A McGraw-Hill Weekly 75 cents August 23, 1963

electronics®

FLUORESCENT TRANSISTOR

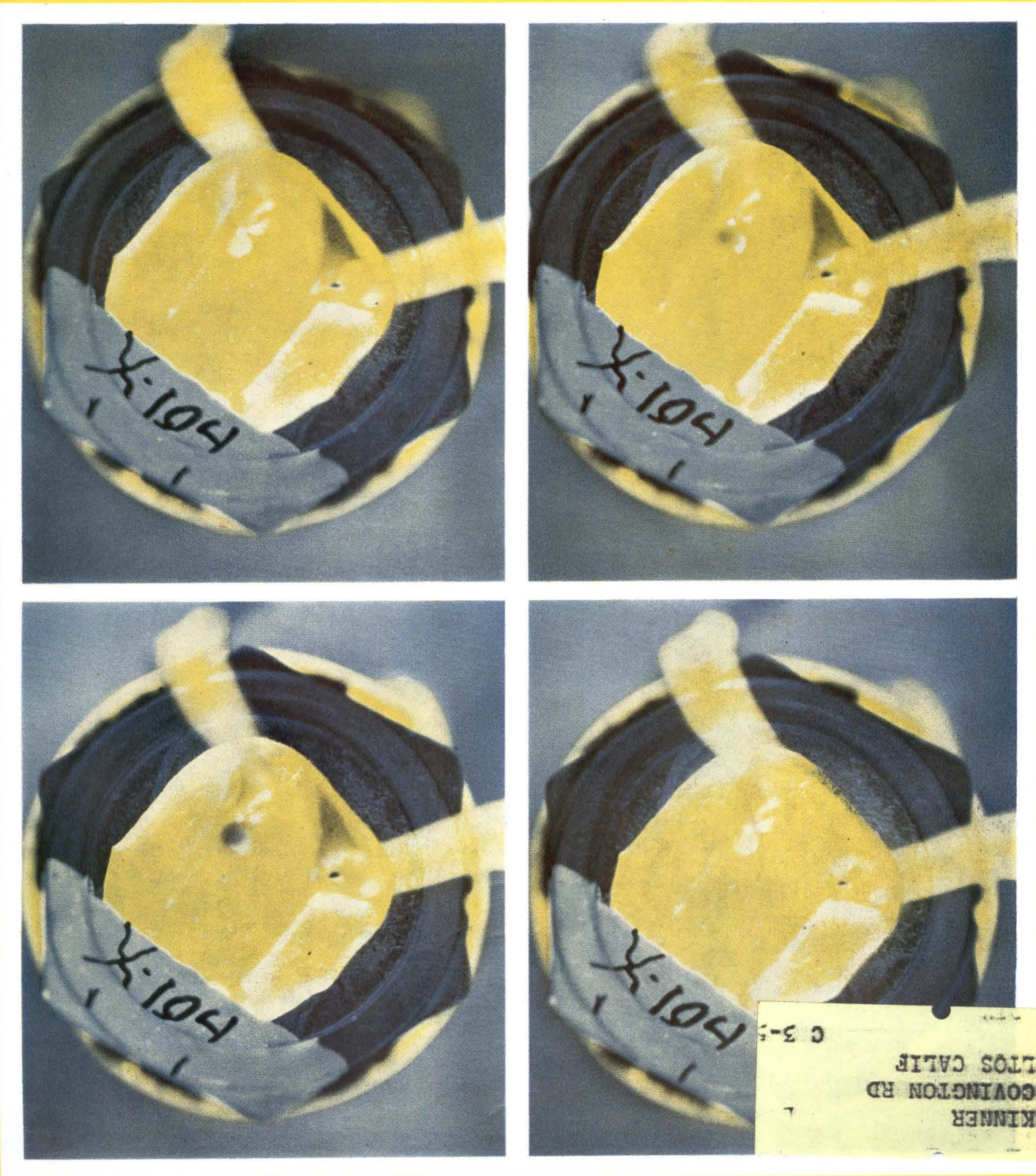
Paint shows heat distribution, p 40
(photo below)

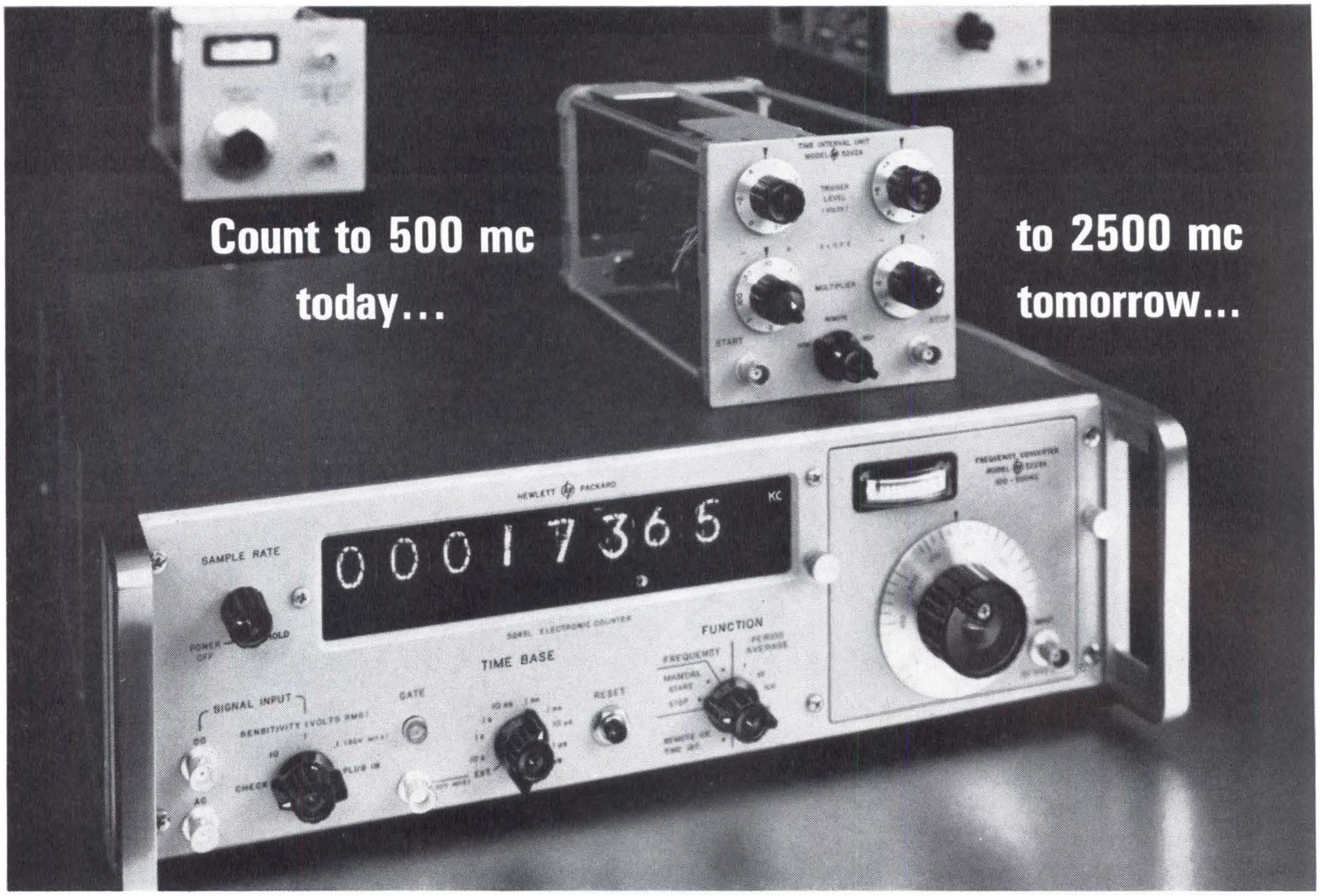
WHY U.S. LAGS IN AIR CONTROL

European systems post gains, p 21

GRAVITY STABILITY

Satellites use long boom, p 16





with the hp 5245L Electronic Counter

The solid state hp 5245L Electronic Counter is an instrument that'll do your job today . . . and keep growing right along with you as your requirements increase. Plug-in versatility is the answer.

Three plug-ins available now . . . more to come.

You can expand the usefulness of the 5245L simply by adding a plug-in, when—but not unless—you need it. As your requirements change, you can easily and economically change the 5245L to meet them.

The basic counter offers a maximum counting rate of 50 mc with 8-digit resolution, and a single plug-in extends that rate to 512 mc. Available soon will be a new plug-in extending the rate to 2500 mc. Other plug-ins include a video amplifier which increases 5245L sensitivity to 1 mv rms and a time interval unit which enables the counter to measure time interval 1 μsec to 10^8 sec.

HEWLETT PACKARD COMPANY

1501 Page Mill Rd., Palo Alto, California 94304, (415) 326-7000. Sales and service in all principal areas. Europe, Hewlett-Packard S.A., 54 Route des Acacias, Geneva, Switzerland; Canada, Hewlett-Packard (Canada) Ltd., 8270 Mayrand St., Montreal, Quebec.

Here are some other unparalleled advantages offered by the 5245L:

Sample rate, independent of gate time, adjustable 0.1 to 5 sec
Time base stability better than $3/10^9$/day
Display storage for continuous display
Readout in close-spaced rectangular Nixie tubes
Four-line BCD output for systems, recorder use
Remote programming capability
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Plug-in circuit construction for easy maintenance
Compact, stackable cabinet only 5¼″ high

Ask your Hewlett-Packard field engineer for full particulars and a demonstration on your bench.

hp 5245L Electronic Counter, $3250
hp 5253B 512 MC Frequency Converter, $500
hp 5261A Video Amplifier, $325
hp 5262A Time Interval Unit, $300

Data subject to change without notice. Prices f.o.b. factory.

8692

August 23, 1963

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A McGraw-Hill Weekly 75 Cents

Contents Continued

electronics

August 23, 1963 Volume 36 No. 34

Published weekly, with Electronics Buyers' Guide as part of the subscription, by McGraw-Hill Publishing Company, Inc. Founder: James H. McGraw (1860-1948).

Executive, editorial, circulation and advertising offices: McGraw-Hill Building, 330 West 42nd Street, New York, N. Y., 10036. Telephone Area Code 212 971-3333. Teletype TWX N. Y. 212-640-4646. Cable McGrawhill, N. Y. PRINTED IN ALBANY, N. Y.; second class postage paid at Albany, N. Y.

OFFICERS OF THE PUBLICATIONS DIVISION: Shelton Fisher, President; Vice Presidents: Joseph H. Allen, Operations; John R. Callaham, Editorial; Ervin E. DeGraff, Circulation; Donald C. McGraw, Jr., Advertising Sales; Angelo R. Venezian, Marketing.

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Subscriptions are solicited only from those actively engaged in the field of the publication. Position and company connection must be indicated on orders. Subscription rates: United States and Possessions and Canada, $6.00 one year, $9.00 two years, $12.00 three years. All other countries $20.00 one year. Single copies, United States and Possessions and Canada 75¢. Single copies all other countries $1.50.

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CONTENTS continued

DEPARTMENTS

Europe's Zero-Zero Landings

FAA's DC-7 *equipped with BLEU automatic landing system, has made over 1,100 landings at Atlantic City facility*

THE U. S. IS LAGGING behind Europe in getting an all-visibility landing system operational for commercial air carriers.

While the U. S. continues to evaluate systems, European planes will be setting down in near zero-zero weather. They will use a system that is essentially automatic, that is triplicated to insure reliability, and that will cut the percentage of flights cancelled because of weather below that of those in the U. S.

For details, of how this system works, see the article beginning on p 21 in this issue by British consultant R. E. Young.

Why has Europe been quicker to settle on a system than the U. S. has? One reason, as author Young points out, is because weather in Europe—especially Great Britain—is worse for flying than in the U. S. Economically, it was more urgent for the Europeans to find a solution to bad-weather flying than it was for U. S. air carriers.

Other reasons also delayed the Federal Aviation Agency's decision to settle on a system. U. S. air carriers are not government-owned, as they are in England, France and other European countries. Selection of a system here must meet the approval of air carriers, Airline Pilots' Association, and other organizations. Also, to give equal opportunity to equipment manufacturers, FAA tested a number of different systems—both civilian and military (ELECTRONICS, p 46, Dec. 14, 1962).

Economically, the U. S. wanted a system cheaper than the one Europe is planning to use. Instead of triplication, the U. S. system will not be redundant but will include facilities for manual backup by the pilot. Not only will this be cheaper but will also satisfy a requirement on which American commercial pilots insist.

The system must retain the pilot as an integral part of the landing loop. The European system lands without pilot participation.

Another reason for waiting was to come up with a system that could be installed in any airliner now operating in the large U. S. air fleet, as well as in future planes. The British system will be installed only in the two planes for which it was built, and those planes built hereafter.

The U. S. landing system, planned for final evaluation by 1966, is the same type selected by the Europeans. Both will make the final landing maneuver by a radio-altimeter flareout system. A prototype installed in FAA's DC-7 has already made some 1,100 blind landings. Under a new contract, soon to be awarded, FAA will install the system in a jet airliner—possibly a 707—for more tests. By 1967 the system should be ready for operational use.

Also in the works, is a second-generation, experimental microwave system (ELECTRONICS, p 24, Aug. 2) that, hopefully, will be ready by the mid-1970's. Being developed by Airborne Instrument Laboratories, it is a follow-on to AIL's Flarescan. It consists of two scanning beams on the ground, and does not require switching over from one system to another during the crucial landing operation. (The British system uses magnetic leader cables for the glide slope and azimuth guidance before switching over to the radio-altimeter flareout technique, and the U. S. system, planned for 1967, uses ILS for azimuth and glide slope and then the radio-altimeter flareout for landing.)

TWO WEEKS FROM NOW IN electronics

. . . .you will find an easy-to-complete questionnaire which we will ask you to return to us. Please take a minute to do so, as completely and as accurately as you can. The more we know about your needs the better we can serve you

---

COMMENT

Microwelding

Congratulations on a fine article, Microwelding: Laser Or Electron Beam?, by New England editor Thomas Maguire in the July 5 issue (p 23).

This article has set forth in very complete form two major developments that may very well influence the whole future of the vital field of microelectronics.

This is the fifth year that Alloyd has been sponsoring the symposium in Boston, from which much of the material for the story was derived.

Fine articles like yours are a great help in setting forth the outlines of what tomorrow will bring in this growing field of microelectronics.

PATRICK G. RUSSELL
Alloyd Electronics Corp.
Cambridge, Massachusetts

RFI

Your article on RFI: Causes, Effects, Cures (p 37, June 21) was excellent.

Do you have any information regarding the time and place of the next National Symposium on RFI?

PAUL C. JOHNSON
Hoffman Engineering Corp.
Anoka, Minnesota

The next symposium will be held in Los Angeles, sometime in June, 1964. The exact date has not yet been decided.

Negative Resistance VII

Regarding Negative Resistance VI (p 4, July 19), I suggest the term *assistor* instead of *negative resistor*, and, of course, consequently, *assistance* instead of *negative resistance*.

W. FERDINAND EBERZ
Capistrano Beach, California

Lab Courses

I usually find time to catch up on some of my reading of your magazine during the summer, and have just come across your Dec. 14, 1962, Crosstalk editorial (p 3), which discusses the problem of laboratory work in engineering educational institutions.

You are, of course, eminently right in pointing your finger at the laboratory as an area needing a study for increased efficiency. It is undergoing a challenge in almost all areas of engineering education, with Electrical Engineering leading the way.

I believe I can show you in Lansing a modern treatment of an Electrical Engineering laboratory, based on the systems concept and the use of miniature equipment. This not only saves the student's time, but also permits him to study the operation of a complete system on a table top. Before he gets that far, he will probably have predicted the performance of his proposed system by mathematics, will have checked out his equations on an analog computer to determine that the equipment with the parameters he expects to use will perform in accordance with specifications, and finally, he will check out the performance of the actual system. While this equipment permits plotting the speed-torque curve of a motor, we do not spend all afternoon doing it, since it can be put directly on a scope in a few seconds. The laboratory work includes hydraulic systems as well as electrical, and often we can make a rapid change from one to the other.

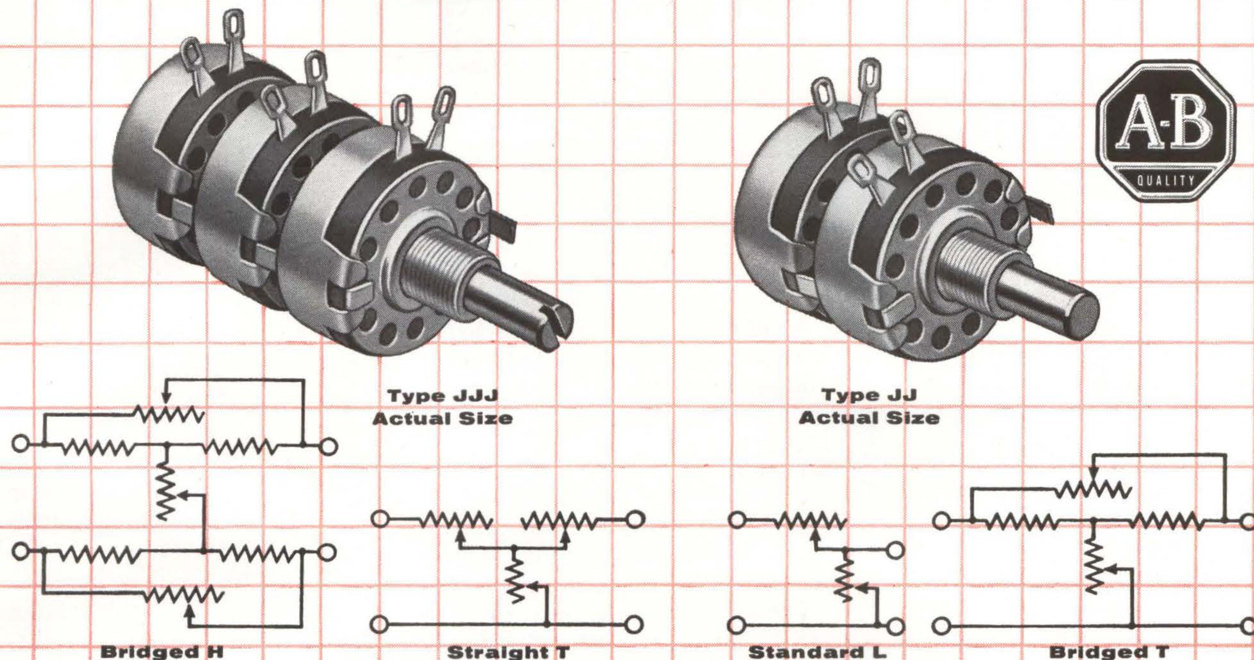
The National Science Foundation has recognized the importance of this work by financing a three-year program of further development here, and we have this morning started a three-week course for teachers from about 30 other engineering institutions to make them aware of the new concepts and possibilities of the method.

A few years ago in a major curriculum overhaul, our Electrical Engineering Department reduced the laboratory hours required of an individual student by 40 percent, and these hours have apparently never been missed.

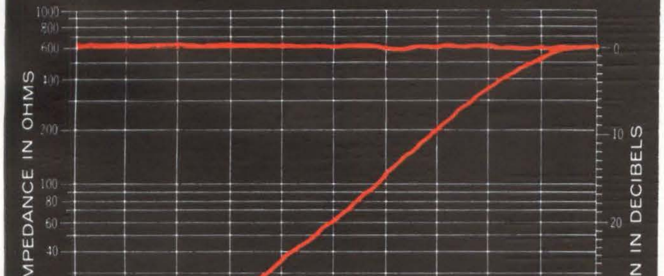
As far as the laboratories at many schools, I could not agree with your editorial more.

J. D. RYDER
Dean
College of Engineering
Michigan State University
East Lansing, Michigan

Allen-Bradley Type J Variable Resistors used in constant impedance attenuators provide quiet, smooth control...at low cost!



Reproduction of actual machine plot of Allen-Bradley 600 ohm Bridged-T attenuator, showing the uniform attenuation and constant characteristic impedance obtainable with such Type J variable resistors.



■ In attenuators, which of these characteristics is most important to you—stability, or smooth control, or constant impedance? Not only will Allen-Bradley Type J variable resistors give you all of these . . . but also long life and a high wattage rating in a remarkably compact structure.

The famous Type J solid resistance element—made by A-B's exclusive hot molding process—provides smooth control at all times—you'll never experience an abrupt change in impedance or attenuation during adjustment.

Allen-Bradley's control of the resistance-rotation characteristics during production assures the desired attenuation—approaching calibration accuracy. And, the characteristic impedance can be held to 10% *throughout* rotation—end to end! The discrete steps inherent in all wire-wound units are eliminated. Don't forget—freedom from inductance insures excellent high-frequency response.

The Allen-Bradley Type J variable resistors are available in dual or triple units for use in attenuators rated up to 5 watts. For more complete information on these Type J controls, please send for Technical Bulletin B5200B. Write: Allen-Bradley Co., 110 W. Greenfield Ave., Milwaukee 4, Wis. In Canada: Allen-Bradley Canada Ltd., Galt, Ontario.

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CIRCLE 5 ON READER SERVICE CARD

Lasers Last Week: More Colors, More Power

PALO ALTO, CALIF.—Last Wednesday, a laser double-header was played here. At 2 a.m., engineers of Radiation at Stanford got their new nitrogen-gas laser running full blast, with some powerful and colorful results. Later the same day, physicists at Stanford University announced their double-pulse method of achieving very high power outputs from xenon flashlamps.

Radiation's new laser—which the company plans to sell for less than $3,000—attained pulse repetition rates up to 2 kc and peak power outputs up to 50 watts—both many times higher than helium-neon lasers usually attain. In addition, the laser puts out coherent infrared radiation over a wavelength range of 0.75 to 1.25 microns, with 28 spectral lines simultaneously in the output.

Most of the power is concentrated in 3 or 4 spectral lines. When the most intense lines (0.7, 1.0 and 1.1 microns) are isolated by harmonic-conversion techniques, using KDP crystals, approximately 0.1 μw of visible violet, blue-green and yellow output is obtained.

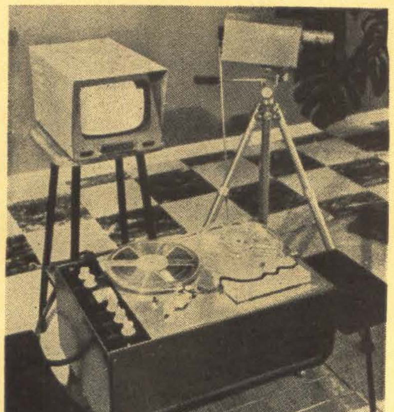
The laser is pulsed by a 1-Mw, 40-kv modulator at rep rates up to 2 kc. At higher pulse rates, saturation is observed and power output decreases.

Radiation says its device can be called a molecular laser. It operates on inversion obtained in the triplet state of the nitrogen molecules employing the inherent band spectra of nitrogen. Molecular energy interactions with the electronic states of the diatomic molecule tend to determine output frequency. The implication is that the laser output frequency can be varied by adjusting the temperature of the gas.

The method for achieving high power output from laser flashtubes, announced by J. L. Emmett and A. L. Schawlow, of Stanford University, uses a double-pulse technique. A stable, low-current discharge is obtained in the tube with a low-current pulse. This initial discharge is at 1 kv from a large capacitor. About 225 μsec after the initial triggering, the peak current density of 2,300 amp/cm² is reached. Then a 15-μf capacitor charged to 5.5 kv is discharged directly across the operating flashlamp. At this time, the circuit is at a low impedance permitting a high current to be achieved with a fast rise time. Current densities of up to 25,000 amp/cm² are obtained.

Application of a high-current pulse to a flashlamp that is not preionized could destroy the tube. The preionization or double pulse may even lengthen the life of the tubes. However, not enough tubes have been tested to date to give valid lifetime data.

Tv Tape Recorder



TELCAN *equipment (Aug. 16, p 7) records tv programs on standard ¼-inch tape. Manufacturer sees replacement of home movies with "canned" home television.*

U.S., Russia Prepare To Open the Hot Line

SOVIET teleprinter equipment is being unpacked in Washington and instruction manuals are being translated as the Moscow-Washington hot line (p 18, June 28) is readied for operation Sept. 1. The circuit is designed to provide instant communications between the two capitals, eliminating misunderstandings that could mean all-out war.

IEEE: NO CONTEST

DEADLINE on nominations for the IEEE presidency for 1964 closed last week with Clarence H. Linder still the only candidate for the post (p 38, Aug. 9). This means he is sure to get the job, although ballots for the election haven't even been mailed out yet. Walter E. Peterson, president of Automation Development Corp., is also certain to be elected vice president as he is the only nominee for that position. An IEEE spokesman said, however, that there will be contests for other offices

The Defense Communications Agency has awarded the prime wire-line contract to American Cable & Radio Corp., an ITT subsidiary. RCA Communications will handle the backup radio circuit via Tangier. Teletype Corp. has reworked equipment to use the international 50-band (66 wpm) rate necessary in passing through European relay centers. AT&T will furnish transatlantic cable to AC&R. Army technicians have engineered the Pentagon terminal.

Four-In-One Computer Has Fast Core Memory

NEW YORK—The RCA 3301 Realcom computer, introduced this week, was designed to be used in varying configurations for scientific, business, real-time management control and data communications applications.

The 3301 main core memory has a cycle time of 1.75 microseconds. A "scratch-pad" magnetic-core memory operates in 250-nsec cycles. The memory ranges from 40,000 to 160,000 7-bit characters. The processor can perform up to 158,000 8-digit additions or subtractions per second.

Various electronic control modules may be added to the basic processor for optional input-output equipment. Monthly rentals range from $14,000 for a basic scientific system, $17,000 for a basic tape system, to $40,000 for a system with disk files, magnetic-tape stations, communications terminals and real-time controls. The 3301 is compatible with the RCA 301, which can serve as a direct-line auxiliary for the large data system.

U. S.-Soviet Space Cooperation Detailed

WASHINGTON—NASA and the Academy of Sciences of the USSR have given final approval to implementation of the cooperative space agreement reached last year (p 8, Dec. 14, 1962).

Echo II passive communications satellite experiments will be conducted between Zemenki Observatory of Russia's Gorky State University and England's Jodrell Bank Observatory at 162 Mc in early 1964. Conventional facilities will bridge the U. S. and England for U. S.-originated experiments with the Soviet Union.

