Electronics®

Operational trigger for fine control: page 50

Analyzing circuits with a computer: page 56

Will microwaves replace infrared? page 66

November 2, 1964
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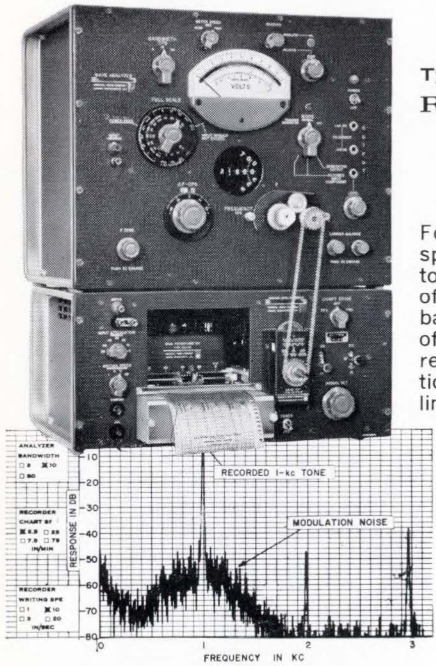
Below: power transistors are getting bigger, page 42

Systems for:

SPECTRUM ANALYSIS
AUTOMATIC FREQUENCY-RESPONSE TESTING
LEVEL vs TIME MEASUREMENTS

These systems are built around the new, improved Type 1521-B Graphic Level Recorder . . . an all-solid-state, servo-type recorder that plots the rms value of ac voltage logarithmically on a linear dB scale. Four interchangeable plug-in potentiometers provide full-scale dynamic ranges of 20, 40, and 80 dB, and a linear range for dc recording. Recordings can be made as a function of time or frequency. Response is ±2dB to 200 kc/s (down 3dB at 4.5 c/s). Input sensitivity is 1mv at 0dB and 0.8V full-scale for dc recording. Price with 40-dB pot is **$995**.



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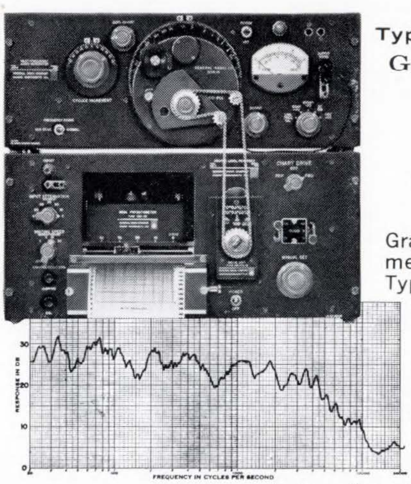

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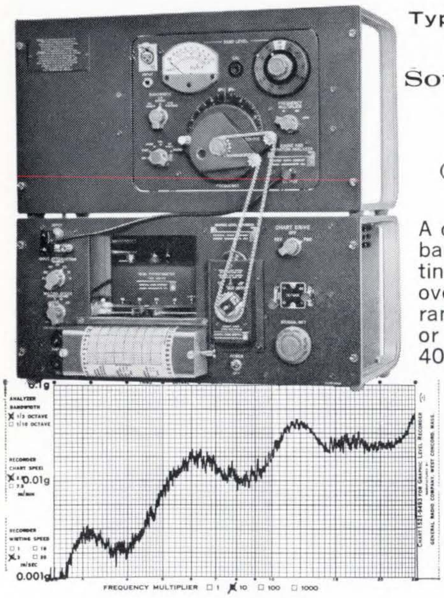

Type 1911-A

Recording Sound and Vibration Analyzer

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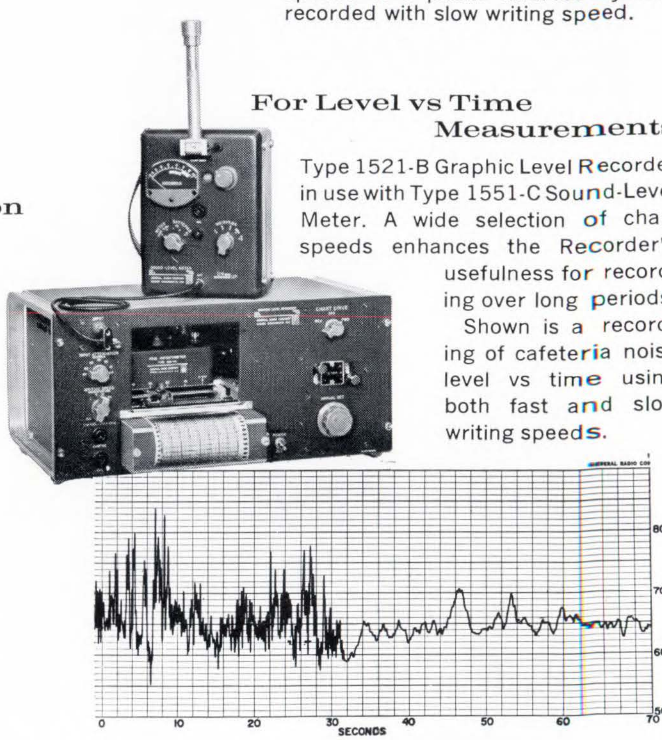

For Level vs Time Measurements

Type 1521-B Graphic Level Recorder in use with Type 1551-C Sound-Level Meter. A wide selection of chart speeds enhances the Recorder's usefulness for recording over long periods. Shown is a recording of cafeteria noise level vs time using both fast and slow writing speeds.

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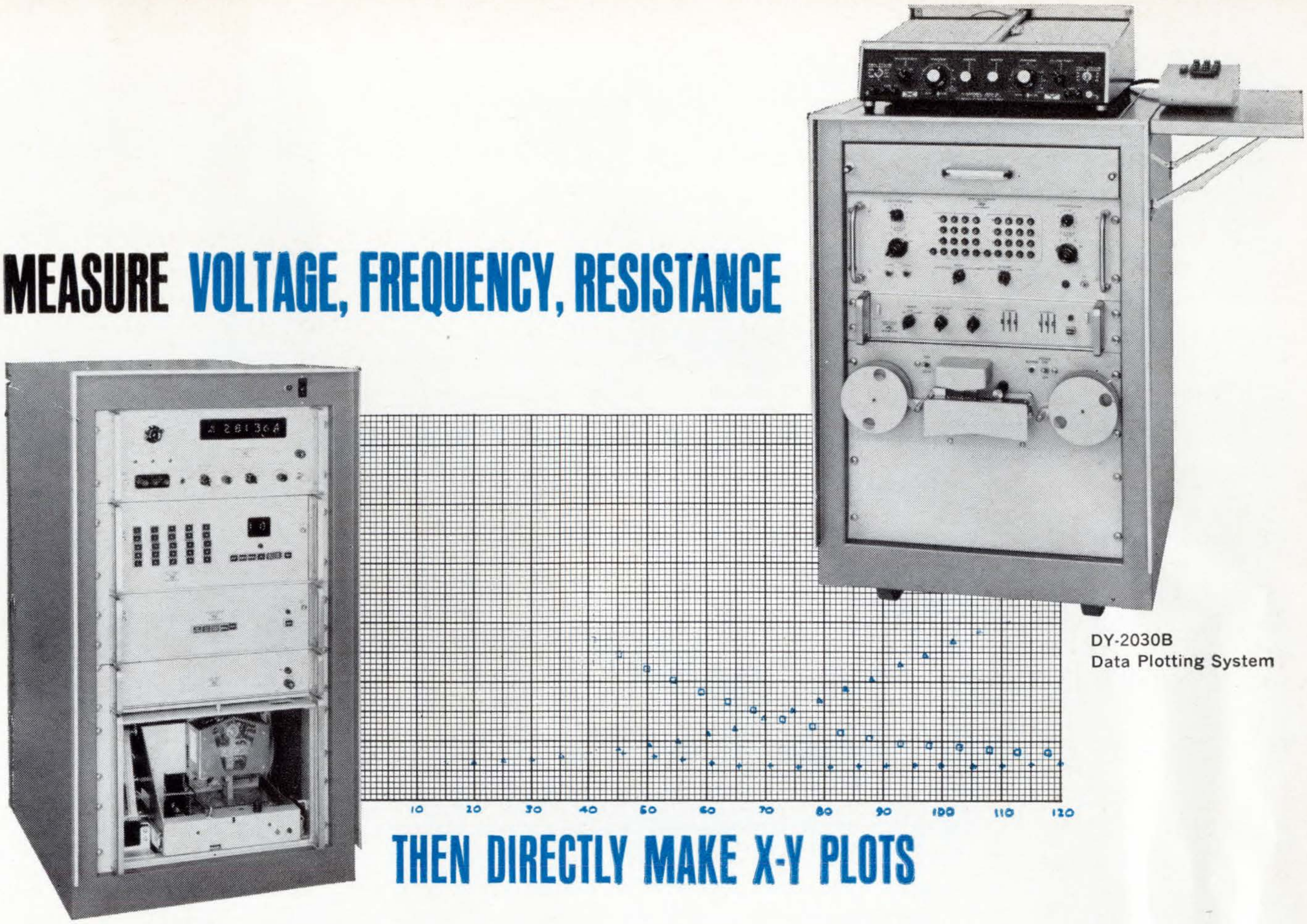

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DY-2010B
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All of these Dymec systems are fully specified and priced, and may be ordered from the catalog. And never before have comparable capabilities been available at the price. $10,800 for the DY-2010B, for example, plus as little as $10,875 for the 2030B with 2734A Editor.

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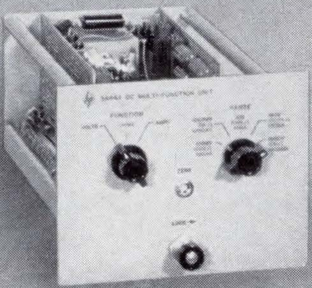
PLUG: 

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Electronics

November 2, 1964
Volume 37, Number 28

Electronics Review

Electronics Abroad

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I. Design

II. Application

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Reprints: T.M. Egan

Publisher: C.C. Randolph

Electronics: November 2, 1964, Vol. 37, No. 28

Printed at 99 North Broadway, Albany, N.Y.
Second class postage paid at Albany, N.Y.

Subscriptions are solicited only from those actively engaged in the field of the publication. Position and company connection must be indicated on orders. Subscription prices: 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.

Published every other Monday by McGraw-Hill Inc. 330 West 42nd Street, New York, N.Y.10036. Founder: James H. McGraw, 1860-1948.

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Readers Comment

Fine Italian hand hits back

Please correct the impression given in your article entitled "Fine Italian hand at the Pentagon," on page 103 of the Oct. 5 issue, as to my and the Department of Defense's attitude regarding the future of the defense-aerospace industry. In order to support what you purport to be my lack of concern for the future of this industry, you make reference to my refusal to attend a conference last spring and you also quote inaccurately from a speech that I gave at a luncheon of the AIAA [American Institute of Aeronautics and Astronautics] in Washington on July 1, 1964.

I am sure that if you examine the two examples you will come to the opposite conclusion. I refused to participate in a symposium on the "conversion" of defense industry specifically because I do not believe that there is a need for conversion of the defense research and development industry; no conversion is necessary if the level of support remains essentially constant. The confusion between diversification, which is useful and desirable, and conversion, which is unnecessary, is very unfortunate but your article does encourage such confusion.

I am attaching a copy of my speech; you will notice that the words printed by you between quotes do not appear in the text. It should become clear from the speech that my concern lies with the "gloom and doom" that appears to stem from a small decrease in the R&D budget of the Department of Defense between 1965 and 1964. It is difficult for me to see how a speech, which was aimed at encouraging the defense industry to do more creative thinking and more creative work and at the same time to promise that no significant decrease in the level of the R&D budget was planned by the Department of Defense, can be interpreted as representing a lack of concern for such industry. I believe that never have the officials of the Department of Defense, beginning with Secretary McNamara, Deputy Secretary Vance, the Service Secretaries, Dr. Brown and the Assistant Secre-

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taries, devoted more time and attention to the effects of Department of Defense decisions on the future of the industry and never have more intensive and meaningful efforts been carried on to obtain a closer cooperation between the industry and government than in this Administration.

Eugene G. Fubini
Department of Defense
Washington

▪ Our point is that there is more to electronics defense industry than R&D. Assistant Secretary Fubini ignores military procurement, a big important part of the market. Procurement slid $1.8 billion this year and is expected to decrease about 4% a year for the next five years. As a result, some electronic companies are recording sales declines of 40% and 50%, enough to worry any company.

Here are the excerpts from Secretary Fubini's speech to the AIAA:

"A year ago many said that there were terrible shortages. I see symposia planned on conversion from defense into commercial enterprises. All this gloom and doom talk from a 5% decrease in defense spending. Is defense business to be the sole United States business where a 5% cut creates a panic? . . .

"I hope that the intent of this talk is clear. It is to express my concern about the talk that implies that the Defense Department is going out of the research and development business; and that a long period of conversion into commercial products is becoming necessary. It is clear that there is no policy within the Department of Defense to shrink our budgetary level in any major fashion; that there is no long-range plan to continually reduce the research and development budget. If enough people believe this sort of talk, despite the fact that there is no clear justification for it, and if they act on it, then there is the possibility that the prophecy may become self-fulfilling. This would be tragic for all of us. The very nature of the research and development process, based as it is on the use of intellectual rather than material resources, makes the possibility of self-fullfilling prophecies more than negligible."

Commuter and computer

I was very interested in "Commuter and computer" [July 13, p. 87], but I was also very disturbed by your statement, "The driverless or robot train is not the goal; neither labor unions nor passengers are ready for the black-box driver." Why is everyone afraid to really solve our transportation problem? We plan to send men to the moon, but we use only half-way measures to correct our transportation problem.

What is really needed is an automatic system using small cars that will take the passenger where he wants to go. The cost of the overhead track for such a system would be less than the cost of the track for a mass transportation system, as the track would have to support only about 2,000 pounds, instead of the weight of a train.

The control system for such an automatic system would not have to be as complicated as it might at first appear. All cars would travel at the same speed at any point on the track. This could be accomplished by having a segmented third rail with the distance between segments determining the speed. The segmented rail could also be used as a block system; that is, passing cars would leave a voltage on the segments that following cars would detect and use for slow-down signals when they became too close to preceding cars. This would be especially necessary where two tracks combined to form one track, such as a lateral feeding onto the main line.

The destination would be selected by a series of switches somewhat similar in principle to the dial telephone. The code selected by the first switch would be compared with the code built into the line at each turn-off to a lateral, until an identical code was found. The car would then turn onto the lateral and the car's next destination switch would be switched into the selection circuit to determine the next turn. Even in an area as large as greater Los Angeles, it would require only four switches to select the destination.

Whether an all-automatic system is feasible or not cannot be determined until it is tried.

N.R. Griswold
Federal Way, Wash.

People

Five years ago Varian Associates invested in the S-F-D Laboratories, Inc., a New Jersey company that produces microwave tubes for countermeasure and radar systems.

Today the microwave company is a wholly owned Varian subsidiary but it may well be that the best byproduct of the original investment is Varian's new vice president. **Joseph Feinstein,** one of the original founders of S-F-D, has just been appointed to direct research for all of Varian's divisions.

The 39-year-old Feinstein invented the coaxial magnetron when he was at Bell Telephone Laboratories and subsequently directed research for S-F-D Laboratories.

He sees his new job primarily as one of "making sure the company gets its money's worth for each research dollar spent." With microwave tubes, he says, "we've done a pretty good job of translating research and product development into sales." Now he's eager to do the same for the rest of Varian's research activities.

Bernard P. Miller, the man responsible for the success of the camera system on the Ranger 7 spacecraft, has received the Public Service Award of the National Aeronautics and Space Administration.

Miller, 35 years old, is Ranger project manager for the Radio Corp. of America. He was cited for his contributions to Ranger's success and to the advancement of the Apollo program.

He started working on the Ranger program in 1961 and will continue with the project through Rangers 8 and 9. After that? He says he wants to manage "more complicated projects."

New MTPH Miniature Wet Slug Capacitors Proven In 1,430,000 Hours of Life Testing

Type MTPH capacitors were developed by Mallory as a result of experience gained producing a similar line for use in the Minuteman II missile system made by Autonetics Division of North American Aviation, Inc.

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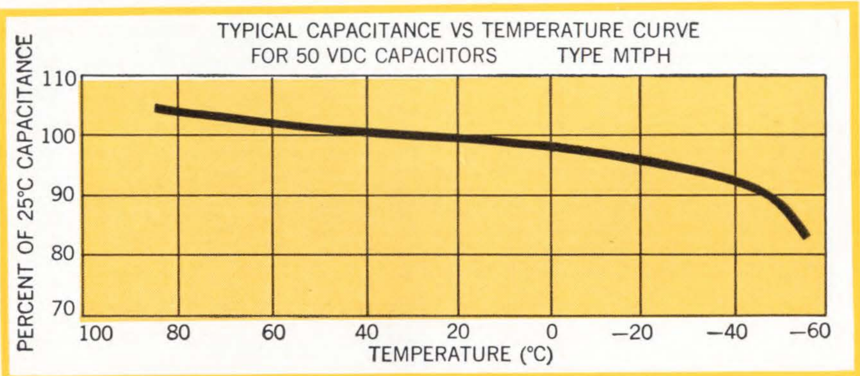
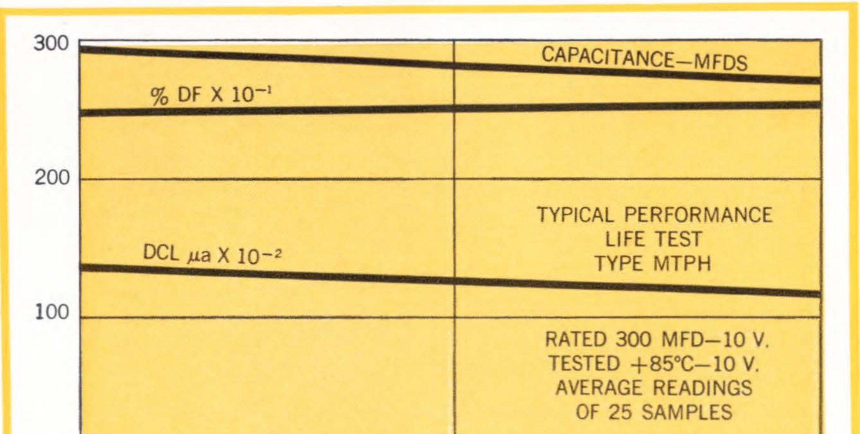
MTPH capacitors have higher capacity-voltage product per unit volume than any conventional wet slug, foil or solid tantalum line. This size factor makes these capacitors very desirable for applications with thin film, integrated and other microelectronic circuits. An additional advantage of the wet slug construction is the absence of the familiar catastrophic failure mode of solid tantalum devices. After 1,430,000 unit hours of life test at 85°C, at full rated voltage, using a low impedance power source, not one MTPH has failed through short circuiting or excessive DC leakage current.

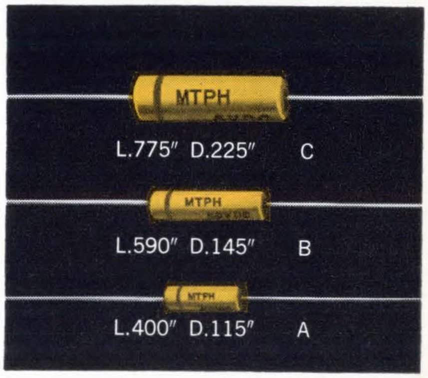
For complete data and prices, write or call Mallory Capacitor Company, Indianapolis, Indiana 46206—a division of P. R. Mallory & Co. Inc.

STANDARD RATINGS

MTPH NO.	Rated Cap Mfd.	Rated Voltage D.C.	DCL μa +25°C	DCL μa +85°C	DF% +25°C	% of +25°C Cap at −55°C	120 CPS Z at −55°C	DF% +85°C	Case Size
MTPH1	6.8	50	3	10	20	70	400	10	A
MTPH2	30	50	8	25	20	70	120	15	B
MTPH3	78	50	10	30	20	60	55	18	C
MTPH4	10	30	3	10	20	65	290	10	A
MTPH5	45	30	8	25	25	60	100	20	B
MTPH6	120	30	10	30	30	55	48	25	C
MTPH7	60	20	7	20	25	55	90	20	B
MTPH8	80	15	6	18	30	55	82	25	B
MTPH9	200	15	8	25	30	50	44	25	C
MTPH10	120	10	5	15	35	50	66	25	B
MTPH11	300	10	7	20	35	40	35	28	C
MTPH12	180	6	5	15	37	50	40	25	B
MTPH13	450	6	6	18	50	40	33	40	C







MALLORY

Meetings

Fall Data Processing Conference and Business Exposition, DPMA; Hilton Hotel, San Francisco, **Nov. 3-5.**

Northeast Electronics Research and Engineering Meeting (NEREM), New England Section of IEEE; Commonwealth Armory and Somerset Hotel, Boston, **Nov. 4-6.**

US Army Material Command and Institute of Environmental Sciences Joint Meeting, USAMC, IES; Aberdeen Proving Ground, Md., **Nov. 5-6.**

Optical and Electro-Optical Information Processing Technology Symposium, ONR, ACM, PTGEC/IEEE, OSA; Somerset Hotel, Boston, **Nov. 9-10.**

University and Industry: Partners in Education and Research, University of Rochester, N.Y. State Advisory Council for the Advancement of Industrial R&D; University of Rochester, Rochester, N.Y., **Nov. 9-10.**

National Electrical Manufacturers Association Annual Membership Conference, NEMA; Americana Hotel, New York, **Nov. 9-12.**

Switching Circuit Theory and Logic Design Annual Symposium, IEEE, Princeton University; Engineering Quadrangle, Princeton University, Princeton, N.J., **Nov. 11-13.**

Annual Science Conference, Belfer Graduate School of Yeshiva University; Hotel Astor, New York, **Nov. 16-17.**

Bioastronautics and the Exploration of Space International Symposium, Aerospace Medical Div., Southwest Research Institute; Granada Hotel, San Antonio, Tex., **Nov. 16-18.**

Engineering in Medicine and Biology Annual Conference, BME/IEEE, ISA; Cleveland-Sheraton Hotel, Cleveland, **Nov. 16-18.**

Machine Tools Industry Annual Conference, MTI-TC, IEEE; Statler Hilton Hotel, Hartford, Conn., **Nov. 16-18.**

Space Simulation Testing Conference, AIAA, PTGAS/IEEE; Pasadena, Calif., **Nov. 16-18.**

Magnetism and Magnetic Materials Conference, IEEE, AIP; Radisson Hotel, Minneapolis, **Nov. 16-19.**

Microelectronics and Large Systems Symposium, Information Systems Branch of ONR, Univac div. of Sperry Rand Corp.; Dept. of the Interior Building, Washington, **Nov. 17-18.**

Tri-Service Conference on Electromagnetic Compatibility, U.S. Army, Navy and Air Force; Museum of Science and Industry, Chicago, **Nov. 17-19.**

American Astronautical Society National Meeting, AAS; Kresge Auditorium, Massachusetts Institute of Technology, Cambridge, Mass., **Nov. 18-19.**

N.C. Section of IEEE Annual Symposium, N.C. Section of IEEE; Greensboro Coliseum, Greensboro, N.C., **Nov. 20-21.**

Definition and Measurement of Short Term Frequency Stability Symposium, NASA, IEEE; Goddard Space Flight Center, Greenbelt, Md., **Nov. 23-24.**

Mid-America Electronics Conference (MAECON), Kansas State University; Hotel Continental, Kansas City, Mo., **Nov. 23-24.**

1964 Winter Annual Meeting, Nuclear Engineering Div. of ASME; Statler-Hilton Hotel, New York, **Nov. 29-Dec. 4.**

New Horizons in Solid State Electronics, Rochester Institute of Technology, Schraffts Motor Inn, Rochester, N.Y., **Nov. 30-Dec. 2.**

The Road to Commercial Electronics: A Conference on Converting Military Capabilities to Civilian Markets. Electronics Magazine, IIT Research Institute; Grover M. Hermann Hall, Chicago, **Dec. 1-2.**

Professional Technical Group on Vehicular Communications Annual Conference, IEEE; Sheraton Hotel, Cleveland, **Dec. 3-4.**

Call for papers

Electrochemical Society Spring Meeting, Electrochemical Society; Sheraton Palace Hotel, San Francisco, May 9-13. Deadline is **Dec. 15** for submitting triplicate copies of 75-word abstract plus 500 to 1000 word extended abstract to Electrochemical Society Headquarters, 30 East 42nd St., New York, N. Y. 10017.

Signal Transmission and Processing Symposium, CTG/IEEE, Columbia University; Columbia University, New York, May 13-14. **January 15** is deadline for submitting 15-page manuscript to L. E. Franks, Bell Telephone Labs., 1600 Osgood St. North Andover, Mass. 01845.

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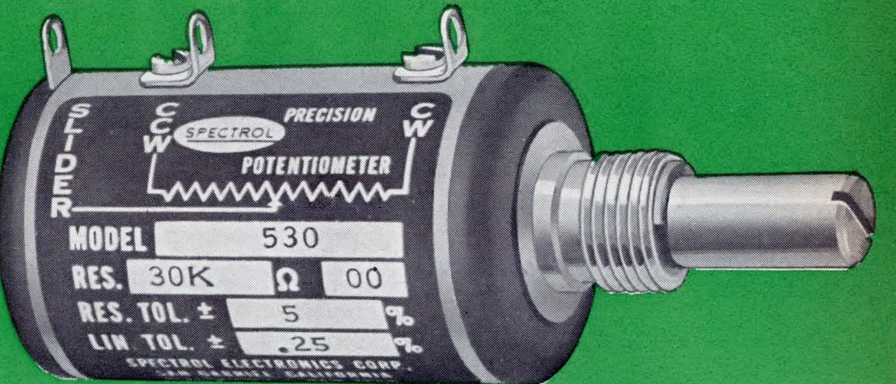

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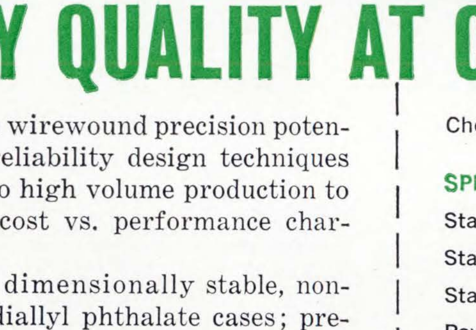

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Standard Resistance Tolerance	±5%	±5%
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Power Rating	2 Watts at 40°C	3 Watts at 40°C
Operating Temperature Range	—55 to +125°C	—55 to +105°C
Case Dimensions—inches.....	½ D x 1 L	⅞ D x 1 4/10 L
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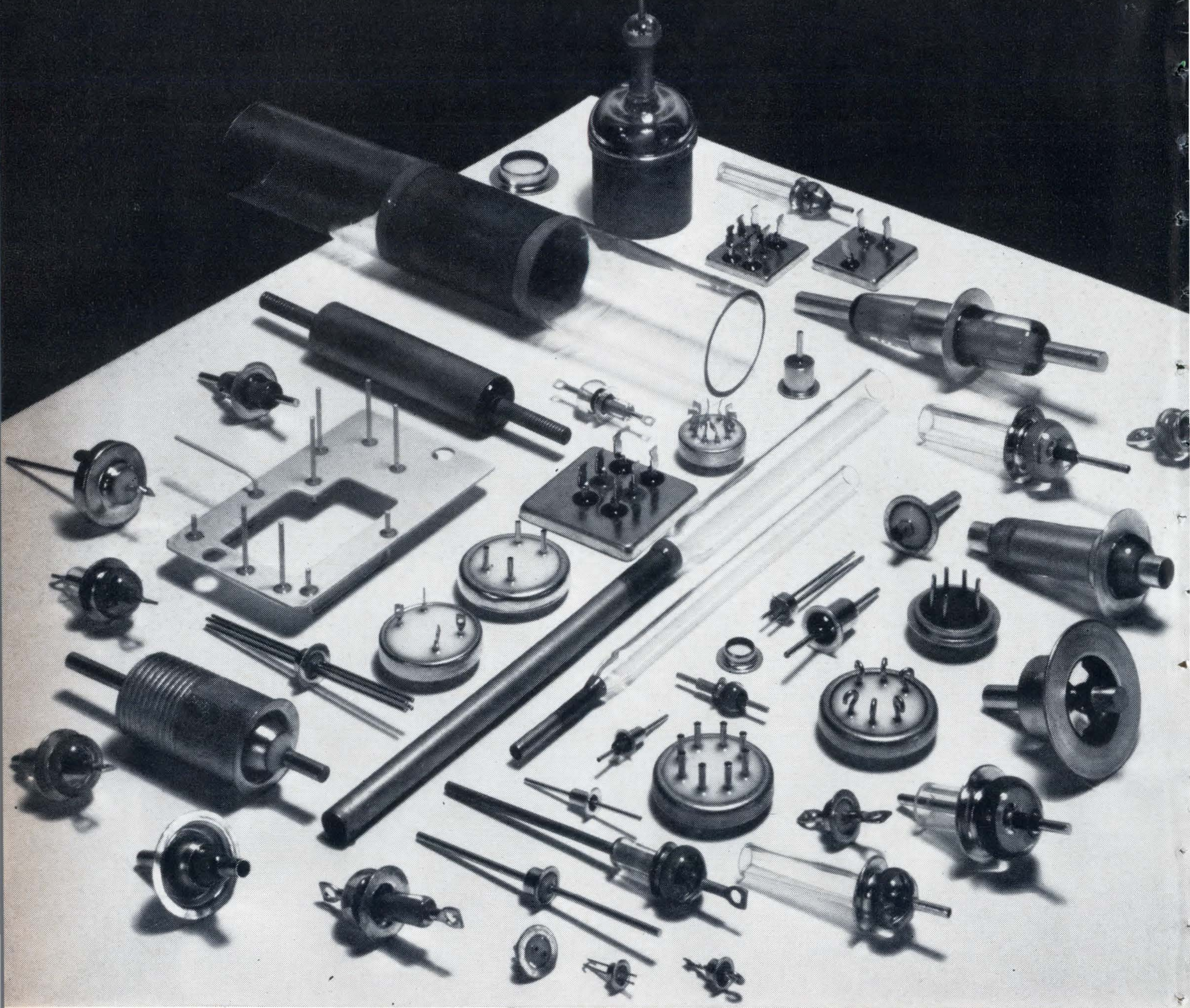

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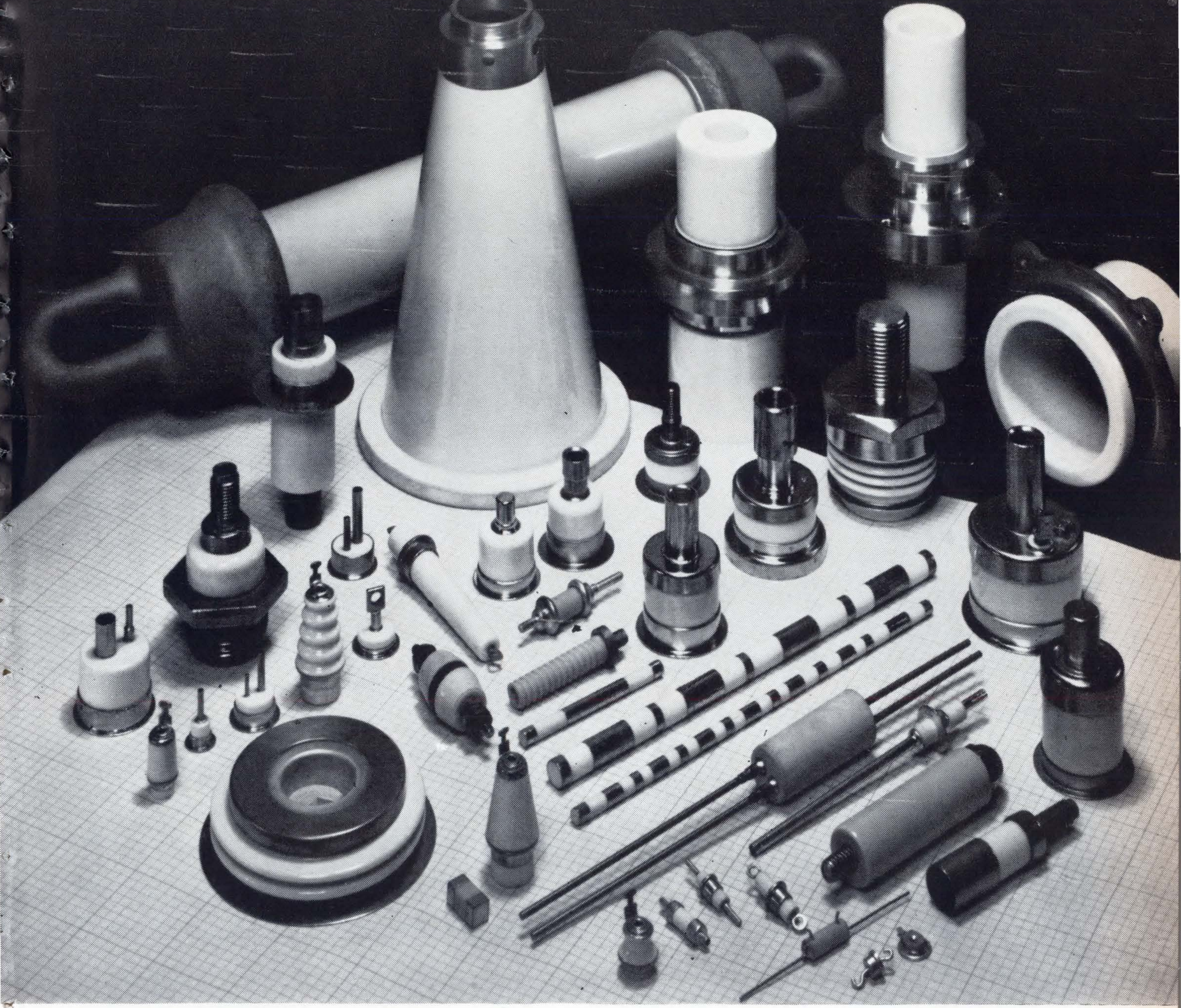

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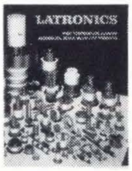

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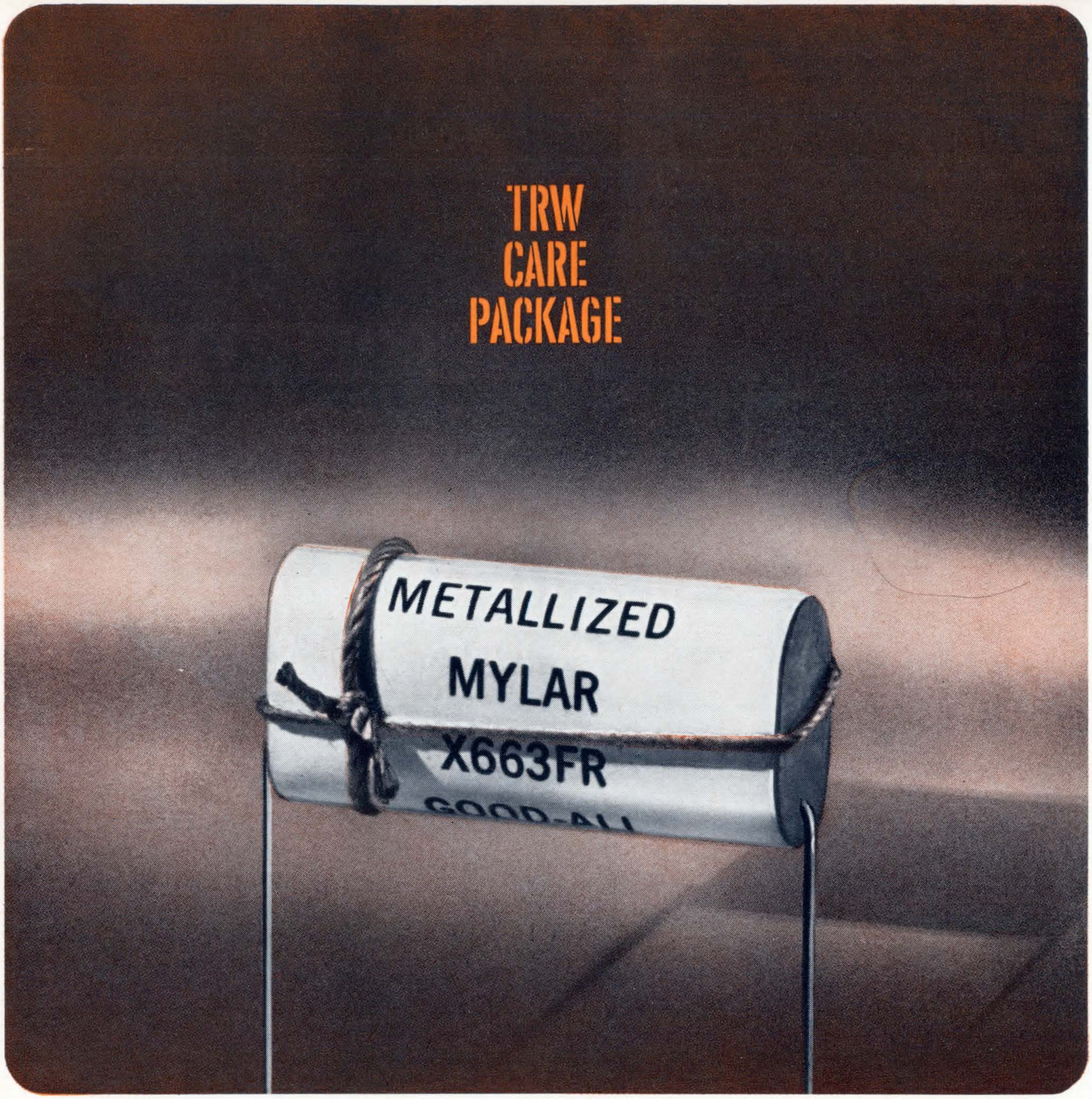

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Editorial

The arrow and the rifle

In the recesses of the Pentagon, technical planners like to tell this old riddle: If a research-and-development team is assigned the task of improving the strength, durability and sharpness of arrowheads, what are the chances it will invent the rifle?

The answer, of course, is practically none.

Behind the riddle is an obvious point: If the military narrows its development scope too sharply, it won't come up with any radical new weapons—except by rare accident.

Today, in the electronics industry, the point can be applied more broadly. As companies search for new markets—in the military, industrial or consumer fields—they must keep their minds open if they are to strike the rich lodes they are seeking.

In such a situation, there's a natural tendency to note first how other people have done something, then to follow along. But the biggest successes in diversification can come from striking out in a new direction, out of the established path. This is particularly true when developing electronic equipment to do jobs that are now done by other kinds of gear—pneumatic, hydraulic, mechanical, electromechanical or electrical.

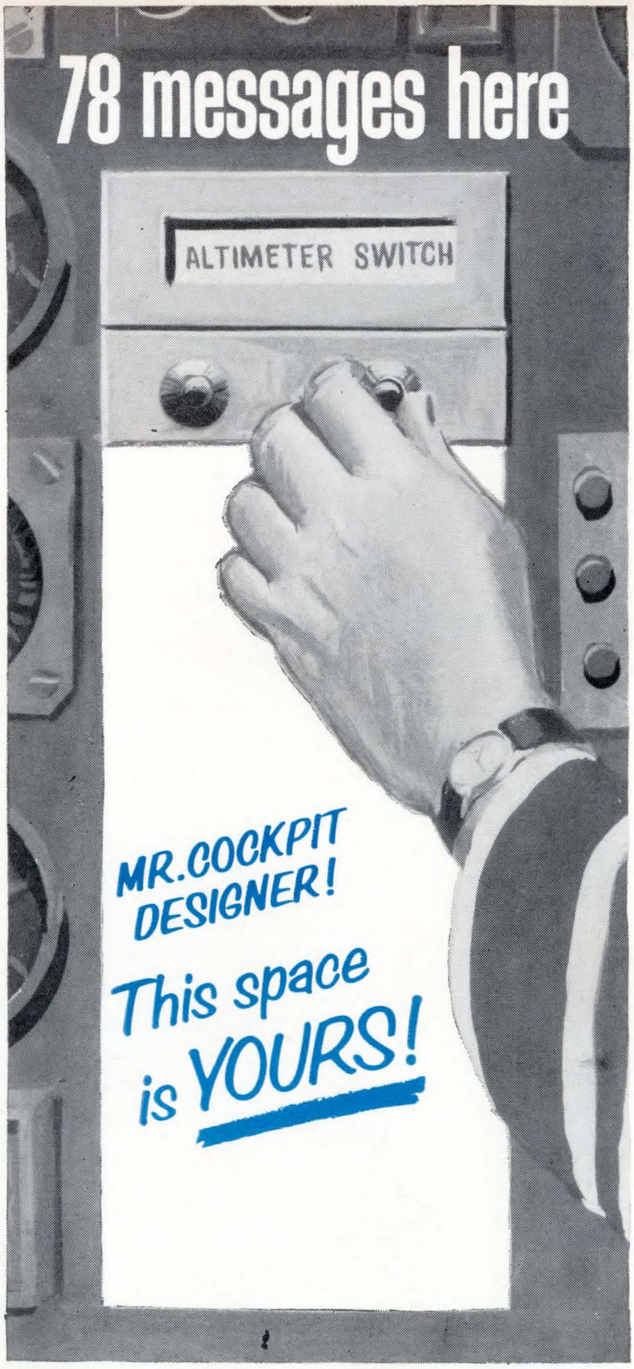
It can be a grave mistake to make an electronic analog. Four or five years ago, electronics companies tried that with new electronic process controllers built to run industrial plants such as chemical and petroleum refining units. The devices were designed to be electronic versions of well-established pneumatic controllers. They did exactly the same things, only faster, but they cost almost 25% more. Acceptance was understandably disappointing.

Now there's a new move afoot, and it promises success. New electronic controllers are appearing, designed to make the most of electronics technology. They are not being offered for every application, only for those in which they have distinct advantages over pneumatic controllers—such as when long signal-transmission lines exist, or when the chemical process to be controlled has fast reaction times, or when the process is to be controlled by a digital computer and electronic signals are available.

An example closer to most electronics engineers can be drawn from the transistorization of equipment 8 to 10 years ago. At first, when an engineer transistorized a piece of equipment, he merely replaced tubes with transistors, ignoring the special characteristics of transistors. This often produced equipment that was too expensive because it used too many transistors.

For some reason, electronics companies often wear blinders when it comes to product planning. Some of the strongest stimuli have had to come from the outside—such as the cigaret pack-size radio and the four-inch portable television set pioneered by the Japanese.

One of the electronics industry's worst weaknesses in all areas is in product planning. Harking back to the Pentagon's riddle, engineers need to stop looking only at the arrowhead, and to give some thought to what the arrow has to do.



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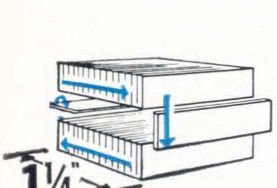

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Electronics Newsletter

November 2, 1964

Contract dispute brews at NASA

A rhubarb is brewing over the National Aeronautics and Space Administration's award of contracts for television cameras for the lunar Excursion Module. The agency's Manned Spacecraft Center in Houston is negotiating a $2.2 million pact with the Westinghouse Electric Co., but two other potential suppliers—the Radio Corp. of America and General Electrodynamics Corp.—say they didn't even get a chance to bid.

GEC is protesting to the Select Committee on Small Business because the contract was awarded without competitive bidding. GEC is particularly bitter because its camera was tested by the U.S. Geological Survey at Sunset Crater National Park, Ariz., under simulated lunar conditions, and recommended to NASA.

Gold beams make leads for circuits

The Bell Telephone Laboratories has made another of those simple, but basic, advances in semiconductor technology. **When the leads of components or circuits are made like cantilever beams, several electrical, mechanical and assembly problems disappear.** The technique was described Oct. 29 by its inventor, M.P. Lopsetter, at the Electron Devices Meeting in Washington.

Beam leads are electroformed extensions of the conventional thin-film electrodes that are deposited on planar devices. The beams are relatively massive—gold bars 10 microns thick. After the beams are made, the unused silicon between the semiconductor devices is etched away, leaving the devices as tiny chips mounted between beams that extend beyond the chip edges. **Beams have withstood centrifugal force of 135,000 g; with this strength, the chips don't have to be brazed to a package header or thin-film-circuit substrate.** The beams are welded or bonded.

Parts of integrated circuits can be isolated by a companion technique devised by H.A. Waggener. Beams interconnect the parts, while etching the excess silicon leaves gaps between the parts. Diffused regions or polycrystalline moats are not needed for isolation. Nor is high-resistivity, p-type silicon required for the substrate; regular epitaxial silicon can be used. Parasitic capacitances between parts are negligible, so logic circuits can operate at ultrahigh speeds. Beams ends can be tapered to match impedances between circuits.

Microelectronics costs declining

Reliability was the big reason the military developed microelectronics, but low cost is becoming a stronger factor in its growth in popularity. **If trends continue, equipment built with integrated circuits will cost less next year than gear built with conventional discrete components.**

That conclusion was reported to the National Electronics Conference in Chicago by Frederick Danner, an engineer who has plotted cost trends at the Grumman Aircraft Engineering Corp.

Experts say **metal-oxide semiconductor techniques will cut costs even more, possibly as much as 90%,** because manufacture requires only 20 steps instead of 140 steps for conventional planar techniques. Most makers of metal-oxide devices are offering only experimental models.

The 20 steps require far more delicate control than those used in planar technology. Static electricity remains a problem; it can destroy the device before it is installed in equipment. Manufacturers are wrapping a fourth lead around the three regular leads to conduct static electricity away from the chip.

The Victor Comptometer Corp. is building a low-cost electronic calculator with metal-oxide semiconductors. If this calculator is a commercial success, it could snowball applications of metal-oxide devices.

Unetched circuits to cost 10% less

How much will printed-circuit prices be cut by the Photocircuits Corp.'s new electroless plating process [Electronics, Oct. 19, p. 28]?

Robert Swiggett, executive vice president, says the price will be reduced 10% to 20% on large orders suitable for the company's new automated plating plant. **The markdown will be even greater for boards with circuits on both sides connected by plated-through holes—these will cost about the same as etched-wiring boards with circuits on one side and unplated holes.**

It should take about a year for customers to change enough designs to bring in many large-volume orders for plated circuits, Swiggett says. Photocircuits will continue to use the conventional etching process for small-quantity production.

Defense outlays trail requests

Defense expenditures for the current fiscal year are expected to be $1.4 billion below the appropriation requested in January. The government's latest budget review declares that $48.6 billion will be spent in fiscal 1965.

The estimate reflects a lower appropriation by Congress than had been requested, the impact of the Pentagon's cost-reduction program, and lower-than-expected obligations from the previous year.

About half the reduction is in the procurement area. The procurement outlay will be $334 million lower than was estimated in January. This mainly reflects cuts made by Congress for electronics and communications programs, the F-4 aircraft, guided missiles for the Army and Marines, and aircraft spare parts.

Research-and-development funds will be $274 million lower, largely because Congress denied funds for continued development of a mobile medium-range ballistic missile.

Foreigners seek sales to Comsat

United States companies can expect stiff competition from abroad for selling equipment to the Communications Satellite Corp. This seems especially true in electronic components such as traveling-wave tubes, masers, repeaters and the like. The British, Germans and Japanese have attained high technical competence in these fields, and their costs are often lower than in the U. S. A 12-member committee will meet Nov. 3 to work out Comsat procurement procedures.

High-noise diode

A high-noise diode, said to be eight times noisier than those previously available, has been developed by the Clevite Corp.'s semiconductor division. **It can be used for jamming radio signals and as a random noise generator for system testing.** The new silicon device, less than .001 inch in diameter, is intended as a replacement for zener diodes that can be used for the same purpose if operated at voltages above breakdown.

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For administrative and procurement management personnel who 'need to know' the role of integrated circuits in electronics today, we are pleased to announce that a two-day seminar will be given December 10-11 in Phoenix, Arizona.

Motorola now offers a special, all-new integrated circuit course to give administrative and procurement management personnel a unique opportunity to learn about the broad engineering and economic aspects of this new technology.

This two-day, semi-technical seminar is designed expressly for procurement, administration, and administrative engineering personnel. It is intended, in part, to serve as a communications link between equipment design engineers employing this new technology and those administrating or procuring for these design activities.

Motorola's top integrated circuit marketing and engineering personnel will direct and present this concentrated course. Providing an overall picture of integrated circuits in the electronics industry today, the course will cover such important management areas as:

- General familiarization with integrated circuits including fundamentals of the technology and classes and types of circuits
- Purchasing considerations, including standard and special circuits, digital and linear types, and high reliability testing — its effect on cost and delivery
- Delivery cycle for standard and special circuits, and integrated circuit price trends
- The integrated circuit product life cycle and the effects of volume, standardization and time

Registration fee for the complete course is $50 and includes tuition, materials, lunches and a graduation banquet. For complete details, just fill out and mail the attached coupon.

