Electronics®

Processing radar signals optically: page 58
Error-control coding in communications: page 70
Special report — Electronics in Europe: page 81

December 27, 1965
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Below: Focus on electronics in European markets: page 85

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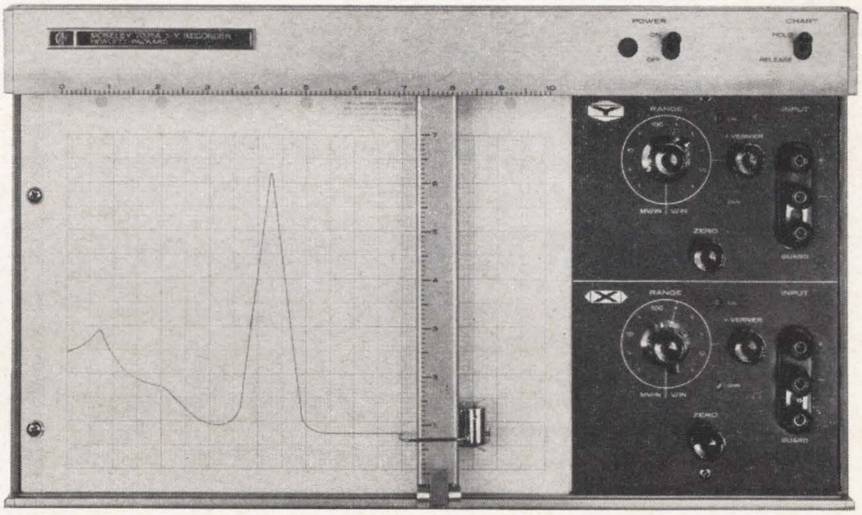

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Electronics

December 27, 1965
Volume 38, Number 26

Electronics Review

Probing the News

Electronics Abroad

Technical Articles

Electronics

Electronics: December 27, 1965, Vol. 38, No. 26

Printed at 99 North Broadway, Albany, N.Y., 12207
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

Another laser pioneer?

To the Editor:

The article "What's a laser patent worth?" [Sept. 20, p. 137] says that the confusion surrounding the development of the injection laser or the semiconductor laser is even greater. I would like to clarify the situation.

Jun-ichi Nishizawa, a professor at Tohoku University and manager of the Semiconductor Research Institute, Sendai, Japan, together with Yasushi Watanabe, president of Shizuoka University, applied for a patent for "semiconductor masers" on April 22, 1957. The patent was granted in Japan on Sept. 20, 1960, two years before the announcement of the observation of laser action in gallium arsenide in the United States.

Ichiemon Sasaki
Semiconductor Research Institute
Sendai, Japan

No camera needed

To the editor:

The Nov. 29 article concerning the Perkin-Elmer laser tv camera was quite interesting. Unfortunately, I do not understand why it was necessary to use a photomultiplier instead of a vidicon or orthicon. Was it because these devices are not sensitive enough to receive the laser light or was it to simplify the circuit?

There might possibly be an advantage to using an image intensifier backed up by a vidicon. It would simplify the scanning requirements of the laser beam.

Bernard Fudim
Calvert Electronics
New York, N. Y.

▪ The multiplier phototube was used for simplicity and economy. One advantage of the laser tv system is that it does away with orthicons and vidicons.

Then there were . . . four

To the Editor:

In your article regarding the power failure, "When the lights came on again" [Nov. 29, p. 101]

All from Sprague!

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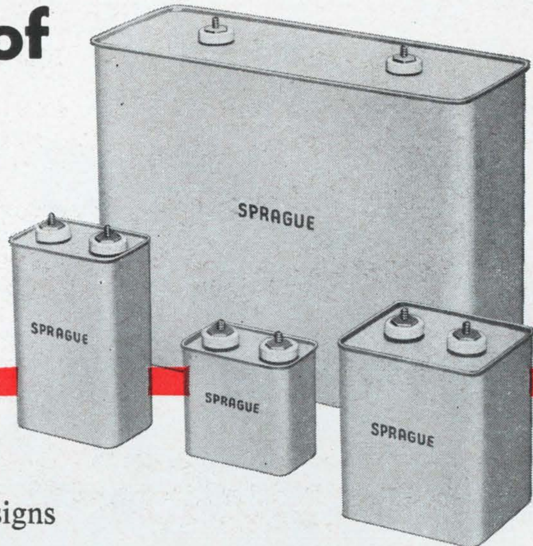
for every type of discharge application



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you state that "While broadcasting stations with emergency generators in the blacked-out Northeast transmitted to transistor radios in streets, restaurants, office buildings and at home, the television transmitters were dead. But few receivers had operating power anyway."

We would like to advise you that one television transmitter did not go dead. WKTV in Utica, N. Y., went on its emergency generators at both the studio and transmitter immediately and continued to operate throughout the blackout, and we can guarantee that we had a minimum of four viewers, people who we personally know had battery-operated transistor television receivers.

D. T. Layton

Chief Engineer
WKTV
Utica, N.Y.

A patented approach

To the Editor:

The deep-sea Geiger counter [Nov. 15, p. 43] for continuous measurement of oxygen in water at depths down to 6,000 feet might be improved by use of a method described in my U. S. patent 2,711,482 (June 21, 1955).

Instead of piping the water and thallium (Tl-204) ions through a small, stainless steel pipe inside the Geiger counter, the solution could flow over or through a scintillation detector (for example, a plastic) which is mounted outside the pressurized housing of the photomultiplier and ancillary electronic components. When beta-rays strike the detector, the light released is transmitted to the photocathode through a glass or quartz window mounted in the wall of the housing.

The equipment described in my patent was designed for use in radioactivity well-logging. However, it should be applicable with little modification to radio-release analysis of oxygen in the ocean and for water pollution problems.

Clark Goodman

Vice President-Technical Director
Houston Research Institute, Inc.
Houston, Tex.

The inventor replies:

The theory is good, but the practice is not possible.

Our first thought was to use a thick plastic scintillator as both the transducer and pressure window. However, we were unable even with the thickest plastic to prevent crazing of the material under pressures of more than 500 psi.

Then we adopted the technique which Goodman suggested: namely, using a thin piece of plastic scintillator optically coupled to a thick glass pressure window which was in turn optically coupled to the photomultiplier at atmospheric pressure. Again, this was not successful.

Plastic scintillators craze under even less than 500 psi and become almost useless as scintillators for our purpose. It was for this reason that we developed the Geiger counter with the internal small stainless steel tubing which carries the beta active solution. Incidentally, we achieve electronic simplicity by using Geiger-counter electronics rather than scintillation electronics.

Harold G. Richter

Radiochemist
Research Triangle Institute
Durham, N.C.

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People

Underscoring the Fairchild Camera & Instrument Corp.'s move to broaden its share of the instrumentation market is the recent appointment of **Victor H. Grinich,** 41 years old, as technical director of the company's instrumentation division. The division, which was created seven months ago, had been a department within Fairchild's huge Semiconductor division in Mountain View, Calif. Instrumentation is now located in Clifton, N. J. Despite the move, technical developments in the Semiconductor division are closely coordinated with the needs of the Instrumentation division.

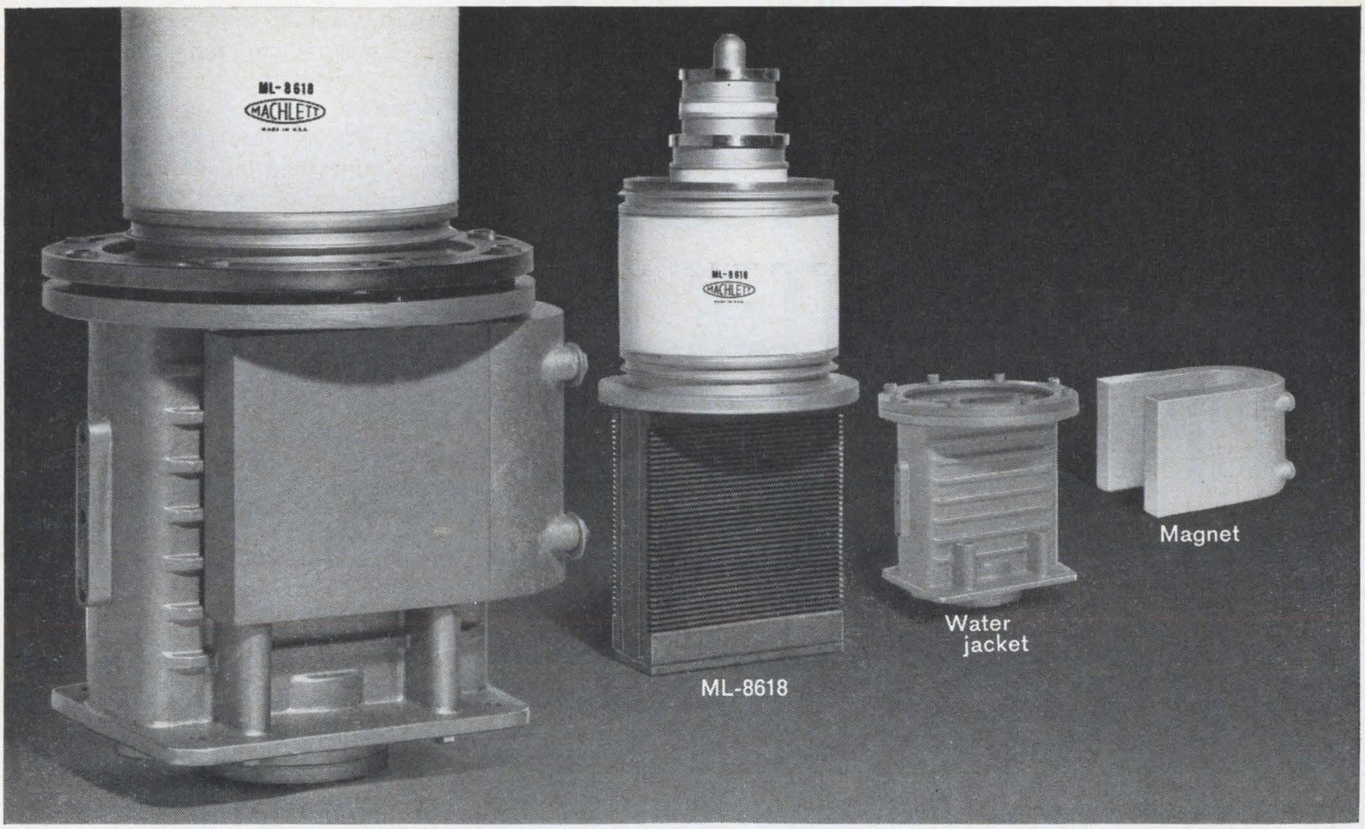
That Fairchild is building bridges between the two units was apparent last week with the shift of Grinich, who had been Semiconductor's manager of applications engineering.

His appointment is probably the last in a round of shifts of Fairchild officials from the Semiconductor unit to top Instrumentation posts. Former marketing manager at Semiconductor, Thomas H. Bay, is now general manager of the Instrumentation division; Robert N. Noyce, Semiconductor's former general manager, is group vice president of both the Semiconductor and Instrumentation divisions; and Charles Askanas, formerly operations manager for Instrumentation's West Coast activities, is now operations manager for the entire division.

The changes offer a good way for Instrumentation to derive more benefit from the company's semiconductor technology, says Grinich, one of the founders of Fairchild Semiconductor.

"We're certain that as our new components get fairly complex, we will have a competitive advantage in the instrumentation business," Grinich asserts. "Most instrument manufacturers are conservative. They didn't accept transistors at first, and now they're very slow to accept integrated circuits. Fair-

200 kW power output with .7 kW drive from magnetically beamed Machlett triode



ML-8618, Machlett's new magnetically beamed water-cooled triode, provides high power gain, high plate efficiency and maximum cathode utilization. Electron trajectory from cathode to plate is magnetically controlled to greatly reduce electron interception by the grid . . . and therefore decrease grid current and heating and allow significantly higher performance levels.

Result: the ML-8618 delivers a typical 200 kW power output with .7 kW drive as a Class C rf amplifier or oscillator. As a switch tube in pulse modulators, it is capable of a maximum 8 Mw high duty pulse. For full operating details, write to The Machlett Laboratories, Inc., Springdale, Conn. 06879. An affiliate of Raytheon Company.

MACHLETT
ELECTRON TUBE SPECIALIST

People

child has a head start in this technology and it will help us gain a more prominent position in the instrumentation field," he adds.

Outlining the Fairchild philosophy in the new organizational setup, Grinich says: "As the semiconductor component technology keeps growing, testing equipment becomes more critical. But on the other hand, the growing instrumentation field needs more sophisticated components. The two are complementary, so why not use the two in-house capabilities to enhance each other?" Fairchild is the only major instrumentation manufacturer that produces its own semiconductors.

Grinich received his bachelor's and master's degrees in electrical engineering from the University of Washington, and his doctorate from Stanford University. He worked at Stanford Research Institute before joining Fairchild.

The Bendix Corp. has formed an optronics division, with **Kenneth R. Stephanz** as general manager. The unit's only product will be Channeltrons, newly developed multiplying radiation detectors.

In selecting Stephanz, who is 38 years old, Bendix turned to a man with experience in both business and engineering. The new manager holds a bachelor's degree in electrical engineering and worked several years with the International Telephone and Telegraph Corp. as general manager of electronic tube operations. He has also served as an executive of several small electronics companies.

Although many of Channeltron's applications are classified, because of the military's interest in the component, this much is known: it will be used in low light level television applications and for detecting x-rays and ultraviolet light in space.

½ to ⅓ the size and less than ½ the weight of conventional units . . .

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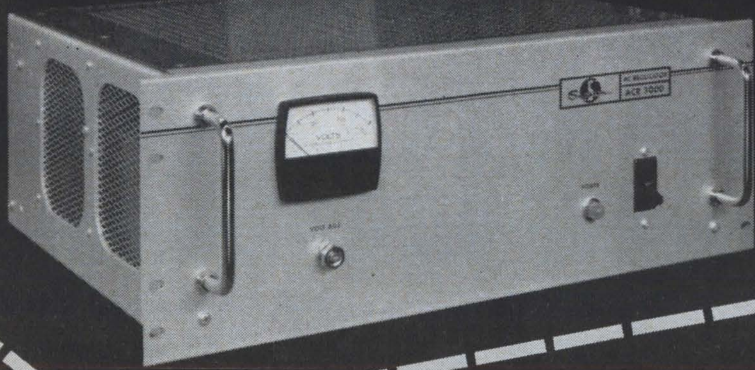

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For complete data on the ACR Series and other Sorensen products, send for the "Controlled Power Catalog and Handbook." Write: Sorensen, A Unit of Raytheon Co., Richards Ave., South Norwalk, Conn. 06856. Or use reader service card number **200**.

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MODEL NUMBER	OUTPUT VA RANGE	REGULATION ACCURACY LINE	LOAD	EFFICIENCY (FULL VA)	TYPICAL POWER FACTOR	TEMPERATURE AMBIENT (°C)	COEFFICIENT (°C)	DIMENSIONS (INCHES) WIDTH	HEIGHT	DEPTH	RACK HEIGHT	PRICE**
ACR 500	0-500	±0.1%	±0.1%	88%	75%	0-50	.03%	15*	5	9	5 1/4	$ 290
ACR 1000	0-1000	±0.1%	±0.1%	90%	75%	0-50	.03%	19	5 1/4	11	5 1/4	340
ACR 2000	0-2000	±0.1%	±0.1%	92%	75%	0-50	.03%	19	5 1/4	15	5 1/4	435
ACR 3000	0-3000	±0.1%	±0.1%	95%	75%	0-50	.03%	19	7	15	7	555
ACR 5000	0-5000	±0.15%	±0.15%	95%	75%	0-50	.03%	19	7	20	7	715
ACR 7500	0-7500	±0.15%	±0.15%	95%	75%	0-50	.03%	19	12 7/32	20	12 7/32	850
ACR 10000	0-10000	±0.15%	±0.15%	95%	75%	0-50	.03%	19	12 7/32	20	12 7/32	1,200
ACR 15000	0-15000	±0.15%	±0.15%	95%	75%	0-50	.03%	19	17 15/32	20	17 15/32	1,500

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Meetings

Solid State Physics Conference, Institute of Physics and The Physical Society; Renold Building, Manchester, England, **Jan. 4-7.**

Sealab II Symposium, U.S. Navy; Statler Hilton Hotel, Washington, D. C., **Jan. 11-12.**

Conference on Electronics in Publishing, American University; International Inn, Washington, D.C., **Jan. 17-20.**

Instrumentation for Process Industries Conference, Texas A&M University; College Station, Tex., **Jan. 19-21.**

Conference on Symmetry Principles at High Energy, AFOSR, AEC, NASA; University of Miami, Coral Gables, Fla., **Jan. 20-22.**

Phonon Interaction in Solids Conference, Princeton University; Princeton, N. J., **Jan. 20-21.**

Helicopter Conference, Helicopter Association of America; Inn of Six Flags, Arlington, Tex., **Jan. 23-26.**

Aerospace Sciences Conference, Statler-Hilton Hotel, New York, N. Y., **Jan. 24-26.**

AE-4 Electromagnetic Compatibility Conference, SAE; General Dynamics/Convair, San Diego, Calif., **Jan. 25-26.**

National Electronic Representatives Association Marketing Conference, ERA; Riviera Hotel, Palm Springs, Calif., **Jan. 26-30.**

American Society of Testing and Materials Spring Meeting, ASTM; Shoreham and Sheraton Park Hotels, Washington, D.C., **Jan. 30-Feb. 4.**

International Symposium on Information Theory, AFOSR, IEEE; University of California, Los Angeles, **Jan. 31-Feb. 2.**

Integrated Circuits Seminar, IEEE, Basic Sciences Committee; Stevens Institute of Technology, Hoboken, N.J., **Feb. 2.**

Winter Convention on Aerospace & Electronics Systems, IEEE; International Hotel, Los Angeles, **Feb. 2-4.**

International Salon of Electronics Components, Federation National des Industries Electroniques; Parc des Expositions, Paris, **Feb. 3-8.**

Solid State Circuits Conference, IEEE, University of Pennsylvania; Sheraton Hotel, Philadelphia, **Feb. 9-11.***

Radioisotope Applications in Aerospace, AFSC and Atomic Energy Commission; Sheraton-Dayton Hotel, Dayton, Ohio, **Feb. 22-24.**

Offshore Exploration Conference, OECON; Lafayette Hotel, Long Beach, Calif., **Feb. 22-24.**

Symposium on Manufacturing In-Process Control and Measuring Techniques, Air Force Materials Laboratory and Motorola Semiconductor Products Division; Hiway House, Phoenix, Ariz., **Mar. 9-11.**

International ISA Aerospace Instrumentation Symposium, ISA, College of Aeronautics; College of Aeronautics, Cranfield, England, **Mar. 21-24.**

International Convention and Exhibition of the IEEE; New York Hilton Hotel and the Coliseum, New York City, **Mar. 21-25.**

Call for papers

Conference on Mass Spectrometry and Allied Topics, Committee E-14 on Mass Spectrometry of the American Society for Testing and Materials; Sheraton-Dallas Hotel, Dallas, May 22-27. **Feb. 15** is deadline for submission of abstracts on subjects related to mass spectrography to Dr. H. M. Rosenstock, National Bureau of Standards, Washington, D. C., 20234.