A full-time telecommunications link for transmitting cloud pictures from U. S. and Soviet weather satellites will be established early next year. Ultimately, the program will include coordinated weather satellite launchings, NASA said. Also, both countries plan to launch satellites in complementary orbits to measure and map the earth's magnetic field.

Syncom II On Station, Hits 300-Hour Mark

WASHINGTON—By today, Syncom II should have chalked up more than 300 hours of transatlantic transmitting time since its July 26 launch. Syncom II, hovering constantly over the same point on the globe, has already overtaken Relay I in this respect. Relay, a medium-altitude satellite, has only about 200 hours transmitting time to its credit for eight months in orbit.

Magnetic Drum Eliminates Echoes

STANDARD Telephone and Cables, a British affiliate of ITT, is installing a new type of sound system in St. Paul's Cathedral, London. A 10-second reverberation time, caused by the immense size of the cathedral, constituted one of the major problems. To overcome it, the sound system records all sound on a rotating drum.

Five playback heads spaced around the drum provide five delay lengths, with the maximum equaling the normal delay incurred by a sound wave traversing the length of the nave. Loudspeakers spaced along the nave are supplied with sound delayed so that the reproduced sound is in phase with the sound coming directly from the pulpit or other speakers.

Anna Firefly Turns Her Lights On Again

ANNA FIREFLY satellite has started operating again after a two-month blackout. The four xenon-gas beacons—each with the illuminating power of a lighthouse—started acting up about two months after launching last October. Finally, in May, a capacitor shorted and the satellite stopped operating. The short has apparently burned itself out and the beacon started flashing again.

Atomic Lighthouses Foreseen by AEC

ATOMIC-powered sonar beacon, being developed for the AEC by Martin, would serve as a low-cost navigational aid for ships and small craft. Sonar equipment manufacturers feel that many problems are yet to be solved if the device is to be used by small craft—such as making an inexpensive directional receiving transducer and overcoming the high noise levels close to the surface—but that these are by no means insurmountable. The sonar beacon would run for 10 years on a strontium-90 source.

In Brief . . .

INFRARED SCANNING has been used for the first time to map a large forest fire from the air, according to U. S. Forest Service research specialists in Missoula, Montana. The scanners produce a detailed map showing fire perimeter, hot areas and spot fires outside the main fire area.

WORLD MARKET for electronic equipment is expected to double in the next six years, with sales volume increasing from $19 billion to $40 billion, William E. Roberts, Ampex president says.

BENDIX' ECLIPSE Pioneer and RCA Data Systems divisions have received $15 million in NASA contracts for components and equipment for Saturn 1B and Saturn V guidance and checkout.

HEWLETT-PACKARD and Yokogawa Electric Works, a Japanese firm, are forming a jointly-owned company that will produce test equipment.

RYAN will build test models of a doppler-radar altimeter for the Navy's hydrofoil ship (p 14, July 5). It will measure in inches the distance of the craft's hull above the water. Data will be fed to an autopilot controlling the underwater wings of the high-speed craft.

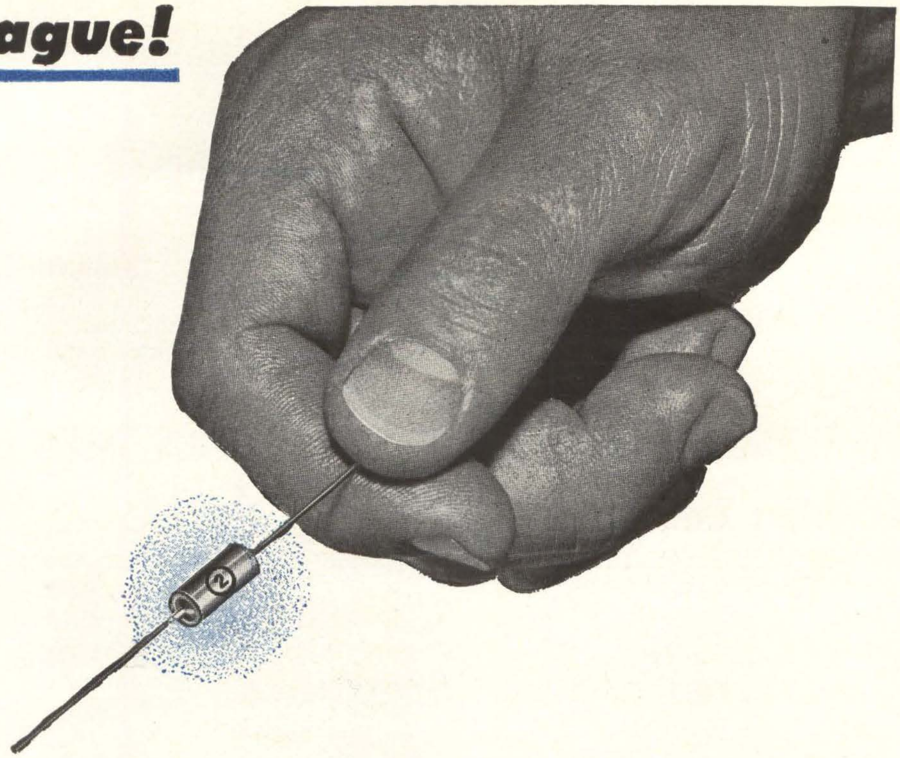
SPACESUIT communications system to enable Project Apollo astronauts on the surface of the moon to converse with each other is being developed by ITT. Speech transmission is voice-actuated; data transmission is manually controlled.

VLF RECEIVERS are to be installed next year at NASA's Minitrack stations to more accurately synchronize clock signals sent from WWVL.

RAYTHEON has introduced a c-w, S-band Amplitron that generates 425 kw at 72 percent efficiency. It is 6 feet long and weighs 400 pounds.

UNITED KINGDOM exported $29.1 million of electronic products to the U. S. in 1962, a 30-percent gain over 1961, according to the U. S. Dept. of Commerce.

Only from Sprague!



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TANTALEX® CAPACITORS
with *PERFORMANCE CHARACTERISTICS* *NEVER BEFORE POSSIBLE!*

■ **DISSIPATION FACTOR CUT BY ½**—Not more than 3% at 20 VDC and up, permitting even higher a-c ripple currents!

■ **LOWER IMPEDANCE AT HIGH FREQUENCY**—With impedances in fractional ohmic values in the megacycle range, Type 150D admirably meets the stringent requirements of high-speed computers.

■ **LOWER LEAKAGE CURRENTS**—Previous limits have been dramatically reduced; in some instances by as much as a factor of three.

■ **INCREASED CAPACITANCE STABILITY**—Capacitance change with temperature is now less than ½ the previous guaranteed values. Capacitance change with life is almost insignificant.

■ **NEW HIGHER VOLTAGE RATINGS**—50, 60, 75 and 100 volt ratings are now available, with associated surge voltages higher than any presently offered in the industry.

NEW ULTRA-MINIATURE TYPE 172D

New end-seal design makes possible two tiny sizes (.085″ dia. x .250″ long, and .127″ dia. x .375″ long) for "cordwood" packaging to supplement standard-sized Type 150D ratings in case size "A".

For complete technical data on Type 150D and 172D Tantalex Capacitors, write for Engineering Bulletins 3520E and 3523, respectively, to Technical Literature Service, Sprague Electric Company, 35 Marshall Street, North Adams, Massachusetts.

Popular ratings of Type 150D Capacitors are available for fast delivery from your Sprague Industrial Distributor

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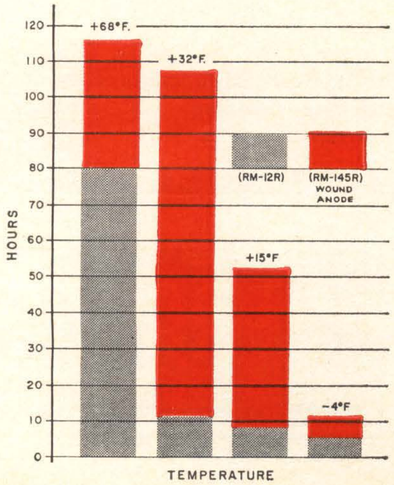
4SC-135-63R2

Wound Anode Mercury Batteries have high energy at low temperatures

When temperatures drop to around 32°F, most dry batteries just don't put out the milliampere-hours the way they do at 70°F. And at 0°F, they practically give up.

Not so with our wound anode series of Mallory Mercury Batteries. As the chart shows, this construction of the famous mercury system pioneered by Mallory has 12 times as much capacity at 32°F as our standard (pressed anode) mercury cell . . . 6 times as much at +15°F. The wound anode cell at 32°F has 94% of its 68°F capacity . . . 46% at +15°F . . . and still has 10% capacity left at —4°F. And this is all the more remarkable when you consider that the Mallory mercury system has nearly four times the energy per pound of conventional Leclanché batteries.



We make the wound anode mercury system in four different cell sizes, with nominal capacities from 400 to 13,000 milliampere hours. Voltage is 1.35 volts per cell. We can either help you select a standard model or engineer a custom-designed power pack for your particular circuitry, space and capacity requirements.

CIRCLE 270 ON READER-SERVICE CARD

New Backing for Semiconductors

Looking for a backing plate for high power semiconductor devices? Then you've probably puzzled over getting a material that has good conductivity and a coefficient of expansion that matches silicon or germanium.

Our Elkonite® materials and other powder metal compositions of refractory constituents could be just what you need. By varying composition, we can tailor their coefficient of expansion to match closely with the semiconductor material. Their thermal conductivity is good, and they have excellent mechanical properties. And we can supply them as discs pressed and sintered to accurate dimensions . . . no more need to worry about close-tolerance cutting from bar stock.

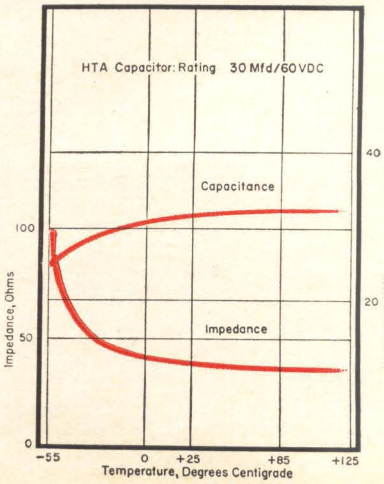
CIRCLE 271 ON READER-SERVICE CARD

Need stability from −55° to +125°C? Try this new aluminum electrolytic

You can get broad-temperature stability and reliability in a new kind of capacitor we have developed . . . the Mallory Type HTA. This is an aluminum electrolytic that has plenty of life and stability at temperatures up to 125°C. And even at —55°C it retains about 85% of its original capacitance. That's temperature performance approaching tantalum . . . at aluminum prices!

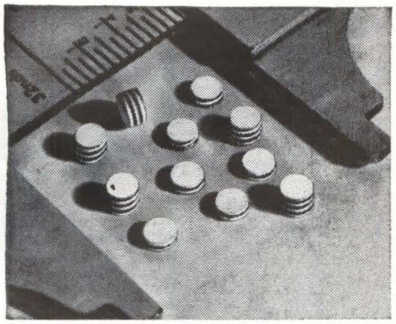
The HTA comes in ratings of 8 to 300 mfd, 60 to 3 volts. Case diameter is 3/8"; case length, 13/16" to 1 5/8".

CIRCLE 272 ON READER-SERVICE CARD



DESIGNER'S FILE

Pellet film resistors for microminiaturizers



We have developed and are now manufacturing a series of microminiature pellet components of economical cost and excellent reliability. These discrete parts are completely compatible with thin films and integrated circuits, and provide time-saving flexibility in prototype work. Using simple, automatable assembly methods, you can get packaging densities of 600,000 components per cubic foot.

Take our pellet film resistors, for example. They all have the same diameter of 0.010″. So you can feed them through automated assembly systems. You can get them in resistance values from 5 ohms to 2½ megohms. Want to change resistance values? Just put in a different resistor pellet. No need for new masks, grinding, etching or reprocessing in vacuum.

Mallory pellet film resistors have a fired-on silver termination. Interconnections can be made by soldering, plating, circuit transfer, welding or conductive cements.

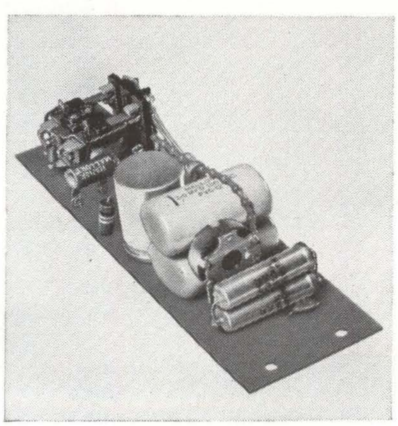
We supply pellet resistors in two thicknesses: 0.063″, in values from 10 ohms to 2½ megohms, nominal ¼-watt; and 0.030″, in values from 5 to 500,000 ohms, 0.1 watt. Ratings are at 125°C with proper packaging. Temperature coefficients between −65 and +150°C are less than 300 ppm/°C. As for reliability, we have had no catastrophic failures in 1 million piece-hours of testing. Resistance changes during 2000 hours of load life at 125°C are generally less than 2%.

And the best thing about them, like our pellet tantalum capacitors, ceramic capacitors and composition resistors, is that we can supply them *now*. Want to experiment? We have two Microkits . . . one at $44.95 from which you can make several complete flip-flop operating circuits, and a larger one at $139.95. Available at Mallory Distributors.

CIRCLE 273 ON READER-SERVICE CARD

Electronic Timer

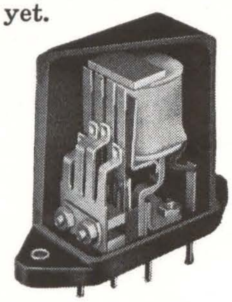
The Mallory Timers Company, our division which specializes in sequence control switching devices, has developed a new all-electronic timer which may be useful in your new equipment designs. It has no moving parts (except for relay contacts which may be needed for heavy inductive loads). It's extremely reliable: we've tested it for over 500,000 cycles. Time cycle is continuously variable from 0 to 10 seconds or 0 to 4 hours. Need something like this? Its price is modest, performance is excellent.



CIRCLE 274 ON READER-SERVICE CARD

TIPS FOR TOMORROW
Self-Holding Resonant Relay for selective switching

A new series of resonant relays which we've developed has interesting possibilities for use in paging systems, remote television or sound equipment control, switching of telephone circuits—and many other selective switching uses that we haven't even thought about yet.



Each channel is held magnetically in the non-operating position. The instant a signal of the frequency for which a channel is tuned reaches the drive coil, the resonant reed snaps into the "closed" position . . . and stays closed until power is removed from the coil. There's no chattering, no bounce, no false action.

We supply one type of relay with four self-holding channels, using frequencies ranging from 50 to 500 cycles. Standard bandwidth is 6 cycles. Channel separation is 20 cycles at the low end, 40 cycles for frequencies above 175 cps. Contacts are rated 2 amps (resistive) at 24 DVC or 110 VAC. Minimum operating power is only 75 millivolt-amperes. The relay rejects noise transients up to 25 milliseconds in duration. Operate time is 200 to 500 milliseconds maximum: release time 20 to 50 milliseconds maximum.

The relay's ability to perform a combination of functions often makes it possible to make notable reductions in the total cost of remote control circuitry.

CIRCLE 275 ON READER-SERVICE CARD

WASHINGTON THIS WEEK

ADMINISTRATION INSISTS TREATY WON'T AFFECT WEAPONS R&D

ATOM TEST-BAN treaty means no dips in weapons budgets, no personnel cutbacks, no slackening in weapons design and production. These are the basic reassurances the administration gave the Senate in its drive for quick, overwhelming ratification of the treaty. A vigorous weapons development program at labs and test sites is to continue under the treaty. Efforts to develop an antimissile missile will be unaffected, AEC Chairman Seaborg maintains, because the warhead is in hand, and it only remains for the Defense Department to decide on specifications for the vehicle. Underground testing can proceed with explosions up to several hundred kilotons, Seaborg says, for the complete development of air-defense, antimissile, antisubmarine weapons, and reduced-fallout weapons for battlefield use. There will be no problems maintaining a force of top-talent weapons men, he insists.

SUPERSONIC AIRLINER— 2 YEARS STUDY

BILLION-DOLLAR effort to develop a U. S. supersonic airliner for commercial service in 1970 is beginning to get off the ground. The Federal Aviation Agency has invited preliminary design proposals from airframe and engine manufacturers. Proposals are due Jan. 15. By May, FAA will narrow the field to two. Final selection will be a year later. The program will provide an important market for advanced electronics equipment—for development testing, for operations within the plane and particularly for air traffic control. Once launched, the plane must proceed along a precisely controlled flight path with little or no delay, greatly depending on automatic flight-control and stabilization systems.

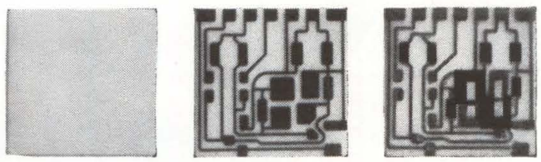
SHORT CIRCUIT FOR MILITARY R&D PROBE?

CARL VINSON (D-Ga.) has launched an investigation by his House Armed Services Committee of military R&D spending. Vinson's move is designed to head off a broader study, sought by a coalition of liberals and conservatives on the House Rules Committee. Rules Chairman Howard W. Smith (D-Va.) wants to look into all government departments doing and sponsoring research, and invade the jurisdictions of committees such as Vinson's.

Vinson appears to have stymied—for the time being—the hankering in Congress to get a grip on mounting R&D. Yet veterans on Capitol Hill detect signs of revolt against Congress' incapacity to understand or deal intelligently with research spending in the space age. Bright younger members of such committees as Space and Armed Services growl that ranking members are just too old to learn. They seem to favor any move that would by-pass their own committees' jurisdictions, if it would help Congress make better judgments.

MORE BACKING FOR OVERSEAS CARRIER MERGER

FCC CHAIRMAN E. William Henry seems to look favorably on creation of a single U.S. carrier of international communications, using the facilities of the Communications Satellite Corp. He has asked for a study to determine the best organization for international communications, in view of the blurring distinction between record (teletypewriter, code, etc.) and voice communications. Satellites can carry both. Henry seems to feel that AT&T and record carriers like Western Union and RCA should merge. Congress would have to pass a law to permit such a merger; Henry offers FCC facilities for the inquiry. Similar merger proposals have been made before—for example by David W. Sarnoff, of RCA (ELECTRONICS, p 12, Aug. 17, 1962.)



a *b* *c*

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- ☐ **STORAGE DRAWER** holds probes, clip leads, accessory items.
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- ☐ **PLUG-IN CARRIER** houses 2 plug-in units, keeps them accessible and dust free, *additional feature on two models only.*

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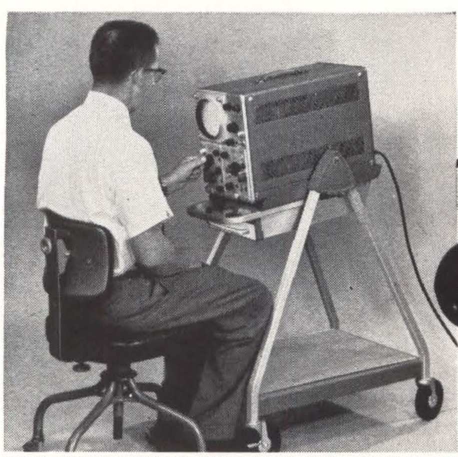

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Model Number	Tray Width	For Tektronix Oscilloscopes	Storage Drawer	Plug-In Carrier	Scope-Mobile® Cart Price
201-1	10½"	503, 504, 515A 516, 561A, 564	Yes	No	$120
201-2				Yes	$130
202-1*	14"	502A†, 507, 517A, 524AD, 661, 530-, 540-, 550-, 580-Series	Yes	No	$120
202-2*				Yes	$130
205-1	17¾"	565, 567, and all RM Types	Yes	No	$135

*Type 202-1 and 202-2 will also accommodate Types 570 and 575 Curve Tracers.
† For use with a Type 502A, a special adapter (part number 436-033, at $2.40) is required.

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Air/Ground Teams Seek New Systems

By JOHN F. MASON, Senior Associate Editor

Strike Command requires command and control to weld Army and Air Force

THE END, last Friday, of one of the biggest joint air/ground exercises ever held marked the beginning of a long, painstaking analysis of the problems it uncovered.

Called Swift Strike III, the month-long "battle" was held in the Carolinas and Georgia. It involved more than 75,000 soldiers and airmen of the U. S. Strike Command (USSTRICOM)—the combined forces of the Continental Army and the Tactical Air Command, and provided an excellent test bed for discovering snags in coordinating electronic systems used by Army and USAF. Most command and control electronic equipment being used was designed for World War II operations, while planes are flying two to three times faster now. Also there are three elements that must work closely together: USAF aircraft, Army aircraft, and the ground forces.

NEW CONTRACTS—New operational procedures will be worked out over the next few months, and new equipment requirements will be forthcoming. These will result in contracts for system design and development, modification, and off-the-shelf buying.

AN/MRC-94, *an air/ground transportable h-f, vhf, uhf communication system, is installed in a ¾-ton truck. Controls of the 1-kw ssb AN/TRC-75 h-f transceiver are accessible through a sliding panel in the rear window of truck. Uhf air/ground communication is provided by an AN/ARC-27. Both units use a TGC/14 teleprinter*

One of the major tasks, which must be tackled jointly by Army and Air Force, will be to reach agreement on the way to handle command and control of Army and USAF air traffic integrated with ground operations. Army feels that light planes in the forward area don't need a command and control system. Air Force doesn't see how any large number of aircraft can operate without one. Final decision will probably have to be made by the Joint Chiefs of Staff before work can get underway.

Another need will be for a navigation system. At Fort Huachuca, Ariz., Army is developing the ground portions of experimental models of grid position systems for navigation (ELECTRONICS, p 32, April 12) while USAF develops the airborne portions. Still to be initiated, however, is work on a grid system for low-level command and control operations. One possibility is to put the transmitters for the grid system in high-flying airplanes that circle over designated spots in friendly territory.

AIR FORCE NEEDS—One system scheduled for updating is the Tactical Air Command's Direct Air Support Center (DASC) which is responsible for providing immediate air support and reconnaissance for Army units. Only known requirements for a new system are that it must be smaller, lighter, more mobile, and cheaper.

A DASC consists of h-f, ssb, and mobile troposcatter equipment. AN/TRC-80 tropo gear is the prime means of communicating with the rear area, and ssb with the forward area. Operating under DASC is the Tactical Air Control Party

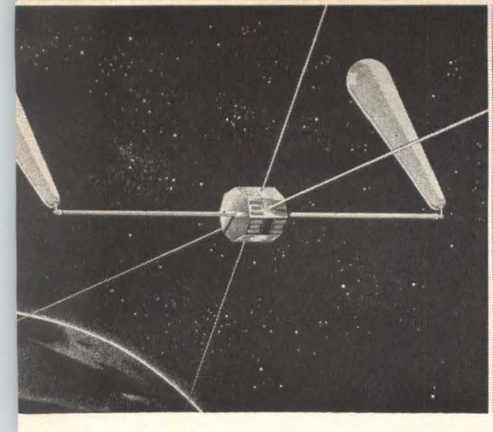
MASSIVE AIRDROPS, *like this one, were only one phase of one of the biggest joint air/ground exercises ever held in the U.S.*

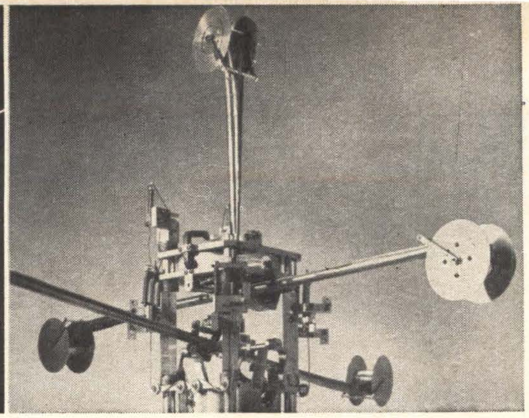
(TACP), using the AN/MRC-94 which includes h-f, ssb, uhf air/ground, vhf a-m, and vhf f-m. At the battalion level there are a number of TACP's which use AN/MRC-95 jeep-mounted ssb, uhf air/ground, plus a full complement of man-pack ssb, uhf, vhf a-m and f-m equipment.

SECURE TRANSMISSION — Today's DASC equipment is better than that used a year ago. Information can now be relayed from the front lines to the rear echelon in one step rather than by a series of short ones. Transmission, however, is still not secure. Needed is development of data processing and transmission equipment to provide real-time secure communications. No contracts are out for changing the DASC system itself since specific systems requirements are not yet established. R&D work is in progress, however, for perfecting the techniques required.

Such a system would use lightweight beacon transponders to go along with digital communications. Rome Air Development Center now has a project to develop a very small, lightweight radio weighing from three to five pounds including power supply. Power supply must be small, limiting transmission capability, but this is not a handicap with digital techniques.

RADAR—Another TAC need is for airborne warning and control radar that detects other airborne targets while operating over land areas. Navy is working on this problem for their Grumman-built E2-A Hawkeye (formerly designated W2-F1). USAF will either share Navy's work or initiate its own.





PASSIVE ORIENTATION *and Damping System by GE has two rigid cross booms and a pair of inflated solar anchors that line up with the sun's rays. At right is Vertistat, developed by General Dynamics/Astronautics. In this photo, reels of BeCu tape have just started to deploy*

Latest Satellite Stabilizers Let Gravity Do the Work

GRAVITY-GRADIENT stabilization systems for earth-oriented satellites are moving swiftly into the forefront of efforts to replace electronic and other types of active attitude control with passive systems.

Passive stabilization still poses problems, but experts in the field expect the impact of newly developed techniques to be felt soon. Passive systems can be lightweight and, once deployed, consume no fuel or power. If successful, they could significantly affect satellite design and use by eliminating the need for electronic attitude controls, ir horizon sensors, gyros or gas jets.

With communications and weather satellites seen as major users, NASA is "taking a long, hard look at" passive systems for long-life, operational spacecraft. The Communications Satellite Corporation says it is seriously interested. Passive attitude control also intrigues designers of navigational, data gathering, geodetic and ionospheric satellites—in fact, any satellite that requires a direct view of the earth's surface.

One system, developed by Applied Physics Laboratory (APL) of Johns Hopkins University, is now pointing a Navy satellite toward earth (ELECTRONICS, p 7, Aug. 2). Other organizations studying or developing systems include General Electric, Bell Telephone Labs., General Dynamics/Astronautics, NASA's Ames Research Center, the Rand Corp. and the University of Toronto's Institute of Aerophysics. The latter has described a system said to provide damping to one-half amplitude in one-third orbit.

