Graduate Center, Farmingdale, N. Y.

The amplifier was designed and built by the Sperry Electron Tube division of Sperry Rand Corp. It delivers pulses with a peak power of 10 Mw. A "microwave flywheel"—something like a cyclotron—steps up power to 100 Mw. The amplifier is coupled to a circular, 500-ft-long pipe. Energy is multiplied as it circulates around in the cavity.

Brooklyn Poly will use the output to observe the reaction of gases and solid materials under high peaks of electrical power. Studies of superpower microwave materials, plasma conductors of high-frequency, high-energy power, and aerodynamic shock tube studies are among research applications. The research program is sponsored by Air Force Systems Command. Sperry plans a line of such amplifiers.

Racetrack Computer Totes Payoff Odds

RACING FANS around the country will be getting the good news a few minutes earlier at tracks equipped with computers which figure payoffs as soon as the race is completed.

American Totalisator Co. is starting to equip its wagering systems with small digital computers to increase speed and accuracy. The company services some 150 jockey clubs and associations in 24 states, using 60 systems to equip 40 tracks at one time.

Totalisator inaugurated service with its new system at Santa Anita Racetrack recently, after testing reliability at five tracks. A second system has been completed and four others are being built at the company's plant in Baltimore. Oscar Levy, vice-president, expects use by 15 to 20 major tracks.

The computer is a modified Clary Corp. DE-60. It is portable, operates on line power and doesn't require special air conditioning. Tracks are equipped with basic cabling and housings, so systems can be transported from track to track overnight.

Pooled figures on the Tote board are scanned, recorded and translated into the numerical system used by the DE-60. While the horses are running, state and track percentages are deducted. When winners are announced, win, place and show prices are calculated and displayed. This takes about 84 seconds, about 1.5 minutes less than manual methods. The computer is programmed for more than 30 payoff variations.

Error factor is estimated at 0.0003 percent, a figure compiled from the $3.75 billion registered by Totalisator machines in 1960.

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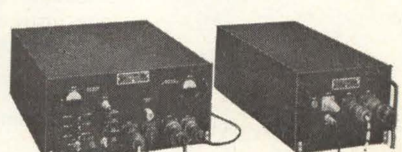

COUNTERMEASURES SYSTEMS

MODEL 2887

TRAK

COMMUNICATIONS & RECONNAISSANCE DEPT., TRAK ELECTRONICS COMPANY, INC., WILTON, CONN.

MEETINGS AHEAD

REDUNDANCY TECHNIQUES FOR COMPUTING SYSTEMS, Office of Naval Research; Dept. of Interior Aud., Wash., D. C., **Feb. 6-7.**

MILITARY ELECTRONICS, PGMIL of IRE; Ambassador Hotel, Los Angeles, **Feb. 7-9.**

SOLID STATE CIRCUITS, Internat. Conf., PGCT of IRE, AIEE; Sheraton Hotel and U. of Penn., Philadelphia, Pa., **Feb. 14-16.**

APPLICATION OF SWITCHING THEORY TO SPACE TECHNOLOGY Symp., USAF, Lockheed; at Lockheed, Sunnyvale, Calif., **Feb. 27-Mar. 1.**

SCINTILLATION AND SEMICONDUCTOR Counter Symp., PGNS of IRE, AIEE, AEC, NBS; Shoreham Hotel, Washington, D. C., **Mar. 1-3.**

MISSILES & ROCKET TESTING Symp., AF Com. & Electronics Association Coca Beach, Fla., **Mar. 6-8.**

EXTRA-HIGH VOLTAGE COMMUNICATION, CONTROL & RELAYING, AIEE; Baker Hotel, Dallas, Tex., **Mar. 14-16.**

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

QUALITY CONTROL Clinic, Rochester Soc for Q.C.; U. of Rochester, Rochester, N. Y., **Mar. 27.**

ENGINEERING ASPECTS OF MAGNETO-HYDRODYNAMICS, AIEE, IAS, IRE, U. of Rochester; U. of Rochester, Rochester, N. Y., **Mar. 28-29.**

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

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

HUMAN FACTORS in Electronics, PGHFE of IRE; Los Angeles, Calif., **May 3-4.**

ELECTRONIC COMPUTERS Conference, PGCP of IRE, AIEE, EIA; Marriott Twin Bridges Hotel, Washington, D. C., **May 8-10.**

NATIONAL AEROSPACE ELECTRONICS Conference, PGANE of IRE; Biltmore Hotel, Dayton, Ohio, **May 14-16.**

MICROWAVE THEORY & TECHNIQUES National Symposium, PGMTT of IRE; Boulder, Colo., **May 22-24.**

SELF-ORGANIZING INFORMATION Systems Conference, Off. Nav. Rsch., Armour Rsch. Fd.; Museum of Sci. and Ind., Chicago, **May 22-24.**

ADVANCE REPORT

WESTERN ELECTRONICS SHOW AND CONVENTION, WESCON: *at Los Angeles in the California Memorial Sports Arena and Statler-Hilton Hotel, August 21-24, 1962. Authors should submit the following materials by April 15 to WESCON Business Office c/o Technical Program Chairman, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.: (1) 100 to 200 word abstract including title of paper, name and address of author; (2) 500 to 1,000 word summary of paper; (3) indication of technical field in which paper falls using IRE professional group classification.*

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CIRCLE 34 ON READER SERVICE CARD→

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Under other circumstances, however, contact "good as gold" may call for radically different construction, different selection of metals, as you well know. All the picky considerations so familiar in switch design are thoughtfully gone over in full *each time OAK develops a switch recommendation.* Common, ordinary silver plate may be best of all. (Generally gives outstanding results where 10,000 cycles use-life is sufficient . . . and then provides brass-to-brass contact up to 200,000 cycles of operation where a bit of circuit noise can be tolerated.)

Then, perhaps, that "good-as-gold" answer will be OAK CMS-202 high-temperature alloy . . . or simply a more familiar silver alloy. OAK recognition of countless significant details helps you save by preventing over-engineered switches — as well as by safeguarding performance.

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Where creativity pays practical dividends

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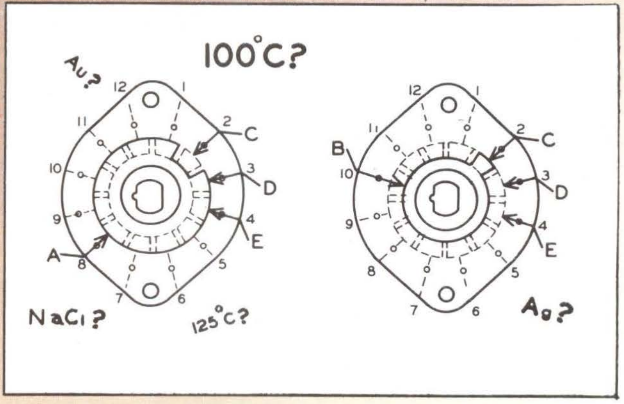
— Good switch-engineering, as you know, doesn't mean designing the most expensive item to do the job, under all conditions, for a hundred years. It means creating the *lowest-cost component that can handle the job and provide proper use-life*. Be it push-button, rotary, lever or slide switch — send your performance and application data along when you order.

Although you may have been dealing with us for years — you can enable us to do a still better job for you. As a switch specialist, OAK can spot needless costs in mechanical and electrical specifications and help control or eliminate them.



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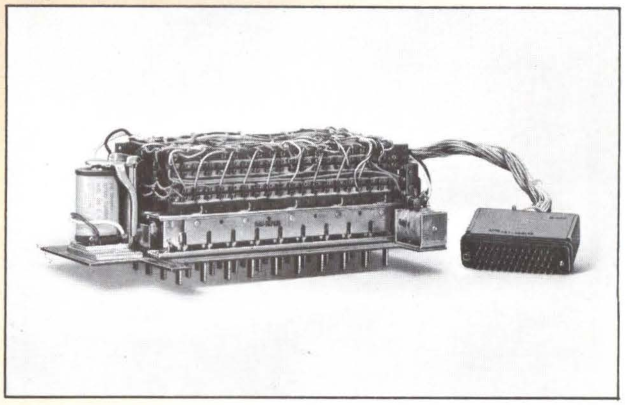

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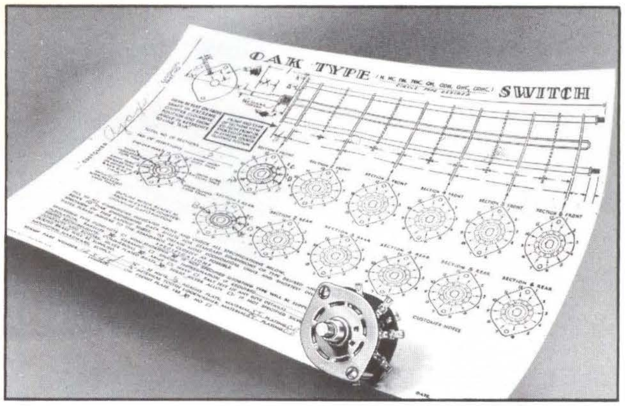

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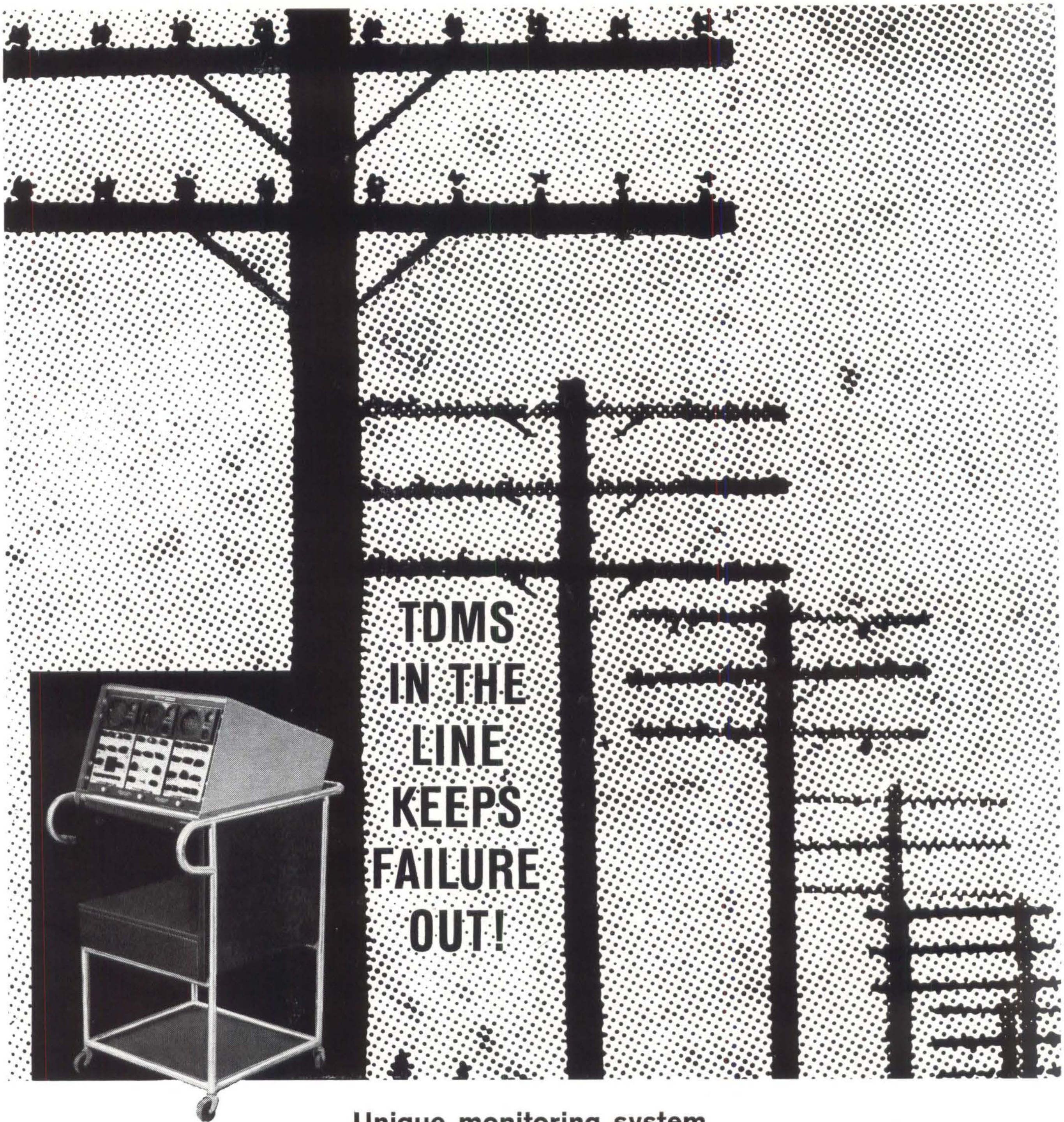

Unique monitoring system anticipates trouble spots in communications networks

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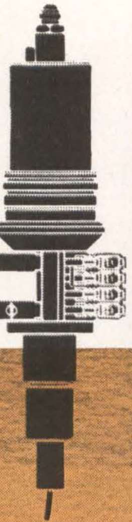
RADIATION *at Orlando*



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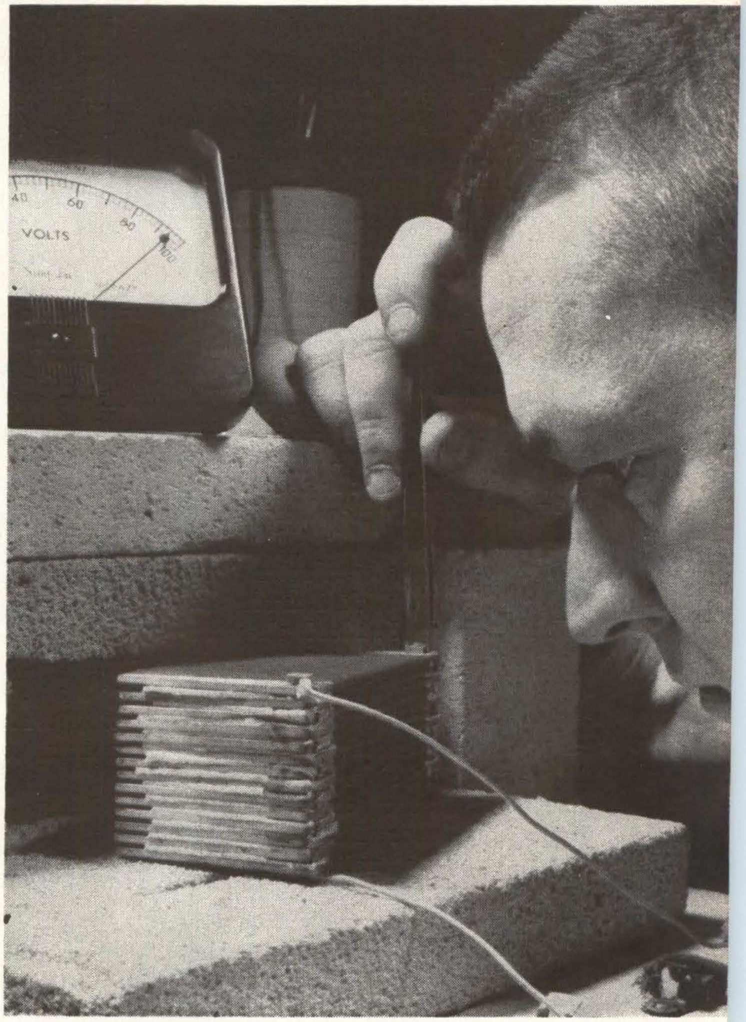
electronics

February 2, 1962



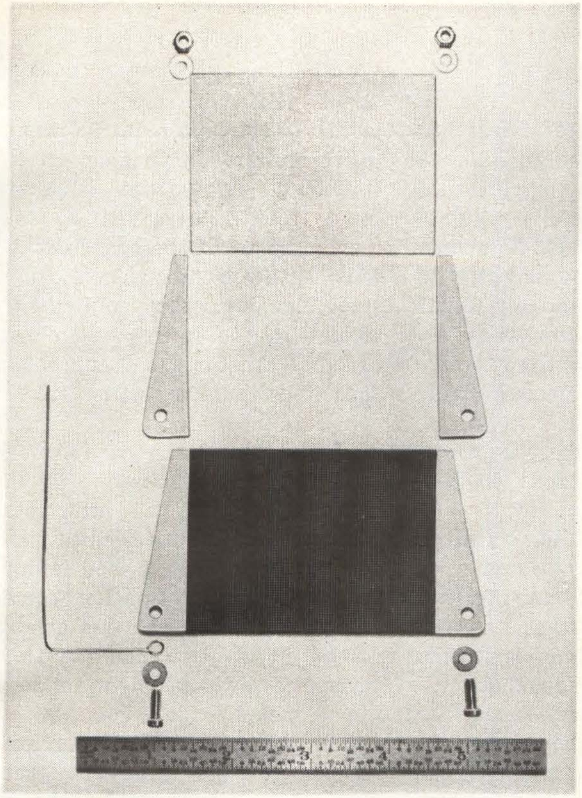


FIG. 1—Exploded view of individual plate (above) with assembled thermoelectric package undergoing tests (right)

HIGH VOLTAGE OUTPUT WITH

Oxide Thermoelectric Generators

Ceramic technology is used to produce an experimental thermoelectric generator capable of producing 100 volts in a twenty cubic inch package heated to 2,400 degrees F

By R. D. FENITY
Minneapolis-Honeywell Research Center, Hopkins, Minnesota

THIS CENTER has been engaged for about four years in the investigation and development of oxide semiconductors and devices based on their properties. Recently, Picatinny Arsenal supported a program on the use of these materials as thermoelectric generators. The first portion of the sponsored work involved a survey of the thermoelectric properties of a limited number of materials and the initiation of a study of the mechanisms involved. The second phase of this program required the design and fabrication of a generator using the best materials found in the first phase. This resulted in a device capable of generating 100 volts and occupying a space of only twenty cubic inches.

This generator was designed to obtain high voltage output in a

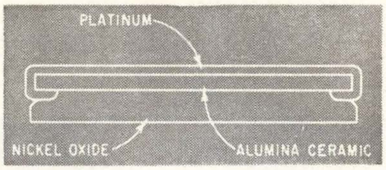


FIG. 2—Cross section of one plate

small volume without regard to current. These design ends were met by an unusual physical construction using ceramic technology. An exploded view of the device is shown in Fig. 1. It consists of an alumina ceramic plate to which has been applied a platinum layer which overlaps the opposite side. A plasma flame sprayed layer of doped nickel oxide is applied to the second side as illustrated in cross section in Fig. 2.

Each plate was then spirally cut with a 0.006-in. thick diamond saw to produce one hundred platinum-nickel oxide junctions in a series connection. The plates were then connected in series to produce 100 volts. Cold-end cooling on this generator was limited to normal losses through radiation, convection and conduction. Figure 1 also shows the generator in its final form.

As can be seen from Fig. 3A, output voltage versus the temperature differential between the hot and cold end, a substantial differential had to be established before appreciable voltage was generated and there was a tapering off of this voltage starting at a differential of about 500 C. The latter effect has been shown to be due to leakage through the ceramic substrate that proved to have appreciable conductivity at about 1,000 C. The low-temperature effect is attributed to a modification of the properties of the oxide semiconductor that occurred when exposed to the extreme temperatures of the plasma flame torch. Both of these effects can be overcome with a resulting improvement of a factor of four in performance.

Figures 3B and 3C illustrate the voltage and current characteristics of this generator with varying load impedance. The power output peaked at 650,000 ohms load, the generator internal impedance.

Oxide semiconductors used for thermoelectric generation are oxides of the transition metals that are doped by the mixed-valency principle to yield properties similar, but not identical to, the normal band conduction semiconductors. An example of the doping reaction is

$$\left(1 - \frac{x}{2}\right)Fe_2O_3 + x\,TiO_2 \rightarrow Fe_{2-2x}^{3+}\,Fe_x^{2+}\,Ti_x^{4+}\,O_3 + \frac{x}{4}\,O_2 \quad (1)$$

or

$$NiO + x\,Li_2O + \tfrac{1}{2}x\,O_2 \rightarrow Ni_{1-2x}^{2+}\,Ni_{2x}^{3+}\,Li_{2x}^{1+}\,O_{1+2x} \quad (2)$$

In both of these cases, the doping agent (TiO_2 or Li_2O) enters the lattice of the host material creating a charge imbalance that must be corrected. The balance is restored by a valence change in an equivalent number of the host ions. Now ions of different valencies of the same element occupy equivalent positions in the lattice and electron or hole transfer can occur between these positions resulting in semiconduction.

The vast majority of thermoelectric research at present is being concentrated on the intermetallic compounds. Perhaps the best known of these materials is lead telluride. As a basis for evaluation, some of the properties of this material are shown in Table I along with the properties of doped iron oxide and doped nickel oxide.

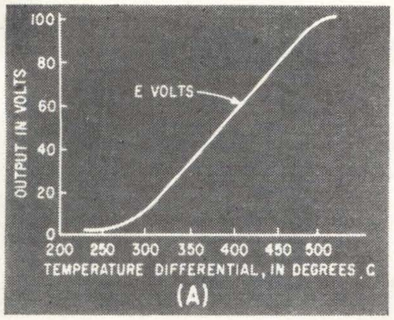
The thermoelectric properties described in this table are greater than those exhibited by the generator. This is due to a number of factors but most importantly denotes a decided improvement in these materials since the generator was completed.