Response to Motorola's IC Design Course

More than 600 top engineers from major electronic equipment manufacturers in the United States and Europe attended Motorola's very successful 1963 and 1964 Integrated Circuits Design Courses. These courses marked the first known instance of a company in the highly competitive semiconductor industry extending a blanket invitation to those technically qualified to learn how integrated circuits are produced and how to design for this technology.

Typical comments from those who attended included . . . "probably could not have been done by any other company in the field," ". . . by far the best compilation of information covering the technology," ". . . a unique textbook that will be talked about for months to come."

The industry's enthusiastic response to the Integrated Circuits Design Course has led directly to the development of this new management-oriented seminar — with the purpose of providing appropriate background for the administrative and procurement management personnel who must prepare to work within the framework of this new technology.

Motorola reserves the right to limit enrollment.

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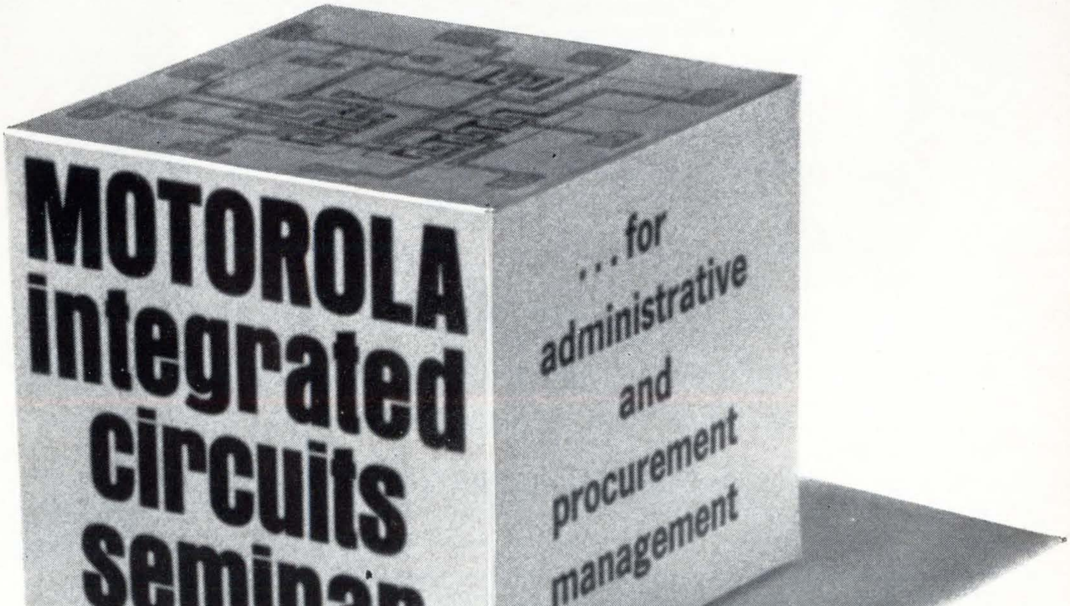

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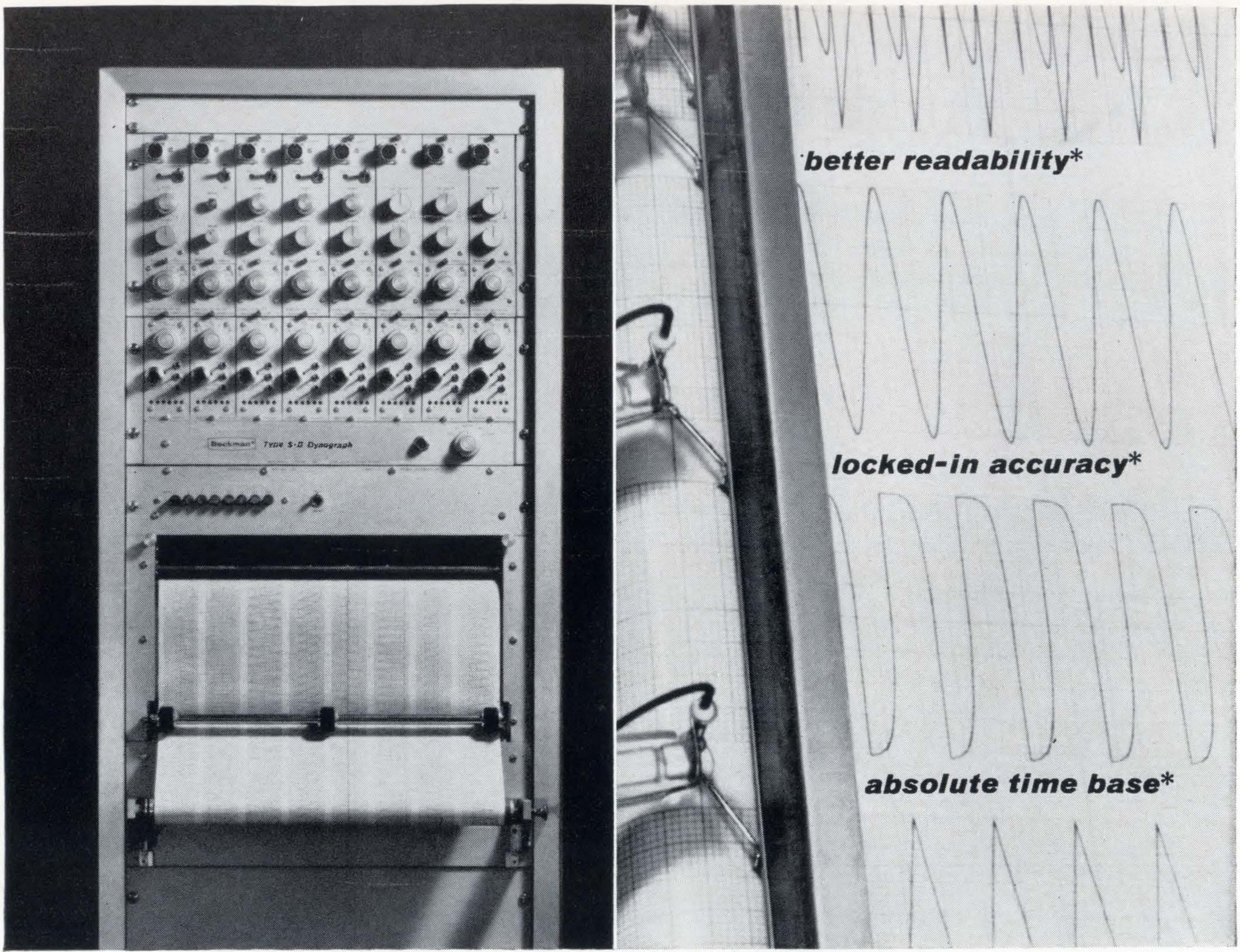

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Electronics Review

Volume 37
Number 28

Patents

In the circuit court

The Supreme Court on Oct. 12 refused to consider lower court decisions that the three basic Eisler patents for printed and etched wiring are invalid.

The decision, it was assumed, would lead to rapid settlement of some 70 suits, involving the same three patents, now pending across the nation, and save the industry more than $20 million in back royalties claimed by Technograph Printed Electronics, Inc., owners of the patents. Technograph wants 10% of the cost of all printed circuits that have been made by the companies being sued. This would cover a period that goes back six years before the suits were filed.

More to come? The issue is far from settled, says Hubert L. Shortt, president of Technograph. He indicated that despite the Supreme Court decision, the patent fight may become as lengthy and as far-reaching as the 15-year series of suits over infringement of the Armstrong patent on frequency modulation. Shortt has pointed out that only one case, has gone to the Supreme Court—Technograph vs. the Bendix Aviation Corp. [Electronics, June 7, 1963, p. 24].

He says the company intends to continue fighting the other 70 cases, one by one. If it continues to lose, he indicated, it will switch the attack to 41 other printed-circuit production and assembly patents owned or controlled by Technograph. Some, he says, involve thin-film circuits—which could open up a new area of dispute.

Eleven patents will be tested in a suit against the government.

One decision. In the Bendix case, Judge R.D. Watkins of the Maryland District Court ruled three Eisler patents invalid because all the processes involved had been disclosed in earlier patents dating back to 1888. He said printed circuits could be made by other processes, so there was no invention. The Court of Appeals in the Fourth Circuit ruled that the process was an obvious one. The Supreme Court refused the case.

District courts in other states were awaiting the Bendix ruling before hearing new cases. Lawyers expect these courts to be influenced by the Bendix decision. Manufacturers being sued will seek dismissals. For example, in Los Angeles, where the Packard-Bell Electronics Corp. is being sued, a "favorable decision" is expected soon by Robert Bell, president.

Lawyers give Technograph one slim chance: Somewhere, a district judge will rule the Eisler patents valid and will be upheld by a circuit court. Then Technograph could go to the Supreme Court.

Who comes first? Shortt claims the Supreme Court has never provided a "proper test of obviousness" to declare a patent invalid. He claims that other patents involving a new combination of prior art have been held valid. So the question, he says, is whether Eisler was the first to make the now-familiar printed circuit.

The "present theater of activity" is in Chicago, Shortt says. He expects five cases there to come up soon: the Automatic Electric Co., TravLer Industries, Inc., Webcor, Inc., Methode Electronics, Inc., and Croname, Inc.

Computers

Competitive edge

In the rough-and-tumble computer business, any competitive edge can mean the difference between success and failure for a company. That's why computer makers tried so hard to hide their concern last April when the International Business Machines Corp. introduced its System 360 fabricated with integrated circuits. Now the competitors are fighting back with their own integrated-circuit machines.

Talk about new machines blossomed all around the Fall Joint Computer Conference in San Francisco (Oct. 27-29).

Item. General Precision, Inc., has the GP-4 designed for scientific, process control and simulation, built of standard Motorola, Inc., integrated circuits.

Item. Digital Equipment Corp.'s new PDP-8 uses the company's own new 10-megacycle "flip-chip" integrated circuits. The machine, priced at $18,000 with a memory of 4,000 12-bit words, has a 1.6-microsecond memory.

Item. Scientific Data Systems, Inc.'s $29,000 computer for direct digital control has a digital-to-analog converter built of integrated circuits made by the Fairchild Camera & Instruments Corp.

Item. Electronic Associates, Inc., long-time dominant figure in the analog computer business, has diversified into digital computers with its 8400, a medium-scale computer built with Fairchild's 20-megacycle micrologic circuits.

Though mighty IBM's System 360 certainly influenced other computer makers to try integrated circuits, that isn't the only reason. The new machines are cheaper because of their microelectronic circuitry and are more reliable. The Digital Equipment Corp., for example, cut the price of its PDP-7 machine from $72,000 to $42,000 with integrated circuits.

Integrated circuits also have helped to boost computer speeds. EAI's 8400 has a 2-microsecond core memory (capacity: 4,000 to 64,000 32-bit words) and performs floating-point multiplication in 5.5 to 7.5 microseconds.

The SDS 92 has a 1.75-microsecond memory cycle time and an input-output transfer rate of 572,-

000 words per second.

What the doctor ordered. To integrated circuit companies, plagued by overcapacity and low demand, the boom in microelectronic computers is just what the doctor ordered. All except one of the new machines use standard components. As shipments of these integrated circuits start flowing to computer makers, the suppliers are likely to reduce prices even more, thus opening the door to integrated circuits in consumer products, where price is all-important.

Military electronics

Nothing new

When the F-111, formerly the TFX, made its debut in Fort Worth on Oct. 15, defense top brass applauded it as the most advanced multi-mission tactical aircraft ever designed. But then observers peeped inside and discovered its electronic gear is old hat.

Defense Secretary Robert S. McNamara and other top government and service officials came down from Washington to watch the General Dynamics Corp., the prime contractor, roll out the first Air Force version. The brass's presence was tacit recognition of the long and bitter fight over the agency's selection of the prime contractor.

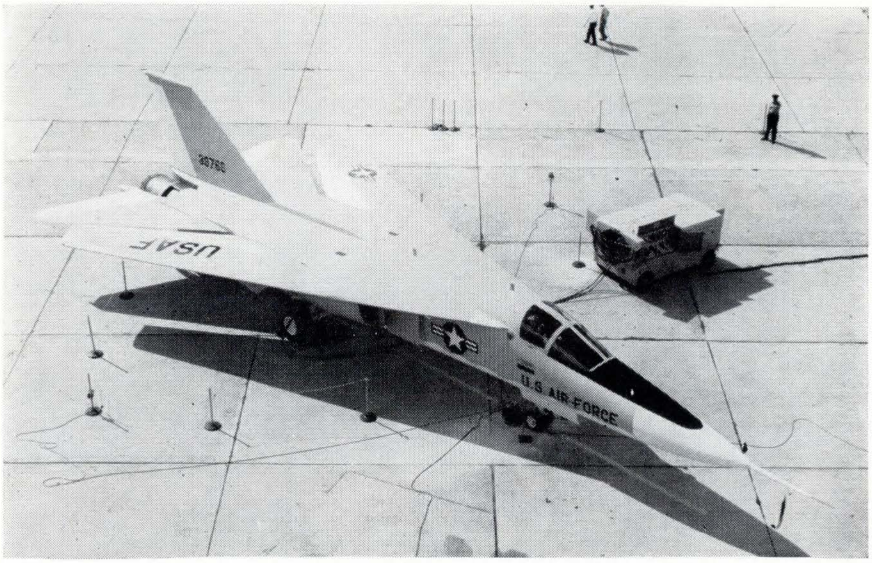
The plane they saw did indeed have some intriguing advances: mainly, variable-sweep wings that are supposed to enable it to fly at slow or supersonic (Mach 2.5) speeds at low or high altitudes.

Electronically, however, it was like last year's Volkswagen. Integrated circuitry, to be expected in a lot of key equipment such as guidance and air data computers, is nearly nonexistent in the nearly 60,000 electronic components that make up the electronic subsystems in each F-111. The excuse: The F-111's electronics are the most reliable if not the most modern.

Put the lid on. Many of the subcontractors for the plane were ready to show exhibits of their wares, after the equipment was cleared by the Air Force and General Dynamics security people. But the Defense Department officials blew in at the last minute and put the lid on. Subcontractors reportedly could see nothing classified.

The fact that the Air Force had cleared the subsystems, ranging from terrain-following radar-to-radio equipment, which such companies as Texas Instruments, Inc., and the Collins Radio Co. wanted to show, backed up reports that the TFX's electronic equipment is fairly plain vanilla at this stage.

Gen. J.L. Zoeckler, who heads the F-111 program for the Air Force, says state-of-the-art systems are being used, but added "the way we have integrated them gives us a capability that is being achieved for the first time."



New look of F-111 belies conventional electronic gear.

Elections

Electronic voting

The first major tests of electronic voting machines will be conducted this Election Day. The potential market for such devices in the U.S. is estimated at $500 million.

While some voters in at least four states select their favorite candidates, election officials will be assessing their favorites among a handful of electronic devices designed to speed the counting of ballots.

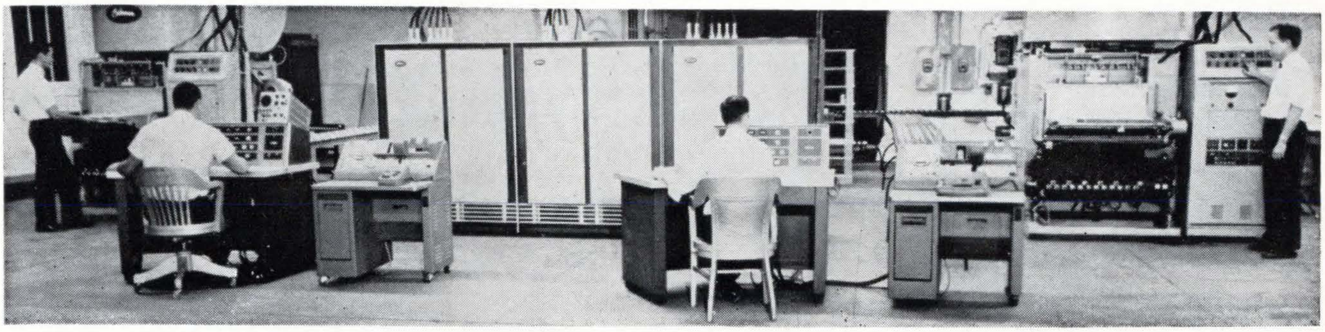
Counting by hand. The need for fast, accurate voting machines is pointed up by the problem facing populous urban areas, where in some cases one out of 65 people will be hand counting ballots.

Basically, there are two types of electronic voting machines: the punch-card system and the optical scanner.

In the punch-card system, the vote is punched directly onto a card that is then taken to a central processor. Under the optical scanner system, a paper ballot is "read" by a computer.

Election officials have the following systems to choose from:

- The Votronics, manufactured by the Cubic Corp., San Diego, Calif., is a desk-sized, hand-fed computer that tabulates one paper ballot every three seconds by scanning the marks made on the ballots. California will use 84 Votronics this year. Each one costs $26,900.
- The Vote Tally is made by the Coleman Engineering Co., Los Angeles. Like the Votronics, it is a computer-tabulated ballot system. The $850,000 system contains a central data processor, two ballot readers, two reader-control consoles and data-punch equipment made by the International Business Machines Corp. The Coleman machine automatically feeds and scans



A computer scans and counts ballots in the Coleman Vote Tally System

10 paper ballots a second. The company has leased three machines in California and two in Ohio.

- The Votomatic, made by Harris Votomatic, Inc., is a punch-card device that weighs five pounds and sells for $125. The voter inserts a pre-scored punch card beneath a printed ballot on the face of the unit and manually punches the card. The cards are tabulated by a central data processor. The Votomatic will be used by San Joaquin County, Calif, this year and, next year in Omaha, Neb.
- The Vote Master, manufactured by the Cybernetics General Co., San Diego, sells for $400. With the Vote Master, the ballot itself is an IBM punch card that is inserted into a machine and punched by pushing a handle. The cards are then forwarded to a central processor. Ten Sacramento County, Calif. precincts will use 40 Vote Master machines. They will also be used in Fulton County, Ga.
- The Coyle, produced by the Coyle Voting Machine Co., Hamilton, Ohio, is also a punch-card system. Priced at $650, it is similar to the Votomatic except that the ballot is printed directly on an IBM card and punched by the voter. The Coyle devices are used in Ohio and have been approved in California. The company has submitted them for consideration in Virginia.

Older manufacturers of mechanical voting machines are also eyeing the field. The Automatic Voting Machine Corp., Jamestown, N.Y., which estimates that its machines are used by 70% of voters who use machines, says, "We feel there is a tremendous potential for data processing." The company says the most difficult problem is finding the best way to transmit the information from machines in the precinct to a central computer.

Components

X-ray inspector

Despite careful screening by suppliers, 10% of the components sold to the National Aeronautics and Space Administration fail to pass the agency's inspection. Sometimes rejections run as high as 50%.

Now NASA is trying out an x-ray system that can catch these flaws more accurately and quickly. It enables an operator to inspect 400 to 500 electronic components an hour.

If the system works out, NASA plans to use it for inspecting all electronic components for missile and space gear. The agency expects savings in the millions of dollars.

26 times as big. The system was developed jointly by NASA and the Philips Electronics & Pharmaceutical Industries Corp. Here's how it works:

The components, on a moving tray, advance past the x-ray beam. A special vidicon tube picks up the x-ray image directly. The image is then magnified 26 times and projected onto a 17-inch television screen.

An inspector sits in front of the screen. By turning a knob, he can rotate the component 360° to seek flaws. The information can also be put on videotape for permanent records.

Seeing red. He can also press a button that will cause red lacquer to be squirted onto any defective component.

NASA plans to use the system early in 1965 at the Marshall Space Flight Center in Huntsville, Ala. Several component makers also are investigating the system.

Patents for the machine are held by the Ohio State Research Foundation.

Connectors: Act 2

The Amphenol-Borg Electronics Corp. seems to be losing its battle to keep its 26500-type connectors in the Minuteman missile. If Amphenol-Borg does lose, much of its airplane connector business could also go elsewhere.

Amphenol made lengthy presentations last month to the Air Force Ballistic Systems division, the Autonetics division of North American Aviation, Inc., and the Boeing Co. But both Boeing and Autonetics accepted the rival NAS 1599 connector for Minuteman [Electronics, June 15, p. 120]. The 1599 was designed by a group of companies, including the Cannon Electric Co. (now a division of the International Telephone & Telegraph Corp.), the Pyle-National Co., the Deutsch Co. and the Bendix Corp.

Cannon had helped Amphenol-Borg design the 26500 and had been one of the suppliers. Cannon withdrew, according to company spokesmen, when it noted flaws early in the component's evolution.

Still a chance. Amphenol insisted that its 26500 is more durable than the 1599, that the 1599's failure rates and modes are unknown, and that changing to 1599 would be "extremely wasteful from a cost standpoint and reckless from a proven reliability standpoint." In addition, the company cited "duplication of training and logistics" whose cost would be "unjustified."

Although both Autonetics and Boeing have accepted 1599 to the exclusion of 26500, an Autonetics spokesman said that both could eventually be used.

Amphenol-Borg's connector business may have received another blow. A large airline was reported to have replaced 10,000 connectors of the 26500 type with 1599s; several other airlines are considering doing the same thing. But David McNally, president of Amphenol's connector division, says Amphenol has received no such report.

Avionics

Airliners weigh in

Commercial airliners must weigh in and be trimmed for balance before takeoff. A fast and relatively low-cost system has been developed that, in effect, uses the three landing gears of the craft as scales and with a bit of computing determines the center of gravity.

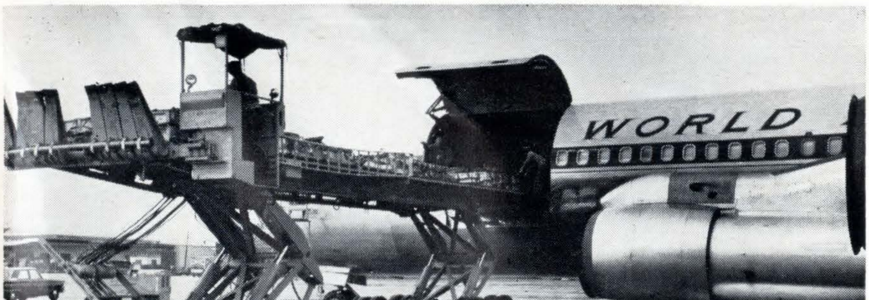
A Fairchild Camera & Instrument Corp. subsidiary, Fairchild Controls Corp., is negotiating to sell about 100 of the systems at $6,000 each to the Pan American Airways Corp.

In and out fast. At present, the crew of a craft has to weigh each piece of cargo as it is loaded or unloaded along the plane's route. Under the Fairchild system, called STAN for Sum Total and Nosegear, cargo can be loaded quickly. Since the monitoring can be done continuously, loading can be stopped or adjusted at the first sign of imbalance or excess weight. The system can also record the effects of ice and snow, factors that previously have only been estimated.

STAN uses three Helical Bourdon-tube pressure transducers on each oleo (hydraulic fluid) strut that supports the landing gears. The transducers sense pressure changes in the hydraulic fluid. Rotation of a helix in the tube, caused by fluctuations in the pressure, is transmitted to the wiper contact on a potentiometer element in the transducer. This produces an output that is proportional to the pressure change.

Fairchild says the system is accurate to within $\pm 0.5\%$.

In the cockpit, the system provides three readings: one for takeoff gross weight, one for lateral center of gravity and one for percent mean aerodynamic chord, which is roughly the deviation from the mean of a line drawn through the wings.



As the aircraft is loaded, the weight and center of gravity are automatically registered on meters in the cockpit

Colorful terrain

Navigators and bombardiers for B-52s are being trained at the March Air Force Base, Calif., on a new flight simulator. It lets them see, in color, the terrain they will eventually fly over.

The Marquardt Corp. built the simulator, called the T-10. It uses a special cathode-ray tube and color film. The tube is a flying spot-scanner—a high-brightness, high-resolution, flat-faced tube whose phosphor emits light in the visible spectrum. A portion of the light is sampled and fed back through an automatic control system that regulates the light output of the tube.

Tricolor layers. The color storage medium is Kodak 5253 film with yellow, magenta and cyan dye layers that absorb light in the blue, green and red portions of the visible spectrum. The film has an internal mask that minimizes fusion of one color into another. There are three color channels in the film: one for latitude and longitude and the other two for a coarse-fine code. The code simulates the lights and shadows of natural terrain.

Color transparencies for the simulator are made by direct contact exposures from black-and-white transparencies that contain cartographic, target prediction and terrain-height information.

Making the map. The color transparency moves with the flying spot-scanner to gain access to any of the data on the film. The movement of the film and the scanner represents a particular flight path.

A collection lens gathers the light transmitted through the film and passes it through thin-film elements. These sort the light according to wave length, then relay it to three photomultiplier tubes. The tubes supply signals that vary in amplitude, depending on the quantity of the dye through which the light from the scanner is projected.

Light and shadow. Analog computers, developed by Marquardt

radiation levels.

Constant interrogation. The master station is designed to interrogate the remote sites and convert data for transmission to a central control center at, for example, the Weather Bureau. It consists of a very-high-frequency receiver-transmitter, an antenna tower, a directional antenna, a sequencer-encoder, a digital clock, a decoder and counter and a programmer. This equipment works on 115 volts at 60 cycles per second.

Each field station contains a 27-foot telescoping tower, wind-speed, wind-direction and temperature transmitters, an antenna, a direction-orientation adapter, signal-conversion electronics, a battery and a radio.

The total bandwidth requirement is 16 kilocycles; minimum recommended channel spacing is 30 kc.

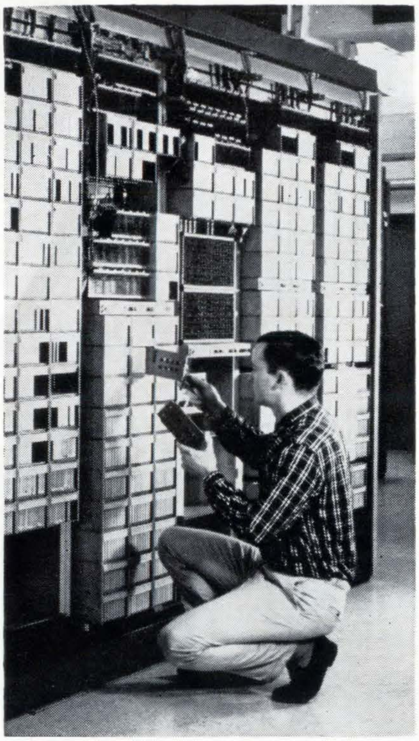
Keep a record. Data from each site is collected in less than 15 seconds with the digital clock making time-of-day correlation. This permits a record to be kept or stored in a digital computer at the central control office, where the data is either recorded on a teleprinter for interpretation or stored in a computer to predict weather.

Communications

They'd rather switch

An immortal machine and a chess master sound like science-fiction. But these unlikely descriptions were used by two officials of the Bell Telephone Laboratories, the research arm of the American Telephone & Telegraph Co., as the scientists spelled out details of Bell's $100-million electronic switching system [Electronics, Oct. 19, pp. 71-86].

Good-bye central. By the year 2000 all telephone central offices will be replaced by the revolutionary switching technique. Bell says a key to the development of the switching system, which uses square-loop magnetic materials to retain binary information until it's needed, is the availability of inexpensive silicon planar epitaxial transistors.



Central control section handles logic and command functions in the electronic telephone office.

Surveillance. Central control equipment keeps telephone subscriber lines and trunks under continual observation. Various "looking" speeds are used. These depend on whether the mechanism is watching for a receiver to go off the hook or inspecting a dial pulse to determine a number.

In describing the function of the electronic central control, William Keister, director of the electronic switching system's engineering center, compared the control with a chess master.

Playing the game. The chess master solves a single chess problem at a time. He moves on to the next problem, solves it and continues until he has completed a round of perhaps 30 problems. Then he starts over again.

Keister compares this with central control when it looks at all lines to see whether a receiver is on or off the hook.

Because the chess master has time, he can play several games of checkers at the same time he's playing chess. Every time a bell is rung, the chess master breaks off his round of chess to play checkers, a faster game. Central control is playing checkers when it scans dial pulses at higher speeds.

The chess master plays solitaire when he's not busy with chess or checkers. This is like the routine maintenance program performed by central control. When central control finds trouble, a report is typed out, and sometimes an alarm is sounded.

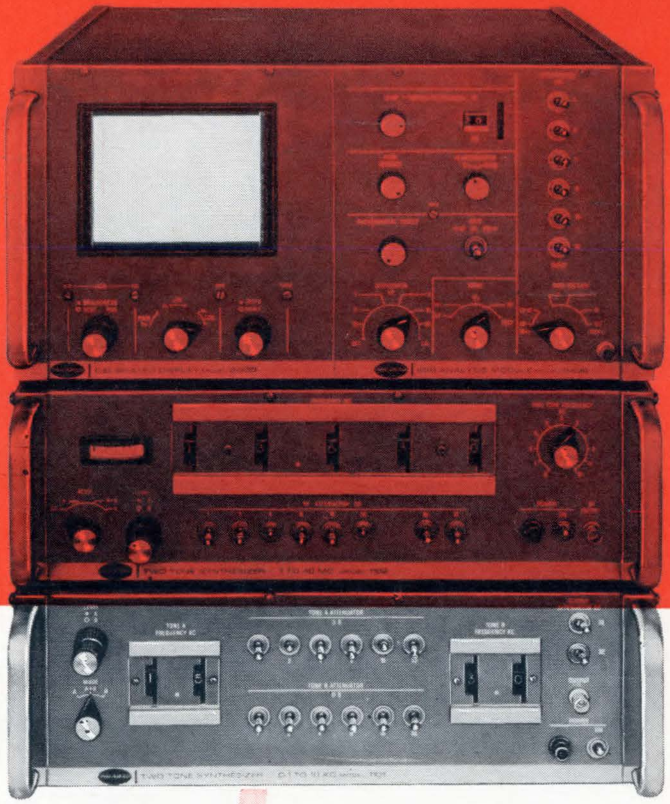
Immortality. Raymond W. Ketchledge, director of the electronic switching laboratory, emphasized the need for reliability. He says that existing electromechanical switching systems have a history of about 11 minutes total outage (inoperative time) in 40 years. It's Bell's goal to cut that time in half.

The search for reliability has led to what Ketchledge describes as a "large immortal machine"—a huge, complex information-processing machine that can be turned on now and shut off decades later. Comparing it with a computer operation, he said that when a computer drops a bit of information, it can be disastrous—like printing out an extra $1 million on a check. When a telephone central control loses a bit, it can be a nuisance to the subscriber but it need not be catastrophic.

Continuing the comparison, Ketchledge said that a computer breakdown might be a nuisance but a central office breakdown would be a disaster. However, the new electronic telephone machine can breakdown and still reorganize itself in the time it takes a subscriber to dial. The customer never knows the difference.

Push-button speed. Subscribers will get new services with great rapidity. If a subscriber wants to arrange for three-digit dialing of seven-digit numbers that are called frequently, he telephones his service representative. She types up the list of numbers he gives her and determines the charge for the service. Should the customer ask when the service will start, the representative pushes a button on a client-request typewriter and answers, "Right now, sir!"

one-eyed jack (of all tests)



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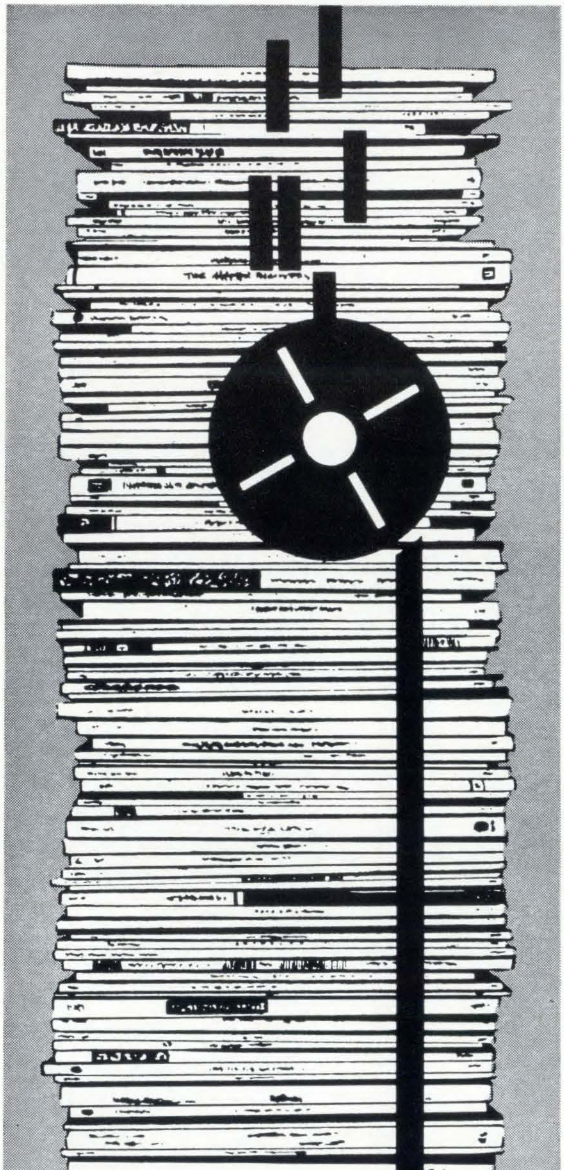

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Edited by H. Thayne Johnson, Head,
Electronic Properties Information Center (EPIC), Hughes Aircraft Company

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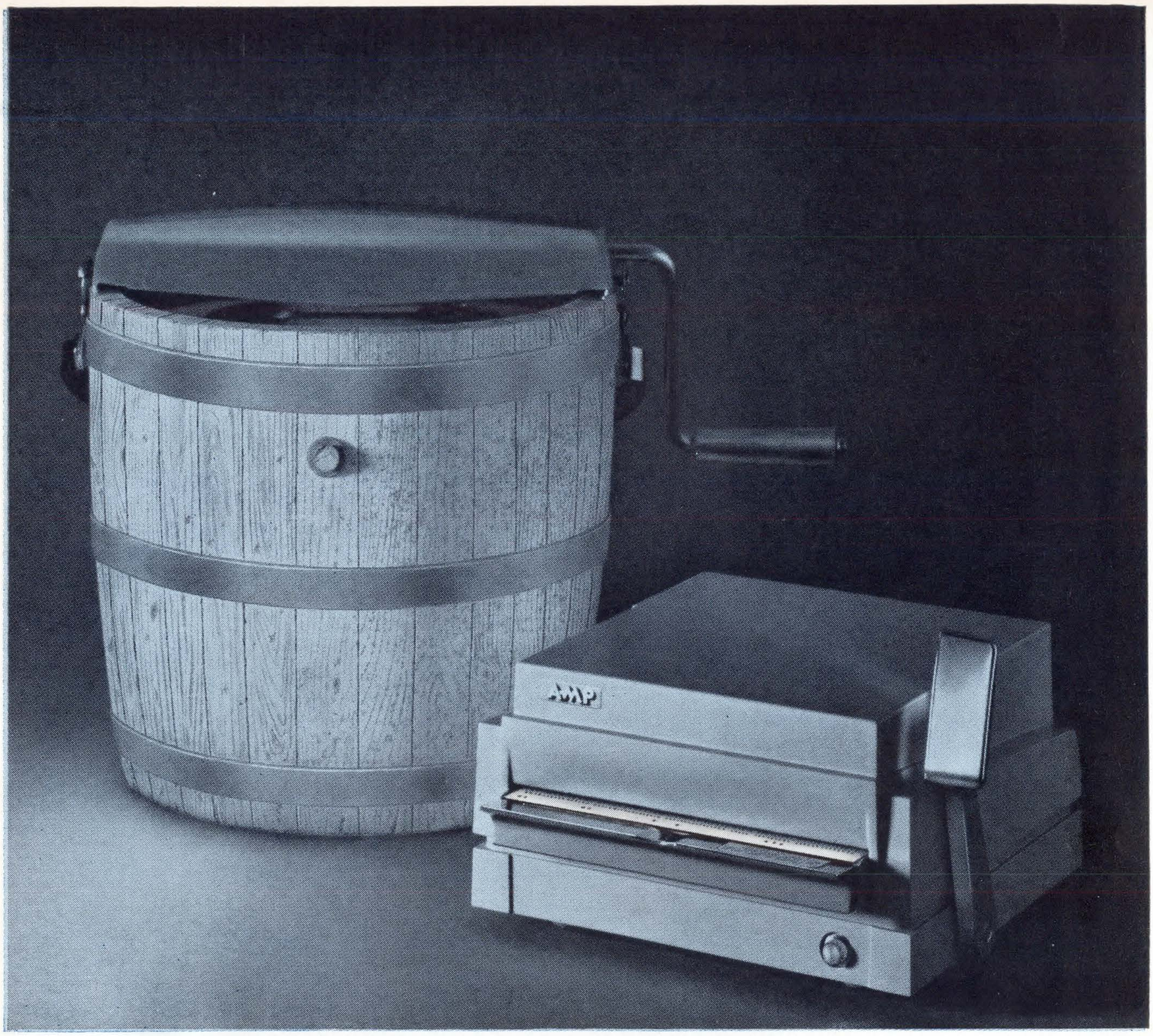
AMP

Washington Newsletter

November 2, 1964

Little change seen in defense outlays

China's A-bomb and the shakeup in Soviet leadership aren't expected to affect the next United States defense budget significantly. It's still expected to hover at or slightly below the present $50 billion level.

But increases are possible if the new Russian leaders carry out their threat to increase military spending. Soviet military commanders can be expected to take advantage of the change in leaders to intensify demands for more and longer-range missiles.

There's less concern about China's nuclear threat. The Chinese bomb indicated a production capability more sophisticated than Western intelligence had anticipated, but the Chinese still lack a delivery system.

Radio tie to Soviet halted at key time

International communications were interrupted twice during critical times in mid-October. On Oct. 15, the day Premier Khrushchev was ousted in the Soviet Union, radio communication with Moscow was lost intermittently for about an hour by the American Telephone & Telegraph Co. This involved a commercial radio circuit and not the "hot line" that links the White House directly with the Kremlin. **On Oct. 16, the day Communist China exploded her nuclear device, traffic on AT&T's cable to Japan was interrupted unaccountably.** In neither case was tampering suspected, however.

Radio transmission to Japan was so poor that AT&T inquired about using the Syncom III satellite to provide a better link. The satellite, however, was in heavy use by the Defense Department.

Military resists Comsat's offer

Cyrus Vance, deputy secretary of defense, has officially turned down the latest offer by the Communications Satellite Corp. to put up about six early-bird satellites for the military. The six-satellite system, providing a back-up satellite for each of the three required for worldwide coverage, would cost $50 million.

The Pentagon said it could save about $20 million—or the cost of the Comsat boosters—by launching its satellites on the Titan III-C while the Comsat booster was undergoing development testing.

20,000-foot dives for subs of 1969

On Nov. 24, **the Navy will brief potential contractors in Washington on a $300-million, five-year program to develop** manned and unmanned vehicles that will submerge 20,000 feet in the sea.

Assigned to the Special Projects Office, which handled the Polaris missile, the Deep Submergence Systems Project will expand capabilities in four areas: search and recovery, military, economic and scientific.

The military implications are tremendous. If missile-carrying submarines can get below the sound channel **they can go wherever they like with little danger of detection.** This would push antisubmarine warfare development even beyond the active effort already under way.

The program will enhance the advanced sea-based deterrent program —a follow-on to the Polaris program that will result in either improved missiles that can operate deeper in submarines that travel below the sound channel, or bottom-mounted systems equipped with missiles.

Economic fallout can result from discovery of natural resources and from the many ways to exploit them.

Scientific gains can come from man's first-hand examination of the ocean depths. **The Navy will also attempt to develop engineering techniques for prolonged stays on the bottom in permanent stations.**

The Navy will tell potential contractors at the all-day briefing what it wants in electronic gear, such as sensors, navigation, communications and integrated control. Also to be discussed in detail is gear for submarine salvage, testing, support ships and submarine modifications.

Industry proposals for a detailed plan are expected to be sought early next month. Contracts are expected to be awarded early in 1965.

Changes urged in R&D awards

A House Science and Astronautics subcommittee has confirmed that a few states and a relatively small number of recipients get a major portion of federal research-and-development contracts and grants. But the panel recommended caution in remedying the situation.

The Subcommittee on Science Research and Development suggested support to deserving but underdeveloped universities, and efforts to award grants and contracts to institutions other than the major current recipients.

It cautioned, however, against sacrificing scientific and technological merit to the difficult job of spreading the R&D funds. It suggested a government-industry conference to study the problem.

Based on an analysis of 60 major awards to industries, the subcommittee concluded that the impact of subcontracting on the geographical distribution of funds is less than anticipated. The study showed that **75.7% of grant and contract funds are retained by the prime recipient,** an average of 5.6% of the contract funds are subcontracted in the prime contractor's own state, and 18.7% go out of the state.

Union threatens a phone strike

Labor trouble looms in the telephone industry as one union decides not to follow the pattern of the Communications Workers Union's agreements with companies.

Five key locals of the International Brotherhood of Electrical Workers, representing 11,000 workers, are threatening a strike at the Illinois Bell Telephone Co., a subsidiary of the American Telephone and Telegraph Co. The locals are demanding separate contract talks. The Bell System is offering increases valued at $2.50 to $5 a week.

The locals demand that talks be conducted on local issues, particularly over the savings they assert the company is making by replacing employees with automated equipment.

The locals at Illinois Bell are free to strike Nov. 19 under a wage-reopener clause in their contract.

Door openers an issue at FCC

Competition in radio-controlled door-openers will be sharpened if proposals of the Federal Communications Commission are adopted. Legitimate manufacturers complain that they are forced to turn out bulky units operating on radio frequencies below 70 megacycles while others produce smaller, more attractive units without the time limiters required by law for equipment operating in the 225-megacycle range. **The FCC plans to rescind its original requirement designed to eliminate interference.**

12:05

"Home for lunch" is just one of the facts of livability in North Carolina. And livability is just one of the reasons why North Carolina leads the Southeast in industrial growth. For *all* the reasons, write Governor Terry Sanford in Raleigh (in confidence, of course).

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Technical Articles

Silicon replacing germanium as power transistors get bigger: page 42

One transistor can do the work of five now that power transistors are capable of handling up to 150 amperes and 300 watts. These silicon devices are finding their way into many new applications, and cutting into germanium's domain.

Precise control with an operational trigger: page 50

An operational amplifier with positive feedback is a simple, useful way to obtain fine control. Because it combines the features of an operational amplifier with a Schmitt trigger, it's called an operational trigger. With it, many devices can be operated from one set of power supplies.

Computer analysis of circuits: page 56

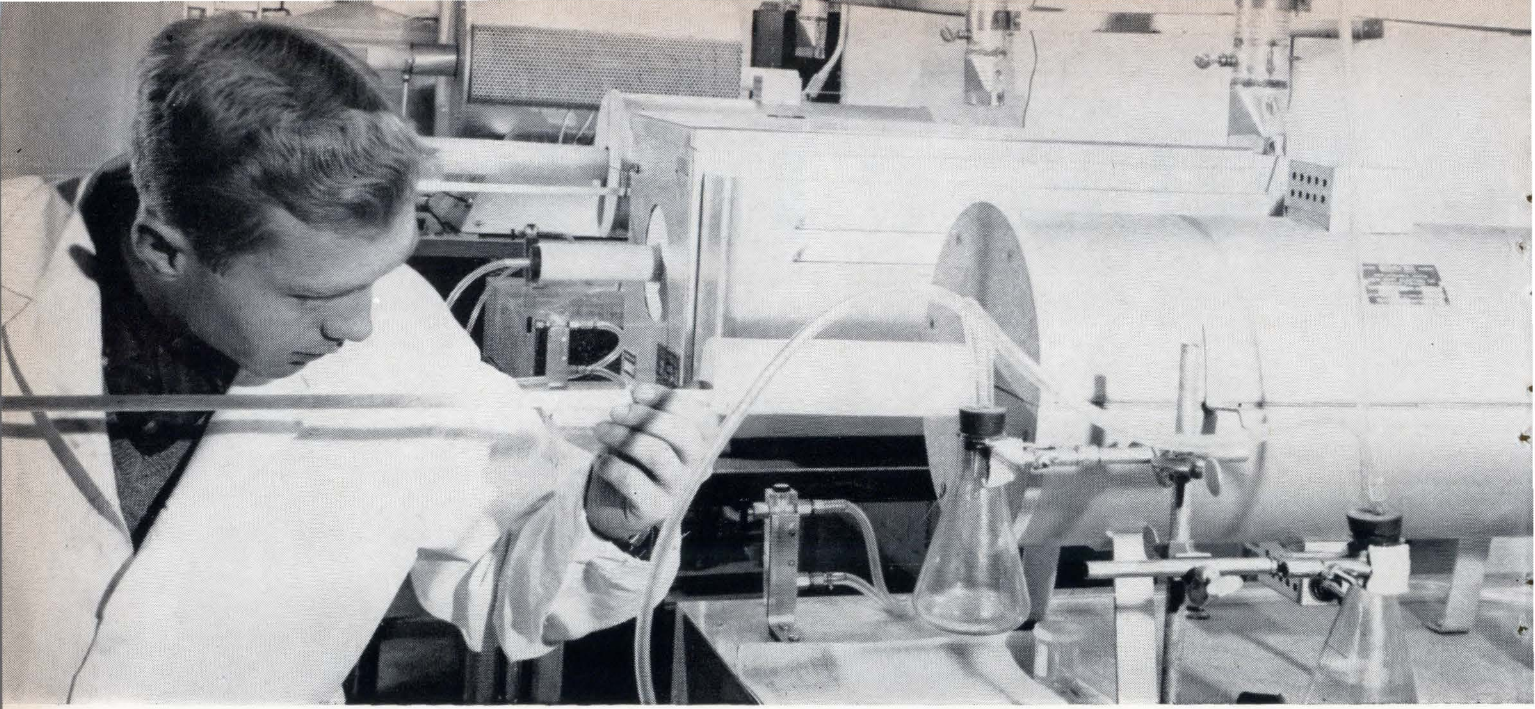
After a circuit has been designed, the engineer needs to examine whether it will work when components degrade with time, usage and environment. Normally, it is a long, tedious job. The computer and computer language can speed analysis.

Microwaves for remote sensing: page 66

When engineers consider radiation from hot bodies, almost always they are thinking about infrared. But microwave radiometry has some distinct advantages over infrared in various applications. Most often, these days, they are in space applications.

Coming November 16

- **Designing inverters with power transistors**
- **New uses of the electron beam in manufacturing**
- **Integrated circuits in a new digital voltmeter**
- **Equipment for nondestructive testing**



Solid state

Silicon replacing germanium as power transistors get bigger

One transistor now can do the work of five, broadening applications for the new devices

By Seymour Levine
Silicon Transistor Corp., Carle Place, N.Y.

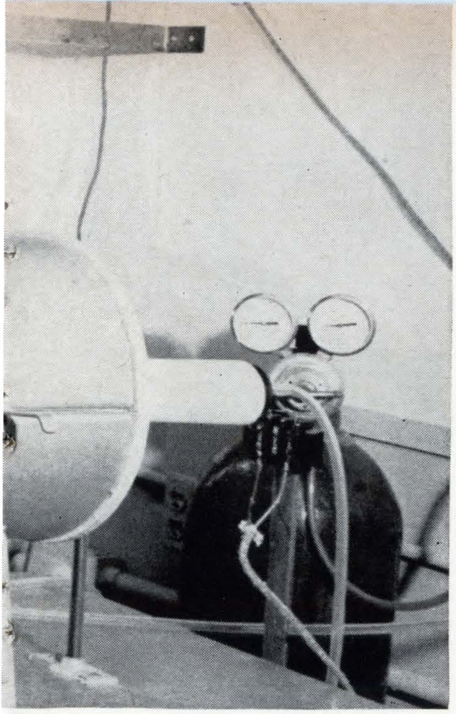
Circuit designers are discovering that new silicon transistors with higher power-handling capacities are saving time, space and eventually money.

Because of recent strides in these solid-state devices, one transistor is now able to do the work of five, simplifying circuit design, cutting down the space needed for such devices and reducing the possibility of breakdowns.

These silicon devices are beginning to replace germanium transistors and have made bold inroads in the field of vacuum power tubes—once the standard of the electronics industry—when high powers are involved.

Although for commercial applications silicon transistors couldn't compete initially with their germanium counterparts because of costs, new production techniques and increased use are narrowing the price gap even though germanium still has an edge. But more important, silicon transistors can handle more power at higher temperatures than germanium devices.

At junction temperatures above 100°C., germanium is no longer functional; silicon can operate to 200°C. New silicon transistors can now handle up to 150 amperes and 300 watts at a case temperature of 100°C. For engineers forced to package high power-handling transistors in hot areas, the new advances with the silicon devices



Step in producing silicon power transistor. The patterned silicon wafer is inserted into the diffusion furnace to diffuse the emitter and collector regions and bring the base width to the desired tolerance.

give the designer a decided advantage.

Thus most producers of military and industrial power supplies have switched to silicon from germanium. And producers of high-fidelity equipment are also beginning to use silicon transistors in the power-output stages, although germanium devices are still being used in low-level stages.