ADVANTAGES — While they would remove electronics from the attitude control function, passive stabilizers could increase utility of on-board electronics simply by extending the satellite's useful life.

If a communications satellite's antenna constantly pointed at earth, a narrower beam requiring less power could be used. Channel capacity could be doubled or tripled. At low and medium altitudes, passive earth-orientation would allow for 6 to 10-db gain over existing systems, according to Greg Andrus, acting chief of communications satellite technology at NASA.

Problems with Nimbus' ir horizon sensor frequency caused some of the slippage on this program at the very beginning. A few hours after Syncom I's launch, a nitrogen gas tank that fed attitude jets exploded (ELECTRONICS, p 18, July 19).

HOW THEY WORK—If a dumbbell is tossed into orbit, one end —either end—will face the earth while the bar connecting the two weights aligns with the local vertical. This is due to the gravity-gradient effect—the decrease in gravity with increase in distance from earth—which tends to torque the long axis of an elongated body towards the vertical. Likewise, difference in the gravitational forces on the ends of a long rod make one end point down to earth. This basically, is the effect employed by gravity-gradient stabilizers to keep a satellite earth-oriented.

APL's system stabilized the Navy satellite at its 400-mile altitude with a 100-foot-long beryllium-copper (BeCu) boom. To damp boom oscillations, APL attached a weight to the end of the boom with a 40-foot spring. The weight moves up and down on the spring like a yo-yo until oscillations end. APL's is a two-axis system using a single-axis damper.

General Dynamics' Vertistat, a three-axis system, uses three rods. A primary rod is vertical to the satellite and for synchronous altitudes is 600 feet long, with the spacecraft in the middle. Two secondary rods, 320 and 240 feet long, intersect at right angles at the top of the satellite and extend horizontally. The shorter rods are

Pulse Radar to

CAMBRIDGE, MASS. — Transponder-augmented pulse radar will guide Gemini astronauts to a rendezvous in space with an unmanned Agena target vehicle (ELECTRONICS, p 18, Feb. 8). First details of the prototype model were disclosed Aug. 14 at the AIAA Guidance and Control Conference at MIT by Wil-

THERE'S NOTHING NEW UNDER THE SUN

Gravity gradient stabilization may be new to man, but not to nature—after all, the principle has kept the moon facing our planet for years. The gravitational forces involved were first accurately described by the French mathematician J. L. Lagrange in 1764. There was, however, a fairly good reason for the 200-year time lag in practically applying the principle—there were no man-made satellites

By JOEL STRASSER
Assistant Editor

mounted on flexure pivots and remove oscillations by viscous damping. Rods are preformed BeCu tape flattened and rolled onto storage spools. In orbit, the tapes unreel and form into rods.

GE's three-axis configurations use two rods 25 to 50 feet long intersecting at a 60-degree angle at the center of mass of the satellite. The effect is the same as a simple boom; local vertical passes through the middle of the acute angle. Passive Orientation and Damping System (Pods) adds a pair of solar anchors that act like a wind sock to line up the sun's rays. In the Gravity Anchored Passive System (Gaps) one cross-boom is rigid and one is movable and coupled to a spring and damper. Gaps is designed for polar orbits and has no inclination restrictions. Both are compatible with stationkeeping requirements and may be used from low to synchronous altitudes.

Guide Gemini

liam W. Quigley, of Westinghouse Air Arm division.

In the system—virtually all solid-state—pulse round-trip time will measure range, and interferometer techniques (ELECTRONICS, p 106, Nov. 30, 1962) will be used for angle measurements. The system will provide digital angle and range information to the spacecraft computer from 250 nautical miles to 500 feet, and display analog range and range rate from 300,000 feet to 20 feet. Digital command link between Gemini and Agena is provided by encoding the radar's interrogation pulses.

PULSE TECHNIQUE — The Gemini interrogator-radar will transmit pulses from an antenna that has a 3-db, solid-angle coverage of 70 degrees. The Agena transponder's reply will be offset in frequency to provide discrimination between the reply and reflected signal, so the Agena will appear to be a point source. Also, the reply pulse will be delayed to arrive after receiver blocking is cleared, enabling tracking into essentially zero range. Interrogation pulses are 1 μsec long at a prf of 250 pps in an L-band frequency. The transponder replies with 6-μsec pulses.

Target line-of-sight angle will be obtined by measuring the difference in r-f path length to receiving antennas. Three antennas are located on orthogonal lines within the roll reference plane. A pair of antennas establish the azimuth direction and a pair establishes the elevation direction. One antenna at the intersection of the lines is common to both channels. One novel technique is using the circularly polarized antenna as a phase shifter.

Each received pulse is time-shared to measure range, elevation and azimuth angle, so only one receiving channel is needed. For r-f switching at submicrosecond speed, Westinghouse developed solid-state microwave diode switches with high phase stability.

Sonar Navigates at 1 Mc

UNDERSEA acoustic doppler navigation aid, operating at a frequency of 1 Mc, will supply continuous speed and course plot for the Woods Hole Oceanographic Institute's new 2-man research submersible, Alvin. The craft, designed to study the sea floor at depths down to 6,000 feet, will be launched in about three months.

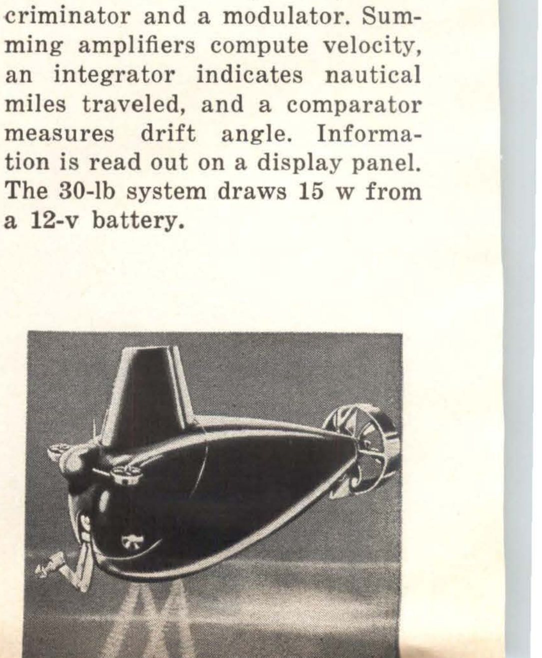
The system was originally developed to aid small pleasure craft. Now it is getting military and research applications for the Navy and various oceanographic study groups, says the developer, Janus Products, of Syosset, N. Y.

Coupled with a north-seeking gyro compass and including an analog computer, the system will calculate true over-the-bottom-velocity and drift angle to accuracies of 1.5 percent and 0.3 degree respectively, as well as true distance traveled. It is sensitive to minimum movements of two yards in any direction and has a range of 250 feet, Janus says.

BEAM PATTERN—Four 3½-degree-wide beams are directed in pairs fore and aft, port and starboard to account for the craft's pitch and roll. Transmitting frequency is controlled by a crystal oscillator in the transducer housing. Acoustic power output is 1 watt c-w per transducer.

Backward reflection, shifted in frequency and sensed by four receiving transducers, indicates velocity. When added vectorially, the four beams give the submersible's drift angle, true speed over sea floor, and when integrated, give distance traveled.

The receiver comprises four transducers and amplifiers, a discriminator and a modulator. Summing amplifiers compute velocity, an integrator indicates nautical miles traveled, and a comparator measures drift angle. Information is read out on a display panel. The 30-lb system draws 15 w from a 12-v battery.



TWO PAIRS *of acoustic doppler beams will be used to detect path of Woods Hole vehicle over ocean bottom*

MEETINGS AHEAD

DATA PROCESSING NATIONAL CONFERENCE & EXHIBITION, Association for Computing Machinery; Denver Hilton Hotel, Denver, Colo., **Aug. 27-30.**

AUTOMATIC CONTROL INTERNATIONAL CONGRESS, International Federation of Automatic Control; Basle, Switzerland, **Aug. 27-Sept. 4.**

MILITARY ELECTRONICS NATIONAL CONFERENCE, IEEE-PTGMIL; Shoreham Hotel, Washington, D. C., **Sept. 9-11.**

ELECTRICAL INSULATION CONFERENCE, IEEE, NEMA; Conrad-Hilton Hotel, Chicago, **Sept. 10-14.**

JOINT ENGINEERING MANAGEMENT CONFERENCE, IEEE, ASME; Biltmore Hotel, Los Angeles, **Sept. 12-13.**

INTERNATIONAL ASSOCIATION FOR ANALOG COMPUTING, AICA; Brighton College of Technology, Lewes Rd., **Brighton, England, Sept. 14-18.**

INDUSTRIAL ELECTRONICS ANNUAL CONFERENCE, IEEE, ISA; Michigan State University, East Lansing, Mich., **Sept. 18-19.**

NATIONAL POWER CONFERENCE, IEEE, ASME; Netherland-Hilton Hotel, Cincinnati, Ohio, **Sept. 22-25.**

INTERNATIONAL TELEMETERING CONFERENCE, IEE, IEEE, ISA, ARS, IAS; London, England, **Sept. 24-27.**

PHYSICS OF FAILURE IN ELECTRONICS SYMPOSIUM, Armour Research Foundation and Rome Air Development Center, Illinois Institute of Technology, Chicago, **Sept. 25-26.**

ELECTROCHEMICAL SOCIETY FALL MEETING, ECS; New Yorker Hotel, New York, **Sept. 29-Oct. 3.**

CANADIAN ELECTRONICS CONFERENCE, IEE REGION 7; Automotive Bldg., Toronto, Ont., Canada, **Sept. 30-Oct. 2.**

SPACE ELECTRONICS NATIONAL SYMPOSIUM, IEEE-PTG-SET; Fontainbleu Hotel, Miami Beach, Fla., **Oct. 1-3.**

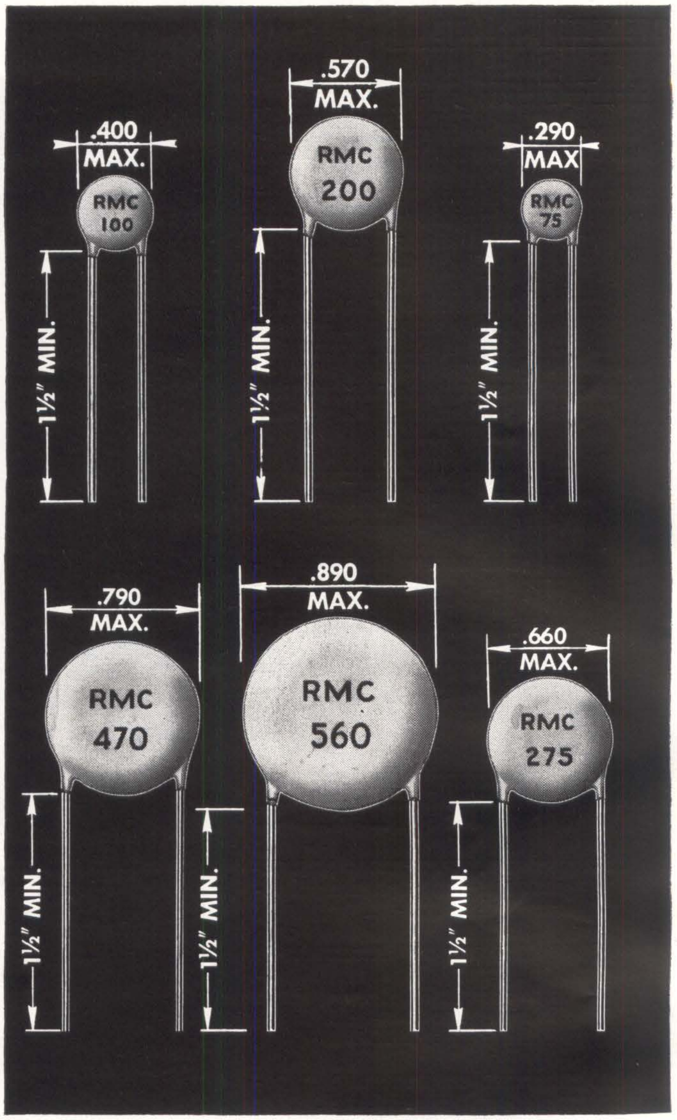
PHYSICS & NONDESTRUCTIVE TESTING SYMPOSIUM, Southwest Research Institute; El Tropicana Hotel, San Antonio, Texas, **Oct. 1-3.**

ELECTROMAGNETIC RELAYS INTERNATIONAL CONFERENCE, IEEE, ICER, IEE, Tohoku University, Science Council of Japan; Sendai, Japan, **Oct. 8-11.**

ADVANCE REPORT

SPRING JOINT COMPUTER CONFERENCE, *American Federation of Information Processing Societies; Washington, D. C., April 21-23, 1964; Oct. 25 is deadline for submitting complete draft in five copies to Jack Roseman, program committee chairman, C-E-I-R Inc., 1200 Jefferson Davis Highway, Arlington 2, Va. Some invited topics: analog and hybrid systems, compilers and translators, displays, industrial process control, man-machine systems, medical diagnosis and data processing, military and space applications, social implications of information processing. Drafts should include 100 to 150-word abstract and be under 10,000-word limit.*

CIRCLE 19 ON READER SERVICE CARD



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NPO	1-15	16- 33	34- 69	70- 85 MMF	86-115 MMF	116-175 MMF
N- 33	1-15	16- 33	34- 69	70- 85	86-115	116-175
N- 75	2-15	16- 33	34- 69	70- 95	96-130	131-190
N- 150	2-15	16- 36	37- 67	68- 95	96-130	131-230
N- 220	2-15	16- 36	37- 75	76-100	101-160	161-230
N- 330	2-20	21- 51	52- 75	76-115	116-190	191-270
N- 470	2-20	21- 51	52- 80	81-120	121-200	201-275
N- 750	2-32	33- 75	76-155	156-220	221-300	301-470
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electronics

A McGraw-Hill Weekly *August 23, 1963*

VC 10 LINER *comes in for a landing during trial run of British Autoland System*

Why U. S. Lags Europe in AUTOMATIC LANDING

Economics and the weather are moving development and application of blind landing systems much faster in Europe than in the United States. This article explains why and describes the basic concepts of European developmental and operational systems

By R. E. YOUNG
Consultant; 12, Whitnash Road
Leamington Spa, England

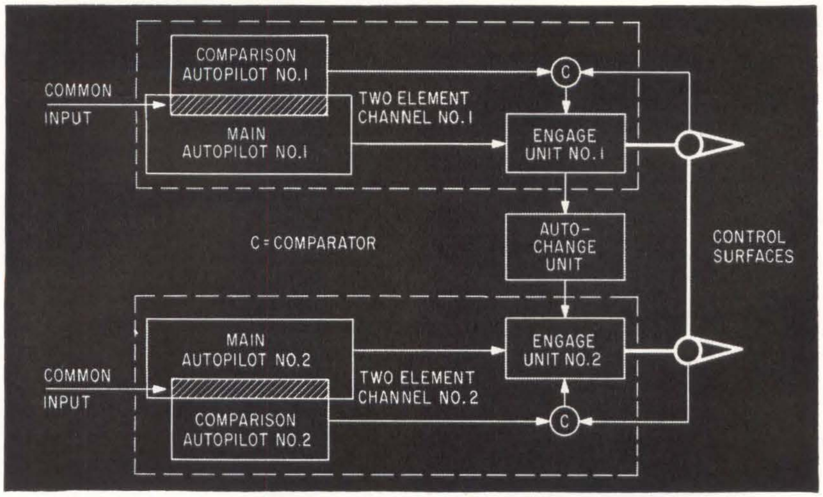
IN EUROPE, automatic landing of aircraft is well beyond the development stage. The British Auto-Land system, about to go into service, had over 10,000 fully automatic landings to its credit before the end of 1962; the Lear-Siegler system, the latest to be disclosed, has been building up a record of successful landings at a rate of more than six per day in France since mid-1962.

Yet, in the U.S., automatic landing remains largely a matter of evaluation. A number of promising schemes have been put forward but no firm decision has been taken. Does this mean that U. S. airline operators and the U. S. public are less interested in safety in the air than European airlines and European public opinion?

Clearly this is not so—the standards and the sense of responsibility of the U. S. airlines are as high as any airline in the world.

Why then, is the scale of development and application of automatic landing so much greater in Europe than in America?

WEATHER—The answer is to be found largely in economic pressures, which are determined partly by the different weathers of Europe and America. Before considering the statistics of all-weather operations, the problem of ever increasing landing speed—which will be aggravated in the not



MULTI-CHANNELS *increase reliability. Shown here is the monitored-duplicate system, which is used in Elliot Bros. version of British Autoland system—Fig. 1*

too distant future by the change-over to supersonic airliners—should be examined.

Even with present day jet aircraft, landing speeds are much in excess of 100 mph. Thus, the reaction times demanded of the pilot are such that he has become a limiting factor in the control loop. As a result, there will undoubtedly be a move to substitute automatic control—perhaps only rate-aided as distinct from direct control—for landing supersonic airliners and perhaps this policy may be adopted even for subsonic types.

However the compelling reason for the use of automatic landing methods at the present time is to defeat zero-zero weather—thick fog or blinding rain. The former is by far the bigger hazard in Western Europe and probably has its greatest effect in the British Isles.

Figures given[1] for British European Airways indicate that nearly $200,000 per year could be saved if diversions to other airfields made necessary by fog at London Airport could be avoided. This sum—for an individual airline operating out of the one airport—was an average derived over a period of 16 years. The peak value, of over $500,000, was reached in 1958/59 which was one of two bad winters experienced during these years.

Added to this incentive to adopt a blind-landing system is the gain resulting from the avoidance of accidents. To assess this gain it is necessary to adopt some arbitrary reliability criterion which will be acceptable operationally. At present this is a failure rate better than 1 in 10^7, that is, less than one failure in 10 million landings. Superficially this appears to be more than high enough. However, with airline fleets carrying out more than 100,000 landings in a year (British European Airways makes 128,000 landings), the margin is small for a normal statistical distribution and a failure rate of 1 in 10^8 would be a better criterion.

Since the modern airliner costs around two million dollars and completely effective all-weather landing would prevent the one catastrophic accident in 7 years, its adoption would "save" $300,000 a year over this period. An additional saving of $300,000 or more would be made since the aircraft would remain in service and earn revenue.

Therefore, a single airline might save more than five million dollars over a seven-year period by using all-weather landing. If this figure is multiplied by the number of European-airline landings at London Airport only, it enters the tens of million dollar region; such figures go far towards explaining the high expenditure of money and effort which has gone into all-weather landing in Europe.

There are other factors, not found in America, which have increased the pressures to develop blind landing in Europe.

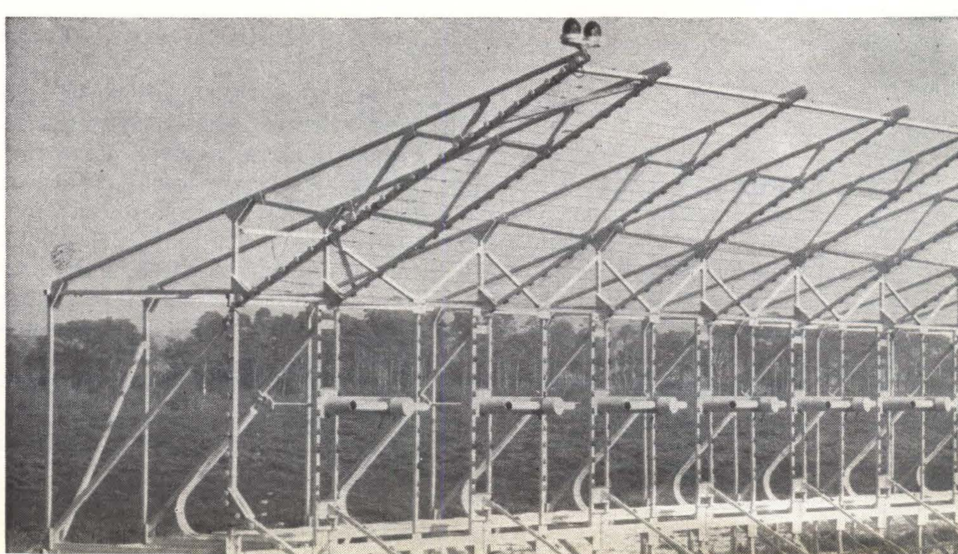
As in most parts of the world, European airports tend to lie 5 to 10 miles from the city center, and the journey to and from the air terminal is rarely less than 40 minutes, and may be one hour.

The helicopter solution seems to be less practicable in Europe than in the U. S. One reason for this is that traffic tends to be concentrated through one large national airport such as London or Schipol (Amsterdam) and the insertion of helicopters into an already over-taxed air traffic control pattern is difficult. Also, stage lengths for European internal services are much shorter than in America. Two comparable runs are Birmingham to Manchester (75 miles) and San Francisco to Los Angeles (350 miles), the traveling public being much the same on both.

Therefore other means of transport, particularly the high-speed trains in Europe, become highly competitive. As soon as fog delays take-off or imposes diversion of aircraft, this competition increases.

THE BRITISH AUTOLAND SYSTEM

BASIC SYSTEM—The all-weather landing system developed by the



WE'RE MOVING AHEAD TOO

Although the U. S. has yet to put into service a commercial all-weather landing system, progress is being made in this field as summarized in this week's CROSSTALK (p. 3). Latest step forward was taken by the FAA when it recently granted a $1,082,000 contract to Airborne Instruments Laboratory for the development of an experimental second-generation all-weather system.

The AIL system, based on radio guidance techniques, would scan the sky from two runway ground installations, determine the aircraft's position in height, azimuth, and distance, and display the necessary information in the cockpit of the airplane and in the control tower. Under all weather conditions the system would furnish complete radio guidance during aircraft approach and landing.

A test version of the system is expected to be installed in two years

Blind Landing Experimental Unit (BLEU) of the Royal Aircraft Establishment, England is based on magnetic leader-cable and a radio altimeter for guidance in azimuth and elevation, respectively. It is essentially a fully automatic system, that is, during landing the aircraft is completely under the control of the autopilot which is guided by the intelligence fed into it.

One advantage of the leader-cable method is that the signals it delivers to the aircraft are sufficiently strong to be noise-free," while constant sensitivity, not possible with radio beams, is maintained. An rms accuracy of better than 10 feet from the center-line is obtained consistently.

The two ground-return magnetic leader cables are usually buried a few feet below the level of the runway, and some 250 feet on each side of its center-line. (For temporary installations they may be laid on the surface.) Cable current, about 4 amperes, is obtained from an inductor alternator that is set up to give equal currents to the two cables. "Left/right" identification is established by allocating specific frequencies, 1,070 and 1,750 cps to the individual cables, detection being by rotating loops mounted on the nose of the aircraft. One immediate advantage of the system is its narrow (1 Kc) signal bandwidth. Hence the system has a narrow noise bandwidth that compares favorably with that of a radio method.

Opponents of the leader-cable principle are chiefly concerned with installation problems posed by the cables, which have to be installed not only along the runway but beyond it. This may be nearly impossible in some cases (a surprising number of major airports are approached over an estuary or an inlet of some kind) and completely impracticable where, as at Hong Kong, the runway is built out into the sea. However, there is a compensating advantage in that the leader cables can be extended to give guidance from the end of the runway to the terminal building if required, an extremely valuable aid for ground handling during thick fog.

Another fundamental principle used in the Autoland system is that initial guidance is obtained from conventional ILS (Instrument Landing System) signals in both azimuth and elevation. Transfer to leader-cable guidance in the horizontal plane takes place about one mile before the aircraft reaches the runway. The corresponding changeover in the vertical plane involves three distinct phases of aircraft descent.

The first phase is automatic descent under ILS-signal guidance. The next phase is a "constant-attitude" phase lasting from 200 ft to approximately 50 ft above the runway; during this phase, the rate of descent is held at a value determined by the attitude of the aircraft in pitch. The last part of descent, the "radio-altimeter flare-out", takes place from the critical height of 50 to 60 ft to final touchdown.

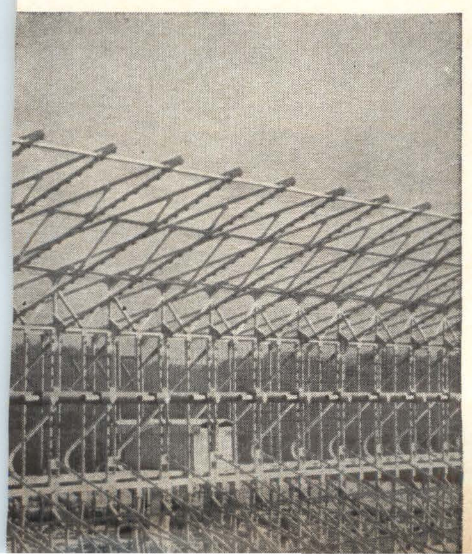
The desired flare-out path, which is exponential, is obtained by implementing the following control equation

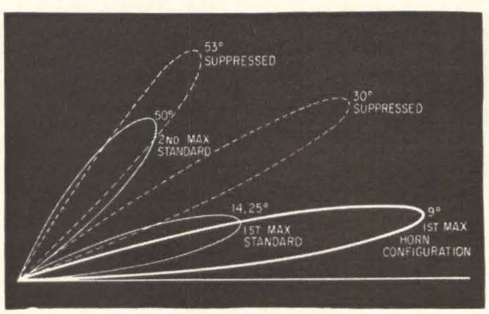
$$\theta_D = h + \tau\ (dh/dt)$$

where θ_D is the pitch attitude (demanded) and h is the height of the aircraft. Time constant τ, which has to be kept at a value of about 5 sec., is made short to avoid the build-up of excessive servo lags.