SPIE Technical Symposium, Society of Photographic Instrumentation Engineers; St. Louis, Mo., Aug. 22-26. **Feb. 15** is deadline for submission of 300-word abstract on aerospace instrumentation, laser applications, optics, range instrumentation, data reduction, and image enhancement processing, to R. T. Hedden, 16 Harneywood Drive, St. Louis, Mo., 63136.

*** Meeting preview on page 16**

Meeting preview

Solid state in Philadelphia

Integrated circuit manufacturers and users will discuss large and complex IC arrays at the keynote panel of the 13th annual International Solid State Circuits Conference in Philadelphia, Feb. 9 to 11. Thirteen panel discussions and 57 papers are scheduled at the meetings, sponsored by the circuit theory group of the Institute of Electrical and Electronics Engineers, the IEEE Philadelphia sections and the University of Pennsylvania.

At the only daytime panel session, keynote panelists will present approaches to large-array integration, including comparisons of conventional and metal-oxide-semiconductor integrated circuits. The economics and problems of interconnection, yield, testing, reliability, packaging, repair and functional capability of integrated circuits will be discussed. Some of these problems will be examined by J. S. Kilby of Texas Instruments Incorporated and J. C. Logue of the International Business Machines Corp.

A second panel discussion, also on large-scale integration but with different panelists, will be held the first evening. M. J. Callahan of Motorola, Inc.'s Semiconductor Products division, will moderate.

Three of the invited papers will deal with bulk semiconductor devices and their applications. They were written by A. G. Chynoweth of the Bell Telephone Laboratories, M. E. Hines of Microwave Associates, Inc. and A. G. Fout of the Massachusetts Institute of Technology's Lincoln Laboratory. A panel discussion will follow.

The 12 evening panel sessions will include discussions of microwave circuits, optolectronics, high-power radio-frequency circuit techniques, linear integrated circuits and solid state devices in medicine and biology.

At one session, trends in solid state microwave circuitry and components will be assessed. There also will be discussions of monolithic versus hybrid circuits and the impact of integrated circuits on the microwave field.

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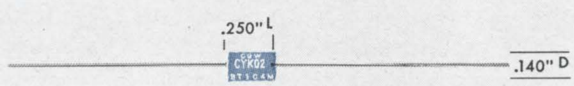

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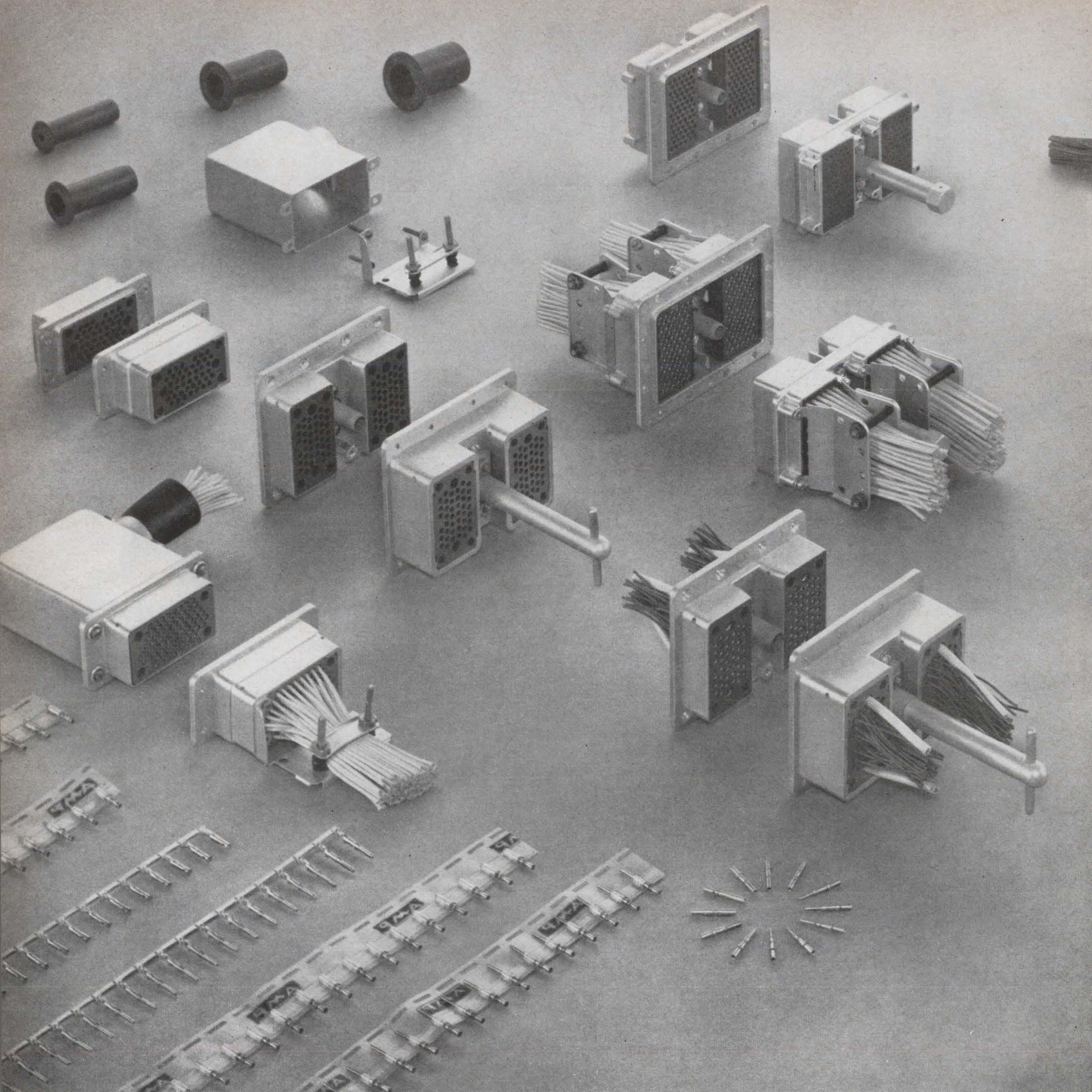
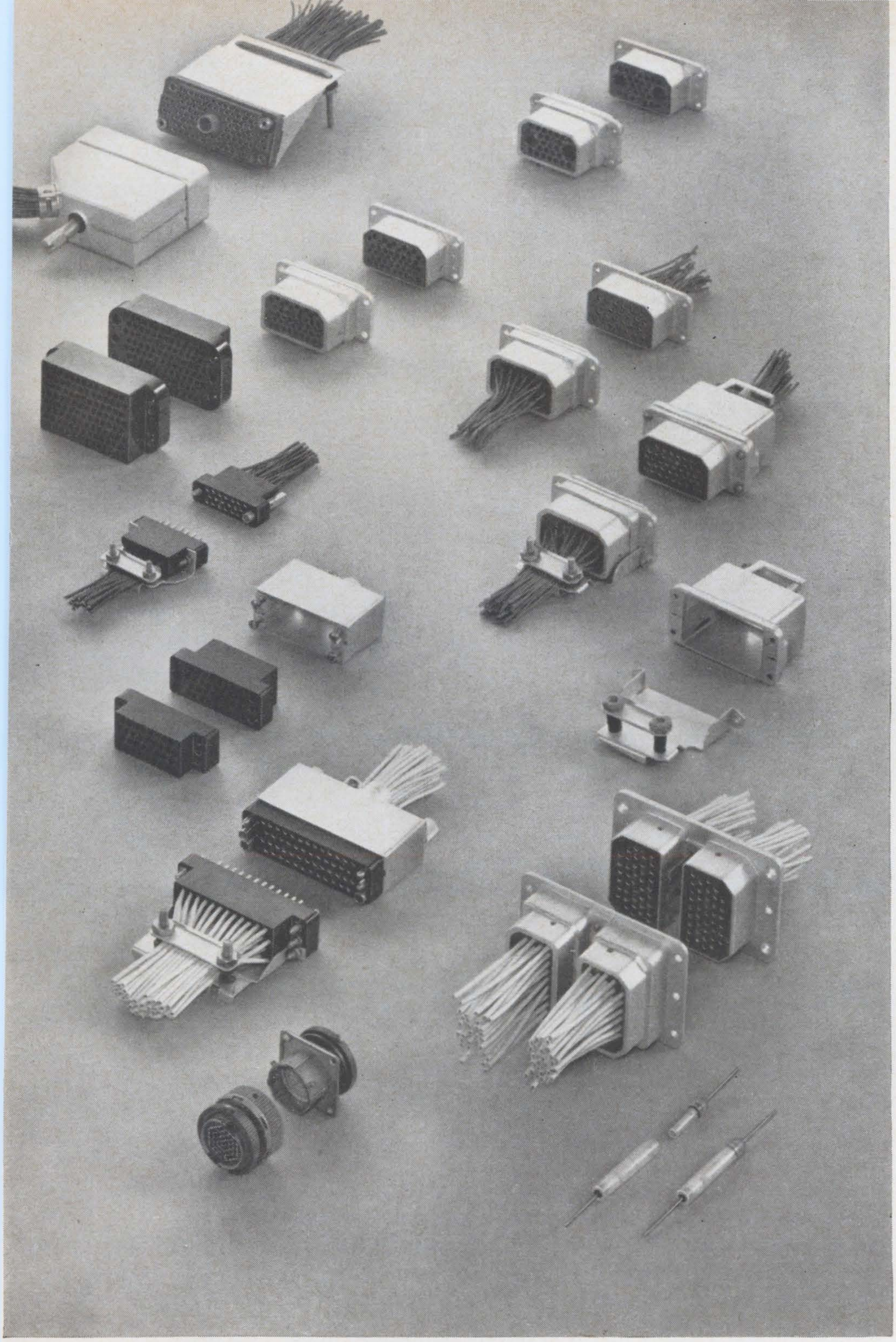
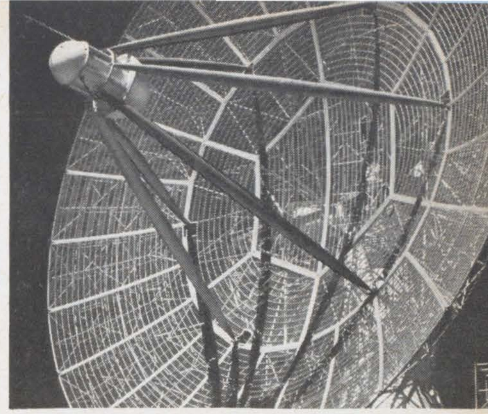
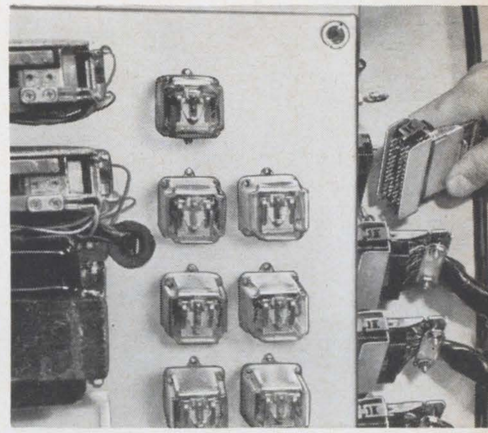




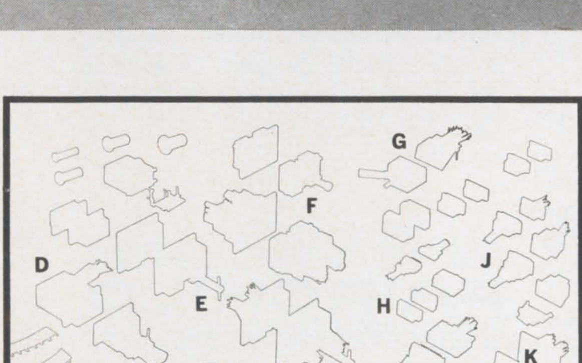


AMP's Series "DDE" pin and socket connectors are on twenty-four hour duty in the Nation's air defense surveillance systems.



The computer portion of this bowling machine is linked to its power source by AMP Series "M" connectors.

AMP connectors are important in stock market data systems; allow desk units to obtain instantly quotations on 4,000 securities.



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- D A-MP★ Series "D" Connectors with accessories
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- F A-MP Series "DDE" Connectors with accessories
- G A-MP 104 Position Center Fastener Connector
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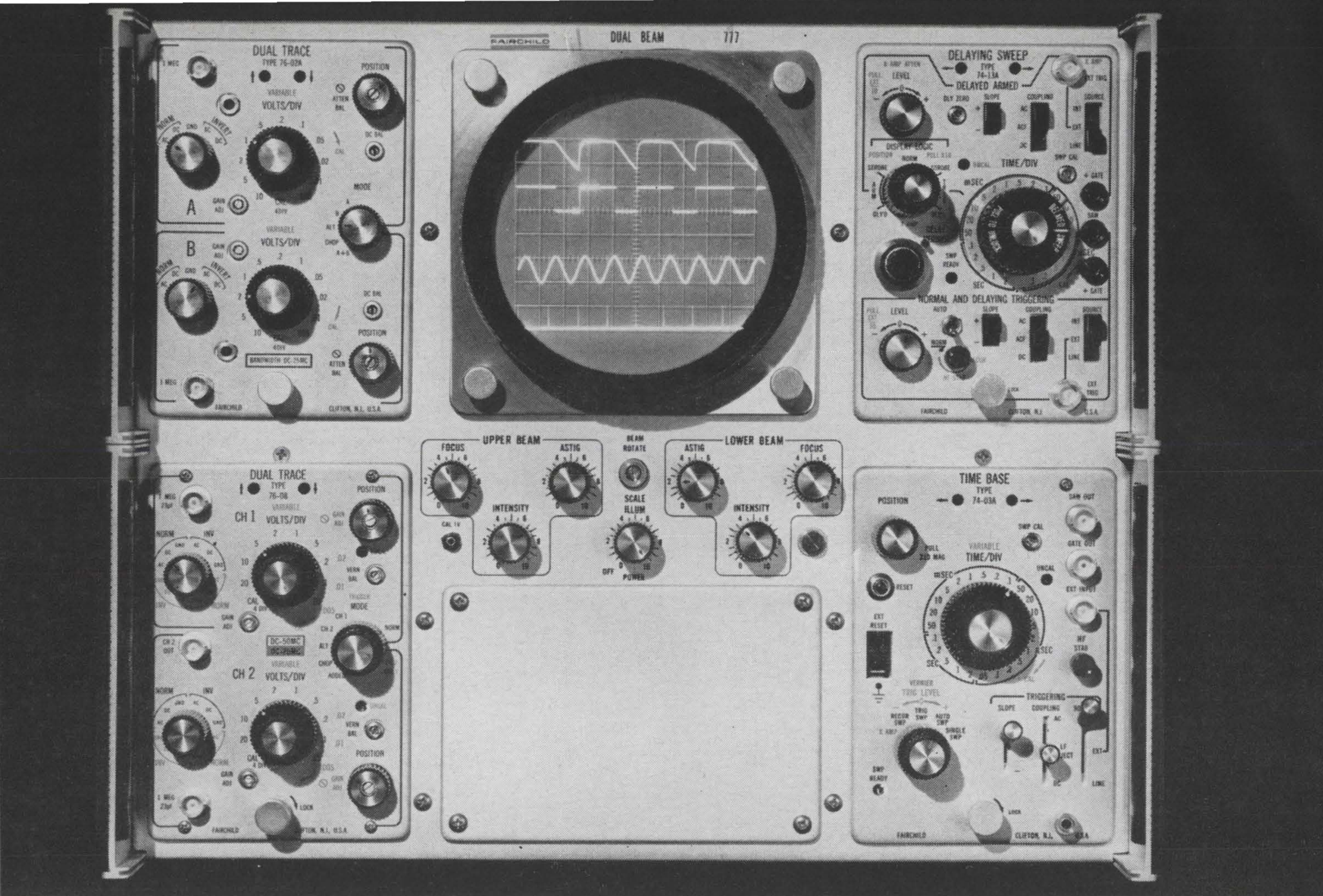
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CH 2

Editorial

No fallout for air traffic control despite Gemini's stunning success

When Gemini 6 and Gemini 7 met in space on December 15, engineers who had worked on the rendezvous radar and computer heaved gigantic sighs of relief, then broke into loud cheers. Everything electronic had worked to perfection.

Technical people involved in space study ran out of adjectives to describe the stunning success. The whole world applauded the achievement. More than any of the many successes the spacemen have had, the rendezvous proved that scientists and engineers have the technology of guidance and control well in hand and are continuing rapidly to advance its frontier.

After considering the magnitude of this accomplishment, a technical man has to wonder again why the same skills aren't being used to prevent midair collisions of aircraft and to control air traffic more efficiently and more safely. Clearly the Federal Aviation Agency has not been able to use technology with the same success as the National Aeronautics and Space Agency.

It's true that the FAA has never had anything like the giant sums of money that were given to NASA. But money is only part of the FAA's shortcomings—and maybe the smallest part. Too often, the agency has tried to freeze technology that was already on the verge of being obsolete. In the past three or four years, it has traded in its militancy on air safety for a Casper Milquetoast attitude. FAA men often seem more concerned about rocking the boat than about solving problems affecting travelers on commercial airlines.

In the past six months fatal air accidents have been frequent and frightening. At this time, it is hard to say which is more terrifying—the collision of an Eastern Airlines plane and a Trans World Airlines jet earlier this month or the FAA's "that's the way the ball bounces" attitude.

After the last major air collision of 1960, the FAA tried to improve its control system. It failed, but at least the agency was recognizing its responsibility. After this month's collision, the FAA figuratively shrugged its shoulders and said it had a system, to be installed by 1970, that might prevent such accidents. Then it went on to less controversial matters.

The FAA's technological history is a record of disaster. In 1958, right after the agency was officially founded through the merger of the Civil Aviation Agency and the Air Modernization Board, it launched a program to automate the air traffic control system with computers.

A contract was awarded and that same day experts outside the agency said the program would never work. The agency stuck by its guns until it proved the experts were right. One reason why the automation program failed was that the FAA insisted on mechanizing a control procedure invented in the mid-thirties to handle aircraft that landed and took off in farmers' fields. It felt it couldn't consider a new system that would use the full capabilities of computers. Another reason was the FAA decision to freeze technology in its system design as of 1958, even though computer technology was and still is among the fastest changing branches of engineering. By 1961, not only was the FAA's automatic system unworkable; its special computers were also obsolete.

It was after the 1960 collision of the United Airlines and Trans World Airlines planes over Staten Island, New York, that the FAA rushed the development of three-dimensional radar. Amid great publicity, a gigantic 14-story antenna, one-third of a proposed system, was erected in Atlantic City. The system never had the discrimination power—to measure altitude within 100 feet—that the FAA needed so the project was buried.