Lead telluride can be machined with difficulty and is not easy to fabricate due to extreme brittleness and poor strength. The oxides can be fabricated by normal ceramic methods and are considerably stronger. Parts can be machined with diamond tools. Oxides may be operated at much higher tempera-

TABLE—COMPARISON BETWEEN PbTe AND DOPED Fe_2O_3–NiO THERMOELECTRIC GENERATOR MATERIALS

	PbTe		Fe_2O_3	NiO
	N	P	N	P
Machineability	Not advisable	Not advisable	Possible[a]	Possible[a]
Operating temperature (T_H)	594 C[b]	594 C[b]	1,300 C	1,300 C
Resistivity at 24 C	5×10^{-4} ohm cm	3.8×10^{-4} ohm cm	6×10^{-1} ohm cm	6×10^{-2} ohm cm
" at T_c[c]	4×10^{-4} ohm cm	3×10^{-4} ohm cm	8×10^{-2} ohm cm	1.9×10^{-2} ohm cm
" at T_H[d]	5.6×10^{-3} ohm cm	5.8×10^{-3} ohm cm	7.2×10^{-2} ohm cm	1.6×10^{-2} ohm cm
Density	8.15 g/cc	8.15 g/cc	5.2 g/cc	6.3 g/cc
Thermal expansion coefficient	18×10^{-6}/°C	18×10^{-6}/°C	13×10^{-6}/°C	12×10^{-6}/°C
Thermal conductivity	0.02 watt/cm/°C	0.02 watt/cm/°C	0.02 watt/cm/°C	Not available
Design ΔT	556 C	556 C	600 C	600 C
Voltage/junction	125 mv	135 mv	228 mv	120 mv

[a] Requires diamond tools
[b] Requires nonoxidizing atmosphere
[c] 10 C for PbTe and 600 C for oxides
[d] 594 C for PbTe and 1,200 C for oxides



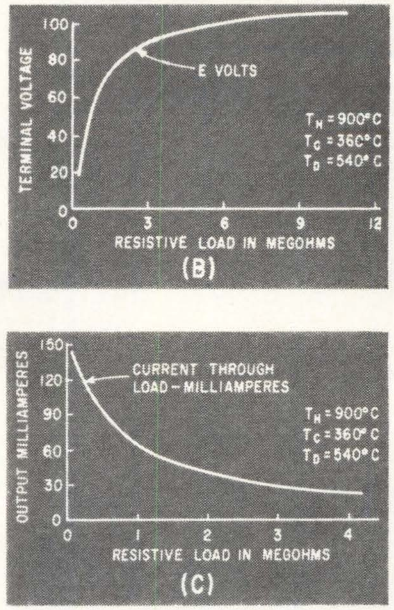
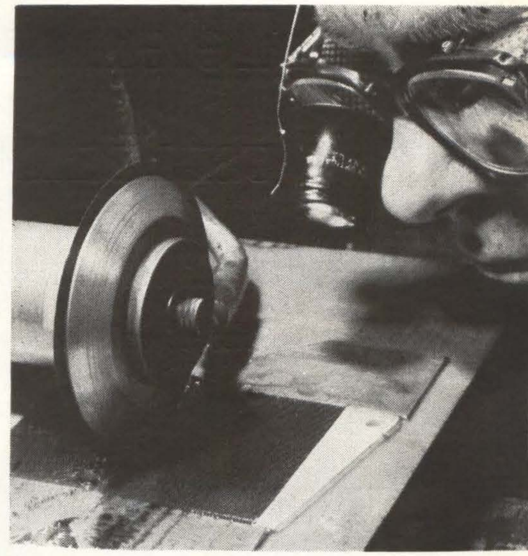


FIG. 3—Output voltage versus temperature differential (A), terminal voltage versus load impedance (B) and output current versus load impedance (C)



Each plate is spirally cut with a 0.006-in. diamond saw

tures, an advantage from a thermal efficiency standpoint. The telluride must be protected from oxidation whereas the oxides may be operated at quite elevated temperatures in air.

The primary disadvantage of the oxides is in their relatively high resistivities. The oxides have between 10^2 and 10^3 times the resistivity of lead telluride at room temperature. However, due to the large negative coefficient of resistance, this difference decreases to ten to one hundred times at operating temperatures.

The oxides have a density about thirty percent less than lead telluride and this may be of importance in airborne applications. The thermal expansion coefficient of the oxides is lower, which should contribute to better thermal shock resistance. The thermal conductivity of doped iron oxide has been measured and is approximately the same as lead telluride. The thermal conductivity of doped nickel oxide is not available but is expected to be in the same range.

Both the potential temperature differential and the thermoelectric voltage are greater in the oxides and, under the design conditions specified in the table, the total voltage per junction from the oxides is greater than that from the tellurides. It should be pointed out that to some extent this is a matter of design. Combinations of doped nickel and iron oxides have been measured at greater than 1,000 μv per degree C, and, if operated between room temperature and 1,300 C, would generate more than one and one-fourth volts per junction. This, however, would be at a relatively high resistance and little power would be obtained. Since the resistivity of these oxides decreases exponentially with temperature while the Seebeck voltage decreases linearly with decrease in the differential temperature, power output increases rapidly as the cold end temperature is raised, assuming a constant hot-end temperature.

To indicate the order of thermal efficiency presently available, a calculation can be made from recent test data using $T_1 = 1{,}473$ K (hot-end temperature), $T_0 = 873$ K (cold-end temperature), $\alpha = 580$ μv per degree C (open circuit), $\rho_p = 0.017$ ohm cm, and $\rho_n = 0.076$ ohm cm. The latter two are average resistivities over operating range $T_0 - T_1$.

Assuming that the doped nickel oxide has approximately the same thermal conductivity as the doped iron oxide (0.019 watt/cm sec), the zeta factor and thermal efficiencies can be calculated.

From Ioffe, the Z factor is

$$Z = \frac{\alpha^2}{(\sqrt{K\rho_P} + \sqrt{K\rho_N})^2}$$

Where α is the open circuit Seebeck voltage, K is the thermal conductivity, and ρ the resistivity. Then

$$Z = \frac{(5.80\times10^{-4})^2}{(\sqrt{0.019\times0.017}+\sqrt{0.019\times0.076})^2}$$
$$= 1.07\times10^{-4} \text{ per deg C}$$

With this, calculate thermal efficiency N:

$$N = \tfrac{1}{2}\,\frac{\Delta T}{T_1 + \dfrac{2}{Z} - \tfrac{1}{4}\Delta T}$$

$$= \tfrac{1}{2}\,\frac{600}{1473 + \dfrac{2}{1.07\times10^{-4}} - \tfrac{1}{4}(600)}$$

$$= 0.015$$

This indicates that 1.5 percent of the thermal energy introduced into the hot end of this material is converted into electrical energy. This figure can be compared with 7.85 percent reported for lead telluride.

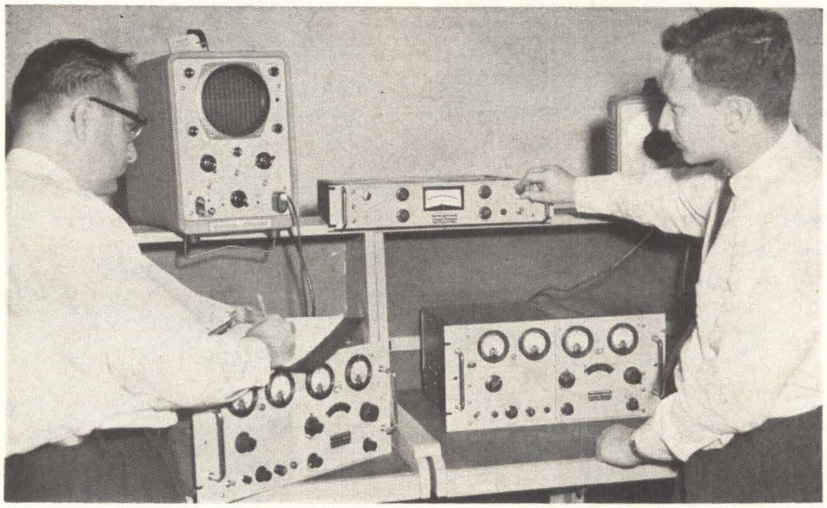
It is not the purpose of the above comparison to imply that in the present state of knowledge, oxide thermoelectric materials can compete from a thermal efficiency standpoint with intermetallics. The purpose is to suggest that they may be useful in applications requiring greater voltage output, better oxidation resistance and superior physical properties.

It is also suggested that a further study of these materials as thermoelectrics and a better understanding of the mechanisms involved in conduction and thermoelectricity in oxides could lead to considerable improvement in the efficient generation of power in these materials.

Telemetry Diversity Combiner

USES BEAM DEFLECTION TECHNIQUE

Circuit responds to high-frequency fading and has wide bandwidth. Control voltage goes to beam-deflection plates



Small size of the combiner enables flexibility in installation

By V. A. RATNER
Director, Systems Engineering, Defense Electronics, Inc., Rockville, Md.

DIVERSITY RECEPTION techniques applied to radio telemetry place some unusual requirements on the art of diversity combining. Most conventional communications systems need only be responsive to relatively slow fading rates and be capable of handling relatively narrow bandwidths. A tumbling, spinning, missile or spacecraft traveling at several times the speed of sound however, may exhibit fades occurring at rates up to several kilocycles. In addition, high bit-rate rcm and other types of telemetry modulation systems require base-band frequency responses from a few cps to over one megacycle. The problems are even further complicated by the fact that a single installation may be required to operate with several different bandwidths from day to day, and subsequent data storage and data processing equipment usually have limited dynamic ranges and require that the diversity system have a nearly constant level output.

Conventional noise sampling combiners have proven impractical because signals of differing bandwidth must be accommodated, and full utilization of bandwidth allows no unused spectrum from which to derive a sample of noise that is free of signal energy. Receiver agc has therefore been selected as an analog of signal strength and hence signal-to-noise ratio, for use as a combiner control signal. Agc in most telemetry receivers is an approximately logarithmic function of signal strength. A control amplifier may be designed with a transfer function to give the ratio-squared combining law, which has been proven optimum for post-detection combining. Post-detection combiners using agc control have been designed using both the expander-compressor technique and the common cathode circuit configurations. Both types however, have suffered from limitations of over complexity, poor fading response, inadequate frequency response, critical balancing controls, and the presence of control voltage variations in the combined output.

A different approach to the problem has resulted in a new type of basic circuit using beam-deflection tubes as combiner elements. This configuration automatically results in ratio-squared combining, and suffers from none of the limitations of previous methods. The circuit of the complete two-channel combiner, Fig. 1, has only five active tubes and is packaged in a 3½-in. standard relay rack space.

The circuit uses the RCA type 7360 beam-deflection tube. This tube, intended for use in single-sideband balanced-modulator applications, has the property of providing output currents that are functions of the product of two input signal voltages. It contains a single cathode, control grid, and screen grid, a pair of deflecting electrodes, and two plates arranged so that a voltage differential impressed across the deflection electrodes causes the beam current to be unequally divided between the plates and proportional to the deflecting potential difference.

The basic combiner circuit consists of two 7360 tubes with corresponding deflection electrodes tied together and opposite plates connected together sharing a common

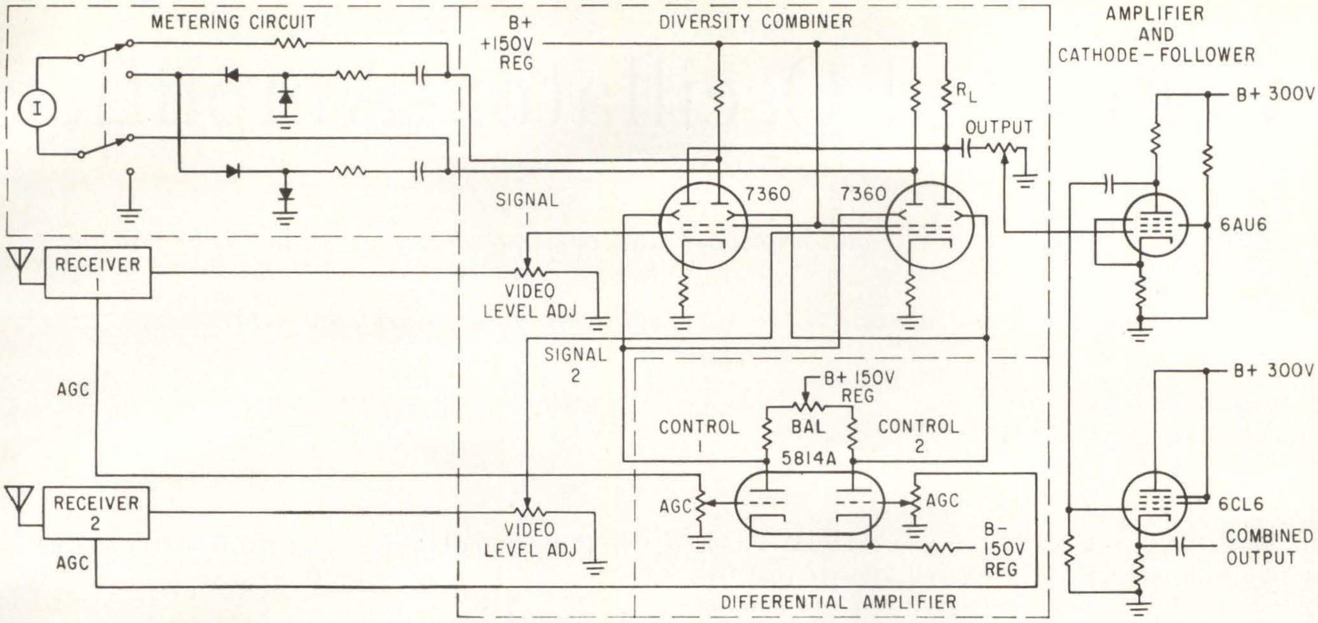


FIG. 1—System consists of four major circuits. Two type 7360 beam deflection tubes in the combiner circuit are the heart of the device

load resistor. The video signals to be combined are fed directly to the grid of each tube individually while the control voltages are applied to the respective deflection electrodes, Fig. 1. Then as the control voltages vary, the total current in the common plate load R_L remains the same but the relative proportion contributed by each video signal changes. The combined output, taken as signal voltage across the common plate load, will not vary in amplitude as long as the two video inputs are of equal amplitude and in-phase. This is normally accomplished by adjusting the attenuators in the video input line and is critical for rejection of control signal variations. Thus, the variations in control voltage do not appear in the output signal.

The required linear control signal for application to the deflection electrodes is derived from the receiver agc outputs. Standard telemetry receivers have agc output voltages that are a nearly logarithmic representation of the r-f input levels, and hence signal-to-noise ratio. A direct-coupled differential amplifier is incorporated in the combiner. By applying the receiver agc voltages (through variable attenuators) to each of the differential amplifier inputs, an exponential transfer function is attained, which establishes an approximately linear relationship between control signals. Use of the differential amplifier accomplishes one other important function—the maintaining a constant mean potential between the deflection electrodes and the cathode of the 7360 to preserve balance and prevent nonlinear operation due to distortion of the beam symmetry.

The circuit is superior to the common cathode combiner in both video frequency response and maximum combining rate. This is because a push-pull arrangement is not necessary to cancel control voltage variations in the combiner output. Video transformers or phase-splitters with their attendant time constants and balancing controls are not required.

Since the combiner requires that the video inputs as well as the agc control voltages be closely balanced, both video and agc metering provisions have been incorporated. Earlier combiner designs used individual meters in each channel and were difficult to adjust due to interaction between channels and variations in meter calibration. The metering circuit in the beam deflection combiner however, uses the unused pair of plates in a bridge type of circuit, Fig. 1. A single zero-center microammeter, Fig. 2, indicates the actual ratio of plate currents, which corresponds directly to the combining ratio. The meter is calibrated in db and gives a more meaningful indication of the combining operation than do individual channel meters. Positive adjustment of the beam deflection combiner with this type of metering may be accomplished within a few seconds, in contrast to the trial and error procedure required of conventional combiners.

The beam deflection combiner, for which a patent application has been filed, may also be incorporated into other communications systems for improved diversity reception.

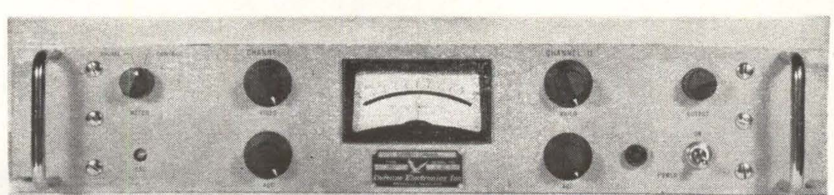


FIG. 2—Control panel illustrates operational simplicity. Built-in metering circuit provides for quick adjustment

Combined Oscillator-Amplifier

How to design cascaded common-base and common-collector stages that can be transformed from an amplifier to an oscillator by changing impedance level of an R-C time constant

By R. C. CARTER, Texas Division, Collins Radio Co., Dallas, Texas

IN TRANSCEIVERS, if one circuit can generate a tone during transmission and selectively amplify that frequency while receiving, the circuit will have advantages over other circuits that may be used for the same application. Such a dual circuit operating at 170 cps has been developed.

One advantage is the smaller number of components in the dual circuit: four frequency determining elements, two transistors and two biasing resistors. Another advantage is that the only transistor parameters that gain and frequency stability depend upon are the grounded-base current gain, and the grounded-collector voltage gain. Both these parameters are stable. Also, practical design equations for the circuit are simple.

The circuit is transformed from a band-pass amplifier to an oscillator by a slight change in the impedance level of an R-C time constant. Using the generalized circuit of Fig. 1A a whole family of circuits can be described. The family includes various oscillators, Q multipliers, notch filters and band-pass, low-pass and high-pass amplifiers. The Butler oscillator may be considered as a member of this group.

Open-loop gain will be considered first by breaking the circuit at point X of Fig. 1A and redrawing as in Fig. 1B

$$i_3 = G_i i_1 = \alpha_1 i_1 \cong i_1 \quad (1)$$

where G_i is the current gain of a common-base stage. Voltage at the output of Q_2 is

$$e_4 = G_v e_3 \quad (2)$$

where G_v the voltage gain of a common collector stage, is

$$G_v = \frac{r_L}{r_e + r_b(1-\alpha) + r_L} \cong 1 \quad (3)$$

if $r_L >> r_e + r_b\ (1 - \alpha)$ voltage e_4 can be expressed as

$$e_4 = i_2(Z_1 + R_{in}) \cong Z_1 i_2 \quad (4)$$

if it is assumed $R_{in} << Z_1$. Point B of Fig. 1B will eventually be returned to point A where R_{in} becomes the input impedance of Q_1. Since the input impedance is usually less than 50 ohms, Eq. 4 may be easily satisfied. At the input to Q_2

$$e_3 = Z_2 i_3 \quad (5)$$

It is assumed $i_{b2} << i_3$. This will be true so long as

$$r_{b2} + \beta_2(r_e + Z_1) \gg Z_2 \quad (6)$$

Combining Eq. 1, 2, 4 and 5

$$G_o = i_2/i_1 = G_i G_v Z_2/Z_1 \cong Z_2/Z_1 \quad (7)$$

where G_o is the open-loop current gain. From feedback theory, the relationship between closed-loop (G_c) and open-loop (G_o) gain (for positive feedback) is

$$G_c = G_o/(1 - G_o) \quad (8)$$

Combining Eq. 7 and 8 gives

$$G_c = \frac{1}{\dfrac{Z_1}{Z_2 G_i G_v} - 1} \cong \frac{1}{\dfrac{Z_1}{Z_2} - 1} \quad (9)$$

Consider Z_1 a series R_1 and C_1 and Z_2 a parallel R_2 and C_2 thus

$$Z_1 = R_1 + \frac{1}{sC_1} = \frac{sR_1C_1 + 1}{sC_1} = \frac{T_1 s + 1}{sC_1} \quad (10)$$

$$Z_2 = \frac{R_2/sC_2}{R_2 + \dfrac{1}{sC_2}} = \frac{R_2}{sR_2C_2 + 1} = \frac{R_2}{T_2 s + 1} \quad (11)$$

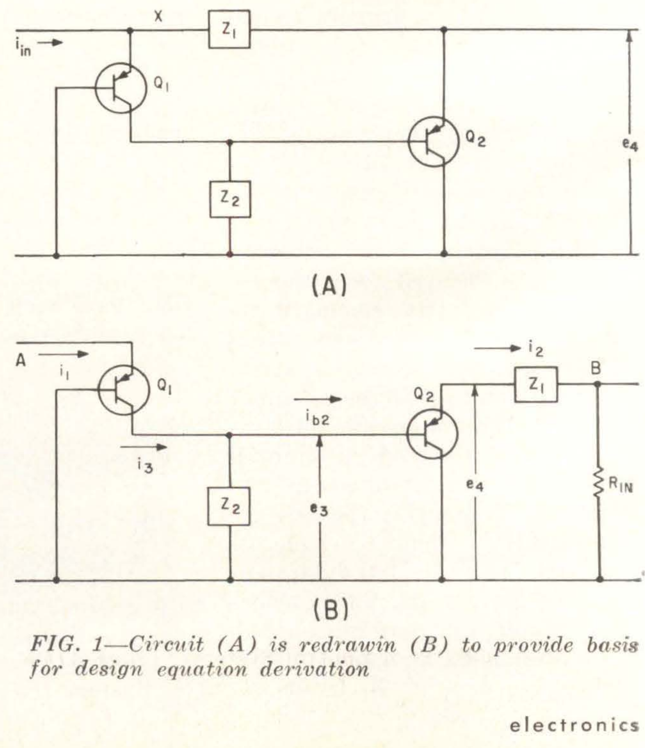


FIG. 1—Circuit (A) is redrawin (B) to provide basis for design equation derivation

for Tone Transceivers

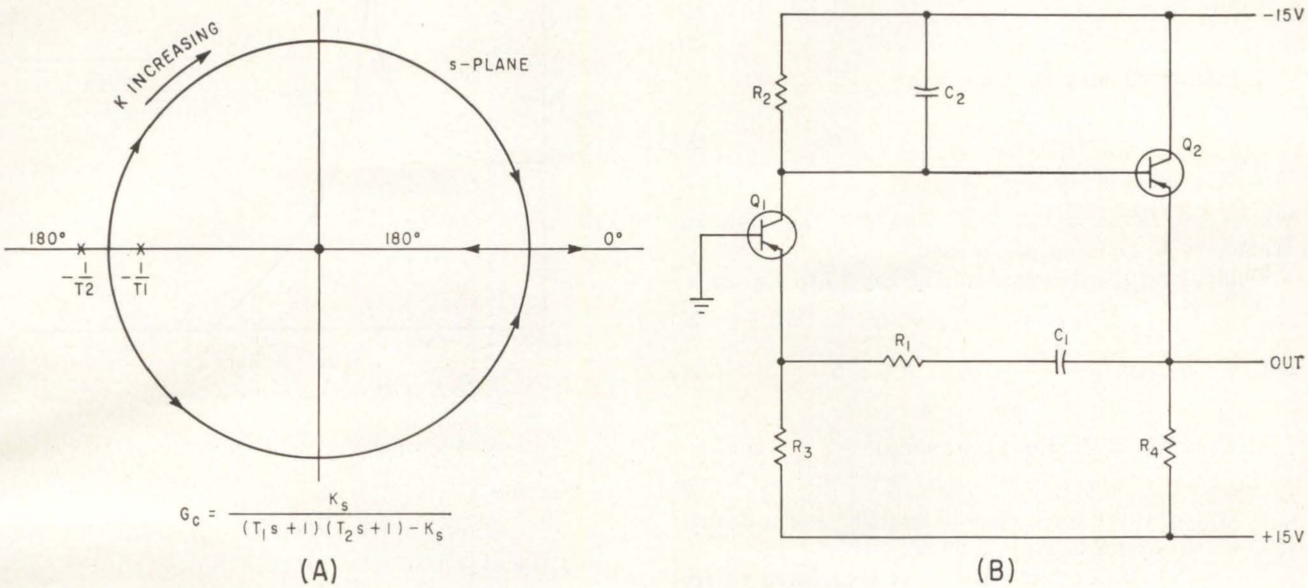


FIG. 2—Root-locus plot of loop gain (A). Circuit for band-pass amplifier and oscillator (B)

where

$$T_1 = R_1C_1 \qquad T_2 = R_2C_2 \tag{12}$$

$$\text{and} \quad s = j\omega. \tag{13}$$

Combining Eq. 9, 10 and 11

$$G_c = \frac{G_iG_vR_2C_1s}{(T_1s + 1)(T_2s + 1) - G_iG_vR_2C_1s} \tag{14}$$

$$G_c = \frac{Ks}{(T_1s + 1)(T_2s + 1) - Ks}$$

$$= \frac{Ks}{T_1T_2s^2 + (T_1 + T_2 - K)s + 1} \tag{15}$$

where

$$K = G_PR_2C_1 \qquad \text{and} \qquad G_P = G_iG_v \tag{16}$$

Equation 15 may be analyzed by the root-locus method if K is considered as a gain factor. Note, however, that K may be varied only by varying R_2 or C_1 (Eq. 16), this would also vary the time constant T_1 or T_2 which would be inconvenient. Time constants T_1 and T_2 may be made independent of K provided two, rather than one, elements are varied. If K is increased by increasing R_2, T_2 may be maintained constant by decreasing C_2.