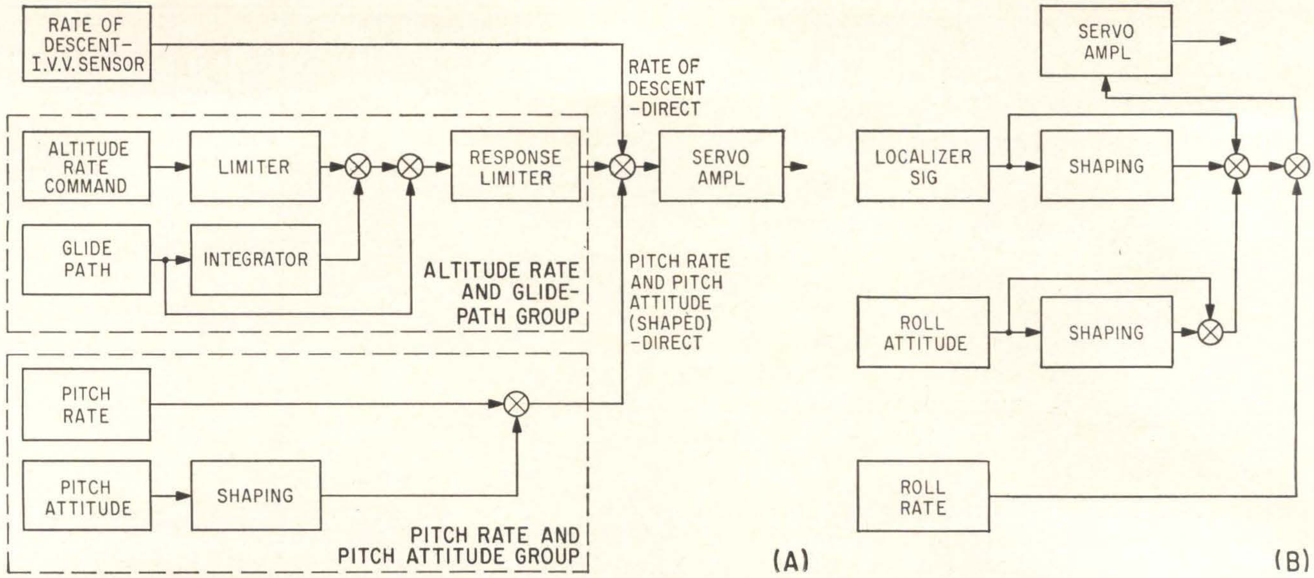
The other major component of the Autoland process is automatic throttle control, engine speed being adjusted throughout.

Thus, this landing system is completely automatic. Not only is the pilot no longer in the control loop once Autoland is engaged, but it is assumed that from that point onwards he will not be called upon to take back control. This philosophy brings with it a number of far-reaching consequences, and is in





AZIMUTH GUIDANCE *is provided by this 165-foot-wide antenna array (photo). The drawing shows radiation patterns; heavy lines denote single-lobe pattern achieved with final design—Fig. 2*



LEAR-SIEGLER *landing system is comprised of vertical-control (A) and lateral-control (B) subsystems—Fig. 3*

marked contrast with that of the corresponding American workers.

The main issue is the role of the pilot during a zero-zero landing. The American attitude is that he should be a "systems manager" and that even with automatic landing he should not be in a subordinate position to the machine. Opposed to this view is the BLEU thesis—that the pilot's authority is surrendered entirely during all-weather landing.

In turn, this leads to the question of monitoring which is closely dependent upon the landing method. The monitoring systems being developed in the U.S. are of the "head-up" type giving a television view of the outside world, and therefore offer a means of blind landing in their own right.

Two main arguments are brought against such visual methods. One is that if the display is fed from the control equipment itself then it is suspect, if not useless, when it is most wanted—during an emergency. The alternative, a completely independent system, as discussed later, is extremely costly and there are formidable technical difficulties in the way.

Therefore the BLEU approach is to undertake a series of in-flight "confidence checks" of the equipment just before going over to automatic control. During a landing, the pilot sits with his arms folded, and to the most hardened observer there is something uncanny about the movement of the engine throttles in their quadrants with no human agency involved.

Aircraft-landing reliability must be beyond question. Translated into the probabilities necessary in an imperfect world, this has been taken as an obligation to meet the better than 1 in 10^7 criterion, and has led to the development of duplicated and triplicated system designs.

DUPLICATION—The all-weather system produced for the VC 10 (see photo) by Elliott Brothers (London), Ltd., is known as the "monitored-duplicate" type. It is claimed that this principle produces a failure-survival capability equivalent to that of a fully triplicated arrangement. As Fig. 1 shows, the system has 100 percent redundancy at all vital points on each of the two channels, and that this is backed-up by quadruplicating the basic electrical system, and, in effect, the control surfaces. This system engages only one autopilot at a time.

Although the Smith Aviation system for the Trident airliner is at duplex level, a triplex version has been produced for the Belfast heavy transport. Smith's basic approach is to use a multiplex autopilot with two or more subchannels operating together, thus providing continuous redundancy. In a triplex installation, failure of one subchannel causes an automatic changeover to the duplex level; thus, faults are cleared by switching out defective elements rather than changing over to stand-by equipment. If, at the duplex level, one of the two subchannels fails, it is switched out completely to give simplex operation, the design being such that no disturbance is caused to the control of the aircraft.

AZIMUTH GUIDANCE — By obtaining guidance in azimuth continuously from one system only, for example, ILS, during landing, a working discontinuity is avoided. Other advantages, such as reduced complexity, accrue, as compared with the mixed ILS-leader-cable scheme.

Standard Telephones and Cables, Ltd., have demonstrated this possibility with an antenna system. This system meets the severe ICAO (International Committee of Aviation Organizations) "Category 3" demands for full guidance from 25 nautical miles out to touch-down and roll-out along the whole runway.

The wide-aperture antenna complex (Fig. 2) is 165 ft across, contains 24 horizontal dipole elements with graded feed and produces a 4-deg beam to null points (see Fig. 2).

In the vertical plane, the wire-mesh horn reflector produces a single-lobe radiation pattern with its maximum at 9 degrees elevation. The dipoles are raised to 1½ wavelengths from the ground compared with the 1 wavelength of the standard antenna system. This gives a first lobe maximum at 9 deg instead of the standard 14.25 deg.

An added advantage of the horn

type reflector is the 10-db gain obtained with it along the approach. This enables the transmitter power to be reduced (from 16 watts) to 3 watts or less, and permits the complete transistorization of the localizer ground equipment.

RADIO ALTIMETERS—Standard Telephones and Cables has carried out a program of development of radio altimeters for the Autoland system. Their latest radio altimeter is the STR 52 an f-m unit whose transmitter is swept over a band of 100 Mc about a mean transmitter frequency of 4,300 Mc. The f-m rate is 300 cs and the counter integrating time about 0.25 second.

Height accuracy is ±3 percent or ±3 ft (whichever is greater) within the height range of 0 to 500 ft. This becomes ±1 ft at touchdown.

This value at touchdown is of vital importance because of the need to have a small but positive dh/dt at this point. Consequently, the zero height datum has to be set below ground level. Thus, with a virtual datum at about −2 ft, altimeter wander must be kept well inside the 1-ft tolerance.

Up to 50 ft of feeder cable can be interposed between the set and the antennas. The antennas are of "suppressed" slot form, and are extremely compact.

An in-flight confidence check is provided by switching an r-f delay line into the transmitter-receiver antenna external path. This simulates a ground return signal corresponding with the critical height at the changeover to flare-out under altimeter (derived) control.

LEAR-SIEGLER SYSTEM

In the broadest sense this system shares the basic principles of the Autoland method, but there are many differences between them in philosophy and design.

The system works with existing ILS ground installations, and either standard or more directional localizer beams can be accepted.

The design aim is to give smooth control during the whole of the approach—landing sequence, a high premium being placed upon the avoidance of switching of the direct control signal during this time. This basic policy can be traced throughout various sections of the Lear-Siegler system.

In the vertical plane, for instance, the ILS glide-slope error signal is not fed directly into the autopilot, but is used as a modifying term in the rate of descent which has been established as a command from the Instantaneous Vertical Velocity (IVV) Sensor (Fig. 3A). Thus, the aircraft follows the glide slope beam, but is not affected directly by perturbations and noise in the ILS beam signals, which are smoothed and limited before being fed into the autopilot servo amplifier.

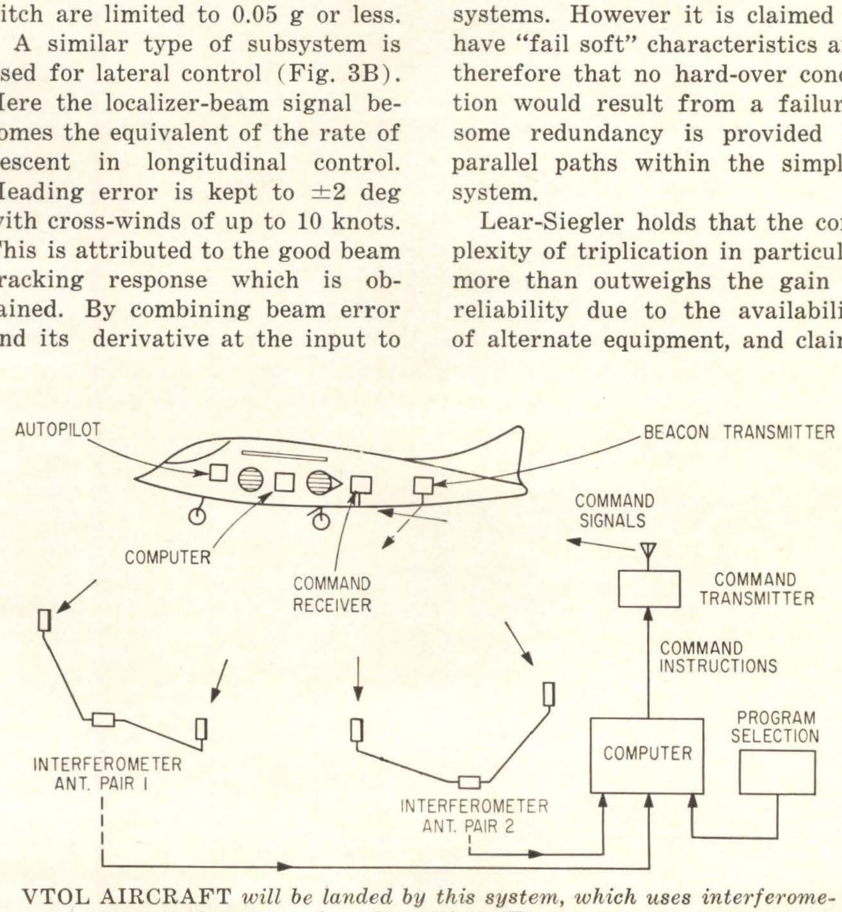
Because of the distorted pattern of the glide-slope beam below the ground interference angle, the error-signal gain is reduced linearly from a height of about 200 ft to give zero signal into the loop at 50 ft, when flare-out begins. At this height, a radio altimeter replaces the glide-slope error signal to modify the commanded rate of descent according to a predetermined program. As with the Autoland system, the exponential flare-out is arranged to give a positive rate of descent at touchdown, in this case approximately 2.5 ft per second. It is claimed that all commands in pitch are limited to 0.05 g or less.

A similar type of subsystem is used for lateral control (Fig. 3B). Here the localizer-beam signal becomes the equivalent of the rate of descent in longitudinal control. Heading error is kept to ±2 deg with cross-winds of up to 10 knots. This is attributed to the good beam tracking response which is obtained. By combining beam error and its derivative at the input to the lateral-control servo amplifier, gyro-heading signals and related integration stages are no longer required. A basically similar servo loop system is also used for throttle control. The primary control term is indicated airspeed which is compared with demanded airspeed to give normal error signal adjustment. Other terms such as pitch attitude (after shaping) can be fed into the system, while either angle of attack or a fore/aft accelerometer can be used instead of indicated airspeed.

The automatic throttle control facility can be used at any time, although the first call on it is for automatic landing, transfer to digital computer instructions being made for the flare-out phase. However, the pilot can override the system or synchronize the engines by individual throttle adjustment. He can do this, either by applying about 25 lb hand pressure or by using a switch, through a disconnect capstan embodying a mechanical slip clutch.

The Lear-Siegler philosophy is in marked contrast to that of Autoland in that it is a simplex system with no duplication of its main subsystems. However it is claimed to have "fail soft" characteristics and therefore that no hard-over condition would result from a failure; some redundancy is provided by parallel paths within the simplex system.

Lear-Siegler holds that the complexity of triplication in particular more than outweighs the gain in reliability due to the availability of alternate equipment, and claims



VTOL AIRCRAFT *will be landed by this system, which uses interferometer antennas to determine aircraft position—Fig. 4* that they will meet the 1 in 10^7 criterion with their simplex system. They also feel that although full automatic landing implies that the pilot should not be expected to take over during the last 100 feet, nevertheless he should be given a continuous situation display all through this phase to touchdown. (Autoland philosophy as stated by Smith's is that the pilot's task becomes exceedingly difficult below 100 feet and that it is preferable to confine monitoring to a "system display" which indicates that the autopilot is working satisfactorily).

DEVELOPMENT TRENDS

VTOL GUIDANCE—The problem of developing landing systems for VTOL (vertical takeoff or landing) aircraft has been tackled by the Royal Aircraft Establishment, Farnborough, England. Their proposed system (Fig. 4) is integrated between aircraft and ground within a general air traffic control framework.

This is a closed-loop system in which a ground controller selects a suitable approach path for a particular aircraft; from this point on, landing is automatic. The approach path is stored as a program in the system computer. Aircraft control is established by reference to this program and comparison with the actual position of the aircraft.

Aicraft position , is measured continuously by microwave interferometers and this data (azimuth, elevation, and slant range) is processed to bring it into a form suitable for handling by the computer.

The control instructions produced from the computation/comparison process are transmitted to the originating aircraft over a multiple-channel data link. The link is multiplexed because it is intended that up to ten aircraft will be handled simultaneously.

One of the main objections made in the past to this closed-loop type of landing system is that the ground computer has to be set up afresh for each aircraft whenever its handling characteristics differ from the one preceding it. This leads to a number of disadvantages particularly delay and the possibility of error. However in the proposed scheme these difficulties are overcome by the use of a simple airborne computer in each aircraft which sets into the control chain such terms as loading, for handling that particular aircraft.

The interferometer equipment can be made relatively simple because of the strength of the signal produced by the identification beacons carried by each aircraft. The degree of obstruction to line-of-sight radio paths would determine the number of interferometer antenna pairs required, which would lie between the theoretical minimum of one and a maximum of three or four.

VISUAL PRESENTATION RADAR—Such systems use a primary radar in the nose of the aircraft working in conjunction with passive beacon runway markers to give a television-type display to the pilot.

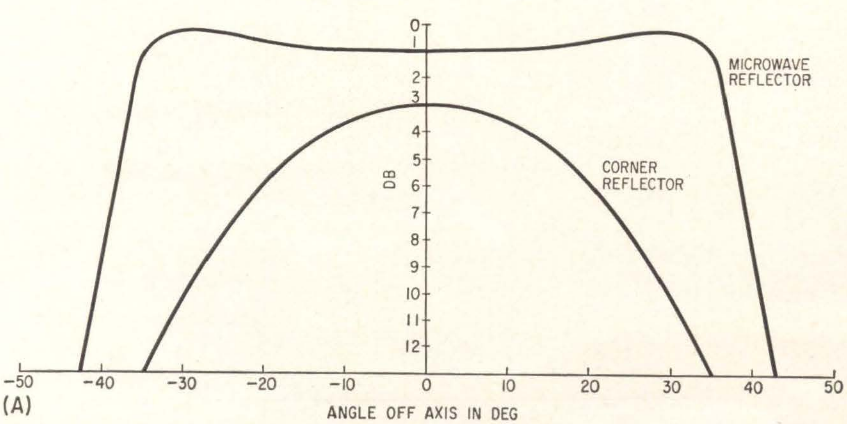
The low signal strength obtainable from passive reflectors has been a serious obstacle, but a new spherical microwave reflector designed by British Aircraft Corp. has an echo area that is eight times that of the equivalent corner reflector. Furthermore, as shown in Fig. 5A, this echo enhancement, which is produced by lens action, is maintained at an almost uniform level over a much wider angle than for the corner reflector. This improvement, when linked with another new development, the high-power bombarded-cathode magnetron, might make it possible to produce a practicable passive reflector system in the not too distant future. These new magnetrons (by Ferranti, Edinburgh) are designed around a high-temperature thoriated-tungsten cathode and give a peak power of 1 Mw at X band, and from 100 to 150 Kw at Q band (average powers are 1 Kw and 100 w respectively).

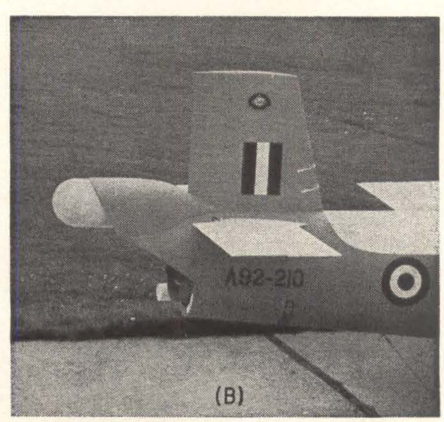
Even at this stage of development, these figures give grounds for hope. A comparatively simple design analysis for an X-band system shows that, with an additional power margin of 47 db with the new magnetron and the improvement in gain obtained from the new reflectors, it should be possible to work through heavy tropical rain. This is the worst operating condition, where the two-way attenuation for a 6-mile path could reach 30 to 40 db, or perhaps more in extreme cases.

Collisions in the air are a growing hazard. The new passive beacons working in conjunction with the airborne landing radar might supply the answer to this hazard. An aircraft carrying these reflectors (Fig. 5B) would show up as an unmistakable signal.

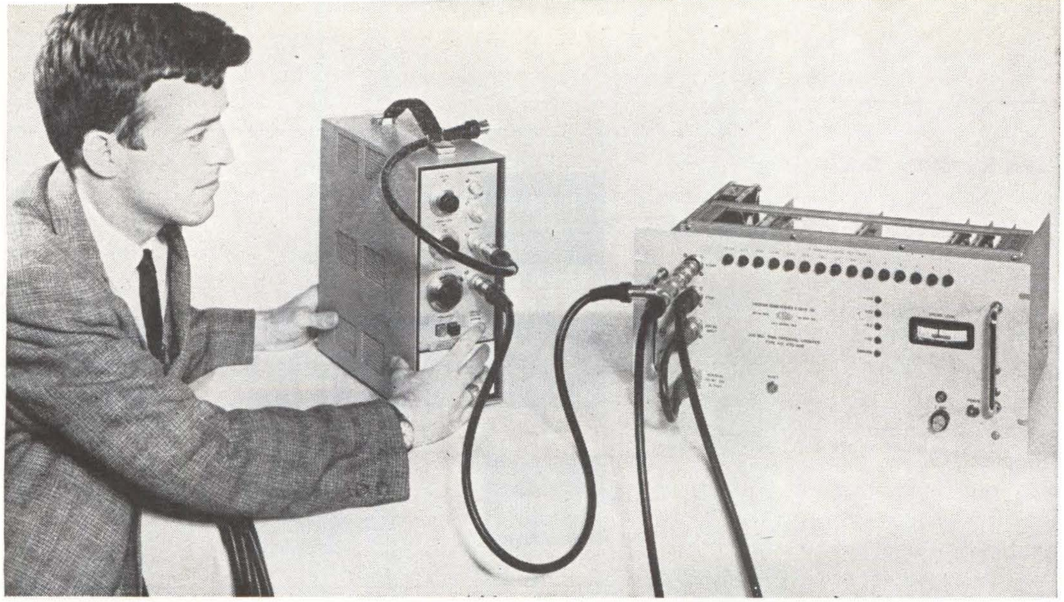
REFERENCE

(1) All-Weather Landing—The Last 100 Feet, *Intl Fed of Air Line Pilots Associations (IFALPA) Conf*, Amsterdam, 1962.





PASSIVE SPHERICAL REFLECTOR *returns more power over wider range of angles than corner reflector of equal aperture (A). A spherical reflector is mounted in aircraft tail (B); installation is simple and cheap—Fig. 5*



INTERVAL COUNTER *(right), pulse generator (left). Readout is taken from the row of digitally numbered lights along the top of the counter*

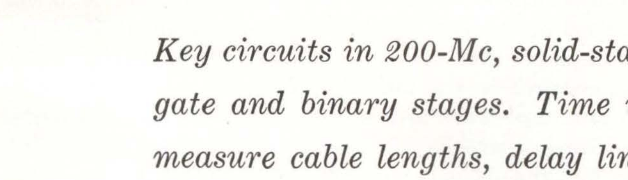
GETTING DOWN TO NANOSECONDS

VHF Counter Measures Time Intervals Precisely

Key circuits in 200-Mc, solid-state, interval timer are high-speed gate and binary stages. Time intervals accurate to 5 nsec can measure cable lengths, delay lines, transducer response time

By C. S. COFFEY, Edgerton, Germeshausen & Grier, Inc., Boston, Mass.

MEASURING TIME intervals of up to a second or so with high precision is becoming more important in electronics and physics. A preferred way to make such measurements is to count the number of cycles of a precision oscillator over the interval being measured. Limitations on the technique are oscillator precision and the maximum speed of the counter, which is typically accurate to ±1 cycle or count.



PULSE *starts the interval timer, then stops it after passing through the delay line. Length of the line is calculated from delay and propagation velocity—Fig. 1*

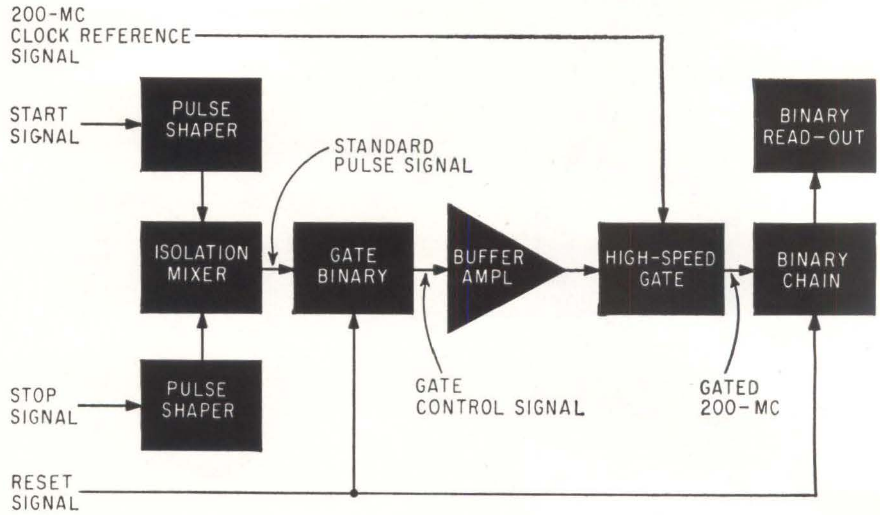
A recently developed counter with a clock rate of 200-Mc will provide a resolution of five nanoseconds, or an accuracy of 5 parts in 10^9. The resolution is sufficient to allow measuring the length of coax cables—such as RG-8, RG-17, RG-18, etc.—to within three feet for a single measurement and to within 0.67 ft for 20 measurements. Accuracy has been enough to save many hours when long cables for weapon test programs are being checked out. The measuring technique is shown in Fig. 1.

Special circuits in the 200-Mc interval counter (Fig. 2) are the high-speed gate, which controls starting and stopping the counting, and the high-speed binary counters. The high-speed gate is controlled by separate start and stop inputs through pulse trigger circuits. The unique design of the gate circuit provides a switching time on the order of 1 nsec. Counting is accomplished in straight binary form to allow simplicity and to avoid the complications of a feed-back pulse, as would be re-

DO OLD TRICKS EVER DIE?

A controlled or measurable time delay is one of the circuit designer's most useful tools. But circuit delays of one kind or another can also be the most important enemy in high-speed electronic circuits.

Sometimes a delay can be designed around or even turned to advantage. Sometimes a delay must be known and measured to high precision. The author shows how modern equipment and a well known trick can be used to solve new and old problems



START *and stop pulses control the high-speed gate, which in turn feeds a 200-Mc burst into the counter—Fig. 2*

quired for binary coded decimal counting at 200 Mc. The first four binaries of the counter (200-, 100-, 50-, and 25-Mc) can operate above 300 Mc. The remaining binaries are standard low frequency circuits. Clock frequency of 200-Mc is supplied by an external stable oscillator.

Circuits of the high-speed gates and binary counters are shown for *npn* transistors but similar circuits using *pnp* transistors have been constructed with equal success.

HIGH-SPEED GATE—Operation at 200-Mc places three requirements on the gate circuit: it must respond to frequencies greater than 200-Mc; switching time from either ON to OFF or conversely must be substantially less than the time base (T_s < 5 nsec); finally, switching the gate to either state should not introduce a transient into the system that could become a false signal.

The schematic of the high-speed gate is shown in Fig. 3A. The circuit is built around two pairs of transistors, Q_1, Q_4 and Q_2, Q_3. Emitters of the transistors in each pair (Q_1-Q_4, and Q_2-Q_3) are connected to a common load. Collectors of the opposite members of each pair (Q_1-Q_2, and Q_3-Q_4) are also connected to a common load. The two emitter and the two collector load circuits are identical: consequently, equal currents flow in each pair. Bases of like transistors of the two pairs (Q_1-Q_3, and Q_2-Q_4) are also connected to identical base circuits. The gate is switched by driving one of the common base connections positive (to about +0.3 volt) while simultaneously driving the other common base connection negative (to about −0.1 volt). Thus one transistor of each pair is turned on while the other is turned off. Since the gate is symmetrical it responds to symmetrical drive signals. Interchanging the drive signals switches the gate back to its original state.

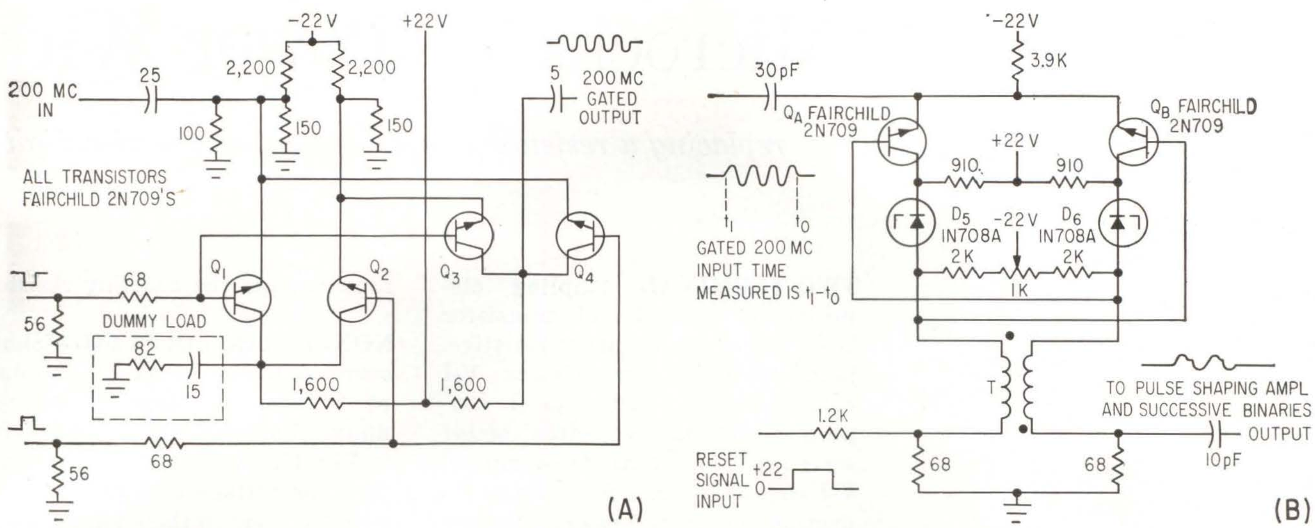
One transistor only in each pair conducts while the other is biased off. When switched to the complementary state, the roles of the two transistors in each pair are reversed. Since one transistor of each pair is always on, the total current through each pair remains constant and, ideally, no voltage change occurs at either the emitter or collector junctions during switching. When the gate is switched, the only change is in which transistor of each pair is conducting.