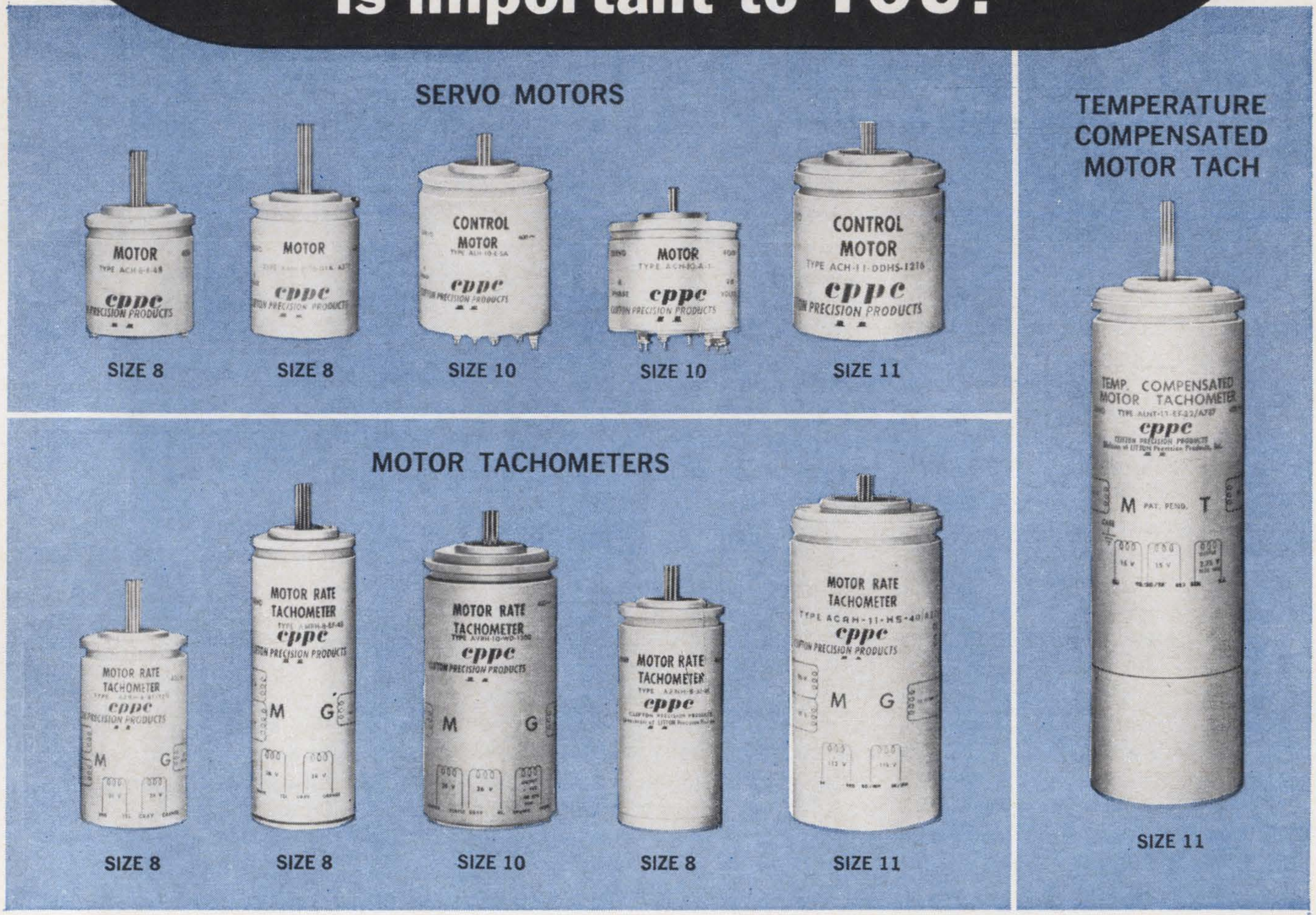
The FAA is now convinced that data processing and three-D radar can never be applied to an air traffic control system. It ignores the unmistakable fact that the technology in both fields has made tremendous strides.

FAA's foot-dragging on safety measures shows up in other ways. Earlier this autumn, a United Airlines plane crashed at the Salt Lake City airport while landing and 42 people trapped in the crash died. One wonders how many might have lived had the FAA refused to allow the kind of seating that's permitted on tourist flights. A passenger who is not in an aisle seat is trapped inextricably if the passenger in front of him leans back. Questioned about the safety of such seating earlier this year, George Keck, president of United Airlines replied, "In a test we've found it takes very little time for a passenger to push the seat ahead of him up so he can squeeze out." But that test wasn't performed by passengers unfamiliar with the airplane, stunned, in shock or suffering broken arms as a result of a crash.

When the airlines blatantly violate an FAA safety regulation, and there's no crash to explain away, the agency is likely to forget the whole thing. For example, more airlines, particularly overseas airlines like Pan American World Airways, are putting freight in passenger cabins, replacing seats with freight loaders when passenger loads are small. Strict regulations about how such freight is to be carried are violated by the airlines. Freight is carried in old jagged containers with sharp corners, without being tied down. Often it's behind the passengers in the cabin, though the FAA insists that freight be placed ahead of passengers. When such violations are reported to the FAA, agency spokesmen shake their heads and ignore them.

A technological society in which two space capsules keep a rendezvous somewhere in the immeasurable universe should have no problem getting safe, efficient, comfortable air transportation. But first a major change in attitude and direction is required. The FAA has to do a lot more than count the bodies after an accident.

The Remarkable New Line of Clifton MOTORS and TACHOMETERS is important to YOU!



In this new line of motors and tachometers, Clifton has overcome to a significant degree, many limitations inherent in current servo motor designs.

For instance, the incompatibility of efficiency and a linear speed torque curve plagues servo motor users. We have designed a motor which will minimize this conflict. Efficiency has been improved by factors as large as 40% at no expense to speed torque linearity. Thus Clifton motors can give you: more torque for the same power input or same torque with less power consumption; better theoretical acceleration; a cooler more reliable motor with high capacity for being "over-driven" if necessary. These improvements have been achieved without degeneration of air gap or single phasing considerations.

Response time is another important area of improvement in our motors. Certain of our units are specially designed to reduce inertia and increase torque, thereby offering: decreased dead zone, increased slew rate, reduced velocity error.

A further refinement in our servo motors is: lower and more uniform starting voltages with levels as low as 1% of control phase voltage. This, of course, increases the dynamic range of a servo system.

In addition, our servo motors and tachometers are using less heat vulnerable materials such as: improved high temperature resistant magnetic wire; improved lubricant; improved slot insulation; welded leads; flanged and shielded bearings; glass to metal seals, and high temperature resistant impregnation. As a result our motors can withstand temperatures considerably above the standard 125°C.

Motor Rate Tachometers

Because of the improved torque to inertia designs mentioned previously, no generator is necessary in situations where inherent self damping is sufficient. Smaller generators with less output, less length and less power consumption can now be used when needed. Synchro length *full drag cup* motor tachometers are now possible—a great saving in size and weight over the present long, heavy units.

In addition to a wide variety of off-the-shelf units, we custom design servo motors and tachometers with special requirements of torque, inertia, and temperature resistance. We are eager to serve your standard or custom needs. Clifton Precision Products, Division of Litton Industries, Clifton Heights, Pa., and Colorado Springs, Colo.

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PRECISION PRODUCTS
DIVISION OF LITTON INDUSTRIES

Electronics Newsletter

December 27, 1965

Hybrid emitter handles higher current densities

The Bell Telephone Laboratories has developed a hybrid cathode that combines the current density-handling capability of a matrix cathode with the electron-emitting advantages of an oxide cathode. **Its life expectancy, estimated at 20,000 to 30,000 hours at 810°C and a current density of one ampere per square centimeter, is far longer than in cathodes now used in klystrons and traveling-wave tubes.**

Several major producers of tubes are studying the development. The Bell device, called a coated powder cathode and designed by researchers Dean Maurer and Charles Pleass, **is comparable in cost to oxide cathodes and less expensive than matrix cathodes.**

To produce the emitter, a thin film of nickel, about 2.5% of the cathode coating, is vapor-plated onto carbonate particles, which are then sprayed onto a cathode base. The nickel increases the conductivity of the cathode coating and improves the ability to handle high current densities. When the cathode is heated, the carbonate is changed to an electron-emitting oxide. Conventional oxide cathodes, used in low-power electron tubes, are formed in much the same way, except that no metal is added to the mixture of barium and strontium carbonates. The coating on a matrix cathode used in high-power electron tubes is usually about 80% metal; this composition results in a relatively ineffective emitting area. It is the oxide, not the metal, which permits emission of electrons from the cathode.

3-D radar order due in January

A production award on lightweight three-dimensional radar for the Air Force is expected by mid-January. The Air Force's Electronic Systems division at Bedford, Mass., is evaluating technical proposals submitted this month. Under study contracts totaling $500,000, the Westinghouse Electric Corp. and the Hughes Aircraft Co. proposed technical approaches for a 3-D radar that will weigh no more than 7,000 pounds and can be carried by a helicopter to a forward air-control post. The Tactical Air Command had asked for a 6,000-pound maximum unit [Electronics, Oct. 5, 1964, p. 118] **but 7,000 pounds is now considered more realistic.**

The new radar will replace the AN/TPS-35 now in the field. This is a two-dimensional L-band surveillance radar.

Inch-long flatpack holds 34 IC chips

Teledyne, Inc., is producing integrated-circuit arrays of up to 34 IC chips, each with a maximum of 50 components. The array fits into a package only 1-inch long, 0.75-inch wide and 0.06-inch high. The packaging density is some 36,000 parts per cubic inch. Other companies have built larger arrays experimentally but **Teledyne says its methods are proven and give a "very high yield" in production.**

The IC arrays are produced by Teledyne's Amelco Semiconductor division for the Systems and Controls division of the parent company. **The arrays go into the computer of the military's Integrated Helicopter Avionics System (IHAS).** The chips are mounted on a 17-mil-thick alumina ceramic substrate and interconnected by bonding gold lead wires to plated-gold wiring on the substrate.

A key problem was obtaining the required resolution of the plated interconnections—lines 8 mils wide and 8 mils apart. Jerry McNeal, project engineer, **solved the problem by adapting the moly-manganese metallizing method, used in microwave-tube production, to coat the**

substrate. Then the gold pattern was electroplated through openings in photoresist. Finally, the excess moly-manganese was etched.

Amelco hopes next to bond the chips face down, directly to a wiring pattern with a 2-mil resolution. This would double packaging density.

The package is sealed by welding a cap to a metal flange brazed to the substrate. The package can dissipate 1 watt of heat. To keep dissipation below this limit a low-power logic design was developed for digital arrays. The technique is also used for analog arrays and **Teledyne expects it to be used in equipment other than IHAS.**

Johnson named MIT president

Howard W. Johnson, 43, will become president of the Massachusetts Institute of Technology on July 1. Johnson, dean of the MIT School of Management for six years, will succeed Julius A. Stratton, who is retiring. Under Johnson, the School of Management has extended its scope to include major research programs in information and control systems.

RCA, Philco expand color-tv facilities

To meet the steadily increasing demand for color television sets, two expansion moves—one in the United States, the other in Canada—were reported this month.

The Philco Corp. says it will spend $20 million to build and equip a color-tv tube plant in Lansdale, Pa., and the RCA Victor Co., the Canadian subsidiary of the Radio Corp. of America, says it will invest $25 million to establish a color tube facility in Midland, Ontario.

Although Canada doesn't broadcast in color, some half-million viewers are within range of U. S. border stations. RCA claims the Canadian plant will be the largest color picture tube facility outside the U. S.

Lincoln Lab tests military satellites for communications

Two satellites that went into a quasi-synchronous equatorial orbit last week on the third flight test of the Titan 3-C are **designed to test new devices and techniques for military communications in space.** They were developed and built for the Air Force by the Lincoln Laboratory of the Massachusetts Institute of Technology and are the third and fourth Lincoln experimental satellites, LES-3 and LES-4. LES-1 and LES-2 were launched earlier this year.

LES-3 is an ultrahigh-frequency signal generator, **designed to measure properties of the communication path between the satellite and various receiving terminals.**

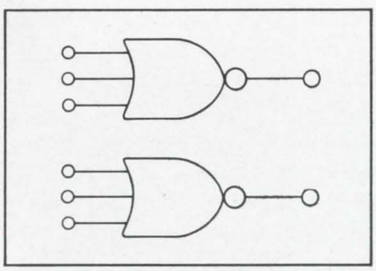
LES-4 is a solid state communications satellite operating in the X-band. **Instead of using a wide beam, LES-4 uses a directional beam transmitted by an eight-horn electronically switched antenna on top of the satellite.** Optical sensors and associated electronics control the switching of the transmitter output from one horn to the next, activating only the one horn whose beam is aimed in the direction of the earth.

Addenda

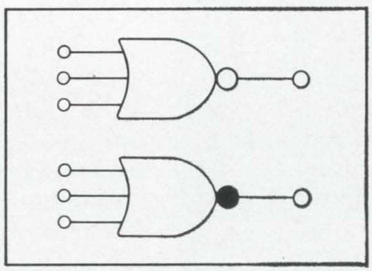
The Sperry Rand Corp. has received **a $39-million order from United Air Lines for a computer system** to handle the airline's reservations and management needs. The system will be built around three Series 1108 computers. . . . The International Telephone and Telegraph Corp. has **built the first portable transceiver for use on a space mission.** The a-m radio—built to withstand heat, cold, vacuum and radiation—measures 1 by 1.8 by 8.6 inches. It's scheduled to be used in May during the Gemini 9 mission and will be worn in a backpack by an astronaut during a space walk. . . . **Pay-television will begin operating in London on Jan. 7** under a two-year test authorized by the British government.

9 nsec X $3\frac{1}{2}$ mw

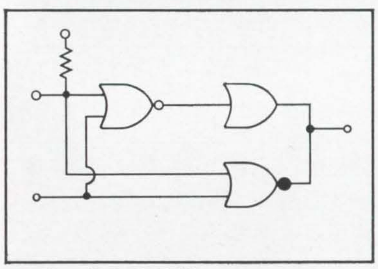
Philco announces the new Super/RTL family. Speed-power product: 31 per gate. Full military grade.



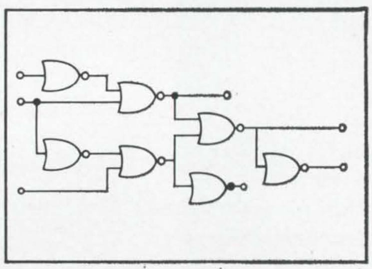
Dual Three Input Gate (PL 9603)



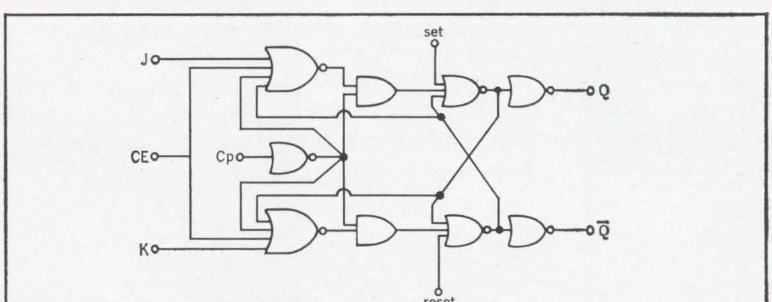
Dual Two Expander (PL 9604)



Buffer (PL 9602)



Half Adder (PL 9605)



JK Flip-Flop (PL 9601)—**also available is a $\overline{JK}$ Flip-Flop** (PL 9600), **identical except for inversion of K input.**

This is the industry's newest line of high-speed, low-power logic circuits. The unprecedentedly low speed-power product of this "3rd generation" RTL family is made possible by Philco-developed small-geometry processing techniques which minimize parasitic capacitance and permit low propagation-delay times.

The S/RTL family of planar epitaxial integrated circuits was developed by Philco for critical high-speed data-processing functions where full military specifications are required. (Operating range: –55°C to 125°C.)

The six functions presently available are illustrated at left. We think you will find them remarkably convenient to work with. Your further investigation of individual functions will uncover some possibly unexpected advantages. (For example—the flip-flop will toggle at 30 mc at 30 mw dissipation!)

S/RTL circuits are available in ¼ x ¼ 14-lead flatpacks.

Speaking of availability: Design-sample quantities are immediately obtainable from Philco. For further information write, wire or phone Philco Headquarter Sales, Lansdale, Pa. (215-855-4681).

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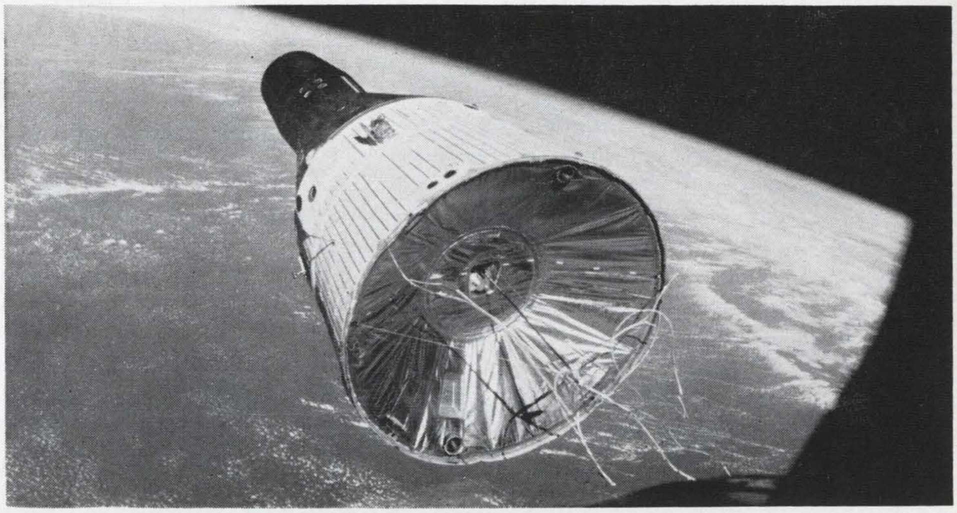
Electronics Review Volume 38 Number 26

Space electronics

The date was kept



Soaring in space: Gemini 7 as seen from Gemini 6.

"We have company tonight." On the 11th day of a fortnight in space that laconic message from Gemini 7, soaring about 180 miles over Guam, raised cheers from a waiting world. It was the signal that a rendezvous had been kept; that two spacecraft, traveling at 17,500 miles an hour would be able to come together for the docking that is a vital prerequisite to landing a man on the moon. The entire mission, of stunning complexity and unprecedented length, went off with barely a hitch.

The loudest kudos went to the Westinghouse Electric Corp.'s radar system [Electronics, April 5, pp. 110-112D] and the International Business Machines Corp.'s onboard computers [Electronics, May 3, p. 71]. The two systems helped the astronauts steer their crafts to the rendezvous.