The root locus of Eq. 15 may be determined as shown in Fig. 2A. The two poles and one zero of the closed-loop response are as shown. Poles of the closed-loop response approach the open-loop poles if K approaches zero and proceed along a certain locus to the zeros of the open-loop response as K approaches infinity. For more on Root Locus see W. R. Evans, Graphical Analysis of Control Systems, *Trans AIEE*, 67, p. 547. Also W. R. Evans "Control System Dynamics" and J. G. Truxal, "Automatic Feedback Control System Synthesis," both McGraw-Hill Book Co., N. Y.

As K increases from zero the poles of the closed-loop response break away from the real axis between $-1/T_1$, and $-1/T_2$ and eventually reach the imaginary axis. At this point the circuit has enough gain to just break into oscillation.

The value of K at this point may be determined by observing that K must have a value that renders the denominator of Eq. 15 to be purely imaginary. The coefficient of the s term must be equal to zero. Thus the requirements for oscillation is

$$K = T_1 + T_2 \tag{17}$$

If Eq. 17 is satisfied, the frequency of oscillation is

$$\omega_o = 1/\sqrt{T_1T_2} \tag{18}$$

It is convenient to let

$$T_1 = T_2 = T_o \tag{19}$$

Then

$$\omega_o = 1/T_o \tag{20}$$

Combining Eq. 12, 13, 16 and 17

$$R_2G_P/2 = R_1 \tag{21}$$

$$C_1G_P/2 = C_2 \tag{22}$$

The relations in Eq. 18, 19, 20, 21 and 22 determine the parameters for designing an oscillator. For a practical oscillator, however, R_1 should be slightly smaller than R_2 $G_p/2$ so the circuit is definitely unstable. Too great a decrease in R_1 results in waveform distortion.

For a band-pass amplifier, K is reduced to make circuit stable. An equation that expresses the relationship of Q and the circuit parameters may be developed by comparing the denominator of Eq. 15 to the characteristic equation for a series RLC circuit

$$LCs^2 + RCs + 1 = 0 \qquad (23)$$

Since

$$Q = \omega_o L / R = 1 / R\omega_o C \qquad (24)$$

Equation 23 may be rewritten

$$\frac{Ts^2}{1 + \frac{1}{4Q^2}} s^2 + \frac{T_o}{Q} s + 1 = 0 \qquad (25)$$

where $1/\sqrt{LC} = \omega_o = 1/T_o$ which is the resonant frequency in radians per second.

Comparing the denominator of Eq. 15 to Eq. 25

$$T_1 + T_2 - K = T_o / Q \qquad (26)$$

and

$$T_1 T_2 = \frac{T_o^2}{1 + \frac{1}{4Q^2}} \cong T_o^2 \text{ if } Q > 5 \qquad (27)$$

If $T_1 = T_2 = T_o$, Eq. 26 becomes

$$Q = 1/(2 - G_P R_2 / R_1) \qquad (28$$

A typical value for G_p would be 0.98. For a desired Q of 20, R_2 would be $R_2 = 1.99\ R_1$.

For an amplifier, the gain must be related to frequency and circuit parameters. One way of using Fig. 2B as an amplifier is to inject a constant-current source input to the emitter of Q_1 and considering the emitter voltage of Q_2 as the output.

Under these conditions it is desired to determine the transresistance R_{21} as a function of frequency

$$R_{21} = \frac{e_4}{i_{in}} = \frac{Z_1 i_2}{i_1 - i_2} = \frac{Z_1}{i_1 / i_2 - 1} \qquad (29)$$

Combining Eq. 29 and 7

$$R_{21} = \frac{Z_1}{\frac{1}{G_P}\left(\frac{Z_1}{Z_2}\right) - 1} \qquad (30)$$

where $G_p = G_i\ G_v$

Comparing Eq. 30 to 9

$$R_{21} = G_c Z_1$$

Thus where $Z_1 = (T_1\ s + 1)/s\ C_1$ and $Z_2 = R_2/(T_2\ s + 1)$

$$R_{21} = G_P R_2 \frac{T_1 s + 1}{T_1 T_2 s^2 + (T_1 + T_2 - K)s + 1} \qquad (31)$$

Using Eq. 26 and 27 and setting $T_1 = T_2 = T_o$

$$R_{21} \cong G_P R_2 \frac{T_o s + 1}{T_o^2 s^2 + \frac{T_o}{Q} s + 1} \quad (\text{for } Q > 5) \qquad (32)$$

Setting $s = j\omega$ and taking the absolute value

$$|R_{21}(\omega)| = G_P R_2 \sqrt{\frac{1 + T_o^2 \omega^2}{(1 - T_o^2 \omega^2)^2 + \left(\frac{T_o \omega}{Q}\right)^2}} \qquad (33)$$

Equation 33 is shown in Fig. 3 for $Q = \infty$ and 10. Note that the value of Q virtually has no effect upon the response at frequencies more than about 10 percent away from $1/T_o$.

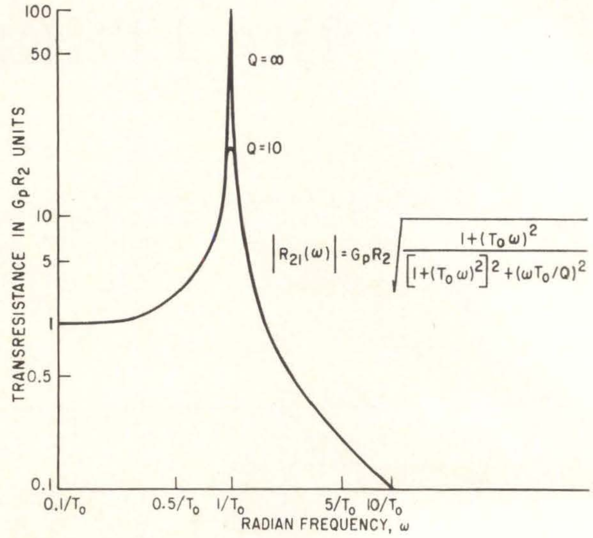


FIG. 3—Effect of Q on transresistance

Setting $s = j/T_o$ in Eq. 32

$$R_{21} = G_P R_2 Q(1 - j) \qquad (34)$$

and the absolute value

$$|R_{21}| = \sqrt{2}\, G_P R_2 Q \qquad (35)$$

Equations 34 and 35 give the gain at the point of maximum response. At $\omega = 1/T_o$ the phase shift is -45 degrees and the gain is a direct function of Q. For a typical oscillator application: assume it is desired to design an oscillator at a resonant frequency of 100 cps and the power supplies are + and -15 v. Refer to Fig. 2B. To obtain maximum output before limiting, the quiescent operating collector voltage of Q_1 should be -7.5 v. A good operating current for Q_1 is 1 ma, therefore, $R_2 = 7.5$ v/1 ma $= 7.5$ kilohms.

Selecting R_2 fixes the values of R_1, C_1 and C_2. Using Eq. 18, 19, 21 and 22: $C_2 = 0.212\ \mu$f, $R_1 = 3.674$ kilohms, $C_1 = 0.424\ \mu$f, assuming $G_i\ G_v = 0.98$.

The values of R_3 and R_4 (Fig. 2B) are determined only by operating-point considerations. Thus, if both Q_1 and Q_2 are to be operated at one milliampere, then $R_3 = 15{,}000$ ohms and $R_4 = 22{,}500$ ohms.

It is desirable to adjust the values of the capacitors to RETMA values: C_2 could be 0.2 μf and C_1 could be 0.39 μf. It is not absolutely necessary that T_1 be exactly equal to T_2, but for oscillation K must be equal to or slightly greater than $T_1 + T_2$.

From Eq. 21 and 22

$$R_1 = R_2(G_P - C_2/C_1) \qquad (36)$$

which may be used to determine the relation between resistances when capacitors are arbitrarily chosen.

The frequency of oscillation will be

$$\omega_o = \frac{1}{T_2(G_P C_1/C_2 - 1)^{1/2}} = (G_P C_1/C_2 - 1)^{1/2}/T_1 \qquad (37)$$

For a typical bandpass amplifier application: assume it is desired to design a bandpass amplifier with a center frequency of 100 cps and a Q of 20. It is desired to have at least a 5-v peak-to-peak output voltage swing from a signal source to 100 μamps p-p at

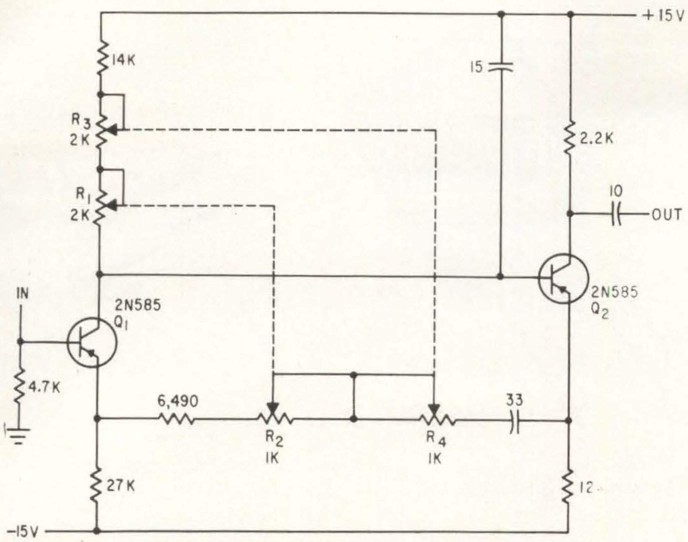


FIG. 4—Band-pass amplifier with center frequency of 0.66 cps and Q of 20

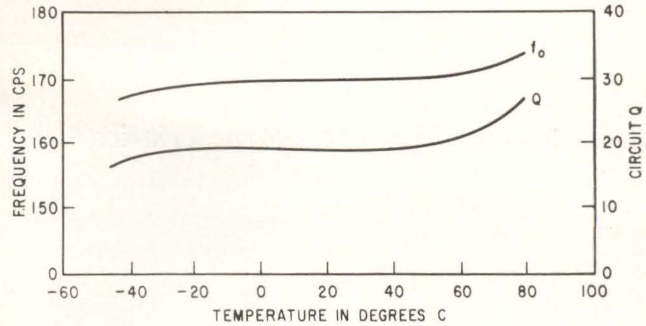


FIG. 5—Variation of Q and center frequency of amplifier with center frequency of 170 cps

center frequency. Power supplies avialable are + and −15 volts.

From Eq. 35, $R_2 = \dfrac{|R_{21}|}{\sqrt{2} G_P Q} = \dfrac{5/10^{-4}}{(\sqrt{2})(0.98)(20)} = 3.54K$

This value of R_2 will give the required gain. To put the collector of Q_1 at 7.5 volts, which allows symmetrical clipping on strong signals, the current required would be

$$i = 7.5/3.54K = 2.12 \text{ ma}$$

This is a good operating point for Q_1, however, if more gain is not objectionable, R_2 may be 7.5 K as in the last example.

Resistance R_1 is then given by Eq. 28

$$R_1 = \frac{G_P R_2}{2 - \frac{1}{Q}} = \frac{(0.98)(7.5)10^3}{2 - \frac{1}{20}} = 3.77K$$

and by Eq. 20, 12 and 13, $C_1 = 0.422\ \mu f$ and $C_2 = 0.212\ \mu f$.

For arbitrarily chosen capacitors and a given Q then relation between resistors is

$$R_1 = R_2 \frac{C_2}{C_1} \left[G_P \frac{C_1}{C_2} + \frac{1}{2Q^2} - 1 + \frac{1}{Q} \left(G_P \frac{C_1}{C_2} + \frac{1}{4Q^2} - 1 \right)^{1/2} \right] \quad (38)$$

However, in the practical case, C_1 and C_2 are chosen to the closest RETMA values as determined by Eq. 20, 12 and 22 and R_1 and/or R_2 are trimmed to give the required Q. To maintain the same center frequency while varying Q, resistors R_1 and R_2 must be varied in the opposite directions according to

$$\Delta R_2 = (-)2\,\Delta R_1 \quad (39)$$

To maintain a constant Q while varying center frequency, resistors R_1 and R_2 must be increased or decreased together according to

$$\Delta R_2 = 2\,\Delta R_1 \quad (40)$$

Resistors R_3 and R_4 in Fig. 2B are determined as before and are 15 K and 22.5 K respectively.

Figure 4 shows a typical application of the band-pass case where the center frequency and Q are adjusted by separate and independent controls. Center frequency is nominally 0.66 cps and Q is nominally 20. Resistors R_1 and R_2 are ganged so that increasing R_1 decreases R_2. This is the Q control (and controls gain). Resistors R_3 and R_4 are ganged so that they vary together to control frequency.

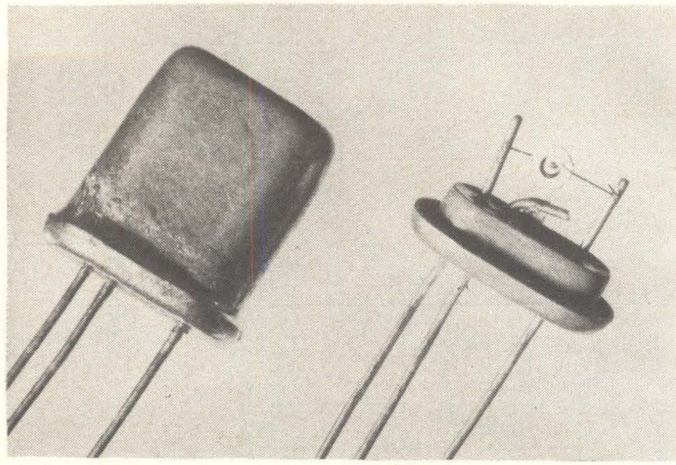
The input is introduced to the base of Q_1 rather than the emitter. This raises the input impedance and allows easier driving. No modification of the design equations is necessary since in Eq. 4 it is assumed that $Z_1 >> R_n$ where R_n is the impedance looking into the emitter of Q_1. This is still true in spite of the added base resistance.

The output may be taken from either the emitter or collector of Q_2. Although the impedance level is low at the Q_2 emitter, no appreciable power may be taken off at this point without adversely affecting the circuit characteristics. If the load is constant, the circuit may be readjusted after adding the load. It is usually best to couple into the circuit with an emitter follower at the Q_2 emitter. If the output is taken from across a resistor in the collector circuit of Q_2 no adverse loading effects will be noted, but this reduces the dynamic range for a given supply voltage.

Figure 5 shows how Q and center frequency vary with temperature for an amplifier having a center frequency at 170. No temperature compensation techniques were used other than selecting stable components. In this case 2N338 silicon transistors, deposited carbon resistors, and polystyrene dielectric capacitors were used.

It can be shown that the percentage change in the transresistance will be 2Q times the percentage change in G_p. Although G_p is temperature stable, it is best not to try for too high a Q in one circuit. A nominal Q of 20 will give stable gain over a large temperature range. Larger values of Q may be used if the temperature range is limited or temperature compensation is used.

Variation of mechanical configuration of field-effect transistor produces a device with various negative-resistance characteristics



Field-effect transistor resembles a conventional alloy-junction transistor

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Field-Effect Transistor as a

FIELD EFFECT transistors have a negative resistance characteristic at their gate.[1] In recent work on various geometrical configurations of field-effect transistors, a new form was developed, also with a negative resistance characteristic. Results of efforts to improve this characteristic have been disclosed.[2, 3]

Configuration of this field-effect transistor, Fig. 1, is similar to an alloy-junction transistor with a ring base electrode. The base material is n-type germanium, but the base width is much narrower than those of conventional transistors. Two electrodes, labeled gate and drain, Fig. 1A form the p-n junction with the base material. The third electrode, source, makes resistive contact with the base.

To operate the device successfully, the distance W_5 between the drain and gate must be larger than the channel width W_4. Channel width W_4 corresponds to the base width of a conventional alloy transistor.

Figure 1B shows a typical operating schematic. The drain is connected to ground, and the other two electrodes are biased negatively. Two batteries supply drain voltage V_d and gate voltage V_g. If gate voltage V_g is reduced to zero, two p-n junctions at the drain and the gate become biased in the forward direction and drain current I_d flows from the drain to the source through the channel. Similarly, gate current I_{g1} flows from the gate to the source.

Under operating conditions, however, gate voltage V_g is not zero, so the p-n junction at the gate is biased in the reverse direction. Current I_{g2}, instead of I_{g1}, Fig. 1B, will flow in the gate circuit. Increasing voltage V_g makes the space charge layer widen into the deeper interior of the channel. This increases the resistance of the channel region. Since an increase in the channel resistance results in a larger voltage drop at the channel, an increase in V_g will reduce the forward bias voltage of the drain p-n junction. Currents I_d and I_{g2} also decrease. When gate voltage V_g reaches a pinch-off voltage V_p, drain current I_d and gate current I_{g2} become zero. Therefore, a voltage-controlled negative-resistance characteristic appears at the gate circuit.

This field-effect transistor is not a unipolar transistor since minority carriers play an active role in its operation. Frequency characteristics can be considered the same as a conventional transistor.

The most important parameters are the pinch-off voltage V_p, maximum gate current I_g(max) and cut-off frequency f_c. Pinch-off voltage determines the voltage operating region of the device. It can be calculated by applying the resistivity of the base material and the channel width W_4

$$V_p = \frac{q\,(N_d - N_a)}{2k\epsilon_0} W_4^2 \qquad (1)$$

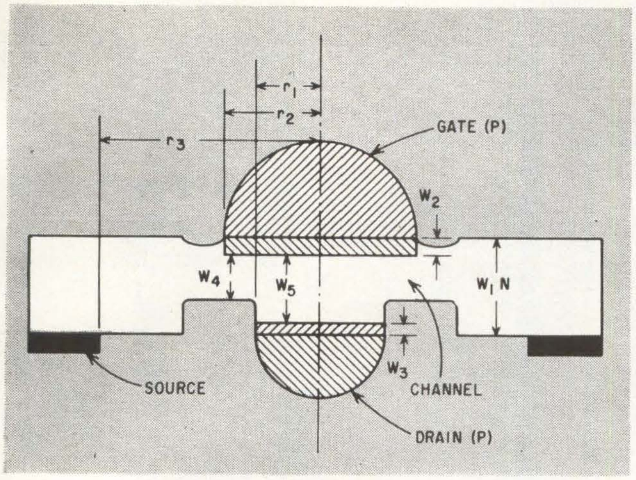
where $k\epsilon_0$ is the dielectric constant of germanium, q is the charge, N_d the donor density and N_a the acceptor density in the base material.

Equation 1 becomes Eq. 2 when type n germanium with a resistivity of 10 ohms cm at room temperature is used for the base material and the width W_4 of the channel is

SPECIFICATIONS OF TYPICAL FIELD-EFFECT TRANSISTOR

Pinch-off voltage	5 v
Width W_1	0.1 mm
Width W_4	0.007 mm
Width W_5	0.04 mm
Radius r_1	0.1 mm
Radius r_2	0.15 mm
Radius r_3	0.4 mm

Base material is type n germanium with resistivity of 10 ohms per cm at room temperature



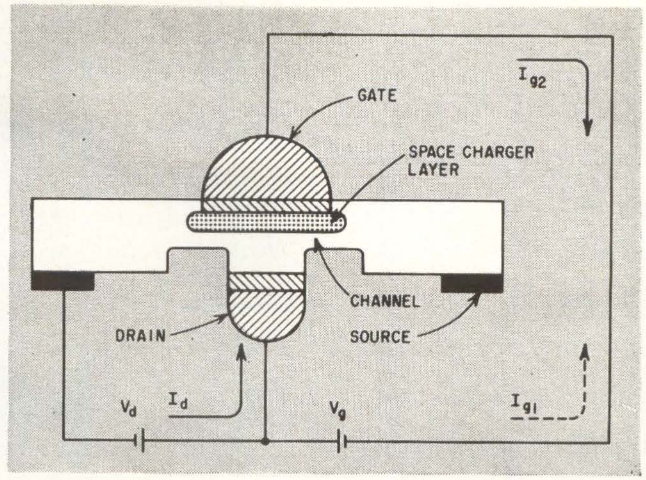


FIG. 1—Width of the channel is the most important dimension in determining the operating characteristics of the field-effect transistor (A) and how the space-charge layer affects the channel resistance (B)

Negative-Resistance Device

given in microns

$$V_p = 0.098\ W_4^2 \qquad (2)$$

Assume a channel width of 7 microns. Then voltage V_p will be 5 v. Best performance of the device was obtained using the type n germanium as base material. The requirements of good electrical characteristics with sufficient mechanical strength dictated the choice of this base material. Also to successfully form a channel using electrolytic etching, a type n germanium material is necessary.

Cutoff frequency f_c is about the same or slightly lower than that of an alloy transistor. Maximum gate current is about the same order as the saturation current of an alloy transistor operating with a grounded emitter. The accompanying table lists the physical parameters of this example. Figure 2 illustrates the static characteristic of a transistor with these dimensions at room temperature. From the curves, pinch-off voltage is 5 v for various values of drain voltage. Maximum gate current never rises above 4 ma.