The 200-Mc clock signal to be gated is connected to the common emitter junction of Q_1-Q_4. If transistors Q_1 and Q_3 are conducting, the clock signal appears at the collector of Q_1 and is fed into the dummy load. In this state the gate is off. When the gate is switched, transistors Q_2 and Q_4 are conducting and the clock signal appears at the collector of Q_4 and at the output. In this state the gate is open. The dummy load approximates the load of the first binary counter and thus acts to provide a constant impedance to the 200-Mc input. Maintaining a constant impedance also aids in suppressing transients.

Since there is no significant voltage change at either the collector or emitter load points, the gate switching generates no transients that could appear at the output and be mistaken for a signal to be counted. Because there is no voltage change at these junctions and thus no energy storage time to consider, the switching time of the gate is low. Using Fairchild 2N709 transistors, typical switching time of the gate is 1 to 1.5 nsec. Because of the symmetry of the gate circuit, switching time is the same for switching either ON or OFF.

Both base input circuits are referenced to ground through a small resistor; consequently, the 200-Mc clock input is effectively channeled through common base amplifiers, which provide a considerable advantage at the frequencies involved. The output waveform is a gated replica of the input signal. Because the gate is transient free and fast, there is very little signal waveform distortion during either the ON or OFF transitions. Since there is no relation between the clock signal and the start and stop input impulses, the gate outputs are in random phase. The circuit as shown in Fig. 3A can gate one cycle of a 250-Mc sinewave with little distortion.

HIGH-SPEED BINARY—The high-speed binary counter, shown in Fig. 3B, is built around two transistors whose emitters are connected together and



HIGH-SPEED *gate (A) can turn on or off in 1 to 1.5 nsec. High-speed binary counter (B) can trigger on pulse widths of 1.5 to 3 nsec*—*Fig. 3*

driven from a high impedance, constant current source. Collector bias is obtained from zener diodes placed in the collector leg of each transistor. Base bias is obtained by connecting the base of one transistor to the collector resistor load of the opposite transistor in the pair. The high impedance, constant current drive acts as a current source and provides approximately 4 to 7-ma to the circuit. Emitters of the transistors are referenced to approximately 0.3 volt negative. When one transistor conducts, its biases the other off by lowering its base potential to that of the emitters. In turn, the nonconducting transistor holds the other transistor conducting by keeping its base above the voltage level of the emitters. The system is stable and, when balanced shows no preference for either state. Balancing, necessary to overcome transistor nonuniformities, is accomplished by a potentiometer that controls the d-c voltage level at both collector resistors.

In switching the binary counter from one state to another, an energy storage element (memory transformer) is used to insure that the binary does not return to the initial state. This memory transformer consists of a set of coils located in the circuits of the transistor pairs. Collector circuits of the transistor pairs are inductively cross coupled by the 1 to 1 inversion action of the memory transformer. Cross coupling provides an effective means of steering the bases of each side of the transistor pair during switching. The polarity of the induced field of the memory transformer gives the proper direction in determining which side will conduct next.

To switch the binary counter, a positive pulse is applied to the emitters of the transistors, momentarily cutting off both transistors. Through the action of the memory coils in the collector circuits, the base of the initially OFF transistor is driven positive and the base of the initially ON transistor is driven negative. After the trigger signal has passed, the base biases are reversed from their initial state and the circuit is switched to its complementary state.

The inductive type memory device places limits on the duration of the trigger pulse. If the trigger pulse persists too long, the inductive time constant, which constitutes the memory, will have time to decay and the memory effect will be lost. The pair of transistors may then cease to act as a binary counter. For operation at 200-Mc, a coil with an LR time constant of about 1.5 nsec was used. This coil had an inductance of approximately 0.1 μh and consisted of 2 turns of Awg No. 19 enameled wire wound bifilarly on $\frac{1}{2}$-inch diameter aircore forms; for the lower frequency counting stages, the coils were of higher inductance and consisted of a larger number of turns.

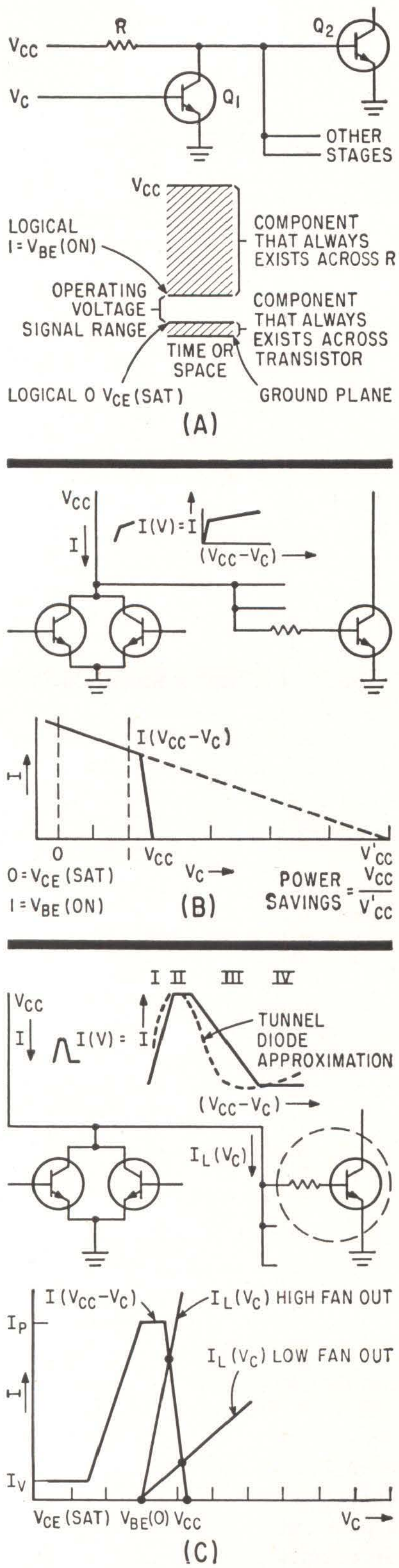
The high-speed binary circuit is inherently fast because the initial switching is done in what amounts to a common-base configuration. Bases are not switched until much of the storage charge has been removed from the transistor junction region by the trigger pulse. To further increase switching speed, a nonsaturating current mode of operation is used. High-speed binary counters incorporating the unique features discussed can trigger on pulse widths ranging from 1.5 to 3.0 nsec, when operated at repetition rates in excess of 300-Mc.

REALIZATION—The completed 200-Mc interval counter contains the gate and binary circuits on printed circuit boards. The boards presented a grounding problem because of the frequencies and the pulse rise time involved and particularly the pulses from the start and stop shaper circuits, which were generated at a base width of 1.5- to 2-nsec. Careful attention to ground paths and printed circuit lead locations, combined with the use of miniature coax and connectors on the printed circuit boards, solved this problem.

The completed instrument, shown in the photograph, was designed to measure time intervals precisely, although the particular application for which it was developed was the determination of the time delay introduced by cables, and thus the length of the cables. Single reading measurements give accuracies suitable for many applications and increased accuracy can be obtained by averaging several readings.

Saving Microcircuit Power With

replacing a resistance type between stages of a digital



TYPICAL *resistance shunt coupling and potential distribution (A), shunt coupling with breakup characteristic and comparison with resistance-shunt coupling with identical performance (B), shunt coupling with a —R characteristic (C)—Fig.1*

TWO-TERMINAL coupling elements in conventional transistor logic stages are normally resistive, being elements with linear V-I characteristics. But typical coupling functions are often better served by nonlinear two-terminal V-I characteristics. Substantial reduction in static power dissipation is a principal advantage if coupling is achieved by the type of V-I characteristic produced by tunnel junctions.

LINEAR COUPLING—A familiar shunt configuration shown in Fig. 1A, uses a resistance coupling element, along with the potential distribution in the system. When Q_1 is nonconducting (logical 1 state), the coupling device and d-c supply are driving the load. The coupling device should have low resistance to accommodate large fan-out loading resulting from effects of other stages. When Q_1 is conducting (logical 0 state), the load current is zero (owing to the threshold nature of the load V-I characteristic). All the current supplied by the coupling device is shunted to ground, serving no useful functional purpose. The coupling device should have high resistance in this state. These requirements cannot be met by a linear coupling characteristic, and resistance shunt coupling is wasteful of power as indicated in Fig. 1A by the large unvarying and, useless component of voltage found across the coupling resistor.

NONLINEAR COUPLING—Shunt coupling with a break-up (the dual of break-down) type of two-terminal characteristic is illustrated in Fig. 1B. As long as V_{cc} is higher than the voltage that exists at the collector node in the logical 1 state, the operation of this circuit will be identical to that of a resistance coupled stage having the same coupling device V-I locus in the signal voltage range. Power savings result because V_{cc} is much lower.

To reduce current drain in the logical 0 state below that of the logical 1 state, the shunt coupling characteristic must have a region exhibiting dynamic negative resistance. Such a characteristic, and its use in shunt coupling, is illustrated in Fig. 1C. This type of characteristic may be approximated by a tunnel-diode static V-I curve, resulting in a new digital logic scheme named tunnel diode transistor logic (tdtl). For the logical 1 state when $I_c = 0$ the load current and supply voltage should be such that the coupling device is in region I. For logical 0, the coupling device must be in region IV. The load characteristic is assumed to have an ideal threshold nature. The slope of $I_L(V_c)$ above the threshold voltage, $V_{BE}(0)$, depends on the number of fan-out load units. Note that load current decreases when fan-out is reduced.

NOVEL AND USEFUL

The workhorse role for the tunnel diode as nonlinear coupling between transistor logic stages employs some but not all of the td's attributes. Power dissipation, a major problem in microsystems, is reduced. Device characteristics may be relaxed compared with resistive coupling methods. System power supply voltage problems are found to be unique. Bistable operation, based upon td negative-resistance characteristic is not, however, utilized. Although switching action is regenerative (an advantage in itself) logic state control is through transistor action

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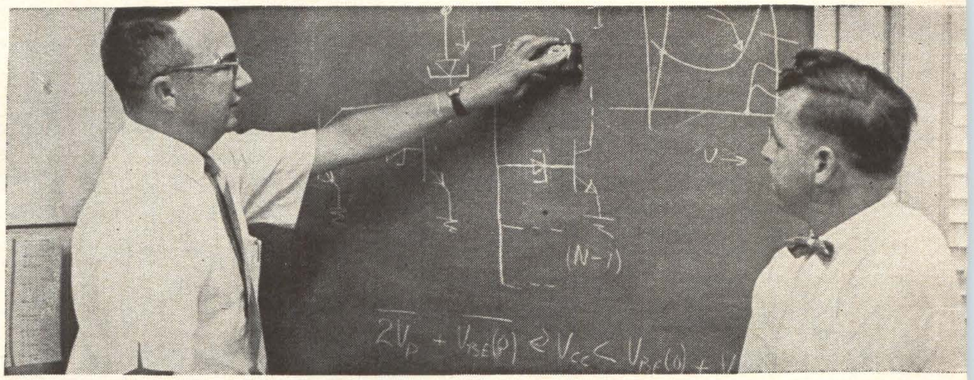
Tunnel-Diode Coupling *Employed as a nonlinear coupling, circuit, the tunnel diode's characteristics can save considerable power*

By H. C. JOSEPHS and J. T. MAUPIN, Honeywell Research Center, Hopkins, Minnesota

This is a favorable relationship since the drive to each stage is almost independent of fan-out. Therefore, the power dissipation per stage and the amount of transistor overdrive with accompanying saturation storage time are kept at their design optimum, regardless of changes in fan-out.



AUTHORS *J. T. Maupin (left) and H. C. Josephs (right) work up schematic circuit diagram for a tunnel-diode-coupled logic circuit*

Static power dissipation is reduced compared to resistance coupling capable of the same maximum load current because V_{cc} is lower, load current tends to vary with number of load units and current in the logical 0 state is much lower.

A comparison can be made of static dissipation for linear and nonlinear shunt coupling based on typical characteristics available from discrete component devices. Since all the system operating power enters through paths provided by the shunt coupling elements, it is convenient to examine system power dissipation per shunt coupling element. This is the product of V_{cc} and the static current flowing in the coupling element. This is the same as the worst case power dissipation per stage if the fan-in and fan-out are equal.

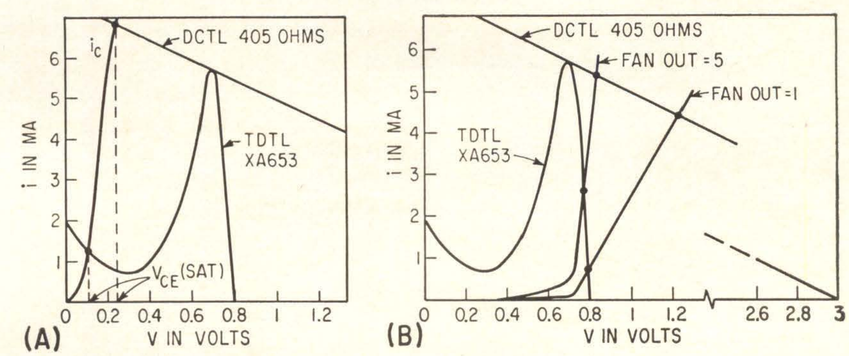
STATIC PARAMETERS — These are applicable to the logical 0 and 1 states, respectively, of a tdtl inverter stage, are shown in Fig. 2. Comparison is made with a resistance coupled stage capable of the same fan-out loading. A 3-volt supply is used with resistance coupling, as this seems to be a typical value for systems such as direct-current transistor logic, dctl. Current in the coupling element may be determined from the intersection of static characteristics. This leads to the comparison of static dissipation in the table. To simplify the comparison, it is assumed in Fig. 2B that all load units have the same threshold characteristics.

The transistor collector current in the on state in Fig. 2A is much lower with td coupling. Thus, the effect of an ohmic component in V_{CE} (SAT) is less, yielding a larger voltage switching transition and improved noise margins. However, propagation delay is also increased if parasitic capacitance loading at the collector node is a major factor in determining delay.

A GaAs tunnel diode type, with reasonable C/I_P values of approximately 10 pf per ma was chosen. Speed cannot be ignored in considering power requirements. A figure of merit for low duty cycle systems may be derived by taking the product of the average static power dissipation per stage times propagation delay per stage. This parameter will be called the delay-power product. Propagation delay per stage is the time interval between 50 percent points on the $V_c(t)$ waveforms in a chain of realistically operated inverter stages.

A chain of tdtl stages has been operated experimentally, using type XA653 GaAs tunnel diodes and type 2N744 transistors. Data on propagation delay and delay-power product are compared with resistance coupling in Fig. 3.

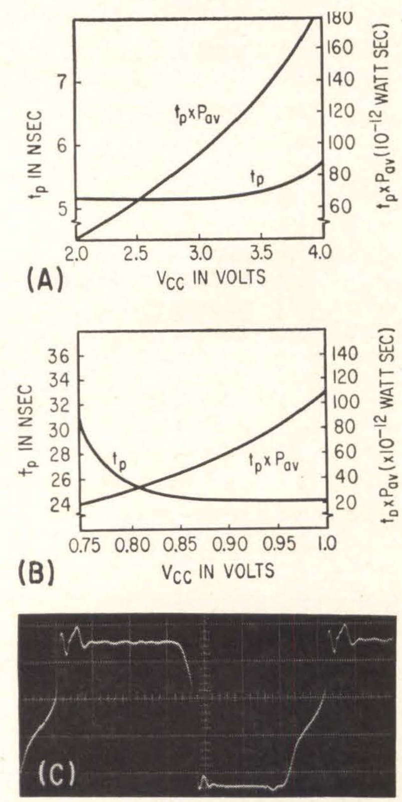
WAVEFORMS — Experimentally observed waveforms at collector nodes are shown in Fig. 3C. Switching action is regenerative during the transition through the $-R$ portion of the td characteristic. The regenerative effect is best seen in the exponentially rising turn-off transient. Once the stage is driven into the $-R$ region, from either direction, it switches of its own volition, and the waveform is independent of the number of stages through which a logical decision



STATIC *characteristics of dctl and tdtl in logical 0 state (A) and the logical 1 state (B)—Fig. 2* has been propagated. The long, slow portion of the turn-off transient corresponds to the valley current region of the td characteristic. The rate of transition through this region is controlled by the C_{TD}/I_V ratio, and this is the major factor contributing to propagation delay. Ideally, a coupling characteristic would be preferred in which the $-R$ portion of the total voltage transition is larger than in the example discussed. Total switching action in this type of stage is extremely complex.

A possible scheme for constructing the tunnel diode and transistor in integrated form is shown in Fig. 4A. This inverter can be the basic building block for a complete tdtl system. Gating would normally be accomplished by paralleling transistor collectors as in the dctl NOR gate. For example, a tdtl half-adder is shown schematically in Fig. 4B.

CURRENT HOGGING—A logic system constructed using tdtl gates



PROPAGATION *delay and delay-power product for dctl (A) and tdtl (B). Regenerative switching action in tdtl 3-stage ring oscillator collector voltage waveform (C) when horizontal is 20 nsec per division and vertical 0.2 v per division —Fig. 3*

will be less susceptible to the familiar current hogging problem of dctl. The problem is illustrated in Fig. 5 for worst-case conditions with a fan-out equal to N in both dctl and tdtl. For tdtl, the resistor $R_C \approx V_P/I_P$ is the tunnel diode resistance in region I. The transistor input characteristics are approximated by a threshold voltage V_{BE} (0) having linear series resistance R_B. An overscored symbol means that the parameter symbolized has its maximum permissible value under worst-case conditions, while an underscore means it has its minimum value. From the requirement that $\underline{I_B}$ must be large enough to provide a certain minimum overdrive ratio, $D = h_{FE}\ I_B/\overline{I_C}$, an expression is obtained for the maximum permissible spread in transistor input threshold voltages.

$$\Delta \overline{V_{BE}}(0) = \overline{V_{BE}}(0) - \underline{V_{BE}}(0) \leq \frac{\Delta V_C - [\rho \underline{R_B} + \underline{R_C} + (\underline{N}-1)\, \rho \overline{R_C}]\, \underline{I_B}}{1+(N-1)\, R_C/R_B} \quad (1)$$

where $\Delta V_C = V_{CC} - \overline{V_{BE}(0)}$ and $\rho = \overline{R_C}/\underline{R_C} = \overline{R_B}/\underline{R_B}$.

This must be large enough to accommodate voltage differences owing to production variabilities, differences in temperature within the system, and noise.

As an experimental verification of Eq. 1, the circuit of Fig. 5B was constructed. For the parameters used in the experiment, the equation predicts failure at ΔV_{BE} (0) = 34 mv. In the experiment, Q_3 failed to operate when the oven temperature was raised 16 C. Since $dV_{BE}(0)/dT \approx 2$ mv per deg C, the agreement is excellent. The collector resistors were then replaced by tunnel diodes and the experiment was repeated. This time Q_3 failed to operate when the oven temperature was raised 57 C. Equation 1 predicts failure when ΔV_{BE} (0) = 112 mv, so the agreement is good.

On the debit side, tdtl is sensitive to systematic changes in the difference $V_{CC} - V_{BE}$ (0). This difference must lie in the range given by Eq. 2 if all load characteristics are assumed equal.

$$\frac{I_P}{h_{FE}}(NR_I + R_B) < V_{CC} - V_{BE}(0) < \frac{I_P}{N}(NR_I + R_B) \quad (2)$$

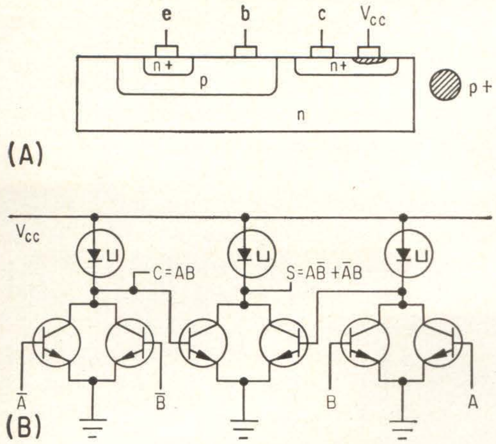
where $1/R_I$ = slope of coupling characteristic in region I
$1/R_B$ = slope of input characteristic above V_{BE} (0)
N = fan-out
I_P = peak current of coupling characteristic

This is not a severe limitation if the supply voltage is also made sensitive to the system temperature, so that V_{CC}-V_{BE} (0) remains constant.

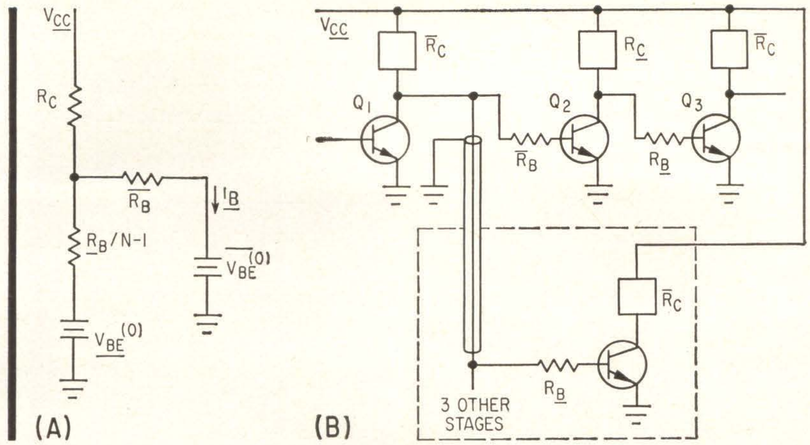
NONLINEAR COUPLING—Sensitivity to V_{CC}-V_{BE} (0) may also be improved if the transistor input is modified to include a series connected break-up characteristic, as illustrated in Fig. 6A. It is possible to approach this type of characteristic with a tunnel diode or backward diode having I_P/I_V approaching unity. The combination of negative resistance shunt coupling and break-up characteristic series coupling is illustrated in Fig. 6B. If the intersection of $I(V_{CC}$-$V_C)$ and $I_L(V_C)$ always occurs in the constant current region of the latter, the logical 1 state is insensitive to V_{CC}-V_{BE} (0). Also, current hogging cannot occur.

There are two general ways to combat current hogging. One method is to reduce the effective coupling resistance R_C so the group of driven transistors is fed from a more nearly perfect voltage source. When the currents are not limited, there can be no problem with unequal sharing. This cannot be accomplished in dctl without excessive power waste. The tdtl, however, accomplishes this with a reduction in power, through the nonlinear tunnel diode characteristic. The coupling resistance in the operating range of importance is lower by a factor of 50 to 100 than that commonly used in dctl.

The other method is to increase the base resistance so each individual transistor is driven from a more nearly perfect current source. Again there can be no problem with unequal current sharing if the current to each load is fixed. This has adverse effects on switching speed in both dctl and tdtl. Furthermore, it cannot be accomplished in tdtl without an increase in supply voltage and a corresponding increase in power dissipation. It cannot be carried far in either system in integrated form without isolating the base resistor.



INTEGRATED *tdtl inverter (A) and tdtl half adder (B)—Fig. 4*



WORST-CASE *current hogging equivalent circuit for dctl and tdtl (A) and experiment for susceptibility to current hogging and permissible spread in V_{BE} (0) (B)—Fig. 5*

TDCL—The ideal situation of using a low resistance to couple the circuit to the power supply and a high resistance to couple stages together can be approached through the use of two tunnel diodes per stage as shown in Fig. 6C. This form is termed tunnel diode coupled logic (tdcl). A possible integrated form of a tdcl inverter is shown in Fig. 6D. Gating would normally be performed in the same manner as dctl and tdtl.

In Fig. 6C, D_1 is the ordinary tdtl tunnel diode with its *n*-region integral with the collector. Unit D_2 is a low current tunnel diode and could presumably be constructed in the base region in the manner shown in Fig. 6D. Both tunnel diodes should have low peak-to-valley current ratios.