Formal wear. The complex steps that led to the rendezvous began the morning of Dec. 15, with the successful launching of Gemini 6. For the occasion of their meeting with Gemini 6, Frank Borman and James A. Lovell, who had been riding in their long underwear, put on their spacesuits. Gemini 6 went into orbit at 8:43 a.m. (EST). Gemini 7 was in a higher and wider orbit at this time, so Gemini 6 had to adjust its orbit with tiny rocket bursts to bring it in line with Gemini 7.

Slowly, during a series of seven steps, the gap narrowed to about three feet.

Much of the catch-up operation was guided from the ground. It was only in the last 235 miles that the astronauts were left to their own devices—radar and computer—to find their way in space.

Direct talk. During the early part of the rendezvous exercise, communication between the two craft was accomplished indirectly: messages from one capsule were first transmitted to the ground and then relayed to the other capsule. When they were within 230 miles of each other, the astronauts turned on small ultrahigh-frequency transceivers inside the craft so they could talk directly to each other. The radio was produced by the Collins Radio Co.

Meanwhile, on the ground, electronics scored another success. Live television pictures of the spacecraft recovery were relayed via Early Bird, from the mid-Atlantic to the shore. Tv pictures of the recovery, taken from the deck of the U.S.S. Wasp, were transmitted with portable equipment developed by the International Telephone and Telegraph Corp. The pictures received by home transmitters were of unusually good quality.

Not a whisper

The one electronic experiment that proved a dismal failure during the Gemini 6 and 7 flights was the laser communication test [Electronics, Dec. 13, p. 34]. But the problem, actually a series of problems, was not with the Gemini 7 laser transmitter, which was produced by the Radio Corp. of America, nor with the ground station gear produced by Electro-Optical Systems, Inc., a subsidiary of the Xerox Corp.

The faults were on the ground and most were human errors. Bad weather also contributed to the trouble: heavy cloud cover often blocked transmission of the laser beam. Trouble began early in the mission. A fire at the first scheduled receiving station, at Ascension Island, destroyed a shed housing some of the ground-base equipment. At the next scheduled station, in Hawaii, trouble in adjusting the laser caused further postponement. By the time Gemini 7 reached the third station, in White Sands, N. M., the craft's angle of inclination was too low for voice communication.

Butterfingers. On succeeding days more problems cropped up. At Ascension, for example, a technician dropped a laser tube. Meanwhile, the astronauts reported they were having trouble spotting the laser beacon. In an attempted solution, the beam's width was widened, but this didn't help.

There was speculation about removing the green filter on the ground stations' transmitters to make the beam more visible but officials decided the task was too delicate to be rushed.

Some success was finally reported over Hawaii, a week after the mission began. Astronaut Lovell spotted the ground station's beacon, locked onto it for two minutes, but didn't get a chance to test the voice communication.

Military electronics

The F-111 market

A broader role for the General Dynamics Corp.'s F-111 (née TFX) could lead to one of the biggest single aircraft electronics markets yet. But this prospect is still full of "ifs."

The F-111 is being developed as a fighter-bomber for the Air Force and as a fighter for the Navy. Up to 1,500 will be bought. Electronics accounts for over 15% of plane's cost.

Now, Defense Secretary Robert S. McNamara has decided to ask Congress for $1.8 billion to develop and produce some 210 long-range strategic and tactical bomber versions of the plane, to be called the FB-111.

This proposal follows another recent McNamara decision to develop a reconnaissance version, the RF-111. No commitment for production of this model has yet been made, but an order for about 100 is expected.

Sales abroad. In addition, the Defense Department is trying to sell the F-111 overseas. Australia has ordered 24. Britain has an option to buy 10 planes initially to replace its now-canceled T5N-2.

But despite this seemingly bright outlook, so much controversy surrounds the F-111 that the market for the plane may never attain its indicated proportions.

The Navy has had difficulty keeping down the weight of its version for operation aboard aircraft carriers. Unless this problem is solved, the order may be cut.

Britain's declining aircraft industry and some members of Parliament have raised a storm about buying the F-111. They are pushing instead for joint development with the French of a similar plane, the Mirage 4. As Britain's F-111 option neared expiration this month, the government still had not made up its mind, so the option was extended.

To sweeten the deal, the United States is making this offer: if Britain agrees to buy the planes, the U. S. will agree to use mostly British-made electronics on them.

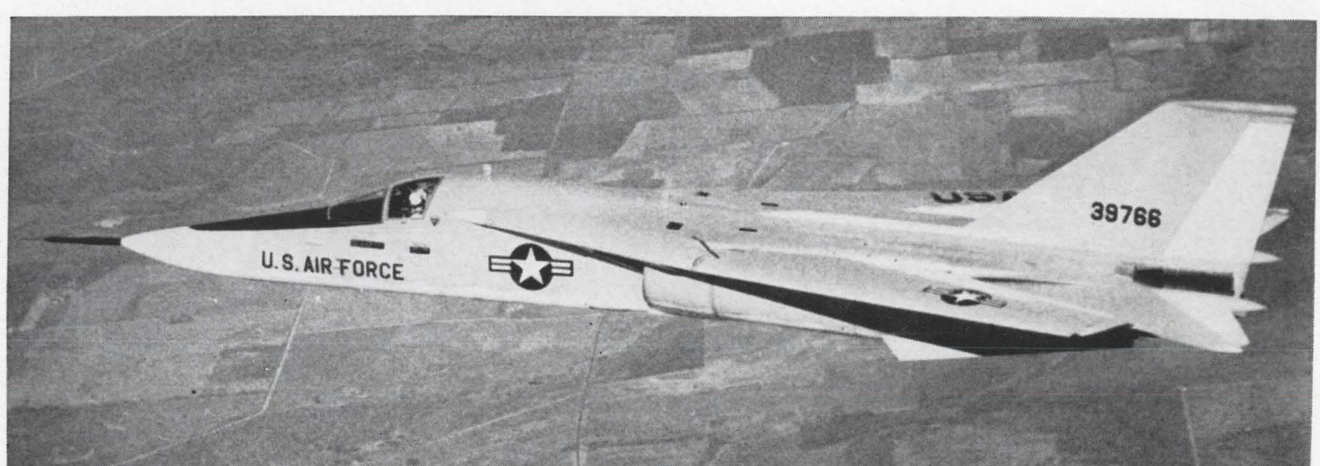
Old B-52's. But the biggest threat to McNamara's plans for the F-111 comes from his long-range bomber proposal. McNamara wants to convert the F-111 into a replacement for 350 older-model B-52's, which would be phased out in the next five years.

Although the Air Force has raised no formal objection to his proposal, its acceptance is certainly reluctant. The Air Force would prefer to develop a brand-new intercontinental bomber. In the past, Congress has consistently sided with the Air Force on this issue and may well refuse to go along with McNamara in funding the F-111 as a substitute.

In any case, a major debate can be expected. The debate will turn on the question of whether the FB-111 can match the B-52's performance. McNamara contends it will equal the older B-52 in range, have twice the speed and possess greater capability to penetrate enemy defenses because of its ability to fly at lower altitudes.

His claims are subject to challenge, depending on the type and length of mission involved, as well as other variables. If the FB-111 does get off the ground, it will initially carry the same general kind of avionics the F-111 carries. McNamara proposes a quick modification program that would make the FB-111 operational as early as 1968. This short period would not provide enough time for the development of avionics especially designed for the bomber version.

Improved avionics. The Air Force, however, is working on two long-range development programs that could lead to improved avion-



Sales of the F-111 family of supersonic aircraft may set record.

ics for an FB-111. One program involves the Mark 2 integrated avionics system that will be in the basic F-111 fighter-bomber during the latter part of its production run. The other program is to develop long lead-time components for advanced electronics that would have been incorporated in the proposed Advanced Manned Strategic Aircraft (AMSA) that would have replaced the B-52. But McNamara has blocked development of the AMSA.

Whatever the fate of the FB-111 controversy, the related Short-Range Attack Missile (SRAM) program will continue. The SRAM could be used on either the remaining late-model B-52's, the RF-111 or AMSA. The Martin Marietta Corp. and the Boeing Co. are competing in a project-definition phase for the development contract.

Aiming with tv

United States fighter pilots firing Bullpup missiles against ground targets must first be within visual range of the target. Even then, they can't hit and run; they've got to remain nearby, guiding the missile by remote control as it zeroes in on the target. So the pilot can remain at a safe distance from ground fire—but still guide the missile and make sure it hits the target—military researchers are rapidly stepping up the development of television-guided missiles and bombs.

All the tv-guided weapons under development operate in the same basic way: tv cameras and transmitters are in the nose of the weapon. Inside the plane, the pilot watches a tv monitor that shows the view in front of the weapon. The weapons also contain equipment that can lock onto a target, keeping the missile on course during the last few moments before it hits.

Tv in the nose. The weapon that's closest to development is the Walleye, a free-fall bomb with a tv camera in its nose. As the bomb falls, the bombardier is able to see the scene below it. By remote control, the bombardier is able to correct the angle of descent by adjusting fins on the bomb's tail. Three companies have been vying for the contract for the past year: North American Aviation, Inc., the Hughes Aircraft Co. and the Martin division of the Martin Marietta Corp. Indications are that the Pentagon will award the multimillion-dollar contract to Martin soon.

Condor progressing. Well along in the definition stage is another Navy weapon—the tv-guided Condor surface-to-air missile. North American and the Nortronics division of the Northrop Corp. have been competing for the development contract since April. The Condor is planned for the carrier-based A-6A attack plane.

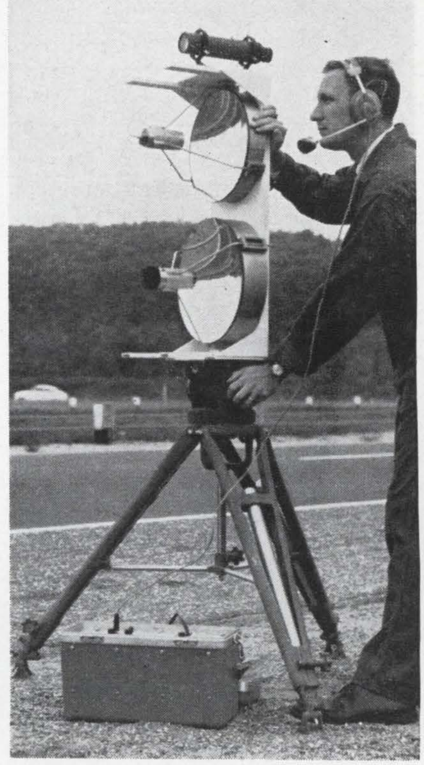
The Air Force is also pushing to get into the field with a proposed tv-guided, air-to-ground missile, to be known as Maverick. The missile, designated AGM-65A, would be launched from the F-4C, F-5 and F-105 fighters. The Maverick has the backing of the Air Force's Aeronautical System division but it has not been finally approved by Air Force headquarters and submitted to the Defense Department's Research and Engineering Office for a go-ahead on starting project-definition competition.

Using North American's guidance hardware developed in the Walleye program, the Air Force modified another missile—the Hornet—for flight tests of the tv-guided system.

Communications

Light talk

The Navy's been doing it for years: using a bright searchlight to send semaphore messages ship to ship. But semaphore is cumbersome because of the slow pace of Morse code. With the development of the laser four years ago, researchers have turned their attention to techniques for modulating a coherent beam with voice signals. Despite many advantages of laser communications, technical problems remain. Moreover, the cost of building and operating a laser prices it out of the market for most communications needs. Now, Edgerton, Germeshausen & Grier, Inc., of Boston has applied the techniques of semaphore, plus the techniques for modulating coherent light with voice signals, and developed a portable optical communications system that uses noncoherent light. The result is a low-cost system that transmits voice messages over distances up to eight miles.



Optical communications system developed by David E. Wright, an engineer at Edgerton, Germeshausen & Grier, Inc. provides a low-cost voice link up to eight miles.

No noise. The system has several advantages: with point-to-point communications, the message is secure from eavesdropping; the electronics are relatively simple; the beam isn't affected by electrical noise in the vicinity, nor does it affect radio transmission or other electronic equipment.

Two instruments have been developed. One, using high-power gallium-arsenide (GaAs) optical diode, sits on a tripod, and produces infrared light. The other, using a xenon-hydrogen discharge tube, produces visible light and is hand-held. Both models convert voice messages into light pulses, using pulse position modulation.

EG&G estimates that a customer could buy the more expensive, two-way GaAs system for about $2,000; in full production, however, the price would drop to about $600. The hand unit would cost considerably less.

The market for such units practically covers the spectrum of short-range communication needs. Power-line repairmen, for example, could use the device to communicate with a repair crew several miles down the line. The use of a walkie-talkie in this instance isn't practical because power lines "leak" so much electromagnetic interference that the high ambient noise obliterates communication; optical sources, however, are immune.

In another application, at a missile-launch facility, for example, the communication unit would be impervious to high ambient noise and wouldn't add noise itself.

Each of the communication systems was designed around the unique properties of its particular optical source.

Beacon, too. The GaAs optical diode, for example, with its extremely small active surface, was readily adaptable to a narrow-beam system for secure communications between fixed points.

The xenon system, on the other hand, with a wide range of peak intensities in the visible spectrum, could be used either as a beacon or as a transmitter. In the beacon mode, the tube's repetition rate is slowed, resulting in a very high intensity beam; in the transmitting mode, the repetition rate is speeded, producing a rapid sequence of lower-intensity peaks. The tube used by EG&G can produce a 10-joule flash once every second or 1-millijoule flashes at a 7-kilocycle repetition rate.

Both systems contain sending and receiving equipment; parabolic mirrors are used to focus a transmitted beam and to receive and focus a beam transmitted from afar.

Range of the systems, of course, is hampered by foul weather. Heavy rain, fog or snow could cut communications completely; but in light rain, snow or haze, some communication is possible over short distances. In clear weather during the day, the GaAs unit has a range of about four miles and the xenon unit, about one mile. During the night, range is about quadrupled.

Hand-held optical communications unit converts voice signals into light pulses. Receiver reconverts the light into voice signals.

The developer of the systems, David E. Wright, an engineer at EG&G, says range can be nearly doubled if more sophisticated receiving circuitry is used to filter out ambient light.

Employment

A sellers' market

The Lockheed Aircraft Corp. sponsored a television program in New York recently that extolled the merits of Georgia as a place to live and work. Lockheed wasn't pushing tourism for the Peach State—it was trying to lure engineers to work in Marietta, Ga., on its C-5A transport plane, the subject of a multibillion-dollar contract. As a back-up to the soft-sell approach on tv, Lockheed has been running full-page want ads in newspapers and magazines across the country.

Lockheed obviously feels the expense is necessary. The problem, as most aerospace and electronics companies are discovering to their chagrin, is that there simply aren't enough good engineers around to fill the ever-growing job lists.

Hard to find. "The situation is terrible; engineers are tremendously hard to find," says a personnel director at Motorola, Inc.'s Chicago headquarters.

The government confirms industry reports of the "tight" labor situation. A recent Labor Department statistical survey on unemployment in engineering had to be called off because there simply weren't enough unemployed engineers to provide meaningful figures. The best estimate that the agency can come up with is that only 1.3% of the engineer population is out of work. But the bureau can't identify the members of the group accurately. Says one agency official: "Many members of this unemployed group are probably moving between jobs." The agency classifies the engineering job situation as "among the tightest of all labor groups."

Accentuating the pinch being felt by electronics companies is the shift in employment trends. A personnel director for a California manufacturer says: "Ten years ago, we would have been happy with any competent engineer. But now, the man has to have a specialty. He has to be a laser expert, or a top-notch microwave man before he's useful to us. The commercial competition is too keen for us to spend time training him."

More engineers. The Aerospace Industries Association says the number of scientists and engineers on member firms' payrolls has climbed 7.3% from July, despite a general decline in the number of other workers.

Another indication of the spurt in the demand for engineers, says Burt Peterson of a Los Angeles recruiting agency that specializes in professional people, is newspaper advertising. "Help-wanted linage for engineers is up more than 50% from last year," he notes. The boost started showing up in March, he adds, and it may not yet have reached its crest.

Not all of this advertising is directly tied to employment needs, concedes one New York employment agency official. "There's no doubt," he notes "that some com-

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- Reduced size 90%
- Reduced cost 73%

IMPRESSIVE? Read on so you can achieve similar savings.

CASE HISTORY

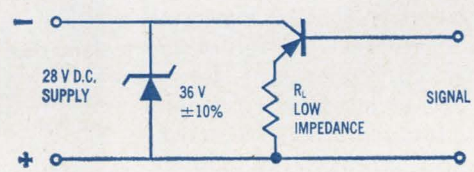
This company has a design engineer--let's call him Bill--who had a problem. Line spikes were causing high base to emitter voltages that were destroying a transistor in the emitter-follower of Bill's solid state amplifier. Transistors with high base to collector voltages were both expensive and difficult to get.

The 24 volts of power for Bill's amplifier came from a high current, low voltage supply that also fed several other sub-assemblies. Bill found that when he inserted sufficient limiting impedance to protect the transistor, the circuit wouldn't operate satisfactorily.

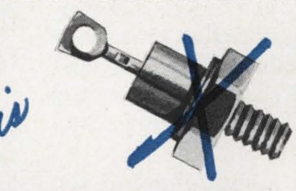
What Bill needed was a line voltage transient clipper that would conduct high current during transient surges while having no steady state power consumption--a 36-volt zener!! Now he had a choice--a bulky 50 watt stud (1N3326), or an equally bulky 50 watt T03 (1N2885).

or

a Unitrode UZ5836, miniature axial leaded zener with a comparable surge rating. He chose the latter and saved in weight, size, and cost.



Not this



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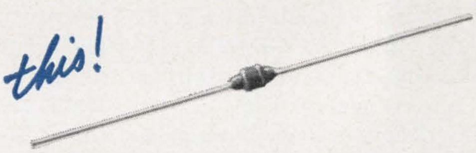

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panies insert frantic want ads in the papers every Sunday in an effort to improve their public image. A potential investor looks at the want ads, thinks that the company's orders are up, and goes out and buys the stock. Presto! The price of the stock climbs."

But he adds, "Today's labor market is so difficult that very few companies are bluffing."

Electronics companies are using some unusual recruiting methods to fill their engineering ranks. Says John Harris, a job agency director in San Francisco: "There's been such an upsurge since last June that the big eastern companies have started coming out here looking for men."

Recruiting efforts merged. Not all companies go that far in recruiting top engineers. In California's San Fernando Valley area, for example, six electronics companies recently merged their recruiting talents and arranged an employment-opportunities weekend at a resort in nearby Orange County. Accentuating the labor shortage is the growing mobility of engineers; they know they can find a new, and possibly better, job without too much trouble.

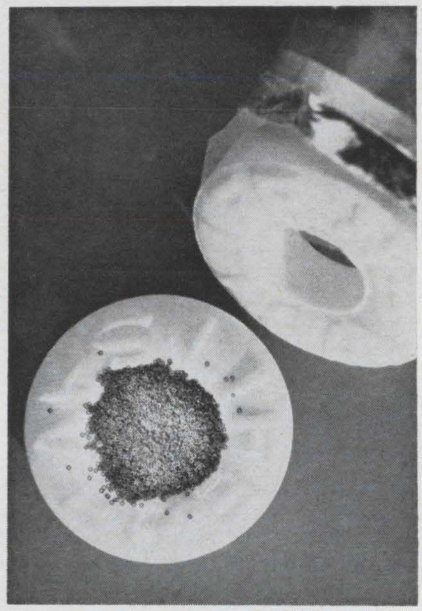
What causes mobility among engineers? "It's not just salary," says Gordon Moore, who directs a Palo Alto, Calif., agency. "Often a guy is just looking for a more exciting area or a more secure firm."