In the fabrication of a field-effect transistor with negative resistance characteristics, the alloying processes are substantially the same as for conventional transistors except that alloying temperatures are about 600 C. This is necessary to obtain a wide recrystallized region W_2, Fig. 1A, to assure adequate mechanical strength.

Electrolytic etching equipment, Fig. 3, etches the channel to the proper width. Electrolyte is 10 percent potassium hydroxide. The cathode is a platinum plate and the anode is the germanium wafer being etched. Variable resistance R_1 adjusts drain current which is read by ammeter MA_2. Gate voltage is set by variable resistance R_2. Ammeter MA_1 reads electrolytic current.

In etching, a gate voltage equal to the desired pinch-off voltage is applied. The drain current decreases during etching. The gate voltage must be held constant. When the drain current reaches zero, the channel for the pinch-off voltage has been formed.

Pinch-off voltage can be set at will, and the on-off ratio of the gate current is 1,000 or more.

REFERENCES

(1) G. C. Dacey, I. M. Ross, *Proc IRE*, 41, 8, p 970.
(2) T. Hayashi, *The Journal of the Institute of Electrical Communication Engineers of Japan*, 43, 3, p 298, (1960).
(3) T. Niimi, T. Hayashi, Y. Sunohara, *The Journal of the Institute of Electrical Communication Engineers of Japan*, 44, 5, p 811, (1961).

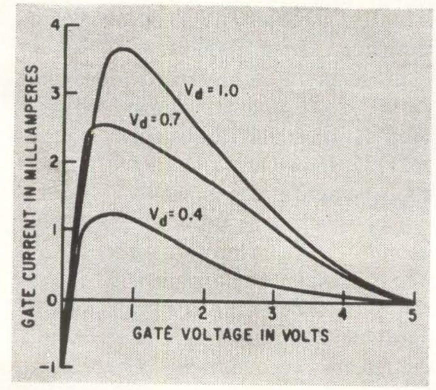


FIG. 2—Current-voltage characteristic of the gate circuit for various values of drain voltage

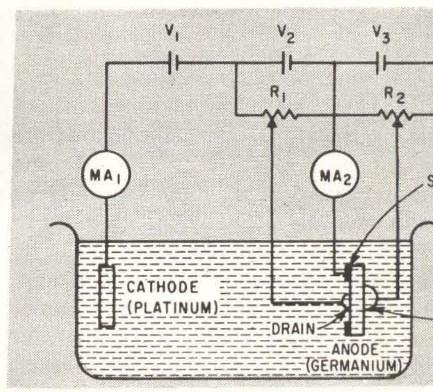
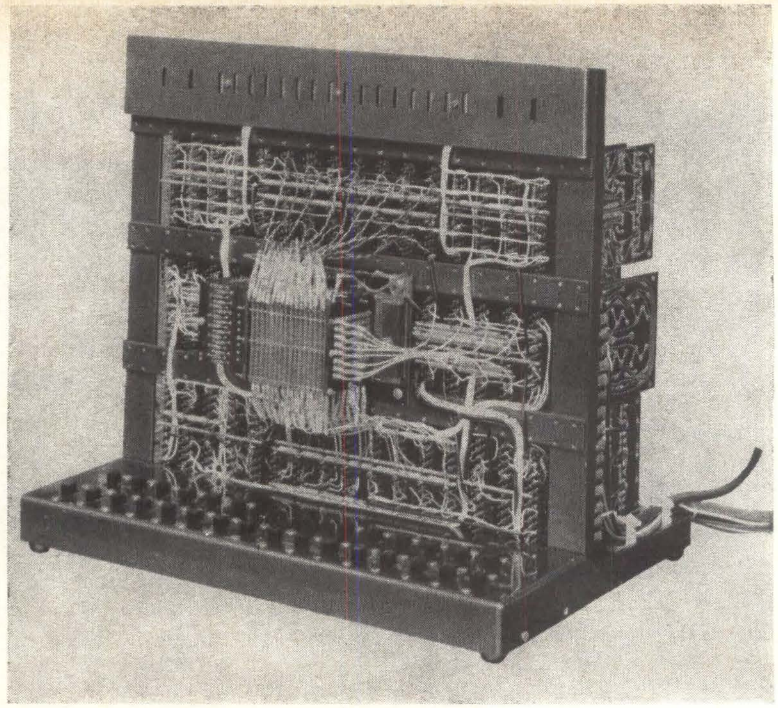


FIG. 3—Connection of electrolytic etching equipment for formation of the channel

Practical high-speed memories can be achieved using cylindrical elements that make effective use of thin magnetic films and permit memory organization that reduces crosstalk. Large outputs are provided that reduce other system requirements and semiautomatic fabrication can be used



First destructive-readout, word organized memory using magnetic rods has been operating continuously for more than two years

Magnetic-Film Rods Provide

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Hawthorne, Calif.

HIGH-SPEED MEMORIES have been proved practical using cylindrical thin magnetic film elements. The rods permit effective use of thin magnetic film properties and a three-dimensional memory organization that limits crosstalk. The memory elements provide outputs that reduce requirements for noise cancellation and gain-bandwidth of sense amplifiers. The small size of the rod elements limits line inductances and propagation delays in high-speed memory systems.

Higher operating speed is a continuing goal of many designers of digital systems, and component designers are striving to provide faster memory elements to satisfy this desire. New elements having high speeds are announced almost every week, many of which look promising. However, these elements are often described only by switching speeds and have not been thoroughly analyzed to determine their suitability for use in high-speed memories. A memory element capable of 1-nsec switching may not be practical for use in computers.

To evaluate a memory element realistically for its ultimate application, many factors must be considered. It should be reproducible and capable of providing long life. The environment required for its operation must be considered, and the device must be compatible with other components and practical for system applications. Physical and electrical characteristics of the element as well as its cost must be considered, and it must comply with requirements of the firm using it. Finally, it must do the job better than any other element.

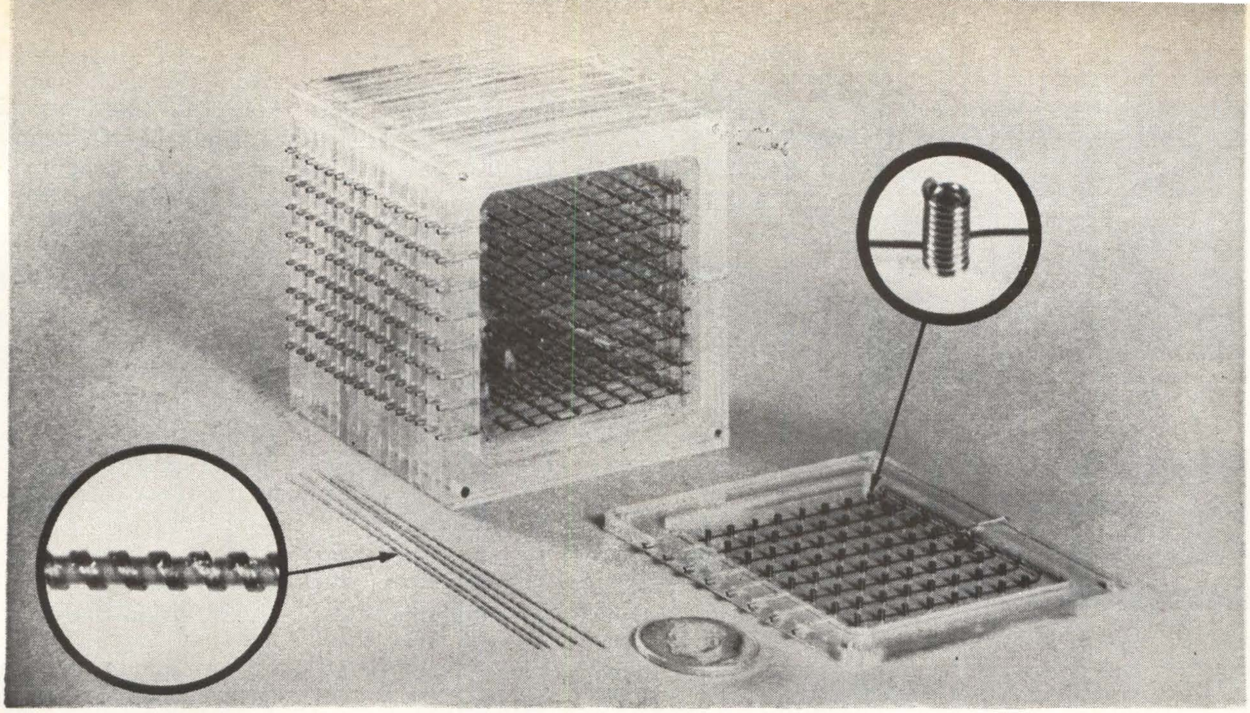
If a memory element does not fulfill even one of these requirements, it sometimes must be rejected. However, even if all these requirements are satisfied, it cannot be assumed that a new memory element will function adequately when used in large numbers in systems. Although no attempt will be made to rate the magnetic rod element in accordance with these criteria, presentation of these considerations indicates some of the tests to which a new element may be subjected before acceptance.

The rod element[1] comprises a cylindrical thin magnetic film electrodeposited over a conductive substrate, as shown in Fig. 1A. Silvered-glass rod and a BeCu wire have proved satisfactory.

The magnetic material is 97 percent Fe and 3 percent Ni and thickness is about 4,000 Angstroms. The hysteresis loop is square, which is required in remnant flux storage applications to provide good signal-to-noise ratio and a threshold for which no switching occurs. The material is also relatively insensitive to variations in ambient temperature, as shown in Fig. 2.

The cylindrical shape of the element reduces some of the problems of thin magnetic films. It permits tight coupling between windings and magnetic material, producing typically 30 to 40 mv per turn, and it facilitates multiple-turn windings that provide large uniform switching fields with reasonable currents. The small diameter solenoids also limit winding inductances.

The rod is a continuous magnetic medium, and a single bit is designated by the location of the solenoid



Coaxial winding is shown enlarged on rod of partly assembled memory module, while word windings, like the one also enlarged, are prefabricated on solenoid and rods inserted later

High-Speed Memory

winding along its length. Solenoid length and the space between adjacent solenoids determine linear bit density of the rod, which should be as high as possible to limit propagation delays.[2, 3] A 10-mil diameter rod that stores 10 bits per linear inch is typical. Each bit usually has switching characteristics like those in Fig. 3, where τ_s is switching time, μV_1 is undisturbed ONE, dV_1 is disturbed ONE, and dV_z is disturbed zero output voltage.

The axial-switching mode results in an open flux path element in which the return path for the magnetic flux leaves the magnetic film at one end of the solenoid and returns through the air to the other end. With this arrangement, the element is sensitive to stray magnetic fields, and the demagnetizing field produced by the discontinuity limits minimum physical length. Both effects can be limited by using a magnetic material for the mem-

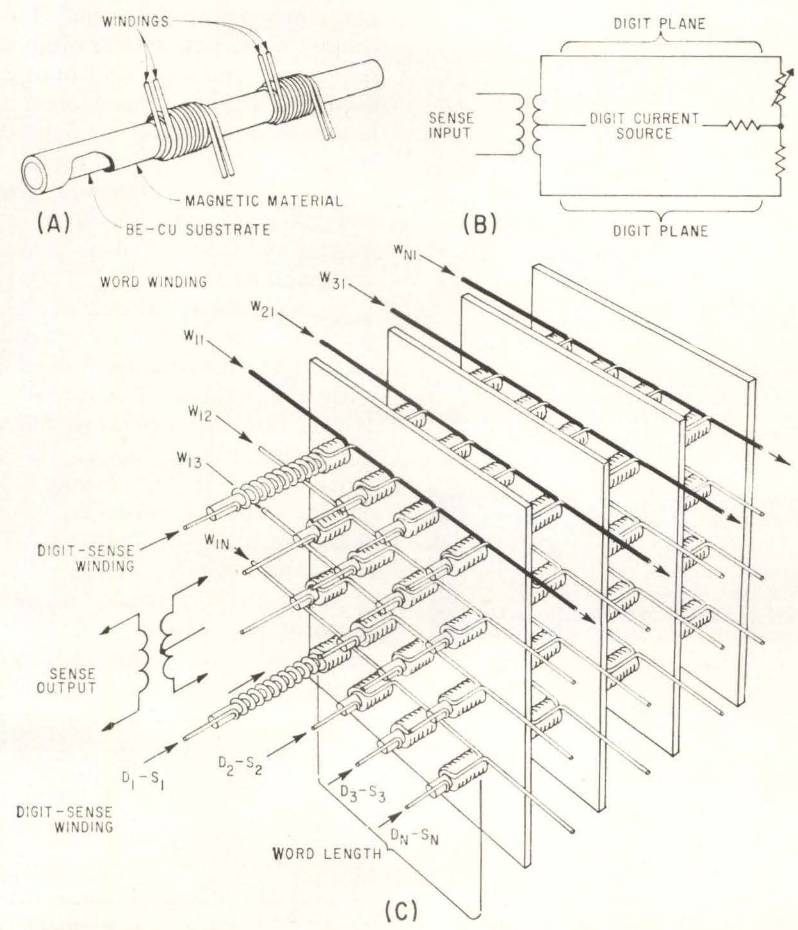


FIG. 1—Rod structure with solenoid windings is shown at (A), shared sense-digit winding bridge at (B) and memory organization at (C)

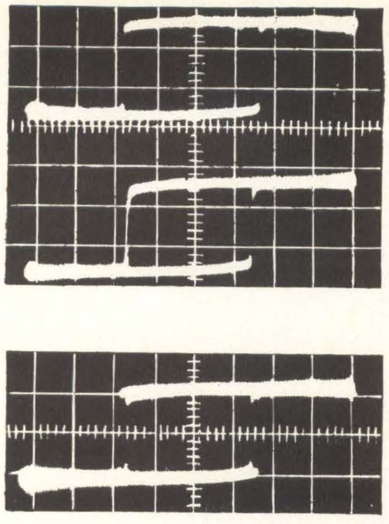


FIG. 2—Top photo shows rod B-H loop at 75 C in upper trace and at 125 C in lower trace. Two traces are superimposed in lower photo

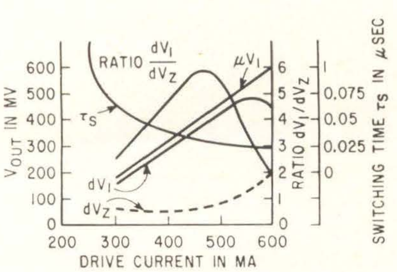


FIG. 3—Switching characteristics for typical rod element

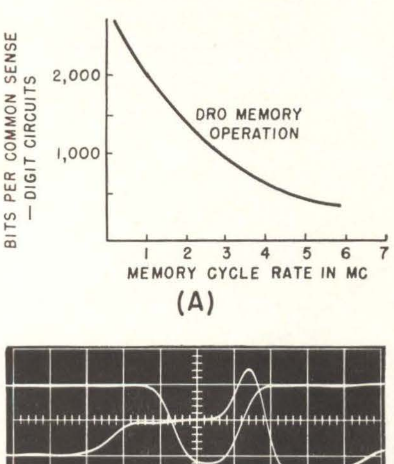


FIG. 4—Number of bits that can share sense-digit circuits is shown at (A) for various cycle rates. Word access time for 5-Mc memory is shown at (B) with sense amplifier output on upper trace and word line voltage on lower trace. Large horizontal divisions are 0.02 nsec and large vertical divisions are 2 volts

ory elements having higher coercivity.

The large coercive force of the rod material (15 oersteds) makes special shielding from stray magnetic fields unnecessary and contributes to the nanosecond switching time because of the large excessive fields that can be used. Although the large coercivity requires a large switching field, it can be provided by the small multiple-turn solenoids with reasonable currents.

In a tightly coupled memory module, crosstalk, noise and recovery transients can arise from many sources. Capacitive coupling must be uniform and balanced, and inductive coupling must be limited. Machine winding techniques have been developed that provide sufficiently uniform windings, and the rod element facilitates a three-dimensional memory organization with orthogonal winding that minimizes crosstalk. Typical packing density of present rod modules is 1,000 bits per cubic inch, and an increase to 4,000 bits per cubic inch is planned for the near future.

A two-winding word-organized memory is shown in Fig. 1B and C, and a memory module ready for assembly is shown photographically. A shared sense-digit winding is used in a bridge arrangement that has proved effective in high-speed operation. The word windings are prefabricated on solenoid planes and the rods inserted later. Both coaxial and solenoid plane windings are machine wound.

Significance of the rod element is its use in destructive readout (DRO), word-organized memories with cycle rates of 1 to 10 Mc. (Cycle rate includes word-addressing time and read-restore or clear-write time.) In any memory, economics requires that many bits share sense and digit circuits. However, fewer bits can share circuits as cycle rate increases, more because of propagation and recovery effects than switching time of individual elements. This limit to sharing is generally true of any high-speed DRO memory. Bit-sharing capability at different cycle rates is shown in Fig. 4A. For a balanced 1,000-bit sense winding, propagation time can be reduced to 0.04 nsec per bit for a delay time of about 20 nsec.

The first DRO word-organized memory[2] using the magnetic rod and shown in the photograph has been operating continuously for more than two years with no degradation in operating characteristics noted. It has 64 words of 16 bits per word and a design cycle rate of 1 Mc, although it was bench-tested at a 2-Mc rate. Required word driver current is 260 ma, digit current is 260 ma, and read d-c bias is 130 ma. Sense-winding output voltage produced across 50 ohms by a word-current with a 0.1 μsec rise time is 125 mv.

Maximum potential speed of thin-film rod DRO memories using the many new and more promising high-speed semiconductor components now available is being studied. Present design effort centers around a 128-word, 8-bit-per-word memory with a 5-Mc cycle rate. Using a rod with slightly lower coercivity has reduced switching current requirements sufficiently to make practical a 5-Mc rate using single-transistor drivers.

The time between the voltage change on a selected word line and sense-amplifier output is about 50 nsec, as shown in Fig. 4B. This time includes driver current rise time, time for the rod to switch to the same amplifier voltage threshold, and propagation and delay time of the sense line and sense amplifier. Sense amplifier gain-bandwidth is about 3×10^9 cycles.

This work demonstrates that the rod element is practical for high-speed memories. Driver-current requirements are reduced, making megacycle repetition rates practical for semiconductor components. In addition, the rod element permits continuous fabrication and testing and the use of automated windings.

The author acknowledges the assistance of A. J. Kolk, I. Richman, R. Clinehens, E. Ostroot, R. Winfeld, L. Douglas and the many others who contributed to the program.

REFERENCES

(1) D. A. Meier, Millimicrosecond Magnetic Gating and Storage Element, *Jour App Phys*, **30**, p 122, Jan. 1959.

(2) D. A. Meier, Magnetic Rod Memory, *Proc* 1960 *Electronic Components Conf*, p 122, May 1960.

(3) D. A. Meier and A. J. Kolk, The Magnetic Rod—A Cylindrical Thin Film Memory Element, *Symposium on Large Capacity Memory Techniques for Computing Systems*, May 1961, sponsored by Information Systems Branch, Office of Naval Research, to be published by MacMillan Co.

CALCULATING

Potentiometer Errors

Nomographs speed calculation of potentiometer errors caused by resistance loading and by contact and equivalent-noise resistance of wiper circuit

By HENRY S. ZABLOCKI
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POTENTIOMETER requirements usually dictate linearity, noise and other specifications. Sometimes overlooked are a number of additional potentiometer errors that can result from the installation itself. These errors include general mechanical errors resulting from mounting and coupling, that is, angular displacement and misalignment, and electrical errors that occur when a finite load impedance is present in the wiper circuit.

The presence of a finite impedance in the wiper circuit of any potentiometer, linear or nonlinear, influences the output voltage so that it differs from its no-load value. Consider the total error to consist of loading error, fixed contact resistance error and equivalent noise resistance error.

Loading error is due to the internal resistance of the potentiometer. The equivalent-Thevenin-theorem internal resistance is the resistance (excluding contact resistance) between the potentiometer wiper and ground or reference point, with all battery supply points shorted. The internal resistance and resistance in the wiper circuit form a voltage divider that causes the output voltage to be less than the open-circuit voltage at the wiper point. The loading error varies from point to point.

$$D_L = \frac{S^2(1-S)}{L + S(1-S)}$$

where D_L = loading error (expressed as voltage ratio), S = wiper position in fractional resistance at the wiper point, and

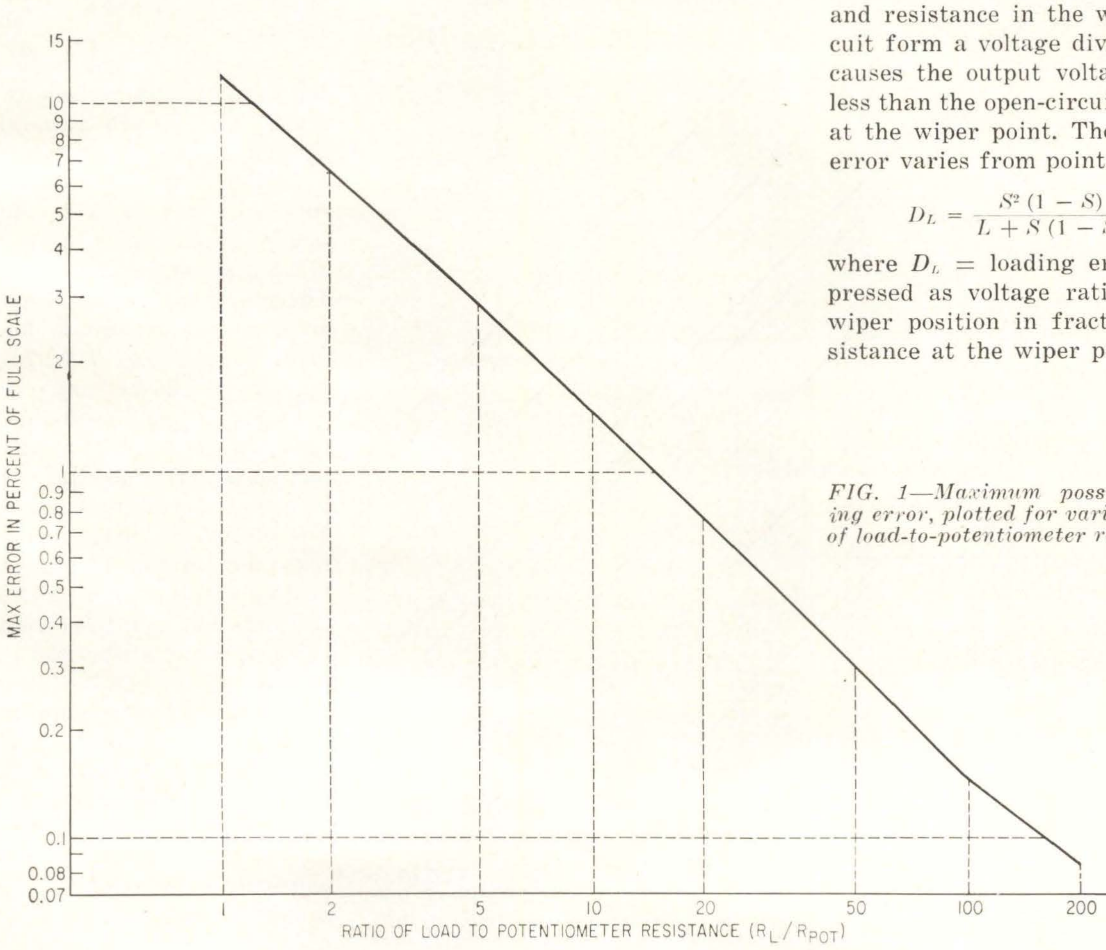


FIG. 1—Maximum possible loading error, plotted for various ratios of load-to-potentiometer resistances

L = the ratio of load resistance to potentiometer track resistance (load ratio).