The static requirements for this combination can easily be derived. The composite input characteristic of the transistor D_2 combination is shown in Fig. 6E, superimposed on the D_1 characteristics. The voltage V_f is the voltage at which the D_2 current in the diffusion region is equal to the D_2 peak tunneling current. From Fig. 6E are obtained

$$M < \overline{I_{V1}}/\overline{I_{P2}}$$

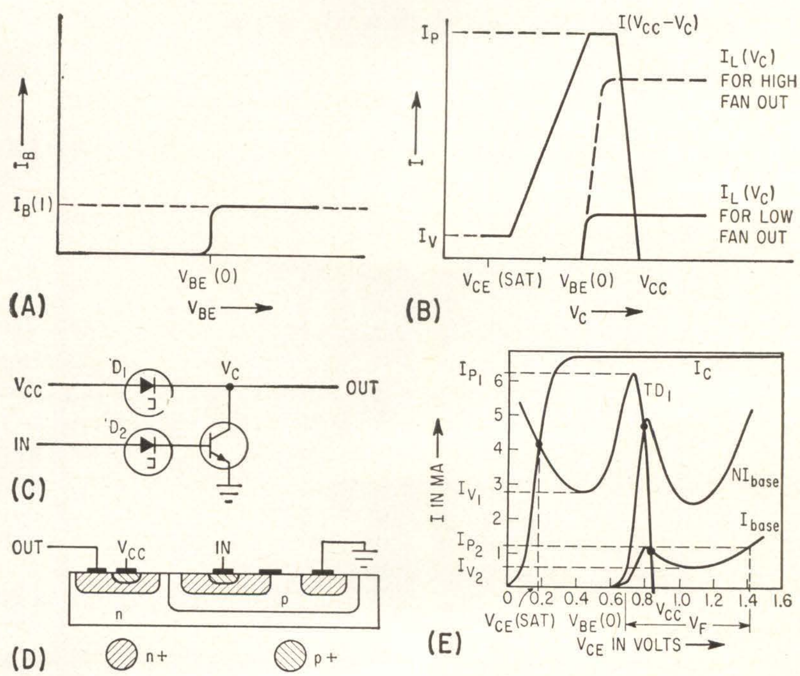
$$I_{V2} \geqq \overline{I_{P1}}/\underline{h_{FE}}$$

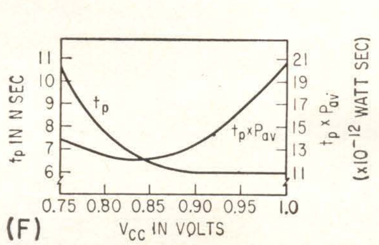
$$\overline{2V_\rho} + \overline{V_{BE}(0)} < V_{CC} < \underline{V_{BE}(0)} + \underline{V_f}$$

When the oven experiment was repeated using a tdcl circuit, Q_3 continued to operate with the supply voltage anywhere between 0.75 and 1.6 volts even when the oven temperature was raised to 200 C. At this temperature the transmission line carrying the signals into the oven failed, so the experiment was terminated.

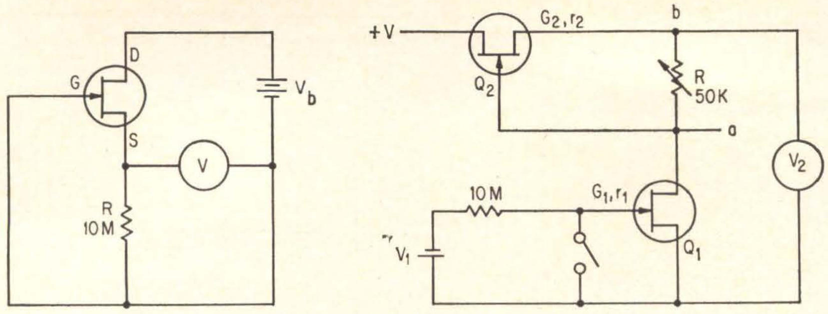
STATIC POWER DISSIPATION COMPARISON—TABLE

	Logical 0 State $V_C = V_{CE}$ (SAT) $I_L = 0$	Logical 1 State $V_C = V_{BE}$ (ON) $I_C = 0$
Resistance Coupling		
Approx. Formula	$V_{CC} \times \frac{V_{CC} - V_{CE}(\text{SAT})}{R_L}$	$V_{CC} \times \frac{V_{CC} - V_{BE}(\text{ON})}{R_L}$
From Fig. 2	20.4 mw	16.1 mw for $N = 5$
TD Coupling		
Approx. Formula	$V_{CC} \times I_V$	$V_{CC} \times N \frac{V_{CC} - V_{BE}(\text{ON})}{R_B}$
From Fig. 2	0.96 mw	2.08 mw
Reduction Factor	21.2	7.8





TRANSISTOR *input modified by break-up characteristic (A) and combined negative resistance shunt coupling and break-up series coupling (B). A tdcl inverter (C) in integrated form (D). Critical design parameters in tdcl (E) and propagation delay and delay power product for tdcl (F)—Fig. 6*



(A) (B)

CHARACTERISTIC *voltage V_p is measured by circuit at (A). Circuit at (B) gives the $G_m r_d$ product of test transistor Q_1. Results are valid for all types and makes of FETs*

SIMPLE CIRCUITS Measure FET Parameters

Low-frequency characteristics of field effect transistors can be measured with these simple circuits. Tests are useful for evaluating experimental units and for incoming inspection

By R. R. BOCKEMUEHL

General Motors Research Laboratories, Warren, Michigan

COMMON source characteristics of a field effect transistor are such that, with zero gate bias, the mutual transconductance and drain current approach maximum values G_m and I_p when the drain voltage reaches a characteristic value V_p. These values are nearly constant at higher drain voltages. Also, the gate voltage required to reduce drain current to zero is $-V_p$. The three parameters G_m, V_p and I_p are important in characterizing low-frequency performance and in evaluating experimental devices.

Measurements of G_m and I_p are straightforward voltmeter-ammeter techniques. Voltage V_p can be measured by noting either the drain voltage at which the current parameters become constant or the gate voltage at which they approach zero. This method is subject to considerable error since the constant values are not approached sharply. Further, continuous measurements of changes in V_p for temperature or other environmental effects are cumbersome.

The simple circuit shown at (A) in the figure provides a continuous direct measurement of V_p. Voltage drop across resistor R biases the transistor toward cutoff. A finite current still flows but this can be a small fraction of I_p: in fact, $I/I_p \cong 2/G_m R$. As supply voltage V_b is increased, V increases and rapidly saturates at a value equal to V_p for all practical purposes.

Resistive parameters of the transistor have little effect on the measurement. Gate to drain resistance has no effect at all. Gate to source resistance merely shunts R and reduces its effective value. Resistance from source to drain r_d (dynamic output resistance) determines the influence of supply voltage on the measured V. However, if $G_m r_d >> G_m R >> 1$, and $V_b > V_p$, then $V \cong V_p$.

Even if r_d and R are of the same order of magnitude, the change in dV/dV_d occurs much more abruptly than in the conventional measurement of dI_d/dV_d. The input resistance of a conventional vtvm is usually sufficient for use as R.

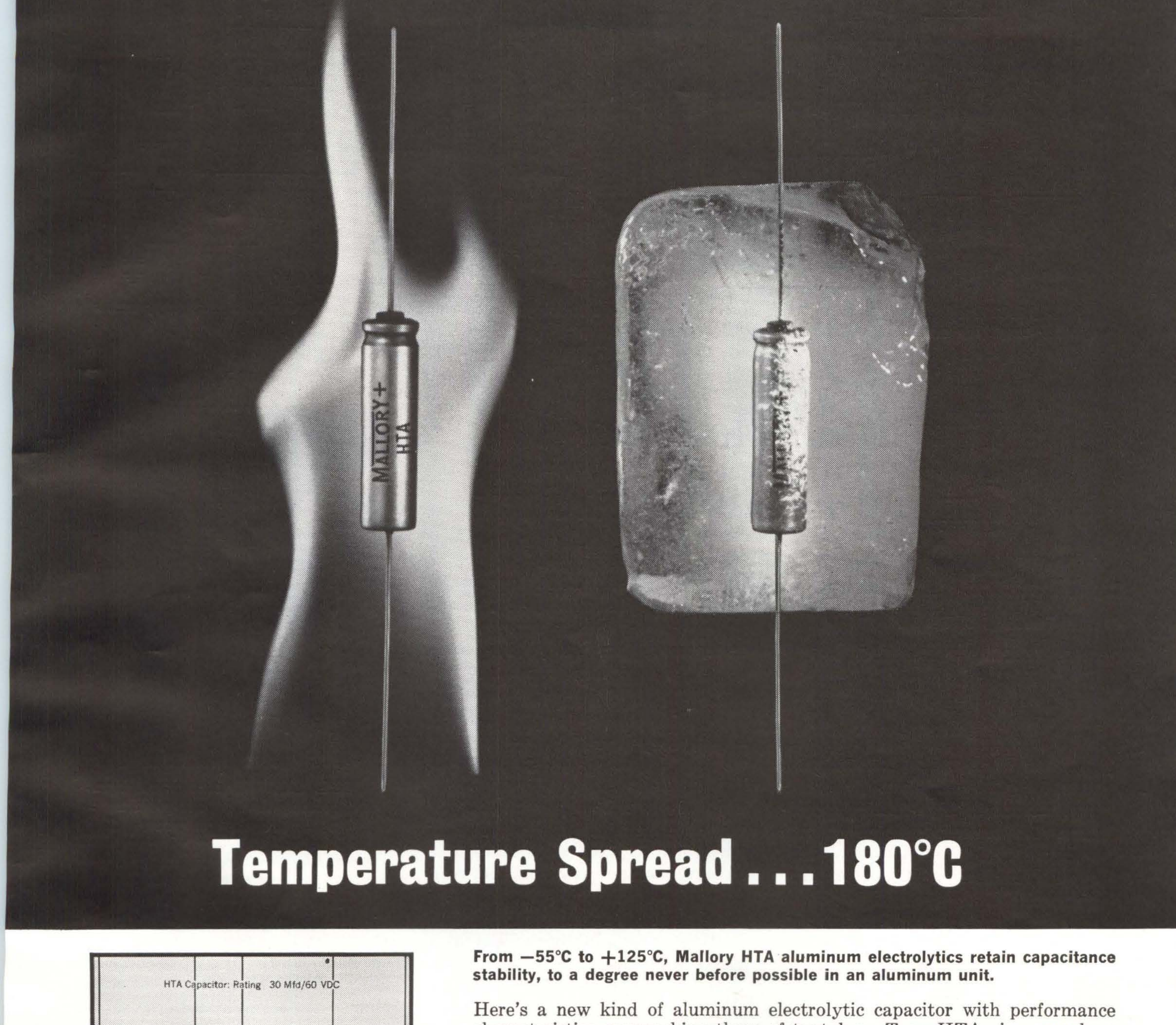
Product $G_m r_d$ is important for high-gain voltage amplifiers. Conventional measurements of $r_d = dI_d/dV_d$ require measuring small fractional changes in current, and require elaborate equipment for accurate results.

The simple circuit at (B) in the sketch measures $G_m r_d$. The upper transistor is selected for large $G_m r_d$ and I_p and, in combination with R, serves as a constant current load for test transistor Q_1. If Q_2 has $G_2 r_2 >> 1$, the effective resistance of the constant current load is $G_2 r_2 R$; the current is approximately V_{p2}/R. Usually $G_2 r_2 R$ is much greater than $G_1 r_1$, so the voltage gain at point *a* is $G_1 r_1$. Since the current through R is constant, the voltage gain at point *b* is the same as at *a*. However, the output resistance at point *b* is usually low enough to permit measurement with a 10,000 ohm-per-volt meter.

The voltmeter will usually indicate a fixed high or low value when Q_1 is first connected. Variable resistor R is adjusted to produce an intermediate indication. This matches the constant current circuit to the Q_1 current I_p. Applying a small d-c voltage V_1 to the Q_1 gate produces a large change ΔV_2 in the voltmeter indication. The ratio $\Delta V_2/V_1$ equals the $G_m r_d$ of Q_1. The supply voltage does not affect the measurement except that it determines the voltage range of the constant current circuit.

This circuit has been useful for rapid inspection of experimental field effect transistors. A resistor added in series with the gate of Q_1 will serve to reject units with excessively low gate resistance.

A New Kind of Aluminum Electrolytic



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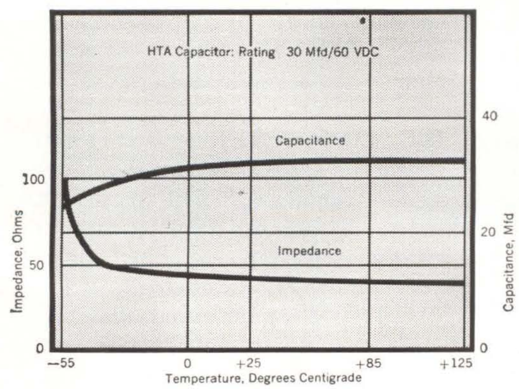

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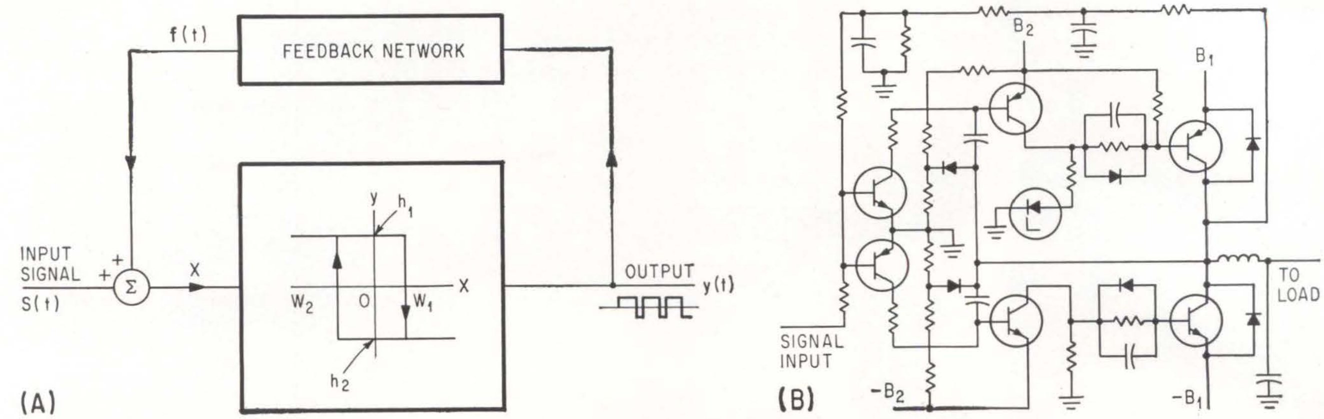

BASIC LOOP *of two-stage modulation system requires nonlinear forward path, linear feedback network, (A); audio power amplifier uses only switching transistors, but preserves high fidelity, (B)—Fig. 1*

Two-State Modulation Simplifies Audio Circuits

MIT system gets around component nonlinearity, cuts down circuit heating

NEW TYPE OF MODULATION announced last week (ELECTRONICS, Aug. 19, p 16), as having possible applications in high-fidelity amplifiers, d-c converters, and control systems, is a combination of frequency modulation and pulse-duration modulation, giving a two-state fixed-amplitude output signal whose average value very nearly equals that of the input signal.

Invented by Professor A. G. Bose of MIT's Research Laboratory of Electronics, the transistorized system converts a continuous signal into a two-state one, eliminates linearity problems and affords very high operating efficiencies. The basic system, as shown in Fig. 1A, is a closed loop having a nonlinear forward path and a linear passive feedback path.

The transistors in the circuit operate only in their switching mode, therefore consuming little power and resulting in high efficiency, light weight and simplicity of operation. The transistors used in the prototype circuits have voltage breakdowns in the 90-to-120-volt range and switching times of 0.2 microsecond or faster, are commercially available though not off-the-shelf.

AMPLIFIER — The two-state modulation has been applied to the design of a simple d-c to 20-kc amplifier, which converts the sine-wave input into a rectangular waveform of fixed amplitude. The output voltage switches between two values; on a scope it appears as a train of rectangles whose vertical edges rapidly oscillate at a rate corresponding to the input frequencies. The distance through which the edges move corresponds to the input voltage amplitude. For large positive values of input, the upper voltage value is on longer; for large negative values of input, the lower level remains switched on longer. The rectangular output can be fed directly into a loudspeaker for high-fidelity reproduction of sound. Circuit diagram of the amplifier is shown in Fig. 1B.

The high-efficiency, low-power operation has largely eliminated the necessity for cooling the amplifier. Prof. Bose said the entire amplifier can be built right into the speaker unit. His experimental unit handles 15 watts, feeds a 16-ohm loudspeaker load.

SCOPE SHOWS *sine-wave input and rectangular output simultaneously, for display purposes. The pocket-sized hi-fi amplifier is connected to the scope, but record pickup in foreground is not*

D-C CONVERTER — Another prototype application is a d-c power system for aircraft and spacecraft, in which the two-state modulation circuits can replace transformers and voltage regulators.

With a constant input, the two-state modulator puts out a rectangular wave whose period increases with the magnitude of the input signal, and with a duty cycle such that the average value of the modulated output nearly equals that of the input signal. For slowly

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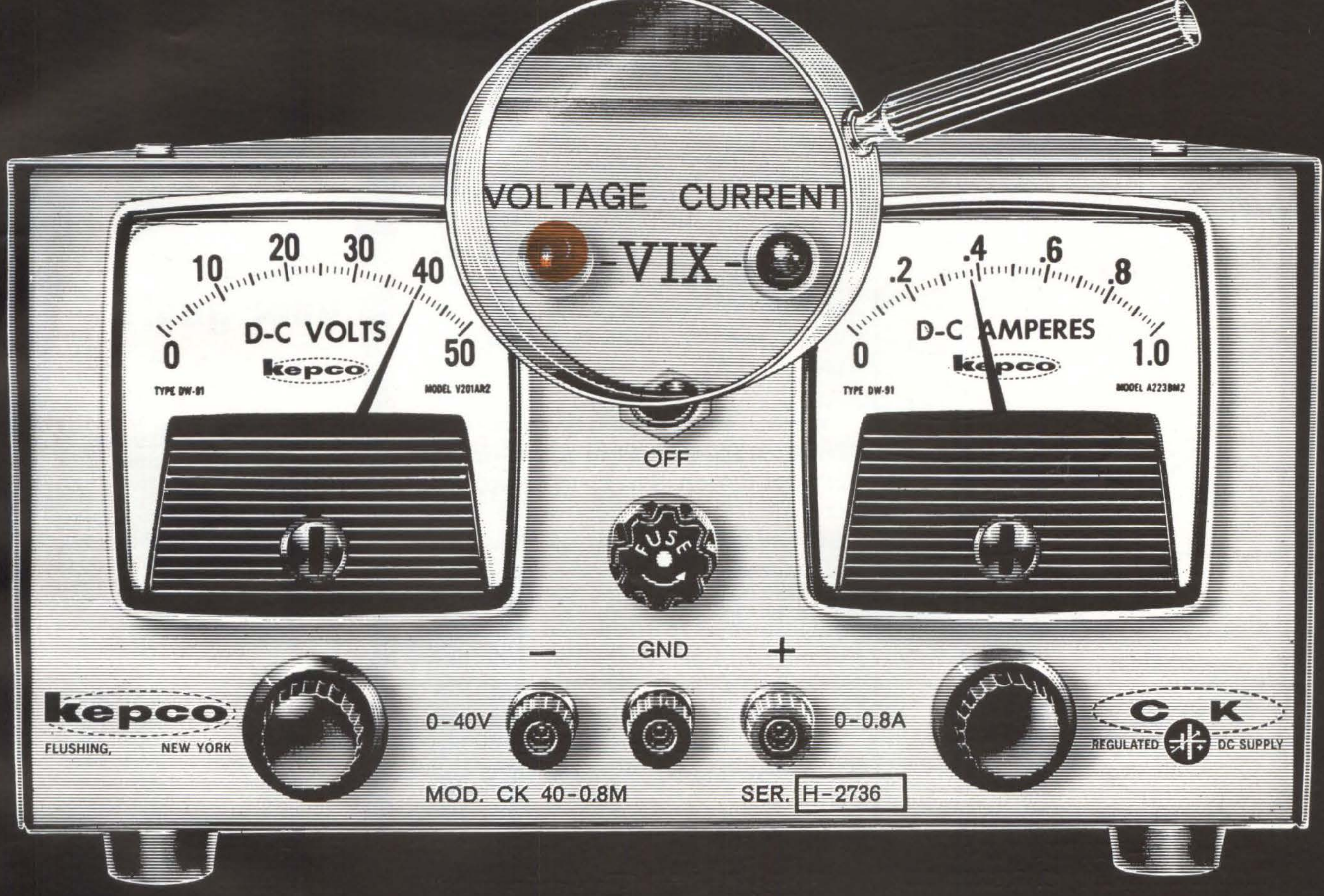

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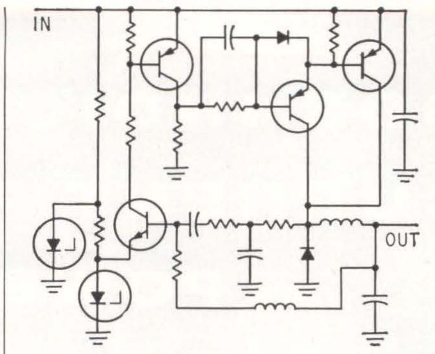


D-C TRANSFORMER *circuit has theoretical efficiency of 100 percent. Additional features are a regulated output and adjustable "turns ratio"—Fig. 2*

varying input signals, the output exhibits a combination of f-m and p-d-m, such that the input can be recovered simply by low-pass filtering. A simple d-c transformer can be built with a theoretical efficiency of 100 percent, and a regulated output.

A three-transistor d-c transformer and voltage regulator was built as an example of a non-linear control device. The circuit supplies one ampere at 15 volts to the load. Switching frequency is 100 kc. Measurements show a better than 60 db attenuation of supply-voltage variations at the load, and a change of only 0.14 percent in the load voltage with a change of 200 percent in the current drawn by the load. An example of a d-c transformer using the two-state technique is shown in Fig. 2.

Three British Experiments Will Go Aboard OSO

LONDON—Three space experiments proposed by British scientists from the University College, London, and the University of Leicester have been selected for inclusion in the NASA "Observatory" series of scientific satellites.

Two of the experiments will be included in the fourth OSO orbiting solar observatory, due for launching in 1965; the third experiment is to be launched in 1966 aboard an orbiting astronomical observatory. A fourth experiment—designed to study solar x-ray emission distribution—has been allocated a standby role also for the fourth OSO.

The two definite experiments for

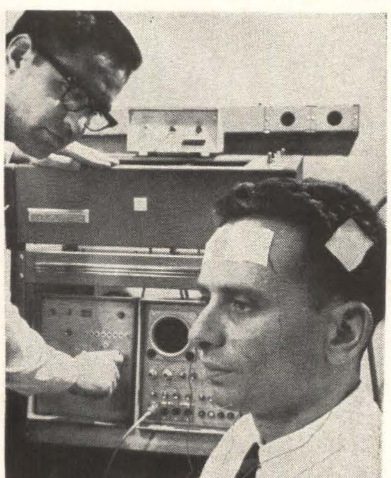
OSO-D are the study of radiation emission from ionized helium in the sun in the far ultraviolet region, and the location of points of high x-ray emission on the sun using a specialized scanning technique. The OSO experiment will study x-ray emission from other stars.

Brookhaven Laboratory Finds New Anti-Particle

CONFIRMING the theory that every elementary particle must have an anti-particle, researchers at Brookhaven National Laboratory observed for the first time the anti-Xi-zero, a rare anti-particle that had been predicted for several years.

The experiment used a 3.69-billion-electron-volt beam of anti-protons, produced by Brookhaven's alternating gradient synchrotron (AGS) and separated by an arrangement of magnets and electrostatic separators before entering a 20-inch liquid-hydrogen bubble chamber. Out of about 300,000 photographs of interactions in the bubble chamber, three contained evidence of the anti-Xi-zero. The particle leaves no tracks because it lacks electrical charge. Its lifetime is about one ten-billionth of a second.

Computer Aids Brain Study



BRAIN'S *electrical responses to controlled stimuli are analyzed during Honeywell experiments aimed at developing techniques for long-distance prediction or control of behavior. Digital computer of average transients sums evoked responses to help isolate them*

Phosphors Trace Heat Flow Patterns

Hot spots show up as device is being pulsed to higher power levels

A DRAMATIC technique has been developed to study heat-effects of components under load (see cover).

The method combines the use of temperature-dependent fluorescent paints with motion pictures taken under ultraviolet floodlights.

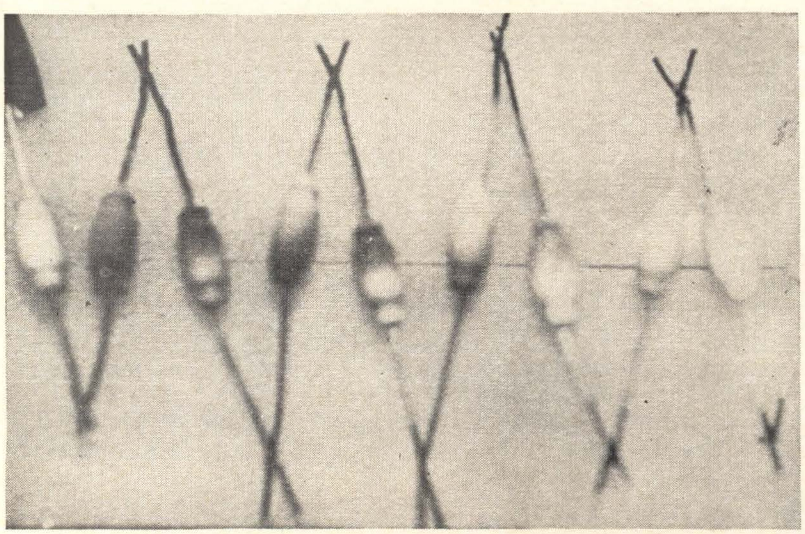
The analysis of heat-wave patterns, given off by components, can lead to improving heat sink paths, the determination of safe power dissipation ratings, and the design of more reliable components. The method of circuit analysis can be applied to microcomponents, as well as large devices.

Techniques for studying temperature distribution were described this week at WESCON. Illustrated talk was given by H. D. Frazier of Pacific Semiconductors, Inc., Lawndale, California.

Frazier uses thermographic pigments, available through U. S. Radium Company. He coats the surface to be studied with a thin film of phosphor pigments that are dispersed in ultraviolet-transmitting paints. A short motion picture is taken under ultraviolet floodlights, while successive increase of power is applied to the circuit.

HEAT WAVES—Under these conditions, various phenomena, related to temperature distribution, are observed. The effect is striking. Waves of heat can be seen to rapidly diffuse. The analyst watches the way in which the heat-distribution pattern deviates from normal over a short period of time. Temperature gradients can be analyzed in minute detail.

The theory is that when units fail under load, the locus of failure originates in a higher temperature area. Under identical conditions, the hottest device is most likely to be less reliable in long term operation.



DARK IS HOT—*Diodes under hot spot tests have conventional mounting to n side of dice and tungsten whisker contact to the other. The heat is dissipated mainly through the n side of the unit. This is clearly shown. Three units have lower voltage drops at the current used and are therefore cooler*

Frazier called particular attention to the use of this technique to study diode-junction temperature, and transistor "second breakdown" phenomenon.

The circuit under study is pulsed to successively higher power-dissipation levels with just enough time to observe the rate of recovery due to interim cooling.

SENSITIVITY—Frazier uses four thermographic phosphors, says one is the most useful. They cover an entire range of temperature from 25 C to 400 C. One phosphor is sensitive between 25 C and 70 C. It has an approximate sensitivity of 25 percent quenching per deg C. The phosphor is as sensitive to infrared directly as it is to heat conducted from the substrate. It has been used to show heat cycling caused by 6 cycles-per-second pulses.