Agency directors and companies' personnel chiefs ascribe the boost to three factors: the generally booming economy, the war in Vietnam—which is boosting demand for weapons systems—and the widespread drive by companies that lean heavily on military and government contracts to diversify into the commercial market.

Computers

The speed limit

A computer memory that is twice as fast as any commercially available memory has been developed—without any radical changes in technology—by packing more bits to the inch. Built and tested only as an engineering model by the International Business Machines Corp., the new memory has a cycle time of 375 nanoseconds. IBM's lead may be short-lived; the delivery date of Control Data Corp.'s first model 6800, with a cycle time of 250 nsec, is mid-1967. Control Data has not disclosed details of the model nor has IBM announced its plans for commercial application of its new memory.



Over 17,000 ferrite memory cores can be poured into the hole in a single Life Saver. The cores, 7.5 mils in diameter, are like those used in an experimental memory recently built by IBM.

IBM's experimental memory's capacity is 8,192 words of 72 bits each, compared with hundreds of thousands of words in some commercially available computers.

G. E. Werner and R. M. Whalen, engineers at IBM's Poughkeepsie, N. Y., labs, attained the 375-nsec speed by incorporating three basic design concepts: tiny cores, close packing to keep the wires short and a memory organization that is intrinsically fast. There is a disadvantage—the short-wire memory organization increases addressing complexity and the cost.

Werner and Whalen are working to cut the cycle time to 110 nsec by using solid-logic driver circuits, different physical arrangements and other design refinements. If they succeed, IBM would halve Control Data's time.

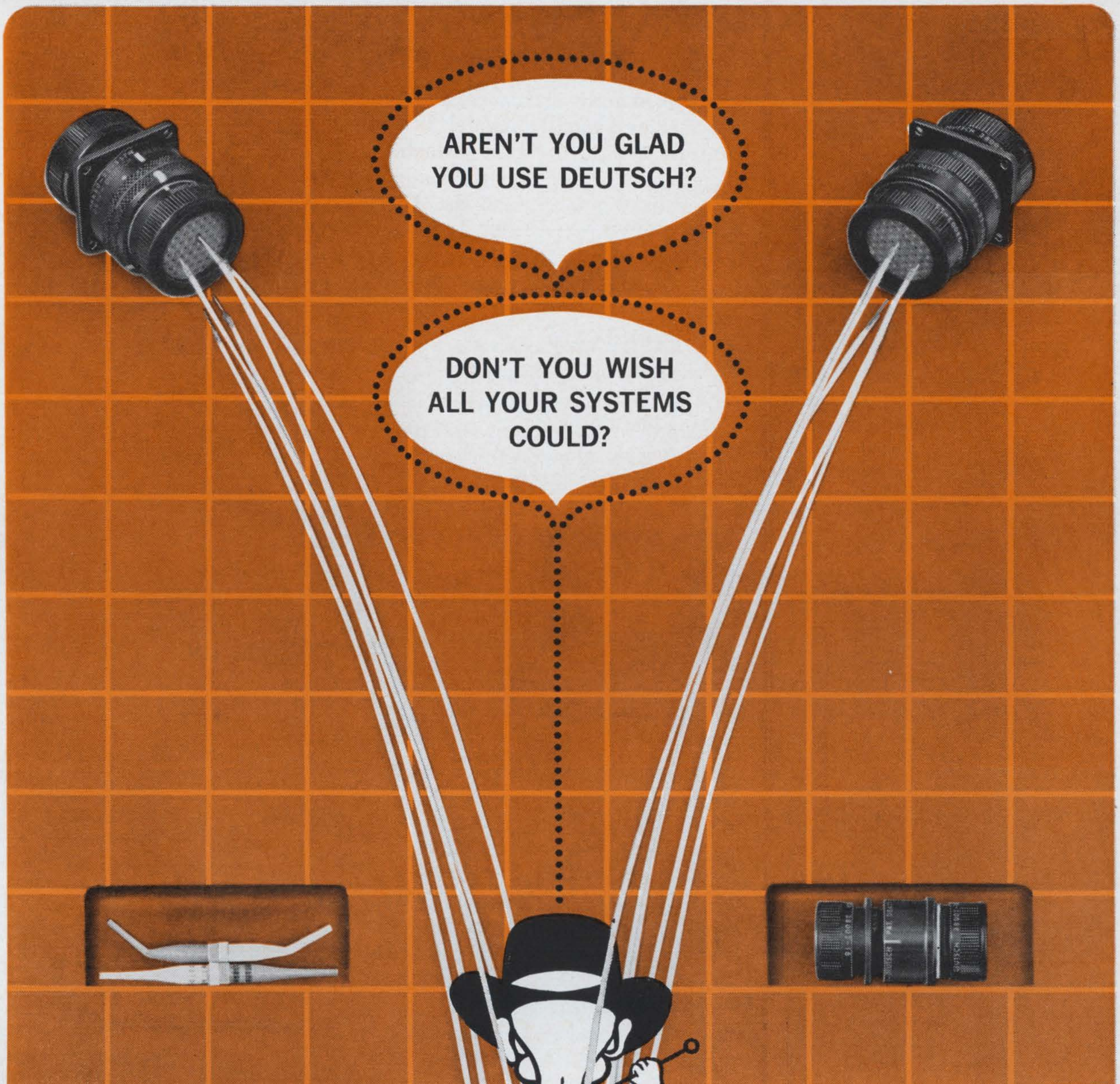
Time to switch. Most memories available now are made from ferrite cores strung on wires. The ferrite core is magnetized either clockwise or counterclockwise, depending on the direction of the wire current. Switching the magnetized state of the ferrite from one direction to the other takes time; the less ferrite there is to switch, the less time it takes. So, the smaller the core, the quicker it will switch, and the faster the memory can operate.

Small cores can be strung closely together so the memory can be strung with shorter wires; the shorter the wire, the lower the impedance. This, too, can increase the speed of the memory.

The cores used in this memory have a 7.5-mil inside diameter—three hairs will barely fit through one of them—and a 12-mil outside diameter. The cores are spaced 15 mils apart, center to center, and are packed 4,000 per square inch. In conventional memories, cores have a 20-mil inside diameter and are packed up to 1,000 cores per square inch. The cores in the new memory are strung on wires close to a ground plane that provides a return path for the current. The closeness of the wires to the ground also helps reduce the impedance even further.

2-D memory. The memory organization is two-dimensional: the cores are strung on two sets of wires. One set, in the x direction, corresponds to the words of data stored in the memory. The other set, in the y direction, corresponds to the bit positions in each word. Each word must have its own driver circuit. The two-dimensional organization is simple and fast, but it requires a complex address decoder for access to each individual word. This makes it expensive for large memories.

Another unusual feature of the new memory is its temperature control. Ferrite-core memories must be maintained at even temperatures for reliable operation. In IBM's memory, cooling liquid is pumped



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Medical electronics

Sound and safe

Some time next year a team of doctors in New York will use an ultrasonic echo-ranging instrument to test for abnormalities in the eyes of 1,000 schoolchildren. The test will determine, among other things, the thickness of the eyeball —a measurement that can't be made directly with optical instruments.

The test points up doctors' increasing interest in echo-ranging as a diagnostic technique. At a Boston symposium on ultrasonics this month, sponsored by the Institute of Electrical and Electronic Engineers, physicians and engineers agreed that ultrasonics is permitting measurements that could not have been made earlier. The use of x-rays, radioisotopic scanning and catheterization all contain an element of hazard when applied to a sick person. Echo-ranging, on the other hand, is hazard-free and can be performed without the patient knowing that a measurement is being taken.

Check the beat. Portable echo-ranging equipment is already checking fetal hearts without disturbing the mother-to-be [Electronics, April 19, p. 35]. In addition, echo-ranging is being used at many hospitals for diagnosis before operations to help a heart surgeon determine which parts of the heart require attention. At the Carnegie Institute of Technology, ultrasonic doppler techniques are being developed to monitor the fetal heartbeat to detect defects prior to delivery of the baby. Joe S. Hitt, a Carnegie researcher, told the Boston meeting that the doppler returns are fed into a computer that is programed to detect heart abnormalities.

The application of ultrasonics to medicine is still in an early stage. Much of the Boston symposium was devoted to discussions among doctors and engineers, with the medical men outlining their needs and the engineers outlining the capabilities, potentials and limitations of the technique.

Among the problems that still need to be solved before ultrasonics can have widespread application in medicine, says Dr. Joseph Holmes of the University of Colorado Medical School, are standards for time-base relationships and for sensitivity, resolution and alignment.

The most perplexing problem, Holmes adds, is the need for tissue standards to permit more reliable discrimination between normal and abnormal tissue as seen in the ultrasonic display. Currently, the edge of the liver, bladder wall or thigh is used as a standard. But this standard is woefully inadequate, says Holmes, for individuals of different physical contour or for cases when a pathological condition is interposed between the transducer and the tissue being used as a standard.

Consumer electronics

Waterproof radio

Until now, if a radio were to drop into water the only sound it might make would come from the splash. Now the MECO Corp. of Santa Barbara, Calif., is marketing a portable radio, called the Mk-II, that will continue to play even if it's submerged. Its designer, Joseph J. Montanaro, says the waterproof radio produces high-fidelity sound.

Montanaro seems to have found a way to encase the radio's loudspeaker in a watertight material without muffling the sound. He used neoprene, a strong material even when sliced into thin sheets, through which sound can pass easily. He determined that a sheet of neoprene less than 1.5 mils thick would rupture when dropped in water. He also learned that if the thickness was greater than 2.5

mils, the sound coming through it would have an echo quality. His choice for the thickness, therefore, was between 1.5 and 2.5 mils.

No seeping. To waterproof the rest of the radio, Montanaro designed the shell of high-impact plastic. O-rings were fitted around the shafts of all the exterior controls to keep water from seeping in behind the knobs.

In addition to resisting water, salt spray, sand and smog, the radio was also designed to withstand shocks. The radio will be built in Hong Kong by International Service Corp.

The company thinks boat owners will be the big market. But, because the radio works under water—at shallow depths, at least —a scuba diver might use it while he's swimming beneath the surface.

Japanese designers have toyed with the idea of a waterproof radio in the past. They attempted to waterproof the speaker by impregnation with a watertight material. The result was a tweeter with poor fidelity and the designs never got anywhere.

Avionics

A record problem

The most valuable clue in determining why an airliner crashed is the data contained in the flight recorder—a $5,000 electronic instrument designed to record a plane's five key movements and survive a crash. But aeronautical investigators claim the instrument doesn't always record enough information, and worse than that, sometimes it doesn't even fully survive the crash. So the Federal Aviation Agency is looking for a new generation flight recorder that will register as many as 24 parameters and will be able to survive an impact five times as great as called for in design of present instruments. Industry officials say that a flight recorder that could accomplish this would cost between

$10,000 and $20,000.

The FAA is about to begin testing two models: one produced by the Whittaker Corp. and another by United Data Control, Inc., a division of the Control Data Corp. However, it will take more than a year for the FAA to evaluate the recorders.

Key measurements. Currently used flight recorders for commercial craft—now required in jets, turboprops and propeller planes pressurized for flights above 25,000 feet—measure five parameters: time, airspeed, altitude, heading and vertical acceleration, or G forces. The only strength requirement is that they be able to withstand an impact of 100 G's—"a pretty mild test" in the opinion of some FAA officials.

In addition to the present five measurements, the new recorder will monitor 19 others, including the angle of attack, pitch rate, yaw rate, roll rate, angle of bank, engine torque on each engine, exhaust temperature on each engine, control column position, rudder pedal position, control wheel position, wing flap position, outside air temperature and horizontal stabilizer reaction.

Tough standards. Survivability standards also are tougher. At the FAA's Atlantic City, N. J., laboratory, the devices will be subjected to an impact of 1,000 G's for five milliseconds, pressure of 4,000 pounds at its three axes for five-minute periods and a series of penetration tests.

Electronics notes

- **'Superman' suit.** An electronically controlled suit, designed to turn even the mildest chap into a Superman, is under development for the Navy by the General Electric Co. The suit, an "exoskeleton" made up of frames and braces that are strapped to the body, enables a man to lift as much as 1,500 pounds, with only 40 pounds of human effort. The existing model receives its power from an external source, but engineers hope to make the suit self-powered.

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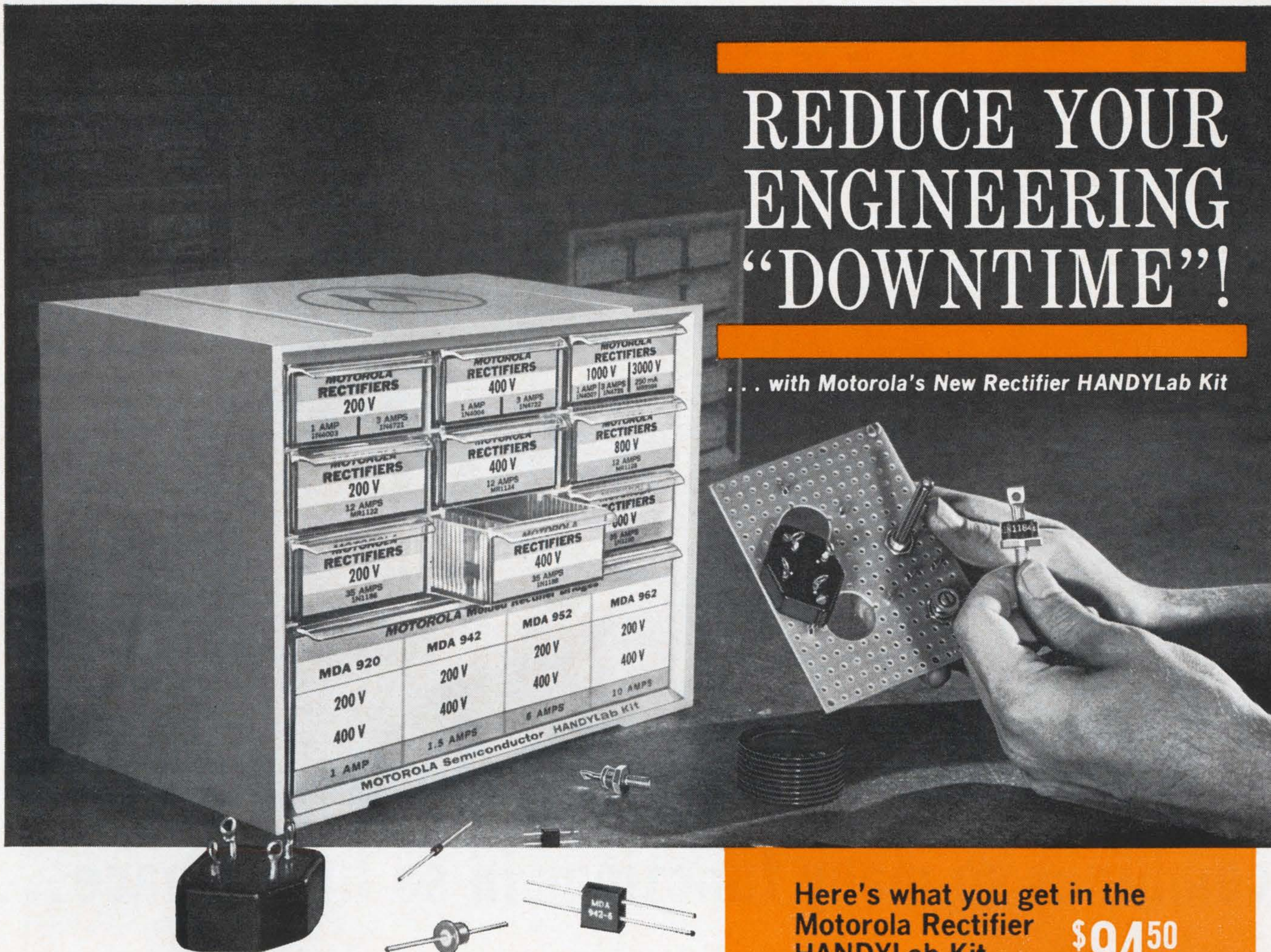

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1N4722	3.0	400	8	7.75
1N4725	3.0	1000	4	25.40
MR1122	12.0	200	4	4.72
MR1124	12.0	400	8	12.00
MR1128	12.0	800	4	22.40
1N1186	35.0	200	4	13.80
1N1188	35.0	400	4	23.40
1N1190	35.0	600	4	27.60
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MDA920-6	1.0	400	2	4.80
MDA942-3	1.5	200	2	5.30
MDA942-5	1.5	400	2	6.20
MDA952-3	6.0	200	1	4.45
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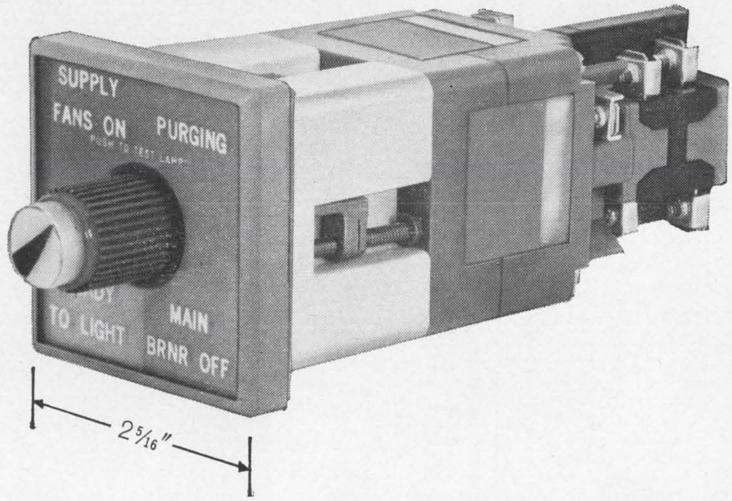

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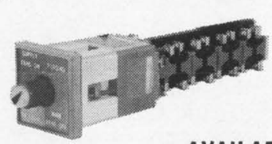

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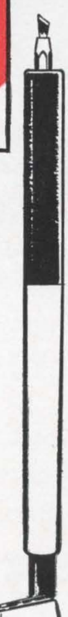

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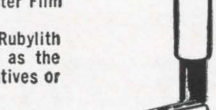