Silicon transistors also are capable of handling collector voltages and current with considerably lower leakage current than can be obtained with germanium.

Another advantage: Silicon power transistors can have inherently higher voltage ratings than germanium devices, 400 volts versus 100 volts. Because of sharper breakdown characteristics, the silicon units can be operated at levels closer to their maximum ratings, providing an opportunity for smaller safety factors and more realistic designing.

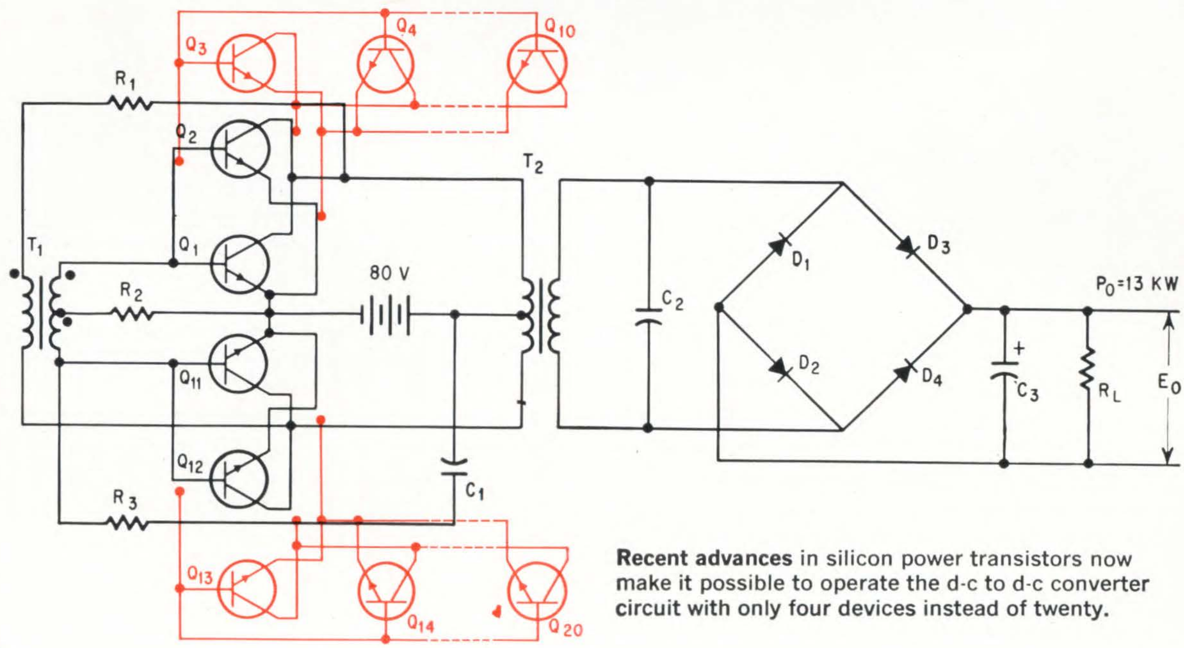
However, germanium has an edge over silicon in its ability to provide lower saturation resistances, but new manufacturing techniques for silicon devices have produced significant improvements. New devices have saturation resistances approaching that of germanium.

Breakdown voltages

Device geometry, base width and the size and resistivity of the semiconductor pellet, or chip, govern breakdown voltage. Such breakdown isn't destructive as long as the circuit has sufficient series resistance to limit the collector or emitter currents to a safe level. Two common voltage breakdowns are shown on page 44: avalanche breakdown, a function of alpha multiplication; and punch-through, or reach-through breakdown, a function of the width of the base-depletion region. A destructive phenomenon associated with the base geometry of the device is second breakdown. This is generally caused by simultaneous application of high voltage and high current. It is a more severe problem in multiple-diffused, high-speed devices where close spacing of the active base region is required.

The base-to-emitter circuit affects the voltage level at which avalanche or punch-through collector-to-emitter breakdowns occur.

The most strenuous test condition for determining collector-to-emitter breakdown voltage is with the base-to-emitter circuit open or containing a resistance of at least 10,000 ohms. The value of



Recent advances in silicon power transistors now make it possible to operate the d-c to d-c converter circuit with only four devices instead of twenty.

the breakdown voltage becomes higher as the resistance is decreased to zero.

Avalanche or punch-through

Low-resistivity material will produce low voltage breakdown, usually in the avalanche mode, and high-resistivity pellets will generally exhibit the punch-through phenomenon. With low-resistivity pellets, the BV_{CEX} rating (base reverse biased) can be as much as 60 volts higher than the BV_{CEO} rating (base open). For example, a transistor with a BV_{CEX} of 120 volts may have a BV_{CEO} of only 60 volts. The design engineer must be aware of the basic circuit requirements in order to select a transistor with an adequate breakdown-voltage rating.

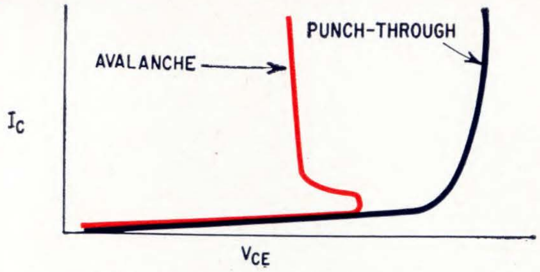
Current rating

The maximum collector-current rating is determined by the size of the pellet, the diameter and material of the collector and emitter leads, the size of the clips connecting the leads to the pellet, the maximum current-handling capabilities of the glass-to-metal seal of the header and the minimum d-c current gain (h_{FE}) of the transistor. The pellet of the largest silicon transistor fabricated for commercial use has a diameter of 0.628 inch. The amount of silicon wafer material required for nine of these pellets can provide up to 20,000 pellets for low-power transistors. This pellet can handle a collector current of 150 amperes. It also allows the transistor to dissipate up to 300 watts at a case-temperature of 100°C. A germanium transistor has also been built that can handle a 150-ampere collector current but only at low temperatures and with considerably reduced dissipation.

Saturation resistance

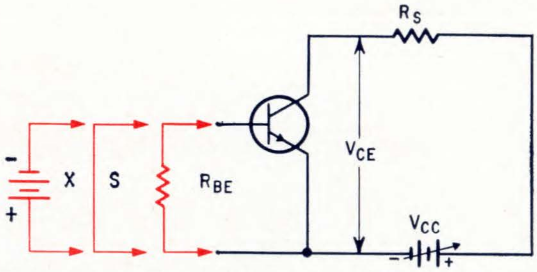
For a transistor to become saturated (fully turned on), the input base-to-emitter voltage must be sufficiently high to forward bias the base-to-collector junction. When this occurs, the transistor is said to be in saturation, or operating on the nonlinear portion of the collector current (I_c) versus collector-to-emitter voltage (V_{CE}) curve. The lower the saturation resistance (or saturation voltage), the lower the power dissipation in the transistor. This will become more apparent in the succeeding paragraphs.

The relationship between $V_{CE\,(sat)}$ and $V_{BE\,(sat)}$ is shown on page 45. As may be observed, $V_{BE\,(sat)} = V_{CE\,(sat)} + V_{CB}$ = the forward voltage drop for the collector junction. An input-equivalent circuit is shown on page 45. The circuit illustrates the relationship between the various internal parameters and the input voltage, V_{BE}. The temperature coefficient can vary considerably since it can be either positive or negative, depending upon the values of the d-c current gain (h_{FE}) the base resistance (r_b'), the emitter resistance (r_e) and the emitter-to-base voltage (V_{be}). The parameters r_b' and r_e have positive temperature coefficients. Voltage V_{be} has a negative coefficient and h_{FE} can have either a positive or negative temperature coefficient, depending upon the value of I_C.



Avalanche breakdown is a function of alpha multiplication. Punch-through is a function of the base-depletion region.

VOLTAGE	TEST CONDITION	CIRCUIT
BV_{CEO}	BASE OPEN OR $R_{BE} \geq$ 10 K OHMS	R_{BE}
BV_{CER}	$R_{BE} \leq$ 10 K OHMS R_{BE} = 33 OHMS	R_{BE}
BV_{CES}	R = 0	S
BV_{CEX}	V_{BE} = −1.5 V	X

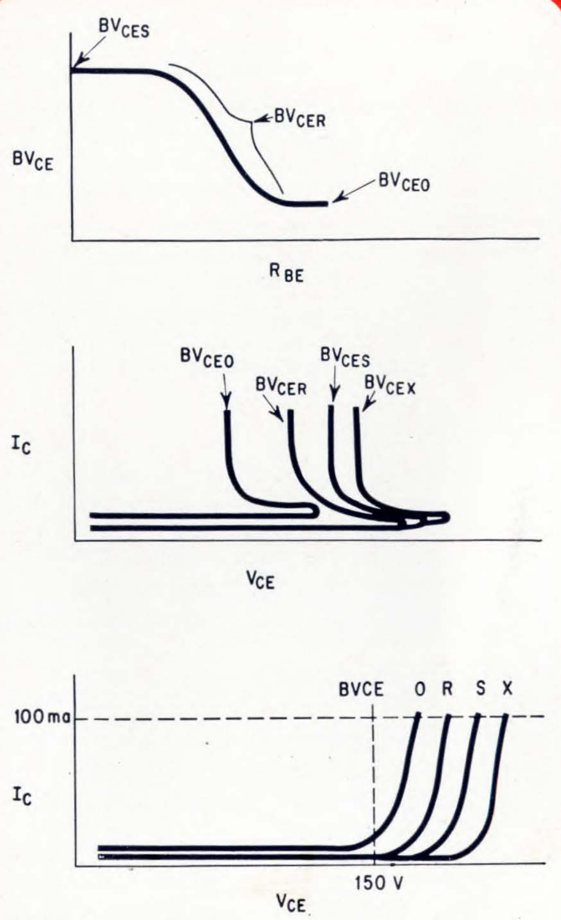


Circuit for measuring collector-to-emitter breakdown voltage.

Transition time

When a power transistor is used as a switching device, the transition time from the on to the off condition and conversely, from off to on, is of great significance. It is during these intervals that the transistor is subjected to a very high power dissipation, which is caused by the simultaneous occurrence of high collector-to-emitter voltage and high collector current.

Power-transistor switching circuits play an important role in high-efficiency regulated power supplies of the switching type, in sampling-type servo circuits, in solid-state relays, in automatic solid-state control systems, in high-power converter and inverter circuits and in numerous other applications that require the handling of high currents. Turn-on and turn-off times for a transistor switching from cut-off to a saturated condition and back should be extremely rapid. The faster these responses can be accomplished, the lower the power and heat dissipation for the transistor and the



Breakdown voltage (top) as a function of base-to-emitter resistance. Typical avalanche-breakdown characteristics (center). Typical punch-through characteristics (bottom).

Further decrease in the turn-off time of the transistor can be achieved by increasing the amplitude of the base turn-off current to the limits of the circuit capabilities. If for some reason the transistor is not saturated during its on period, there is no loss of time due to storage because the transistor will always be operating in its nonsaturated linear regions. Turn-on times can change dramatically with changes in overdrive factor.

Overdrive factor is the ratio of the current gain measured during nonsaturated operation on the linear portion of the curve to the forced gain for the same collector current. Forced gain is the gain measured when the transistor is in saturation. An overdrive factor of two is usually used to assure saturation of the transistor. Theoretical calculations have shown that turn-on times can be reduced to approximately 30% of the time that elapses in unsaturated operation by using an overdrive factor of two. Storage time also increases appreciably with overdrive factor. A typical test circuit is shown on page 46.

Power losses

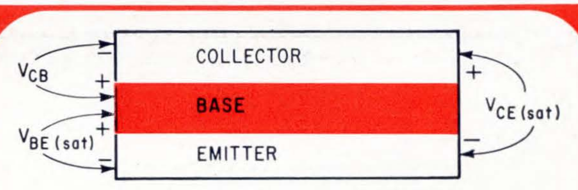
It is evident that the lower the saturation resistance during the on condition for a transistor, the lower the power losses in the transistor.

The importance of low saturation resistance in nonsaturated power-transistor circuits, however, is a little less apparent. To illustrate its significance in a nonsaturated circuit, consider the conventional Class A series regulator shown on page 46. Assume that transistor Q_1 is biased so that V_{CE} for Q_1 is 15 volts with a load current (I_C) of 10 amperes. The high collector-to-emitter voltage is necessary to maintain operation of the transistor on the linear portion of the curve. If an excessively large de-

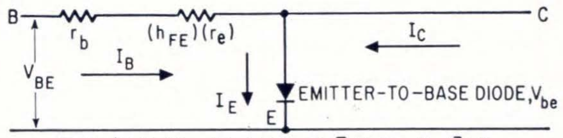
higher the efficiency. In complex switching systems, where a considerable number of power transistors may be used, the speed of response of the transistor becomes important in determining operating cost and reliability.

Speed factors

Although speed of response is directly related to the gain-bandwidth product (f_t) of the transistor —the higher the f_t, the faster the response—there are other factors that influence turn-on and turn-off times. Externally, the turn-on time is a function of the base-drive current. Hence, the stronger the base drive, the shorter the turn-on time. However, because of the higher density of carriers injected into the base with strong base drives, the storage effects will be more severe and the turn-off will take longer. When the transistor is turned off, the collector current (I_C) will not decrease until these stored charges are swept from the base region. Accordingly, the turn-off time of the transistor may be appreciably reduced by reversing the input current (I_B) when turn-off is desired, rather than merely removing or shorting the drive signal.



During saturation, the expressions for $V_{CE(sat)}$ and $V_{BE(sat}$ are: $V_{CE(sat)} = V_{BE} - V_{CB}$; $V_{BE(sat} = V_{CE(sat)} + (0.6 \text{ to } 0.8 \text{ volt})$.



$$V_{BE} = (I_B)(r_b') + (I_B)(h_{FE})(r_e) + V_{be} = I_B\left[r_b' + (h_{FE})(r_e)\right] + V_{be}$$

$$\text{SINCE } I_B = \frac{I_C}{h_{FE}}, \quad V_{BE} = \frac{I_C}{h_{FE}}\left[r_b' + (h_{FE})(r_e)\right] + V_{be}$$

Transistor equivalent input circuit

crease in the input voltage were to force V_{CE} for Q_1 to fall below the bend of the transfer-characteristic curve, the system would no longer regulate. The transistor would not be operating in its linear region but would be in the saturated state. Because Q_1 actually serves as a variable resistor, it is required to continuously operate in the linear region. And thus a relatively high collector-to-emitter quiescent voltage would have to be maintained.

Under these conditions, the quiescent power lost in the regulating transistor would be 150 watts. This unused power cuts deeply into the efficiency of the regulating system and requires complex heat-sink arrangements and sufficiently large and expensive transistors to handle the wasted power. Considerable improvement can be obtained by using a regulator transistor with a lower saturation resistance characteristic. With the same load current and dynamic operating range as before, another transistor might be used with a quiescent V_{CE} of 6 volts and with a quiescent power dissipation of 60 watts. The savings are considerable.

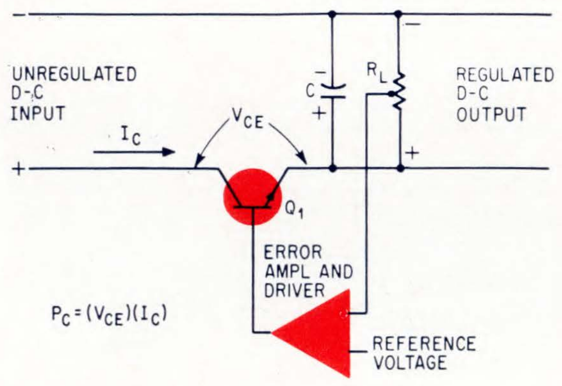
Manufacturing techniques

In selecting a power transistor for a particular application, the design engineer is faced with a fairly large choice of basically different types, each manufactured differently and each with unique advantages and inherent disadvantages. In most cases, the circuit-design requirements will dictate the choice of transistor.

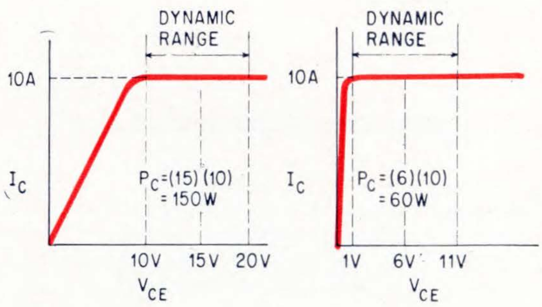
Three major techniques are used to make silicon-power transistors: the single-diffused mesa, the triple-diffused mesa and the triple-diffused planar techniques. The chart on page 47 tells which of the various techniques each manufacturer uses.

Single-diffused process

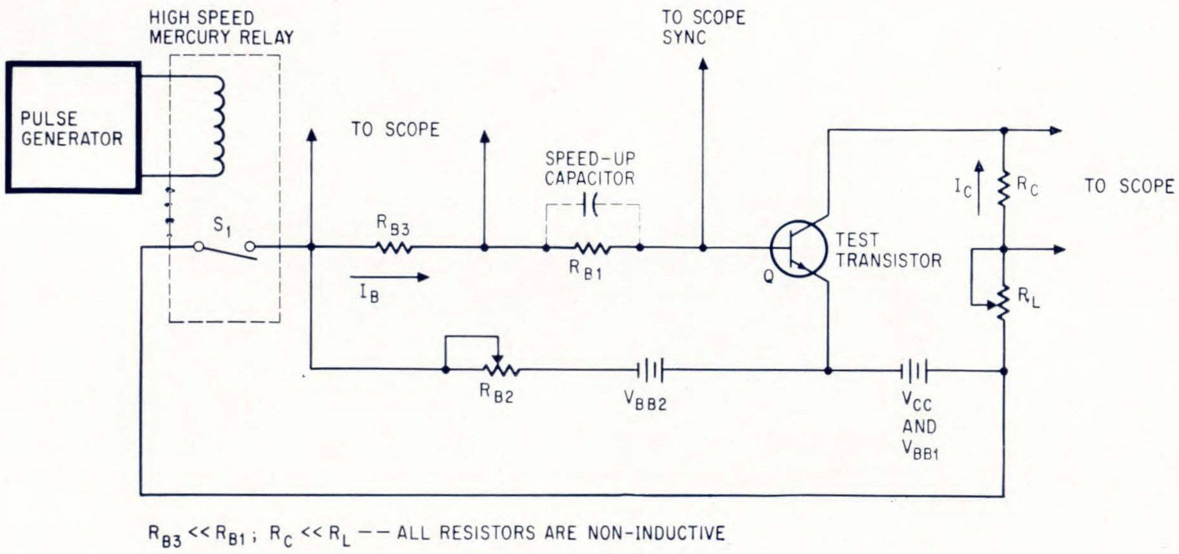
The single-diffused process produces a relatively low-frequency power transistor with a typical gain-bandwidth product of 1.5 to 2 megacycles. Depending upon the size of the pellet, the value of f_t can vary considerably. Larger pellets needed for collector currents of 150 amperes and power capabili-



Class A series regulator circuit



Operation characteristic with transistor having a high saturation resistance is at the left. Characteristic for a transistor with a low saturation resistance is at the right.



Circuit for determining transistor speed of response

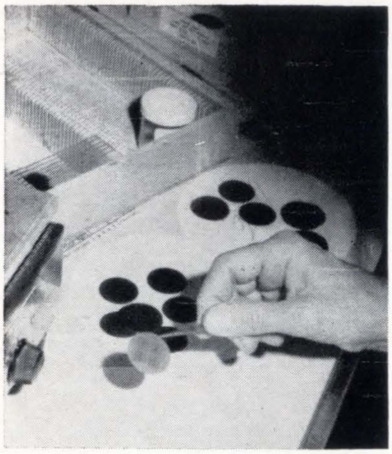
Guide to high-power silicon transistors*

Manufacturer	Amp.	Type numbers	Dissipation Rating watts	at °C.	Manufacturing process
AMF Semiconductor dept., Vandalia, Ohio	13	AMF201A-AMF201E	85	25	SDM
Bendix Semiconductor div., Holmdel, N. J.	10	2N3018	25	25	SDM
	10	B3143,-46,-49	25	25	SDM
	10	B3163	25	25	SDM
	15	2N3235	117	25	SDM
Continental Device Corp., Hawthorne, Calif.	10	2N1899-2N1904	125	25	TDP
Delco Radio div., Kokomo, Indiana	10	2N2580-2N2583	150	45	TD
	10	2N3079-2N3080	150	45	TD
Honeywell, Inc., Riviera Beach, Fla.	10	MHT7011-MHT7019	40	100	TDP
	20	MHT8002-MHT8003	100	100	TDP
	20	MHT8012-MHT8016	100	100	TDP
	30	MHT8301-MHT8304	100	100	TDP
Philips Gloeilampenfabrieken Eindoven, Netherlands	10	BLY17	150	25	PE
RCA, Electronic Components and Devices Somerville, N. J.	10	2N2015-2N2016	150	25	SDM
	15	2N3055	115	25	SDM
	15	40251	115	25	SDM
	25	2N3263-2N3264	115	25	DDME
	25	2N3265-2N3266	175	25	DDME
	30	TA2544A	150	25	SDM
Silicon Transistor Corp., Carle Place N. Y.	10	2N2015-2N2016	150	45	SDM
	10	2N3235	117	25	SDM
	10	2N3236	150	25	SDM
	15	2N3238-2N3240	150	25	SDM
	20	2N2815-2N2818	200	25	SDM
	20	2N3237	200	25	SDM
	20	STC1726,-31,-36	200	25	SDM
	20	STC2220-STC2223	200	25	SDM
	25	2N2819-2N2822	200	25	SDM
	25	STC2224-STC2227	200	25	SDM
	30	2N2823-2N2825	200	25	SDM
	30	2N3260	200	25	SDM
	30	STC1728,-33,-38	200	25	SDM
	30	STC2228-31	200	25	SDM
	30	STC3706	200	25	SDM
	60	STC2106-08	300	50	SDM
	65	STC2103-STC2105	300	50	SDM
	70	2N3149-51	300	50	SDM
	150	STC2500-STC2501	300	100	SDM
Texas Instruments, Inc., Dallas, Texas	12	TIX210-TIX211	40	100	TDM
	20	2N1936-2N1937	150	100	TDM
TRW Semiconductors, Inc., Lawndale, Calif.	10	2N1899-2N1904	125	25	TDP
	10	2N3076	125	25	TDP
	10	PT900	125	25	TDP
Western Electric Co., Laureldale, Pa.	10	2N1675	100	25	SDM
Westinghouse Electric Corp., Youngwood, Pa.	10	2N2226-2N2233	150	75	A
	10	2N3470-2N3477	150	75	A
	20	2N2739-2N2742	200	75	A
	20	2N2745-2N2748	200	75	A
	20	2N2751-2N2754	200	75	A
	20	16304-16320	200	75	A
	30	2N1809-2N1814	250	60	A
	30	2N1816-2N1819	250	60	A
	30	2N1823-2N1826	250	60	A
	30	2N2109-2N2114	250	60	A
	30	2N2116-2N2119	250	60	A
	30	2N2123-2N2126	250	60	A
	30	2N2130-2N2133	250	60	A
	30	2N2757-2N2761	200	75	A
	30	2N2763-2N2766	200	75	A

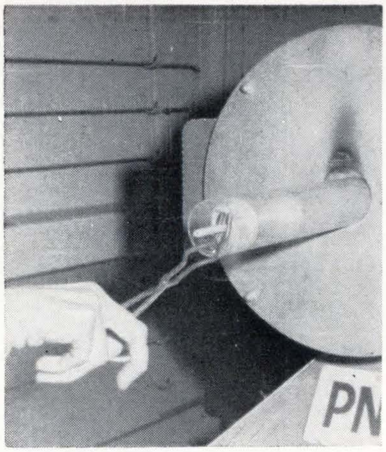
*Types with collector-current ratings of 10 amperes or above. All types are npn. To date no silicon pnp types have been made with ratings as high as 10 amperes.

Abbreviations for manufacturing process

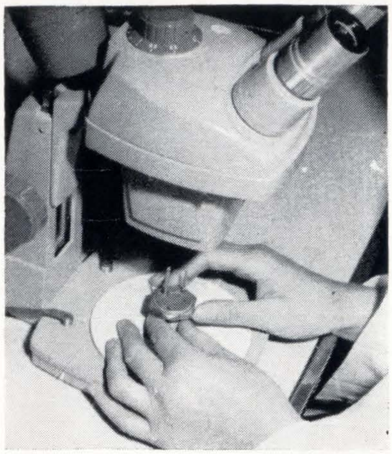
A — alloy
DDME — double-diffused, mesa-epitaxial
PE — planar-epitaxial
SDM — single-diffused, mesa
TD — triple-diffused
TDM — triple-diffused, mesa
TDP — triple-diffused, planar



Inspection of the silicon wafer following diffusion of the emitter patterns, prior to the dicing operation.



After the polished wafer has been acid rinsed and washed it goes into a deposition furnace.



Inspecting a transistor pellet that has been mounted upon a header prior to further assembly operations.

ties of 300 watts at 100°C. will probably have a value of f_t between 50 to 75 kilocycles.

These single-diffused, large-pellet devices are rugged and can handle high peak-switched power, in most cases up to 20 times their d-c rating for short pulses. They can sustain high voltage and current simultaneously and are not very susceptible to the destructive phenomena of second breakdown.

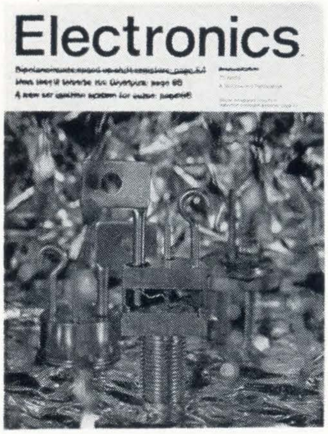
The saturation resistance of these devices can be made extremely low, in some cases approaching that obtained with germanium. Although the leakage current of single-diffused transistors is considerably below that of germanium, they are not classified as low-leakage current devices. With single-diffused transistors, BV_{CEO} ratings of 200 to 300 volts are quite common, and it is possible to produce transistors with BV_{CEO} ratings of 400 volts. In applications where high frequency and fast response is not needed, the single-diffused transistor is very desirable for power amplifiers and switching circuits with high-power, high-voltage and high-current requirements.

Triple-diffused mesa process

The triple-diffused mesa process was developed as a high-frequency and high-speed power-switching transistor. Power transistors manufactured by this process have typical gain-bandwidth products of 10 to 80 Mc, with some power types reaching 100 Mc. Because of the high-frequency response of these devices, the switching times are short—20 to 60 nanoseconds for turn-on and turn-off.

To achieve these characteristics, transistors manufactured by the triple-diffused process must have a much narrower base width to allow a higher recombination rate than the single-diffused type, and therefore are more susceptible to second breakdown. With the simultaneous application of both high voltage and high current, they are approximately 10 times more susceptible to this destructive phenomenon. (Generally, they can only handle about one-tenth of the peak power switched of comparably sized single-diffused transistors.)

The leakage currents for triple- and single-diffused mesa transistors are essentially equal. The h_{FE} versus I_C curve for triple-diffused mesas is somewhat flatter than the curve for single-diffused mesa transistors. Generally, the saturation resistance of triple-diffused devices is slightly higher than comparably rated single-diffused types. The maximum BV_{CEO} ratings available at the present time are about 100 volts with V_{CBO} ratings up to 400 volts. For applications where either fast response, high-frequency power applications or both are required, a designer should generally specify triple-diffused rather than single-diffused devices. They are particularly useful in high-frequency linear amplifiers and converter and inverter circuits operating at 50 to 100 Kc.

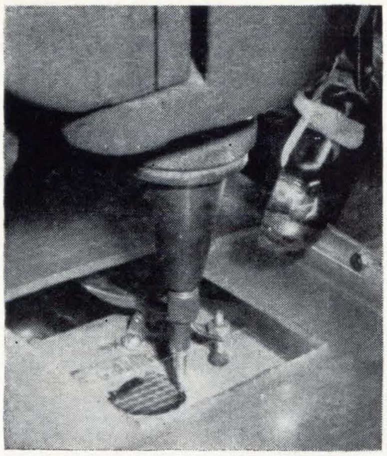


The cover

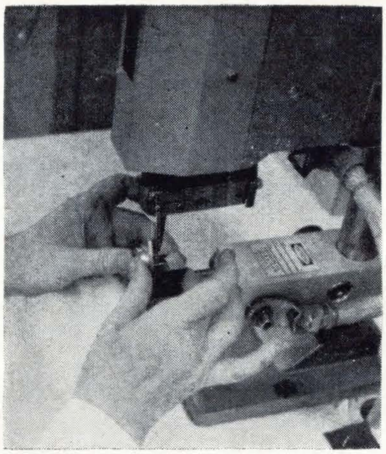
The biggest silicon power transistor ever built comes from the Silicon Transistor Corp. It can handle 300 watts, 150 amperes at 100° C with a pellet of semiconductor material nearly 0.7 inch in diameter.

Triple-diffused planar process

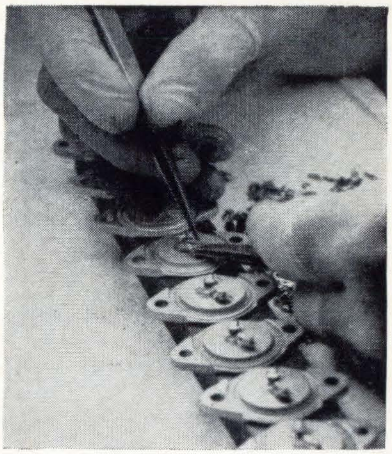
Transistors manufactured by the triple-diffused planar process have essentially the same high-frequency, high-speed characteristics as the triple-diffused mesa, and the same susceptibility to second breakdown. However, the planar process pro-



Welding solder lugs on to the terminals of a completed transistor in a standard TO-3 package.



Dicing silicon wafer into individual transistor chips is accomplished with a pantograph cutting machine.



Mounting the clips that connect the terminals of the header to the appropriate elements of the transistor pellet

duces transistors with extremely low leakage and excellent stability. The leakage levels of transistors made by this process are approximately 20 times lower than either the single-diffused or triple-diffused mesa devices.

Where a single-diffused or triple-diffused mesa transistor has an I_{CBO} specification of approximately 2 microamperes, a triple-diffused planar transistor of similar size and rating would have an I_{CBO} specification of approximately 50 to 100 nanoamperes. At present, the maximum BV_{CEO} ratings for the planar devices are below 100 volts with V_{CBO} ratings of 120 volts maximum. Like the triple-diffused mesa transistors, the planar types are ideally suited for high-frequency linear amplifier and high-speed switching applications, but especially for applications requiring high reliability.

Other manufacturing processes

Two other processes for producing silicon power-transistor processes are the double-diffused and alloy-junction techniques. The double-diffused mesa process was first used as an intermediate step between the single- and triple-diffused stages, and was intended as a compromise to achieve a higher frequency transistor until the newer triple-diffused process was perfected. It has a narrower base width than obtained with the single-diffused process and hence a higher frequency response. However, the disadvantages of this type are that it has a high inherent saturation resistance and is fairly susceptible to second breakdown.

The alloy-junction process has been successful in the manufacture of germanium transistors. However, when applied to silicon production, difficulty is encountered in controlling the base width and maintaining junction uniformity. To achieve low saturation resistance and desirable h_{FE} characteristics, a larger pellet is required than needed for a germanium device.

A large pellet combined with a wide base width has produced transistors that have inherently higher leakage characteristics and considerably slower switching speeds than even the single-diffused mesa transistors. The advantage of the alloy-junction transistors is its ability to withstand high-power transients during switching. Because of the larger pellet and the wider base width, it isn't very susceptible to second breakdown. Also an inherent result of this process is a higher-than-normal emitter-to-base breakdown voltage.

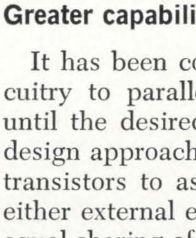
Greater capabilities

It has been common in the design of power circuitry to parallel a number of power transistors until the desired capacity is obtained. Under this design approach it is necessary to either match the transistors to assure similar characteristics or use either external emitter or base resistors or both for equal sharing of the load. This wastes power, space and money.

The ideal solution would be to use a single transistor with sufficiently high power and current capabilities to fulfill the design requirements. This approach is particularly desirable in switching circuits where the turn-on and turn-off times are critical and a speed-of-response mismatch across a parallel transistors may cause a circuit malfunction.

Reprints of this report are available. See the reader service card at the back of this issue.

The author



Since last November, Seymour Levine has been manager of field engineering and product planning at the Silicon Transistor Corp. Before that, he was manager of applications engineering.

Operational trigger for precise control

This device combines features of a Schmitt trigger with those associated with operational amplifiers

By Peter Lefferts

Electronics Division of Carter Products, Inc., Princeton, N.J.

An operational amplifier with positive feedback is being used for fine electronic control.

Because it combines some features of an operational amplifier with those of a Schmitt trigger, it's called an operational trigger.

A version of the circuit is being used by the International Telephone and Telegraph Corp. to monitor voltage and current in a communication system. And the Rocketdyne division of North American Aviation, Inc., is using another version to check the positions of servo pots, pressures and other variables in a test stand for a rocket engine.

The operational trigger is sensitive to minute changes in input. It can be set to trigger when a 100-volt signal changes by only one millivolt, with 250-microvolt repeatability. This is a triggering accuracy of one part in 10^5.

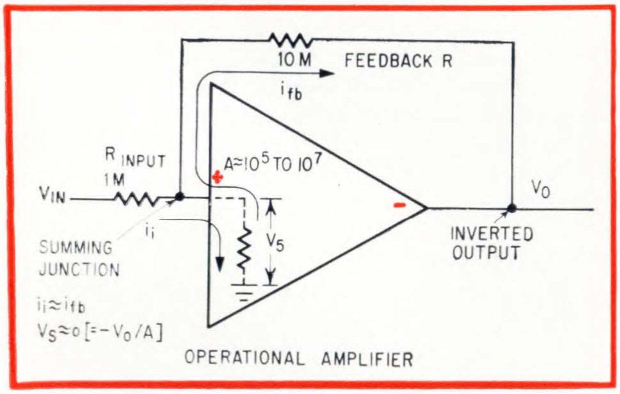
It uses external resistors similar to those that set the gain, summing-ratio accuracy and gain stability in an operational amplifier. In the operational trigger, these control the levels of inputs that are used as references and trigger levels. They also determine common-mode rejection and hysteresis or deadband—the range over which the input signal can vary without changing the output.

Amplifier for trigger

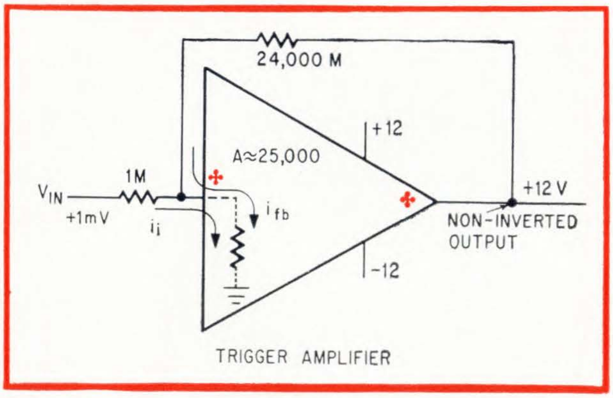
Most operational amplifiers have high gain, high d-c stability, and high resistance to oscillation when a large amount of negative feedback is used. Input signals are usually applied through large values of resistance [sketch below, left].

With a typical gain of 10^5 to 10^7 without feedback, a small input at the amplifer's summing junction generates a large output of opposite polarity. When input and feedback resistors are added, a current flows in the feedback resistor that is approximately equal but opposite to the current in the input resistor that is due to V_{in}. The voltage at the summing junction nears the vanishing point, and the output voltage is determined by the ratio of feedback-resistor to input-resistor values.

In this way, resistor ratio sets the amplifier gain. If several input resistors supply input currents, the output will cancel the sum of the input currents. The output voltage then is the sum of the input



Typical operational amplifier has inverted output and 10^5 to 10^7 internal gain. Over-all gain is controlled by ratios of the external resistors.



Amplifier for operational trigger has non-inverted output. Trigger level and circuit deadband are set by external resistors.

voltages if all resistors are equal.

If an amplifier is to be used as an operational trigger, it must have a noninverting output; feedback therefore is positive. Other characteristics of the two types of amplifiers are compared in the table at the right.

Add 2 power supplies

Connecting two power supplies to the amplifier, as in the sketch below, produces a prototype of the operational trigger. An input of +1 millivolt produces an input current of +1 nanoampere and a full-scale output of +12 volts. The feedback resistor of 24,000 megohms then provides positive feedback of +0.5 nanoampere, which is sufficient to hold the amplifier in saturation (latched) even if the input signal drops to zero.

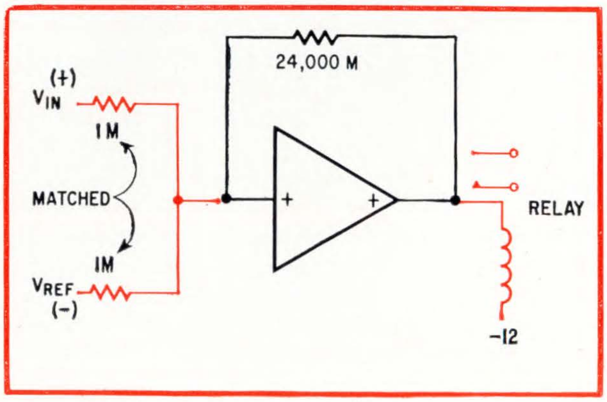
However, a −1-millivolt input will cause the amplifier output to snap to −12 volts and remain there. The result is a circuit similar to a Schmitt trigger, with hysteresis of about 2 millivolts when driven from a signal source having one megohm resistance.

A more practical version of the circuit uses a relay as a load, as shown in the sketch below. This circuit can compare with an unknown signal with a known reference. The relay opens or closes as the monitored signal becomes either greater or less than the reference.

The input summing resistors supply two currents, one proportional to V_{in} and one proportional to V_{ref}, similar to operational amplifier circuits. For example, if V_{ref} is −1 volt and V_{in} is +1.001 volt, the current from V_{ref} through the one-megohm resistor and into the amplifier is −1,000 nanoamperes and the signal current from V_{in} is +1,001 nanoamperes. Resulting input current is then +1 nanoampere; the amplifier output snaps to +12 volts and the relay closes.

But as soon as the input signal drops to +999 millivolts, the sum of amplifier input currents becomes −1 nanoampere, the output goes to −12 volts and the relay opens.

The prototype operational trigger is now a control relay with positive set-points that are controlled by the magnitude of the negative reference voltage. Similarly, negative set-points can be obtained by making the reference voltage positive. Hysteresis, or deadband, is two millivolts and accuracy is controlled mainly by the accuracy with which the input resistors are matched.



Basic trigger circuit balances a negative reference against a positive signal, and triggers when total input current is +1 nanoampere.

Operational amplifier characteristics

1. Very high voltage gain
2. Output inverted ($V_o = -A V_{in}$)
3. Can respond to less than 10^{-6} ampere and can work with megohm input and feedback resistors
4. High d-c voltage stability (referred to input signal)
5. Low hum and noise
6. Low phase shift with high-frequency rolloff to achieve stability with large amounts of feedback

Amplifier for prototype operational trigger

1. Voltage gain over 25,000
2. Noninverting output ($V_o = + A V_{in}$)
3. Full scale output with one-half nanoampere input
4. Eight-hour d-c stability of approximately two millivolts and two nanoamperes
5. Noise and hum comparable to operational amplifier
6. Stability against oscillation, even with positive d-c feedback and megohm-source impedances

Amplifier for adjustable operational trigger

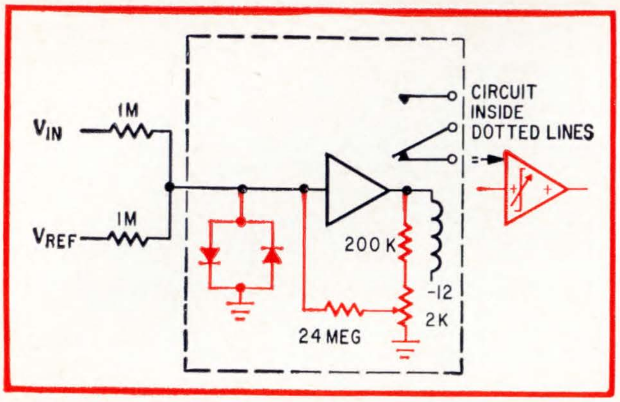
1. Internal voltage gain practically infinite
2. A relay contact for either polarity of input current unbalance
3. Hysteresis adjustable to a fraction of a nanoampere In practice, hysteresis of 250 microvolts with two megohm series resistor has been achieved
4. Eight-hour d-c stability of better than two millivolts or two nanoamperes
5. Less than one nanoampere (equivalent input) peak hum and noise under best practical shielding conditions
6. Operating conditions stable (depending on source noise) with positive feedback internally adjustable from almost zero to 20 nanoamperes (equivalent input)

Feedback and input

The sketch on page 52 shows still another level of improvement. The 24,000-megohm resistor, which is too high to be stabilized easily for temperature and humidity changes, is replaced by a variable voltage divider and a 24-megohm feedback resistor that is more stable and less expensive. The potentiometer allows the feedback current to be varied by a factor of 10 either side of the nominal amount of ±0.5 nanoampere.

But this improvement requires that the amplifier have much higher gain. With the higher gain—actually infinite in comparison with other circuit parameters—the latching feedback current almost entirely determines the hysteresis of the circuit.

The final improvement is achieved by shunting the summing input with a pair of low-leakage silicon diodes. Where currents generated by V_{REF} and V_{in} are balanced within nanoamperes, and hence millivolts, the diodes are, in effect, open circuits and do not affect input sensitivity. For



Input diodes to prevent amplifier saturation and modified feedback circuit

large input unbalance, the diodes conduct excess current to ground, preventing amplifier saturation and damaging overloads. With protecting diodes and stable summing resistors, excellent performance is achieved even with hundreds of volts overload.

Amplifier specifications for the adjustable trigger are included in the table previously mentioned.

Savings

With the operational trigger, many voltage-comparison or go/no-go devices can be operated from one set of power supplies using a common ground. This is not always possible with differential or floating comparators, which often require floating power supplies.

Since all reference sources of one polarity can be derived from a single power supply with appropriate voltage dividers, the cost of such references is less than with separate power sources. Power supplies regulated to 0.1% or better can sometimes do double duty as references. Also, the same trigger module can be used to sense resistance, current, voltage, sums of currents, sums of voltages, and low-frequency a-c waveforms by switching or multiplexing input circuits as required.

The operational trigger's resemblance to operational amplifiers makes it useful in certain analog computer applications. For example, when the computer is part of a control loop, a switch to control the process must be closed at a certain voltage level. Analog computers used in aircraft simulation and training equipment are often required to display certain failure lights somewhere in the cockpit. The operational trigger can be set to trigger at some part of a simulation waveform, or it can be set to trigger at a combination of output voltages by using several input resistors.

Go/no-go circuits

In normal use the trigger is operated with its input voltage and current each almost at zero. The standard input circuit of two resistors meeting at the input can be thought of as forming half of a wheatstone bridge, where the plus and minus inputs V_{in} and V_{ref} are approximately balanced.

Typically the final trigger has 1.5 millivolts or less hysteresis with two input resistors. Since the circuit is, for all practical purposes, open just before it triggers, input-voltage sensitivity is better than 0.7 millivolts from any source of 500-kilohms or less.

In the voltage monitor in the drawing at the right, a set of voltages are tested to be sure that they remain above a positive limit. The power supply is used as a reference; the 12-megohm plus 120-kilohm resistors from the −12-volt supply produce a negative input current of −990 nanoamperes. Each test-point resistor is selected to produce one microampere from the voltage it is monitoring: for instance, 2.5 megohms for the 2.5-volt source.

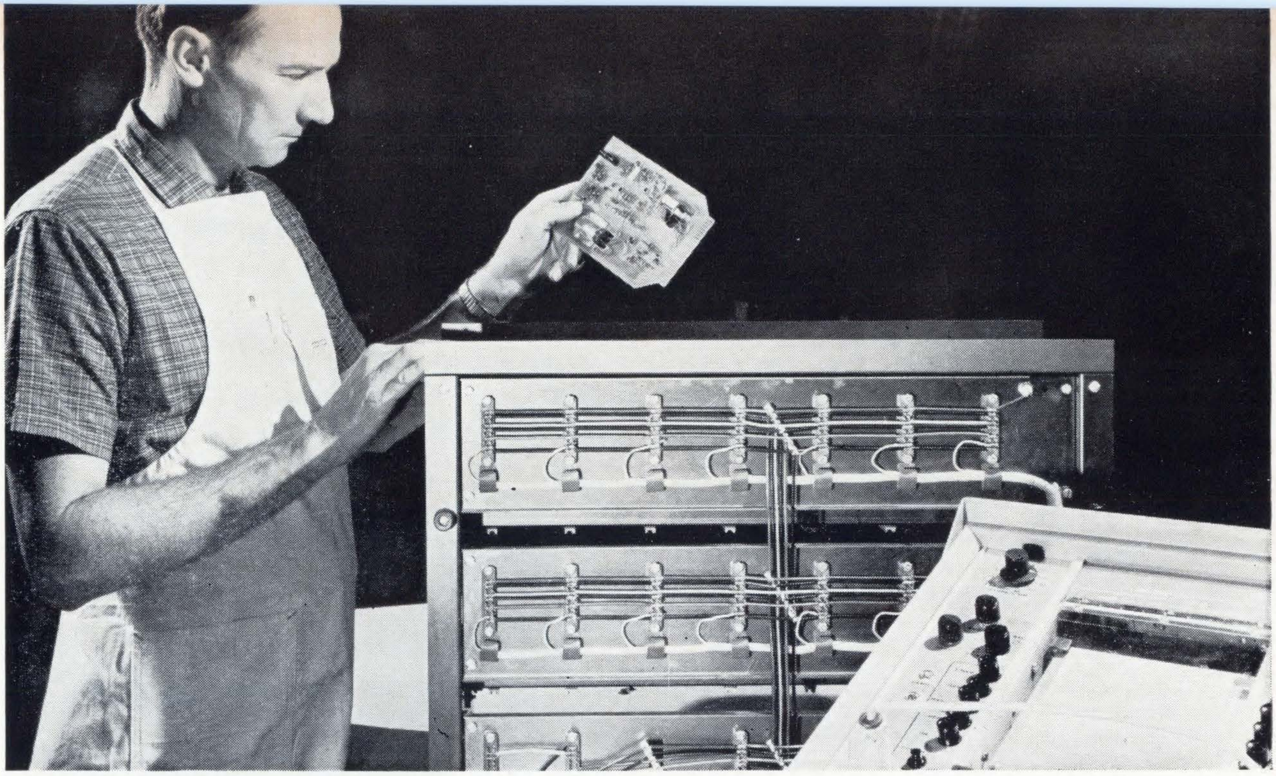
As long as the voltages being monitored remain at or above their design value, the input current to the trigger is +10 nanoamperes or more at all test points, and the relay does not change state from one point to the next. If any voltage being monitored drops 1% below a predetermined level, the input current becomes zero but the relay does not change state. If any voltage drops 1.1%, the current sum to the trigger is −1 nanoampere and the relay changes state. The 500-kilohm resistor to ground provides a satisfactory input impedance when the stepping switch is between positions.

Checking for tolerance

The resistance tester shown checks resistors by placing them in the open leg of a bridge powered by a floating power supply or battery. If the test resistor is equal to the standard, the bridge is balanced except for the unbalance introduced by the "acceptance-limit" potentiometer. Since this unbalance is negative for the circuit shown, the net current flow to the comparator is negative.

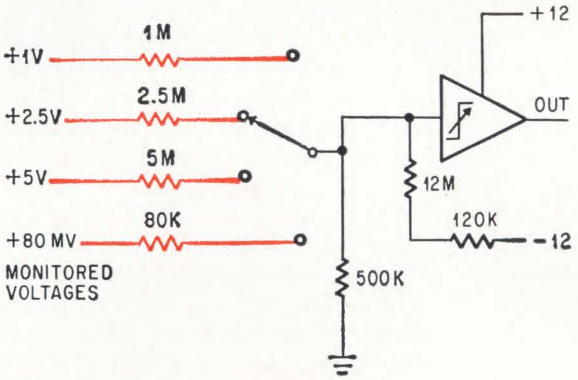
Suppose one-megohm resistors are to be measured to an accuracy of ±0.1%. Since the other half of the bridge uses 100-kilohm resistors, the acceptance-limit pot is set to 100 ohms, or 0.1% of 100-kilohms. With the switch up, the bridge is biased 10 millivolts negative and will stay that way until a test resistor is 0.11% too high, or more. This extra 0.01% unbalance provides about one millivolt positive directly at the input to the comparator at an impedance of approximately 600 kilohms. This is enough to operate the trigger. Reversing circuit polarity as indicated by the switch allows resistors that are low in value by as little as 0.11% to be detected.