The phosphors are not new. They have been used to indicate surface temperatures in aerodynamics, in ultrasonics, and in determining the cooling efficiency of motion picture film.

Still pictures cannot do justice to the description of this method, according to Frazier. Even relatively slow observation of steady-state conditions does not really develop the story, Frazier added. The striking aspects of the materials as an observational tool is pulsed operation, developed through motion picture analysis. Frazier said that this may be reason while such a versatile and valuable tool for circuit analysis would lie dormant for so long.

Motion picture observations can be made on devices of microscopic size under as high as 100 diameters, or as large as desirable up to the sides of large furnaces.

HOT SPOTS—Frazier showed motion-picture examples of devices in which defects were spotted.

One transistor had a void in the

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- **VAX-3-BR.** Brushless d.c. for long life. 65 cfm. @ 0.6″ back pressure. 4″ long. 17 ounces.
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- **VAX-3-GN.** Same performance as BD version. 115 v.a.c., 60 cycles. Can operate on d.c. also. 3¼″ long. Request Bulletin VAX-3 from **Globe Industries, Inc.,** **1784 Stanley Avenue, Dayton 4, Ohio.**

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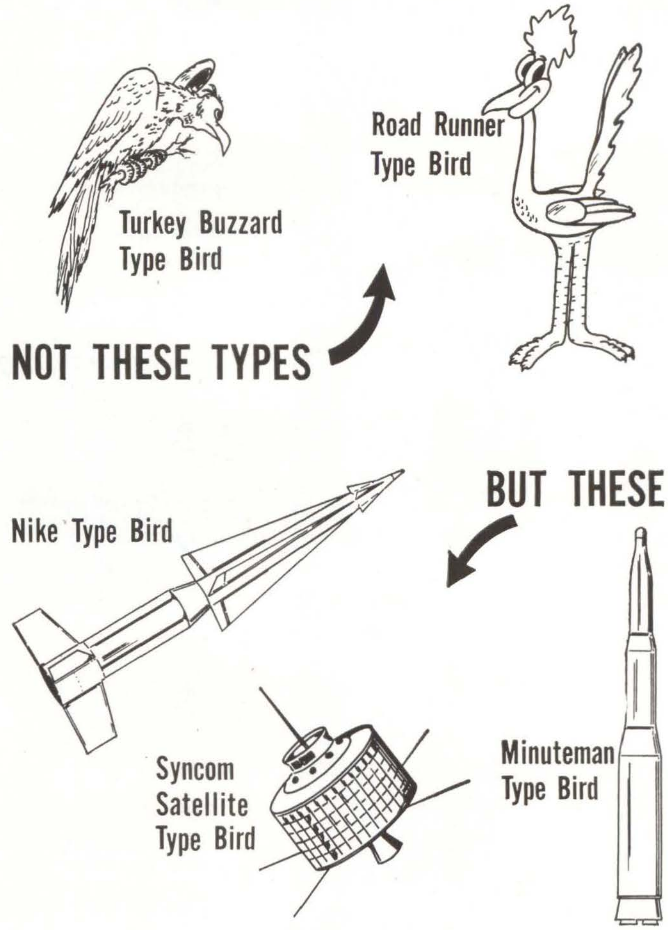

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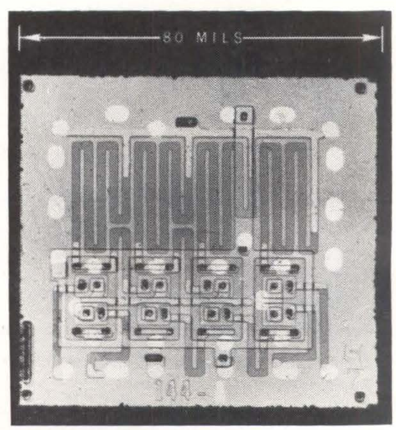
heat-sink bond. The unit developed second-breakdown characteristics at about 10 amperes and about 20 volts at power peak delivered by a Tektronix transistor tester. The defect was clearly observed as a growing black spot. The unit was driven to destruction so that the location of the failure could be compared to the test, which terminated at 70 C.

The failure point occurred in the precise center of the position indicated by the dark spot. Heat patterns were shown for a transistor that did not have such a defect.

Other motion-picture sequences showed a diode 0.030-in. sq with poor thermal contact, and first indications of failure for a large varactor diode.

Initial reliability tests are just getting underway. First indications auger well, but tests for corroboration take a great deal of time and are not yet finished, Frazier says. The total cost of setting up apparatus to examine a large number of phenomena or devices can be under $100, he added.

Micropower Wafers Keep Getting Smaller



A HALF shift register is now carried on an 80-mil square chip. Twenty-four metal film resistors are deposited on the same silicon wafer into which eight transistors have been diffused. Total resistance is 1 megohm. Transistor betas are as high as 100 at 1 μa collector current. Power level is 1.5 μw per transistor for the new CBS wafer.

The wafer is part of an analog-to-digital converter for a meteorological satellite. Converter is the size of a pack of cigarettes.

CAREER NEWS FROM HUGHES

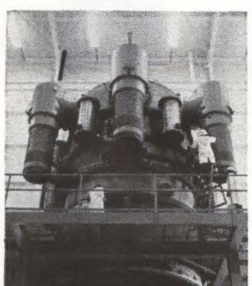
Aerospace Divisions in Culver City, California

NEW AND CONTINUING PROGRAMS AND PROJECTS

F-111B PHOENIX Missile System
MMRBM (Integration, Assembly and Checkout)
SURVEYOR Lunar Landing Vehicle
SYNCOM Synchronous Communications Satellite
POLARIS Guidance
TOW Anti-tank Missile
VATE Automatic Checkout System
FALCON Missiles
HARD POINT DEFENSE

These examples of Hughes Aerospace activities are representative of *more than* 230 major product and service capabilities ranging from aerospace vehicles to ASW systems.

OUTSTANDING TECHNICAL FACILITIES

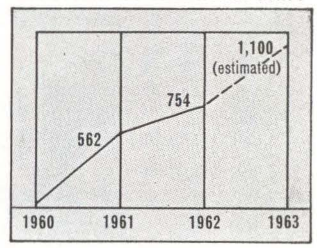


This giant environmental test chamber at Hughes new Space Simulation Laboratory is just one of a complete range of facilities maintained by the company for the Technical Staff. Hughes physical plant and professional atmosphere, unexcelled in industry, encourage individual achievement.

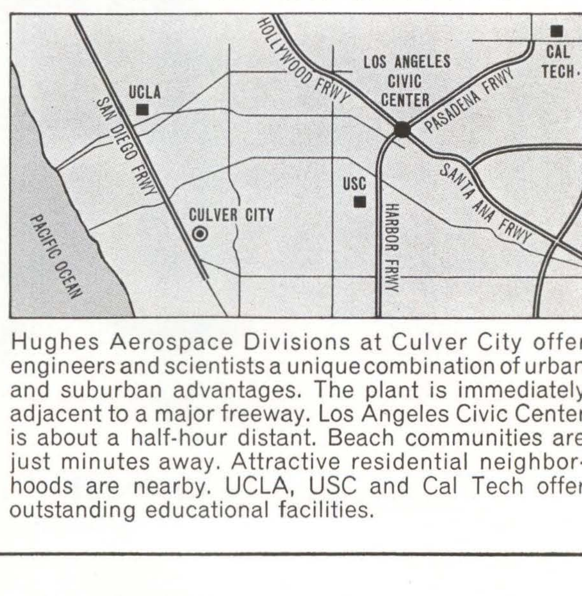
GROWTH OF THE TECHNICAL STAFF

Of the nearly 9,000 employees of these divisions, 2,600 are Members of the Technical Staff. Average length of experience is 10.0 years. Average age is 32 years.

ADDITIONS TO TECHNICAL STAFF



HUGHES/CULVER CITY & LOS ANGELES



Hughes Aerospace Divisions at Culver City offer engineers and scientists a unique combination of urban and suburban advantages. The plant is immediately adjacent to a major freeway. Los Angeles Civic Center is about a half-hour distant. Beach communities are just minutes away. Attractive residential neighborhoods are nearby. UCLA, USC and Cal Tech offer outstanding educational facilities.

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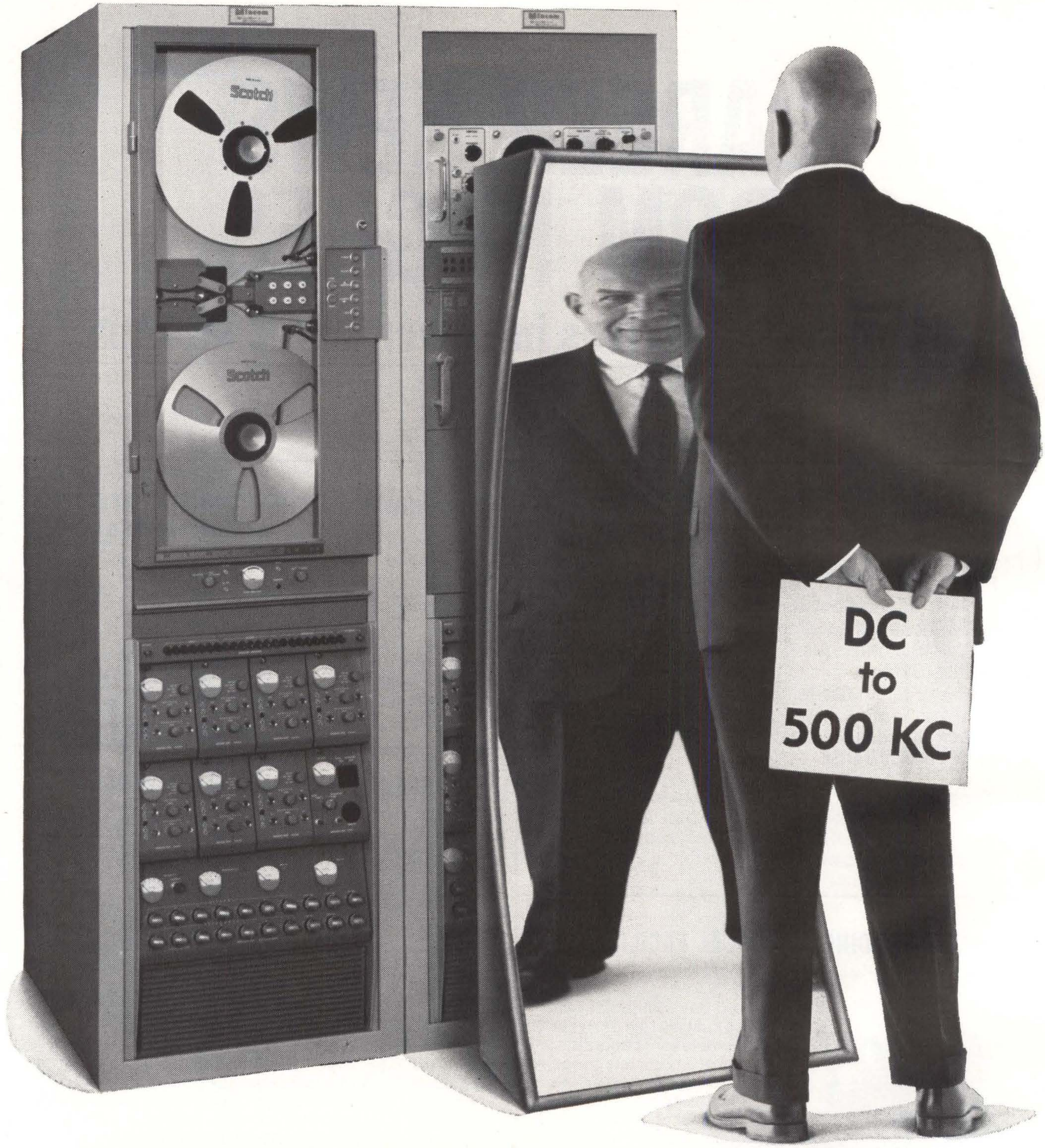

WIDEBAND FM recording, using 1.5-megacycle analog techniques to attain an improved frequency response of DC-500 kc, is Mincom's latest telemetry development. Heart of the new system is the standard **Mincom 1.5-mc CM-114 Recorder/Reproducer.** The extended FM responses enable telemetry facilities to record simultaneously the most complex narrow-band and wideband signals in PCM, PCM/FM, PDM, and FM/FM modulation. More advantages: Extended low frequency response, excellent linearity, seven or fourteen recording tracks, versatility without modification, greater dynamic range, dropout reduction virtually to zero. Write today for details and complete specifications.

Mincom Division 3M COMPANY

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Preformed Circuits Reduce Joining Operations

Etched wiring augments packaging, improves reliability, cuts costs

By L. B. STEARNS
Chemical and Aerospace Products, Inc.
Gardena, Calif.

INTERCONNECTION of circuit modules to form systems can be considerably accelerated and simplified by using a chemical process to form the interconnecting wiring. Structurally, this wiring has a 3-dimensional self-supporting capability that does not require substrate support.

This technique has advantages in eliminating costly operations such as punching holes, lacing wires, lap-welding ribbons or wires, building of fixtures and tooling. Also, resulting systems are more consistently reliable without cables, harnesses and plugs.

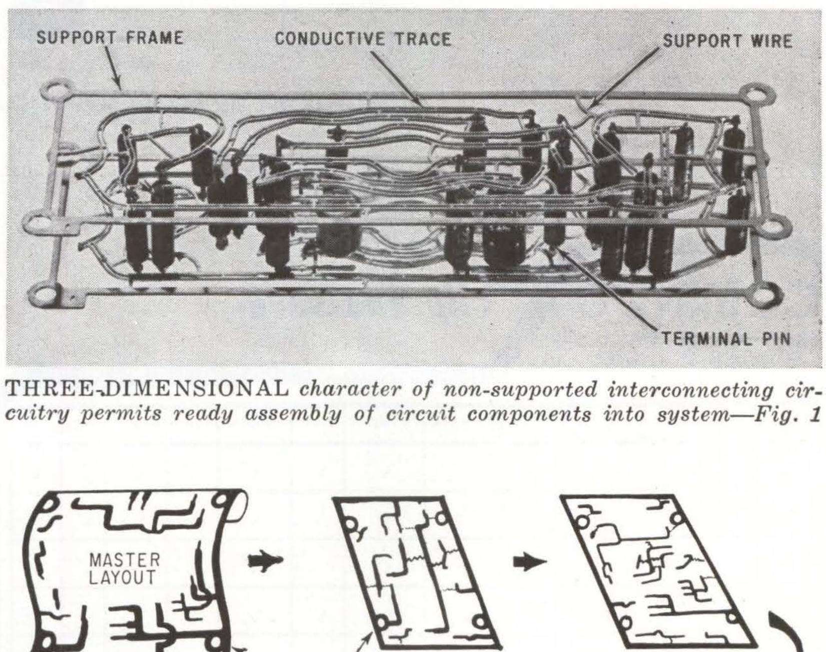
Called Intri-cut, this photo-etching process produces "wiring" terminal pieces from sheet metal stock, usually phosphor bronze or nickel (Fig. 1). These terminal pieces, rigid and self-supporting, are able to hold both ends of electrical components or modules in place. They provide a large number of interconnecting paths eliminating welded or soldered joints except where needed for connecting terminals. Reductions up to 80 percent of required connectors have been achieved. Grooves in the terminals assure accurate positioning of circuit elements. Supporting "wires" for aiding assembly can also be incorporated in the frame for positioning. They maintain proper spatial relationships for the individual traces and are later removed with the support frame. Epoxy glass or Mylar sheets are similarly photoetched to provide dielectric positioners or insulators. Channels are made in the epoxy so the interconnecting circuit elements lie within the epoxy surface. Thus subsequent layers of interconnecting epoxy-circuit insulators can be stacked to achieve correct interconnection paths between circuit components or modules Fig. 2.

LAMINATING TECHNIQUE — Master layout controls operations. Position of tooling holes in the master layout corresponds to position of holes in assembly fixture and frame. Thus holes in insulating Mylar sheets register precisely with component leads.

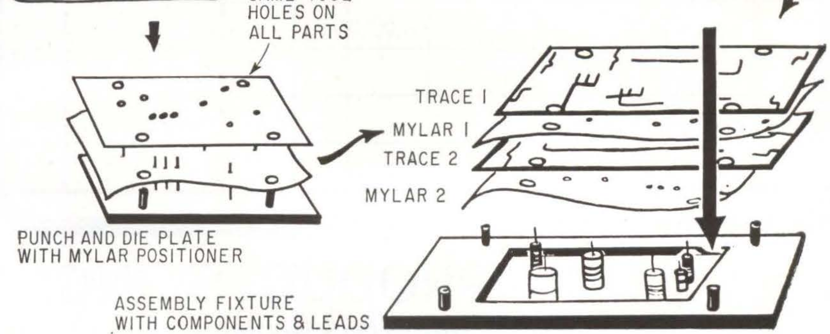
PROCESS ADVANTAGES—Advantages of a chemical process in pre-forming interconnects are particularly important when:

- Blanking very brittle materials such as tungsten, beryllium, and Alfenol
- Blanking of very thin materials: thicknesses of 0.001 inch and under are feasible
- Blanking of tough, work-hardening alloys such as titanium and nickel alloys
- Going into prototype production: changes in design are easily accommodated at low cost.

These interconnects have been flight-approved, confidence tested and installed in a production model. They demonstrated a flexi-



THREE-DIMENSIONAL *character of non-supported interconnecting circuitry permits ready assembly of circuit components into system—Fig. 1*



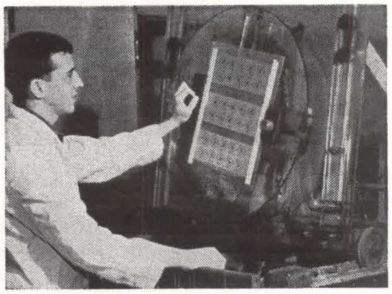
MASTER LAYOUT *controls all assembly operations having laminated interconnecting structures—Fig. 2* bility of design, which can be planned so that interconnects bend around corners or fit around obstacles. A minimum number of mechanical joints has enhanced system reliability.

New Limits For Chem-Blanking

TOLERANCES up to 50-millionths of an inch are being achieved in mass production of following components using high-speed chemical blanking: vacuum tube parts, electronic screens, micro-circuit lead preforms. Chemical Micro Milling Co. of Philadelphia, Pa., applies process to metals that are too thin to stamp within an accuracy of ± 0.0005-inch.

Key advantages claimed for mass-production process include: low-cost prototyping as against the expense of tools and dies; speed—hours rather than days or weeks; intricate-shape duplication is no problem; difficult-to-machine metals—molybdenum, titanium, berylium—can be etched precisely; no burrs and edge stresses.

FINISHED MASTER *magnification needed to produce parts as specified tolerances is determined from engineering drawing. Master shown is 20 times larger than part layout*

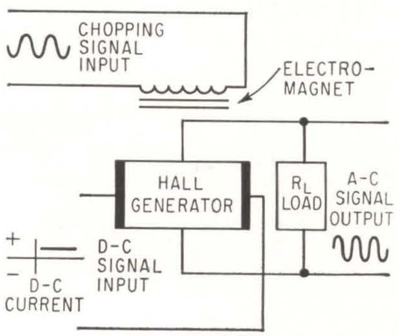


VIBRATION DETECTOR *springs produced in etching machine are held to a tolerance of ± 0.001 inch. They are burr free, unstressed and reportedly manufactured at ¼ cost of conventional metalworking*

Hall Elements Linear Beyond 30 Kilogauss

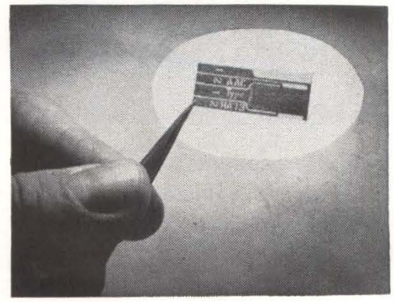
Thin-film construction reduces noise to less than 0.1 μvolt

MANUFACTURED by American Aerospace Controls, Inc., type HA Hall-effect generators are four-terminal elements that accept both current and magnetic flux-field inputs. Devices are thin film solid state and flexible. They are constructed of a slab of indium arsenide or indium antimonide on a ceramic or ferrite substrate. Input leads are located across opposite sides of the element and Hall leads are at the equipotential points on the two other sides.



According to the manufacturer, HA series generators are linear over a wide magnetic-flux range and elements are linear beyond 30 kilogauss. Unlike semiconductor elements that are subject to electrical noise due to boundary layer and junction effects, this series is virtually noiseless with limitation of only thermal noise with a value of less than 0.1 μvolt. Units have a positive temperature coefficient preventing thermal run away and are completely nonmagnetic.

In the application shown in the diagram, a-c output voltage is directly proportional to d-c input current for a constant-amplitude chopping signal. No moving contacts are required for this circuit.



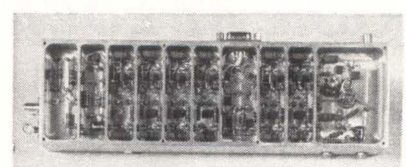
Series HA Hall effect generators have typical input resistances of 1 to 10 ohms, output resistances between 1.5 and 20 ohms, sensitivities as high as 50 millivolts per ampere-kilogauss and rated input power that varies between 0.015 and 0.5 watt in free air and 0.1 and 3.5 watts when heat-sinked. Moreover, they will perform between temperatures of −269 and +100 C.

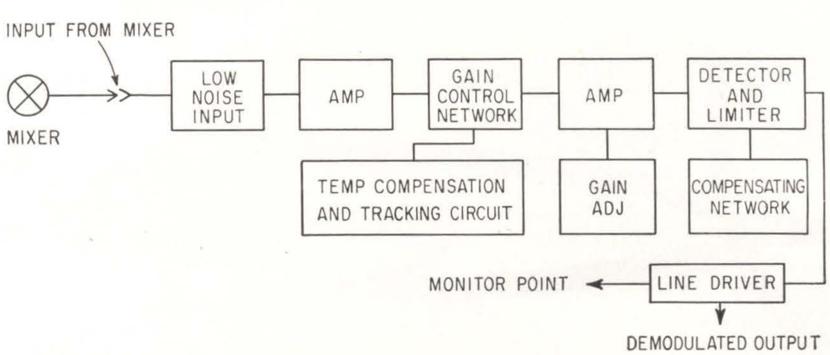
CIRCLE **301**, READER SERVICE CARD

Hybrid Amplifier Has 105 db Gain

ANNOUNCED by LEL, Inc., Akron Street, Copiague, N. Y., hybrid main amplifier IHM-1 features a nuvistor input circuit for best signal-to-noise ratio and following stages using silicon transistors for improved reliability with minimum power consumption. Designed to operate in an environmental temperature range between −55 C and 100 C, the amplifier is constructed on a machined aluminum block that creates lateral webs to minimize chassis resonances and provide optimum compartmental shielding.

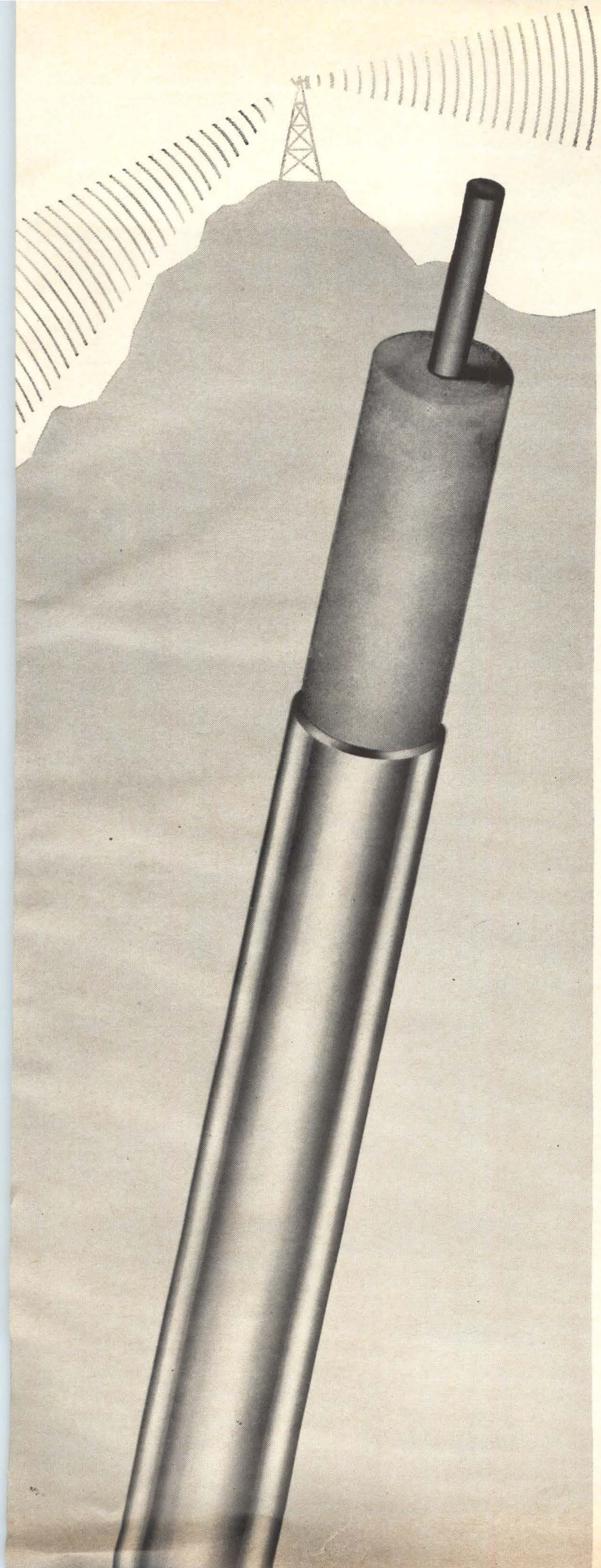
Attenuation is achieved with a special solid-state circuit that gives a 40 db range. Compensated gain vs agc voltage make the unit ideal where data on absolute signal strength is to be telemetered or recorded. NASA construction, wiring and conformal coating techniques are used through all phases of construction. **(302)**





Photofets Yield G_m of 1,000

ANNOUNCED by Siliconix, Inc., 1140 West Evelyn Ave., Sunnyvale, Calif., P-102 photosensitive field-effect transistor consists of a diffused, passivated, silicon photodiode functionally integrated with a high-



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Stabilize Frequency Response
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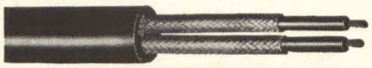
Lower Cable Attenuation

Newest of the Simplex electronic cables, economical Foam-Cel foam-polyethylene insulated coaxial cable, is filled with tiny air cells which provide superior insulating qualities in high frequency transmission. Ideal for community TV antennas, closed circuit TV, EDP signal transmission, and information circuits of all types, Simplex Foam-Cel has a solid aluminum outer sheath which is continuously seam-welded by a plasma jet welding process, making the cable impervious to liquids and gases. The resultant product is one which offers superior operating characteristics to those of conventional solid dielectric cables of the same dimensions . . . at substantial savings in cost.