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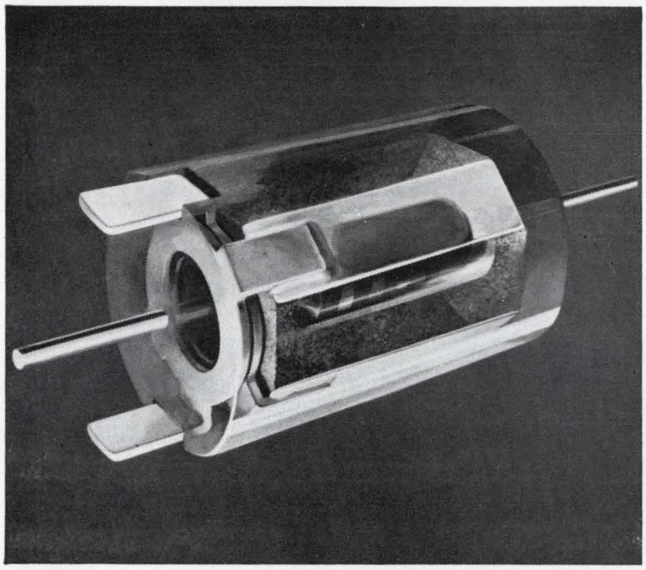

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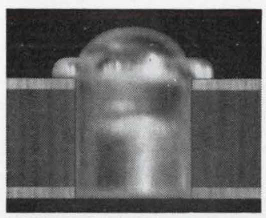

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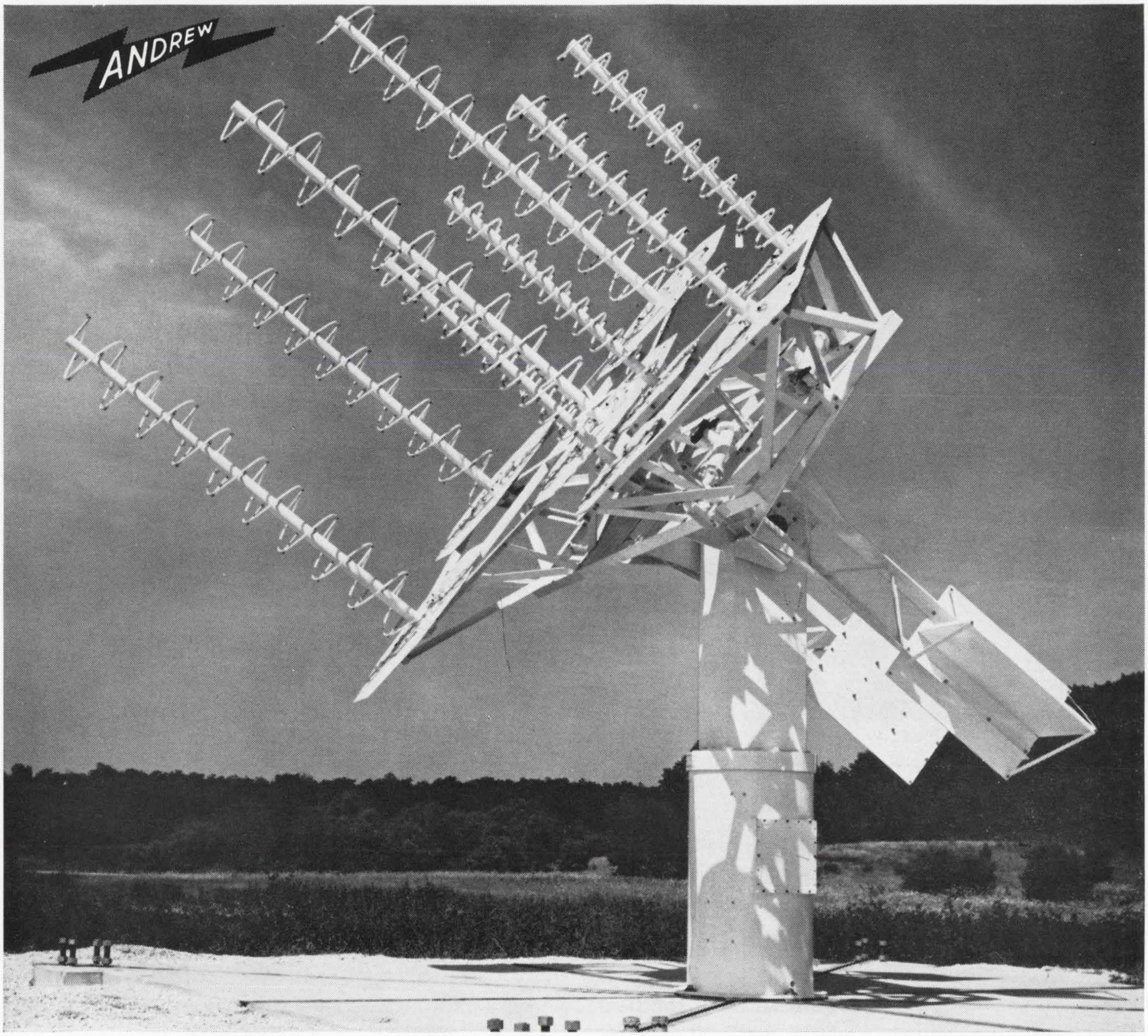

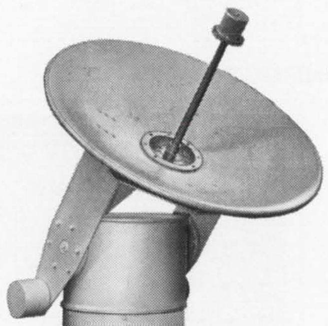

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Washington Newsletter

December 27, 1965

Military may face supply shortages

The Vietnam war is placing increasingly greater pressure on the military's supply facilities. **Orders for off-the-shelf items the Defense Supply Agency buys for the military are running about 40% ahead of six months ago.**

The rapid pace of shipments to Vietnam may lead to shortages of some military items. **So far, however, no shortages of electronic items have been reported.**

The DSA is already tackling the problem of potential shortages: it's warning industry—the textile industry now, with warnings to other industries likely later—that it may invoke production and delivery priorities under the Defense Production Act of 1950 to insure prompt delivery of war materiel.

For the next six months, **the supply agency plans to boost spending for electronics equipment 20%,** to $81.3 million from the original estimate of $67.4 million.

Vietnam spending delays Nike X . . .

The rise in military spending for the Vietnam war is resulting in some federal budget casualties. For example, Defense Secretary Robert S. **McNamara is expected to recommend that the White House delay, for at least a year, its approval of production of the Nike X antimissile missile.** McNamara's concern about a Red Chinese missile threat has not lessened—this was evident in his recent warnings to the North Atlantic Treaty Organization—but he feels there is still time to meet this potential missile threat even if production of the Nike X is put off for another year.

The Nike X program is expected to cost between $6 billion and $20 billion, depending on the sophistication of the electronics equipment designed for the system.

. . . development of the MOL . . .

Another casualty of the budget squeeze is the proposed manned orbiting laboratory (MOL). **The Air Force requested $300 million in fiscal 1967 for the MOL, but will receive only half of that or less.** The cut would delay the first launch for one year to 1968 or 1969. This could mean serious trouble for the military project, because by then the National Aeronautics and Space Administration's three-man Apollo spacecraft will have been checked out for a landing on the moon, making the Apollo vehicle an attractive substitute for MOL.

Apollo is being developed by North American Aviation, Inc., and MOL by the Douglas Aircraft Co. and the General Electric Co.

. . . and NASA's probe of the sun

Suspension of work on the Advanced Orbiting Solar Observatory (AOSO) —another victim of White House budget-cutting—**leaves several R&D projects in electronics uncompleted** [Electronics, Nov. 29, p. 32]. The prime contractor for AOSO was the Republic Aviation Corp., which had a $58-million order for two satellites. The major subcontractors were Honeywell, Inc., with a $14.2-million contract to build the stabilization system, and Texas Instruments Incorporated, with a $12.3-million order for a data-handling system for the satellite.

The announcement of the suspension caught the contractors by surprise: the Bendix Corp. disclosed a nearly $1-million order to make a star tracker for AOSO just days before the stop-order was made public by NASA.

Despite the suspension, **NASA says the project—which was to be begun in 1969—may still be reinstated.**

Second source for satellites

By selecting TRW, Inc., to negotiate for the development of six 1,200-channel global communications satellites, **the Communications Satellite Corp. is ending the virtual monopoly of the Hughes Aircraft Corp. in that field.** The move gives Comsat a second source for synchronous communications satellites.

TRW won the contract even though its bid was reportedly about 20% higher than Hughes's. **Another factor influencing Comsat's decision is said to have been TRW's assurance that it will use a dozen or more foreign components in its satellites.** Comsat's overseas partners want a bigger share of the communications company's procurement dollar.

One action that will broaden Europe's participation in Comsat was **Spain's decision to build its own ground station and begin service with 24 channels by 1967.** Negotiations for the construction of the station, which would use an 85-foot dish, are being conducted with the International Telephone and Telegraph Corp. Other countries considering ground stations are Nigeria, Colombia, Peru, Ethiopia and Kuwait. And Algeria may build a station that would serve a bloc of Arab nations.

Within weeks, Comsat will issue a call for a multipurpose synchronous satellite capable of handling ship and aircraft communications as well **as television distribution;** the satellite may also be required to carry weather data. It's believed that Comsat will want the new satellite in service by late 1967.

Log-rolling delays work on accelerator

It will be at least a year before construction starts on that 200-billion-volt accelerator, proposed several years ago by the Atomic Energy Commission. Because of budget problems and politicians' squabbles over the site of the $300-million facility, government officials are deleting from fiscal 1967's budget most of the $7 million in engineering and design money needed to get work under way.

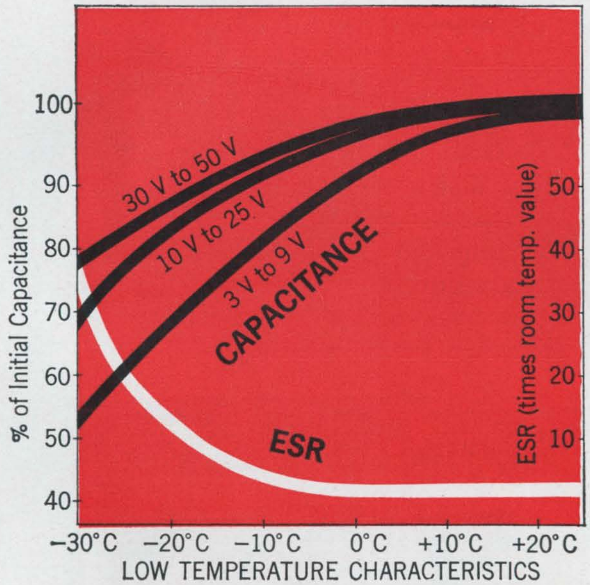
Italy's F-104 deal means $170 million for U. S. suppliers

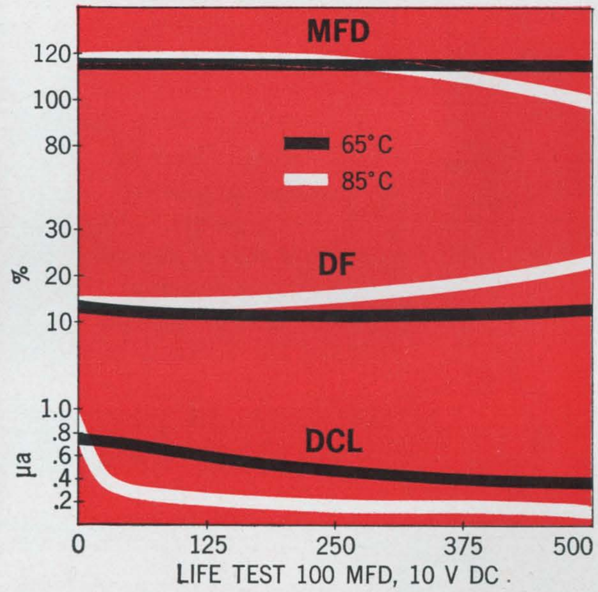
Agreement between the United States and Italy for Italy to build 162 F-104's, under license with the Lockheed Aircraft Corp., **will mean about $170 million in business for U. S. electronics companies.** The U. S. government is arranging for $85 million in credit for the deal, with Italy to finance the balance of the $400-million purchase on its own.

Italy's Fiat S.p.A. will build the Mach-2.4 airplane, which will undergo some changes. **The Raytheon Co. will partially redesign the Sparrow missile** so it can mate with the F-104; **the Autonetics division of North American Aviation, Inc., will modify the aircraft radar, and Lockheed will make some structural changes in the airplane.**

U. S. suppliers will probably carry the program through the R&D and flight-test stages; Italian production should start within a year.

If you can't believe a low-cost molded electrolytic can be this good... Test the MTA yourself.





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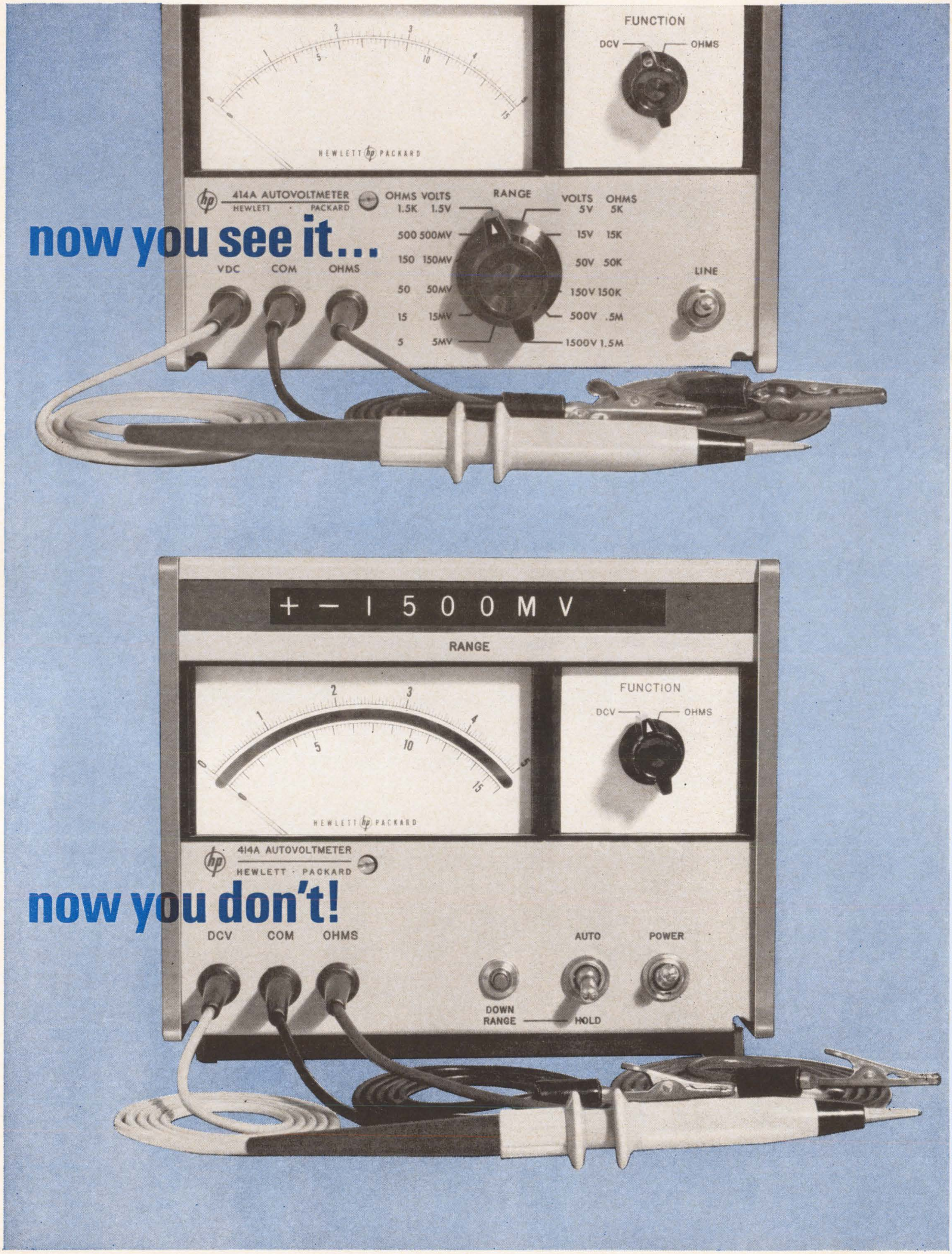
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A $650 analog dc volt-ohmmeter with fast automatic ranging plus an accuracy of ±0.5% of full scale ±0.5% of reading!

No more manual range switching with the Hewlett-Packard 414A Autovoltmeter. Range and polarity change automatically . . . provide digital range, polarity readout in less than 300 milliseconds . . . and still give you the convenience and economy of unusually accurate analog measurements! What's more, the 414A lets you make *resistance* measurements, again with automatic ranging, on a *linear* analog meter scale!

Here's the world's first "touch-and-read" analog voltohmmeter with accuracy anywhere approaching what you require for trouble shooting, tweaking, peaking and nulling, probing a circuit without a schematic. Use it for maintenance testing, on the production line, in the lab.

In the dc voltage function you simply touch the point to be measured and in less than 300 msec read the range and polarity of the measurement on the digital display at the top of the 414A . . . the precise dc measurement on the individually calibrated, mirror-backed taut-band meter. Range 5 mv full scale to 1500 v full scale in 12 automatically selected and displayed ranges.

Or measure resistance 5 ohms to 1.5 megohms . . . on a linear scale that gives unprecedented accuracy, especially on the lower ranges. The 12 resistance ranges are automatically selected and displayed, as well.

Ranges also can be selected and held manually. Another feature is a Down Range control which lets you drop to the next lower range merely by pushing a front-panel button. High input resistance. All solid-state. Compact, only 10¼ lbs.

The details are in the specifications. But to get the true significance of this automatic instrument, you need to see it perform on your bench. Call your Hewlett-Packard field engineer for that convincing demonstration. Or write for complete information to Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva; Canada: 8270 Mayrand Street, Montreal.

SPECIFICATIONS

DC VOLTMETER	
Voltage range:	±5 mv to ±1500 v full scale, 12 ranges, manual or automatic ranging
Accuracy:	±0.5% of reading ±0.5% of full scale
Input resistance:	10 megohms on 5 and 15 mv ranges, 100 megohms on 50 mv range and above
Superimposed ac rejection:	insensitive to 60 cps signal with peak value less than 7 times the full-scale dc level of the range in use in "Hold" position (rejection is 20% of reading in Autoranging)
OHMMETER	
Resistance range:	5 ohms to 1.5 megohms in 12 ranges (manual or autoranging with linear scale)
Accuracy:	±1% of reading ±0.5% of full scale on any range
Source current:	1 ma through unknown up to 5 K ohms, 1 μa above 5 K ohms
GENERAL	
Range selection:	voltage and resistance, automatically selects correct range in less than 300 msec; a particular range may be selected manually
Polarity selection:	automatic
Meter:	individually calibrated taut-band meter with mirror scale; linear scale, 0 to 5 and 0 to 15
Isolation resistance:	at least 100 megohms shunted by 0.1 mf between common terminal and case
Floating input:	may be operated up to 500 v dc above ground
Dimensions:	6 18/32" high, 7 25/32" wide, 11" deep (87 x 130 x 279 mm); 10¼ lbs (6,4 kg)
Price:	$650

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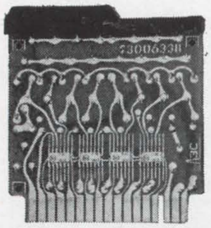
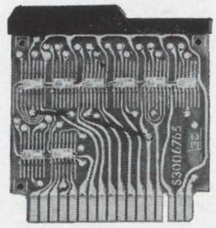
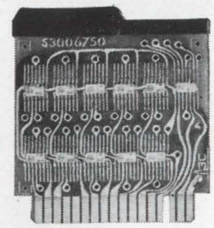


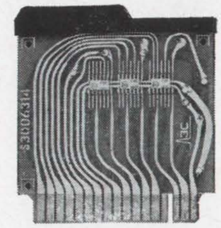
OD-335 OCTAL/DECIMAL DECODER PAC contains a prewired binary-to-octal decoder and two additional independent NAND gates to expand the matrix for BCD-to-decimal decoding.