The next circuit measures voltage from a low impedance source such as a saturated transistor. The transistor is biased to saturate the collector circuit to within 100 millivolts of ground; a collector load is chosen so that 10 milliamperes flows. These specifications are necessarily arbitrary for a given transistor. The 100-Kilohm resistor at the comparator input is high compared with the collector impedance and as a result a reference current of approximately one microampere flows from the −12 volt supply. The comparator input is thus biased

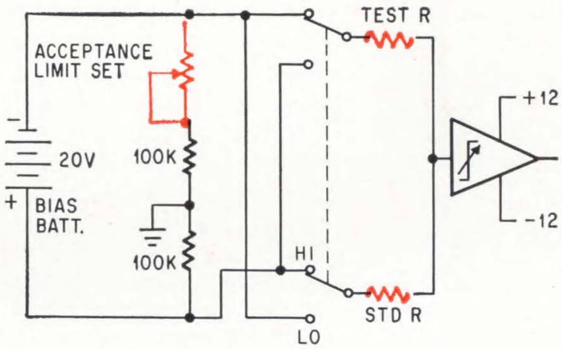


Individual circuit card containing trigger is about to be plugged into equipment. Because of circuit's high sensitivity, cards are often individually shielded.

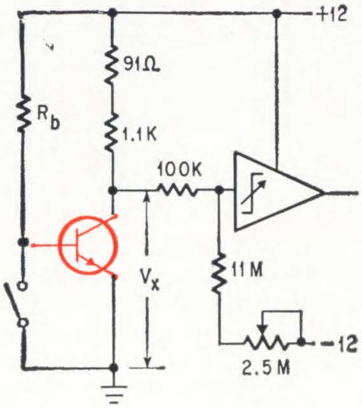
Five trigger applications for go/no-go testing



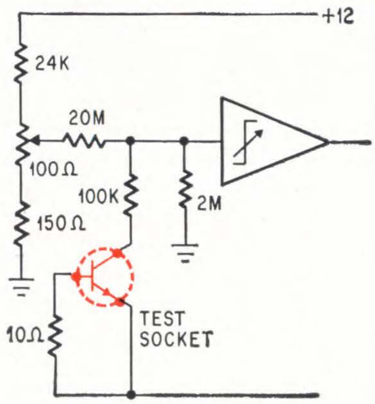
Voltage monitor



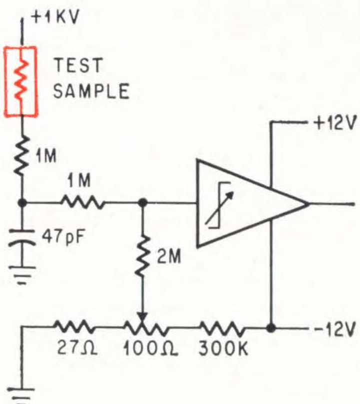
Resistance tester triggers when test resistor is 0.01% higher or lower than acceptable values



Transistor saturation set to trigger if V_x is 1 mv greater than 100 mv at $I_c = 10$ ma.



Leakage test set to trigger if I_c is greater than 5 na

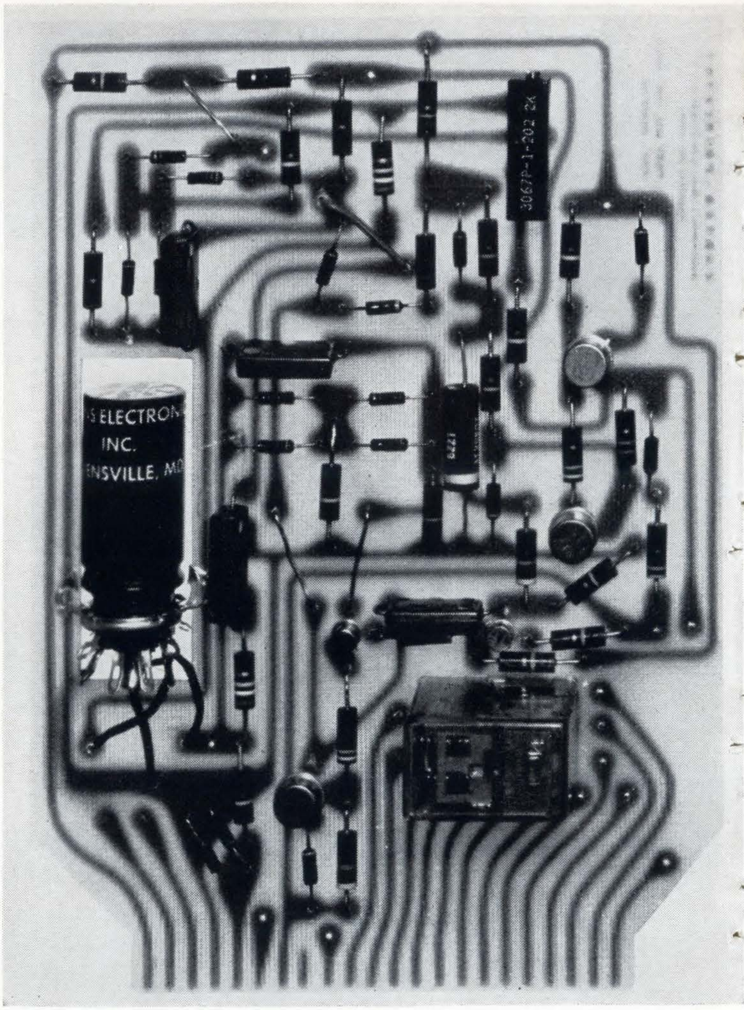


Hi-pot leakage test triggers if sample's resistance is less than 5 x 10^5 megohms

100 millivolts below the transistor collector voltage. If the saturated collector voltage rises to 101 millivolts, the comparator will receive a trigger voltage of almost one millivolt because the reference bias circuit has an impedance two orders of magnitude higher than the 100-kilohm input resistor.

An excellent circuit for determining transistor leakage of five nanoamperes or more is shown in the diagram; it requires careful construction and shielding to prevent spurious pickup. The two-megohm resistor to ground limits the pickup. The 100-ohm pot is trimmed to provide +4.5 nanoamperes input to the trigger with the test transistor out of its socket. When the npn transistor is in the test socket, and collector leakage is five nanoamperes or higher, one-half nanoampere is available to trigger the comparator. The circuit reacts in 40 milliseconds or less, compared with 100 to 300 milliseconds required by conventional systems.

The hi-pot tester shown has high sensitivity to leakage resistance. The voltage divider attached to the −12 volt supply is adjustable from approximately −1 to −5 millivolts. This voltage drives 0.5 to 2.5 nanoamperes through the 2-megohm resistor to the comparator input. If the voltage divider is adjusted to produce −1.5 nanoamperes a flow of two nanoamperes through the test sample provides 0.5 nanoamperes of input unbalance and 1 millivolt, which is enough to trigger. Triggering occurs when the resistance of the test sample is 5×10^5 megohms or less, because this is the resistance value that permits two nanoamperes to flow when 1,000 volts is applied. The filter, consisting of two one-megohm resistors and a 47-picofarad capacitor between the test sample and input eliminates noise and possible spikes caused by corona or voltage transients in the 1,000-volt power supply.



Plug-in operational trigger uses five silicon transistors and operates on one-millivolt, one-nanoamphere input.

Control and alarm

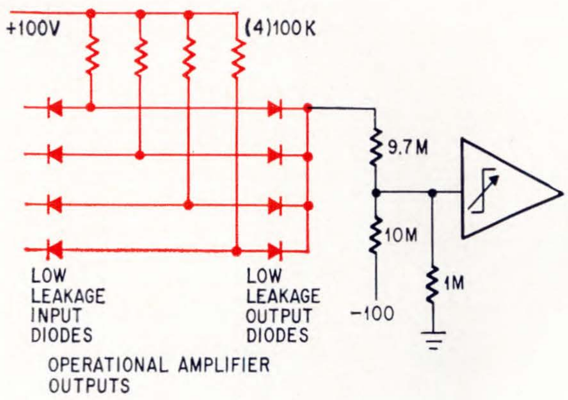
The positive limit alarm circuit in the figure on page 55 warns if any outputs of the operational amplifiers being monitored has gone off-scale—that is, if it has gone more positive than +99 volts. This method is more accurate than the neon bulb indicators sometimes used, and the relay contacts can correct the computation or set off an alarm.

As long as analog amplifier outputs are below +99 volts, there is current flow from the +100-volt source through the input diodes to the output circuits of the analog amplifiers. Modern semiconductor amplifiers can accept this extra load current, but some vacuum-tube types cannot. The resulting voltage drop across the 100-kilohm resistors keeps the junctions of the diodes below triggering voltage. When any amplifier output reaches +99 volts, the associated input diode becomes nonconducting and the 100-volt supply delivers almost 1% more current at the trigger input than does the −100-volt supply. This is far more than is needed to trigger the comparator.

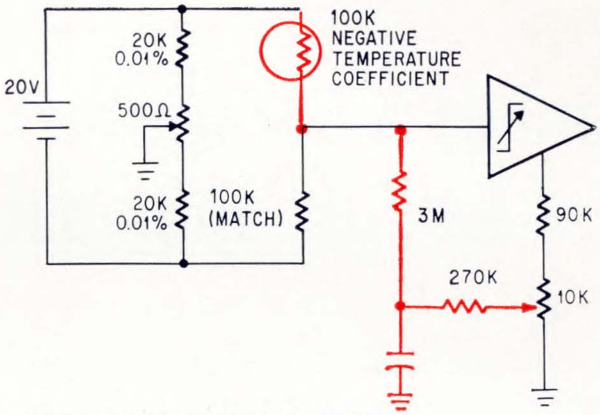
If a higher reference voltage is available, the input circuit can be designed so that the diodes conduct at all times and thus have a constant voltage drop despite small changes in current through them. With matched diodes operating in their conducting region, the circuit can be designed to trigger within a few millivolts of a +100-volt setpoint.

The next circuit provides temperature control to 0.001°C. The circuit is a bridge, with the arm of the balance pot going to ground and the power supply floating. For a typical thermistor with a −3% resistance change per degree centigrade, the bridge develops almost 300 millivolts per degree. When the temperature being controlled drops, the trigger operates and turns on the controlled heating element, which is not shown in the sketch. When the temperature rises, the trigger relay opens.

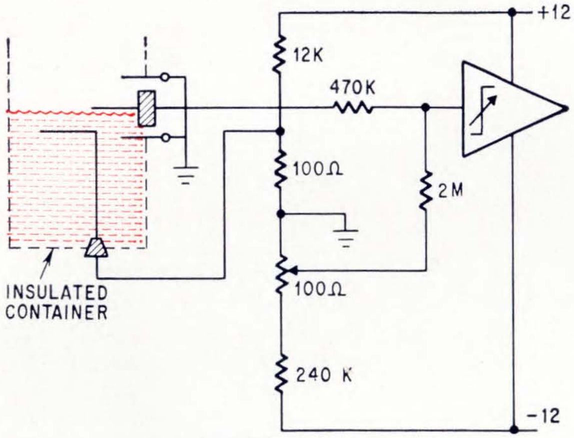
So far, this is plain on-off control. The resistor-capacitor circuit, fed with negative feedback from a connection available on the trigger, provides time-proportional control. The negative feedback signal builds up on the capacitor until it overrides the signal from the bridge. This provides more sensitive control. Typically the range over which time-proportioning is effective—the proportional band—is 0.1°C. Resolution with time-proportioning is determined by trigger repeatability, because the nor-



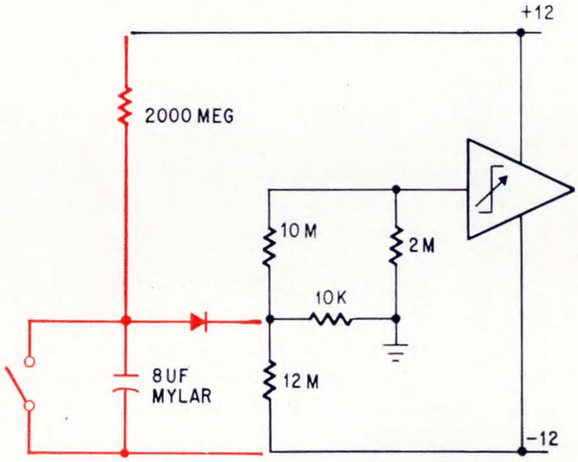
Positive limit alarm for analog computers



Proportioning temperature control



Liquid level control can control level to 1 millimeter



Long time delay

mal hysteresis is practically cancelled by the negative feedback.

A resistance-actuated circuit for sensing liquid level is shown in the figure. Even distilled water, alcohol and some organic solvents have enough residual ionization or impurities to conduct some current at an applied voltage of 100 millivolts. An insulated liquid tank is shown with the bottom electrode charged to 100 millivolts through the divider to the +12-volt supply.

The second electrode is inserted through a ground-guarded insulator and attached to the trigger through a 470-kilohm resistor. The trigger input is normally biased negatively about one-half nanoampere by adjusting the 0- to 5-millivolt divider to about −1 millivolt, using the 100-ohm pot. When the liquid touches the second probe, and if it has equivalent resistance less than 100 megohms, it will supply more than one nanoampere current from the 100-millivolt electrode and trigger the comparator.

The next circuit can provide several hours of time delay. The 2,000-megohm resistor and eight-microfarad capacitor have a time constant of 16,000 seconds, or more than four hours. Through the network of 12-megohm, 10-kilohm and 10-megohm, the comparator is biased at one nanoampere negative. When the switch opens, the capacitor starts charging from −12 volts toward +12 volts.

When it passes ground potential, the diode begins to conduct, and quickly provides 1.5 to 2 nanoamperes positive current to trigger the comparator. Timing accuracy is good because the capacitor is drawing six nanoamperes relatively constantly at the triggering point, so there is adequate input current available. The diode that isolates the capacitor during the timing delay is critical, however, and should leak only a small fraction of a nanoampere. The circuit is reset by closing the switch.

The author

Peter Lefferts has designed circuits for medical electronics, telemetry, voltage comparators and feedback control. He has patents pending for several circuits. He's a 1958 graduate of Princeton University.

Using a computer for circuit analysis

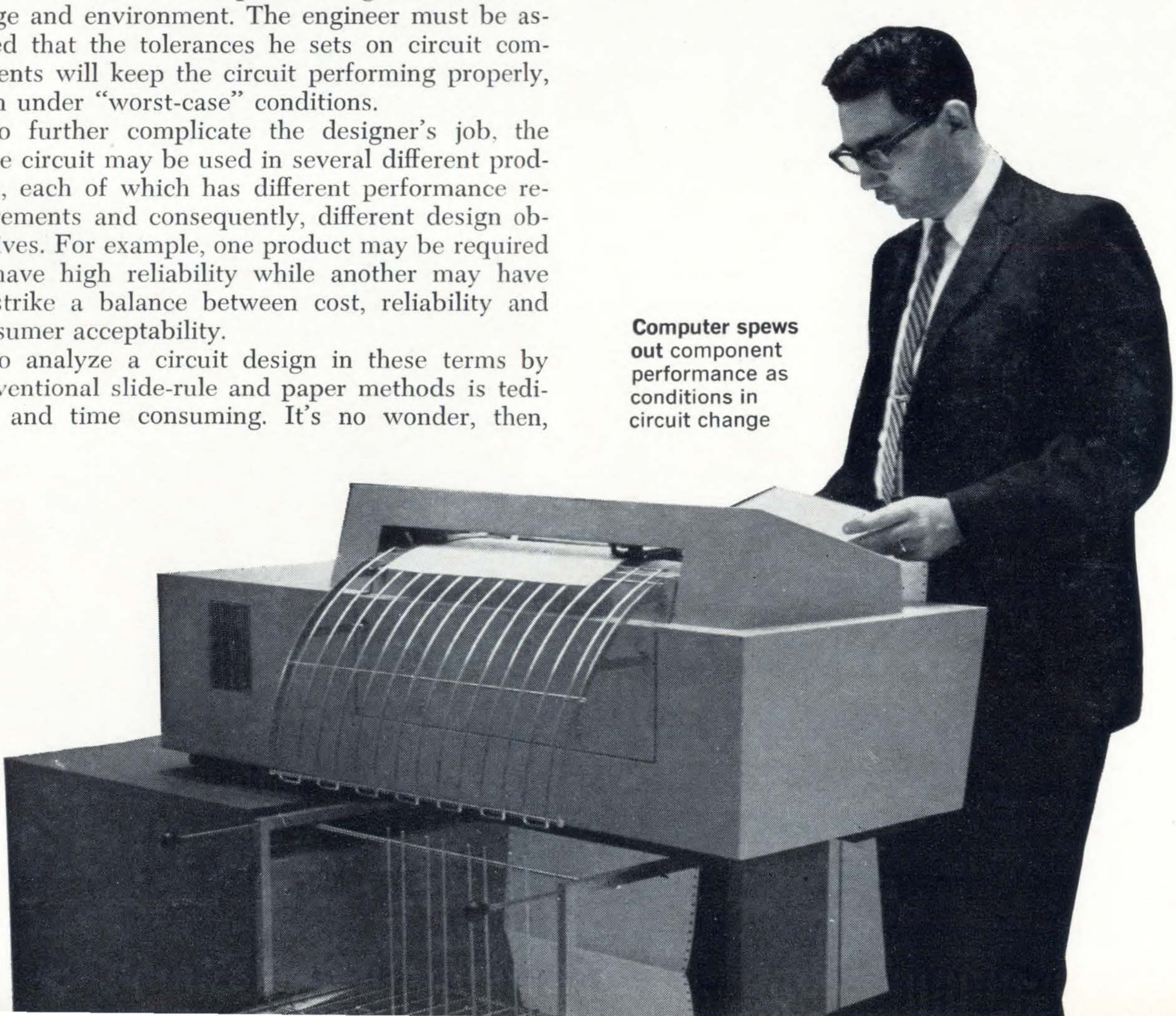
Once he learns the special input language, the designer can communicate with the machine and get answers to circuit-design questions more quickly, completely and accurately.

By Herbert M. Wall
International Business Machines Corp., Cambridge, Mass.

The circuit designer's job doesn't end when he sketches or breadboards a circuit that nominally performs the required electronic function. The circuit must be analyzed to determine if it will continue to work when components degrade with time, usage and environment. The engineer must be assured that the tolerances he sets on circuit components will keep the circuit performing properly, even under "worst-case" conditions.

To further complicate the designer's job, the same circuit may be used in several different products, each of which has different performance requirements and consequently, different design objectives. For example, one product may be required to have high reliability while another may have to strike a balance between cost, reliability and consumer acceptability.

To analyze a circuit design in these terms by conventional slide-rule and paper methods is tedious and time consuming. It's no wonder, then, that engineers are learning special machine languages to communicate with computers. The computer can then be used as a design tool to determine the right value for critical components, to test



Computer spews out component performance as conditions in circuit change a design and what happens to it as components change, and even to predict the behavior of components that are not yet available.

In circuit design, the tolerance required of each individual circuit component must be established to obtain an over-all circuit performance with specified tolerances. This relationship between individual component tolerance and over-all circuit performance is not a direct one, however. It cannot be said that to obtain a maximum of ±1% variation of a given circuit-output parameter, all components must be 1% components or less (tolerances of ±1% nominal value). In fact, it may be that some components will require a ±0.5% tolerance while others can be as high as ±10%.

Using pencil and paper to determine all the possible combinations of components can be extremely tedious, if not impossible. Building and testing large numbers of circuits with various combinations of components can be equally difficult. Still, the design engineer frequently asks that both be done to safeguard an immense investment in time, national security, manpower and money.

Monte Carlo techniques

Digital computers have been used in an attempt to overcome these problems. At first, small programs were developed to provide a set of instructions for a computer. These were intended to assist the designer in his analysis problem and to obtain more complete and accurate results faster. The programs ranged from the simple solution of sets of simultaneous equations to problems utilizing Monte Carlo techniques for statistical reliability evaluation. (Monte Carlo techniques involve statistical sampling to obtain approximate solution.) By these means, the engineer could study the effect of parameter variation on output variables; this allowed him to manipulate his data to obtain an envelope of operation (the acceptable parameter limits).

While this was a big advantage, the methods used were cumbersome. It still was necessary for the engineer to work out the circuit equations for input to the computer, and to handle a great deal of other data himself.

It was evident that if design logic could be coded into instructions for use in a computer program, much of the time-consuming effort of repetitive manual design could be eliminated.

Cause and effect

Design logic follows the rigid law of cause and effect. That is, if type A resistor is inserted in a circuit, then associated components will be affected in manner B; if type B transistor is inserted, the associated components will be affected in manner C; and so on. Being able to determine these variables within the computer enables the engineer to evaluate the circuit to determine critical components. These are those circuit elements whose tolerance must be maintained within closer than standard limits, to prevent exceeding specific design criteria (such as particular node voltages or current flow, for example). This kind of computer program can be used to prove out a design, and it allows the designer to measure the relative merits of alternate designs. It also provides an alternative to the expensive and time-consuming building of prototype models.

Circuit simulation also allows experimentation with components not readily available, if suitable models for these components have been determined. For example, a designer could simulate a transistor that was not yet available, without having to order a sample lot at a very high cost. Furthermore, simulating malfunctions or component failures by computer makes it possible to compile trouble-shooting data to assist field maintenance and repair personnel.

Circuit analysis program

A major portion of such tasks now is being handled by an electronic circuit-analysis program (ECAP), an integrated set of prepared computer programs designed by the International Business Machines Corp. for use on a 1620 data-processing system with a 1311 disk-storage unit. The 1620 at present is the only IBM system with which these prepared programs can be used.

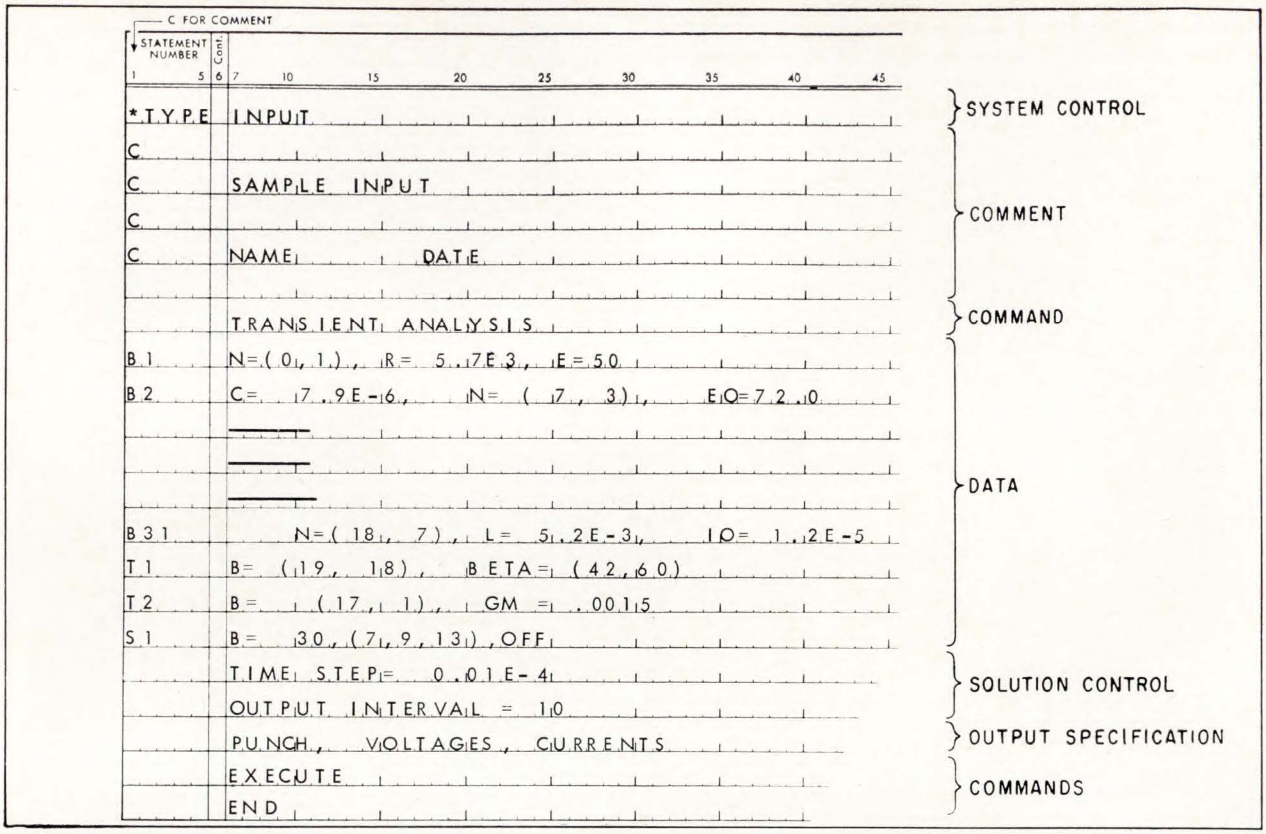
The program consists of four operational sections: an input processor or monitor, an a-c program, a d-c program and a transient-analysis program. These are generalized routines which require no modification by the engineer.

The monitor reads and interprets the input cards which are prepared by the engineer and written in a language very similar to his own. It retrieves the program requested (a-c, d-c or transient) from the auxiliary 1311 disk-storage unit, and transfers 1620 control to that program automatically. Upon completion of the analysis by the 1620, control is returned to the monitor, and the next deck of input cards, if any, is read.

To use the system, the engineer starts with a schematic diagram representing the desired circuit. He then numbers the nodes and branches of the various networks. A special input language, requiring only a few hours to learn, is then used by the engineer to describe the circuit and its physical characteristics to the computer. He also uses this input language to describe various user-options, such as type of output, type of analysis to be performed and circuit parameters to be varied.

This description goes on a coding form (p. 58). It can be seen that only six classifications of input data are required: system control; comment; command; data; solution control, and output specification. These individual statements are the only ones the engineer need specify before entering them into the 1620.

Next, this information is keypunched on state-



Any suitable encoding form may be used; this is a Fortran form.

ment cards. In the case of simple problems, the data can be entered manually on the 1620's console. When ECAP is used, additional "control" cards are necessary. These are prepunched file cards that are inserted in the deck prior to processing to provide any added information to the 1620 monitor control system.

The engineer's approach

In processing, the combined 1620-1311 system interprets the input cards, determines the network topology, generates the network equations and performs the desired analysis. During the course of solution, the engineer can intervene at the console and modify various input parameters at the console typewriter. Thus, the system allows either intervention for manual modification or completely automatic modification and solution. The engineer can thus simulate his own normal approach to a design problem that is usually experimental at the outset, and work through to a final fixed design. Presented graphically, a circuit analysis procedure would appear as shown in the upper figure on p. 59.

Some of the other features of this system are:

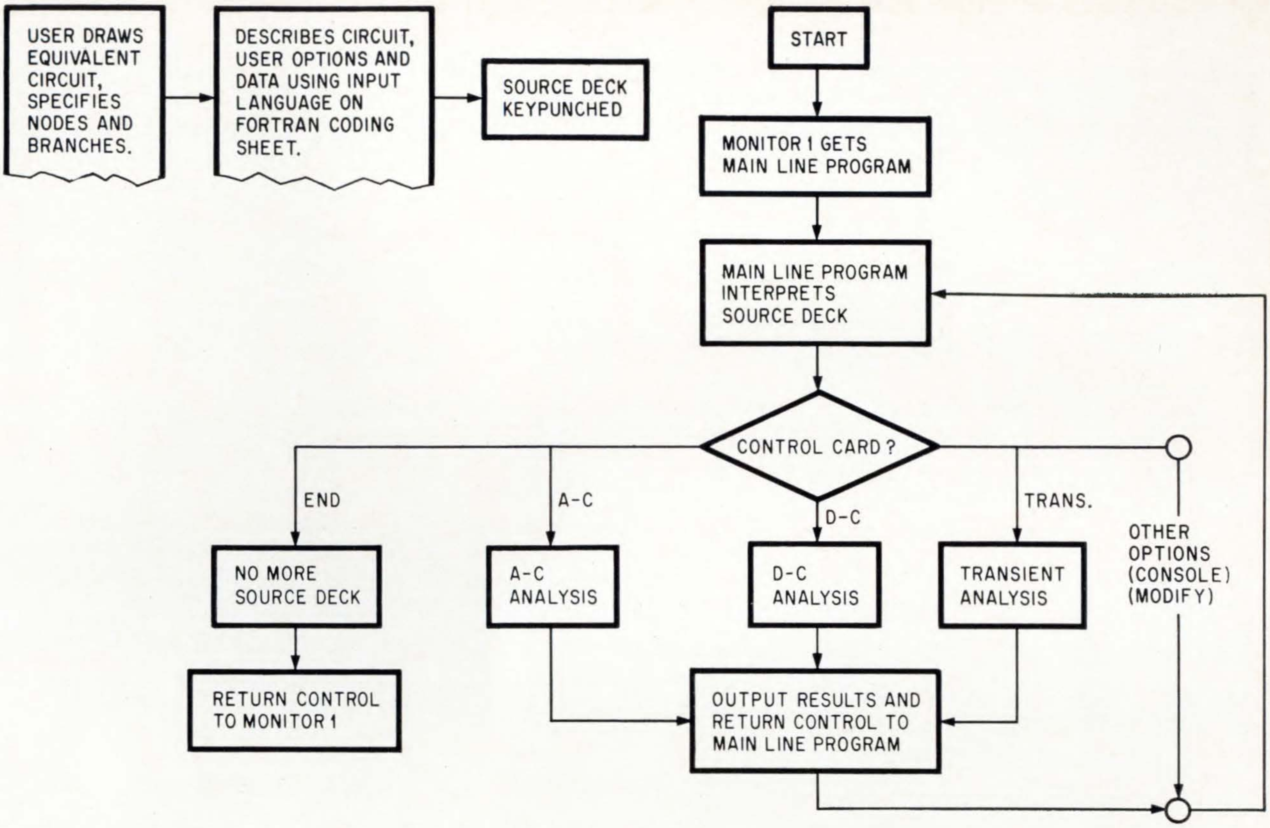
- Networks of up to 20 nodes and 60 branches can be processed.
- Nonlinear circuit elements can be handled in the transient-analysis program through linear approximation, by automatic switching of circuit elements from one value to another to change the characteristic of the model being used.
- Numerical stability of the transient solution is not affected by the size of the time period over which the numerical integration is taken. Thus the user can select suitable time steps to quickly obtain an indication of transient behavior.
- Sensitivity coefficients for a circuit may be obtained with the d-c analysis program; these coefficients indicate the relative effect of variations in the circuit elements on circuit ouput behavior.

A few of the results obtainable from this kind of circuit analysis include: node voltages, branch currents, branch voltages, power dissipation, switching times, sensitivity coefficients, standard deviation of node voltages, "worse-case" analysis (which yields the maximum and minimum variations of node voltages when the worst possible combination of circuit element tolerances occurs) and coefficients of the circuit equations generated by the system.

Solving a circuit-design problem

When he uses the electronic circuit-analysis program the engineer's first task is to number the nodes and the branches of the network to be analyzed.

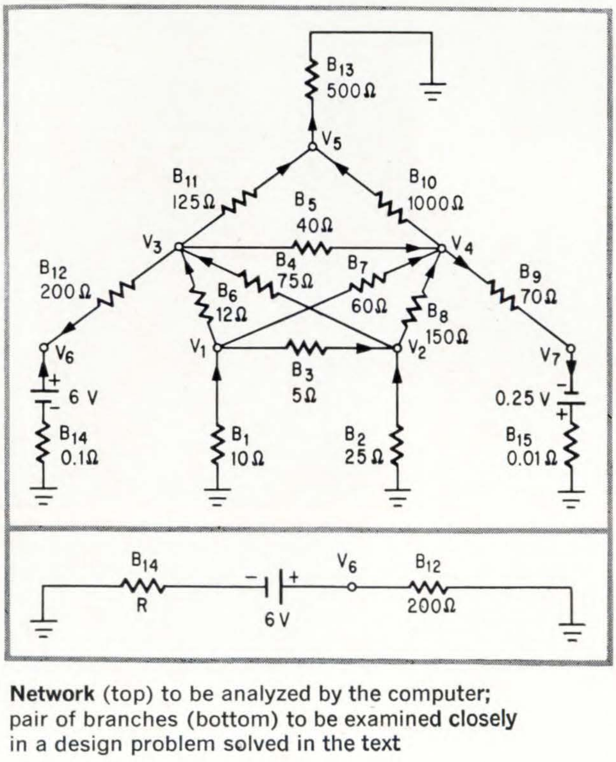
In the resistor network shown on page 59, the numbers in the d-c analysis program, for both nodes and branches, are assigned in each case starting with the number 1. The nodes are numbered from 1 to 7 inclusively, and the branches from 1 to 15. The reference or ground terminals of the cir-



Circuit-analysis procedure followed by the 1620 computer

cuit are assigned the node number zero.

Next, boundary conditions must be specified. In this case it is desired that V6 = 6.0 volts, and V7 = 0.25 volts. These conditions are, of course, easily satisfied by connecting voltage sources of the appropriate magnitude from ground to V6 and V7. However, a voltage source is available only as an element of a standard branch so that the boundary conditions are satisfied by connecting branches from ground to V6 and V7. (A standard branch is made up of an R, L or C element with a voltage source in series and a current source in parallel with it.) The voltage source in each branch (B14 and B15) is then set to the proper value, and the corresponding resistors to very small values, although they must not be set to zero.



Network (top) to be analyzed by the computer; pair of branches (bottom) to be examined closely in a design problem solved in the text

Choice of resistors

In this problem some attention should be focused on the choice of the resistors in B14 and and B15. They may actually represent, for example, the internal resistances of the voltage sources. But, if not, the chosen values of the resistors must not be so large that they will load the circuit. In either case, the resistors must not be so small as to be outside the precision range of the computer.

To make a sound selection, considerations of the following type are useful. First, an acceptable deviation from the desired boundary conditions must be decided upon. For example, a node voltage at V6 of 6.005 would be acceptably close (less than 0.1%) to the desired value (boundary condition) of 6.0 volts. At V7, a deviation of 0.005 volt should also be reasonable since the desired voltage there is more than an order of magnitude less than at

```
NODE VOLTAGES

NODES              VOLTAGES

1- 4      .15879316E+00      .14569300E+00      .38149607E+00      .15523973+00
5- 7      .29156438E+00      .59971916E+01     -.24994210E+00


ELEMENT CURRENTS

BRANCHES           CURRENTS

1- 4     -.15879316E-01     -.58277200E-02      .26200320E-02     -.31440408E-02
5- 8      .56564085E-02     -.18558575E-01      .59223830E-04     -.63644866E-04
9-12      .57883117E-02     -.13632465E-03      .71945352E-03     -.28078478E-01
13-15     .58312876E-03      .28084000E-01      .57900000E-02
```

Computer results. The two digits following the letter E are the floating-point exponent; if the sign after E is positive, move the decimal point to the right as many places as indicated by the exponent; if negative, move it to the left.

V6. The maximum currents that flow from the voltage sources in B14 and B15 can be estimated using the bottom figure on page 59 as follows:

Ground the nodes adjacent to V6 and V7, and compute the resulting current flow. In the case of V6 (assuming that R is small compared with 200 ohms) the current is 30 milliamperes. The largest acceptable voltage deviation from the desired boundary conditions at V6 is 0.005 volts. Thus, as long as R is less than 0.005/0.03, or 0.1667, this condition is met. On the other hand, R should not be more than, say, four orders of magnitude (to maintain the significance of the mathematical calculation) less than the smallest resistor connected to node V6. Since the only resistor connected to V6 is that of B12, or 200 ohms, R should be at least larger than 0.02. Hence an R of 0.1 ohm should be suitable.

To prove manually whether this hypothesis is accurate would require countless hours of tedious calculation. However, when the same initial data is entered into an electronic circuit-analysis format as shown in the figure at right, and processed through the 1620 system, verification is provided within a matter of minutes.

Computer results

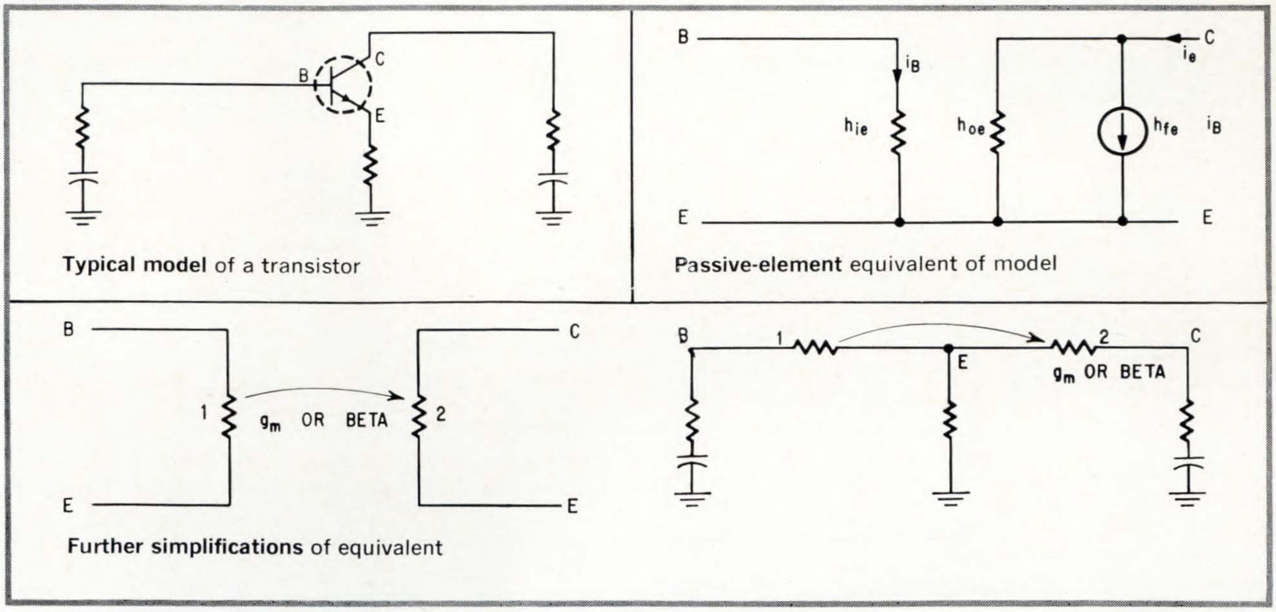
In this particular problem, the computer results shown above are referred to as the nominal solution of the resistor network since the input data contains nominal, or mean, parameter values. Note, however, that the voltage at V6 is 5.9972 volts, or a deviation of 0.0028 volts (less than 0.05%). Moreover, the current balance at V6 is excellent: 0.028084 amperes into the node, and 0.028078 amperes out.

A similar process is undergone for the choice of resistor value for B15. In this case, a value of 0.01 ohm is selected. The resulting voltage at V7 is well within the acceptable deviation from 0.25 volts. In addition, the current balance is excellent.

While this is a relatively simple example of the procedure, it does illustrate the ease and accuracy possible with computer circuit-analysis and

```
C          RESISTOR NETWORK
C          IBM 1620                4/7/64
C
C
           DC ANALYSIS
C
C
B1         N(0,1),R=10.0
B2         N(0,2),R=25.0
B3         N(1,2),R=5.0
B4         N(2,5),R=75.0
B5         N(3,4),R=40.0
B6         N(1,3),R=12.0
B7         N(1,4),R=60.0
B8         N(2,4),R=150.0
B9         N(4,7),R=70.0
B10        N(4,5),R=1000.0
B11        N(3,5),R=125.0
B12        N(3,6),R=200.0
B13        N(5,0),R=500.0
B14        N(0,6),R=0.1,E=6.0
B15        N(7,0),R=0.01,E=0.25
           PRINT, VOLTAGES, CURRENTS
           EXECUTE
```

Initial data entered into the computer



Typical model of a transistor

Passive-element equivalent of model

Further simplifications of equivalent

Transforming a transistor into a passive-element model. h_{ie} is base resistance in ohms, h_{oe} is collector conductance in mhos, h_{fe} is forward current gain.

design. To use the a-c, transient, or other d-c analysis programs, the only major change in basic input format is the replacement of active devices in the circuit (such as transistors, diodes and vacuum tubes) by a network of passive elements which "model" the actual device.

To illustrate, transistors are active elements which amplify an input signal. This implies the existence of a dependent current-generator (the transistor) whose output is a function of an independent current flow (in the base). The ratio of dependent to independent current then is the gain (beta).

Circuit analysis

Many models have been proposed for these devices in journals, manufacturers' published data and current texts in the area of circuit analysis. While no one model is universally acceptable, an example of a typical model could be the transistor shown in the top left figure above (a-c components neglected).

This transistor may be replaced by the network of passive elements representing a model of the transistor. A common representation is shown in the top right figure, using the familiar hybrid parameters.

By analyzing this circuit it can be shown that:

$(V_B - V_E) = (h_{ie})(i_B)$ (no reverse voltage gain)

$I_c = (h_{fe})(i_B) + (h_{oe})(V_E - V_B)$

$I_b = (V_B - V_E)/h_{ie}$

$I_c = (h_{fe}/h_{ie})(V_B - V_E) + (h_{oe})(V_C - V_B)$

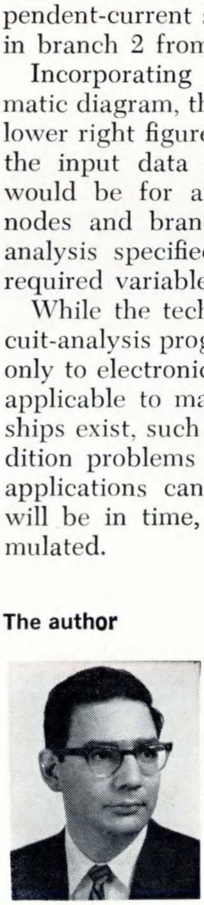
Here we refer to h_{fe} as beta and to ratio h_{fe}/h_{ie} as g_m or transconductance; V_C, V_B and V_E are the static values of collector, base and emitter voltage; h_{ie} and h_{oe} are the common-emitter small-signal input impedance and output admittance; I_c and I_b are collector and base current (rms); and i_B is instantaneous total base current.

This enables further simplification of the circuit description to use the transconductance value as shown in the lower left figure which implies a dependent-current source equal to $(h_{fe}) \times (i_B)$ flowing in branch 2 from C to E.

Incorporating this model in the original schematic diagram, the result is derived as shown in the lower right figure. From this circuit diagram, then, the input data cards are prepared just as they would be for any other procedure; that is, the nodes and branches are numbered, the form of analysis specified (d-c, a-c or transient), and the required variables stated.

While the techniques used in the electronic circuit-analysis program might appear to be applicable only to electronic circuit analysis, they actually are applicable to many areas where network relationships exist, such as control systems, boundary condition problems and heat transfer. Some of these applications can be readily handled now; others will be in time, when suitable programs are formulated.

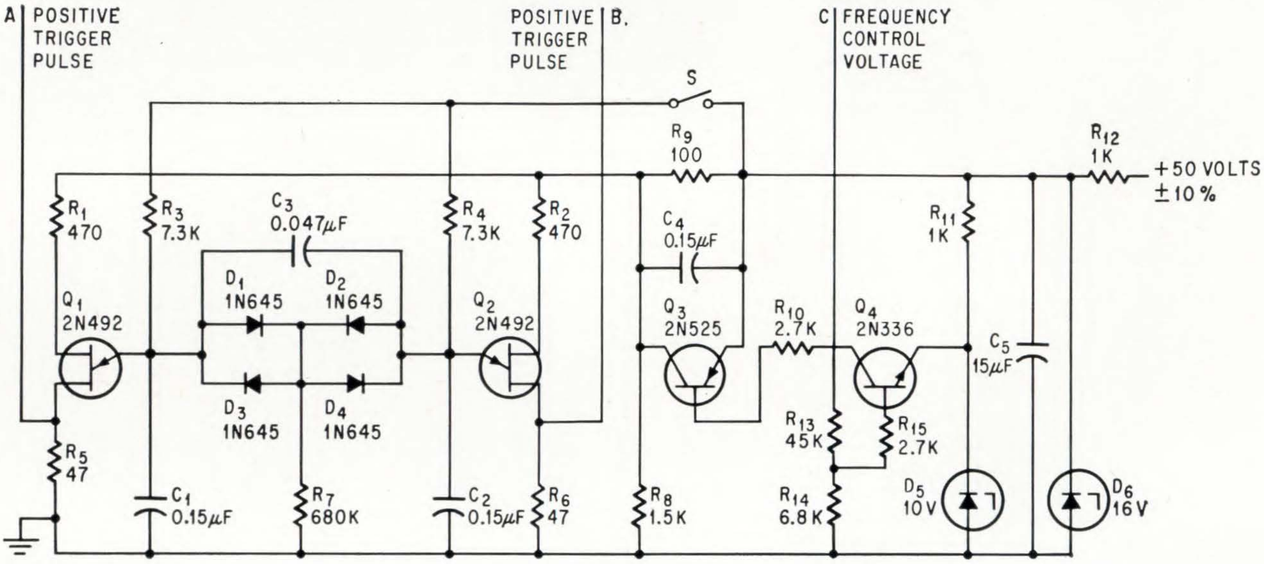
The author



Herbert M. Wall has a bachelor's degree in electrical engineering and a master's degree in business administration. He has worked on the development of computer program for electrical and industrial testing. For the past two years, in the data processing division of IBM, he has been project leader of a team that designed, developed, programed and documented a computer system for electronic circuit analysis.

Designer's casebook

Designer's casebook is a regular feature in Electronics. Readers are invited to submit novel circuit ideas, packaging schemes, or other unusual solutions to design problems. Descriptions should be short. We'll pay $50 for each item published.



Voltage at terminal C controls frequency of the dual triggers.

Voltage controls dual-pulse scr trigger

By Thomas Wilson

Dept. of Electrical Engineering
Duke University, Durham, N. C.

The trigger circuit shown above was designed to supply alternating pulses to two silicon controlled rectifiers in a d-c to d-c voltage converter. The output voltage of the converter was proportional to the frequency at which the scr's were triggered.

The trigger circuit comprises two unijunction-transistor relaxation oscillators connected to a common controllable d-c voltage source. When switch S is closed, capacitors C_1 and C_2 charge, and the voltage at the emitters of Q_1 and Q_2 rises. Because there are inherent differences in the characteristics of transistors, the peak point voltage of one unijunction transistor will be lower than that of the other.

For the purpose of analysis, assume that C_1 charges to the peak point voltage of Q_1 first. The emitter-base impedance of Q_1 then becomes low, and C_1 discharges through this impedance and R_5. Capacitor C_2 also discharges, through diodes D_2 and D_3, the emitter-base impedance of Q_1, and R_5. As the capacitors discharge, the voltage at the emitter of Q_1 will reach some minimum value which causes Q_1 to cease conduction, terminating the pulse appearing at output A.

When this occurs, the voltage on C_2 exceeds the voltage on C_1 by an amount equal to the forward voltage drop across diodes D_2 and D_3. These diodes also present a path through which the excess charge can distribute itself between C_2 and C_1. However, the forward bias of D_2 and D_3 immediately drops to a low value, causing their dynamic forward impedance to increase, and slowing the rate of charge distribution. Therefore, the capacitors will charge again but, because the voltage on C_2 is higher than the voltage on C_1 at the start, C_2 will charge to the peak point voltage of Q_2, before C_1 can charge to the peak point voltage of Q_1. The emitter-base impedance of Q_2 drops to a low value, and C_2 discharges through this impedance and R_6. Similarly, C_1 discharges through D_1 and D_4, the emitter-base impedance of Q_2, and R_6. At the termination of pulse B the larger voltage will be on capacitor C_1 and the cycle repeats.

The frequency of the triggering pulses is controlled by varying the base-to-base voltages of the unijunction transistors. This is accomplished by varying the impedance of Q_3 in parallel with R_9 of voltage divider R_8-R_9 across the zener-regulated input voltage.

Increasing the control voltage at point C to a higher level than the voltage of the zener reference diode D_5 causes a base current to flow in Q_4 and a proportionately larger base current to flow in Q_3 ($I_{b3} = I_{c4} = \beta_4 I_{b4}$). Higher base current in Q_3 makes it equivalent to a low impedance in parallel with R_9; the voltage across R_8 increases, and the base-to-base voltage of the unijunction transistors increases, reducing the trigger frequency.

After the switch is closed, it may be required that the first generated pulse appear consistently at point A. In thise case, select unijunction transistors so that the peak point voltage of Q_1 is lower than that of Q_2 or provide a slight asymmetry in the oscillator circuits by making $R_1 < R_2$.

Using the component values shown in the circuit diagram, an output frequency controllable from 650 to 900 cps was achieved. This circuit was used in a converter where the output voltage (75 volts) was connected to point C of the trigger circuit. A closed-loop frequency control of ±0.75% was obtained with ±10% changes in the converter input voltage, and a 5:1 change in load.

Simple voltage regulator limits load current

By G.H.P. Kohnke
Rijksuniversiteit, Groningen, Netherlands

A voltage-regulated, current-limited power supply was needed to charge a nickel-cadmium battery.