The maximum loading error occurs at approximately 67 percent of the total resistance (66.7 for $L \rightarrow \infty$; 68.9 percent for $L = 1$.) Figure 1 presents this maximum error effect as a function of the load ratio (L). The loading error can be compensated for during manufacture of the potentiometer by tailoring the resistance element to take into account the droop in output caused by load resistance.

The presence of actual or apparent contact resistance in the wiper circuit results in a voltage dividing action between it and the load. Thus, if a potentiometer is compensated for loading error only, an error could still occur because of voltage drop in the contact resistance. This error is a fixed percentage of the output voltage and can be compensated for by adjustment of system gain. The magnitude of this error can be determined from Fig. 2

$$D_c = \frac{NR_c}{R_c + R_L}$$

where: D_c = error in voltage ratio due to contact resistance; N = nominal voltage ratio at the wiper point under load if no contact resistance were present (expressed as a fraction of applied voltage); R_c = apparent contact resistance in ohms; and R_L = load resistance in ohms.

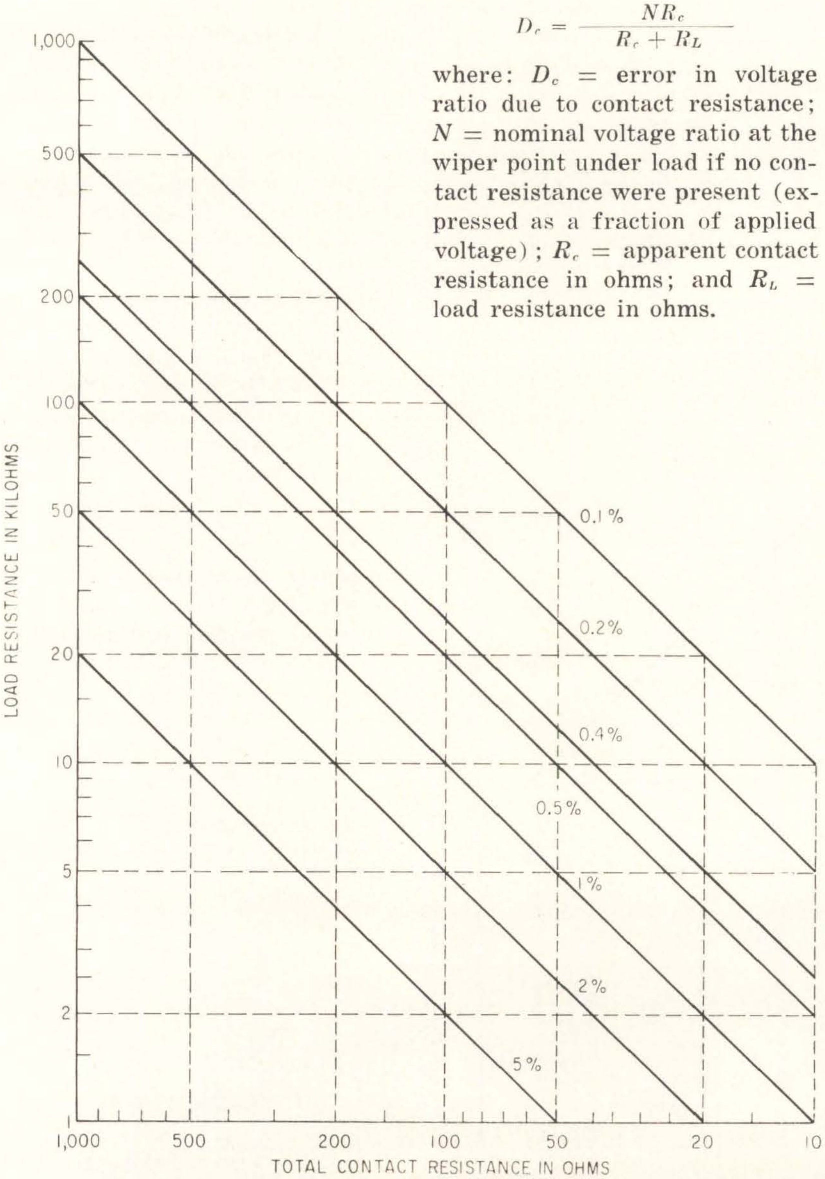


FIG. 2—Error resulting from contact or equivalent-noise resistance and load resistance, expressed in percent of nominal full-scale output voltage

A wiper circuit also has an equivalent resistance that varies with wiper position. This equivalent noise resistance also forms a voltage divider with the load resistance, and causes the output voltage to differ from the ideal. The magnitude of this error is also determined from Fig. 2

$$D_N = \frac{NR_n}{R_n + R_L}$$

where D_N = error in voltage ratio due to equivalent noise resistance and R_n = noise resistance. With conductive plastic potentiometers, repeatable noise caused by definite variations in apparent contact resistance can be compensated during manufacture.

Consider a potentiometer with these parameters: track resistance is 10,000 ohms; contact resistance is 200 ohms; equivalent noise resistance is 100 ohms; and load resistance R_L is 50,000 ohms. Thus, $L = 50{,}000/10{,}000 = 5$.

From Fig. 1, maximum loading error is 2.9 percent of full scale. This occurs at about 67 percent of full output voltage.

In Fig. 2 the 50,000-ohm load resistance and the 200-ohm contact resistance lines intersect at a full-scale error of 0.4 percent. Therefore, the contact resistance error at the maximum loading error point is $0.67 \times 0.97 \times 0.4$ percent = 0.26 percent.

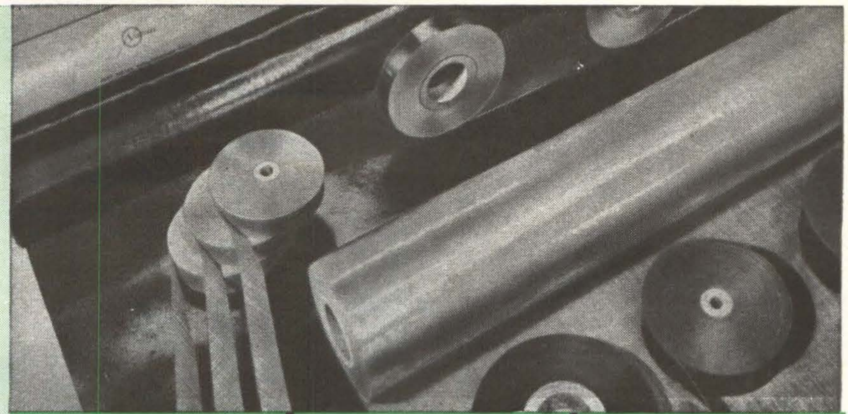
In Fig. 2, the 50,000-ohm load resistance and the 100-ohm contact resistance lines intersect at a full-scale error of 0.2 percent. Therefore, the equivalent noise resistance error at maximum loading error point is 0.67×0.2 percent $\times 0.97$ = 0.13 percent.

Thus, the total error at the 67 percent point that is caused by wiper circuit impedance is (in percent):

$$2.9 + 0.26 + 0.13 = 3.2$$

Note that this analysis must be applied to each section of the resistance network in a potentiometer that generates nonmonotonic functions.

3 New NATVAR Special-Purpose INSULATIONS



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Unmatched for variety and completeness, the Mallory line of tantalum capacitors includes wet slug, solid electrolyte, miniature, microminiature, and high temperature (to 200°C.) types. For our latest literature, or to arrange a consultation, write Mallory Capacitor Company, Indianapolis 6, Indiana.

Type	Mallory Designation	Temp. Range	Case Style
PLAIN FOIL	Type TAF	−55°C to 85°C	CL34, CL35
	Type TAG	−55°C to 125°C	CL30, CL31
			CL32, CL33
ETCHED FOIL	Type TBF	−55°C to 85°C	CL24, CL25
	Type TBG	−55°C to 125°C	CL20, CL21
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Supplied in all military case styles and all ratings.

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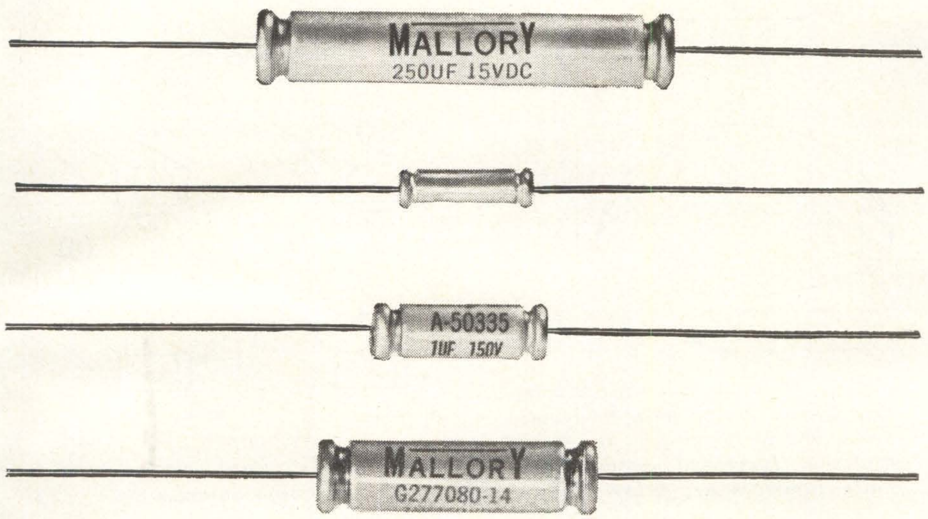

better than MIL specs!

	MIL-C-3965B Limits	Typical Test Values: Mallory Type TAF (160 mfd 15 VDC)
After 2000 hour life test at 85°C:		
Leakage Current	48 μa	0.4 μa
Change in Capacity	±25%	−5%
Power Factor	19.5%	3.8%
25°C:		
Leakage Current	48 μa	0.2 μa
Power Factor	15%	4.5%
−55°C:		
Change in Capacity	−35%	−12%
Impedance	14.0 ohms	7.0 ohms
85°C:		
Leakage Current	240 μa	6.5 μa
Change in Capacity	−0 +15%	+4.8%
Power Factor	15%	4.5%

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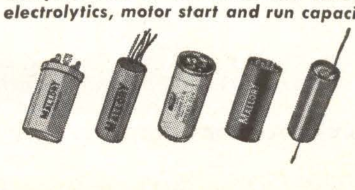

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Millimeter Waves Are Generated With Ferrites

HARMONIC generation using ferromagnetic resonance has produced 60 watts output at 70 Gc and comparable output is expected at 140 Gc. Carefully engineered apparatus and growth of a low-loss single crystal with planar anisotropy promise further improvements. The work was done at the Defense Research Telecommunications Establishment, Electronics Laboratory, Ottawa, and described in a paper by G. W. Williams and A. W. Smith at the Canadian Electronics Conference.

A free electron in a magnet field precesses about the direction of the field at a frequency equal to the product of the field and the ratio of magnetic moment to angular momentum. This ratio is 2.8 Mc per oersted so resonant frequency is in the X band with a 3,600-oersted field. Resonance can be driven by a microwave field circularly polarized in a plane perpendicular to the d-c field. Individual electron spins in the ferromagnet in Fig. 1 are aligned by exchange interaction, producting domains of magnetization. An external field simply aligns the domains. The sample can be represented by a magnetization vector that is the sum of the spins, with resonance determined by the whole sample.

If the sample is driven by a circularly polarized magnetic field, the vector precesses about the magnetic field direction. Resonant frequency is determined by the internal magnetic field and the angle by sample loss (line width). With the linearly polarized field in Fig. 2, the vector relaxes toward the d-c field direction, and the path of the vector on the sphere containing it becomes an ellipse instead of a circle.

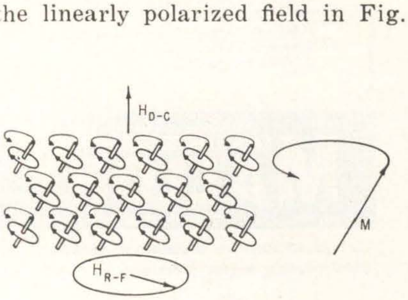

FIG. 1—External field aligns domains in ferromagnet and magnetization vector represents entire sample

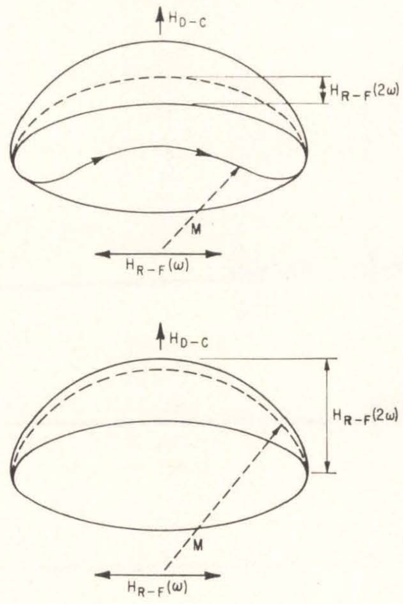

FIG. 2—Linearly polarized driving field causes vector path to deviate from circle to ellipse in upper drawing. Increased amplitude finally produces arc below

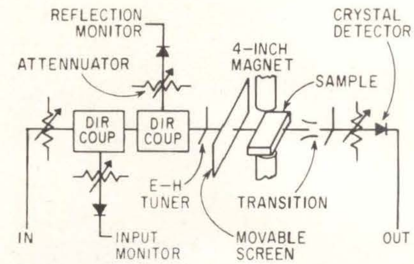

FIG. 4—Mounting positions used fed by magnetron to test samples

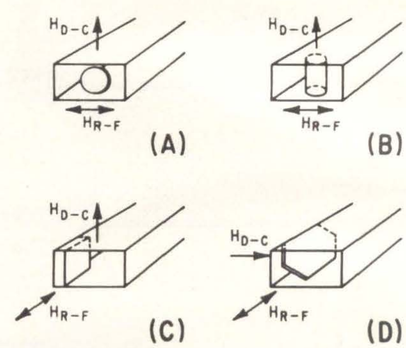

FIG. 3—Microwave circuit was for different type samples

A second harmonic in the path provides second harmonic power with amplitude proportional to the square of driving field amplitude. In the limiting case of completely damped motion, the vector is just driven in an arc. The second harmonic component is maximum but most input power is consumed in sample loss and conversion efficiency is low.

Sample shape also causes the magnetization vector to deviate from a circular path. In a disk magnetized in the plane, precessing the magnetization out of the plane generates an internal demagnetizing field that opposes vector motion, forcing it into an elliptic path. This approach promises good conversion efficiency since it does not depend on sample loss but limits sample volume because the disk must be thin.

Most ferrites have a cubic structure with an anisotropy field below 50 gauss, but hexagonal ferrites may have fields of tens of kilogauss. If the anisotropy coefficient is positive, the crystal has an easy axis of magnetization. By applying an external field at an angle to the axis, the magnetization has an equilibrium position between the two directions that can enhance harmonic generation as in a thin disk. If the anisotropy constant is negative, the crystal has an easy plane of magnetization. Applying the field in this plane confines the vector to the plane, producing a large second harmonic.

With either type of anisotropy, low loss materials can be used and volume is not limited. Also with high anisotropy materials, the field is added to the internal field resulting from the external applied field. Thus requirements on the magnet at high frequencies are reduced.

The waveguide test section is a tapered transition from input to harmonic frequency guide. The out-

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For a complete discussion of constant-current power supplies with ratings up to 1A, ask for Specification Sheet 3072B. It lists all the models and specifications, too.

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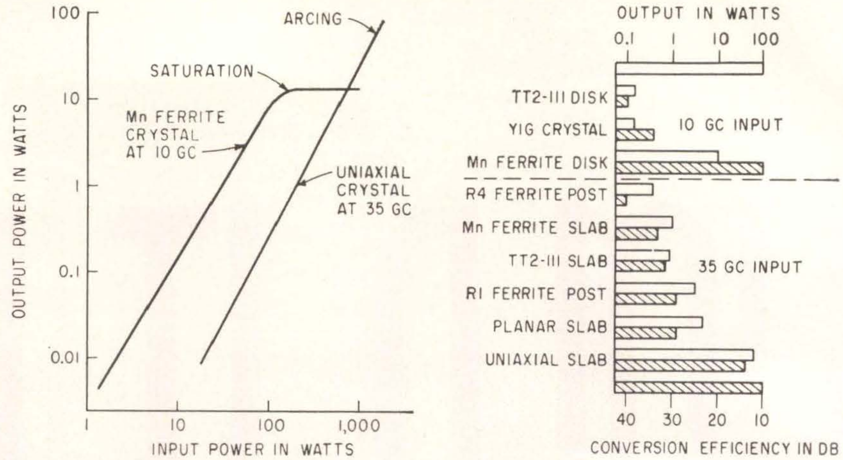


FIG. 5—Harmonic power of two best samples is shown at left, while output and conversion efficiency for all samples is shown at right

put guide is rotated 90 degrees because the second harmonic is generated orthogonally to the driving field. The taper acts as a short, reflecting fundamental power back toward the sample. The sample is mounted an even or odd number of quarter wavelengths from the short, depending on the drive field required. A movable screen of wires parallel to the broad face matches the sample to the transition. It passes fundamental power and reflects the second harmonic.

A magnetron provides 1-usec pulses at 50 Kw peak power. Variable repetition rate is generally set at 50 pps to avoid heating effects. A directional coupler and attenuator in Fig. 3 monitor power incident on the test section. Another coupler samples reflected power and is used to adjust the E-H tuner and the magnetic field to sample resonance.

Mounting Ferrite Samples

The mounting positions of samples are shown in Fig. 4. The disk (A) is mounted across the guide with the d-c field in the plane. The post (B) is centered in the guide with the field along the cylindrical axis. The slab (C) is mounted on the narrow wall. The slab (D) is at 45 degrees to the narrow wall. It was used for a uniaxial crystal since the field had to be inclined 45 degrees from the perpendicular to the crystal plane.

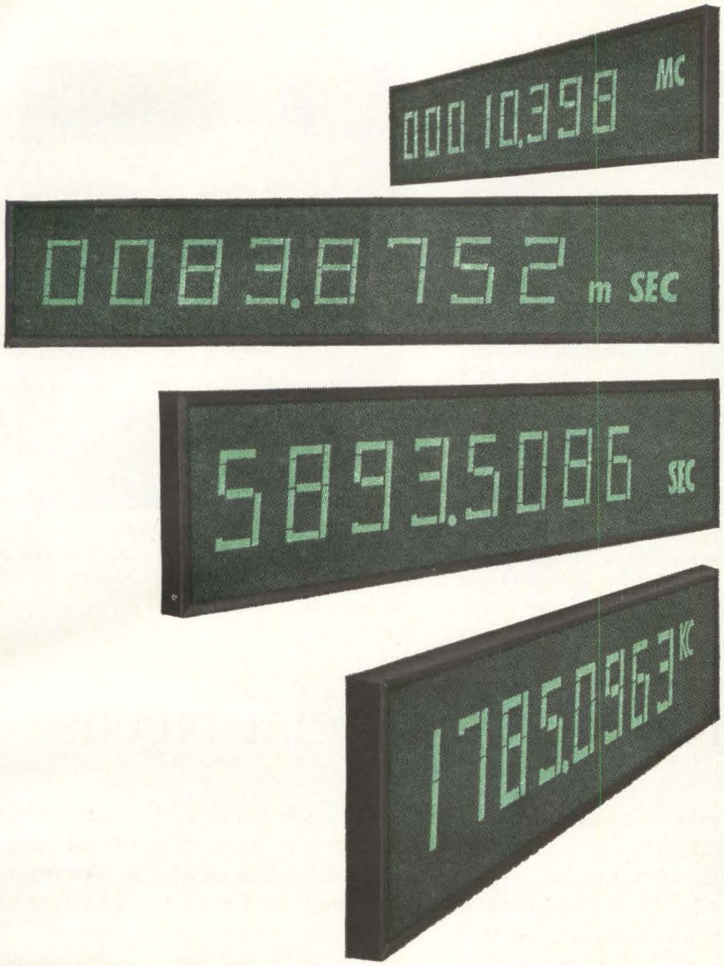
Variations in second harmonic with input power are shown in Fig. 5 for the two best samples. Saturation in low-loss samples of a manganese ferrite disk occurred in the X band. This single crystal with resonance line width of 25 gauss saturates at 100 watts. All samples followed a square law below saturation and best conversion efficiency was −10 db.

At 35 Gc input, the uniaxial crystal slab had wide line width. Power input was limited at nearly 2 Kw only by arcing. Conversion efficiency was −14 db and maximum power output was 60 watts.

Sample Performance

Sample TT2-111 in Fig. 5, a ceramic nickel-zinc ferrite for K-band isolators, is fairly lossy. The YIG crystal, grown at the laboratory, was left as a raw crystal to raise saturation level. Samples R1 and R4 (Ferramic), ceramic magnesium manganese ferrite, are quite lossy. The planar ferrite is an oriented ferrite but was too lossy to provide the expected performance of a planar ferrite.

The single crystal hexagonal ferrite, probably barium ferrite was obtained from A. O. Smith Corp. It has an anisotropy field of 14 kilogauss, which would give zero field resonance at 51 Gc. It was operated at a resonance at 3,500 gauss, where domain structure must be retained. Harmonic output was enhanced by the test position, but existence of domain structure makes an explanation of the high efficiency difficult. This crystal will be operated at a high enough field to saturate it, Gc. It is expected to deliver quite useful power at a frequency of 140 Gc.