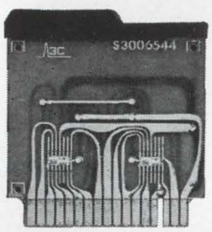
BC-337 FAST CARRY COUNTER PAC contains an eight-stage prewired counter which can be easily converted to a binary counter or BCD counter by using jumper connections.



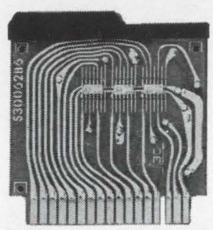
BC-336 BINARY COUNTER PAC contains between 8 and 20 prewired binary counter stages; number of stages is determined by user. Can be used for counting and frequency division.



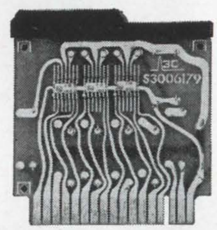
BC-335 COUNTER PAC contains six independent flip-flops with appropriate inputs for operation as binary counters; may also be employed individually as complementing flip-flops.



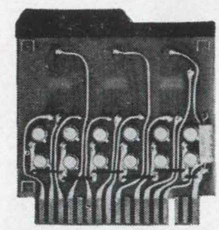
EO-335 EXCLUSIVE OR PAC contains five independent functional gate structures and one independent NAND gate; each contains 3 two-input NAND gates and performs AND-OR and AND-OR-INVERT functions.



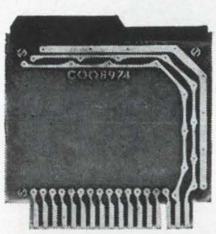
BR-335 BUFFER REGISTER PAC contains six flip-flops with independent set-reset capability for parallel loading of information. Common clock reset inputs make possible simultaneous operations on all stages.



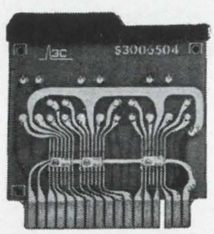
XD-335 TRANSMISSION LINE DRIVER PAC contains 6 two-input driver circuits. Each circuit is capable of driving standard 50 ohm, 75 ohm and 93 ohm coaxial cables at repetition rates up to 5 megacycles.



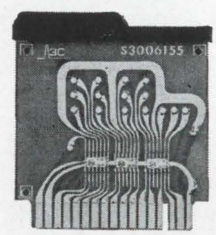
LD-330 LAMP DRIVER PAC contains twelve identical independent lamp driver circuits. Each circuit is capable of switching 70 milliamps of current at any positive voltage up to 20 volts, at a maximum frequency of 1 mc.



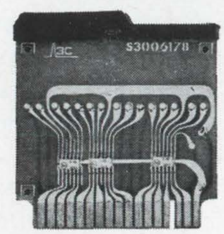
BP-330 BLANK PAC — standard card with etched buses for +6V, −6V and ground — facilitates mounting special circuits using standard component lugs and point-to-point wiring. Also available: standard copper clad PAC kit for custom etching.



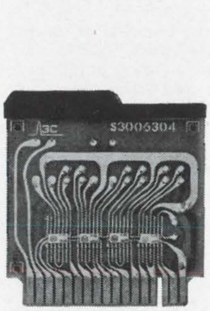
DL-335 NAND TYPE 2 PAC contains 6 four-input NAND gates; two have disconnected collector load resistors brought out on separate terminals. By tying the gate outputs to a single load circuit a number of gates can be connected in parallel without reducing output drive capability.



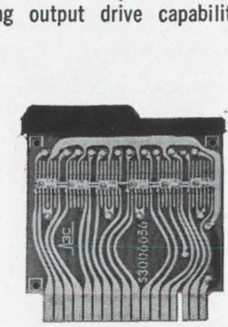
DN-335 EXPANDABLE NAND PAC contains 6 three-input NAND gates with nodes; two have disconnected load resistors which are brought out on separate terminals. Gate node input allows for expansion of the number of gate inputs by attachment of diode clusters.



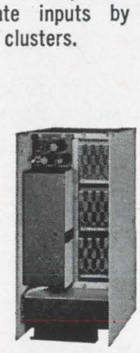
DI-335 NAND PAC contains 10 two-input NAND gates; two have collector loads separate from the collector outputs. By tying the gate outputs to a single load circuit, a number of gates can be connected in parallel without reducing output drive capability.

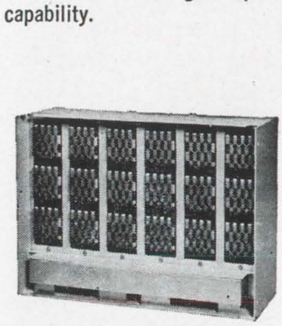


DG-336 SELECTION GATE TYPE 2 PAC contains two independent functional gate structures; each has 4 three-input NAND gates and performs the AND-OR-INVERT function.



DG-335 SELECTION GATE TYPE 1 PAC contains four independent functional gate structures. Each has 3 two-input NAND gates and performs the AND-OR-INVERT function.

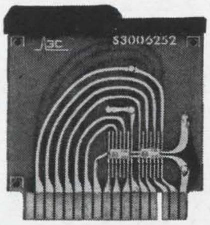




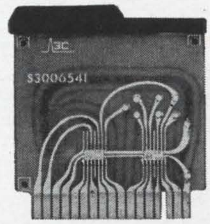
MOUNTING HARDWARE is available with PAC capacities between 24 and 144 modules, and a choice of wire-wrap or taper pin connectors. Power supplies are offered in plug-in or rack-mount models. Accessories include auxiliary wire wrap kits, wire wrapping tools, taper pin insertion tools, extender PACS, jumper lead sets, instruction manuals and logic symbol sticker kits.

Modules

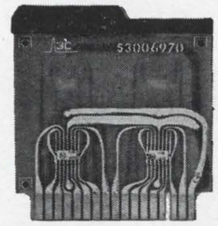
5 mc operation • high packaging density • low cost per logic function • inherent reliability • noise protection in excess of one volt • low power consumption • NAND logic • DC coupled circuitry



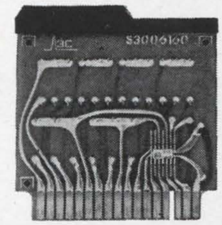
FA-335 GATED FLIP-FLOP PAC contains four independent flip-flops, each with AC and DC inputs and a common reset; allows for control of the flip-flop from a variety of level and pulse inputs.



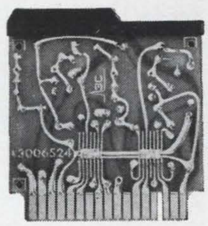
UF-335 UNIVERSAL FLIP-FLOP PAC contains three independent flip-flops each with AC and DC input gating and a common reset; can perform all functions of other μ-PAC flip-flops plus many additional logic operations.



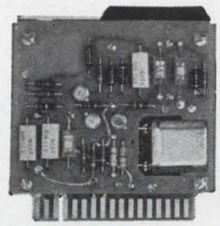
FF-335 BASIC FLIP-FLOP PAC contains eight independent flip-flops. Each stage has a DC set and reset input and a set and reset output. Circuit consists of two NAND gates internally wired back-to-back.



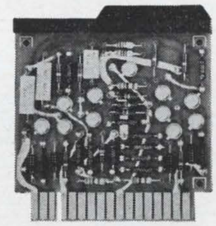
DC-335 MULTI-INPUT NAND PAC contains 2 six-input NAND gates with nodes and 4 three-diode clusters. Gate node input allows for diode cluster expansion of the number of gate inputs.



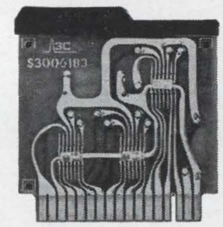
DM-335 DELAY MULTIVIBRATOR PAC contains two independent monostable multivibrators capable of generating assertion and negation pulses in a variety of widths. Each circuit has two NAND inputs, an Enable and three discrete variable delay taps.



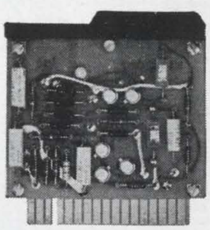
MC-335 MASTER CLOCK PAC contains a crystal controlled oscillator, a pulse shaper and a pulse amplifier. The oscillator operates between 200 kc and 5 mc. The pulse shaper section can vary pulse width between 50 and 150 nanoseconds.



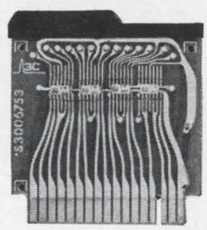
ST-335 SCHMITT TRIGGER PAC contains two independent trigger circuits capable of converting various shaped inputs to a μ-PAC output. Switching levels can be varied from $+2.5$ volts to -2.5 volts by making appropriate pin connections.



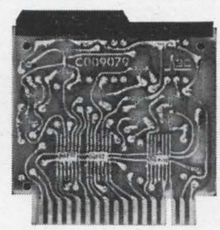
PA-335 POWER AMPLIFIER PAC contains 6 three-input high-drive NAND gates, each capable of driving 25 unit loads and 250 picofarads stray capacitance. Each gate has two electrically common outputs to reduce load distribution current.



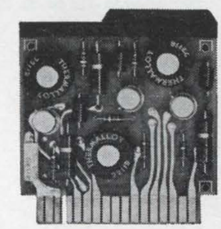
MV-335 MULTIVIBRATOR CLOCK PAC contains a free-running variable frequency multivibrator, a pulse shaper and a pulse amplifier. The multivibrator operates between 200 kc and 5 mc; frequency and pulse widths can be varied by means of potentiometer-capacitor networks.



TG-335 TRANSFER GATE PAC contains four independent functional gate structures. Two of the structures have 4 two-input NAND gates, one input on each gate being common to the four gates. The remaining two structures have 3 two-input NAND gates, one input being common to the three gates.



LC-335 NEGATIVE LOGIC LEVEL CONVERTER PAC contains 10 independent two-input circuits. Each circuit accepts signals at ground and -4 to -15 volts and provides a μ-PAC output. Also available is the S-PAC LC-35 Positive Logic Level Converter PAC which mates μ-PAC signals with 3C's S-PAC.



SD-330 SOLENOID DRIVER PAC contains three independent circuits for driving heavy resistive, capacitive or inductive loads. Each circuit has two NAND inputs and is capable of switching up to one ampere of current at 500 cycles per second from a positive supply of up to 28 volts. One independent two-input NAND gate is also included.

3C SALES OFFICES: NEEDHAM, MASS.; FOREST HILLS, N.Y.; LEVITTOWN, PA.; SYRACUSE, N.Y.; SILVER SPRING, MD.; HOUSTON, TEXAS; HUNTSVILLE, ALA.; ORLANDO, FLA.; DES PLAINES, ILL.; DETROIT, MICH.; CENTERVILLE, OHIO; LOS ANGELES, CALIF.; PALO ALTO, CALIF.; KENT, WASH.; ALBUQUERQUE, N.M.

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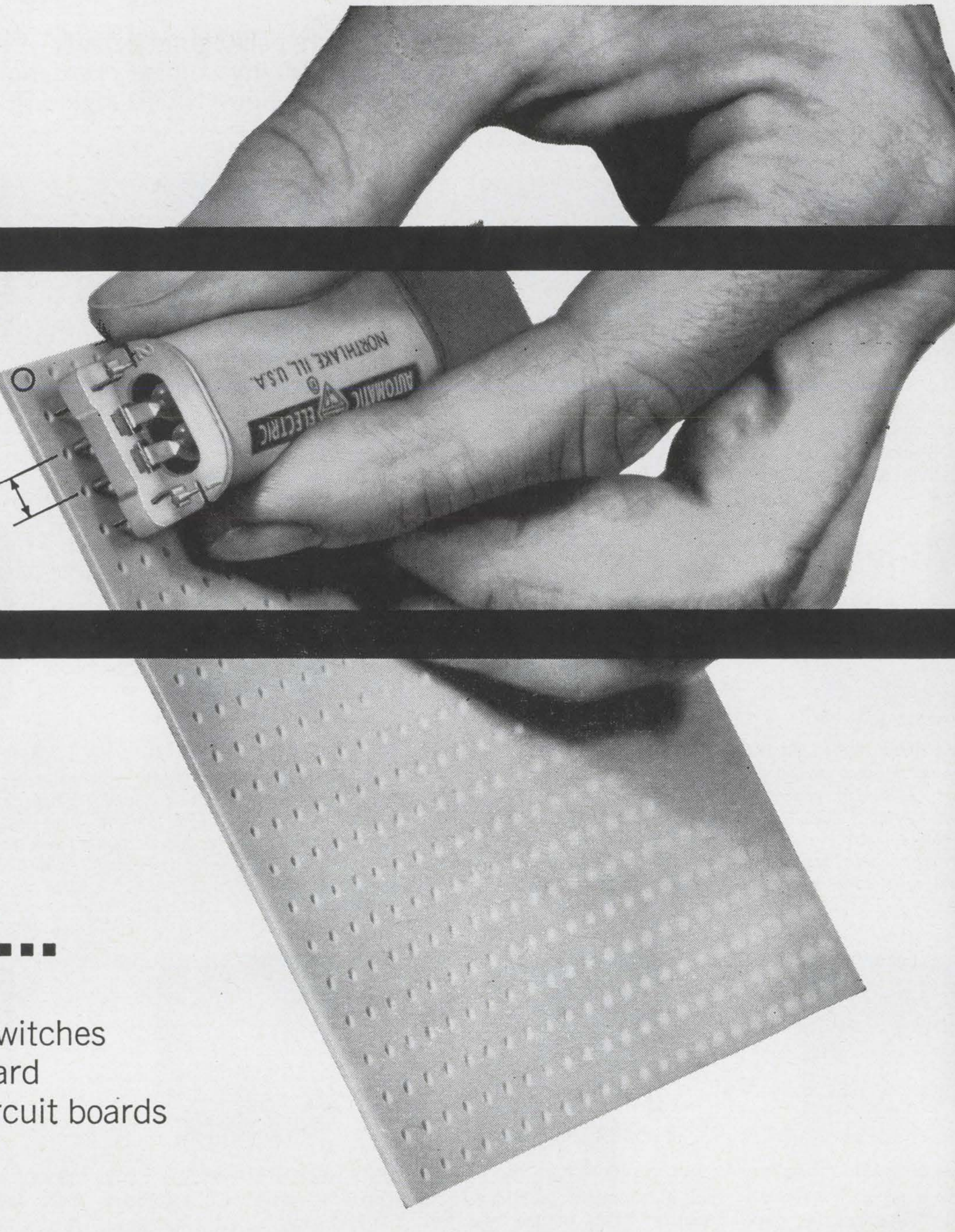

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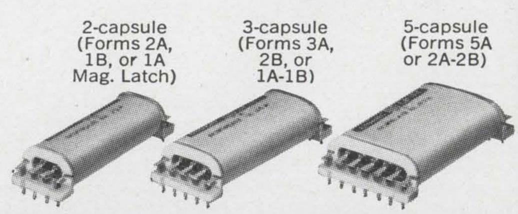
In addition to this feature, PC Correeds have separate terminals to eliminate strain on the glass capsule. These terminals are "ribbed" for added strength and rigidity, and are welded . . . not soldered . . . to the capsule leads. Individual capsules can be removed without having to remove the entire package. The bobbins are made of glass-filled plastic for greater strength and to eliminate breakdown due to moisture absorption.

For the full facts on how these new AE Printed-Circuit Correeds meet the requirements of modern electronic circuitry, write to the Director, Electronic Control Equipment Sales, Automatic Electric, Northlake, Illinois 60164.

2-capsule (Forms 2A, 1B, or 1A Mag. Latch) | 3-capsule (Forms 3A, 2B, or 1A-1B) | 5-capsule (Forms 5A or 2A-2B)



*Patent applied for.

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Technical Articles

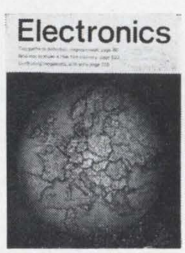
New target for radar—sharper vision with optics: page 58

As radar peers farther, sights more sharply and penetrates jamming better than ever, the information-processing capacity becomes a critical limitation. To cope with an explosion of data, engineers are developing optical signal processing techniques to replace conventional electrical ones. Because the new systems are two-dimensional, they can process two parameters simultaneously.

Coding for error control; an examination of techniques: page 70

In the struggle to make digital communications error-proof, engineers are developing a lot of new codes and new approaches to coding. The brute-force method of repeating transmission is being replaced by block codes; nonblock codes have been proposed, but they are still in their infancy.

European electronics markets 1966: page 81



In Europe, the application of electronics grows rapidly, creating broad new markets for European, Japanese and U. S. products. Until now, there have been no detailed statistics available. To fill this gap, the editors of Electronics have surveyed the key countries of Europe—West Germany, Great Britain, France, Italy, The Netherlands, Belgium, Sweden, Switzerland and the Soviet Union—to produce the first detailed information. Additionally, they examined the trends in technology and markets. In general, the biggest growth areas are in computers, communications and industrial electronics. Sales of consumer products seem to be in a plateau, faced with saturation, while production of military electronics declines because of the uncertainties in the future role of the North Atlantic Treaty Organization. For the cover, art director Saul Sussman created a unique world globe to focus on Europe.

Coming January 10, 1966

- **Electronic's annual U.S. market report**
- **New semiconductor lasers**
- **Wideband oscillator uses tunnel diodes**
- **Electronic resolvers for analog computers**

New target for radar: sharper vision with optics

Information-processing capacity of systems faces challenge of supersonic speed; with optical techniques, more data is handled faster with less equipment

By A.J. Talamini, Jr., and E.C. Farnett
Radio Corporation of America, Moorestown, N.J.

Radar peers farther, sights more sharply, and penetrates jamming better than ever before. Big systems must sort out vast amounts of information on targets that are sometimes moving at supersonic speeds. To cope with this explosion of information, engineers are developing signal-processing methods based on optical rather than electrical systems.