A simple solution was obtained by driving the commonly used pnp series regulator transistor from a differential amplifier consisting of npn transistors. In the circuit diagram shown below, when the output terminal A-B is short-circuited, transistor Q_1 is cut off since I_{b1} is zero. Therefore, I_{e1} is zero and the voltage across R_1 as determined by the reference voltage is

$$V_{ref} \cong I_{e2} R_1$$

(neglecting the base-emitter voltage of Q_2). The maximum output current can then be determined from $I_{o\,max} = \beta_3 I_{e2}$ or

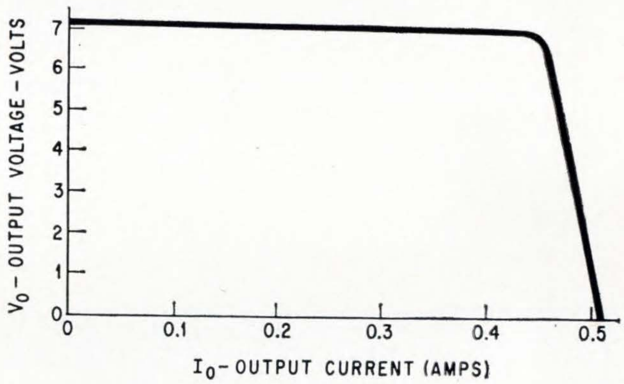
$$I_{o\,max} \cong \beta_3 \frac{V_{ref}}{R_1}$$

The value of the maximum output current is determined by R_1 and its value can be selected accordingly. If the load R_L is some value other than zero (short circuit), this current-limit condition will be valid as long as $V_o \leqq V_{ref}$.

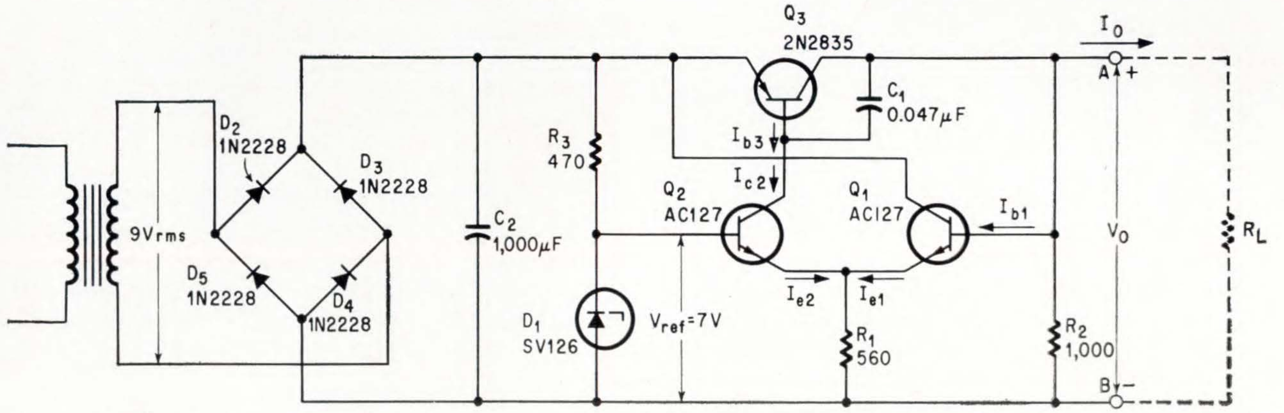
As soon as V_o is greater than V_{ref}, Q_1 starts conducting. A small increase in V_o causes a larger increase in the emitter current of Q_1 because $I_{e1} = \beta_1 I_{b1}$. Since the voltage across R_1 is constant, I_{e2} decreases by the same amount that I_{e1} increases. This causes I_o to decrease, $I_o \cong \beta_3 I_{e2}$, and the output voltage decreases. The output voltage is regulated for any load current in the region

$$I_{o\,max} \geqq I_o \geqq 0$$

R_2 prevents the open-circuit voltage from rising



V-I characteristic for the voltage-regulated, current-limited power supply



The maximum output current can be adjusted by the value of R_1 since $I_{o\,max} \cong \beta_3 V_{ref}/R_1$.

above the reference voltage due to the leakage currents of Q_2 and Q_3. Capacitor C_1 suppresses spurious oscillations.

The output resistance for the constant-voltage region can be calculated from the following expression, $R_0 \cong 2r_i/\beta_1\beta_3$, where r_i is the incremental base-emitter resistance of Q_1.

In the current-limit region the output resistance is determined only by the incremental collector-emitter resistance of Q_3.

During the short circuit condition, all the delivered power (approximately 4.5 watts) is dissipated in Q_3. The output voltage-current characteristics for the regulator are shown in the graph (p. 63).

D-c voltage converter needs no transformer

By Alfred J. Durocher

General Instrument Corp., Rectifier Division, Newark, N.J.

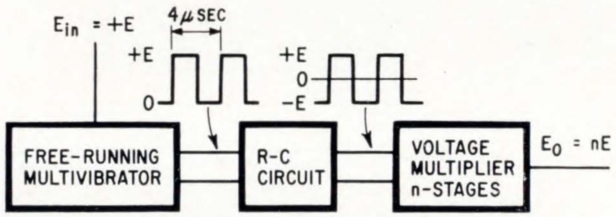
The d-c to d-c voltage converter shown in the block diagram, below, was constructed without a transformer. It consists of a free-running multivibrator, a resistance-capacitance coupling circuit with a time constant larger than the period of multivibrator frequency, and a standard diode-capacitor voltage multiplier.

The multivibrator generates unidirectional square waves whose frequency depends on the multivibrator component values and whose amplitude is approximately equal to the d-c input voltage. The multivibrator output is coupled to the voltage multiplier through an r-c circuit which blocks the d-c or average component E/2, of the unidirectional square wave, but passes alternating square waves with peak values of +E/2 and −E/2. The alternating voltage is necessary for a voltage multiplier to function as such.

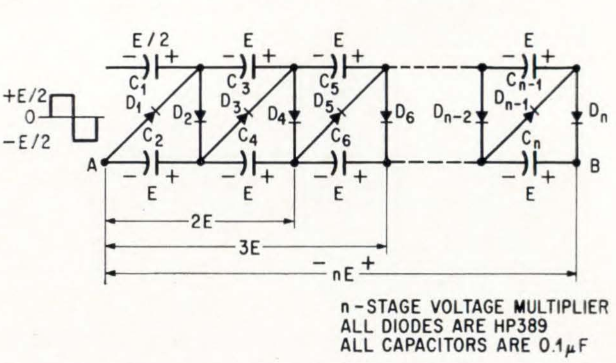
By reversing the diode connections in the voltage multiplier, the voltage polarity at the output can be reversed.

The converter can be connected in several alternate ways. The simplest converter consists of a voltage multiplier that is connected to one side of the multivibrator. Voltage multipliers can also be connected to both sides of the multivibrator. In this case, the multipliers can be connected in parallel, if higher load current must be obtained, or in series if higher output voltage is required. In the series configuration, one multiplier must have a positive voltage at its output, and the other, a negative polarity. The load must be isolated from ground.

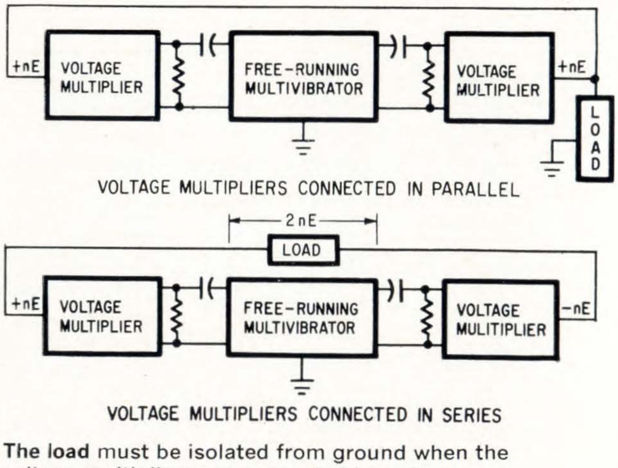
The converter (top p. 65) was tested with a 14-stage multiplier on both sides of the multivibrator connected first in parallel, and then in series. In both cases the output power was approximately 10 milliwatts at about 1% efficiency. The output voltage with the multipliers connected in series was about 120 volts, and the output voltage in the parallel mode was about 60 volts. The efficiency decreases for output voltages above or below these values. The frequency of the multivibrator was 250 kc. This high frequency was selected to mini-



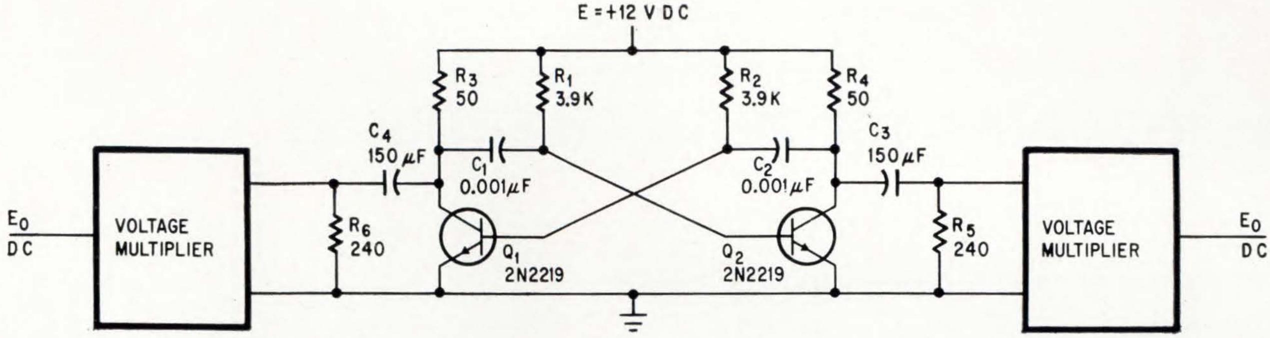
Transformerless d-c to d-c voltage converter is made up of a free-running multivibrator, an r-c circuit which blocks the average value of the unidirectional pulse, and a standard diode-capacitor voltage multiplier.



The output of the voltage multiplier is taken between points A and B as shown in the circuit diagram above. The polarity of the output voltage can be reversed by reversing the direction of the diodes.



The load must be isolated from ground when the voltage multipliers are connected in series.



Voltage multipliers can be connected to both outputs of the multivibrator.

mize the need for filtering the output voltage and to reduce the size of the components used.

Efficiency could be improved by using fast recovery diodes to lessen switching power losses, selecting multiplier capacitors with low power loss at high frequencies, and by proper impedance-matching between multivibrator output and the load and multiplier circuits.

Transistor becomes sensor in temperature regulator

By Sherwin Greenblatt,

Research Laboratory of Electronics,
Massachusetts Institute of Technology, Cambridge

A simple temperature-control circuit was constructed by taking advantage of the predictable variation of transistor parameters with temperature. In the temperature-control circuit shown, Q_1 is the temperature sensor. The collector current of Q_1 varies with temperature when the base-emitter voltage is constant. The base-emitter voltage of Q_1 is maintained constant by voltage divider R_1-R_2-R_3 placed across a zener reference diode D_1.

The output transistor Q_3, can provide 10 watts of power to the 50-ohm heater from a 24-volt power supply without loading the sensor transistor Q_1. The series base-emitter junctions of Q_2 and Q_3 provide a convenient, low-dissipation operating point for Q_1.

With a fixed base-emitter bias on Q_1, the collector current increases as the oven temperature increases. This causes a decrease in the collector-emitter voltage of Q_1, which then reduces the collector current in Q_3. The lower collector current means that less heat is dissipated in the combination of the 50-ohm heater and Q_3, and the oven temperature drops toward the set temperature. The set-point can be lowered by adjusting R_2 to increase the base-emitter voltage of Q_1.

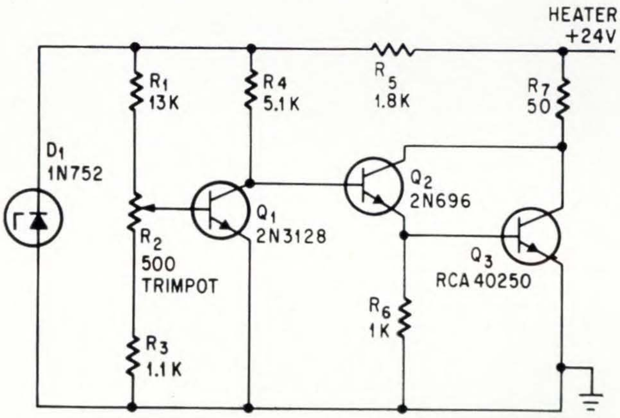
The 2N3128 sensor is a silicon microtransistor that is placed in thermal contact with the element to be temperature controlled (in this circuit, a 50-ohm heater R_7.) The small size of the transistor (0.05 × 0.05 × 0.035 inch) insures that the thermal lag caused by the thermal time constant of the transistor case and junction is minimal. Its small size also allows for easy mounting with a spot of epoxy cement. Maximum temperature is 150°C.

The circuit was mounted in an oven cavity to maintain the temperature in a small crystal oven at 70°C. The oven temperature varied by less than 0.2°C with moderate variation (approximately 10°C.) in ambient temperature. The controller is 100% efficient, since any heat dissipated by the circuit components is contained within the oven.

With the controller circuit mounted in the oven, the maximum oven temperature is limited by the junction temperature rise in the output transistor Q_3. For higher oven temperatures, Q_3 should be mounted on a heat sink to insure that its junction temperature does not rise significantly above the oven temperature, exceeding its maximum rating.

Acknowledgment

Development supported by U.S. Navy, Army, Air Force, National Science Foundation, National Institute of Health, and NASA.



In the temperature controller, Q_1 is the temperature-sensing element in tight thermal contact with the heater, R_7. The temperature set-point is adjusted by R_2.

Microwaves for remote sensing

Radiometry at microwave frequencies may replace infrared detectors in aerospace navigation

By E.O. Frye

Collins Radio Co. Cedar Rapids, Iowa

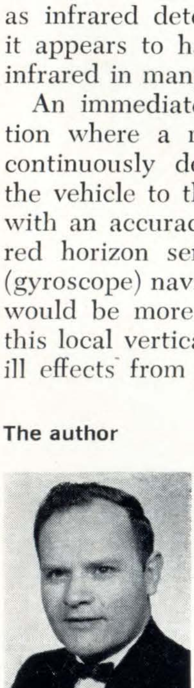
All materials above absolute zero temperature radiate microwave frequencies in amounts that depend on their temperature and emissivity. Emissivity is the power per unit area radiated by an object compared to that radiated by an ideal black body. With suitable receivers, this microwave radiation can be detected and the measurements used to obtain information about the radiating object's temperature, nature, and location, relative to the receiver.

More succinctly, microwave radiometry is the art of measuring the electromagnetic power radiated toward an observer by some target or area. It is a passive technique for sensing certain characteristics of the environment surrounding a location or vehicle.

Microwave radiometry has not been used as much as infrared detection and measurement; however, it appears to have some distinct advantages over infrared in many practical applications.

An immediate example is in aerospace navigation where a microwave radiometry system can continuously determine the vertical line joining the vehicle to the gravitational center of the earth with an accuracy much greater than that of infrared horizon sensors. Compared with an inertial (gyroscope) navigation system, a microwave system would be more economical, and able to generate this local vertical bearing much faster without any ill effects from the vehicle's accelerations.

The author



E. O. Frye has specialized in air and space navigation equipment, including doppler radar, aircraft collision-avoidance and identification equipment. His present work involves aerospace navigation studies and studies of microwave radiometry as applied to atmospheric sensing and research problems.

In detecting radiation from a surface, such as the earth or the lunar surface, the microwave sensor would be much less affected by small surface irregularities than an infrared or visible-light system, and again give more accurate readings.

A highly accurate aerospace navigation system has been proposed, combining an optical star-tracker with a microwave vertical-line determining subsystem.

Another useful possibility for the microwave radiometer is the measurement of temperature of remote bodies, surfaces and parts of the atmosphere. Work has been done in this direction at the Collins Radio Co. and an experimental radiometer operating at 5.5 millimeters has been built.

Basic theory

The amount of microwave power radiated by a material depends on its temperature and emissivity. The thermal power emitted by a perfect black body (one having an emissivity of unity) is shown at right.

Any power impinging upon such a body will be perfectly absorbed, will raise the temperature of the body, and be reradiated in accordance with the graph. If the body has finite reflectivity, it will reflect a fraction of the incident power determined by its reflectivity. The sum of the emissivity and reflectivity for an opaque body is always unity.

It is convenient to think of the radiometric power received by an antenna in terms of temperature rather than received power. The antenna temperature is defined as the temperature of a resistive termination, replacing the antenna, that would yield the same input power. For wavelengths over one centimeter

$$T_a = \frac{P_r}{K \Delta f}, \qquad (1)$$

where T_a is antenna temperature in degrees Kelvin, P_r is received power in watts, K is Boltzmann's constant, 1.38×10^{-23} joules/°K, and Δf is the receiving bandwidth in cycles per second.

For semitransparent materials, the radiated power is a function of the electromagnetic losses of the material and of the thermal temperature associated with these losses. In the absence of internal reflections, the radiometric temperature of a portion of material is equal to the product of the fractions of received power that is dissipated in it (loss fraction) and its absolute thermal temperature. However, the radiometric temperature of this portion, as seen by a remotely located antenna, will be modified by the temperature and losses of the intervening material.

The antenna temperature T_a, measured when an antenna looks into a lossy medium of infinite extent, is

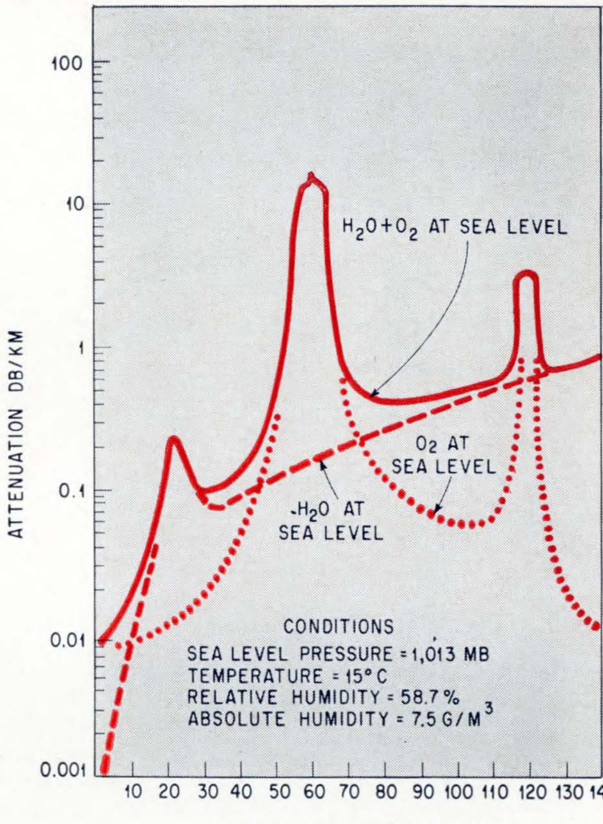
$$T_A = {}_0\int^{\infty} a_r T_r \exp\left(-{}_0\int^{r} a_r dr\right) dr \qquad (2)$$

where a_r is the emissivity (or losses) at range r, and T_r the thermal temperature of the medium at range r.

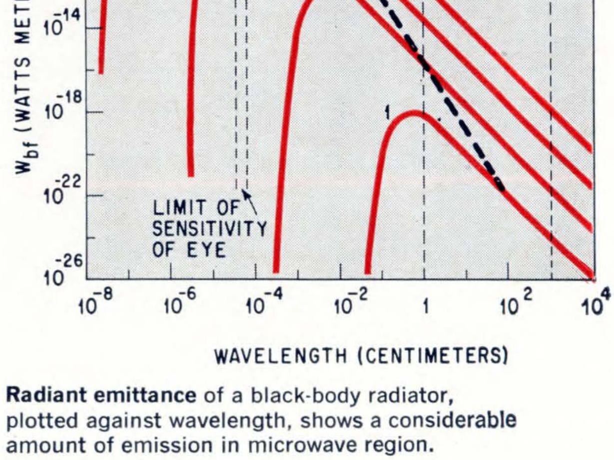
If the lossy medium in question is the atmosphere, losses in the microwave region are due, in large measure, to water vapor and oxygen molecules. Emissivity, then, is a function of temperature, pressure, relative humidity and the wavelength of the observation.

Although the functional relationships governing the emissivity of the atmosphere are extremely complex, it is possible to gain some information regarding the distribution of the temperature if the other three parameters are known.

Curves showing typical atmospheric attenuation as a function of frequency are given above, right. The peaks in the atmospheric losses at f = 23.5 Gc and f = 60 Gc are due to molecular resonances in the water-vapor and oxygen molecules respectively. These characteristics govern the behavior of microwave radiometers operating in the atmosphere, and point the way to applications based on the measurement of radiometric temperatures.



The combined attenuation due to water vapor and oxygen in the earth's atmosphere, calculated from theory, show peaks that determine the radiometer frequencies to be used for specific atmospheric uses, right.

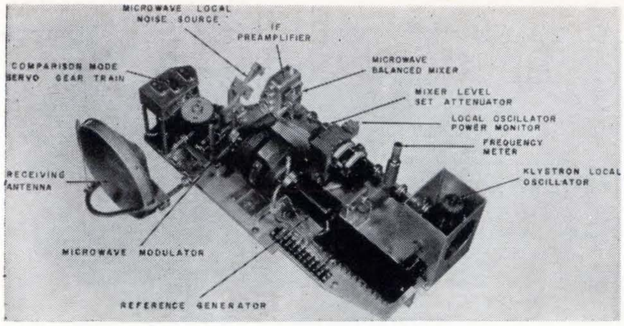


Radiant emittance of a black-body radiator, plotted against wavelength, shows a considerable amount of emission in microwave region.

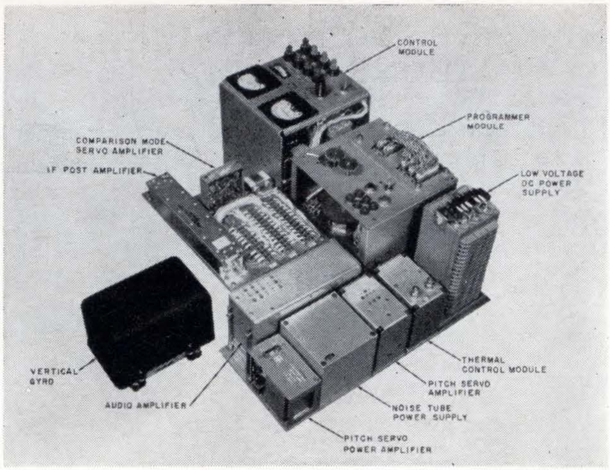
Radiometric receivers

The output of a radio receiver can be considered to be made up of two components, one due to the power collected by the antenna, and the other due to the noise power developed inside the receiver. A radiometer receiver is designed to separate these two components, and to present a measure of the power introduced by the antenna. It should be noted that in radiometer service, receiver noise is often far larger than the desired signal. The receiver can be a superheterodyne, tuned radio-frequency or crystal video type.

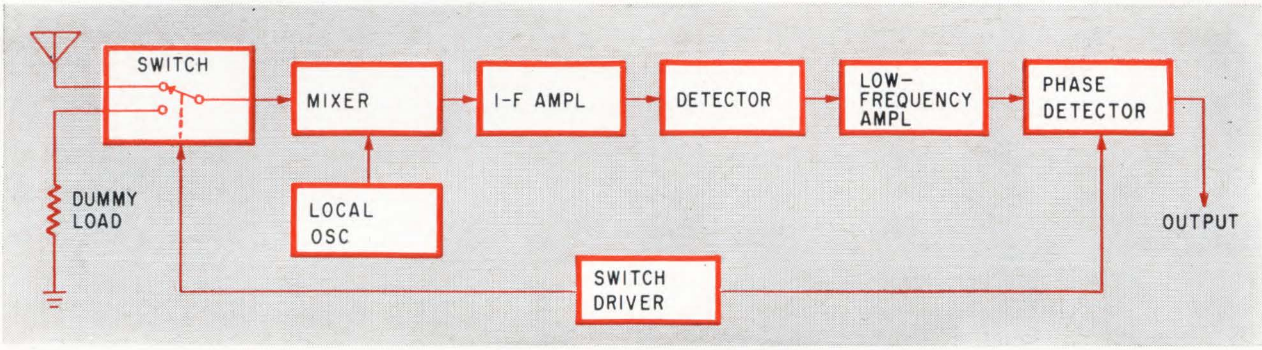
A block diagram of the popular Dicke-type radiometer using a superheterodyne receiver is shown on page 68. In this radiometer, the receiver input is alternately switched between the antenna and a temperature-controlled dummy load; the power level at the second detector thus alternates between that associated with the dummy load (receiver inherent noise plus power due to the temperature of this load) and that due to the power collected by the antenna plus the receiver's inherent noise power. This detected signal is amplified and phase-



A 5.5 millimeter research radiometry receiver, used for atmospheric studies, has a six-inch antenna reflector, at lower left. Only radio-frequency portions are shown here.



Power supply and control sections of the experimental 5.5-mm receiver



Typical Dicke radiometer switches constantly back and forth between its antenna and a temperature-controlled dummy load; this permits accurate measurement of the antenna temperature.

detected against a signal representing the switch position. The phase-detector output is then a varying d-c voltage, proportional to the difference between the power contributed by the dummy load and that collected by the antenna. It is often considered to be a measure of antenna temperature through the relationship of equation 1.

The temperature sensitivity of a radiometer is defined as the minimum detectable antenna temperature increment, δT, and is determined from

$$\delta T = K \frac{T_a + T_r}{\sqrt{B\tau}} \qquad (3)$$

where K is a constant depending upon the signal-processing technique, T_a the antenna temperature in degrees Kelvin, T_r the receiver excess noise temperature in degrees Kelvin, B the receiver predetection bandwidth in cps, and τ the receiver postdetection averaging time in seconds.

The r-f portions of the research radiometer operating at wavelengths around 5.5 mm, used in ground and airborne atmospheric oxygen emission studies, are shown at top, left. The parabolic reflector for the antenna shown is six inches in diameter. The power supply and control portions of this radiometer are shown above, top right.

Vertical sensing

Radiometric vertical sensing is based on the determination of the direction of the axis through an observer around which the space-averaged atmospheric oxygen temperature and pressure distributions appear constant.

The upper figure, page 69, is a qualitative model of the earth's atmosphere. Consider that an observer is placed at point 0 and a radiometer, operating at approximately 60 Gc, is pointed successively in various directions around the observer. The lengths of the arrows shown in these directions are qualitative indications of the "radio depth" of the atmosphere, which can be defined as the path length along which 99% of the emission occurs. As the elevation angle increases, the antenna beam encounters fewer oxygen molecules and these are at colder temperatures; the beam, therefore, penetrates further, and the antenna temperature decreases.

The antenna temperatures are plotted as a function of antenna elevation angle for a typical model atmosphere, center of page 69.

Assuming that the oxygen in the earth's atmosphere is spherically stratified due to the earth's gravity, then the apparent direction of the local true gravity vector can be determined by sensing the direction of the antenna scan axis which gives a constant radiometric temperature output as the antenna is scanned in azimuth.

Computations performed at Collins, based on this assumption, indicate that the direction of the local gravity vertical can be determined to an accuracy measured in minutes of arc for ground-based equipment in good weather. In high-altitude applications the accuracy is considerably higher.

Because of the effects of weather, the assumption of spherical stratification of the atmospheric oxygen is not strictly correct, and both the atmospheric water-vapor and condensed-water distributions are by no means homogeneous. Theoretically, disturbances due to water-vapor effects will not seriously affect the accuracy of a well-designed system, at the higher altitudes, providing a suitable operating frequency is selected, but this has yet to be confirmed by physical observations. Present knowledge indicates that the atmosphere can support more accurate vertical determination at selected microwave frequencies than in the infrared region.

Aeronautical uses

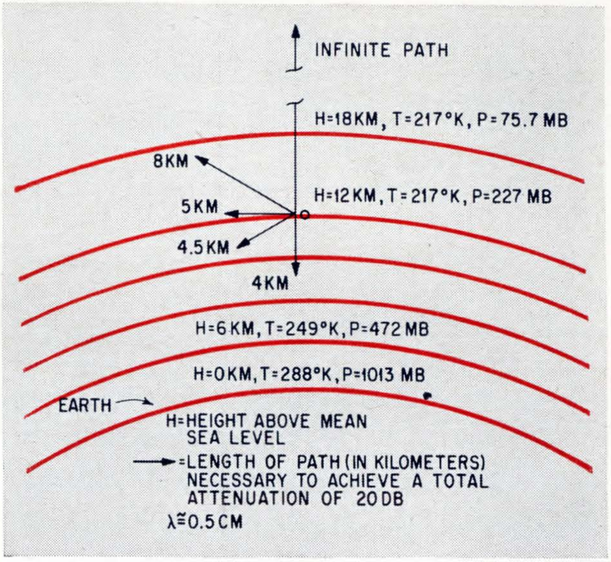
Applications of radiometric vertical sensing in the field of aeronautics include vehicle attitude-sensing and determination of the local vertical for navigation by celestial observations. Because celestial observations are usually possible for aircraft operating at or above the altitudes used by present-day jet aircraft, accurate vertical determination looks attractive for new navigation systems combining radiometric vertical with optical star-tracker data. The accuracy of such navigation systems in determining the local vertical (and hence the overall navigation accuracy) would be substantially independent of vehicle accelerations. Finally, the device could act as a vehicle-attitude reference while the vehicle is climbing to the operational altitude required for the coming generation of supersonic aircraft.

A block diagram of a radiometric vertical-optical star tracker navigation system is shown on page 70. An advantage of such a system over one based on inertial vertical reference is that in the radiometric case, platform-leveling can be accomplished in a few minutes without external-velocity or vertical-direction information. Furthermore, at least in the present state of the art, the radiometric platform may cost less to build and maintain than a comparable inertial platform.

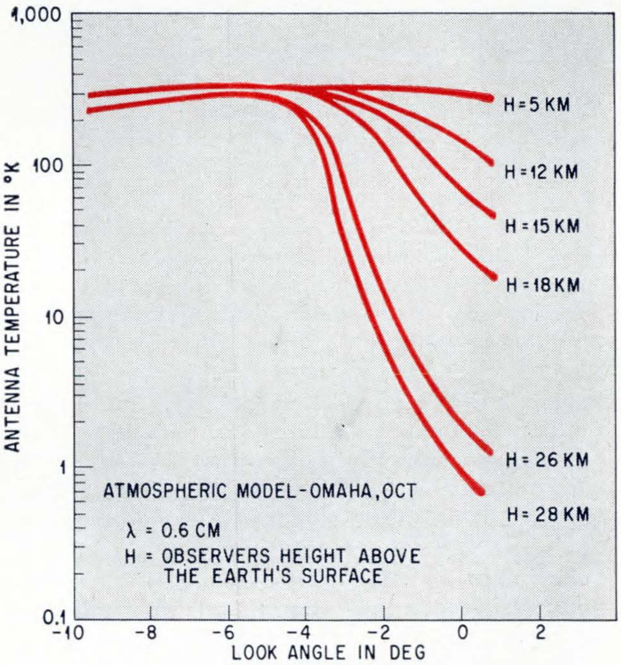
Space uses

A prime need for cislunar space missions is the precise orientation of the line joining the space vehicle with the center of mass of the earth, the moon or the sun. This information is necessary for terminal guidance, position-fixing and vehicle orientation under way or during the terminal phase.

Although devices operating in or near the optical wavelengths can be used, microwave radiometry is more accurate for measuring radiation under irregular surface conditions. For example, by using wavelengths which emanate from beneath the moon's surface at depths where thermal temperature fluctuates very little, the moon can be made to appear nearly uniformly bright regardless of its phase. This, of course, leads to improved ac-



Earth's atmosphere is considered as spherically stratified in this diagram. It is the stratification that permits a radiometer to make accurate vertical-line determinations.

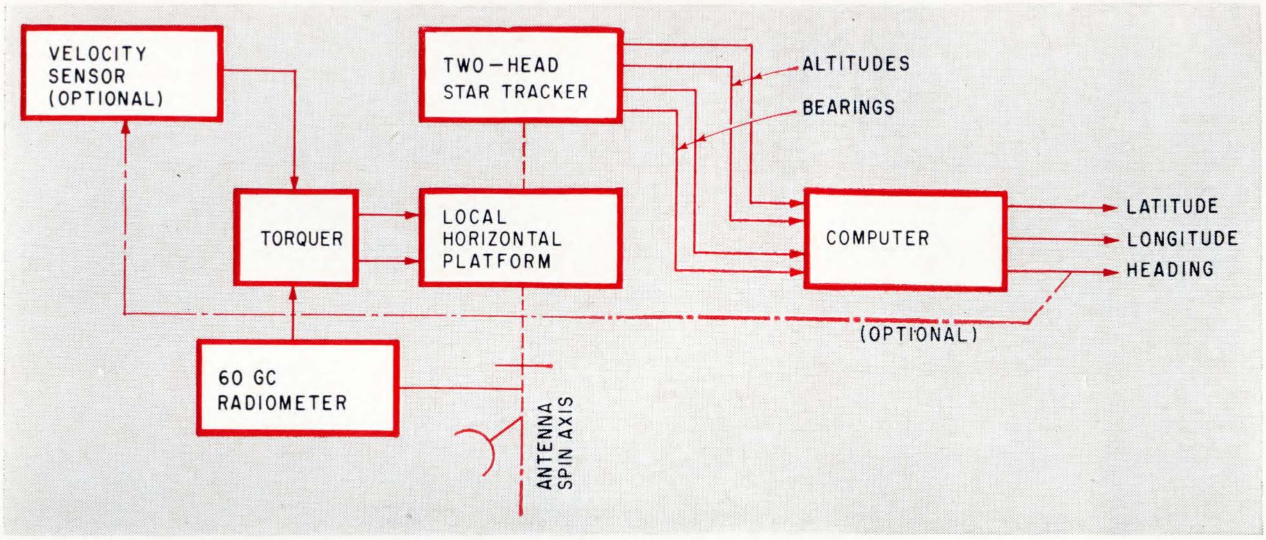


As the antenna height is increased, the radiometric temperature gradient becomes steeper and attitude determination is thus easier. This is shown in a plot of antenna temperature against its look angle for various heights in the model atmosphere.

OPERATING WAVELENGTHS FOR CISLUNAR* RADIOMETRIC SYSTEM

	MOON	EARTH	SUN
DESIRED WAVELENGTH	> 0.5 CM	0.5-0.6 CM	< 4 CM
CAUSE OF LIMITATION	PHASE VARIATIONS	ATMOS TRANSPARENCY	SOLAR DYNAMIC ACTIVITY
ACCURACY (MIN ARC)	2	1-5	< 2
MAJOR ERROR SOURCE	PHASE	DIURNAL	SOLAR DYNAMIC ACTIVITY

* The near side of the moon



An accurate aerospace navigation system can be built, combining a vertical-line microwave sensor with an optical star-tracker. The results would be integrated by computer to yield latitude, longitude and heading of vehicle.

curacy in the sensing of its center of mass.

In the case of the earth, there are daily changes in brightness, as well as significant optical brightness variations over the surface of the earth. Here, the solution is to use wavelengths which do not penetrate the spherically stratified portions of the atmosphere; hence the rather uniform brightness of the oxygen in the atmosphere would be sensed rather than the quite uneven brightness of the earth surface. Operating frequencies near the 0.5-cm oxygen resonance are ideal for this.

In the case of sun tracking, the sun's radiometric center does not necessarily coincide with its optical center and, in general, the correlation worsens as wavelength increases. Therefore, the shorter wavelengths are more suitable for sun tracking.

These considerations are summarized in the table on page 69, which indicates the desired wavelengths and resulting accuracies of equipment designed for vertical sensing in cislunar missions.

The uses of microwave radiometry to provide selective temperature sensing are exemplified by the recent Mariner 2 Venus probe, which carried 1.35-cm and 1.9-cm radiometers. The 1.35-cm water-vapor line radiometer was used primarily for estimating the atmospheric water-vapor content of Venus, while the longer wavelength radiometer was designed to penetrate the Venusian atmosphere and measure the surface temperature of the planet.

Applications in aerospace

Perhaps the most intriguing possibilities for future application of microwave radiometry to aerospace problems lie in the field of remote temperature measurement. Since it is possible to learn a good deal about the temperature of opaque objects viewed through a nearly transparent propagating medium, or even to deduce the temperature distribution of a lossy medium around an observer, it should be possible to determine the thermal temperature of the atmosphere ahead of a vehicle. Such informatiton would be of considerable interest to meteorologists and flight personnel, especially since a growing body of evidence indicates that clear-air turbulence [Electronics, Feb. 7, p. 33] is associated with areas of substantial horizontal temperature gradients. If this is the case, microwave radiometry may be able to detect these gradients in time to permit action to be taken in preparation for the turbulence.

A specific application well within the current state of the art lies in the measurement of airport runway temperatures. If a directional beam is pointed down a runway, and if the operating frequency is chosen to permit the beam to penetrate the atmosphere for one to two kilometers, then the antenna temperature will consist of a weighted mean of the thermal temperature of air encompassed by the antenna beam. This will be the thermal temperature of the air in which aircraft will be immersed during takeoff, hence it is precisely that temperature which is needed to predict takeoff performance. Use of this technique would eliminate the common error sources experienced with current runway temperature measurement practices using conventional thermometers.

While many of these uses for microwave radiometry in aerospace appear theoretically feasible, quantitative characteristics remain to be determined by actual experiment.

Because the current state of the art will support basic radiometric equipment capable of the accuracy and data acquisition rates necessary for the applications discussed, the design of the necessary hardware is not likely to present a serious problem.

Acknowledgment

The Collins Radio Co. acknowledges the role of the Flight Dynamics Laboratory, Research and Technology division, Wright-Patterson Air Force Base, Ohio, in supporting much of the work on oxygen-line radiometry and radiometric vertical sensing reported here.

One circuit: phase modulation, frequency multiplication

Simplified technique uses varactor multipliers to increase phase deviation with improved linearity

By David O. Fairley

Lenkurt Electric Co., San Carlos, Calif., subsidiary of General Telephone & Electronics Corp.

Most microwave systems require a separate circuit for phase modulation and frequency multiplication. Now a new simple technique combines both functions in a single circuit, simplifying design, increasing flexibility and improving performance.

One big improvement is in linearity. Combining phase modulation and frequency multiplication in one circuit produces greater frequency deviation for the same linearity as a conventional phase modulator, but with fewer components.

The core of the system is a varactor frequency multiplier that is phase modulated by variations in its bias voltage.

A varactor is a semiconductor diode in which the capacitance of the pn junction varies in a nonlinear way with the magnitude of its reverse bias voltage between zero bias and breakdown.

Because of the simplicity of the circuit, every varactor in the multiplier chain becomes a potential modulator. This means that separate multipliers can be modulated by individual signals to produce a single multiplexed output. The new circuit, called a parametric-multiplier-modulator (pmm) achieves this performance with hardly any increase in circuit cost or complexity.

Easier to achieve

Phase modulation (p-m) is a form of frequency modulation (f-m), but it is much easier to achieve than true f-m. An ordinary phase modulator gets its carrier frequency from a stable crystal oscillator. The phase is then shifted by varying some element of a tuned circuit in accordance with a modulating signal. In contrast, frequency moulation takes place in the master oscillator. Since the frequency of the oscillator is constantly changing, it is unstable and requires more circuitry to keep the average frequency of the output around the carrier.

True f-m can be generated from p-m in two ways. The first is to integrate the modulation signal before it is fed to the modulator. The second is to attenuate the output of the phase modulator at the rate of 6 decibels per octave across the audio range.

However, true f-m is seldom desired; f-m with preemphasis is almost always used to reduce system noise. Since most of the audio-frequency energy is in the low-frequencies, the medium and high frequencies are subject to more noise at the transmitter. Preemphasis before transmission reinforces the medium- and high-frequency components that have a lower energy; these are attenuated at the receiver for a flat response.

Simple correction network

The need for preemphasis is another reason that p-m is preferred over f-m. For example, preemphasis for f-m mobile service is 6 db per octave. In this case, f-m with preemphasis and p-m exhibit equal characteristics. The Federal Communications Commission requires preemphasis steeper than 6 db per octave for commercial f-m broadcasting, but the p-m signal requires a simpler correction network than a true f-m signal.

The maximum allowable phase shift in a phase

The author

This is David O. Fairley's second article for Electronics, his first, "Designing Solid State Microwave Generators", appeared in the Oct. 11, 1963, issue. He received his master's degree from the University of Southern California in 1960, and has been in the microwave development section of Lenkurt since 1961.

Evaluating the pmm

Evaluation of the circuit, compared with conventional phase modulators, quantitatively shows the improvement in modulation.

The circuit may be represented by the linearized equivalent circuit shown on page 74, where element values [3] for an optimum efficiency doubler using a reverse-biased square law varactor are:

$$C_o = C(V_o) = C(0.349\ V_b), \qquad (1)$$

where V_b is the reverse-bias breakdown voltage of the varactor and is much larger than the contact potential;

$$R_1 = \frac{0.08}{\omega_o C_{min}} \qquad (2)$$

where C_{min} is the capacitance at V_b; and,

$$R_2 = \frac{0.136}{\omega_o C_{min}} \qquad (3)$$

The primary and secondary inductances of the equivalent circuit resonate with C_o at the input and output frequencies, respectively. The capacitance C_T is identical for primary and secondary circuits and consists of two terms, C_o, the average value, and C(t), the capacitance resulting from the modulation voltage. The capacitance variation due to input frequency is contained in the equivalent generator e_2.

The three sources of phase deviation that appear at the output of the equivalent circuit are: the shift due to modulation in the primary circuit, ϕ_1; the doubler action of the second harmonic voltage generator, e_2, which doubles ϕ_1; and the shift due to the modulation in the secondary, ϕ_2. The separate phase deviations will add numerically such that

$$\phi_{total} = 2\phi_1 + \phi_2. \qquad (4)$$

Except for the variational capacitance, the circuit is at resonance and

$$L_1 = 1/\omega_o^2 C_o \qquad (5)$$

$$L_2 = 1/4\omega_o^2 C_o. \qquad (6)$$

For matched conditions at the input,

$$R_g' = R_1 \qquad (7)$$

the phase deviation of the primary circuit may be calculated as follows:

$$\phi_1 = \tan^{-1} \frac{X_1}{2R_1} = \tan^{-1}\left[\frac{1}{2R_1}\left(\frac{1}{\omega_o C_T} - \omega_o L_1\right)\right] \qquad (8)$$

assuming $\tan^{-1} X = X$ and using (5) and (2):

$$\phi_1 = \frac{C_{min}(C_o - C_T)}{(0.16)\ C_o C_T} \qquad (9)$$

In a similar way, the phase deviation of the second harmonic current will be:

$$\phi_2 = \frac{C_{min}(C_o - C_T)}{(0.272)\ C_o C_T} \qquad (10)$$

By taking the percentage ratio of second harmonic current phase deviation, ϕ_2, to doubled fundamental phase deviation $2\phi_1$, the improvement of the pmm over the conventional modulator of the previous comparison may be found as:

$$\frac{\phi_2}{2\phi_1} = \frac{0.08}{0.272} \times 100 = 29.4\% \qquad (11)$$

The following analysis shows the relationship between phase deviation and capacitive nonlinearity that is found in the pmm process.

For a tone-modulating signal, and neglecting contact potential, the abrupt junction varactor capacitance will be:

$$C = KV^{-1/2} \qquad (12)$$

from this, $$C_o = KV_o^{-1/2} \qquad (13)$$

$$C_T = K[V_o + V(t)]^{-1/2} \qquad (14)$$

$$C_{min} = KV_b^{-1/2} \qquad (15)$$

Using (4) and making the appropriate substitutions, the total instantaneous phase deviation is found to be

$$\phi_{total} = 9.557\left[\frac{[V_o + V(t)]^{1/2}}{V_o^{1/2}} - 1\right] \qquad (16)$$

assuming $V(t) = V_m \cos \omega_m t$ and maximizing (16) an expression is found for ϕ_{max} as:

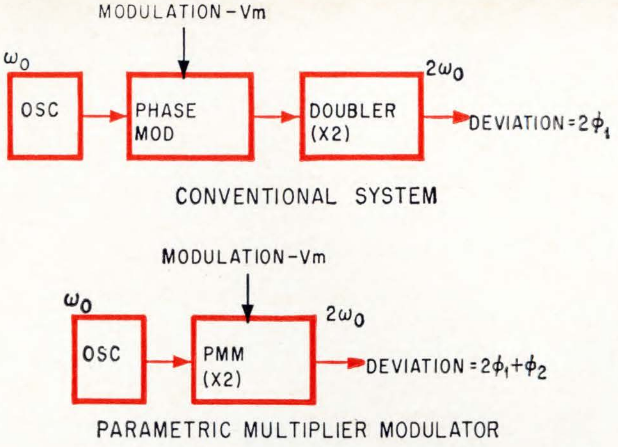
$$\phi_{max} = 9.557\left[\frac{(V_o + V_m)^{1/2}}{V_o^{1/2}} - 1\right] \qquad (17)$$

Equation (17) may be solved for V_m and this substituted into (16) to give a general expression for the phase deviation in terms of a tone modulating signal and the maximum phase shift:

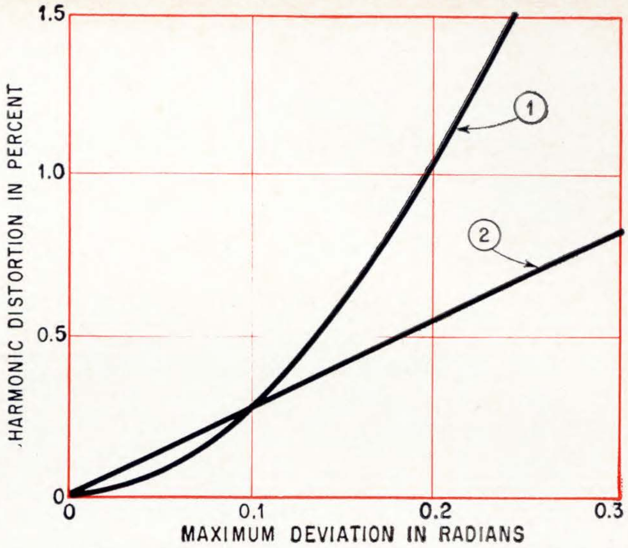
$$\phi_{total} = 9.557\ [(1 + M \cos \omega_m t)^{1/2} - 1] \qquad (18)$$

$$\text{where } M = \left[\left(1 + \frac{\phi_{max}}{9.557}\right)^2 - 1\right]$$

From this relationship a five-point harmonic analysis can be performed for various values of ϕ_{max}. These values are then plotted as $2\phi_1 + \phi_2$ versus distortion in curve 2 on page 73.



Deviation produced by parametric multiplier modulator compared with conventional phase modulators.



(1) third-harmonic distortion for deviation $2\phi_1$ due to normal phase modulation process; **(2) second harmonic** distortion for deviation $2\phi_1 + \phi_2$ in pmm process.

modulator is limited by how much third-harmonic distortion can be tolerated. To produce phase deviation of the magnitude and linearity required in a communications system, modulation is done at a sub-harmonic of the desired carrier frequency. Then frequency multipliers convert this output to the carrier frequency and simultaneously increase the phase deviation by the same factor.

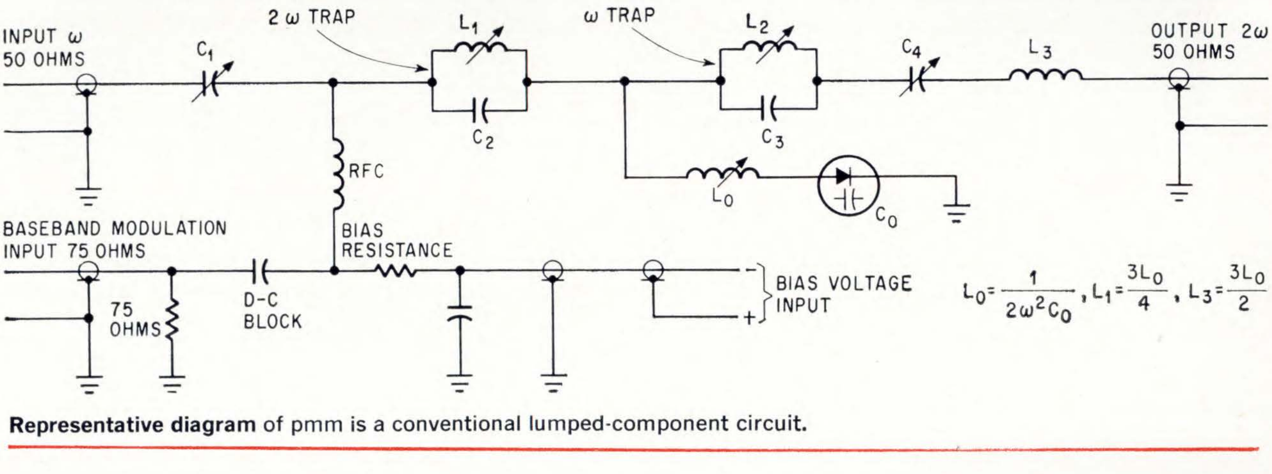
Pmm simplifies phase modulation by combining the circuit functions of the modulator and the multiplier. In addition, the pmm creates substantially less distortion for the same degree of phase deviation than does p-m.