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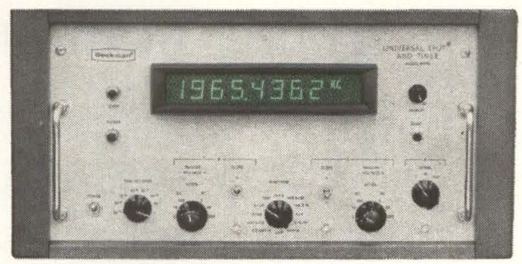

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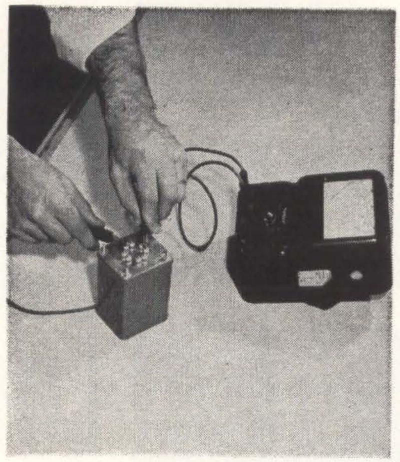
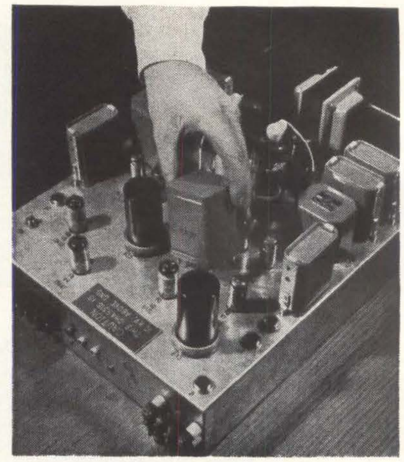


Transformer manufacturer builds, and tests custom-type transformer to meet required parameters. Standard parts are used for cores and cases



Special unit is ready for circuit within three weeks. Mechanical design integrates electrical requirements, relates volt-amperes to case size

Specifying Transformers for Special Needs

By R. QUIMBY
E. PODSIADLO
Raytheon Company, Microwave and Power Tube Division, Magnetics Operations, Waltham, Mass.

WHILE IT IS POSSIBLE to quickly and economically obtain reliable standard components such as tubes, resistors and capacitors, the range of electrical requirements for transformers is so great that only representative types are usually listed in manufacturers catalogs. And this often creates a specification problem for equipment design engineers who seek special transformers.

The fact that standard electronic components are fixed mechanically simplifies the problem of chassis layout, size and weight estimating, and manufacturing for both the component supplied and the equipment manufacturer. The military recognized the advantage of standard case sizes for cased, hermetically-sealed transformers when it specified standard Mil Cases in the replacement of Jan T-27 with the now well-known MIL-T-27A specification some years ago.

Raytheon's standardization program is currently confined to 60 and 400 cycle power transformers, but will include other transformer types such as audio, pulse, signalling transformers, etc. Development of a line of minimum weight, premium grade aircraft transformers to meet all military requirements using wound cores and encapsulated for full moisture protection is presently underway. Each basic line of standard sizes will include cased-hermetic designs, encapsulated core and coils, and open varnish-treated core and coils. The first two are designed to meet Mil-T-27A grade 4 or 5 and temperature classes R and S. A more limited line of silicone encapsulated units are available for Class T requirements and cased-hermetic designs in the Class U range for a maximum temperature of 325 C.

It is possible to anticipate possible combinations of electrical characteristics required by the equipment designer in advance, and to design prior to receiving an inquiry. This technique also enables the manufacturer to prepare data from which the user can determine the size of component that meets his requirements.

The user selects the style of transformer he needs based on environmental conditions and then calculates the total load in volt amperes (LI^2 for inductors). Derating factors for voltage, frequency, and number of load circuits are then applied to this figure to determine the power output under a particular set of electrical requirements. A graph is consulted which shows power output and regulation for various package sizes and values.

The following example illustrates the method for specifying transformers:

A class R, cased, hermetically-sealed transformer is to be specified with the electrical requirements shown in Fig. 1. Ambient temperature is 65 C, allowable time rise is 40 C, and regulation is 4 per cent. The total *va* output is calculated,

S_1 = 100 va, S_2 = 100 va for a total of 200 va.

Electrical requirements complicated by lower frequency, voltage input taps, high test voltages and rectifier loads are adjusted by

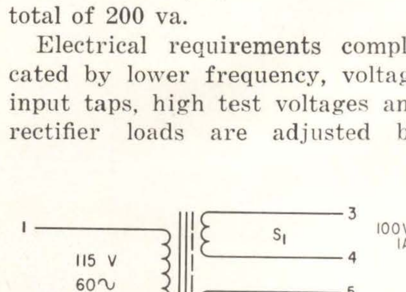


FIG. 1—Electrical requirements of transformer in example

Compact chassis of Osborne 300 CBT Citizens Band Transceiver.
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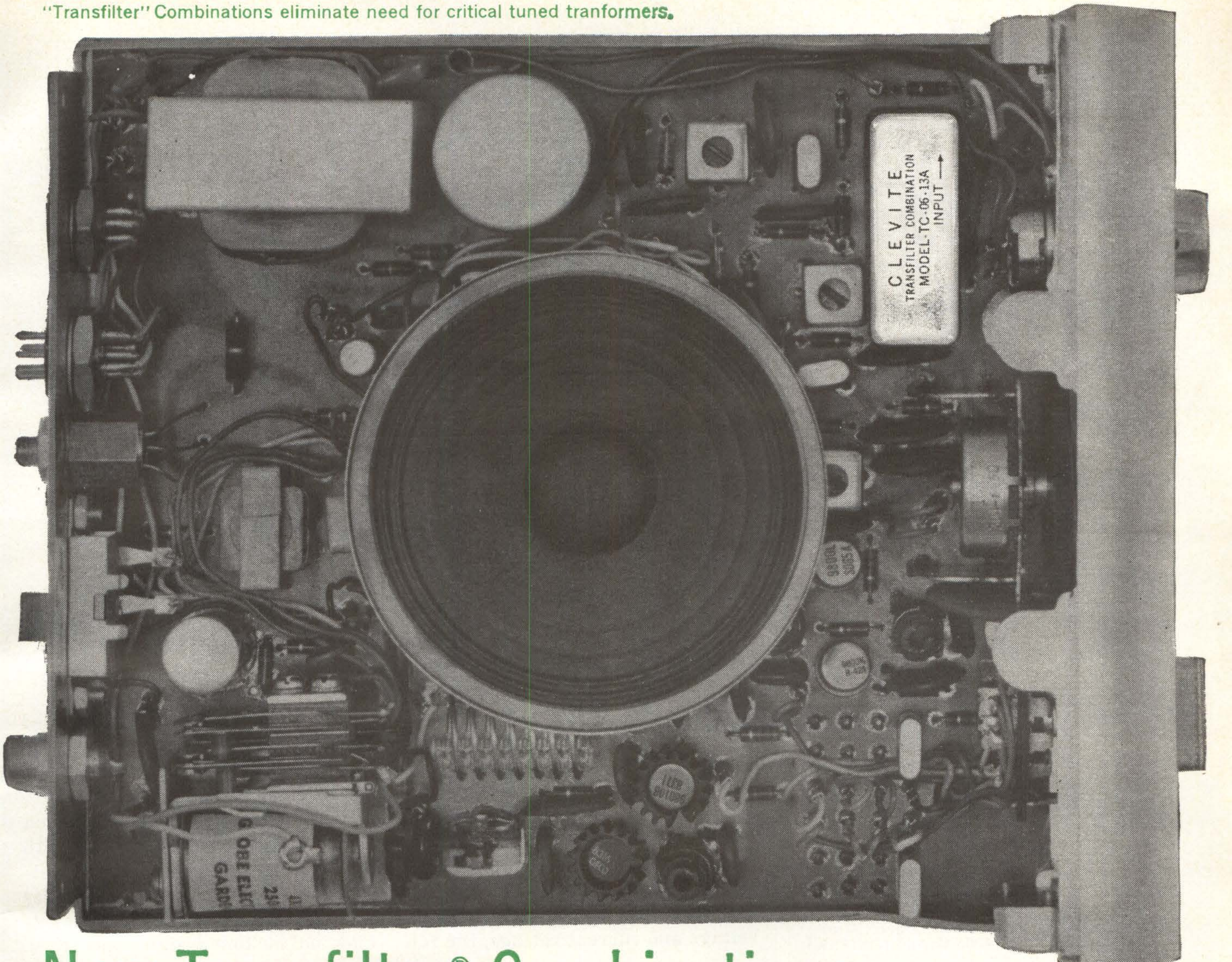

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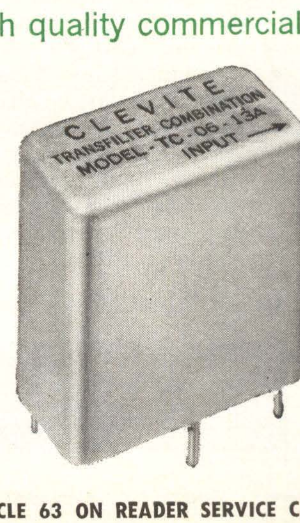

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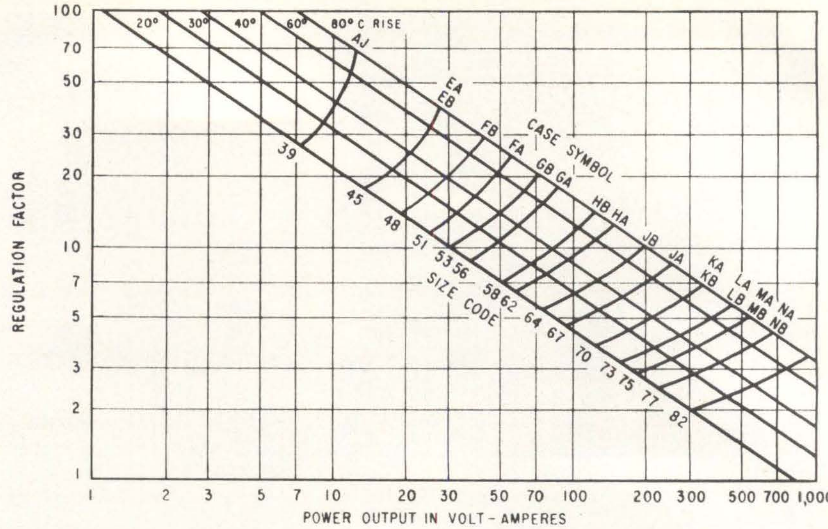


FIG. 2—Basic power curve used in selecting transformer size

simple conversion methods to *va* values which can be applied to the basic power curve.

The size of the unit is selected from the basic power curve in Fig. 2.

Note that the LB case must be used to get 4 per cent regulation. Temperature rise will be only 30 C. The KB case could be used if regulation requirement is relaxed to 5 per cent. Assume that the KB case is selected.

The terminals are selected from chart in Fig. 3. Using operating voltage and current ratings, the following selections are made:

Terminal Numbers	Selections Made
1 & 2	P1
3 & 4	P1
5 & 6	P2

The terminal areas are checked from the chart. If it is desired to have terminals in the center area of the case, KA must be used.

This concept of standardization integrates mechanical design with electrical output by relating volt-amperes to case size, and ensures most of the advantages of both catalog and custom design approaches.

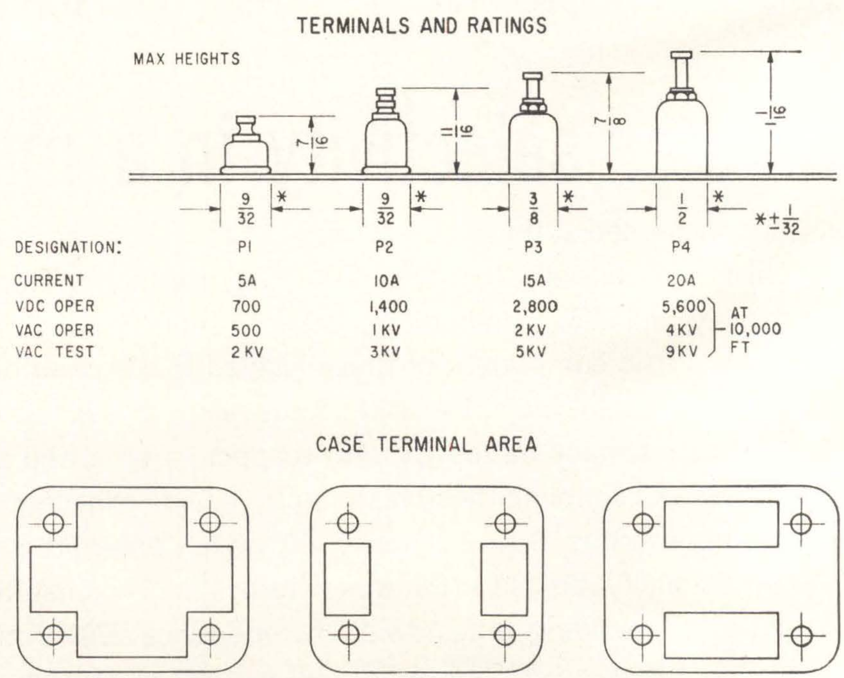
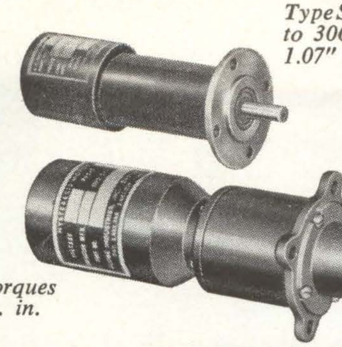


FIG. 3—Terminals and terminal layout guide



Type SC torques to 300 oz. in. 1.07" dia.

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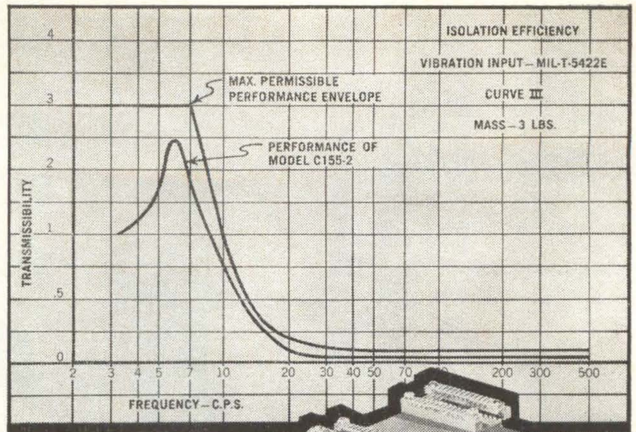

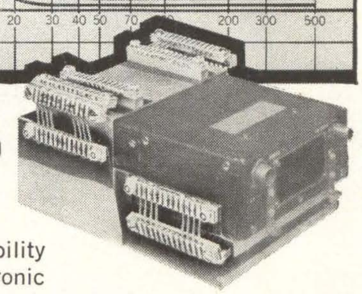

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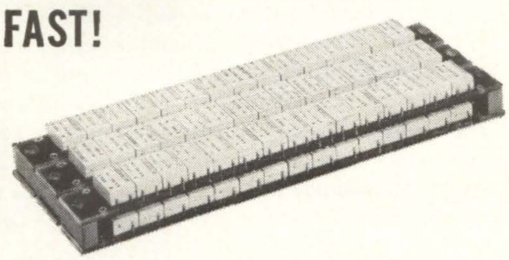

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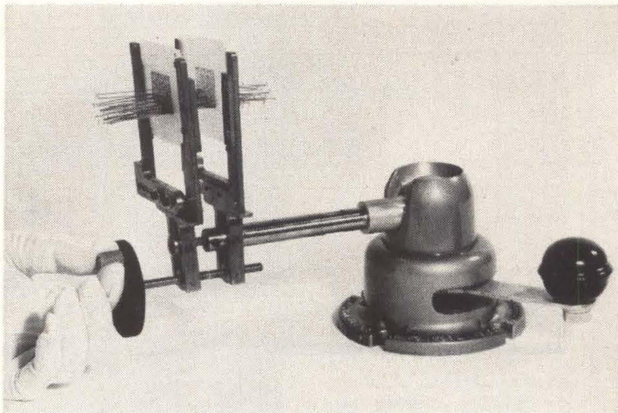
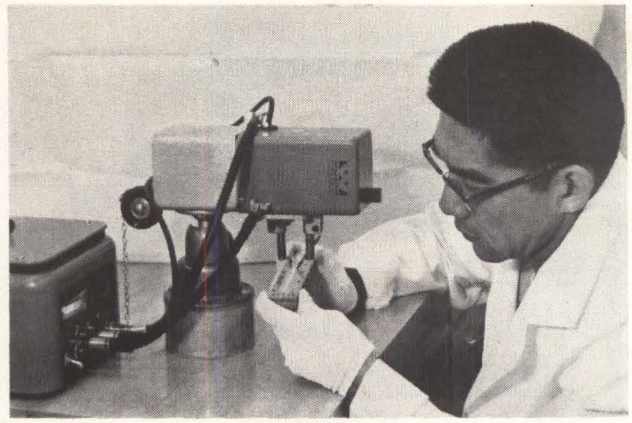


Butterfly assembly fixture is one of many special fixtures that can be designed to improve welds



Special fixture has been designed for holding connecting pins during the welding operation

Production Methods for Welded Circuits

By LLOYD ARMSTRONG
Space Technology Labs.,
Los Angeles, Calif.

FABRICATION methods and practices, equipment and personnel selection, and inspection and quality control procedures have been investigated at STL as part of a study of welded modules. The information developed has proved useful in the Titan and Minuteman programs and can be applied to commercial and industrial electronics production.

For prototype and pilot production, each welding station is supplied with one or two welding heads equipped with treadle type switches, a five-power magnifying glass and an adjustable lamp. Most lead and wire materials can be welded with miniature capacitance discharge d-c welders. Their short welding times prevent heat damage to sensitive components and help prevent shorts through components, as previously discussed (ELECTRONICS, p 72, Sept. 22, 1961). An a-c welder with a thyratron contractor and heat program timer is used for certain types of welds, such as copper-to-copper, or when it is desirable to approach an anneal process for the metals welded.

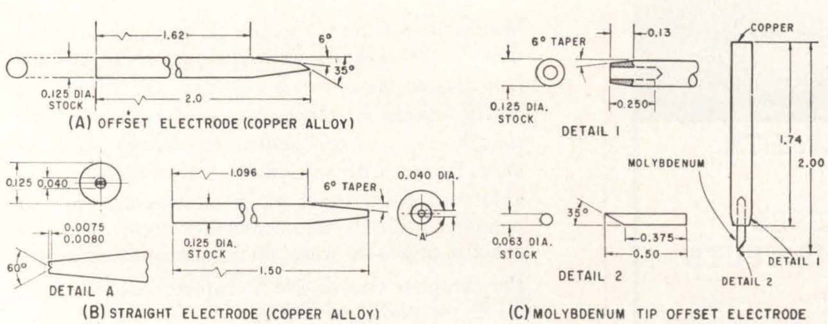
Electrode materials depend on the materials being welded. In each case, the best compromise between high thermal conductivity, low specific resistivity, wear resistance and strength should be selected. Lead materials with high conductivity require electrodes or electrode tips of higher resistance and viceversa. Different upper and lower electrodes can be used to weld dissimilar metals. Electrodes recommended for various materials are shown in the table.

Typical electrode configurations are shown in Fig. 1. Shanks can be coated with polyurethane to help prevent shorts. Color-coding the coating simplifies storage and identification and the color also helps show coating wear and peeling.

Redressing of electrodes by the operator should be avoided, especially if tips are tapered or welding schedules are critical. A supply of freshly dressed electrodes may be supplied. Any redressing on the machine should be minimal and should be done lightly with fine emery paper on a paddle. Offset electrodes are needed to reach into confined spaces. Their alignment should be checked with a triangular tool.

A variety of accessories, tools, jigs and fixtures have been developed. Some of these are shown in the photos. The butterfly jig, for example, facilitates the construction of wafer board modules. The plastic end wafers are held apart at a distance convenient for component insertion, after which the wafers are brought together. Spacers can then be inserted between the plates or can be built into the fixtures.

Special jigs and molds can be devised for any module design. For



The right electrode for each weld depends on such factors as the diameter of the wire being welded, accessibility of the weld area, flexibility of component leads, and pressure-energy requirements of the weld schedule *for communications engineers:*

2 problems in magnetic design SOLVED BY PIC

1: *An instrument for calibrating ILS equipment needed these unusual filters . . .*

TRUE INSERTION LOSS: 3.5 db ±0.15 db

OPERATING TEMPERATURE: −20° C to +50° C

Z in: 2000 ohms.

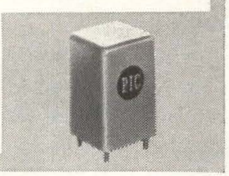
Z out: 18,000 ohms, CT, isolated.

Attenuation:	Filter #1	Filter #2
<0.15 db	90 ±1 cps	150 ±1.5 cps
<1 db	90 ±3 cps	150 ±5 cps
>30 db	54 and 150 cps	90 and 250 cps

Dimensions: 1¾" x 1¾" x 2¾"

SOLUTION:

Borrow this filter for your own tests—samples can be made available if required.



2: *Communications engineers asked for this filament regulating magnetic amplifier . . .*

Input: 200 V ±7%, 3φ, 400 cps ±5%

Output: 6.4 V dc, 5-30 amps.

Regulation: ±0.125 V for any combination of line, load, frequency and temperature.

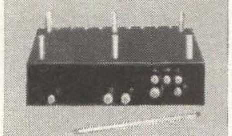
RIPPLE: 20 mv rms max.

Operating Temperature: −55° C to +85° C

Size: 3" x 3½" x 12"

SOLUTION:

Borrow this magnetic amplifier for your own tests—samples can be made available if required.



Send us your next "tough" problem in magnetic design . . . PIC is willing to gamble that it can design the magnetic component you have been looking for. Better yet, phone direct to our Custom Design Department — its number is BR 9-4660.