Deep Sea Applications



This double-armored High Molecular Weight Polyethylene insulated Simplex electronic cable has, in addition to power and instrumentation circuits, the required tensile strength for lowering and retrieving complicated electronic equipment in ocean depths of several miles. Balanced-torque double-armored construction minimizes residual torque of the armor wires.

Reduce Low-Level Signal Noise

Simplex special polyethylene insulated antimicrophonic designs reduce externally caused noise to a level of 2 millivolts — 96.7% lower than a typical RG 8/U cable subjected to identical severe mechanical abuse. Stocked for immediate delivery are high demand items such as 2 conductor #18 and single conductor #16. Antimicrophonic features may be incorporated in any special cable construction.

In addition to a wide variety of standard electronic cable types, Simplex has the capability to produce specific cables to meet your particular requirements. For complete details write to Department 365, Simplex Wire & Cable Co., Cambridge, Mass.

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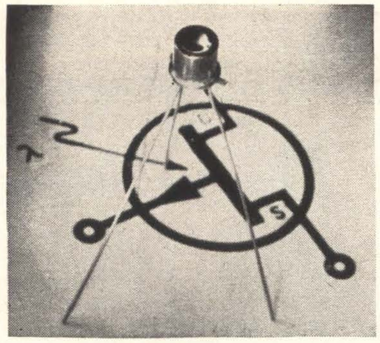
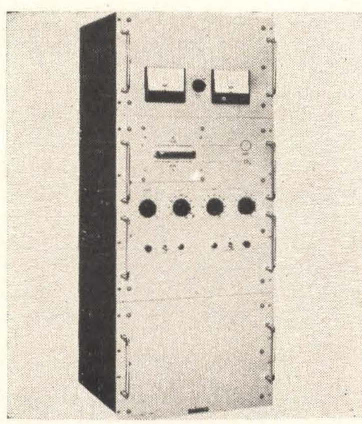
CIRCLE 49 ON READER SERVICE CARD



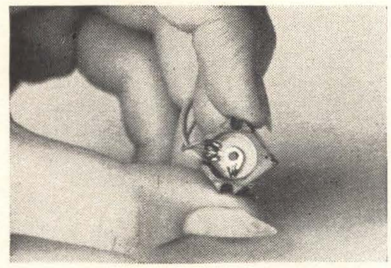
impedance, low-noise preamplifier. According to the manufacturer, this photodetector is ideal for high-impedance, high-output transistor systems and will find applications in log or integrating response, adjustable threshold and low-drift d-c operation. A specific directivity of 10^{10} cm-cps$^{1/2}$/watt (equivalent input noise power of 10^{-12} watts/cps$^{1/2}$ at 1 kc) can be obtained with the output of the detector operating into a 2,000 to 10,000 ohm load for optimum coupling to standard transistor amplifiers. P-102 has input sensitivity of 5 μa/μwatt, spectral response of 0.4 to 1.1 microns, dark current of 10 namp maximum, transconductance of 1,000 μmhos minimum and amplifier noise figure (R_G = 1 meg, 1 kc) of 1 db. Units are priced at $29 in quantities between 100 and 299.

CIRCLE **303**, READER SERVICE CARD



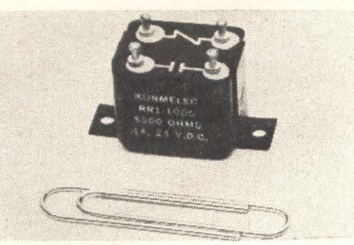
D-C Power Supply Has High Stability

A NEW 30,000-v, regulated d-c power supply is available. Model 430A delivers calibrated d-c from 10 to 30.22 kv with output current capability of 0 to 10 ma. Other features are line regulation of 0.005 percent, load regulation of 0.01 percent, stability of 0.005 percent and front panel polarity reversal plug, interlocked for safety. Weight is 260 lb; price, $3,900. John Fluke Mfg. Co., Inc., Box 7428, Seattle 33, Wash. **(304)**



Subminiature Trimmer Rated 1 W at 40 C

WITH each of 7 component parts designed for low-cost mass fabrication and assembly, a new trimming potentiometer is described by its manufacturer as offering extremely high use/cost performance value. Model 2600 $\frac{3}{4}$ in. long, 22-turn trimmer has a resistance range of 100 to 20,000 ohms and a power rating of 1 w at 40 C. It terminates in printed-circuit pins. Borg Equipment Division, Amphenol-Borg Electronics Corp., 120 S. Main St., Janesville, Wisc. **(305)**



Reed Relay Offers High Reliability

MAGNETICALLY shielded reed relay, model RR1-1000, has turret-type terminals, dimensions of 0.937 in. by 0.750 in. by 0.750 in., no-chatter vibration range of 10-2,000 cps at 20 g, shock resistance of 75 g at 11 ± 1 millisec. Pull-in voltage is 9 v d-c max; drop-out voltage, 0.6 v d-c minimum; max coil voltage, 125 v d-c; coil resistance, 5900 ohms ± 10 percent; operate time, 2.8 millisec max at 9 v d-c; contact rating, 0.1 amp at 24 v d-c; price $4.75 each in lots of 1,000. Kurman Electric Co., division of Kurman Instruments Corp., 191 Newel St., Brooklyn 22, N. Y. **(306)**

Literature of the Week

AUTOMATIC DRAFTING MACHINE Gerber Scientific Instruments Co., P.O. Box 305, Hartford, Conn. Technical data sheet covers the 1,000 series automatic drafting machine for fast, reliable line drawing and point plotting. **(311)**

SWITCHES The Milton Ross Co., Second St. Pike, Southampton, Pa. A 25-page catalog covers a line of snap-action and limit switches. A free sample of the S800B snap-action switch is included with each qualified request. **(312)**

VHF/UHF TELEMETRY RECEIVER Defense Electronics, Inc., 5455 Randolph Rd., Rockville, Md. Bulletin TMR-5A describes salient engineering features, performance specifications and general applications for use throughout complete frequency spectrum. **(313)**

SOLID-STATE AMPLIFIER Taber Instrument Corp., 107 Goundry St., North Tonawanda, N. Y. Bulletin P-63198-4 describes a 90-db solid-state a-c voltage amplifier. **(314)**

MAGNETIC AMPLIFIERS & REACTORS General Electric Co., Schenectady 5, N. Y. Bulletin GEA-6930A discusses solid state magnetic devices for amplifying low-level signals from signal source to controlled device. **(315)**

NUCLEAR INSTRUMENTS Technical Associates, 140 W. Providencia Ave., Burbank, Calif., offers a 60-page catalog on its line of nuclear instruments, including counting and spectrometry systems for the radioisotope laboratory. **(316)**

PRESSURE SWITCHES Haydon Switch Inc., Waterbury 20, Conn. Bulletin 1700-2 gives complete engineering data and drawings of series 1700 barometric pressure switches. **(317)**

ELECTROLYTIC CAPACITORS Aerovox Corp., New Bedford, Mass., has issued a 24-page catalog on type QE aluminum electrolytic capacitors designed for applications requiring high reliability and long life. **(318)**

P-C COMPONENTS Cinch Mfg. Co., 1026 South Homan Ave., Chicago, Ill., offers a 24-page catalog of its components for printed circuitry. **(319)**

R-F INDUCTORS Nytronics, Inc., 550 Springfield Ave., Berkeley Heights, N. J. Shielded subminiature r-f inductors with inductances from 0.1 μh to 180,000 μh in 76 values are offered in a catalog sheet. **(320)**

TRANSFORMERS Freed Transformer Co., Inc., 1718-1736 Wierfield St., Brooklyn 27, N. Y., offers its 1963-64 catalog featuring information and specifications for a line of quality transformers. **(321)**

Westinghouse Reassigns Executives

DONALD C. BURNHAM, new president of Westinghouse Electric, has announced the election of eight vice presidents.

The company's seven product groups are being consolidated into six and will report to the president through two executive vice presidents.

Elected executive vice presidents were Ronald N. Campbell, formerly vice president in charge of the air conditioning group and George L. Wilcox, formerly deputy executive vice president.

Marshall K. Evans, vice president for management services, was elected to the newly created position of vice president, operations staff.

Also elected were: A. C. Monteith as senior vice president; Douglas D. Danforth, succeeds Burnham as vice president of the industrial group; John W. Simpson as vice president of the electric utility and marine group; Richard F. Austin as vice president, management services, and R. E. Kirby as vice president, engineering.

Physical Sciences Appoints Earl

APPOINTMENT of J. Alfred Earl as vice president in charge of research and development at Physical Sciences Corp., Arcadia, Calif., is announced. The company, an affiliate of Packard Bell Electronics, manufactures environment-resistant connectors and nuclear instrumentation.

Earl has been in charge of the chemical-ceramic metallurgical laboratory at Physical Sciences since the founding of the company in 1959.

Gladstone Joins Electron Products

SAMUEL R. GLADSTONE has been appointed product assurance manager of Electron Products, division of Marshall Industries, Monrovia, Calif., producer of precision capacitors. In this capacity, he will head the testing laboratory and inspection department, and will be responsible for the division's overall quality control program.

Before joining Electron, Gladstone was associated with the Raytheon Co., Missile Systems division.

Tung-Sol Elects Chief Executive

FRANK J. EHRINGER has been elected president and chief executive officer and a director of Tung-Sol Electric Inc., Newark, N. J.

Ehringer, who has been vice president and general manager of the company's automotive products division, succeeds Milton R. Schulte who has retired.

Announce Formation of New Company

TEK-COUNSEL, INC., a newly formed consulting firm, has been established in Chevy Chase, Md., to service the needs of the telemetry and instrumentation field.

Morton H. Cohen and Elton N. Sherman are principal officers. Cohen was formerly with Electro-Mechanical Research, and Sherman with Telemetrics, Inc.

PEOPLE IN BRIEF

Ronald E. Jachowski promoted to mgr. of applications engineering for instrumentation products at Motorola Instrumentation and Control, Inc. **R. Ray Weeks,** formerly with Sperry Gyroscope, appointed v-p and chief engineer of the Wilton, Conn., operations of Trak Electronics Co., Inc. **A. Robert Hildebrand** raised to mgr. of product development in the Television Products div. of Corning Glass Works. **Joseph C. Gausepohl,** previously with NASA, now reliability mgr. at Lockheed Propulsion Co. **Herbert M. Penningroth** moves up to exec engineer at the Delco Radio div. of General Motors Corp. **Daniel C. Schiavone** transfers from Martin Co. in Md. to the Orlando div. as director of reliability, test and evaluation. **Robert Berkovitz** leaves Dynaco, Inc., to join Jensen Mfg. Co. as product mgr. **Tom Shea** advances to closed circuit tv product mgr. at Blonder-Tongue Laboratories, Inc. **James A. Mason,** from Lear Siegler, Inc., to Fawick Corp. as chief engineer-magnetic products. **Joseph D. Lambert,** ex-Hughes Aircraft, named mgr. of the Western div. of Sierra Research Corp. **Walter J. Schafer** raised to program director for re-entry systems in the Space Systems div. of Fairchild Stratos Corp. **Warren T. Eriksen,** technical director, appointed acting g-m of the Semiconductor div. of Hoffman Electronics Corp. **Alvah A. Russell, Jr.** upped to v-p in charge of engineering at Ripley Co., Inc. **Earle F. Cook,** Maj. Gen. USA Ret., joins Radio Engineering Laboratories, Inc. as director of technical operations, Eastern area.

Planning to change your address?

Use the form below to indicate a change of address. Because our issues are addressed in advance, please try to allow at least 5 weeks for change of address to become effective. Attach the address label from your most recent issue in the space provided below.

(Please print the following information for proper service)

Title or position..............................

Name..............................

Chief Job Responsibility..............................

Distributor ☐
Manufacturer ☐

Company and Div..............................

Product or Service.............................. Approx. No. of Employees ....

Address..............................

City .... Zone..... State or Prov. ....

Mail to home address below:

Address..............................

City .... Zone..... State or Prov. ....

Mail to: Fulfillment Manager, **electronics**
330 West 42nd Street, New York City 36, N. Y.

***Paste present mailing label or address from wrapper or envelope here.**

EMPLOYMENT OPPORTUNITIES

electronics

WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

ATTENTION: ENGINEERS, SCIENTISTS, PHYSICISTS

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

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

STRICTLY CONFIDENTIAL

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

WHAT TO DO

1. Review the positions in the advertisements.
2. Select those for which you qualify.
3. Notice the key numbers.
4. Circle the corresponding key number below the Qualification Form.
5. Fill out the form completely. *Please print clearly.*
6. Mail to: Classified Advertising Div., ELECTRONICS, Box 12, New York, N. Y. 10036. (No charge, of course).

COMPANY	SEE PAGE	KEY #
AFSC-AFLC Joint Professional Placement Office New York, N. Y.	63*	1
ATOMIC PERSONNEL INC. Philadelphia, Penna.	55	2
BELL AEROSYSTEMS CO. Div. of Bell Aerospace Corporation A Textron Company Buffalo, New York	55	3
LOCKHEED MISSILES & SPACE CO. Div. of Lockheed Aircraft Corp. Sunnyvale, California	47	4
LINK DIVISION General Precision Inc. Binghamton, New York	64*	5
NORTH AMERICAN AVIATION INC. Space & Information Systems Div. Downey, Calif.	38, 51	6
SNELLING & SNELLING Professional Placement Center Waltham, Mass.	55	7
UNION CARBIDE NUCLEAR COMPANY A Division of Union Carbide Corporation Oak Ridge, Tenn.	55	8

* These advertisements appeared in the August 16th issue.

(cut here) **electronics WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE** (cut here)

(Please type or print clearly. Necessary for reproduction.)

Personal Background

NAME ....

HOME ADDRESS ....

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

HOME TELEPHONE ....

Education

PROFESSIONAL DEGREE(S) ....

MAJOR(S) ....

UNIVERSITY ....

DATE(S) ....

FIELDS OF EXPERIENCE (Please Check) 82363

☐ 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	☐ ....

CATEGORY OF SPECIALIZATION

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)	......	......
SALES (Proposals & Products)	......	......

CIRCLE KEY NUMBERS OF ABOVE COMPANIES' POSITIONS THAT INTEREST YOU

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

EMPLOYMENT OPPORTUNITIES

The advertisements in this section include all employment opportunities — executive, management, technical, selling, office, skilled, manual, etc.

Look in the forward section of the magazine for additional Employment Opportunities advertising.

— RATES —

DISPLAYED: The advertising rate is $40.17 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.

An advertising inch is measured 7/8" vertically on a column—3 columns—30 inches to a page.

Subject to Agency Commission.

UNDISPLAYED: $2.70 per line, minimum 3 lines. To figure advance payment count 5 average words as a line.

Box numbers—count as 1 line.

Discount of 10% if full payment is made in advance for 4 consecutive insertions.

Not subject to Agency Commission.

SEARCHLIGHT SECTION
(Classified Advertising)

BUSINESS OPPORTUNITIES

EQUIPMENT - USED or RESALE

ADDRESS BOX NO. REPLIES TO: Box No. Classified Adv. Div. of this publication. Send to office nearest you.
NEW YORK 10036: P. O. Box 12
CHICAGO 60611: 645 N. Michigan Ave.
SAN FRANCISCO 94111: 255 California St.

SELLING OPPORTUNITY WANTED

NASA/Houston Representation. Qualified Technical Space Consulting Company. Presenting your capabilities at lower fixed sales cost. RA-2777, Electronics.

MISCELLANEOUS

License Available: Thermostats. Small temperature responsive switch devices for supervising and regulating fixed operational temperatures (US-Patent). More information by KAPAZITATENVERMITTLUNG. Dr. Raabe, Obernhainer Str. lo, 6 Frankfurt/M., Germany-West.

"Put Yourself in the Other Fellow's Place"
TO EMPLOYERS
TO EMPLOYEES

Letters written offering Employment or applying for same are written with the hope of satisfying a current need. An answer, regardless of whether it is favorable or not, is usually expected.

MR. EMPLOYER, won't you remove the mystery about the status of an employee's application by acknowledging all applicants and not just the promising candidates.

MR. EMPLOYEE you, too, can help by acknowledging applications and job offers. This would encourage more companies to answer position wanted ads in this section. We make this suggestion in a spirit of helpful cooperation between employers and employees.

This section will be the more useful to all as a result of this consideration.

Classified Advertising Division
McGRAW-HILL PUBLISHING CO., INC.
330 West 42nd St., New York 36, N. Y.

PROFESSIONAL SERVICES

INDEX TO ADVERTISERS

■

• See advertisement in the July 25, 1963 issue of Electronics Buyers' Guide for complete line of products or services.

This Index and our Reader Service Numbers are published as a service. Every precaution is taken to make them accurate, but **electronics** assumes no responsibilities for errors or omissions.

electronics

Audit Bureau of Circulation — Associated Business Publications

Audited Paid Circulation

JAMES T. HAUPTLI (2210)
Advertising Sales Manager

DAVID CUNNIFF (3139)
Promotion Manager

HENRY M. SHAW (3485)
Market Research Manager

■

Electronics Buyers' Guide

R. S. QUINT (2335)
General Manager

■

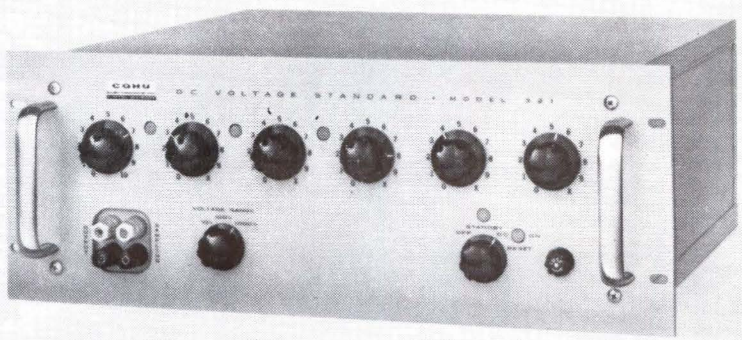
RICHARD J. TOMLINSON (3191)
Business Manager

THEODORE R. GEIPEL (2044)
Production Manager

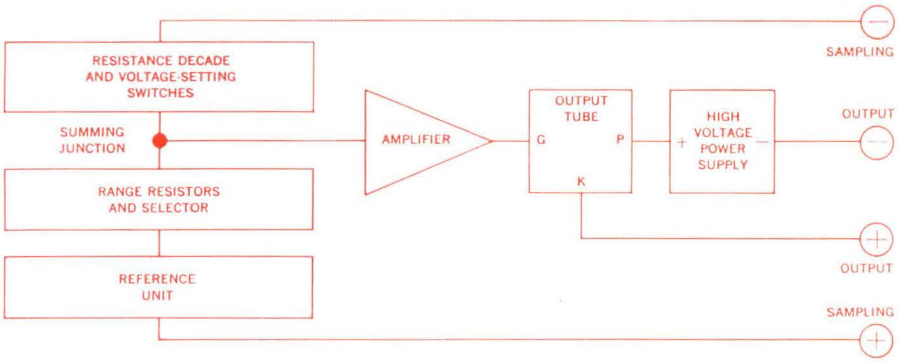
NEW YORK TELEPHONE: Dial Direct: 971 plus number in parenthesis, Area Code 212

Look what KIN TEL brings you in a DC voltage standard for just $1995!

outside view:



diagrammatic view:



engineer's view:

MODEL 321
DC VOLTAGE STANDARD

0 to ±1111.110 volts

10 volt, 100 volt, 1000 volt ranges

10-μv, 100-μv, 1-mv steps

current up to 25 ma

0.01% accuracy

0.0025% voltage output stability/8 hours

0.005% voltage output stability/30 days

0.001 ohm source impedance

floating output

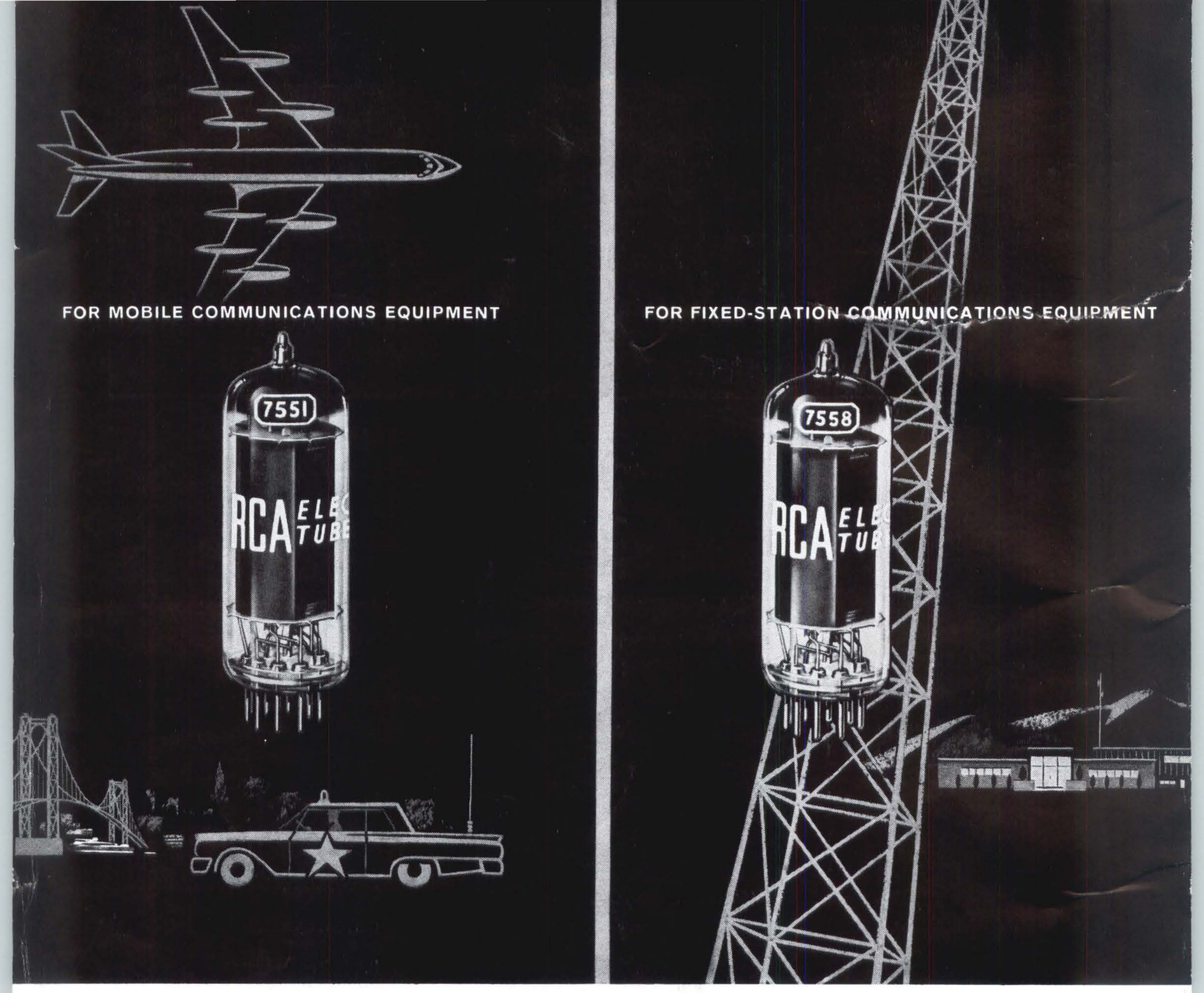
overcurrent protection

Write today for detailed information or a demonstration of this latest voltage standard in the KIN TEL line. Representatives in all major cities. All prices F.O.B., San Diego, California. (Additional export charge.)

5725 Kearny Villa Road
San Diego 12, California
Phone 277-6700 (Area Code 714)

COHU
ELECTRONICS, INC
KIN TEL DIVISION

CIRCLE 901 ON READER SERVICE CARD



Best Miniature Beam Power Tubes in their Price Class

More performance per dollar is packed into the RCA-7551 and 7558 miniature beam power tubes than in any comparable tubes on the market. With the 7551 and 7558, you can design top-quality communications equipment while keeping costs down.

Either tube gives top performance as a Class C r-f amplifier, oscillator, or frequency-multiplier at frequencies up to 175 Mc. Either may also be used in modulator or a-f power amplifier applications. A pair of either type, in Class AB_1 push-pull a-f amplifier service, can deliver up to 20.5 watts signal power output.

Identical in all respects except for heater ratings, the 7558 has a 6.3-volt heater (for use in fixed-station communications equipment) while the 7551 operates over a fluctuating heater-voltage (12 to 15 volts) such as that encountered in mobile systems operating from 6-cell storage-battery systems. In addition, the 7551 is subjected to rigid controls and tests for heater cycling, H-K leakage, interelectrode leakage, low-frequency vibration, and 500-hour intermittent life—to assure dependable performance in mobile systems.

Features contributing to efficient high-frequency performance of these tubes include:

- *Low lead inductance*
- *Two base-pin connections for both the cathode and the No. 2 grid—to minimize degeneration and facilitate r-f bypassing*
- *Low interelectrode capacitances*
- *Low r-f loss and high input resistance—permit use of high grid-No. 1 circuit resistance to minimize loading of the driver stage.*

These remarkable tubes help you to design compact communications equipment with assurance of dependable performance and long life. See your RCA Field Representative, or write, Commercial Engineering, Section H-19-DE-3, RCA Electronic Components and Devices, Harrison, New Jersey.

RCA

The Most Trusted Name in Electronics

RCA FIELD OFFICES: EAST: 32-36 Green Street, Newark 2, N. J., (201) 458-3900. MIDWEST: Suite 1154, Merchandise Mart Plaza, Chicago 54, Ill., (312) 527-2900 • WEST: 6801 E. Washington Blvd., Los Angeles 22, Calif., (213) RAymond 3-8361 • 1838 El Camino Real, Burlingame, Calif., (415) 697-1620.