A comparison of a conventional phase modulator with a pmm is shown above at left. In a conventional system, an in-line phase modulator would be followed by a frequency multiplier chain. Assuming that the first multiplier following the phase modulator were a doubler, the phase deviation out of this doubler would be $2\phi_1$—where ϕ_1 is the angle of phase deviation from the modulator.

When the pmm is used, the phase modulation and frequency multiplication both occur in the doubler. The original phase modulation ϕ_1 is produced in the fundamental frequency circuit; this is then impressed upon the nonlinear capacitance of the varactor. This nonlinear capacitance causes frequency multiplication of the modulated carrier due to the harmonic frequency components of the stored charges in the junction. The second harmonic generated in the device is then filtered out, resulting in both doubled frequency and phase deviation. A further deviation takes place in the second-harmonic output current so that the total phase deviation in this case is $2\phi_1 + \phi_2$. The additional deviation, ϕ_2, will be shown in the analysis (see panel, facing page) to be up to 30% of $2\phi_1$.

There are two types of distortion to be considered in the parametric-multiplier-modulator (see graph above). The first is the third harmonic distortion that is inherent in the phase-modulation process (curve 1). The second is the primarily second-harmonic distortion found in the pmm process due to capacitive nonlinearity (curve 2). Pmm's advantage over normal phase deviation is in its substantial increase in deviation without a correspondingly large increase in distortion.

The representative pmm circuit shown on pre-



Representative diagram of pmm is a conventional lumped-component circuit.

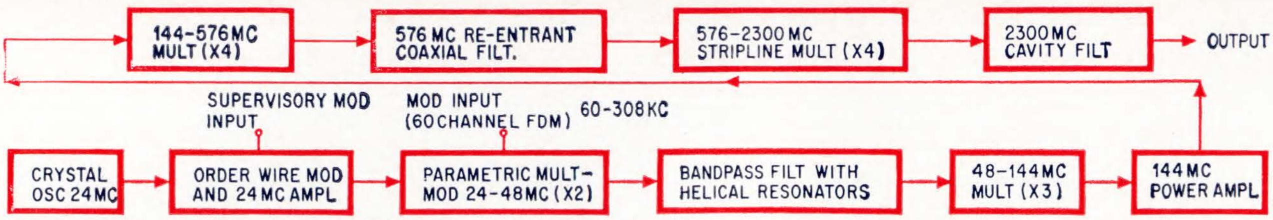
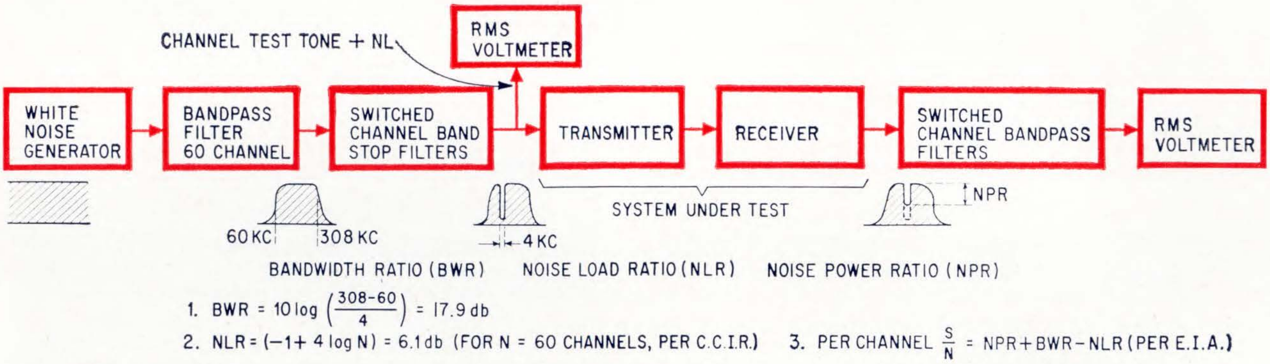
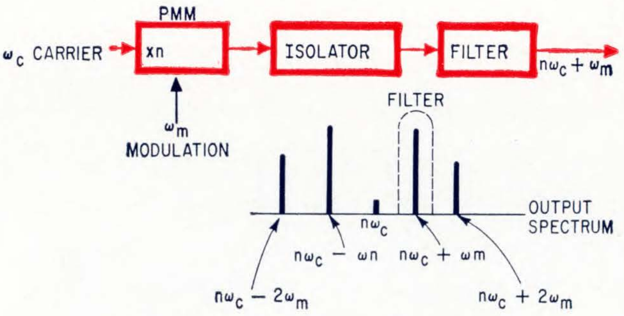


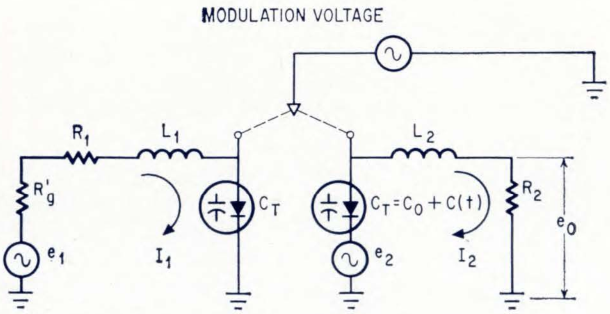
Diagram of a solid-state communications transmitter that uses the pmm for its modulation.



High signal-to-noise-level ratio is achieved in a test of the transmitter.



By impressing a tone onto the pmm, the tone can be added to the carrier in this simple up-converter.



In a linearized equivalent of the pmm, the primary and secondary circuits of the varactor are shown separated for convenience and analysis.

ceding page is a conventional lumped-component circuit, though the pmm technique has been successfully demonstrated with coaxial and waveguide varactor multipliers as well. The circuit is a multiresonant doubler[1] in which the input circuit is resonant through C_o at $2f_{in}$. Input and output traps tuned to $2f_{in}$ and f_{in} respectively, provide isolation between the source and the load. Because the series inductance L_o will attenuate higher harmonics and the traps isolate the input and output, ideal filtering conditions are approached.

A pmm was used in a 2-Gc development model of a frequency-division multiplex communications transmitter that carries 60 voice channels. This solid-state transmitter is shown in the block diagram at the top of this page. The modulator circuit is a doubler configuration with an output at 48 Mc from a crystal-controlled input at 24 Mc. This is followed by varactor multipliers that have a multiplication factor of 48. The transmitter has a per-channel deviation of ±100 Kc rms. The baseband modulation range is 60 to 308 Kc. When the system was noise-loaded across this bandwidth, a minimum per-channel signal to noise (intermodulation plus thermal) ratio of 69 db was measured. Details of the noise-loading test are shown above.

The parametric multiplier-module has other applications besides phase modulation; it can be used in a simple up-converter. The converter, shown above, can be made by modulating the pmm with a tone signal or information subcarrier and then filtering out the first sideband of the resulting spectrum.

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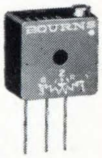
Humidity:	MIL-STD-202B, Meth 106 (cycling)	



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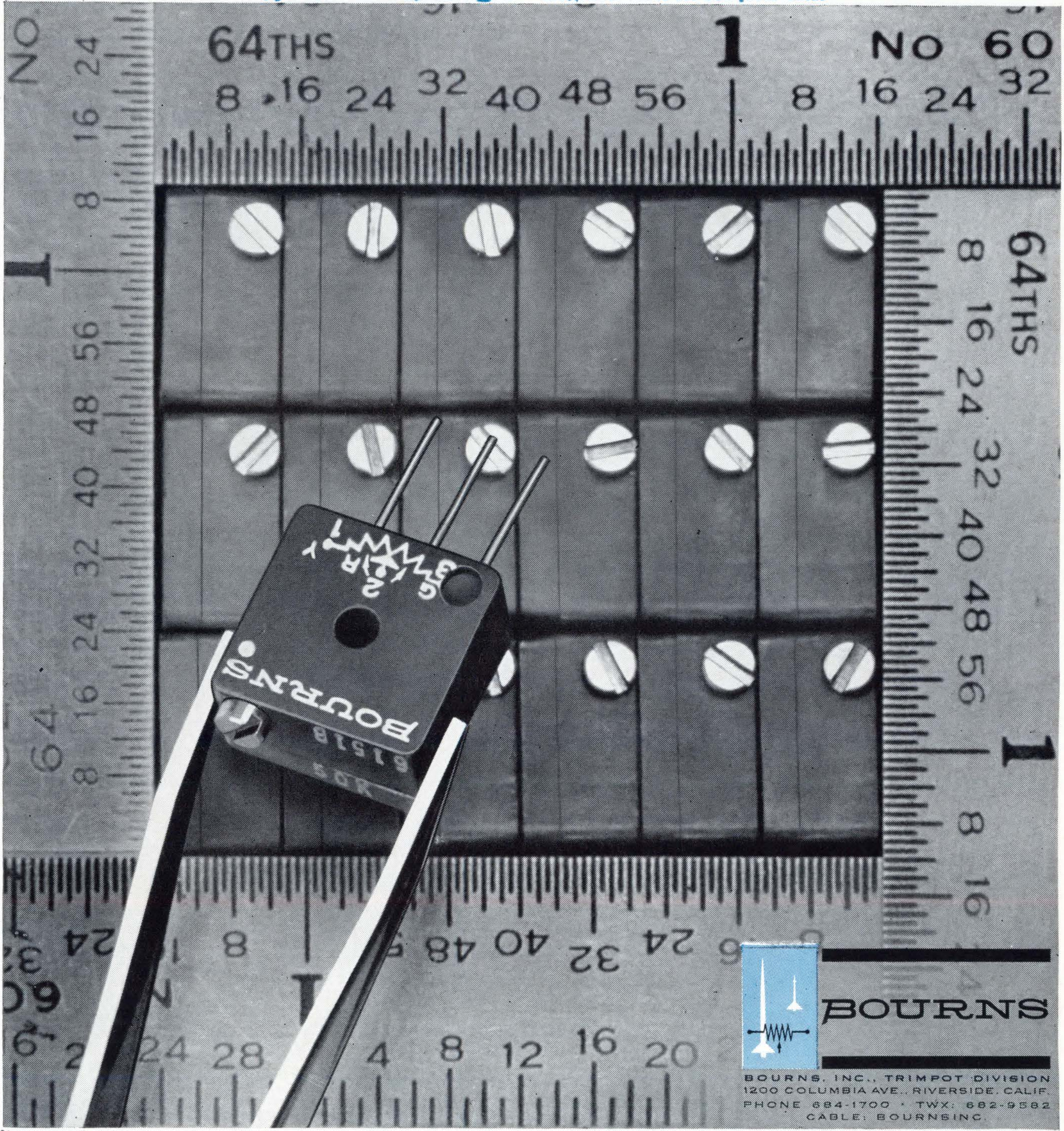

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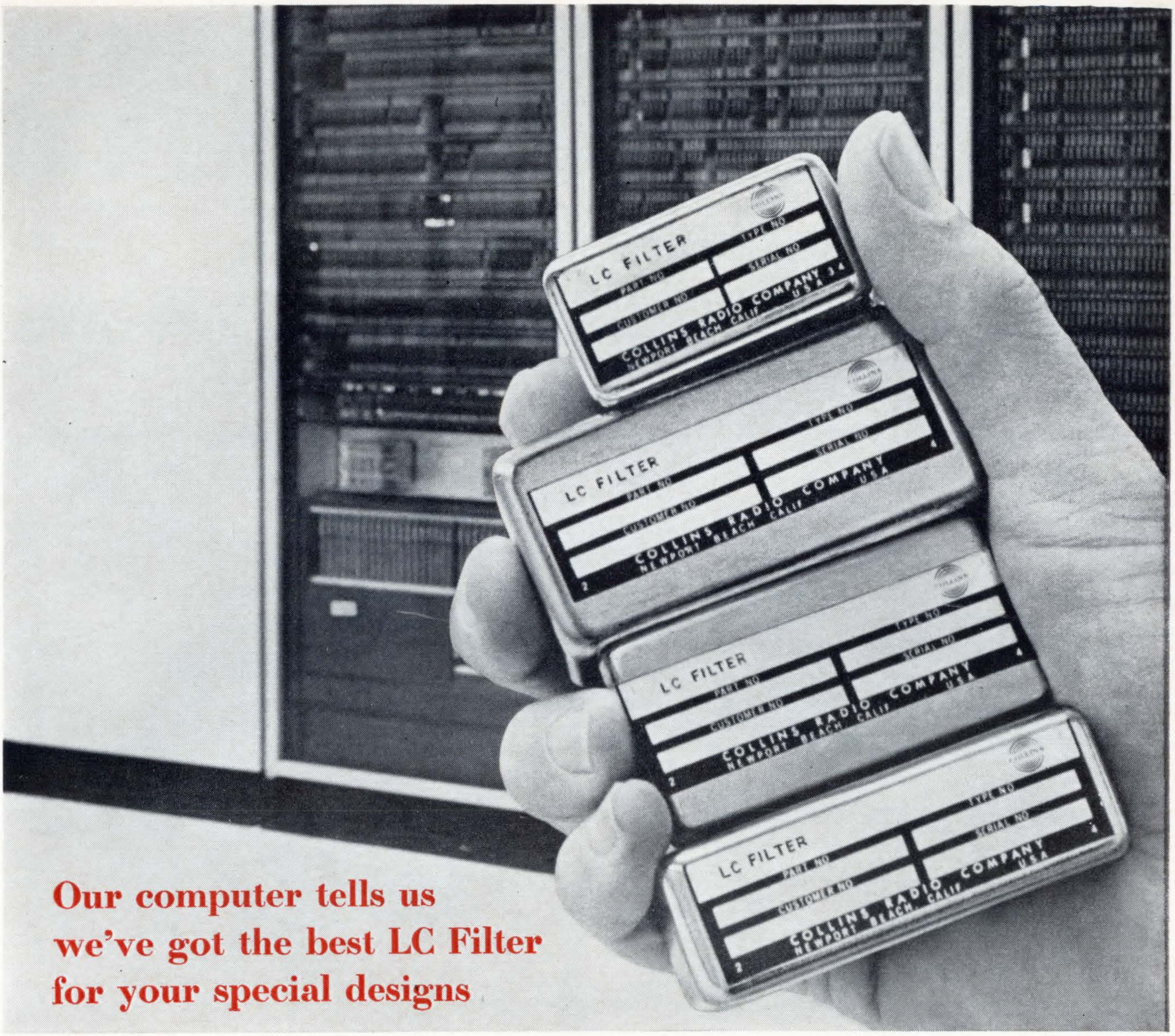

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Probing the News

Trade

Trade activity with Reds picking up—so is smuggling through Iron Curtain

Electronic gear, including some strategic items, find way through Iron Curtain; further increases expected

A distributor for a major United States communications company, in West Berlin recently on business, received a mysterious offer: $5,000 if he would come into the Eastern zone to evaluate a piece of electronic equipment.

He didn't go. But he couldn't help wondering: "Why didn't the Communists evaluate the machine before they bought it? And why don't they get the evaluation from the manufacturer?"

Later he learned that the manufacturer was his own company. The equipment was so advanced that he hadn't even been given it to sell.

The product was part of a trickle of electronic gear that finds its way into Communist countries outside the regular trade procedures. Some of these goods are listed on embargoes of strategic materials by the United States, Japan and the 15 members of the North Atlantic Treaty Organization. Others, though not restricted, are made by companies that don't want to sell to Communists.

Yet the equipment continues to find its way into Eastern Europe. Demand seems strongest for such articles as gas and ruby lasers, specialized transistors, inertial guidance equipment, radio navigational gear and gas chromotographs, and certain microwave components.

I. Controlling trade

The U.S. maintains tight controls on exports to Communist countries. It separates products into three groups: a "munitions list" of items that require State Department approval for export to a Communist country; a "restricted trade" category that requires export licenses which are easy to obtain, and an "unrestricted" class.

U.S. trade is prohibited with Communist China, satellites such as North Korea and Cuba. However, China managed to buy goods from the West last year totaling $573 million.

Japan and members of NATO maintain their own control offices to enforce restrictions on sales of strategic goods. This embargo, which is less extensive than the U.S.'s, is enforced by an agency

Trade fair in the Soviet Union is used by Elliott-Automation, Ltd., of Britain to promote computer sales.

called Cocom, for Coordinated Committee of the Consultative Group.

NATO members in Cocom include Belgium, Britain, Canada, Denmark, France, West Germany, Greece, Italy, Luxembourg, the Netherlands, Norway, Portugal, Turkey and the U.S.

Standards vary. Cocom is concerned only with items of military value. The U.S. restrictions cover goods whose sale to a Communist country may be detrimental to the welfare of the U.S.

There's the added complication of reshipments to the East from European countries outside NATO. These include Austria, Finland, Sweden and Switzerland. Controls on exports to the Red bloc vary from country to country.

Sweden, for example, sold $133 million of goods to the Soviet bloc last year, including $364,000 to Russia. This nearly equals the U.S. total of $166 million exports to the East, including $22 million to the Soviet Union. U.S. exports to Russia include $215,000 of telecommunications gear.

How much trade? Most Western countries encourage trade with Communist nations—provided it doesn't violate military embargoes. The most effective method of selling industrial goods to the East seems to be the trade fair.

On Nov. 2, Britain will open the largest industrial exhibition ever held in Communist China. Two hundred leading British companies will show equipment valued at $3 million. The exhibition is subsidized partly by a $90,000 grant from the British Government Board of Trade.

British exports to the Soviet bloc last year totaled $343 million, including $2 million of telecommunications equipment to Russia.

U. S. restrictions for trade with Communist countries are expected to be relaxed soon. One reason is industry pressure to permit U.S. companies to sell articles that the Communists are able to obtain elsewhere.

Enforcement agency. Suspicious exports to the Communist bloc are reported to the U.S. Commerce Department. The agency's Office of Export Control has about 40 investigators in this country, in addition to special agents all over the Western world, looking into complaints.

The office has jurisdiction over equipment assembled overseas, as well as direct exports from the U.S. No product may be shipped by a foreign subsidiary that the American company itself could not ship. If violations are found, a first step is to warn the company; if the violations persist, the company's export license can be withheld.

II. How to cheat

F. D. Hockersmith, the office's director, concedes that enforcement is difficult, especially when it concerns complex electronic equipment.

The list of strategic electronics equipment spells out in detail what kinds of equipment are banned from trade with Communist countries. But a slight variation in the equipment's performance or operation sometimes can make it eligible for entry into the Eastern bloc.

Imagine the chagrin of a border guard trying to decipher the complex markings on a piece of electronic equipment to decide whether to let it through. Faced with a helium-neon gas laser uncrated for his inspection, he sees what might be, to him, anything from a neon sign, to a spectrometer.

With the NATO Cocom list in hand, he must try to understand the subtle differences in specifications between embargoed equipment and gear that is allowed to pass—this, despite the fact that terms like angstrom, pumping wavelength, micron or response spectrum are alien to him.

Worse, a piece of equipment may be falsely marked, making it im-

Technical training and lectures about computers are offered by Elliott-Automation at trade fair in Russia.

possible for the inspector to identify its true nature. And a border guard with no understanding of binary logic cannot hope to ascertain the performance specifications of, for example, a shift-register module for a computer.

The diverters. An electronics dealer in Kaiserlauten, West Germany, recently had all U.S. export privileges denied to him for an indefinite period. The Bureau of International Commerce charged the dealer, Manfred Kausch, with failure to furnish information about receipt and disposal of strategic electronic equipment received from the U.S. The suspension of privileges covered the three concerns in which he is a principal, and includes all U.S. commodities and technical data exported under license. This is the only case in the electronics field in which the U.S. Government has taken action recently.

Kausch may have been one of a new breed of international wheeler-dealers.

Diverters are the biggest category of known West German violators of trade embargoes. They are import-export agents who transport strategic goods imported from the U.S. and other Western nations to high-paying customers in the Communist bloc.

Dodging the inspectors. East-bloc priority lists are well known to European diverters. The Comcon control office at the U.S. Embassy in Bonn has conducted 100 investigations this year of companies importing goods from the U.S. and reexporting them to the East. About 60 exporters dealt exclusively in electronic equipment. At least 10 of them were convicted and fined, imprisoned or both. In addition, West German customs authorities convict about five diverters a year, most of them blatant violators.

III. How to trade legally

Strategic goods, which require State Department approval for sales to the East, are described in detail on a list obtainable from the Commerce Department.

Goods on the unrestricted list require no special government action, so there's no problem with them.

For goods in the third, or restricted, area, an export license is required.

A manufacturer with an order from the Communist bloc files the order and equipment specifications, along with a standard application form, with the Office of Export Control. The order is assessed for its strategic value; if the sale is considered in the "national interest," a license is granted for that specific item.

Getting an order. Agencies within Communist countries look over a list of manufacturers and select articles they want. These government agencies buy the goods and resell them to the organizations that will use them.

Most of these agencies don't care about price; if they want a product, they're willing to pay for it, even at unreasonable prices.

But many Eastern agencies place sample orders for equipment and components so they can copy them. Then, according to one U.S. manufacturer, "You never hear from them again." The best clues that an order is for copying are when only one or two pieces are bought, one each of a wide variety of a company's products.

Information, please. One-of-a-kind purchases are bad enough, but the Communists often go further. Texas Instruments, Inc., and the Collins Radio Co. say they frequently get inquiries from Red-bloc countries for technical information and operating manuals for TI or Collins equipment that was never sold in the East—at least not by the manufacturers.

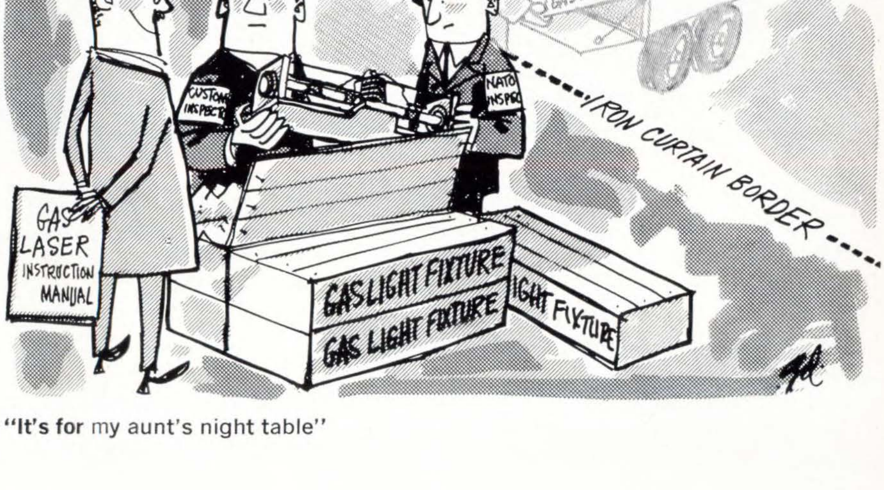
Both companies refuse to trade behind the Iron Curtain.

The Ampex Corp., which also has a policy against trading with Communists, says the Russians have built at least 20 tape recorders that are duplicates of American makes, and even refer to them as "Ampexes". The name is a trademark, registered in the Soviet Union in both the Roman and cyrillic alphabets.

Eye on the future. Despite all the difficulties, many companies consider the Communist countries good potential markets. And many take issue with Ampex, TI, Collins and others on the ethics of dealing with the Reds.

"If our government thinks it's in the national interest," says one company official, "who am I to over-rule that judgment?"

The president of another electronics concern declares: "We're sending representatives to the trade fairs in the East and are actively seeking business in the Red bloc. So far this isn't much. But if the door is ever opened wide to trade with the East, we're going to be there."



"It's for my aunt's night table"

A computer to count on

Triple redundancy, majority rule, back-up memories and hybrid integrated circuits are making the guidance computer for Saturn V the most reliable ever built

The value of Saturn V's payload is beyond reckoning. The priceless cargo to the moon will be three astronauts and United States prestige. The key word in every preparation for the flight is reliability. Nowhere is this better demonstrated than in the radically improved computer being built for the launch vehicle by the International Business Machines Corp.

The computer's mean time before failure will be 45,000 hours. This is 60 times better than the mean time before failure of the Saturn I computer.

Triple redundancy—each circuit is triplicated and all three receive the same problem at the same time—with voting circuits in seven major areas of the computer and data adapter, backed up by error-detection circuits and two redundant memories, contribute to the over-all reliability.

Hybrid integrated circuits permit using 80,000 components; yet they account for only 43 of the system's 253 pounds.

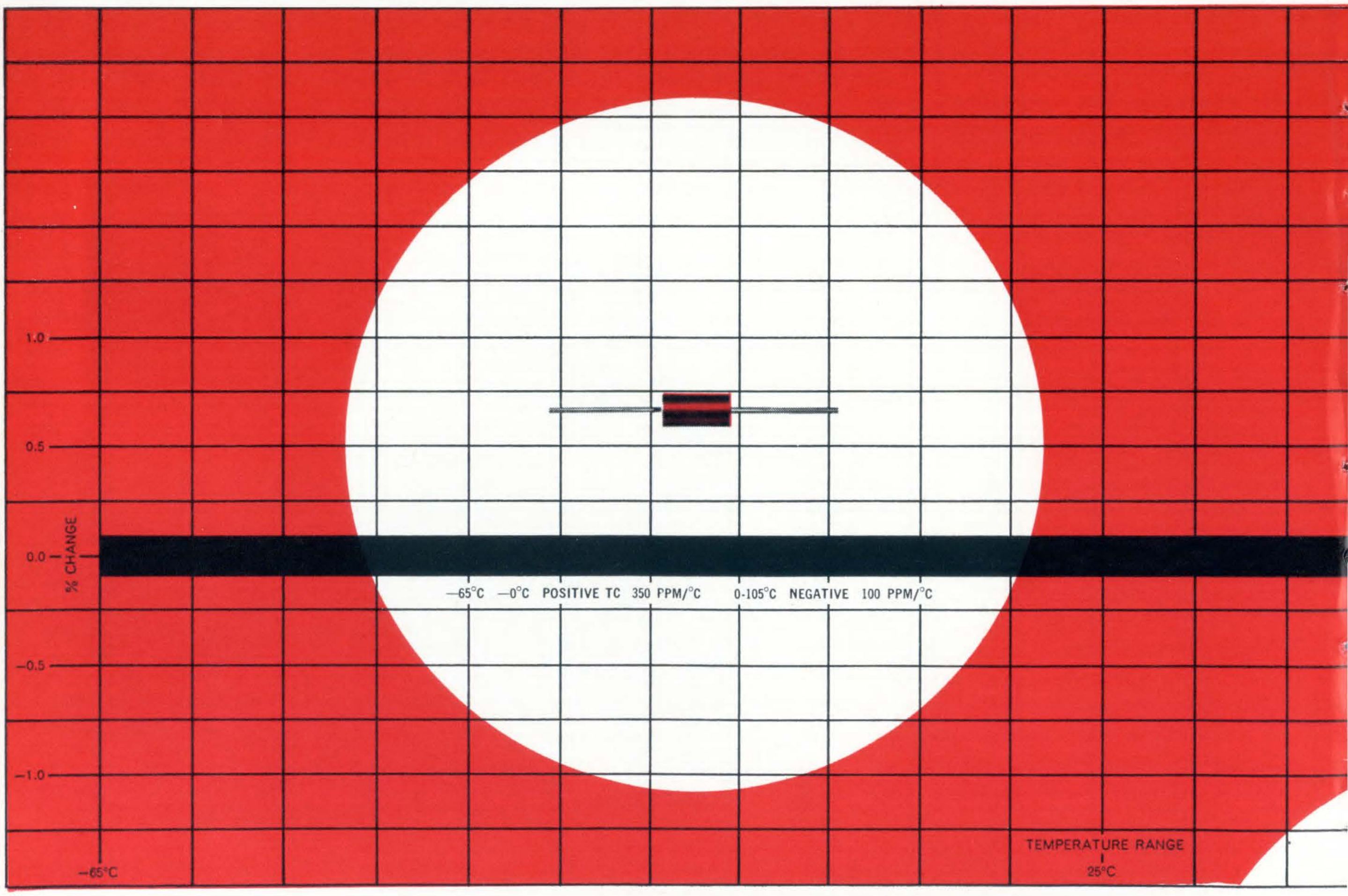
I. Voting circuits

Saturn V logic is divided into seven sections and each section is further divided into three identical channels or modules. The outputs of the three circuit modules in each section are compared in a majority-rule voter circuit. If one output differs from the other two it is disregarded as an input, because the circuit assumes the majority of inputs to be correct. As a result, a component failure will not cause a system malfunction.

Any disagreement is detected by a monitor that telemeters the information to the ground when all voter inputs are not identical. Outputs of the disagreement detector are compared so that malfunctions can be isolated to one, two or three replaceable subassemblies. Altogether, 79 signals are voted on in the seven computer-logic sections. [For more on voting circuits, see "Majority voting protects aircraft and pilot," May 18, p. 85.]

II. Back-up memories

The two redundant ferrite-core memories in the Saturn V system use conventional toroidal cores in a self-correcting redundant (duplex)



system. This will be the first use of ferrite-core memories in a missile. Drum memories were used in earlier computers.

The Saturn V core memory can be expanded to 920,000 bits capacity (the Saturn I drum memory has a storage capacity of 100,000 bits). Speed of the computer system is 512,000 bits per second, about three times greater than the speed of either the Saturn I or the commercial IBM 1401 system.

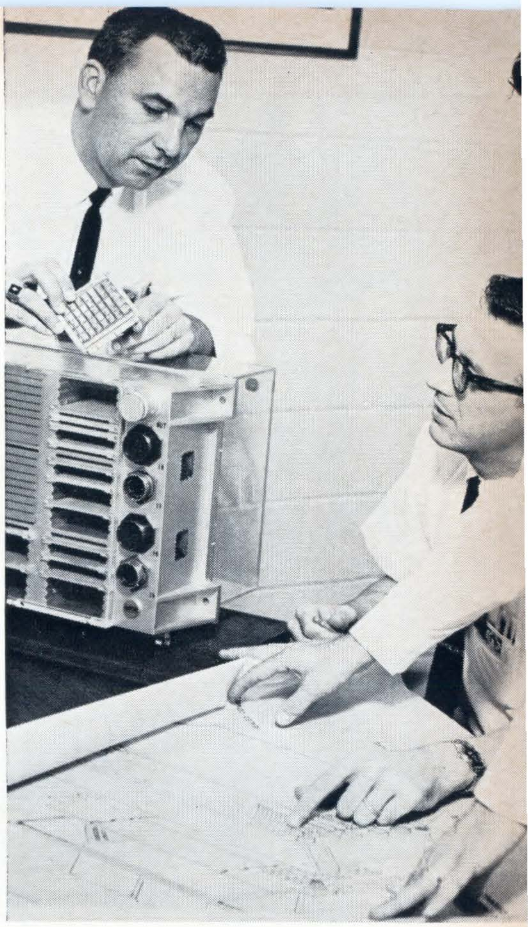
Each memory consists of up to eight identical 4,096-word memory modules that may be operated in duplex pairs for high reliability, or singly (in simplex) for increased storage capability.

One memory has a storage capacity of 115,000 bits, or 23,000 bits for two redundant arrays operating individually. This can be expanded to 460,000 bits when the two duplex pairs are operated in simplex. Although the Saturn V flight system only calls for two duplex pairs, the computer can accommodate two more pairs to provide a maximum storage capacity of 920,000 bits.

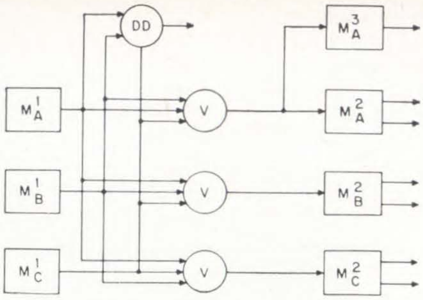
Self-correction. Unlike conventional toroid random-access memories, the self-correcting feature of the basic duplex system permits correct information to be regenerated after transients or intermittent failures. If memory A fails, for example, the system will correct itself by switching to memory B and correcting memory A. Then if memory B fails, the system will switch to the restored memory A. The faulty memory is restored from the buffer register of the good memory.

The pair of memories provides storage for 8,192 14-bit words for duplex operation, or 16,384 14-bit words for simplex operation. Each simplex memory has its own instrumentation for timing, control, address driver, inhibit driver, sense amplifier, error-detection circuitry and input/output connections to simplify failure isolation.

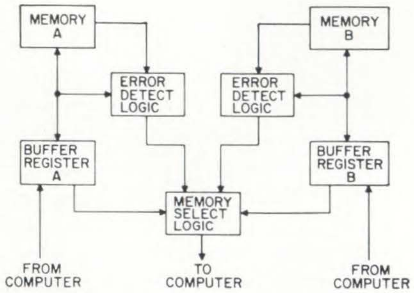
Synchronizing gates. The computer functions, which are separate for each simplex memory, consist of synchronizing gates that provide the serial data rate of 512,000 bits per second. This data rate is required by the computer to gener-



Saturn V computer is about the size of a two-suiter. It contains 80,000 components.



Seven areas of the Saturn V computer are equipped with disagreement detectors (DD) and triple redundant voting circuits (V). If one input differs from the others, it is disregarded. Corrections are made with the aid of a disagreement detector.



Redundant computer memories correct each other. If memory A fails, the system will correct itself by switching to memory B and correcting memory A. If memory B fails, the system will then switch to the restored memory A.

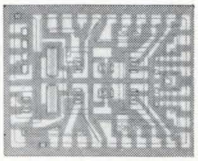
ate a start command for the memory at 128,000 bits per second.

These gates also select multiple simplex memory units for storage flexibility. They permit partial or total duplex operation through the entire mission and extend the mean time before failure to 45,000 hours, compared with 750 hours for the Saturn I computer.

III. Hybrid integrated circuits

Getting the most redundancy with the least weight and space was accomplished with hybrid integrated circuits called unit logic devices. Since 1961, IBM has tested the devices for more than 20 million hours.

The computers and data adapters will cost the National Aeronautics and Space Administration about $70 million, including development. IBM's Space Guidance Center is producing 30 flight-model computers and data adapters for $38,527,450, as well as seven prototype computers and six prototype data adapters for $31,087,750.



BREADBOARD CIRCUIT (12X)

Why waste six weeks while somebody designs and builds the experimental micro-circuit you need this week?

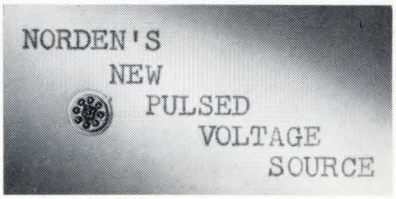
Norden can do it in 48 hours.

Now you can get fully integrated microcircuits in just 48 hours. That's because Norden has developed a series of single-crystal "Master Dice" breadboard circuits that contain all elements required by a wide variety of advanced microcircuits. All that is lacking are connections between circuit elements.

Simply tell Norden what connections you want. Then, within hours, you'll have a low-cost fully integrated .065" x .085" microcircuit for immediate trial. And you can have quantity production just one week after tests show the circuit is adaptable to your new design.

This new microcircuitry concept is based on a design originally developed for the Apollo program. Each breadboard contains 15 resistors and 7 NPN transistors. Circuits already produced by this new Norden technique include 2-strobe sense amplifiers, differential current amplifiers, Schmitt trigger and a binary switching element.

Complete information on this rapid, new, low-cost approach to microcircuits is available. For details, contact Dept. E, Norden Division of United Aircraft Corporation, Norwalk, Connecticut, or telephone 203:838-4471.



Norden's new pulsed voltage source is capable of unprecedented switching speed and power. It can complement existing circuitry or can be incorporated as new circuitry in computer designs.

The unit will accept a low level logic pulse signal, typically from the collector of a NOR gate or buffer, and provide at its output a 2 volt pulse, into a 50 ohm resistive load, shunted with 62 pfd of capacitance.

Rise time, fall time, storage time and propagation delay time are less than 15 nanoseconds each. Write for full details and data sheets.

Norden DIVISION OF UNITED AIRCRAFT CORP. UA

NORWALK, CONNECTICUT

Lasers as messengers

Four new techniques for modulating the light beam will be reported this week at Boston meeting

Since the birth of the laser in 1960, scientists have been struggling to learn how to exploit one of the light beam's main potentials: carrying a tremendous amount of information for radar and communication.

Four techniques that represent incremental advances in this direction will be reported this week (Nov. 4-6) at the Northeast Electronics Research and Engineering Meeting in Boston. In each case, the investigation centers on finding a better material to modulate the beam of light. Three of the techniques modulate the beam after it has been produced; the fourth, while it's being produced.

I. Search for a crystal

Specifically, the aim of the various approaches is to widen the bandwidth of the carrier beam while using as little power as possible to obtain full modulation. What's needed is a crystal with relatively large optical effects per volt that can be shaped into a structure which will yield a wide bandwidth.

The four new approaches are partially successful; they include the use of traveling wave structures, new organic crystals, low-inductance injection laser diodes and adaptation of a measurement device as a modulator.

Up to now, the most common approach to externally modulating a laser beam has been to utilize the electro-optic effects in such materials as potassium dihydrogen sulphate (KDP) or ammonium dihydrogen sulphate (ADP). These materials exhibit a change in their index of refraction when an electric field—in this case, the modulation—is applied. The crystals are usually enclosed in a resonant cavity through which the laser beam is passed for modulation. But due to the limitations of the resonant cavity, bandwidths have been limited to about 10 megacycles using this type of structure, and a modulation level of several hundred volts is required. To overcome these limitations, the trend is toward the use of traveling wave-type structures that utilize the distributed characteristics of a transmission line, such as waveguide or coax. Such structures have inherently wide bandwidth.

Full modulation. C.J. Peters of Sylvania Electric Products, Inc.'s laboratory has developed a modulator that achieves a 1-gigacycle bandwidth and 100% modulation with an input of 50 volts. Sylvania is a subsidiary of General Telephone & Electronics Corp. The device consists of 8 KDP crystals, each 2-inches long, assembled between two lengths of stripline or concentrically arranged in a coaxial line.

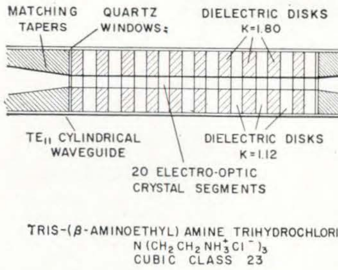
In the Peters' modulator, a linearly polarized light beam is incident upon the KDP crystals to which the modulation field is applied via the traveling wave structure. The structure is so designed that the group velocity of the light in the crystals and the phase velocity of the modulation are equal. The interaction resulting from this plus the result of the natural birefringence of KDP imparts a retardation or elliptical polarization to the light beam that is proportional to the instantaneous value of the applied modulation field. Birefringence is a double refraction effect that causes the wavefront entering the crystal to split at right angles and continue at different velocities. Since birefringence is a function of the crystal temperature, another birefringent crystal is placed after the modulator to compensate for the temperature dependence.

"Primitive as laser modulation is today," says Peters, "we can still build a reliable, unattended tv link of perhaps a couple of miles."

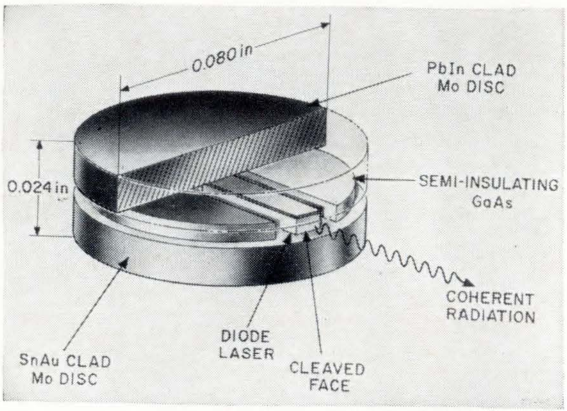
II. New organic material

At GT&E laboratories, C.F. Buhrer is using a new organic material in a cylindrical waveguide traveling wave modulator. He calls the new material, developed at GT&E labs, tren chloride, short for a much longer and virtually unpronounceable designation. The formula is $N(C_2H_4NH_3{}^+Cl^-)_3$. According to Buhrer, large strain-free cubic crystals of tren chloride are as easy to grow as KDP from a water solution. In a cubic crystal the atoms form a lattice in the shape of a cube. This results in a crystal that is optically isotropic, i.e. its effects on light are independent of the direction from which the light enters the crystal. Thus less tolerance is required in assembling the modulator.

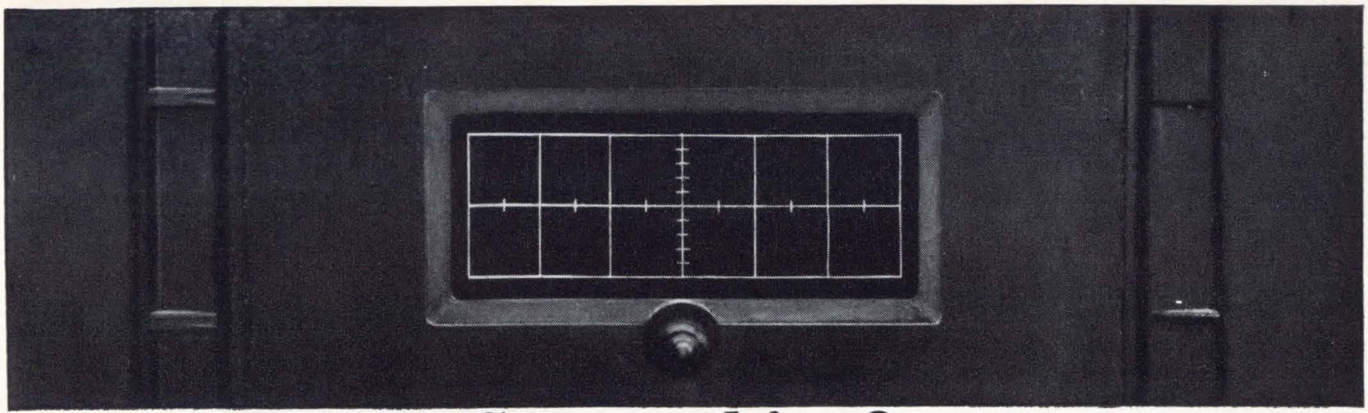
The modulator (see p. 86) con-



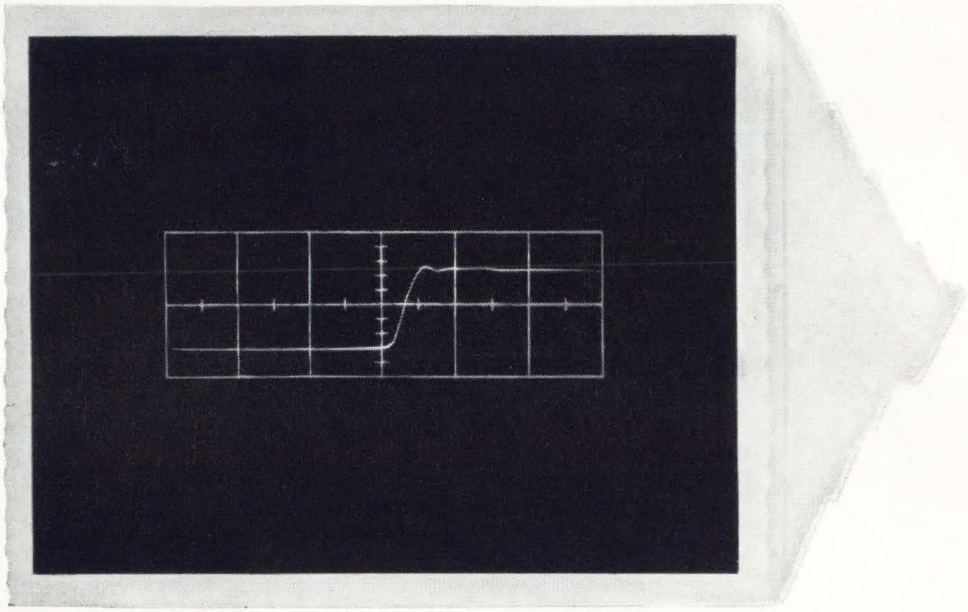
Traveling wave light modulator developed by General Telephone & Electronics' laboratories produces single sideband modulation in the frequency range of 8.5 and 9.5 gigacycles. Indications are that the range can be extended.



Pill-packaged diode made by the Lincoln Laboratory is used to modulate laser. The frequency range has been extended to 4 gigacycles.



See anything?



This new film did.

This new film saw something the eye couldn't: the rise time of a single pulse on a Textronix 519 scope at a sweep rate of 2 nanoseconds/cm. The new film, Polaroid PolaScope Land Film, actually extends the usefulness of existing oscilloscopes by supplying "brightness" that the scope hasn't got!

The reason is that this PolaScope film has an ASA equivalent rating of 10,000, which means it can see things your eye cannot. It has about twice the writing rate of the Polaroid 3000-speed film, currently the standard for high speed oscilloscope photography. (No other commercially available films come anywhere near the speed of PolaScope film.) And because it's made by Polaroid you get a finished usable print—see above—ten seconds after exposure.

PolaScope film will also give you better shots of slower pulses and stationary waveforms. So little light is required, camera aperture and scope intensity can be reduced considerably, and that's how to get really sharp oscilloscope pictures.

And wherever else light is at a premium—such as photomicrography and Kerr Cell photography—PolaScope film will make new applications possible, old applications more useful.

PolaScope Type 410 Film is packed 12 rolls to the carton. The price is about the same as the Polaroid 3000-speed film. For the name of the industrial photographic dealer nearest you, write to Technical Sales Department, Polaroid Corporation, Cambridge 39, Massachusetts.

POLAROID®

New Polaroid Land 10,000-speed film for oscillography

sists of 20 dielectric disks arranged along the axis of a TE_{11} cylindrical waveguide. The tren chloride crystals, 0.5 centimeters in diameter and 0.5 centimeters long, are inserted into holes in the center of the disks.

The device has produced single sideband modulation in the frequency range of 8.5 to 9.5 gigacycles, and calculations indicate it will work equally well over the range of 7.5 to 12 gigacycles. Unfortunately, high-pulsed modulation power (200 kilowatt peak) was required, although Buhrer is already working on alternate designs that he anticipates will make c-w operation feasible.

III. Lincoln's Research

With the advent of the semiconductor injection laser, modulation techniques were expected to be simpler and more flexible because these devices lend themselves to internal modulation. Gallium arsenide lasers of this type can be pumped with pulsed or direct currents, depending on the temperature of operation, and if desired, radio-frequency modulation can be superimposed on the pumping current.

"A modulated gallium arsenide injection laser is a practical device right now," says Benjamin S. Goldstein of the Lincoln Laboratory of Massachusetts Institute of Technology. "However, we want more power; we'd like better uniformity of output; and we'd like to get injection lasers at visible wavelengths." Goldstein, R.M. Weigand and J.D. Welch are authors of the paper on modulation of diode lasers.

Low temperatures. "You can get several watts out of a single diode operating coherently at liquid helium temperature," says Goldstein. For c-w it is still necessary to work at this temperature. But for pulsed mode, it is possible to operate at liquid nitrogen temperature, or even at room temperature.

Superimposing r-f current on the d-c pumping current of a gallium arsenide diode laser is equivalent to amplitude modulating the optical radiation with an r-f coherent subcarrier, according to Goldstein. Thus the subcarrier can be modulated and demodulated using conventional r-f techniques.

According to theory, the upper modulation limit of gallium arsenide lasers should be well into the microwave region. Using a pill-packaged diode of very low inductance, the Lincoln lab trio has extended the modulation frequency to 4 gigacycles.

IV. Baird Atomic

S.R. Blom and V. Del Piano Jr. of Baird Atomic, Inc., have experimented with a Fabry-Perot interferometer to get wideband external modulation of laser beams. Ordinarily used to investigate and measure small linear and angular displacements, optical path length differences and light wavelengths, the Fabry-Perot interferometer consists of two optically flat and parallel glass or quartz plates held a short, fixed and known distance apart. The adjacent surfaces of the plates are made almost totally reflecting by a thin silver film. What Blom and Del Piano have done is insert KDP between the plates. Applying modulation voltage to the KDP changes the optical path length between the mirrors and causes intensity modulation of the beam.

The Baird-Atomic scientists say the technique is feasible. Wideband modulation was achieved with several hundred volts, yielding 25% amplitude modulation.

Regions

Industrial revolution brewing in New England

Leveling-off of military contracts and opening soon of NASA's electronics research center spell change for region

Two isolated news items point up the changes about to take place in New England's electronics industry:

- The Northeast Electronics Research and Engineering Meeting (Nerem) in Boston this week (Nov. 4-6) will sponsor a panel discussion on the topic, "The Electronics Profession in a Peacetime Economy."
- The National Aeronautics and Space Administration this week opens temporary staff quarters for its proposed Cambridge, Mass., electronics research center.

I. Executive talk

These two items provide a clue to the kind of thinking and talking that is going on now in executive

That's not a golf ball in flight; it's the radome for Haystack erected by the Air Force. Project Haystack cost $15 million. It's typical of the research and development being carried out in Massachusetts.