PIC

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Instrument Company
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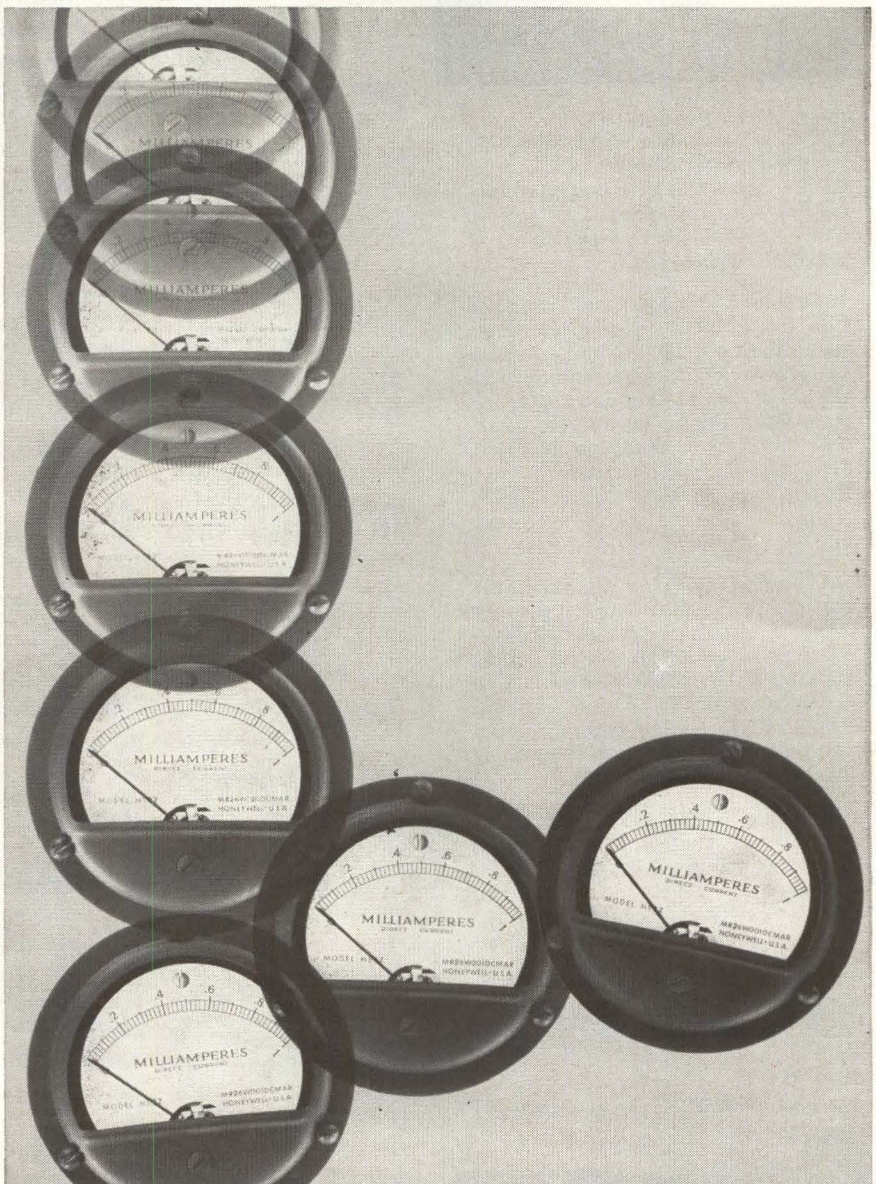
RUGGED: HONEYWELL METERS

Honeywell's sealed, ruggedized panel instruments are about as tough as meters can get. They shrug off all kinds of shocks, vibrations, stresses and strains. They're immune to dust, moisture and ordinarily troublesome climatic and atmospheric conditions. They're not affected by magnetic panels because of the special plated steel case. ■ A three-point rubber mounting cushions internal shock. New fastening techniques and materials prevent magnet fracture, increase shear resistance, and minimize whipping and collision between the dial and pointer assembly. High torque-to-weight ratios permit larger radius pivots and reduce the load on bearings. Special beryllium copper hairsprings reduce zero shift, raise the fatigue point, and reduce deformation. ■ For a catalog describing the full line of Honeywell meters (including ruggedized models) write to Honeywell Precision Meters, Manchester, New Hampshire.

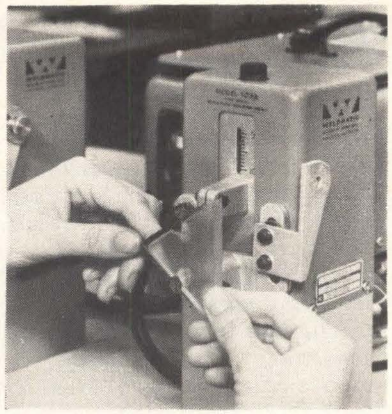
HS2Z (2½ inch sealed, ruggedized meter) illustrated. Built to conform to MIL-M-10304B.



"where electronics meets the eye"

Honeywell

H Precision Meters



Electrode alignment tool helps insure standard practices

TABLE—RECOMMENDED FACING ELECTRODE FOR VARIOUS TYPES OF METAL

1. Aluminum, Magnesium, Nichrome, Platinum: Resistance Welders Manufacturer's Association #1.
2. Alnico, Brass (yellow), Bronze (phosphor), Constantan, Beryllium, Gold, Iridium, Iron, Novar: RWMA #2.
3. Molybdenum, Monel, Nickel, Nickel Silver, Palladium, Steel, Stainless Steel, Tantalum, Tungsten: RWMA #2.
4. Brass, Copper, Silver: RWMA #3 or Molybdenum.
5. Osmium: Molybdenum.

example, a diode matrix required some 600 parts; these are inserted in a preformed, three-ply, laminated plastic block before welding. Tooling included a Silastic mold for the block and an aluminum pattern for exact placement of the diodes.

Production Control

An assembly line technique is recommended for weld reliability. Each machine is set to the proper weld schedule and is not changed. Work is passed from machine to machine. The operator has no other job except to place the proper two wires between two electrodes and press the foot pedal. Therefore, a thorough dexterity test is one of the most important personnel evaluation tools.

Inspection stations are equipped with 30-power binocular microscopes for weld inspection. Stress testing of welds in modules is likely to impair reliability while radiography yields little information on resistance weld strength. The best quality assurance is rigid control of equipment, process and materials variables, and the establishment of correct weld schedules. Employees should be thoroughly trained and impressed with the need for reliability. Visual aids can continually emphasize proper technique.

The human element can be minimized by following such general rules as: limit the operators' responsibility for changing pressure and energy settings; group and standardize electrodes for families of welds; redress and maintain electrodes in the machine shop; use fixtures and jigs to support modules during welding; use alignment tools to position electrodes; lay out modules so weld positions are easily accessible in sequence; and attach risers or extension leads at test points so they can be clipped off after electrical tests.

Destructive tests can be made on coupons furnished for each different weld at regular intervals. Information should be quickly fed back to the production shop. Machine pressure and force should be periodically calibrated. Changes indicate the frequency of calibration required and will also indicate preventive maintenance needed.

Since it is difficult to rework welded modules, 100 percent testing of components before assembly is recommended. Circuit performance should be tested before potting and again after potting.

Inspection Procedure

The leads of components should be inspected as part of incoming inspection. Variations in lead coating, thicknesses, consistency and composition must be controlled.

The inspection procedure recommended is to clip 12 leads from one side of parts in lots of 100 or less. The samples are welded to an interconnecting lead material according to a previously developed weld schedule for that material. Eleven of the weld samples are tensile tested to failure and the results compared with the strength established for that material. If discrepancies are slight, a metallographic examination is made of the twelfth sample and compared with data used in developing the original weld schedules.

If variations are excessive, the lot must be rejected or a new weld schedule developed.

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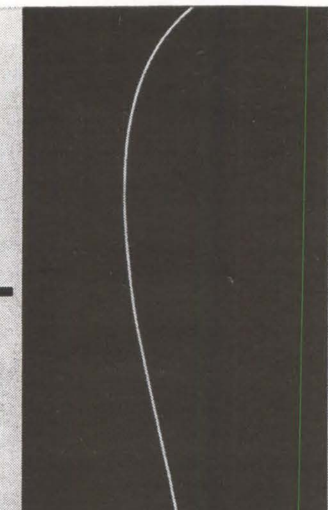

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Long experience, technical know-how and specially built equipment enable us to plate wire of uniformly high quality at moderate cost.... One application is the Gold plating of Nickel wire. This combines the desirable characteristics of the base metal with the corrosion-resistance of Gold.... In our process of continuous electroplating, adherence and quantity deposited are precisely controlled.

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Space helmets to propulsion units, first fly Delta Jet before they zoom to outer space. Delta Air Freight is always faster, often cheaper than surface transportation for routine or rush shipments. Delta has next day nationwide delivery plus connections to every international destination.

EXAMPLES, DOOR-TO-DOOR:

100 lbs. Los Angeles to Canaveral	$29.85
300 lbs. Miami to Chicago	$28.95

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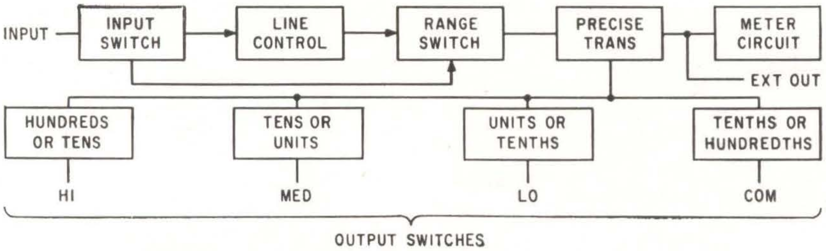
CIRCLE 71 ON READER SERVICE CARD

DESIGN AND APPLICATION

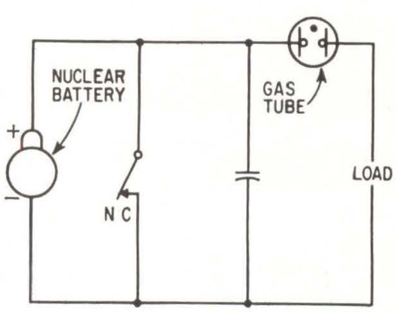


A-C Voltage Standard

ACCURACY TO ±0.05 PERCENT

WILK INSTRUMENTS, 3700 South Broadway, Los Angeles 7, California recently announced Model P-4, a new instrument designed for rapid and accurate calibration of a-c voltmeters, ammeters, wattmeters, power-factor meters, phase-angle meters and for use as a precision a-c supply and current transformer. The unit can operate between 50 cps and 5 Kc supply frequency and has output ranges from 0 — 1,511 v in 0.1 v increments and 0 — 151.1 v in 0.01 v increments. The heart of the calibration unit is a precision tapped transformer having 42 separate windings specially positioned to insure minimum capacitance effect and leakage reactance to maximize frequency response of the system. A special expanded-scale, high-accuracy voltmeter with an accuracy of ±0.05 percent of the center-scale value between 50 cps and 5 Kc is used. The meter is calibrated for rms reading of a sine wave. As shown in the sketch, output is determined by four switches with associated dial indications. An illuminated decimal point is automatically positioned by the range switch.

CIRCLE 301 ON READER SERVICE CARD

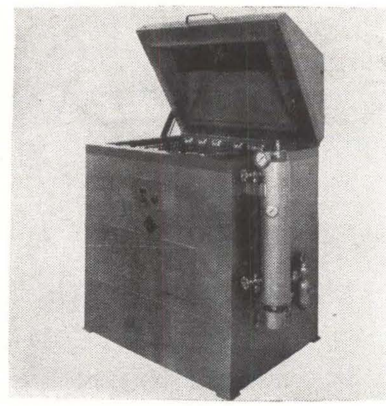


Nuclear Battery

USEFUL LIFE OF 10 YEARS

RECENTLY announced by Leesona Moos Laboratories, 90-28 Van Wyck Expressway, Jamaica 18, New York is a nuclear battery using Krypton 85, an inert gas which is not metabolized by the body. The battery can produce voltages in excess of 10,000 v, charging linearly to 1,000 v and is essentially a constant-current device with a current capability of 1,000 $\mu\mu$amps. A small glass ampoule is filled with this gaseous isotope with the filling tube serving as the positive electrode. A copper coating plated on the outside of the glass is the collector or negative electrode. High-energy electrons from the radio isotope cross the glass dielectric and are collected thus creating a potential difference. Because Krypton-85 has a half-life of 10.4 years, the battery has a minimum useful life of ten years. If a capacitor is connected in parallel with the nuclear battery, as shown in the sketch, and then through a cold-cathode diode to the load, the value of the capacitor and the breakdown of the diode will determine the time delay between opening the switch and the discharge of the capacitor through the diode and load. The battery is stored in a short-circuited condition and is indifferent to this short circuiting.

CIRCLE 302 ON READER SERVICE CARD



Salt Spray Chamber

MULTIPURPOSE DESIGN

STANDARD CABINET CO., INC., 56 Washington Ave., Carlstadt, N.J. Line of moderately priced salt spray, salt fog, high relative humidity test chambers feature heavy gage steel construction with rubber composition liner. Chambers meet MIL requirements. Standard sizes range from 2.6 to 22.5 cu ft of work space. Temperature range is ambient to +160 F; humidity range 95 percent, ±5 percent.

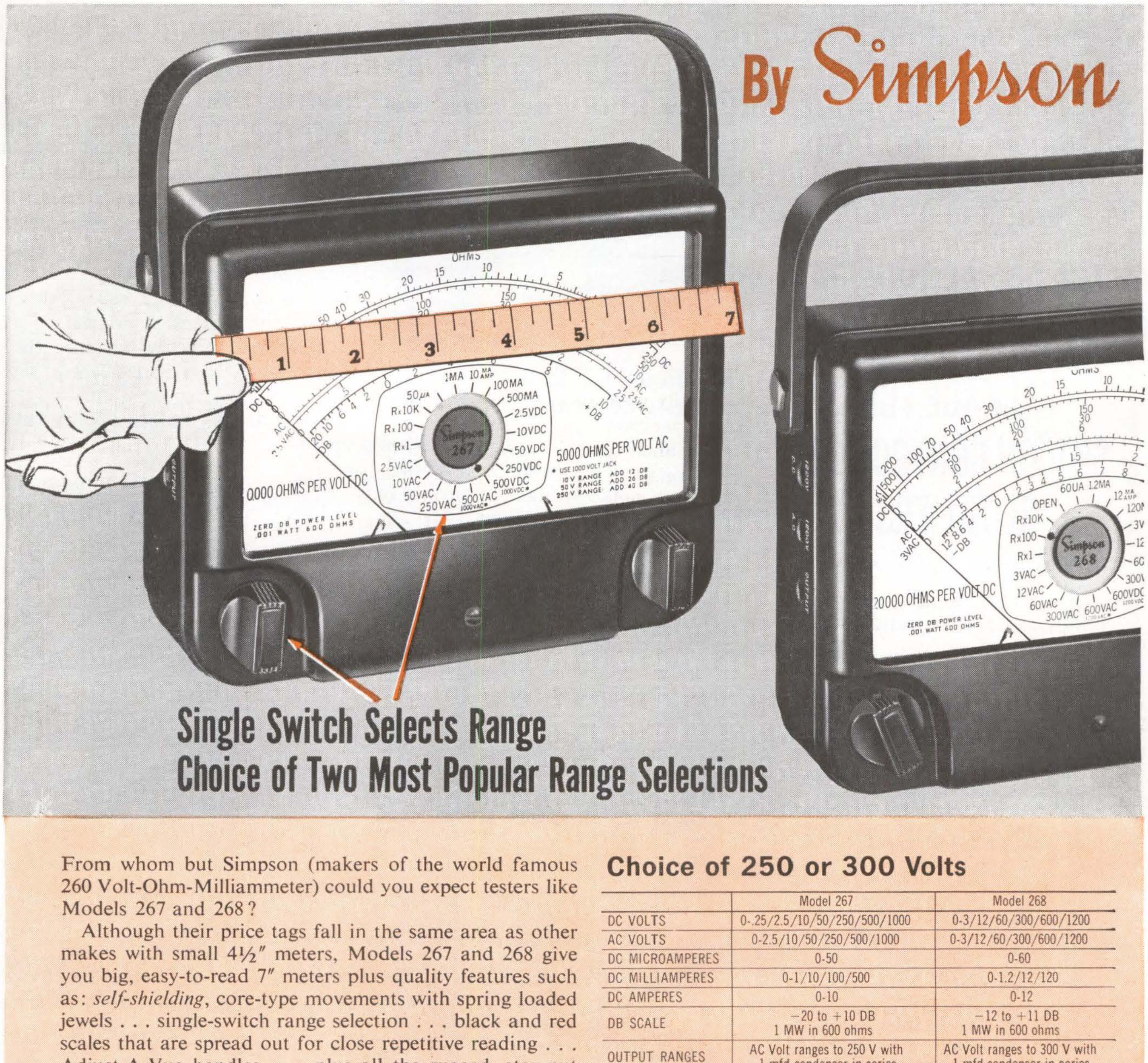
CIRCLE 303 ON READER SERVICE CARD

High Speed Converter

ANALOG-TO-DIGITAL

RAYTHEON CO., 1415 Providence Highway, Norwood, Mass. Model AD-10A operates at up to 500,000

NEW 7-INCH VOMs AT $49^{95}



From whom but Simpson (makers of the world famous 260 Volt-Ohm-Milliammeter) could you expect testers like Models 267 and 268?

Although their price tags fall in the same area as other makes with small 4½″ meters, Models 267 and 268 give you big, easy-to-read 7″ meters plus quality features such as: *self-shielding*, core-type movements with spring loaded jewels . . . single-switch range selection . . . black and red scales that are spread out for close repetitive reading . . . Adjust-A-Vue handles . . . plus all the rugged, stay-put accuracy that you *expect and get from Simpson.*

Vital statistics for Models 267 and 268 are: DC sensitivity, 20,000 ohms per volt; AC, 5000 ohms per volt. Accuracy: DC volts, ±3% of full scale; AC volts, ±5% of full scale.

Have your distributor bring one out for trial.

Choice of 250 or 300 Volts

	Model 267		Model 268
DC VOLTS	0-.25/2.5/10/50/250/500/1000		0-3/12/60/300/600/1200
AC VOLTS	0-2.5/10/50/250/500/1000		0-3/12/60/300/600/1200
DC MICROAMPERES	0-50		0-60
DC MILLIAMPERES	0-1/10/100/500		0-1.2/12/120
DC AMPERES	0-10		0-12
DB SCALE	−20 to +10 DB 1 MW in 600 ohms		−12 to +11 DB 1 MW in 600 ohms
OUTPUT RANGES	AC Volt ranges to 250 V with .1 mfd condenser in series		AC Volt ranges to 300 V with .1 mfd condenser in series
OHMS Ranges / Ctr. Scale Value	RX1 / 12	RX100 / 1200	RX10K / 120,000

Also Available: carrying cases, high-voltage multipliers, and special types of test leads.

Model 267 or 268 complete with test leads and operator manual ...... $49^{95}

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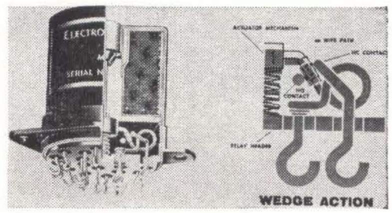
complete 10-bit conversions per sec. Output is either serial or parallel straight binary on all units. Serial output is 5 million bits per sec while parallel output is up to 500,000 words per sec. Accuracy is 0.097 percent ± ½ the least significant bit. The unit can be operated internally or externally for sampling command. Price is about $6,800 complete with power supply.

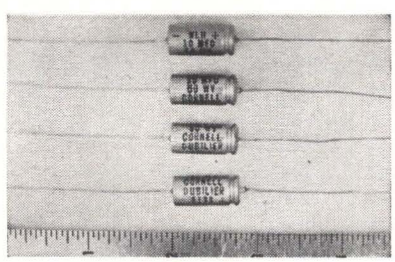
CIRCLE 304 ON READER SERVICE CARD



Six Pole D-T Relay
HIGH CONTACT PRESSURE

ELECTRO-TEC CORP., 1 Henderson Drive, West Caldwell, N. J. Mark II type 1000 Wedge-Action relay meets requirements of MIL-R-5757D for 125 C operation. It employs a powerful plunger type solenoid to actuate the six moving contacts. These movable contacts are positioned between two rigidly mounted stationary contacts. In either the energized or de-energized position, contact pressure increases between the moving contact and the fixed contact. Contact resistance is 0.015 ohm.

CIRCLE 305 ON READER SERVICE CARD



Miniature Capacitors
COMPUTER-GRADE

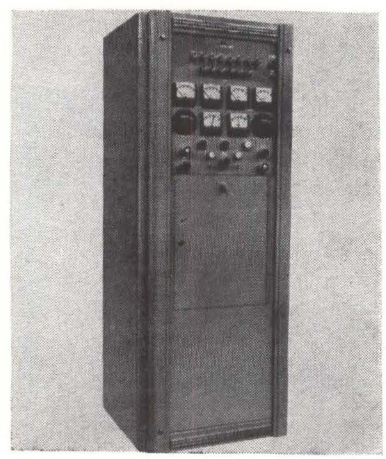
CORNELL-DUBILIER ELECTRONICS, 50 Paris St., Newark, N. J. Type NLH Computamite electrolytic capacitors are available in ratings of 1 to 300 μf at 3 to 150 v d-c working. They are ¼ in. diameter by 11/16 in. long in lower ratings and ⅜ in. by 1½ in. long in higher ratings; are designed for an operating range of −40 C to +85 C. High gain etching and forming of 99.99 percent purity aluminum foil yields up to twice the capacitance of previous techniques with no detrimental changes in dissipation factor or leakage current.

CIRCLE 306 ON READER SERVICE CARD

Lock-Nut
UNLIMITED RE-USE

DYNALOC FASTENERS, INC., 977 Mt. Read Blvd., Rochester 6, N.Y. The Dynaloc self-locking nut is easy starting, free spinning and locks in last turn. Features: unlimited re-use; it will not strip, gall, shear or otherwise damage mating part; compression action creates no residue; and vibration resistance is very high. Company says nut exceeds government standards on all torque requirements by more than 200 percent. It is available in standard sizes starting at 4-40.

CIRCLE 307 ON READER SERVICE CARD



Soft Tube Modulator
THREE PULSE WIDTHS

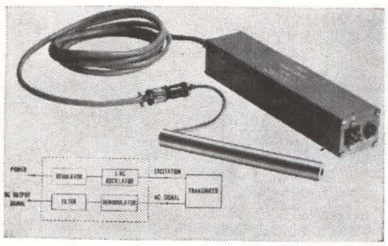
THE NARDA MICROWAVE CORP., Plainview, L.I., N.Y. Model 11040 soft tube modulator provides peak power outputs up to a maximum of −33 Kv at 33 amp. It is furnished with three standard pulse widths of 0.5, 1.0 and 2.5 μsec, the pulse repetition rate being continuously variable from 200 to 2,000 pps. Price is $9,650.

CIRCLE 308 ON READER SERVICE CARD

Radio Altimeter
TRANSISTORIZED

INTERCONTINENTAL ELECTRONICS CORP., 300 Shames Drive, Westbury, L. I., N. Y. The AM-220 transistorized radio altimeter features zero to 1,000 ft range. A guaranteed accuracy of ±3 ft under 50 ft and ±6 percent above 50 ft is claimed over the full range of temperature and operating conditions. Also featured are modular construction for easy maintainability, compact size, and a total system weight of 18.6 lb.

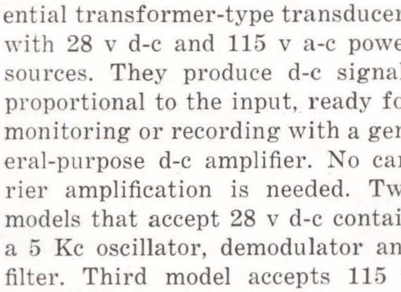
CIRCLE 309 ON READER SERVICE CARD



Transducer Converters
THREE MODELS

SANBORN CO., 175 Wyman St., Waltham 54, Mass. Series of transducer converters permits use of differential transformer-type transducers with 28 v d-c and 115 v a-c power sources. They produce d-c signals proportional to the input, ready for monitoring or recording with a general-purpose d-c amplifier. No carrier amplification is needed. Two models that accept 28 v d-c contain a 5 Kc oscillator, demodulator and filter. Third model accepts 115 v ±10 percent, 60-cycle a-c.

CIRCLE 310 ON READER SERVICE CARD



Toggle Switches
SHOCK RESISTANT

ELECTROSPACE CORP., 12 Morris Ave., Glen Cove, N. Y. Line of toggle switches has electronic circuit switching engineered for aircraft, missiles, ground handling equipment and other applications. Units are military approved and meet applicable requirements of MIL-S-3950. Electrical ratings: 10 amp at 125 v a-c, or 30 v d-c. Endurance: greater than 10,000 cycles at +85 C. Dielectric strength: over 1,000 v, 60 cps a-c. Insulation resistance: over 1,000 megohms.

CIRCLE 311 ON READER SERVICE CARD

PRODUCT BRIEFS

VARIABLE DELAY LINE for radar range calibrators. Andersen Laboratories, Inc., 501 New Park Ave., West Hartford 10, Conn. **(312)**

COMPACT POWER SUPPLY wide range. Electronic Research Associates, Inc., 67 Factory Place, Cedar Grove, N.J. **(313)**

PHYSIOLOGICAL STIMULATOR applies electronic pulse. Theratron Corp., 263 Griggs-Midway Bldg., St. Paul 4, Minn. **(314)**

TANTALUM FILM CIRCUITS in various form factors. Texas Instruments Inc., 13500 North Central Expressway, Dallas 22, Texas. **(315)**

TRANSISTORIZED COUNTING STRIP modular design. The Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, O. **(316)**

COAXIAL HYBRID COUPLER with crossover feature. Dielectric Products Engineering Co., Inc., Raymond, Maine. **(317)**

SURFACE ANALYZER SYSTEM repeatable recording. Brush Instruments, Div. of Clevite Corp., 37th and Perkins, Cleveland 14, O. **(318)**

CIRCUIT TRIAL CASE self-contained unit. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge 38, Mass. **(319)**

VARIABLE ATTENUATOR high-power, zero-loss. Merrimac Research & Development, Inc., 517 Lyons Ave., Irvington 11, N.J. **(320)**

LOW POWER WATTMETER rack-mounted. Voltron Products, Inc., 1020 South Arroyo Parkway, Pasadena, Calif. **(321)**

POWER SUPPLY high filter. Dynatech Corp., 471 N.E. 79th St., Miami, Fla. **(322)**

VARIABLE TRANSFORMER 40-volt unit. The Superior Electric Co., Bristol, Conn. **(323)**

RECORDER/REPRODUCER SYSTEM all solid-state. Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif. **(324)**

BROADBAND VHF AMPLIFIER low-cost. Motorola Inc., 8330 Indiana Ave., Riverside, Calif. **(325)**

Literature of the Week

DISK INTEGRATOR Disc Instruments, Inc., 3014B S. Halladay, Santa Ana, Calif. Illustrated 4-page booklet details performance capabilities of the series 200 disk integrator. **(326)**

POWER RESISTOR DECADES Clarostat Mfg. Co., Inc., Dover, N.H. Catalog contains electrical and mechanical specifications for power resistor decades. **(327)**

AUTOMATIC CONTROL Zenith Electric Co., 152 W. Walton St., Chicago 10, Ill. A 64-page catalog provides complete information and prices on electromagnetic controls and timing devices. **(328)**

SERVO RECORDERS Houston Instrument Corp., P.O. Box 22234, Houston 27, Texas. Four-page folder contains illustrated description, ordering information and prices for T-Y moving pen recorders. **(329)**

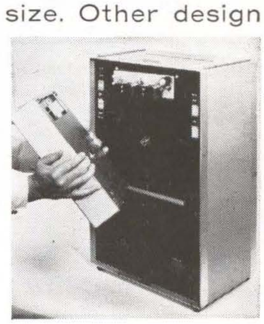
MODULAR POWER SUPPLIES Micro-Power, Inc., 20-21 Steinway St., Long Island City 5, N.Y. Data and selection guide for a line of modular power supplies for microwave tubes is available. **(330)**

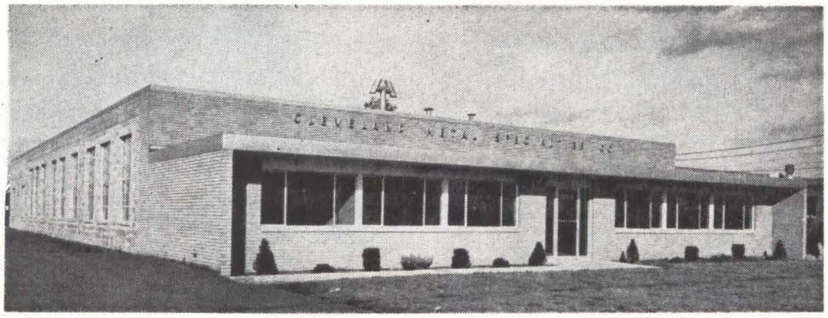
D-C VOLTAGE REFERENCE Binary Electronics, Inc., 30-48 Linden Place, Flushing 54, N.Y. Bulletin describes a precision, dual-channel, d-c voltage reference, featuring electrical program ability through specially designed binary-coded decimal, Kelvin-Varley resistive dividers. **(331)**

STAND-OFF TERMINALS Standard Plastics Co., Inc., 62 Water St., Attleboro, Mass. Three technical data sheets offer complete information on custom molded Standite series A, B and C miniature insulated stand-off terminals. **(332)**

FRACTIONAL H-P MOTORS Motordyne, Inc., 2221 Barry Ave., Los Angeles, Calif. Catalog is devoted to p-m and wound fractional h-p d-c motors, as well as centrifugal blowers, and axial fans. **(333)**

COMPOSITION RESISTORS Ohmite Mfg. Co., 3694 Howard St., Skokie, Ill. Bulletin 140 describes Little Devils molded composition resistors available in resistance values as low as 2.7 ohms in the ¼, ½ and 1-w sizes. **(334)**





CMS Ready to Occupy New Facility

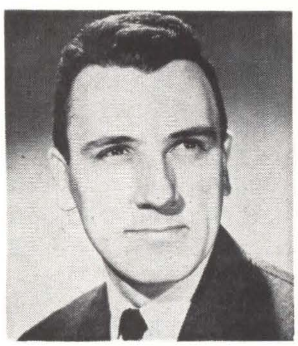
CLEVELAND METAL SPECIALTIES CO. will move into its new plant on Cleveland's southwest side, on April 1. The plant, located on a one-acre site, is designed for rapid expansion. Even before occupancy, a 2,000-sq-ft addition was built, making total space 9,000 sq ft.

The 55-year-old company entered the electronics field several years ago. It produces photoengraved printed circuits, partial and complete subassemblies, system subassemblies and packaging, and microminiature product design and assembly.

Roger Middlekauff, president, says the company provides complete printed circuit services, from conversion of schematics to artwork, through production.

CMS, which recently acquired prime contractor status from Army Ordnance Corps, is now engaged in a classified warhead fuzing program. It recently designed and packaged, with Diamond Ordnance Fuze Laboratories, a miniature arming programmer-timer that has had five successful test flights.

The company's industrial and commercial nameplate and jewelry divisions will also be housed in the new plant.



DATA-tronix Corp. Elects V-P

ELECTION of David N. Dry as vice president and director of DATA-tronix Corp., Norristown, Pa., has been announced. DATA-tronix is a recently formed telemetry components and systems company.

Before joining the firm, Dry was chief engineer of Sonex, Inc., Philadelphia, Pa. He was formerly supervisor of the analog telemetry group, American Bosch Arma Corp., with responsibilities for both airborne and ground station component design. While with Philco Corp., Dry also designed and developed circuits for new compact portable tv units.

General Electric Elevates Schwartz

NATHAN SCHWARTZ has been appointed manager of application engineering at the General Electric Company's Electronics Laboratory, Syracuse, N. Y.

Schwartz was formerly a consultant-advance planning and analysis at the laboratory. Since joining the lab in 1953, he has been concerned with the application of solid-state physics to electronic devices and equipment.

Daystrom Appoints Eric Weiss

ERIC WEISS was recently appointed to a staff position as technical advisor for Daystrom, Inc., Control Systems Division, LaJolla, Calif. He had been one of the division's original members when it was established in 1956.

Most recently Weiss was general manager of Rheem Advanced Technology Laboratory, LaJolla, which became the LaJolla Division of United ElectroDynamics, Inc.

Babcock Electronics Hires Dressel

D. W. DRESSEL recently joined Babcock Electronics Corp., Costa Mesa, Calif., in the new position of manufacturing manager.

Prior to joining Babcock, Dressel served as factory manager with the Astronics division of Lear Inc.

Set Up New Company In Microwave Field

AMONG newest entries in the field of microwave components and subsystems is Applied Microwave Laboratory Inc., of Wakefield, Mass.

The company, which emphasizes design and manufacturing of devices employing cavities, was founded in October 1961 by a group which included five engineers

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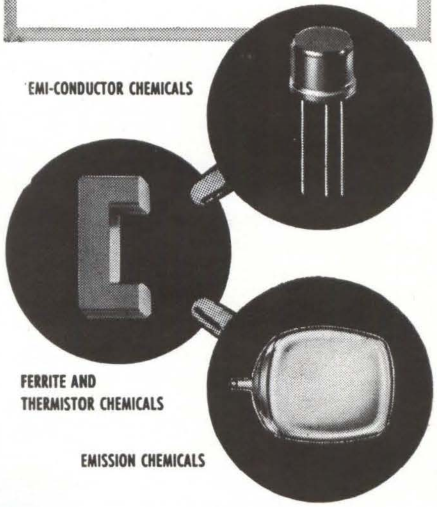

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formerly with Amerac Inc.

J. F. Lane is president of AML; Alden Matsubara is product manager; and Ray Fuller, engineering manager.

Featured line of microwave devices includes oscillators, amplifiers, and multipliers using planar or pencil triodes, and klystrons for either c-w or pulse applications. The company develops complete microwave front-end assemblies utilizing mixers, preselector filters and diplexers in addition to the cavity energy sources.

Electronics Capital Appoints Root

DONALD E. ROOT has joined Electronics Capital Corp., San Diego based small business investment company, as senior management services officer. Previously, he was associated from 1953 to 1961 with Cubic Corp. of San Diego, where he was general manager of that company's industrial instrument division.

Mazzarese Joins Digital Equipment

APPOINTMENT of Nick J. Mazzarese to the post of computer applications engineer at Digital Equipment Corp., Maynard, Mass., is announced.

Prior to joining Digital, Mazzarese was an engineer at Hazeltine

Electronics in New York City, Sylvania Electric in Needham, Mass., and Instrument Associates in Arlington, Mass.

George Harmon Co. Expands Facilities

THE GEORGE HARMON CO., INC., Northridge, Calif., announces expansion of facilities to handle a $4 million backlog of commercial and military electronic products. Manufacturing floor space has been increased from 5,500 to more than 11,000 sq ft, and engineering and production personnel have been added.

Proprietary products currently in production include an automatic crash locator beacon for aircraft, a personnel locator beacon, and several types of impact and pressure switches for military applications.

PEOPLE IN BRIEF

Morris Cohen leaves Loral Electronics Corp. to rejoin PRD Electronics, Inc., as microwave dept. head of the Products and Components div. **James W. Hart** from Motorola, Inc., to Mark Products as mgr. of the Microwave div. Three v-p's of Dunn Engineering Corp. are elected to the board of directors—**Conrad E. Bloom, Jr., Paul R. Likins,** and **Sydney Minault. William L. Quine,** previously with U.S. Dynamics Inc., named mgr. of thermistor and solid state switch development for Hydro-Space Technology, Inc. **Robert Bollen,** formerly of Allen B. DuMont Laboratories, appointed field engineering supervisor for Visual Electronics Corp. **Col. Charles G. Patterson,** U.S. Army, Ret., is elected a director and v-p of Belock Instrument Corp. **John F. McCole,** ex-Sylvania, now with the applications engineering staff of Watkins-Johnson Co. **John D. Lovely,** from Rediffusion Inc. to the engineering staff of Benco Television Associates Ltd. **William B. Harris,** ex-AEC exec, joins the engineering staff of Del Electronics Corp. **Leonard Pincus,** v-p and director of Quantatron's microwave laboratory, elected to firm's board of directors.

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2. Select those for which you qualify.
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5. Fill out the form completely. *Please print clearly.*
6. Mail to: D. Hawksby, Classified Advertising Div., ELECTRONICS, Box 12, New York 36, N. Y. (No charge, of course).

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EITEL-McCULLOUGH INC. San Carlos, California	84	2
ESQUIRE PERSONNEL SERVICE INC. Chicago, Illinois	116*	3
GRUMMAN AIRCRAFT ENGINEERING CORP. Bethpage, L.I., New York	83	4
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electronics WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

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NAME ....

HOME ADDRESS ....

CITY .... ZONE ...... STATE ....

HOME TELEPHONE ....

Education

PROFESSIONAL DEGREE(S) ....

MAJOR(S) ....

UNIVERSITY ....

DATE(S) ....

FIELDS OF EXPERIENCE (Please Check) 2262

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

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Please indicate number of months experience on proper lines.

	Technical Experience (Months)	Supervisory Experience (Months)
RESEARCH (pure, fundamental, basic)	......	......
RESEARCH (Applied)	......	......
SYSTEMS (New Concepts)	......	......
DEVELOPMENT (Model)	......	......
DESIGN (Product)	......	......
MANUFACTURING (Product)	......	......
FIELD (Service)	......	......
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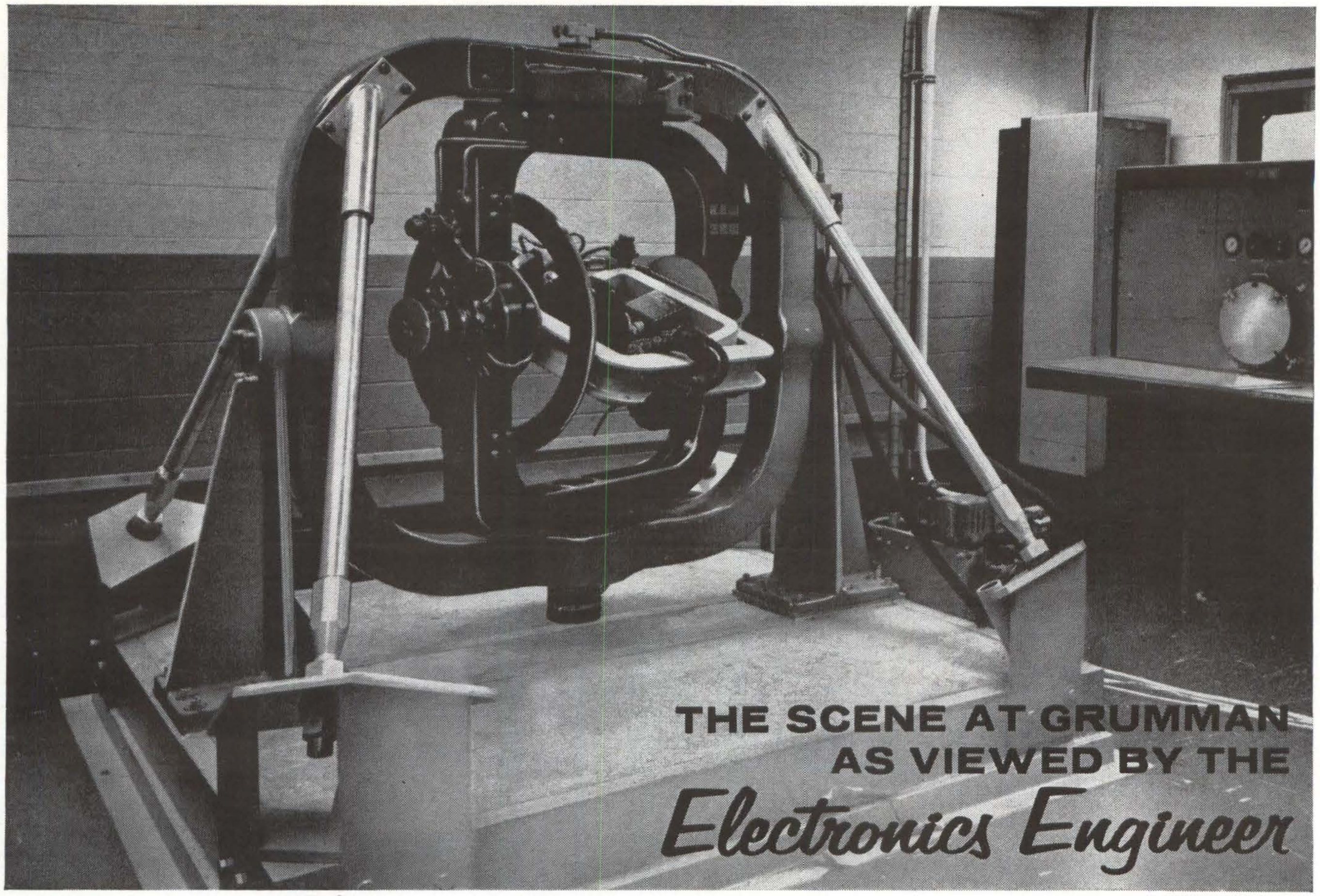

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Data Processing Engineers—Background in digital data processing, logic circuit design, memory devices, R-F modulation techniques and related digital techniques required. Opportunity to participate in advanced design of systems concepts and hardware development. BSEE or BS in Physics with a minimum of 3 years' applicable experience is required.

Laboratory Equipment Engineers—BSEE with 5-10 years experience in laboratory test programs of airborne electronics equipment. A working knowledge is required in a majority of the fields of airborne communication radar, navigation and digital computers. Work will be conducted in our new Electronics Systems Center with the finest facilities and equipment available. Applicants must be willing to extend their technical capabilities to new challenging areas ranging from DC to microwaves.

To arrange an immediate interview, send your resume to Mr. W. Brown, Manager Engineering Employment, Dept. GR- 76 (U.S. citizenship required)

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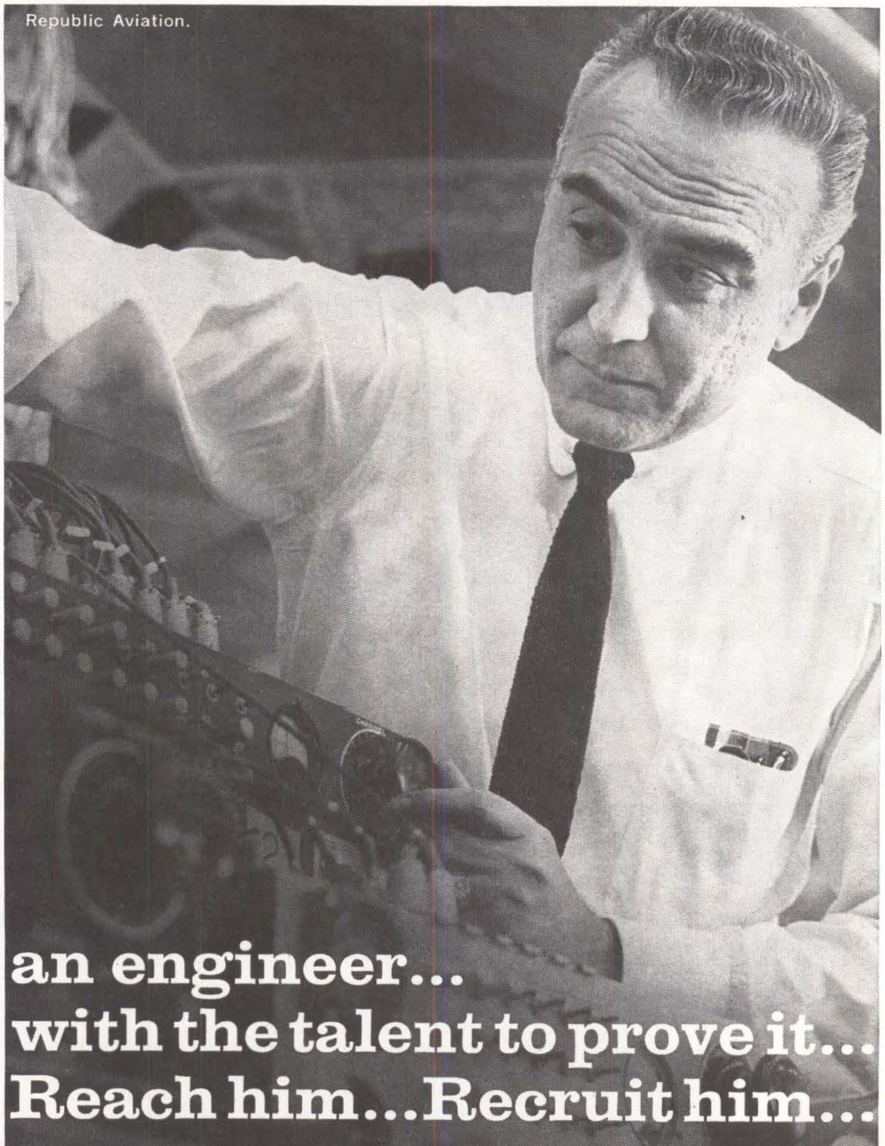

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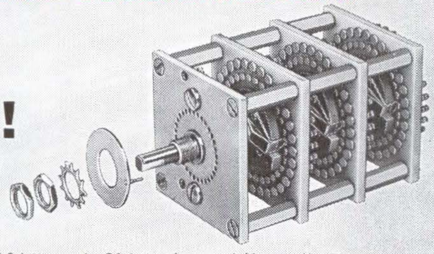

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RCA can design and make the Cascaded Image Tube you need

RCA can design and build Cascaded Image Tubes with very high sensitivity–out to the threshold of absolute darkness–for operation in various regions of the spectrum.

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