Meeting on Electronics

The Northeast Electronics' Research and Engineering Meeting (Nerem) opens in Boston Wednesday and will run through Friday.

The theme of the session—sponsored by the northeast sections of the Institute of Electrical and Electronics Engineers—is "Electronics—Sentry and Servant." Some 20,000 persons are expected for the technical sessions and exhibits at the Commonwealth Armory and Hotel Somerset.

The technical sessions are planned to present an image of broad research—instrumentation, microelectronics, radio astronomy and biomedical engineering.

A panel led by Dr. Jerome B. Wiesner, dean of the school of science, Massachusetts Institute of Technology, will explore the question, "The Electronics Profession in a Peacetime Economy."

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offices of most New England electronics companies.

Accelerating this kind of thinking on the executive level is the realization by the industry that military spending isn't going to climb. If anything, it will hold steady or slip a bit. In the year ended last June 30, military spending for research and development fell $600,000 from fiscal 1963 to $5.1 billion.

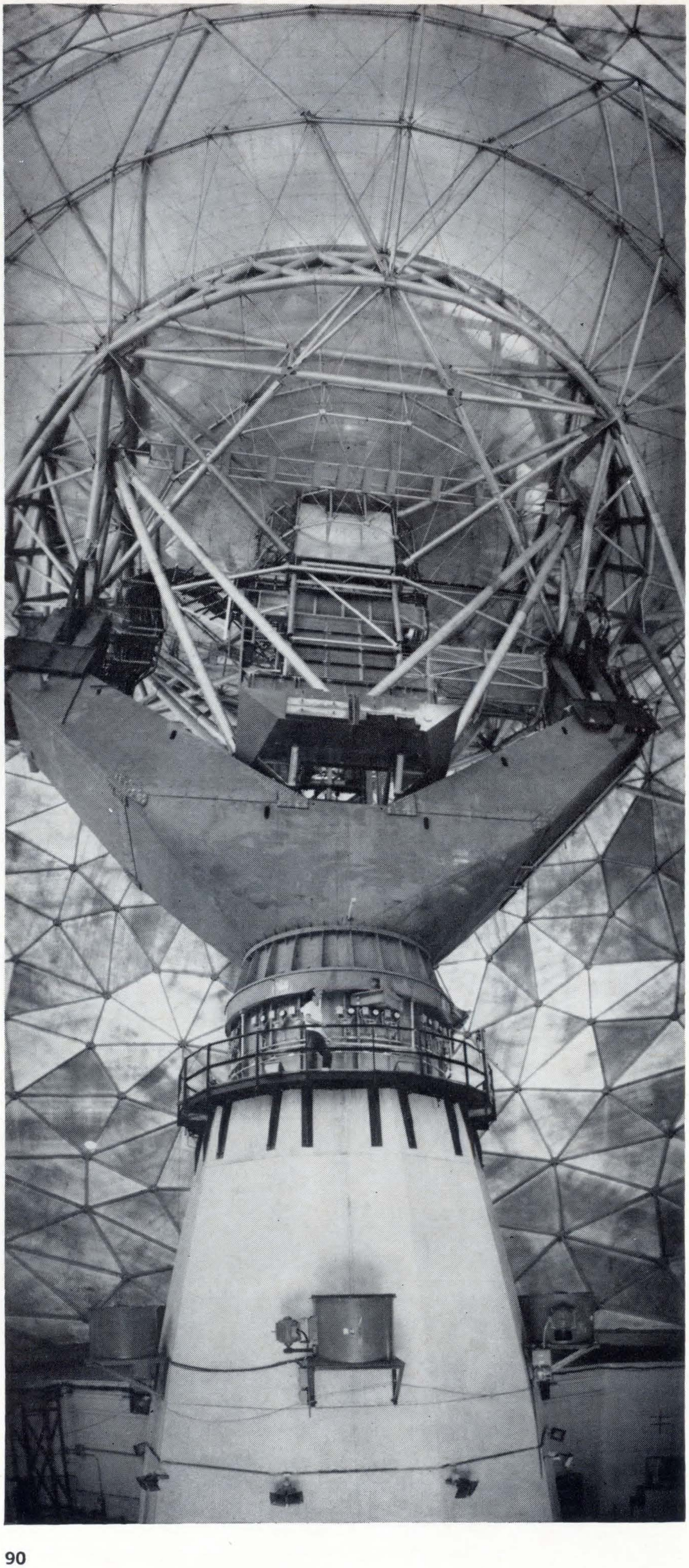
So executives are now thinking what might happen to business if peace suddenly broke out.

Although few of these business leaders doubt that change is coming, many are uncertain of the timing and the impact on their companies.

Faster pace. In fiscal 1963, the latest year for which regional figures are available, the New England area received a total of $487.4 million in contracts from the Defense Department, or 7.9% of the total. It ranked behind the Pacific, Mid-Atlantic, South Atlantic and Rocky Mountain regions.

New England's share of NASA contracts was only $53 million, or only 2% of the total for that fiscal year. Massachusetts alone, with $43.5 million, received the bulk of the region's space agency awards, and Connecticut was awarded some $9 billion, placing second in the area.

Several events are in the works that are expected to accelerate the pace of the aerospace contracts in the region. When the NASA center



is in full operation by 1970, some 2,100 professional and supporting personnel are envisioned. Its research budget will include about $35 million for in-house work and $45 million in grants and contracts to academic and industrial organizations throughout the country.

But these figures provide only a hint of the revolution that will hit this area in a handful of years. Around the NASA center will spring a host of auxiliary companies and school expansions to feed the scientific appetite of the center.

Says a spokesman for the Greater Boston Chamber of Commerce: "We have them (private concerns) waiting in the wings now." Adds a real estate broker: "Land marked for industry after urban renewal near the center is already well spoken for."

And the Massachusetts Institute of Technology, focal point of the area's research strength, is in the midst of the biggest building program in its 100-year history. In the 10 years ending in 1967, the school's physical plant will have been doubled.

Such growth is documented by the Federal Reserve Bank of Boston, a watchdog of the economic future of the region. The bank forecasts that employment in the area's electronics industry, now totaling some 78,000, should climb near the 100,000 mark by 1970.

II. Manpower woes

Currently one out of ten persons in the electronics industry works in this six-state region. But with the acceleration that is being forecast, that ratio is expected to start leaning more in favor of New England.

Such rapid growth is likely to be a source of problems, and the most important probably will be manpower. Where will these highly skilled people come from?

To be sure, many will come from

Inside the giant radome, looking up at the antenna. Engineers at Harvard University and the Massachusetts Institute of Technology will use the know-how gained from designing the mammoth Haystack antenna to plan other, even bigger, dishes for more powerful radar and communications systems.

the universities that ring the center, but says a NASA official: "We're getting applications for scientific and engineering positions from all over the country."

'Gentleman's agreement.' Earlier this year, NASA officials discounted speculation about "pirating" engineerings from industry in the area and from Air Force research centers. The commanding general of the Air Force electronics systems division at the time said the service and NASA had a "gentleman's agreement" under which wholesale personnel moves from the Air Force to NASA wouldn't be encouraged.

When asked about such pirating from industry for the space agency, Albert J. Kelley, now deputy director of the Cambridge center, commented: "That's the first time I ever heard of government salaries luring engineering from industry."

III. Spending for the future.

The giants in the electronics industry in the region are taking a long, hard look at this so-called revolution before they commit dollars to any shifts in their programs.

Raytheon Co.'s chairman, Charles F. Adams, comments, "We intend to continue as a defense contractor . . . however, Raytheon looks for growth not in defense, but in space contracts, air-traffic control, industrial electronics and overseas markets."

But Bernard J. O'Keefe, executive vice president of Edgerton, Germeshausen & Grier, Inc., puts it another way: "The paradox which faces the defense industry and the nation is how to retain this military asset . . . while . . . adapting the excess resources of the (defense) industry to other segments of the economy."

Job security. It is this "excess" in resources that now is worrying the 78,000 people who work in the region's electronics industry. They remember 1962-63, when some 5,000 persons lost their jobs, principally because of troubles in the semiconductor business.

But the optimistic picture being drawn by bankers, government officials and industrial leaders seems to point in the other direction: New England is growing, and the biggest growth will be in aerospace and commercial industry.

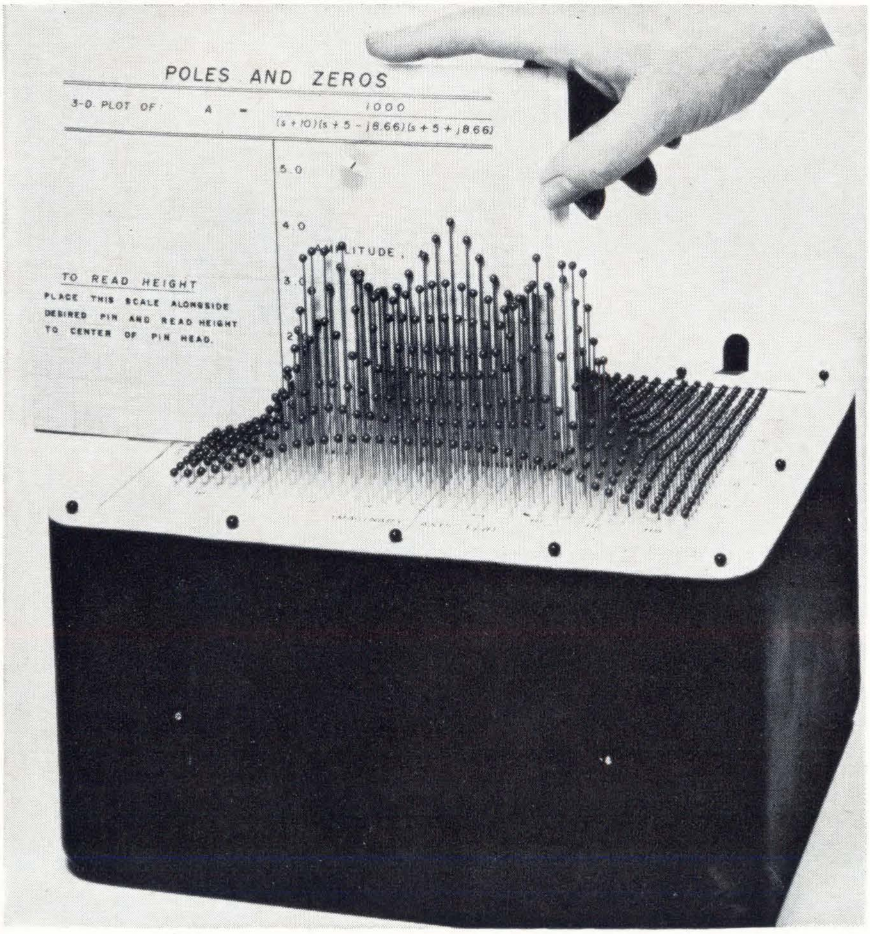
Faster three-dimensional plotting

Pre-plotted array, containing 4,096 pins, simplifies X-Y-Z plotting of complicated data

The most effective of the senses for conveying information is sight. The natural three-dimensional characteristics of vision and the enormous information capacity of a volume compared to an area make the 3-D graph ideal for allowing complicated data to be grasped.

With the Dimen-Plot technique, the three-dimensional display of quantitative data in a volumetric region is obtained by locating headed pins at discrete points on a supporting base and by adjusting the height to which the pin heads project above the supporting base. The location of the pins on the supporting base defines two coordinates (X and Y) of a plotted point and the height defines a third coordinate (Z).

True three-dimensional manual plotting is now faster and simpler with the new Dimen-Plot pre-plotted (in X and Y) pin array. This addition to the standard line of Dimen-Plots eliminates the need for inserting pins and provides over four times the number of points that can be displayed. Useful for displaying any three-variable function, the plotter is said to be invaluable for research, development, education, design, analysis, experimentation, presentations and display. Some typical uses include plots of breakdown voltage vs pressure vs magnetic field; poles and zeros in filter and servomechanism design; and signal amplitude as a function of receiver parameters.



To plot a 3-D graph, the pins are merely set to the desired height. A pin lifter-pusher and a plasticized vertical scale are supplied for convenience in accurately setting heights. Plots may be stored or changed indefinitely without deterioration. Pins remain in place once set and may be reset at any time.

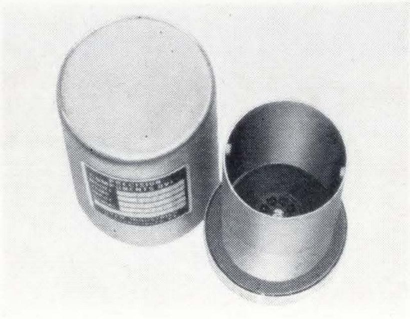
The array contains 4,096 six-inch-long pins spaced ¼ in. apart in a rectilinear 64 by 64 configuration. The plotting area, which is 16 in. by 16 in., may be used for one 3-D plot of 4,096 points, two separate plots of 2,048 points, four plots of 1,024 points, etc. Maximum plotting height is 5½ in. Pin heads are colored plastic spheres in red, yellow, white, blue, green, turquoise or brown. Different colors in the array may be interspersed by line, quadrant, etc. In a finished plot the vertical scale may be inserted between pins to read vertical height accurately at any point. Price is $225.

Dimensions, Inc., 95 Madison Ave., Hempstead, N.Y. 11550.
Circle **301** reader service card

Co-ax phase shifter operates in C-band

A C-band coaxial phase shifter is electronically variable and said to be ideally suited for applications requiring remote phase control. Electrical characteristics of model C102LPC, from 5.4 to 5.9 Gc, include 0° to 180° minimum phase shift achieved over the temperature range of +45°F to +160°F, 1.0 db maximum insertion loss, vswr of 1.3 maximum and a power rating of 1.0 kw peak and 3.0 w average.
E&M Laboratories, 7419 Greenbush Ave., N. Hollywood, Calif. **[302]**

New Components and Hardware



Proportional-control component oven

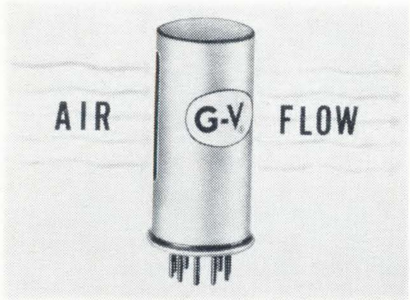
Models 2100AC and 3200DC proportional-control ovens feature ±1°C stability over a 50°C ambient change. Stability will range up to ±0.005°C over a narrow ambient range. These units are available with any a-c input voltage at any frequency on the 2100 series and any d-c input voltage on the 3200 series. Cavity size is 1½ in. diameter by 1⅞ to 2¼ in. deep. The cavity is equipped with a 7 to 9-pin miniature socket and there is a wide choice of header and mounting options at no additional cost. This unit is available at any cavity temperature between +30°C and +85° C. For 1 to 3 units of the 2100, price is $94.50. The 3200 in the same quantities costs $112.50.

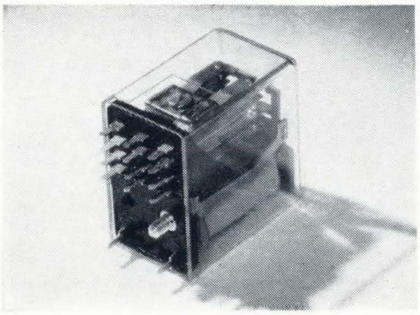
Oven Industries, 5235 E. Simpson, Mechanicsburg, Pa. **[311]**

Thermal-type switch senses air flow

A new air-flow sensing switch of the thermal type is used to provide alarm or automatic shut-down if cooling air flow ceases or drops below a safe value. Its small size, $\frac{13}{16}$ in. diameter by 1¾ in. height, produces minimum interference with air flow. Inherent thermal lag avoids contact operation on brief insignificant interruptions of flow. An internal thermal element is constantly energized and is cooled by the normal flow of air through the case of the sensing switch. If this flow drops below the critical value, temperature rise of the thermal element operates the contacts. Complete interruption of air flow will normally produce contact action within 10 to 20 seconds. Switches with slower response can be supplied. Type FS air flow sensing switch is mounted in a standard 9-pin miniature tube socket. Heater voltages of 6.3, 26, and 115 are standard. The heater draws 2½ w. Contacts may be normally closed, opening on air flow failure, or normally open, closing on air flow failure. Contact rating is 2 amp, 115 v a-c or 1 amp, 28 v d-c resistive. Price is $5.50.

G-V Controls Inc., Okner Parkway, Livingston, N.J. **[312]**





Relay can be plugged right into p-c board

A new relay has been developed for military and industrial requirements. It incorporates special printed-circuit terminals which permit circuit, packaging, and project engineers to plug it directly into a p-c board, thus eliminating the need for a mating socket. The RP-200 is a new version of the R-200 series, said to be the smallest dust-covered, telephone-type relay available. It features small size and long

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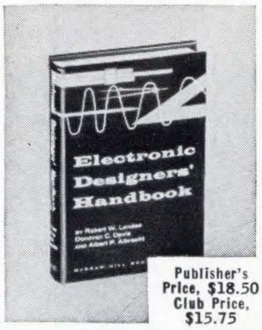

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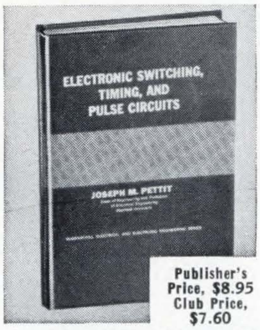
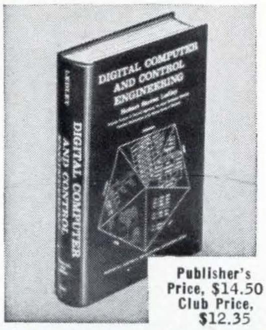
Electronic Designers' Handbook, Edited by R. W. Landee, D. C. Davis, and A. P. Albrecht. Presents detailed, practical design data.



Publisher's Price, $8.95 Club Price, $7.60

Electronic Switching, Timing, and Pulse Circuits by J. M. Pettit. Provides a practical understanding of complex circuits.



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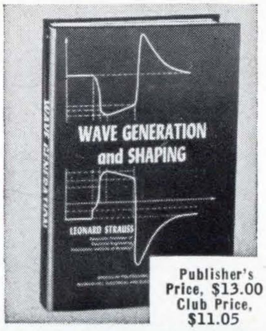

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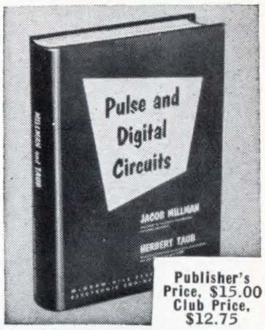
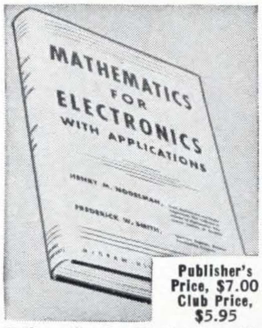
Wave Generation and Shaping by L. Strauss. Essential features and techniques of practical wave-generating and -shaping circuits.



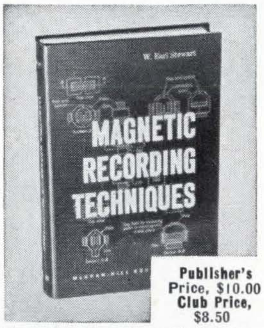
Publisher's Price, $15.00 Club Price, $12.75

Pulse and Digital Circuits, by J. Millman and H. Taub. Fully explains pulse and digital circuit operation for electronic systems design.



Publisher's Price, $7.00 Club Price, $5.95

Mathematics for Electronics with Applications by H. M. Nodelman and F. W. Smith, Jr. Methods for solving practical problems.



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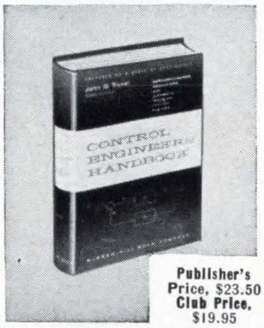
Magnetic Recording Techniques by W. E. Stewart. Full description of magnetic recording methods and devices.



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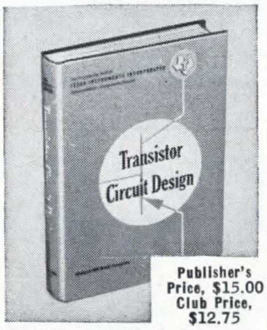
Control Engineers' Handbook by J. C. Truxal. A wealth of practical help on automatic feedback control systems.



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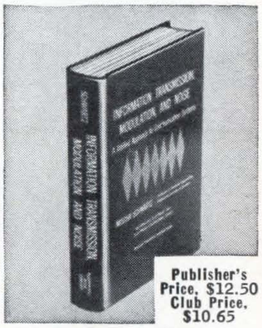

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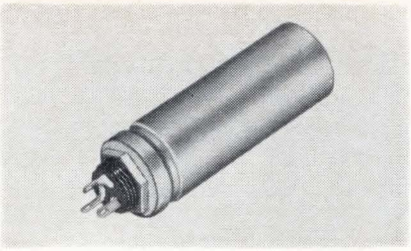
life, and has wide applications for high-speed, multiple-pole switching with low power requirements, such as computers, communications, and industrial control fields. It can also be used as a general purpose relay. The p-c terminals enable engineers to simplify design and reduce overall costs.
Relaymatic Inc., Sag Harbor, L.I., N.Y. [313]

Thin capacitors of solid tantalum

The modular Minitan solid tantalum capacitor measures only 0.125 in. by 0.070 in. by 0.040 in. The "U" size capacitor is available in ratings from 1.5 μf at 2 wvdc to 0.0047 μf at 20 wvdc. The thin rectangular configuration of the "U" capacitor makes it an ideal complement to today's microminiature thin-film and integrated circuits. The capacitor also offers exceptionally high volumetric efficiency to the designers of small circuit modules utilizing conventional discrete components, according to the manufacturer. The inherent stability of the devices, together with their availability in tolerances as close as $\pm5\%$, suits them for use in tuning, timing, by-pass and coupling applications where the required capacitance is larger than can be provided by thin-film and integrated-circuit techniques. The "U" series capacitors are provided with 0.010-in. diameter, tinned nickel leads which are easily attached by conventional soldering or welding techniques. For maximum circuit layout flexibility, the capacitors can be provided with either axial or radial leads. Prices are currently less than 55 cents each in quantities of 1,000.
Components, Inc., Smith St., Biddeford, Maine. [314]

Oil-filled capacitors conserve space

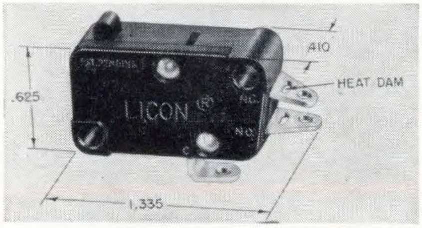
Compact G and H type oil-filled capacitors are designed for use where space is at a premium and



mounting ease and convenience are of extreme importance. They are made in single or dual style and range in capacitance from 0.5 to 8 μf, 600 to 1,500 v d-c. Indco oil or Viscofilm are used, depending on the temperature range and power factor required. A molded mounting neck is locked in the capacitor case and gasketed to produce a hermetic seal. The mounting neck is threaded and a flat solid hex nut that is self-locking to the threaded neck permits quick and easy mounting.
Industrial Condenser Corp., 3243 No. California Ave., Chicago, Ill. 60618. [315]

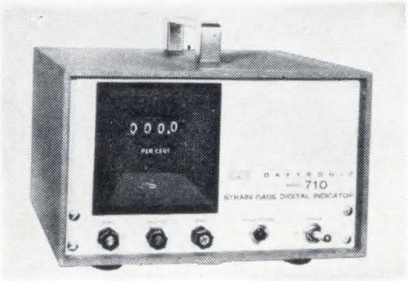
Snap-action switch in miniature size

The new type 23 series miniature snap-action switch is said to offer unparalleled mechanical life and electrical rating. Mechanical life exceeds 20 million operations and the switch is rated at 10 amps, 125/250 v a-c resistive. Operational to 180°F, the switch is available in spdt (form C), normally open (form A), or normally closed (form B) contact arrangements. A "heat dam" slot to eliminate the flow of solder and flux inside the case is



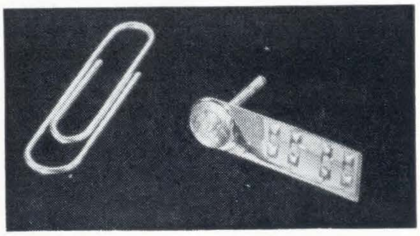
provided on solder terminal models. The type 23 is also available with screw or quick-connect terminals. Integral roller and straight lever actuators are available.
Licon Division Illinois Tool Works, Inc., 6615 W. Irving Park Road, Chicago, Ill. 60634. [316]

New Instruments



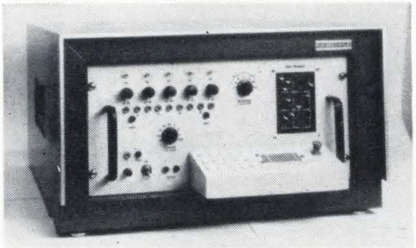
Strain gage digital indicator

Precise, digital indication of load, torque, pressure, thrust, and other quantities measurable with resistance strain gage transducers is achieved with the model 710 strain gage digital indicator. Designed for both industrial and research applications, the compact, solid state instrument combines the versatility of widely adjustable zero, span, and signal damping with the long-term stability and accuracy of an automatic null-balance circuit. The instrument is accurate to 0.15% of scale and is adaptable to all commonly used resistance strain gages and transducers. Electrical output is available for operation of auxiliary recorders or data processing equipment. Price is $495.
Daytronic Corp., 2875 Culver Ave., Dayton, Ohio 45429. **[351]**



Transducer measures differential pressures

This bidirectional differential transducer, model SDT, is 0.250 in. in diameter and 0.024 in. thick. Pressures are applied to a port opening in the bottom of the transducer and to the top surface. The unit is available in several different pressure ranges: ±2 psid, ±10 psid, ±15 psid, ±30 psid and ±100 psid. All models can be flush or surface mounted without special mounting fixtures. A small tube with an o-d of 0.073 in. extends from the back of the transducer so flexible tubing can be attached for supplying a reference pressure, or measuring a second pressure some distance from the first. Especially useful for measuring differential pressures in wind and shock tunnels, and use in airfoil profile studies, the SDT transducers operate over the temperature range from below −40°F to +150°F. Special models are available for measuring differential pressures in water or other liquids.
Scientific Advances, Inc., 1400 Holly Ave., Columbus, Ohio 43212. **[352]**



Portable test set for integrated-circuits

A portable, manually operated test set has been introduced for measuring d-c parameters of integrated circuits with high accuracy and reliability. The series 400 is designed for the applications engineer or the device evaluation engineer who must make accurate measurements on small numbers of devices. It will replace power supplies, meters and interconnecting wiring with a single package and a readout device. Weighing about 98 lb, the series 400 is approximately 13 in. high, 23 in. wide and 25 in. deep. Operation is manual, and the set performs one test at a time. High accuracy readout can be performed by using a digital voltmeter with the set; low accuracy readout with an oscilloscope, and go/no go readout by visual interpretation. Price of the series 400 is $4,900.
Fairchild Semiconductor Instrumentation, 844 Charleston Road, Palo Alto, Calif. **[353]**

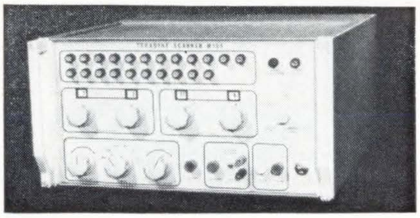
Instrument measures frequency difference

Model 527 frequency difference meter measures the instantaneous frequency difference between two precision standards. The unit incorporates a center-reading front panel meter and oscilloscope pattern for reading out difference to parts in 10^6, 10^7, 10^8, 10^9, 10^{10}. Scope pattern tuning allows parts in 10^{11}. Recording output is available on the rear panel. Three and one-quarter inch rack or cabinet mounting is optional. Input frequencies for signal and reference input standards may be 100 kc, 1 Mc, 2.5 Mc, or 5 Mc. Price is $3,500.

Tracor, Inc., 1701 Guadalupe, Austin, Texas 78701. **[354]**

Reed relay scanners offer versatility

New reed relay scanners have been developed that switch at speeds up to 400 steps per sec. They are designed to identify, sort, control and record medium-power, low-level, and r-f signals. Said to be the most versatile units yet designed for handling different power levels and frequencies, the scanners contain switching modules that may be added as required to increase capacity, or removed from the scan cabinet and placed close to the signal source to eliminate separate amplifiers when the signal must be transmitted over long distances. True random access, double-time delays, and many other control and packaging features also add to their versatility. Most important from



the performance standpoint, according to the manufacturer, is the fact that the scanners are very carefully guarded and shielded to prevent degeneration through crosstalk and leakage of common mode rejection; and that the thermoelectric offset is several orders of magnitude lower than usually associated with equipment of this type. This reduces inherent limitations on accuracy, sensitivity, and bandwidths, thus making the scanners suitable for low level and high accuracy measurements where stray signals and high impedances would ordinarily limit their use. Operating modes can be selected on the front of the control panel, and are available at the rear of the cabinet for external electrical control. Applications for the scanners range from computer linkage and communications trunking down to 10^{-18} watt measurements that require operation over a broad range of electrical levels and impedances.

Teradyne, Inc., 87 Summer St., Boston, Mass. **[355]**

Precision-adjustable signal conditioner

A new signal conditioning unit, called the SSZ-1 switchable span and zero unit, is a precision-adjustable input divider containing a zener-diode-regulated power supply for zero suppression, elevation and calibration. It may be used on any potentiometric recorder with the proper span and input impedance characteristics. The unit provides switchable spans of from 1 mv to 12.5 v full scale, with a continuous adjustment of 1 to 2.5 times the selected span. Zero adjustment is ± 100 mv on the 4 to 50-mv spans; ± 1 v on the 100 mv to 500-mv spans and ± 10 v on the 1 to 12.5-v spans. Input impedance on the 5-mv span is 60,000 ohms and increases to 1.2 megohms on the 100-mv span and above. The SSZ-1 has an internal zener diode power supply which is used for either zero adjustment (elevation or suppression) and also as a voltage source for calibration of the recorder with which it is being used. Price is $325.

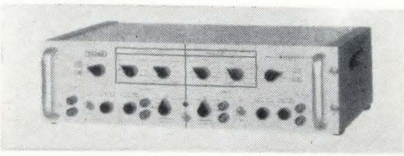
Westronics, Inc., 3605 McCart St., Fort Worth, Texas. **[356]**

Telemetry checkout works automatically

It is now possible to test the 18 IRIG channel vco's of a frequency-modulated telemetry system in 2 minutes by use of Telecheck, a portable and automatic telemetry checkout system. By applying a calibrated d-c voltage to the vco input, Telecheck automatically checks the vco output frequency to determine if it is within a selected frequency boundary. The system employs 5 uniform steps in testing each of the 18 number and 5 letter IRIG channels. Telecheck automatically steps from one test point to another if the frequency being calibrated is within limits. Out of tolerance deviations stops the cycle and visual indicators show high or low results. A manual control is employed to advance check past test points found to be out of the preselected boundaries. The boundary limits may be selected to accept a 1% or 2% error in vco output fre-

quency. The system also contains a crystal oscillator for self-calibration.

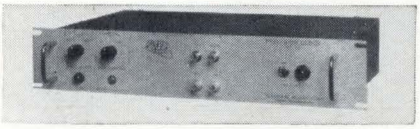
Standard Precision, Inc., P.O. Box 1297, Wichita, Kansas 67201. [357]



Tunable filter for multiple use

Model 723 may be operated as a low-pass, high-pass, band-pass, or band-reject tunable filter. Two completely separate filter sections are housed in a single instrument package. The cutoff frequency of each filter section is adjustable from 1 cps to 100,000 cps. As a low-pass filter, the response extends to d-c. The attenuation rate may be either 36 db/octave or 72 db/octave. Panel height is 5¼ in. The instrument is useful in rejecting the noise spectrum in telemetry and communications applications. Other applications include sound and vibration studies, geophysical and seismological investigations, and general laboratory use. Price is $1,390.

Dytronics Co., Inc., 5566 North High St., Columbus, Ohio 43214. [358]



Stable oscillator in precision clock

Model PC-111 precision clock contains a basic oscillator of 1×10^{-8} stability, and fail-safe logic producing pulse outputs at periods of 1, 10, and 100 μsec and 1.0 millisec. It features push-button digital stepping of the output pulse position to enable setting of the clock to within 10 μsec of time reference. The output pulse may be either advanced or retarded by a fixed time period, as determined by a step duration selector switch.

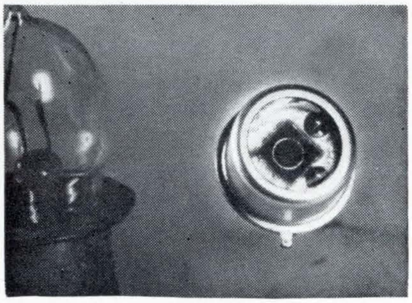
Aerospace Research, Inc., 130 Lincoln St., Boston, Mass. 02135. [359]

New Semiconductors

Monolithic-type integrated circuits

Three new monolithic integrated circuits are announced for use in DTL logic circuits. Offered in either a TO-5 can or a flat pack, the new units are the RC221, a dual two-input NAND/NOR gate; the RC222, a single three-input NAND/NOR gate; and the RC229, a dual three-input NAND gate. Designed primarily for commercial and industrial applications, the RS221 and 22 feature high speed with a turn-on time of 22 nsec and a turn-off time of 24 nsec. Prices, in quantities of 100 to 999 are: \$12.10 each for each model in a TO-5 can and \$14.40 each in a flat package.

Raytheon Co., Semiconductor Division, 350 Ellis St., Mountain View, Calif. **[331]**



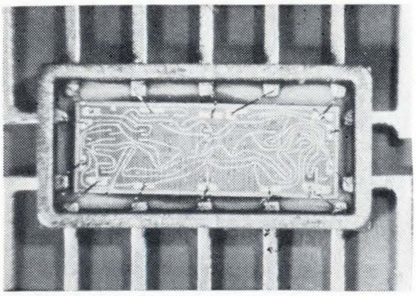
Silicon diodes for use with lasers

Two new silicon, photovoltaic diodes perform the functions of mixing and detecting. They are designed for operation with solid-state gallium arsenide emitters and lasers. Designated the L4503 and L4504, the diodes exhibit a peak spectral response at 0.85 micron with greater than 50% of the peak value being obtained from 0.6 to 1.0 micron. In addition, they feature large light-sensitive areas of 3.5 mm^2 while maintaining typical diode cutoff frequencies of 300 Mc and 600 Mc, respectively. One of the units is illustrated, with a flashlight bulb on the left indicating size. Both diode types utilize planar passivated fabrication techniques and are packaged in a hermetically sealed metal case for maximum reliability. A glass window exhibiting excellent transmission characteristics over the usable diode spectral range of 0.5 to 1.0 micron permits the incident energy to fall directly on the active area of the diode. The L4503 has a breakdown voltage of 50 v. The L4504, with a breakdown voltage of 90 v, can be operated at higher reverse voltage levels permitting higher cutoff frequencies. In addition to their excellent performance as detectors and mixers for emitter and laser radiation, the low leakage current, fast response, broad spectral bandwidth, and low noise characteristics of these diodes make them useful in many other applications. These include high speed readout, laser ranging, single event monitoring, and star tracking. The L4503 and L4504 cost \$65 and \$75 respectively in quantities of 1 to 9.

Philco Corp., Special Products Operation, Lansdale, Pa. **[332]**

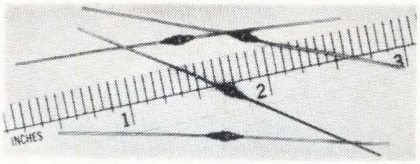
Integrated-circuit differential amplifiers

Two differential amplifiers have been added to the series 52 line of linear Solid Circuit semiconductor networks. The SN523A (illustrated) and SN524A low-level amplifiers are built entirely within monolithic bars of silicon, with fully isolated npn and pnp transistors in the same structure. The two networks are fabricated from the same Master Slice wafer; only the deposited internal interconnection pattern is changed. The SN523A features both differential inputs



and differential emitter-follower outputs, providing considerable design flexibility. The amplifier is designed with a resistance network in the emitters of the input stage, allowing gain to be adjusted over a wide range (40 to 70 db) simply by shorting various lead combinations. The SN524A includes a Darlington input which gives a high typical input impedance of 5 megohms. Another feature is the large dynamic output range, typically 15 v peak-to-peak, single-ended. Voltage gain is a typical 60 db. Frequency response for both units is typically d-c to 150 kc; both operate from ±12-v power supplies. The series 52 Master Slice bar contains two pnp and five npn transistors, with each transistor usable as a diode if desired. The circuit bars also contain six tapped resistors with values from 400 to 50,000 ohms.

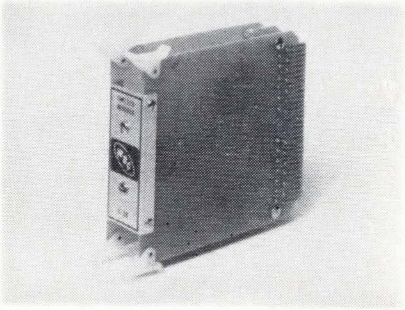
Texas Instruments Inc., 13500 North Central Expressway, Dallas, Texas. **[333]**



Universal zener is highly stable

This new zener now enables standardization on one item to fill needs for six different power ratings from 400 mw to 3 w. Zener voltages are available from 6.8 v to 400 v in a package size said to be smaller than presently available 250 mw units. The whiskerless construction of the UZ zener is obtained by metallurgically bonding pins and silicon dice of identical diameter. A hard glass sleeve is fused onto the junction to form a monolithic void-free hermetic seal. The end result is a part 0.160 in. long by 0.085 in. in diameter, that offers 3 w operating power, 50 w surge, high stability and high shock and vibration immunity. Volume prices vary between 49 cents and $1, depending on quantity and zener voltage specified.

Unitrode Corp., 580 Pleasant St., Watertown, Mass. **[334]**



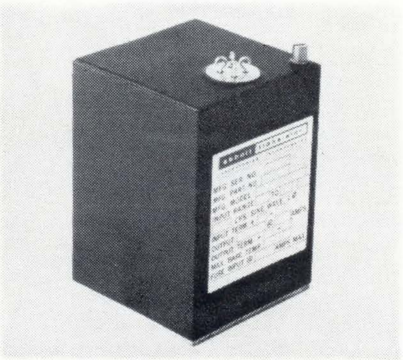
Multiple-switching plug-in module

A module has been developed for double-throw switching of 12 to 28 functions. Coil voltages are 6 to 110 v d-c and 110 v a-c. Contact ratings, noninductive, are 3 amps make and break and 5 amps carry. Modules may be racked for multichannel switching, bulb switching, read-out panel and computer display panel functions, and many other purposes. Standard modules are for a 31-pin connector but almost any size can be readily supplied. Price is $95.

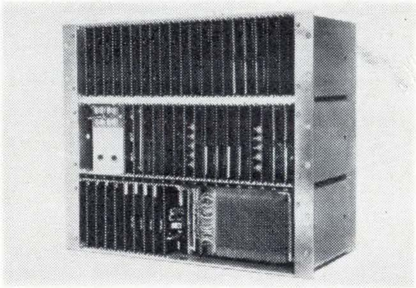
Western Biotronics Co., 240 Barham Ave., Santa Rosa, Calif. **[371]**

High-temperature power modules

A family of Hi-Temp compact power modules is designed for 400-cycle power and capable of sustained full-load operation at 212°F (100°C). At 50-w output power, this U5/GB5 series provides any output voltage required from 5 v d-c to 3,650 v. Latest modular design techniques are employed in units of this class to provide a package as small as 2¾ in. by 2¾ in. by 4 in., which weighs just 2½ lb. Use of quality components, including all silicon semiconductors which are assembled with sound thermal design, insures a highly reliable solid-state device with long service life. Housed in rugged steel containers fused to thick aluminum bases, these converters are hermetically sealed and encapsulated to meet the tough environment of MIL-E-5272C at the high temperature so often encountered in missile, space, and airborne systems. The modules also feature isolation of outputs and inputs, a 12% adjustment range from the nominal output voltage, close regulation (0.2%) for line variations of 105 to 125 v a-c, and a regulation of 0.3% for loads varying from ½ load to full load. Price is $395.



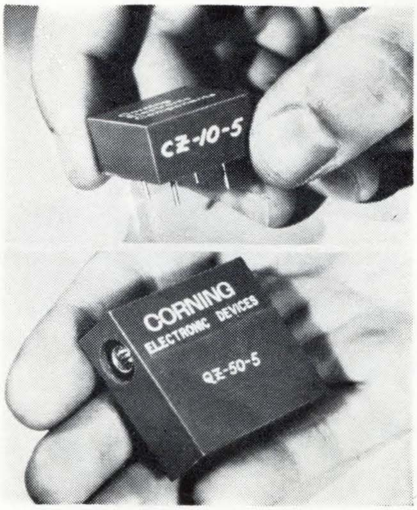
Abbott Transistor Laboratories, Inc., 3055 Buckingham Road, Los Angeles 16, Calif. **[372]**



Memory system exhibits high speed

A coincident current memory system, the 52.02 has a read/write cycle time of 2 μsec and an access time of less than 1 μsec. It is available with capacities up to 16,384 words, each 52 bits long, and features low temperature coefficient cores and silicon semiconductors to provide an operating temperature range from 0°C to +65°C. All logic circuitry is hermetically sealed to provide the maximum degree of reliability under all environmental conditions. Logic functions are performed by diode-transistor NAND circuitry with levels of 0 and +6 v. Compact overall dimen-

sions are only 19 in. wide by 10½ in. deep and 28 in. high for a 4096 × 30 system. To realize maximum system flexibility, the 52.02 is capable of operating in a variety of modes: read/restore, clear/write, and split-cycle. Input/output circuitry, capacity, and power requirements are available to meet virtually all memory system applications.
Ferroxcube Corp. of America, Saugerties, N.Y. [373]



Glass memories offer high-speed storage

Two new glass memories offer high-speed serial storage of 10 to 250 bits. They operate at rates of 10 Mc and 50 Mc with access times of 1 to 5 μsec. Small size and light weight make the units suitable for both commercial and aerospace applications as shift registers and scratch-pad memories. The 10-Mc memory can be obtained with attached drive and sense amplifiers using either discrete components or thin-film circuitry. The 50-Mc unit is designed for use in advanced data processing equipment. Both memories are made from Code 8875 Zero TC glass, a special composition with a nominal zero temperature coefficient of time delay. The 10-Mc memory measures 1 by 1 by 0.5 in. and is terminated by four wire pins extending through the bottom of the case. The 50-Mc unit measures 1.5 by 1.75 by 0.5 in. and is equipped with standard connectors on each end of the case.
Corning Glass Works, Corning, N.Y. [374]

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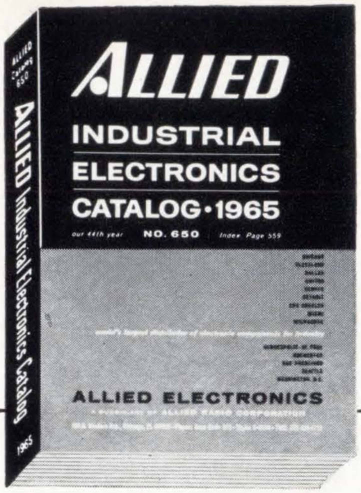

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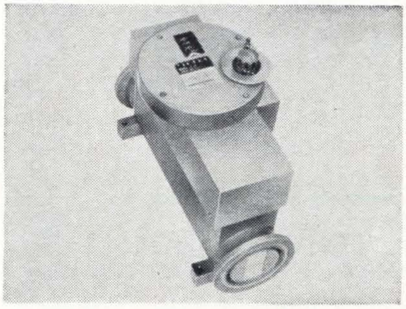
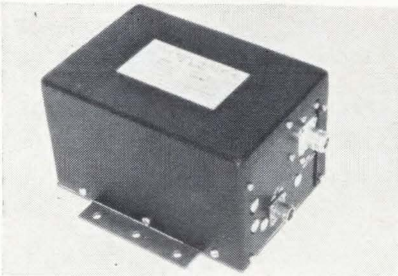


Direct reading band-pass filters

These compact, lightweight filters, tunable from 960 Mc to 12,400 Mc, eliminate the need for reference to calibration charts. According to the manufacturer, they save tuning time, are easy to use, easier to read and reduce the incidence of error. Units are available for frequency reading or channel reading in two or four-cavity designs. The direct-reading dial assemblies are adaptable to all the company's low-cost standard band-pass filters. They can be flush mounted to a front panel. Applications include troposcatter, radar, laboratory and communications.

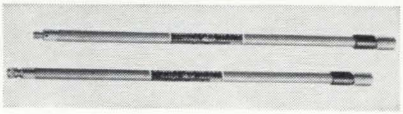
Gombos Microwave Inc., 40 Webro Road, Clifton, N.J. **[391]**



Crystal-controlled microwave oscillator

The c-w power output of the D91C2 crystal-controlled oscillator is 1 w minimum at 6 Gc. All-solid-state circuitry permits generation of microwave energy directly from d-c or a-c sources in a 5 in. by 5 in. by 7 in. conduction-cooled module weighing 6½ lb. Input power required at 28 v is 50 w including crystal oven. Performance proven for beacon application in aircraft and missile environments, this lightweight unit provides a long-term frequency stability of 1 part in 10^7 and maintains spurious signal rejection greater than 30 db. Minor variations on the basic oscillator design provide electronically tunable operation; pulse, phase or f-m modulation. Addition of a $\times 3$ multiplier stage provides a high-stability, Ku-band paramp pump source with an output level of 200 to 300 mw. Prices are $3,000 to $5,000 depending upon specific requirements.

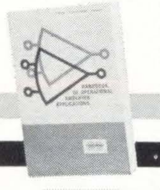
Sperry Microwave Electronics Co., P.O. Box 1828, Clearwater, Fla. **[392]**

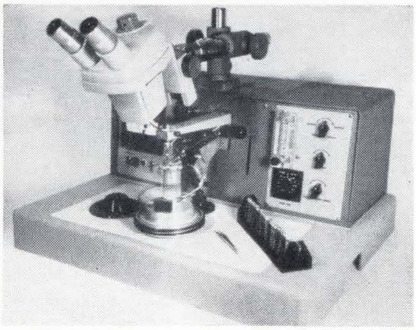


Coaxial terminations span 2 to 12.4 Gc

Highly stable, broadband (2 to 12.4 Gc) coax sliding terminations are announced. They can be used to evaluate the residual vswr of coaxial slotted lines, as well as the vswr of couplers and attenuators. The terminations are useful in laboratories to standardize miniaturized coaxial impedance measuring equipment and to determine the vswr of RG/141 r-f cables, connectors and adapters designed for RG/141 cables. When connected to the output of coaxial connectors, the slide control serves to reduce the effect of the termination. Available in two models—4372 M and 4372 F—with miniaturized NPM connectors, the units have a terminating element vswr of 1.05 (maximum). Their power capability is 10 w (average); 2.5 kw, peak. Improved efficiency is afforded by the use of a precision-formed tapered iron-powder element. Size is 13¼ in. minimum by 17¼ in. maximum (approximately). Price is $200.

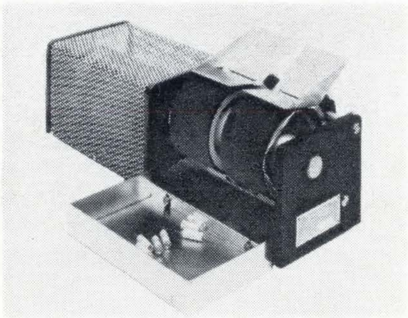
Narda Microwave Corp., Plainview, L.I., N.Y. **[393]**





High speeds possible in aluminum bonding

High-speed thermocompression bonding of aluminum wire is now made possible by utilizing a new concept in wire handling. Bonding speeds are said to be far greater than nail head bonding. Bonds are achieved by a method of automatically handling wire and removing tails in one operation. The device is bonded with a gentle wedge shape on both the die and the post for maximum reliability. Wire diameters of 0.0003 to 0.010 in. are within the capability of model 1102 aluminum wire bonder. Micro Tech Mfg., Inc., 1246A Birchwood Drive, Sunnyvale, Calif. [421]

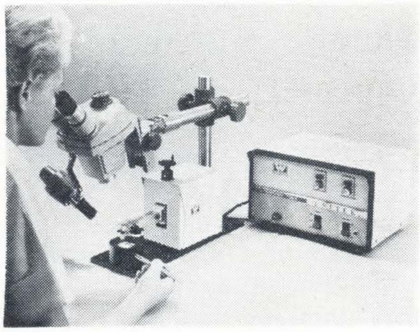


Lead straightener fed by hand

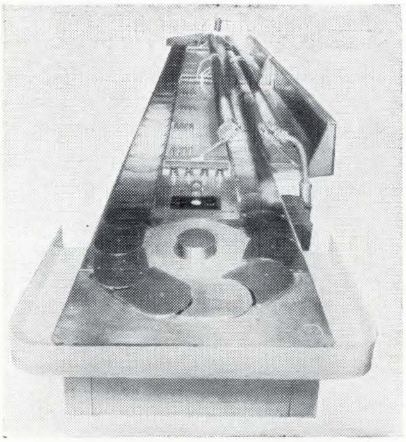
A low cost, hand-fed, portable lead straightener is available for resistors, capacitors and other axial lead components. It is said to be ideally suited for processing short run quantities of components where no succeeding operations are needed, and as a pre-straightener before mechanical finishing operations. The device is easily operated, and is adjustable for components with body lengths ranging from 1/4 in. to 2 1/4 in., and overall lengths from 2 1/8 in. to 7 3/4 in. While straightness will depend to some degree on the lead material, components with lead lengths of 1.5 in., bent at approximately 30°, can generally be straightened to within the shadow of the body. Many components with bends greater than 30° can be processed if manually pre-straightened. Output is dependent on operator dexterity and conditions of the components before processing. Under average conditions, output of 2,000 an hour can be expected. The standard model 2415 is priced at $495 east of the Rockies; $520 west of the Rockies. Universal Instruments Corp., Binghamton, N.Y. [422]

Flatpack welder with dual sensing

Wide variations in flatpack lead and printed-circuit pad dimensions are completely compensated for in a new production welding system. Called the Unibond welder, the solid-state system incorporates a sensing circuit which compensates during each weld to provide the correct amount of energy to insure reliable welds. It is self-adjusting to lead and pad volumes varying as much as 3 to 1, using only one force and energy setting. Dual sensing circuit eliminates blowouts and need for weld schedules. The Unibond model 1124 power supply provides constant amplitude control to compensate for lead and pad variations. It also automatically adjusts the pulse duration between



1 millisec and 10 millisec during the weld cycle, thus providing additional compensation for variations in lead and pad volumes. Amplitude and pulse duration controls are digital readout. Delivered energy is 7.5 watt-sec. Repetition rate is 60 welds per minute. Unibond weld head is model 1125 with compliant, self-aligning tips and adjustable gap control. Force is adjustable over a range of 8 oz to 10 lb with digital readout. Actuation is optional hydraulic, treadle or swing foot pedal. Provision is made for mounting of optics and illumination. System price is $1,950 plus accessories.
Weldmatic Division/Unitek, 950 Royal Oaks Drive, Monrovia, Calif. [423]



Conveyor systems used in heat processing

A line of vibrationless, horizontal, flat-bed conveyor systems is announced for use with various types of heat-processing equipment. Principal applications include the curing of epoxy resins; drying of finishes, cements and adhesives in small parts assembly; packaging and heat sealing; curing of solder resist in printed circuits; and production brazing. Each conveyor system can incorporate a variety of production heating equipment, such as thermal radiation, dielectric, induction, convection, and plasma arc torch. System modifications can be made to suit individual production requirements. The conveyors are available with a variety of drives, either fixed or variable speeds, manual or automatic control.
Velotron, Inc., 1186 Broadway, New York 1, N.Y. [424]

New Books

Physics for electronics

An introduction to Electronics
B.V. Rollin
Oxford University Press,
New York, 1964, 216 pp., $4.80

Although there are many electronics textbooks written on the senior-to-graduate engineering level, this particular volume has several notable distinctions.

Above all, this is a concise though complete summary of the basic physics that underlies modern electronics. Presented without oversimplification, and including all necessary mathematics, the volume provides the basis for further study of circuits, devices, components and systems ranging from resistors to parametric amplifiers and lasers. Electromagnetic radiation, elements of microwave, semiconductors, radar, nuclear magnetic resonance and optoelectronics are some of the topics covered.

The volume serves very well to point out how limited the physical foundation is on which the electronics industry is built. A senior engineering student or a technical man in some field other than electronics would obtain from this book a keen though somewhat abbreviated picture of electronics.

Since the text is only an introductory one, each chapter carries a bibliography for further study. The final chapter lists the procedures and apparatus for a course of fifteen experiments, which would appear to be unusually sophisticated for an elementary text book.

New handbook

RCA Receiving Tube Manual, RC-23
Radio Corporation of America
Electronic Components and Devices
Harrison, N.J., 1964, 608 pp., $1.25

Probably one of the most used handbooks in the electronics industry, RCA's useful volume has once again been revised and expanded.

Only active receiving-tube types are covered in detail by the new technical data section, and another section contains defintive data, in tabular form, on the renewal and discontinued tube types. The application guide section has been expanded to include 42 specific function classifications. Data is provided for RCA picture tubes, both black-and-white and color, as well as for voltage-regulator and voltage-reference tubes.

Other features, such as the text chapters and the circuit section, are unchanged from previous editions.

Network analysis

Linear Electric Circuits
By Wallace L. Cassell
John Wiley & Sons, New York
1964, 603 pp. $10.75

Written on a junior-sophomore level, this textbook is remarkably thorough as an introduction to circuit theory. Starting with the introduction of the rotating-phasor concept and the waveform-model transformations, the author develops the response of circuits to steady-state and transient functions in terms of a simple linear circuit and a generalized exponential function.

The Laplace transformation and the elementary solutions derived from it are dealt with next, and a table of Laplace transform pairs is included. Application of transforms to circuits and time-domain concepts are then introduced. The necessary mathematics is given with the circuit work, so that only basic calculus is needed.

The next chapters deal with power and energy considerations, physical circuit models, resonance, reactance and susceptance calculations, so that network topology is introduced only in the 10th chapter. This is followed by the mesh and nodal-pattern solutions, equivalent network theorems, polyphase systems and locus diagrams. Bode plots and two-port network theory follow, preceding two chapters on practical filter design and operation, including filter transformations, Butterworth approximations and the Chebyshev filter-design method.

The volume concludes with Fourier series and wave analysis, having given the reader a thorough and up-to-date treatment of linear networks.

All chapters are accompanied

by, numerical problems and illustrations. The emphasis is on practical design; no superfluous theory is introduced. The integrated treatment of the necessary mathematics, together with appendices on complex numbers and hyperbolic trigonometry, obviate the need to refer to mathematical texts.

Math as a tool

Laplace and Fourier Transforms for Electrical Engineers
Edward J. Craig
Hold, Rinehart and Winston, Inc., New York, 1964, 516 pp., $13.50.

The application of Laplace and Fourier transforms in engineering design—a sore point with many practitioners—receives refreshing treatment in this book. Besides serving as a college text, the volume is designed for the practicing engineer as a refresher and as a reference. The author, who is an industrial consultant and a professor, points out throughout the text errors common to students, and then lists ways of avoiding them.

A basic knowledge of electrical theory and calculus is presupposed by the author.

An unusual and helpful feature is a preview chapter, which orients the reader in general terms to the contents of the volume.

A chapter on sources, signals and circuits sets the groundwork for the mathematical meat of the book with the necessary concepts from network analysis. The Laplace transform is introduced next, in a chapter describing its properties and direct application.

The following chapter covers the methods of solving transformed equations. The inverse transform and the Laplace expansion theorem are explained next. This section ends with matrix network analysis and matrix algebra.

Fourier series and transforms, both general and special, are treated next. The three final chapters deal with the applications of Fourier transforms to circuit problems such as different modulation systems, practical filters—including Butterworth and Chebyshev filters—and the solution of noise problems.

George V. Novotny
Advanced Technology Editor

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Technical Abstracts

No transformer

A one-transistor flip-flop
B.E. Briley,
Automatic Electric Laboratories
Northlake, Ill.

A transformerless, one-transistor flip-flop has been constructed using the collector-following effect.

The collector-following effect occurs when a saturated transistor, connected in the common-emitter configuration with a large collector resistor, has its base potential rapidly changed in the direction of cutoff. The collector voltage "follows" the base voltage, and remains at the furthest point of its voltage excursion for some time before rising to that of the collector supply voltage.

This effect is contrary to most published descriptions of transistor behavior, but it has been observed and reported for the special case of alloy junction transistors.

A qualitative description of the collector—following effect is given. When the transistor is heavily saturated, a large emitter current flows and β drops to a very low value, e.g., 1/30. The base current is then approximately equal to the emitter current which makes the collector current small by comparison. At the emitter-base junction, electrons are injected into the base (for npn) at a high-level to support the heavy emitter current. These electrons experience a low mortality rate in the base, because the base width is short compared to the diffusion length. These electrons diffuse into the collector, forward-bias the collector-base junction, injection electrons into the base and holes into the collector. The result, at equilibrium, is a net rate of charge flow equal to the collector current.

When the base potential is rapidly reduced to a level below that of the emitter, the emitter-base junction becomes reverse-biased. The collector potential will follow the base potential during its drop, because current is not available to change the potential at the collector-base junction. The excess charge in the base and collector must be removed by recombination and collector-base current. Thus, the mechanism of the collector-following effect consists of storing a charge with a low impedance source (the emitter-base circuit), and removing it with a high impedance sink (the collector-base circuit) and recombination.

The period during which the collector voltage follows the base voltage is a function of the resistance in the collector circuit.

A versatile precision delay can be obtained using the collector-following effect. Also, since the collector-following effect is sensitive to minority carrier lifetime, it could be applied to radiation detector circuits.

Presented at the 1964 Western Electronic Show and Convention (Wescon) Aug. 25-28, Los Angeles

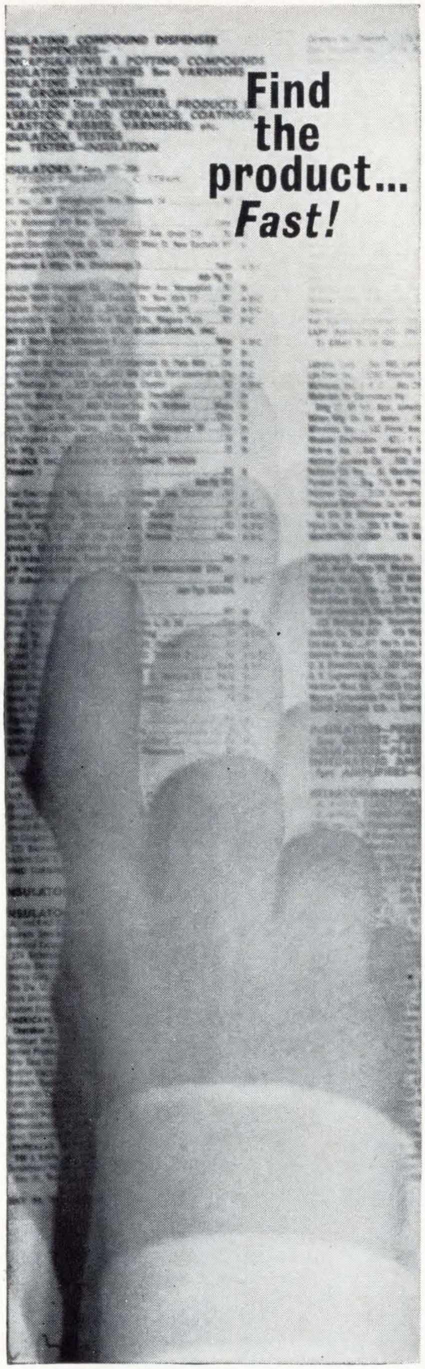
Space electronics

Future communication satellites
Robert L. Walquist
TRW Space Technology Laboratories
Redondo Beach, Calif.

An appraisal of the future of communications satellites shows that serious thought is now being given to nuclear power sources, new types of communications antennas, laser communications and new applications for communications satellites including contact with the far side of the moon.

Power sources described include nuclear turbo electric units, solar collectors, fuel cells, thermoelectric converters and oriented solar cells. A nuclear reactor combined with a turbogenerator in the SNAP-8 program can produce electrical power in the 50-kilowatt range, but weighs 5,000 to 6,000 pounds requiring a larger booster. After the satellite is positioned in orbit, a radio isotope generator can generate electric power.

To improve antenna performance, the next step being considered for the immediate future is to concentrate all the radiated power from a satellite in the direction of the earth and then to direct it to a localized area. At synchronous altitude (22,300 miles), the antenna beamwidth to cover the visible area of the earth is about 18°. If only



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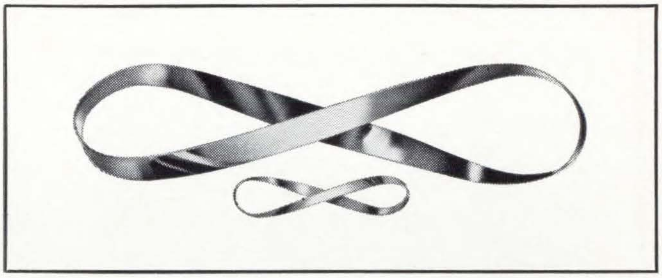
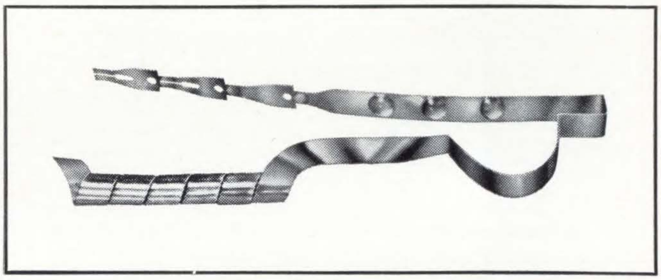
REFRACTORY METALS APPLICATION NOTES

There's no end to G-E molybdenum ribbon and its uses.



General Electric flattened wire molybdenum ribbon is available in continuous lengths in an almost infinite combination of thicknesses and widths, bare or nickel clad, gold or silver plated. Temper can be varied from as-rolled to dead soft.

Bend it, twist it, die form it, punch it, pull or coil it. It can be formed by almost any mechanical operation.



G-E moly ribbon's strength, moderate weight and ability to remain electrically conductive and provide a high modulus of elasticity even at high temperatures makes it ideal for many applications.

Its uses include high temperature contact springs, furnace windings, helices for traveling wave tubes and cross-straps for frame grid electronic tubes. Where can you use it?

Get wrapped up in G-E molybdenum ribbon. Write today for complete data. General Electric Co., Lamp Metals & Components Dept., 21800 Tungsten Road, Cleveland, Ohio 44117. Or call (216) 266-2970.

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the continental United States were to be covered, the beamwidth could be reduced to 6.3°. To do this, the satellite would have to be attitude-stabilized and as the antenna beamwidth becomes narrower, the attitude stabilization system must become more accurate.

The system aboard the Orbiting Astronomical Observatory is designed to have pointing accuracies of a few seconds of arc. Larger antennas or higher communications frequencies would help achieve the narrower bandwidths.

In the laser field, beamwidths of several seconds of arc have already been achieved. In a test in the millimeter wave region, a 15-foot antenna operating at 94 Gc had an effective beamwidth of less than 0.1° used with a 3.2 mm radiometer.

Two methods of using communications satellites to maintain contact with the far side of the moon are also discussed in this paper. One involves communications from the far side of the moon to a satellite and then from the satellite to earth. The orientation of the satellite's antennas must be such that one antenna always faces the moon and the other faces the earth.

The number of satellites around the moon could be reduced if satellite-to-satellite communications were employed. In this case, the lunar satellite network would be used to relay signals to a point on the front side of the moon. From there, the signals could be sent directly to the earth.

For deep space communications, surface relay stations on the moon will probably provide a much more stable reference for narrow beam communications than can be expected with artificial earth satellites. Such moon stations would receive signals from deep space in the millimeter band or by means of lasers.

The moon station would then relay the information to earth at a frequency that could penetrate the earth's atmosphere. Two moon relay stations are required to provide continuous deep space communications as the moon orbits the earth.

Presented at the International Convention on Military Electronics, Sept. 14-16, Washington

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NATIONAL COVERAGE

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

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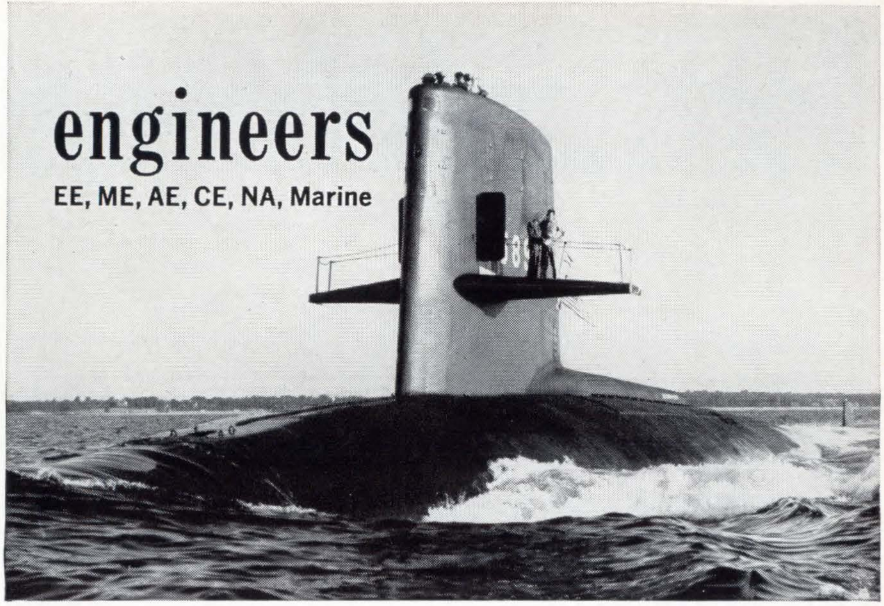

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2. For work in connection with the design and installation of interior communications, navigation ship control and/or fire control equipment and systems.
3. To develop control systems and to prepare component specifications for electric plant equipment. Involves power plant fluid system/electrical system design, AC/DC power distribution systems design, motor and controller design and/or application, electric plant test or maintenance.
4. For design of instrumentation and control systems with application for both surface ships and submarines, requiring experience in servomechanisms, pneumatic and electrical controls circuitry.

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HEWLETT-PACKARD: 120AR Scope **$245**; 151A Scope Plug-in **$85**; X281 Adapter **$15**; 350A Attenuator **$35**; 380A Attenuator **$95**; 400A VTVM **$65.00**; 400C VTVM **$80**; 400D VTVM **$145**; 400HR VTVM **$185**; 410B VTVM **$145**; 415B SWR Meter **$135**; 430B Power Meter **$95**; 430C Power Meter **$145**; 506A Tach Head **$85**; 520A Scaler **$265**; 623B Shf Test Set **$645**.

TEKTRONIX: 112 Amplifier **$95**; 161 Pulse Generator **$65**; 162 Waveform Generator **$65**; 516 (MOD 101) Scope **$645**; 535 Scope **$595**; 541 Scope **$495**; Z Plug-in **$295**.

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KEPCO POWER SUPPLIES: SR-12-50 **$395**; SC-32-5 **$185**; SC-32-10 **$225**; SC-32-15 **$275**; SC-150-1 **$185**; SC-300-1 **$275**; 2SC-32-1.5 **$175**; 2SC-100-0.2 **$185**; SC-3672-0.5 **$135**; SC-3672-1M **$195**; PSC-10-2 **$195**; PSC-20-2 **$195**.

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B&K INSTRUMENTS: 1014 Audio Oscillator **$695**; 2110 Audio Spectrometer **$1,245**; 2305A Level Recorder **$1,095**; 2603B Voltmeter/Amplifier **$395**.

BECKMAN: 5914 In-Line Readout **$175**; 5630-37 Predetermined Counter **$125**; 7350R Electronic Counter **$475**.

SANBORN: 356-5840W 6-Channel Recording Oscillograph **$1,450**.

BRUSH: BL-262 Dual Channel Recorder **$245**; BL-530 Dual Channel Amplifier **$195**.

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ESTERLINE-ANGUS: 5-0-5 Ma. Recorder AW **$135**.

STATHAM INST. CO. TC-5B/2-3 Temperature Test Chamber **$495**.

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DuMONT OSCILLOSCOPES: 304H **$115**; 304AR **$165**; 301A **$145**.

KROHN-HITE: 340A Servo Design Filter 0.01 to 100 cps **$125**.

GERTSCH: PT-1R Ratiotran **$145**. ST-100A Transformer **$45**.

BALLANTINE: 300E VTVM **$165**.

BARNES: Type 4 Data Recorder **$750**.

SORENSON: FCD3P 1000-M1 Frequency Changer **$1,450**.

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6	600	.99	1	25KV	45.50
8	600	1.09	2	6000V	15.00
10	600	1.35	2	10KV	33.50
14	600	1.98	2	16KV	65.50
32	600	3.50	5	10KV	65.00
40	600	4.15	9	10KV	105.00
1	3000	2.15	15	5000	39.50
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the *Searchlight Section*
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Equipment Opportunities

New Literature

Tape recorder/reproducer. Leach Corp., 1123 Wilshire Blvd., Los Angeles 17, Calif., offers a 6-page brochure on the MTR-3200 instrumentation quality, portable tape recorder/reproducer. Circle **451** reader service card

Electronic circuit modules. Bryant Computer Products, 850 Ladd Road, Walled Lake, Mich., has published three new data sheets describing its NAND circuit 8050, gate driver 8060, and read-mode switch 8090 electronic circuit modules. [**452**]

Oscilloscope probe. WMA Andersen Co., Inc., Pleasant Valley, Conn., has issued a bulletin on a waveform-amplifying oscilloscope probe designed for use in the computer and communications fields where extremely low-level waveforms exist. [**453**]

Magnetic materials. The Arnold Engineering Co., Pacific Division, 1551 E. Orangethorpe Ave., Fullerton, Calif. A six-page illustrated brochure describes the company's capabilities for fabricating and supplying magnetic shielding materials. [**454**]

Radar absorptive material. McMillan Laboratory Inc., Brownville Ave., Ipswich, Mass. 09138, has available a 4-page brochure on Multi-Core, an absorptive material that reduces the effectiveness of radar detection. [**455**]

Lasers. Korad Corp., 2520 Colorado Ave., Santa Monica, Calif. 90406. An eight-page catalog covers a line of optically pumped and semiconductor lasers and laser accessories. [**456**]

Magnetoresistance multipliers. American Aerospace Controls, Inc., 123 Milbar Blvd., Farmingdale, N. Y. A two-page application bulletin describes the use of magnetoresistance multipliers as the active element in analog divider circuits. [**457**]

Programer. Lundy Electronics & Systems, Inc., Glen Head, N.Y. 11545, has published a 4-page brochure entitled "Digital Tape Programmer." [**458**]

Positioning control. General Electric Co., Schenectady 5, N. Y., has issued bulletin GEA-7674 on a simplified numerical control system for automatic positioning of production machines. [**459**]

Digital system modules. Digital Equipment Corp., Maynard, Mass. A 250-page catalog describes a complete line of 50-kc, 5- and 10-Mc digital system modules and accessories. [**460**]

Component temperature-test systems. The Scionics Corp., 8900 Winnetka Ave., Northridge, Calif. A 4-page brochure illustrates and describes systems for the temperature testing and processing of semiconductors, microcircuits and other components. [**461**]

Pressure transducers. F&F Engineering, Inc., Maple Shade Industrial Center, Maple Shade, N. J., has published a brochure on pressure transducers and load cells that utilize wire and semiconductor type sensors. [**462**]

Core, plane and stack testers. Computer Test Corp., Route 38 & Longwood Ave., Cherry Hill, N.J., offers a 26-page technical booklet on automatic memory core, plane and stack testers. [**463**]

Pressure measuring system. Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif., announces bulletin 1164 describing its universal electromanometer, a rugged, precision pressure measuring system featuring secondary standard accuracies. [**464**]

Instrumentation. The Singer Co., Metrics Division, 915 Pembroke St., Bridgeport, Conn., has released four new individual catalog digests covering each of its major lines of field and laboratory measuring instruments and related products. [**465**]

Phase-to-voltage converter. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343. A 2-page bulletin describes model 791 phase-to-voltage converter which utilizes a solid-state silicon design. [**466**]

Electronic counter. Lavoie Laboratories, Inc., Morganville, N. J., has available a 2-page catalog sheet providing details on the LA-82 electronic counter with 50-Mc direct counting range. [**467**]

Conductive epoxy compound. Technical Wire Products, Inc., Cranford, N. J. Preliminary data sheet RF-501 contains applications, limitations, physical and electrical properties of CE-2700 conductive epoxy compound for metal-to-metal bonding. [**468**]

Ultrasonic cleaning systems. Branson Instruments, Inc., 37 Brown House Road, Stamford, Conn. Bulletin S-867 describes the A series automatic ultrasonic cleaning systems. [**469**]

Solder cream. Alpha Metals, Inc., 56 Water St., Jersey City 4, N. J., has issued bulletin 40 on screenable solder cream 890-06, a combination of pre-alloyed solder and rosin flux formulated for micromodule work. [**470**]

Epoxy resins. John C. Dolph Co., Monmouth Junction, N. J. A 4-page brochure gives technical data on epoxy resins specifically formulated for casting, potting and dipping. [**471**]

Data modem. Lenkurt Electric Co., Inc., 1105 County Road, San Carlos, Calif., has issued a brochure describing the 26B Duobinary-Datatel data modem, which provides 2400 bits-per-sec data transmission over standard 3-kc voice channels derived on cable, open-wire, or microwave radio systems. [**472**]

Insulation materials. National Beryllia Corp., First & Haskell Aves., Haskell, N. J., offers a compact and up-to-date chart on mechanical and electrical properties of beryllium oxide and pure oxide ceramics. [**473**]

Relays and switches. Automatic Electric Co., Northlake, Ill. Bulletin C-1053-A lists more than 200 kinds of relays stepping switches and accessories available off-the-shelf. [**474**]

RAYTHEON DIGITAL PRODUCTS

EQUIPMENT/SYSTEMS

for today's needs and tomorrow's speeds

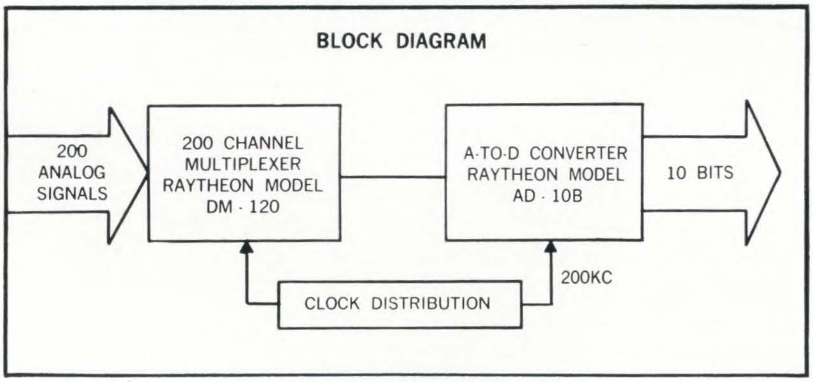
Application Note #2

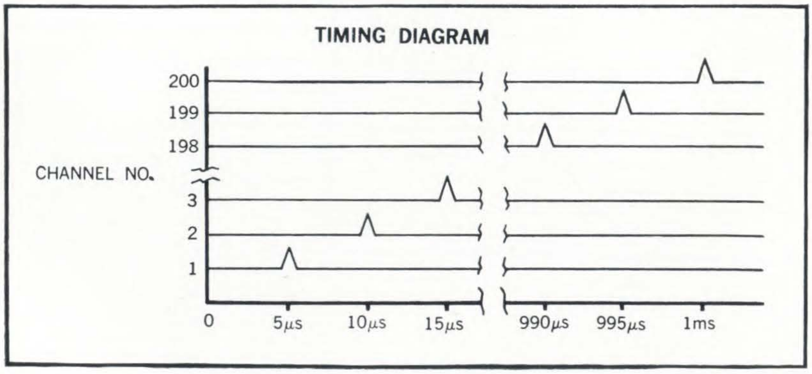
This is the second in a series of helpful application engineering tips from Raytheon . . . leader in impulse instrumentation for the high-speed data processing field.

PROBLEM: To digitize multiple inputs (200) in a very short period of time or within close time correlation (1 millisecond).

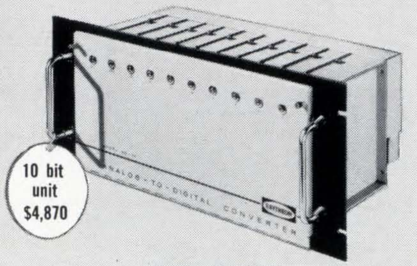
SOLUTION: The system illustrated in the block diagram sequentially samples 200 input signals in 1 millisecond in the Raytheon Model DM-120 Multiplexer. Used with the associated analog-to-digital converter, Raytheon Model AD-10B, the system is capable of digitizing the signals to a 10 bit accuracy at a 200 KC rate or a 2 MC bit rate.

This system overcomes, **for the first time,** the economic disadvantage of using a number of A-to-D converters which run at a slower conversion rate and require additional buffering at their output.



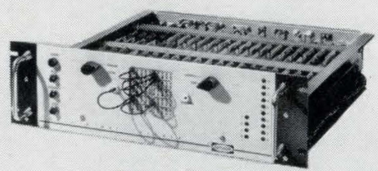


For complete application notes covering this system write (on company letterhead) to: Dept. E-1064



AD-10B Ultra High Speed A/D Converter

Raytheon's Model AD-10B is a solid-state, high speed unit capable of up to 250,000 complete 10 bit conversions per second at 0.1 percent accuracies. Its combined speed and accuracy are ideal for applications requiring burst data acquisition.



DM-120 Multiplexer

The Raytheon Model DM-120 Multiplexer provides 24 analog switches per unit (expandable to 576 channels in multiple arrays) plus addressing and sequencing logic. The switches are used to connect many analog signals into one A-to-D converter at multiplexing rates up to 1 million channels per second. The unit is capable of super commutating as well as de-multiplexing.

FREE TRIAL OFFER!

Evaluate a Raytheon AD-10B Converter in your own facility at our expense. Contact your Raytheon representative or call collect: Ron Eisenhauer, Area Code 617, 762 - 6700, extension 406. **Raytheon Company, CADPO, 1415 Providence Turnpike, Norwood, Massachusetts.**

RAYTHEON

Electronics Abroad

Volume 37
Number 28

Great Britain

Technology chief

The hopes and fears of Britain's electronics industry are focused largely on a former truck driver.

He's Frank Cousins, chief of the new Ministry of Technology that was created two days after the Labor Party was voted into power.

It's Cousins' job to fulfill Labor's pledge to boost Britain's production by automation and advanced technology. He's in charge of all advanced industrial technologies—atomic energy, inventions, and all of the government's civilian electronics and computer activities.

Union leader. Cousins, 60 years old, was a surprise appointee. As head of Britain's biggest labor union—the Transport and General Workers Union—he didn't seem likely to spur automation that might cost jobs.

But Cousins' philosophy was expressed succinctly when he said, "There is no need to fear automation, for automation and technical progress should be designed to take the labor out of life." Now observers see him as ideally suited to "sell" the British worker on new machines and manpower policies.

The new Technology Minister is expected to spur the placement of more research-and-development contracts in consumer and industrial electronics. Government assistance to the computer industry, by ordering further in advance and by relaxing some specifications, is also on Cousins' agenda.

Distinguished aide. Cousins' chief aide will be Charles P. Snow, a novelist and researcher in molecular structure.

Sir Charles' books stress the interaction of science and the humanities. They include "Corridors of Power" and "The Two Cultures and the Scientific Revolution."

Further steps. The new government's most immediate problem is the gap between imports and exports, now at the third-highest level ever—$300 million a year.

Labor bigwig Frank Cousins

The Wilson Administration has already imposed a 15% surcharge on imports and has granted tax concessions for exporters. Both steps could have strong repercussions in the electronics industries in Britain and the United States. Britain now imports $42 million of her electronic instruments, 32% of this coming from American companies.

The new administration of Prime Minister Harold Wilson includes supporters of subsidies and other incentives to strengthen the British electronics industry's position in the world markets. If their proposals are adopted, U. S. companies could encounter increased competition around the world.

'Merger' in flatpack

Ferranti, Ltd., is combining integrated semiconductor circuits and thin-film components to produce complete instrument-channel subassemblies in a single flatpack.

The company is already producing complete amplifier networks of three or four stages. The customer merely has to connect the package between an input transducer and output terminals.

The approach is stirring considerable interest in Britain. Unit cost is lower because Ferranti can use integrated circuits now in production and supplement them with thin-film resistors and capacitors.

Ferranti adds that making thin-film components separately also increases reliability.

Ceramic strip. The flatpack is about 1¼ by 2¼ by ⅜ inch. Diffused-silicon integrated-circuit chips are kept cool by mounting them on a ceramic strip that provides a heat-conduction path to the package surface. Glass substrates carrying the thin-film circuits are mounted on each side of the ceramic strip. Thermocompression-bonding interconnects the circuits with gold wire.

Ferranti declines to identify the ceramic, explaining that would disclose the manufacturing process.

The thin-film capacitors are silicon monoxide sandwiched between aluminum electrodes on a glass substrate. Capacitor values up to 0.5 microfarads are simulated by using the Miller effect on a one-nanofarad capacitor connected in an integrated-circuit amplifier. The Miller effect, which is used extensively in the time-basis circuits to generate linear sweeps, results when a capacitor is coupled between the input and output of an amplifier device. Feedback increases the apparent size of the capacitor.

The thin-film resistors are of nickel-chrome. Resistor values range up to four megohms per square inch.

3 subsystems made. Three basic subsystems are in production: an a-c input/d-c output control amplifier for amplifying and detecting carrier-borne signals, an a-c servo amplifier, and a d-c chopperamplifier with a drift of less than 10 microvolts per degree centrigrade.

Each assembly has about 25 transistors and 10 diodes, and provides complete signal amplification. The a-c-to-d-c amplifier, for example, includes an a-c input amplifier with a gain of 900 followed by a differential amplifier coupled as a full-wave, phase-sensitive demodulator.

The demodulated output feeds into a d-c output amplifier capable of providing ±100 milliampere drive.

A complete subsystem costs about $280.

Brazil

Color tv in Rio

"Nineteen sixty-five will be the boom year for color tv," says a network executive in Brazil, where only about 1,000 color sets exist and only 2.5 million homes have black-and-white television in a population of 80 million.

The prediction is made by Alberto Maluf, technical director of Televisao Excelsior S.A., Brazil's second-largest tv network. Excelsior has backed up its forecast with cash—$180,000 for color equipment from the Marconi Co. of Britain. This includes a live camera with burst generator, flag generator and color plexor, three color monitors and color tape recorders. Transmitter equipment would cost about $80,000 more.

Excelsior says it plans to go on the air next year with variety programs and live telecasts of soccer games in color. The network has stations in Rio de Janeiro, Sao Paulo and Porto Alegre.

Started last year. Brazil's oldest and largest network, Televisao Tupi, began broadcasting in color on May 1, 1963. It put three programs on the air, including "Bonanza" from the United States. The telecasts have stopped, but Tupi says this is only until new contracts are negotiated.

Tupi is equipped to transmit in color. It has a TT6AL transmitter made by the Radio Corp. of America, a videcon camera, a 16-millimeter projector and a slide projector, all for color. But it has no gear for filming color programs.

Color sets are subject to heavy import duties in Brazil and cost as much as $1,000. And manufacturers aren't inclined to begin domestic production.

Wavering voltage. An official of one tv manufacturer declares: "When Brazil is ready for color sets we'll be ready to make them. But we can't envision successful color tv in Brazil in the foreseeable future because of erratic voltage and frequency."

Stabilization still seems far off in underpowered Brazil. The quality of the Tupi color broadcasts was described by one engineer as "poor."

However, television is expanding rapidly. Ten years ago there were no stations in Brazil; today there are 40.

Germany

Fog detector

An early-warning system for fog has been devised by physicists at Impulsphysic GmbH in Hamburg. It uses powerful ultraviolet beams of about one billion candlepower, transmitted in pulses of below one microsecond.

As described by Frank Frungel of Impulsphysic, backscatter from the light is received by a phototube and a broadband amplifier with an automatic measuring bridge for determining the light's peak value. With low visibility, the backscatter signal creates a high impulse voltage on the phototube. Twice the visibility gives half the backscatter.

The device, which has been field-tested for six months, is designed to detect backscatter from minute droplets of water that will become fog in an hour or two, but that are invisible even in daylight. The detector can operate in full daylight as well as at night.

The pulse-light transmitter attains a peak intensity of several megawatts in the region of 1,000 to 5,000 angstrom units.

Japan

Home edition

"Turn on your radio or television set to get the daily newspaper." That's what two Japanese companies may one day be urging newspaper readers to do.

Mainichi Shimbun, whose daily circulation of 2.8 million is the third-largest in Japan, has been demonstrating a facsimile system in the Seibu department store, 7.6 miles from the paper's publishing plant in Tokyo. It uses equipment made by the Toho Electric Co.

The Japan Broadcasting Corp. (NHK), the noncommercial quasi-governmental broadcasting system, has a much more ambitious program. It's developing a system to deliver a complete facsimile newspaper to its radio or tv subscribers.

96 seconds a page. The Toho device uses a three-watt transmitter to feed 469-megacycle signals into a yagi antenna at the receiver in the store. Voice is broadcast on the main carrier; the fascimile signal uses an f-m subcarrier that is used in the United States for subsidiary communications authorization. A one-page news bulletin can be printed while a program is on.

The receiver is a modified version of an electrostatic office unit made by the A. B. Dick Co. It receives the contents of one sheet of paper in 96 seconds to match the information rate of the narrow-band channel available.

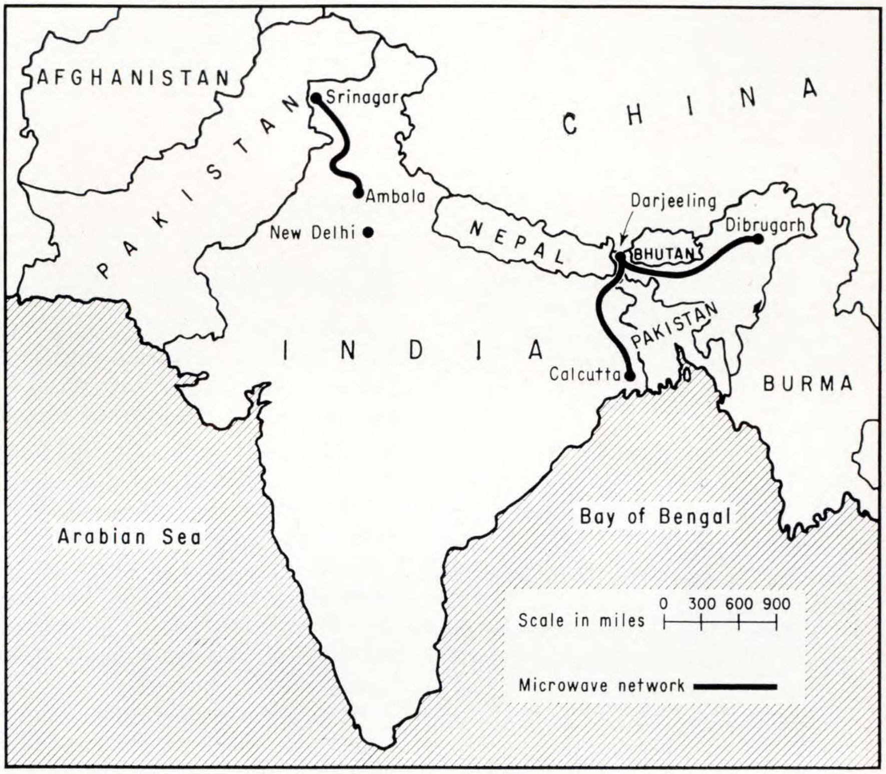
Toho concedes that its receiver is still too large and too expensive.

Frets over freeloaders. For NHK's bigger plans, the subsidiary channel is too narrow. The broadcasters hope to gain access to a two- or three-megacycle chunk of the ultrahigh-frequency band, which is still comparatively empty.

NHK says there are still two bugs in its equipment: high cost and unauthorized reception. The company is supported by subscription fees from listeners.

Turnabout. Several other big Japanese newspapers have commissioned electronics firms to devise facsimile systems. Some consider this a way to boost their circulations. To others it's a wedge to get into broadcasting. They've been barred from tv and a-m, but there's still no commercial f-m in Japan.

But NHK's effort in newspaper facsimile reverses the situation. It's a case of a broadcaster threatening to invade the newspaper business.



China

Sampling Scope

A sampling scope with a bandwidth of one gigacycle has been described by Li Chin-lin in Tien Tzu Hsueh Pao, a Communist Chinese technical publication.

The first sampling oscilloscope in the United States was built in 1958 by Lumatron Electronics, Inc., now General Applied Science Laboratories, Inc. It had a bandwidth to about 500 megacycles, thereby expanding waveform viewing from somewhat below 100 megacycles. A range to one gigacycle was obtained about two years ago, and plug-ins have now carried the technique up to 3 to 4 Gc.

The Chinese scope uses a generator producing pulses one nanosecond wide, and a sampling gate consisting of two microwave crystal detectors having a bandwidth of one gigacycle. The vertical section has a rise time of less than 0.5 nanosecond used with noise less than two millivolts. Operation to 2 Gc appears to be possible.

The article gives no indication whether the scope is being produced in China.

India

Through the Himalayas

Like the United States, India is beefing up her communications with far-off defense areas. Washington is strengthening the electronic network through such trouble spots as South Vietnam. New Delhi has begun work on microwave links with remote regions in the Himalaya Mountains near India's borders with Communist China and Pakistan.

China invaded India in 1961 and still occupies some territory formerly held by India. India also has had friction with Pakistan along India's northeastern and Northwestern frontiers.

1,100-mile arm. One arm of the $10-million microwave project will extend 1,100 miles. Starting in Calcutta in the northeast, it will go north to Darjeeling, then loop eastward through Tezpur to Dibrugarh in the state of Assam.

Another arm, in the northwest, will consist of a 300-channel system from Ambala, just north of New Delhi, to Srinagar, 300 miles to the north in the state of Punjab.

Company expanding. One effect of the project is an expansion of Indian Telephone Industries, Ltd., to produce most of the necessary equipment. The microwave network is scheduled for completion by mid-1965; by the end of that year, partly as a result of the impetus generated by that communication system, the government-owned company plans to be producing, in quantity, transistorized insulation testers, counters, and fault-finders for coaxial cable, as well as vacuum-tube voltmeters.

India plans to buy $4 million of equipment for the first stage of the communication network. Most of this is being supplied by the Nippon Electric Co. of Japan; some has been ordered from Italy.

The government has had trouble installing overhead wires or coaxial cable in the mountainous terrain in the north. The microwave equipment is being designed to withstand 100-mile-an-hour wind.

Soviet Union

Computers vs. capitalism

There's a race going on in Russia between creeping capitalism and the electronic computer.

Soviet economic planners are facing the hard fact that Marxist theory is inadequate when confronted with the complexity of modern production and marketing. This spurs activity in two fields:

- Officials have begun to develop ways of "bending" communist doctrine, even talking about incentives and profits.
- Soviet engineers are engaged in a crash program to develop a general-purpose computer system for a communist-planned economy.

A recent survey showed that attaining the Soviet government's economic goals for 1980 by present methods would require full-time planning by every man, woman and child in Russia. That would leave nobody to run the factories. The only solution would be high-speed computers with vastly greater capability than anything now available.

Profits. Nearly two years ago, Prof. Yevsey Liberman of Kharkov University suggested that present production norms for factories be replaced by profitability norms. A plant manager's success should be based on how efficiently he produces, Liberman contends, rather than on how many units his plant turns out.

Liberman's view receives strong support from V. A. Trapeznikov, a specialist in process controls and a full member of the Soviet Academy of Sciences.

Trapeznikov, 59 years old, envisions a system in which every plant would be responsible for finding markets for its products, and in which price bargaining based on quantities and distances involved could be permitted. He is also identified with proposals that at least a portion of the "profits" from each plant be split among workers as an incentive to produce more and better goods.

Computers. The Liberman-Trapeznikov approach would involve calculating such factors as raw materials, handling costs, depreciation and production efficiency. It would require acceleration of electronic data-processing in the Soviet Union. There's evidence that the Russians are already working on software suitable for such a system.

At present, electronic data-processing is used only by the largest plants in Russia. Unlike Western factories, Soviet plants aren't interested in using the technique for profitability studies—at least not yet.

Canada

Alpha beta—now gamma

A solid-state detector of gamma rays, 10 times more sensitive than any now in use, is in pilot production at the RCA Victor Co. of Montreal, an associate of the Radio Corp. of America.

The device should be useful in low-energy physics, for measuring the excited states of atoms. Physicists have been unable to catalog the characteristics of some atoms because of inability to pick up the gamma rays the atoms emit. One big problem has been noise; a low-noise amplifier, developed with the detector, permits detection of signals that formerly were lost in noise.

The equipment also can measure the existence and effects of radioactive fallout.

Drifting lithium. The detector, to be sold for about $1,000, is produced by drifting lithium ions through an n-type crystal of germanium. It was developed jointly by RCA and Atomic Energy of Canada, Ltd., at Chalk River, Ont. The joint effort produced alpha detectors in 1959 and beta detectors in 1961.

Temperature is a major problem overcome by the new detector. Operated at —200°C, it must be stored at —20°C or lower because lithium ions in germanium are highly mobile at room temperature. Yet these detectors can be shipped at room temperature and reconditioned upon arrival.

RCA says it chose germanium because silicon has a higher photoelectric cross-section—about 50 times that of germanium at low energies and even greater at high energies.

The project is led by Rene Whitehead of RCA and A. J. Tavendale of Atomic Energy of Canada.

Color them slow

The technology is ready, production lines are tooled up and consumer demand seems to be building, but color television is still years away in Canada—perhaps as far off as the 1967 World's Fair in Montreal.

The government, which must approve color television, won't even consider the matter until 1965. A hearing, scheduled Nov. 3, has been postponed indefinitely by the Board of Broadcast Governors.

One reason for the latest delay may be cost. The government-owned Canadian Broadcasting Corp. recently completed a microwave network for distributing programs to about 50 affiliated stations and is committed to building broadcasting centers in Montreal and Toronto. It may not be ready to assume the added cost of a color-tv system, estimated at $20 million.

Another obstacle is the political necessity of also providing color telecasts to the French-language network.

Industry impatient. The Electronic Industries Association of Canada insists the public wants color tv now. It notes that ownership of color receivers is expected to climb this year from 2,130 to 7,000 despite the fact that color telecasts can be picked up only in cities close to the United States.

A spokesman for the association estimates that $60 million of color sets could be sold next year in Canada if Canadian programs were available.

D. C. Marrs, vice president for consumer products at the Westinghouse Electric Corp.'s Canadian subsidiary, assails the uncertainty as a "great obstacle" to the development of color tv in Canada.

Canadian Westinghouse has special reason for disappointment. It is ready to produce Canada's first color tv sets at its Brantford, Ont., plant. Two other companies—the RCA Victor Co. and the Canadian Marconi Co.—also have advanced plans for producing color-tv sets. RCA is an affiliate of the Radio Corp. of America.

The road to commercial electronics

Electronics and IIT Research Institute to sponsor conference on diversification

On December 1st and 2nd in Chicago, Electronics magazine and the Illinois Institute of Technology Research Institute will sponsor a conference to study the special problems of entering the civilian electronics market efficiently and profitably.

HOW TO DIVERSIFY

Although top management in defense-oriented electronics companies recognize the need to diversify into other market areas, the big problem has been how to go about it. Commercial operation demands different philosophy, organization and procedures than those to which military suppliers are accustomed.

THE ROAD TO COMMERCIAL ELECTRONICS

This two-day conference will have separate sessions devoted to the elements of product planning, marketing, engineering and manufacturing — highlighting in each case the difference between military and civilian outlooks with special emphasis on roadblocks to be overcome for profitable operation.

INDUSTRIAL LEADERS

Speakers have been chosen on the basis of their long and successful experience in commercial markets. These industrial executives will describe practical approaches to solving the problems of invading commercial markets. Dr. L. T. Rader, vice president of the General Electric Co.'s Industrial Electronics division, will keynote the conference, discussing "The management view of commercial operations."

THE CONFERENCE PROGRAM

Session I. Product Planning

1. Comparing commercial and military product planning
2. What is a good product idea?
3. Panel: How we do product planning in:
   Consumer electronics
   Industrial electronics
   Medical electronics

Session II. Engineering

1. Engineering organization and philosophy for commercial products
2. Cost consciousness in design
3. Profile of the engineer needed for commercial work

Session III. Manufacturing

1. Slanting production to commercial markets
2. The engineering aspects of commercial manufacturing

Session IV. Marketing

1. The basis for commercial marketing
2. Marketing opportunities
3. Marketing panel
   Consumer electronics — The retailer's view
   Industrial electronics — The distributor's view
   Medical electronics

REGISTRATION

The conference will be held at Grover M. Hermann Hall, 3241 South Federal Street, Chicago, on the Illinois Institute of Technology campus. Registration fee is $30.00. The fee includes the Tuesday luncheon. Registration forms are available by writing to:

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IIT Research Institute
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Chicago, Illinois 60616

Electronics
A McGraw-Hill Market-Directed Publication
330 West 42nd Street, New York, N.Y. 10036

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November 2, 1964

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F. J. Eberle, Business Mgr.

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