A basic advantage of optical systems is their two-dimensional capability. Electrical systems are one-dimensional. This two-dimensional capability may be used, for example, to process two parameters simultaneously—such as range and velocity, or velocity and acceleration—through a single information channel. A significant advantage of this capability is that the system provides means of processing tremendous quantities of data in real time. Also, optical processing permits a considerable reduction in the size and complexity of the equipment over that required by typical electrical approaches.

Several types of optical radar signal processors have been used over the past few years. Some of these have used cathode ray tubes, various types of film processing systems, and transparent optical quartz delay lines with both quasi-coherent and noncoherent optics for processing radar returns. Much of the work that will be described here has been derived from the concept of using a rotating optical disk as the basic component in the optical processing system.

Rotary optical correlator

The concept of using a rotating optical disk was first applied to a noise-correlation radar system. Noise-correlation radar systems often transmit continuous wideband noise-like signals. Targets are detected by correlating the received signals with a delayed replica of the transmitted signal. The delay that must be introduced to achieve a correlation peak is proportional to the target range.

The classical approach to a noise-correlation radar system is seen at the top of page 59. A pseudo-random or noise-like signal is generated and transmitted. A replica of this transmitted signal is delayed and then electronically multiplied with the received signal. The maximum integrated product occurs when the delay is equal to the round-trip time to and from the target. Thus, the presence of a target can be detected.

In practice, this system is limited since targets at only one range can be detected at any given time. By allowing the delay time to vary slowly, the system can be extended to detect targets at more than one range. The rate of change of delay, however, must be sufficiently slow to permit adequate integration time for any given target. An

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alternate way to increase range coverage is to add additional delays of varying lengths with multiple parallel multipliers and integrators.

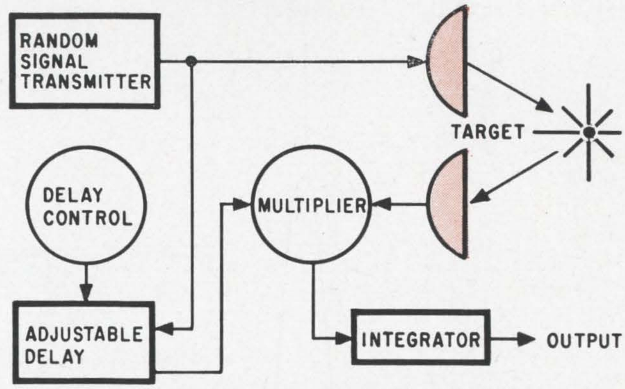
A rotary optical correlator provides these additional delays without the need for actual physical delay lines, simultaneously performs the parallel correlation processes and, in addition, provides the capability of extracting doppler, or velocity, information as well as range information.

The capability of this rotary optical correlator is equivalent to a pulse compression ratio of 50,000 to 1, with a flexible exchange of time and bandwidth within this value. The ratio is that of the radiated signal pulse length to the equivalent range-resolution element. The rotary optical correlator can provide up to 50,000 range elements and 240 doppler elements for a total of 12-million range-doppler elements. A range or doppler element is the minimum resolvable distance or radial velocity, respectively, between targets. Readout requirements were set at 1,200 range elements and 240 doppler elements for a total of 280,000 range-doppler elements to be available at any one time, and techniques have been developed to allow search through the entire range dimension.

Loop of film

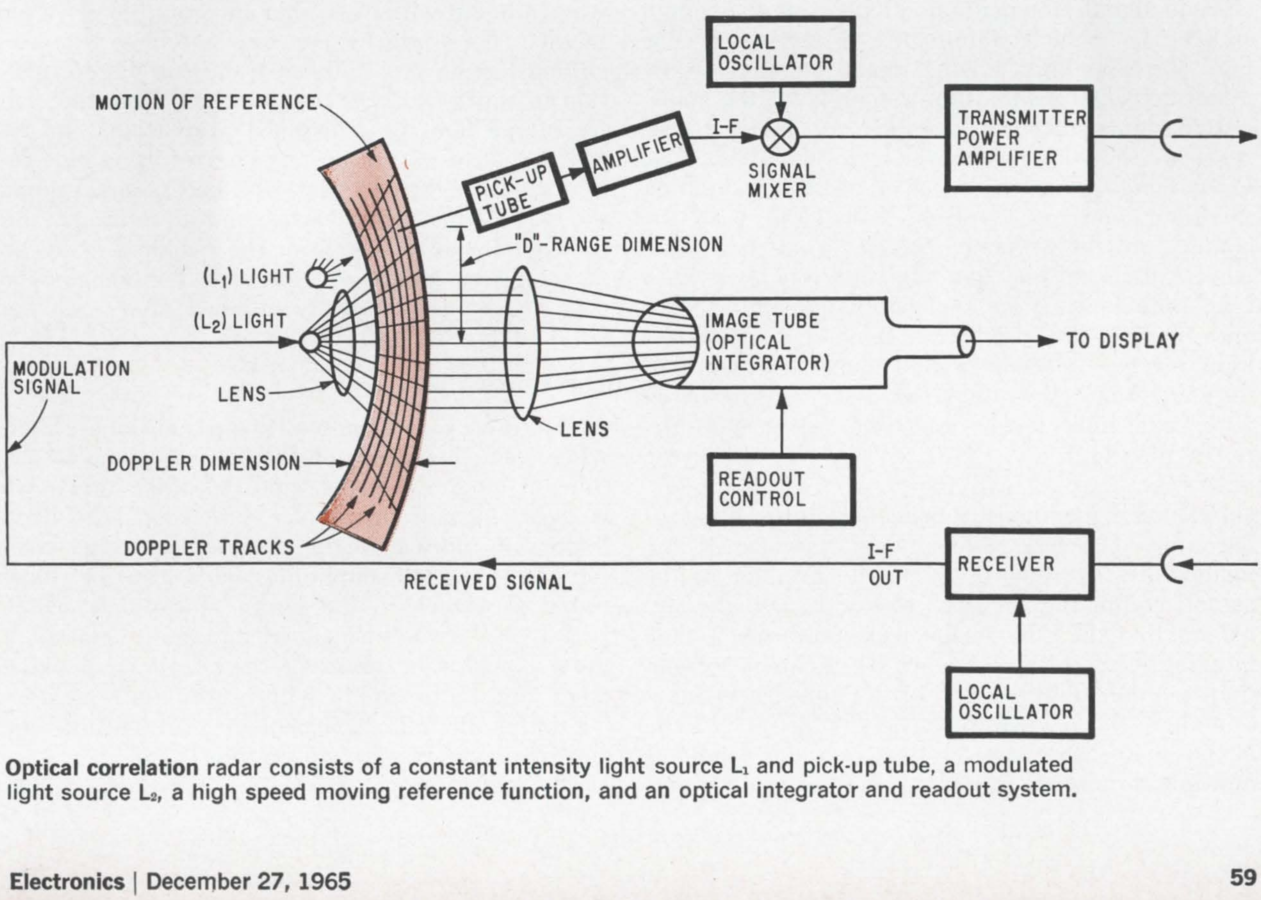
To introduce the concept of the rotary-optical correlator, the general method of operation will first be presented as though the reference signal, or transmitted signal, is obtained from a moving loop of film. Extension of this idea to a rotating optical disk will be obvious.

The optical correlation radar system is illustrated in the diagram below. The system has a constant-intensity light source L_1 and pick-up tube, a

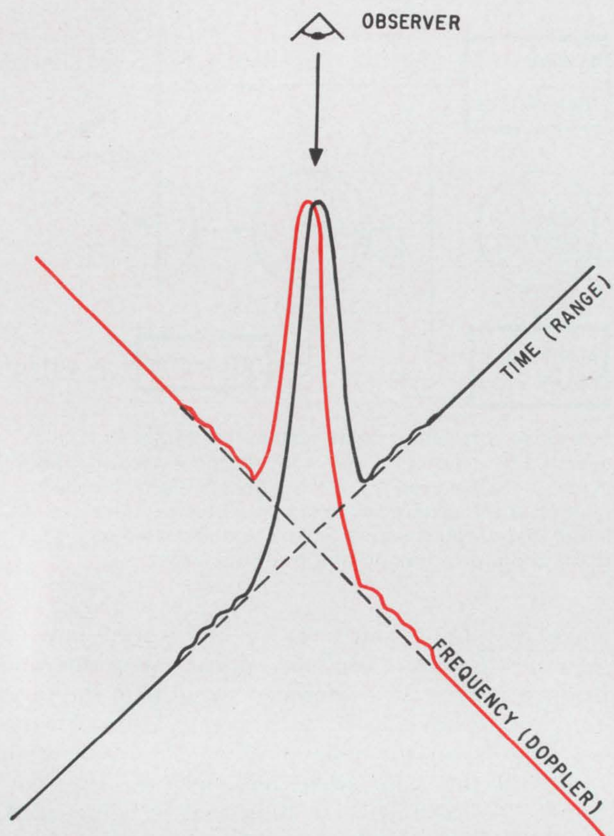


In a noise-correlation radar system, the target is detected by generating and transmitting a pseudo-random signal. A delayed replica of the signal is electronically multiplied with the received signal. The maximum integrated product occurs when the delay is equal to the round-trip time to and from the target.

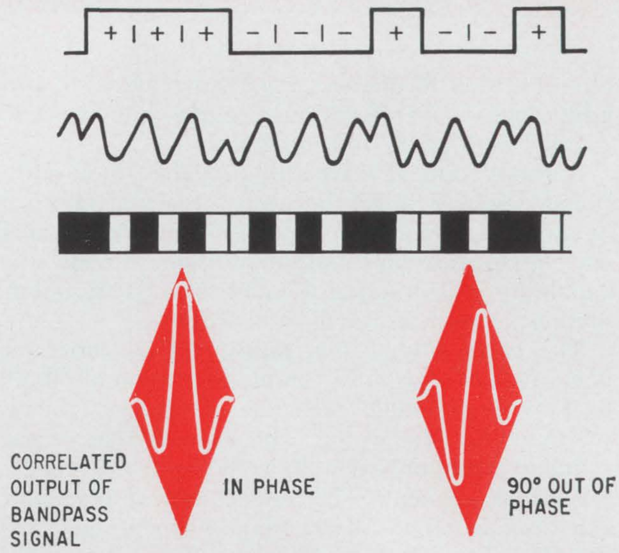
modulated light source L_2, a high-speed moving reference function, and an optical integrator and readout system. The reference signal is in the form of alternate transparent and opaque areas of varying lengths on the loop of film. The spacing or widths of the transparent and opaque areas correspond to the type of coding that is being used. This may be in the form of a frequency-modulated code, a pseudo-random noise code, or whatever form of complex coding is required. A light beam from a constant-intensity light source L_1 passes through the center track of the loop of film shown by the line through the center of the film. As the film loop moves past the light source, the beam of light is interrupted at a rate determined by the coding of this reference track. The light signal at



Optical correlation radar consists of a constant intensity light source L_1 and pick-up tube, a modulated light source L_2, a high speed moving reference function, and an optical integrator and readout system.



Typical two-dimensional ambiguity plot of a radar signal. Display brightness represents amplitude and display displacement represents time and frequency (range and doppler).



The sequence shown at the top is the pseudo-random binary phase code. It represents a code length of 50,000 elements, corresponding to a range of about 800 miles. A c-w sinusoid, which has been modulated by the code, is shown in the second line of the figure. This signal is translated to a radio frequency and used as the transmitted signal. Received signals are translated down to the same intermediate frequency and applied to the light modulator. The type of pattern on the disk is shown in the third line of the figure. On the disk are 241 doppler tracks, each with a slightly different scale factor corresponding to a particular doppler element. The resulting correlation function at the bottom of the figure shows the envelope of the function and the fine structure underneath the envelope for two particular phases of the received signals.

the phototube pickup is thus modulated in accordance with the coding in the reference track and, upon translation to the radar-carrier frequency, becomes the transmitted signal. The received signal intensity-modulates another light source, L_2, which illuminates a portion of the film corresponding to the range interval to be monitored. During the time required for the transmitted signal to reach the target and return to the receiver, the film has moved through a distance, D, at which point the received signal modulating the light source L_2 will be coincident with the coding on the reference track. That is, transparent areas on the film will be coincident with high light levels from the modulated light source and opaque areas will be coincident with low light levels. At other points along the length of the film some opaque areas will be associated with high light levels, and vice versa, with the result that only at a position D inches from the phototube pick-off will there be a maximum accumulated light intensity collected on the integrating tube. The light intensity on the face of the image tube is proportional to the product of the signal modulating the light source L_2 and the signal on the film; the image tube performs a time integration of this product which yields a correlation function. The position of the correlation function along the vertical dimension of the image tube is thus a measurement of time or radar range. If multiple targets are present, a number of positions, D_1, D_2, and so on, will result.

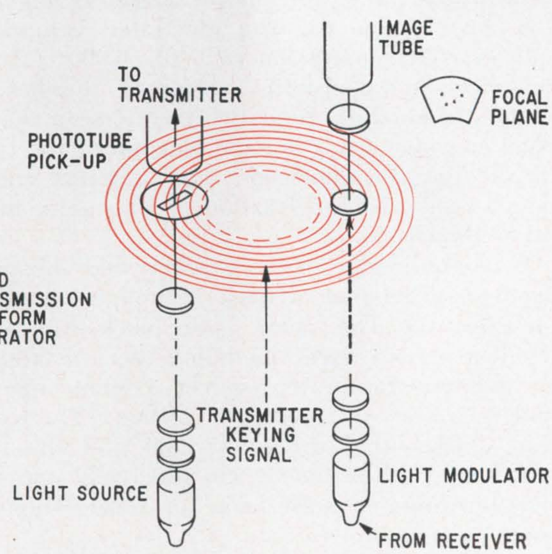
In addition to the single track along the center of the film, many other tracks may be placed on either side of the center track with the same coded waveform but with expanded and compressed scale factors. These tracks are for matching doppler-shifted signals, and will cause the correlation function to appear horizontally displaced from the center of the film by a distance proportional to the radial velocity of the target. The resulting correlation function thus appears at some point D along the vertical dimension corresponding to range, and horizontally displaced from the center line by an amount corresponding to doppler. The image tube can then be electronically scanned after each desired integration interval.

Three dimensions

The process is thus a two-dimensional filter, where one dimension of the optical plane is the time, or range dimension, and the other dimension is the frequency, or doppler dimension. The third dimension (normal to the plane of the other two) represents signal amplitude. This can be illustrated as shown in the figure at top left which is a typical two-dimensional ambiguity plot of a radar signal. The observer, in effect, is "looking down" on the function—with brightness representing amplitude and displacement representing time and frequency (range and doppler).

The rotary optical correlation approach utilizes a rotating glass disk upon which is photographically placed the complex coded waveform from which the transmitted signal is derived, and doppler-shifted versions of the waveform against which received signals are correlated. The concept of the rotary optical correlator is shown in the figure below. The left portion of this diagram describes the generation of the coded waveform, which is used as the transmitted signal; the right portion of the diagram shows the two-dimensional optical correlator.

Transmitter excitation is obtained from the coded transmission waveform generator. A beam of light from a constant intensity light source passes through a track on the disk containing the coded waveform. The phototube pick-up is excited by the light beam as the disk revolves and thus generates the coded waveform which is used as the transmitted signal. Received signals are applied to a light modulator which intensity-modulates a light source corresponding to the received target information. The light modulator illuminates an area on the disk corresponding to the desired range-doppler window to be monitored. An integration plane collects the resulting modulated light, which is proportional to the product of the received signals and the patterns on the disk, and yields the resulting correlation functions. An image orthicon camera chain and monitor may be used for the integration plane and for the display. Time-of-arrival of the received signal, since proportional to the disk position referenced to the transmitter pick-off, provides the range information. Doppler is obtained from the doppler track yielding the correlation function. Hence, doppler is a function of the radial distance from the center of the disk, and range is proportional to distance measured along the circumference of the disk. Thus, a continuous analog range dimension is obtained. This contrasts with discrete range steps common in



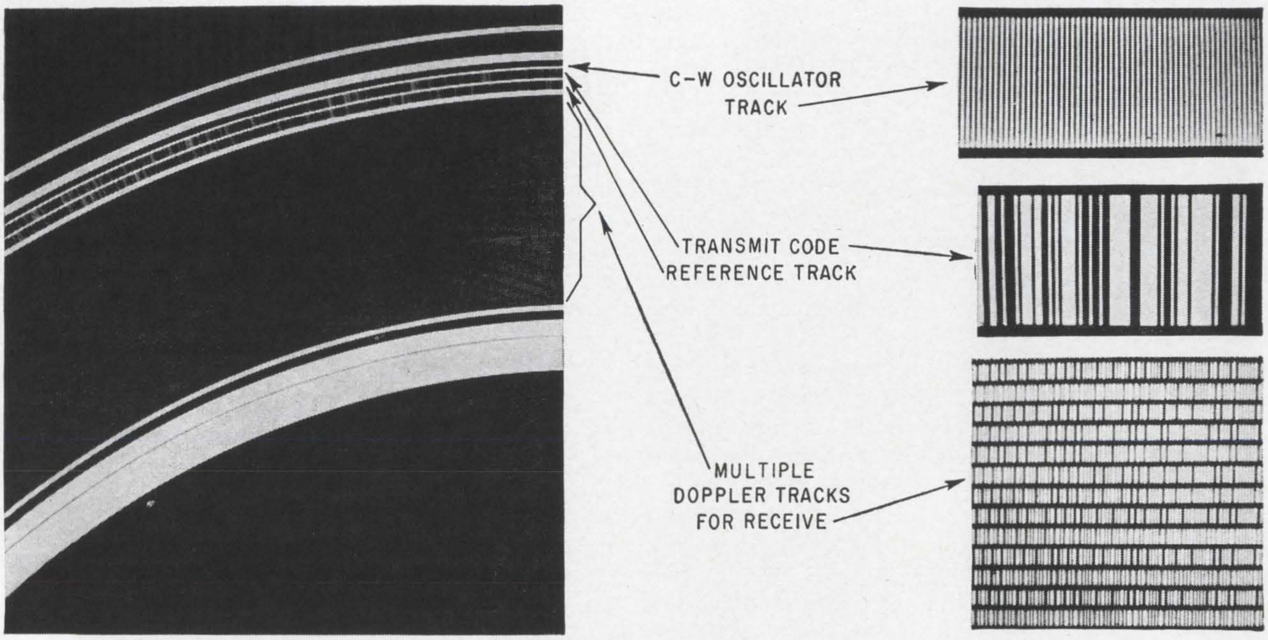
Rotary optical correlator. The left portion of the diagram shows the generation of the coded waveform used as the transmitted signal; the right portion shows the two-dimensional optical correlator.

electrical implementation by delay lines. In essence, an almost infinite number of delay lines is present in the form of the disk's angular position at any instant of time. For application in a system which does not employ separate antennas for transmission and reception, a transmitter keying signal may be provided by a timing code on the disk alternately to turn the transmitter on and off and to allow reception when the transmitter is keyed off.

Clock pulse used

The type of code used is a pseudo-random binary phase code, shown on the preceding page. The code is generated by a feedback shift register technique, consisting of a binary shift register with selected stages added to determine the new input to the register. The output of the register is shifted out of the last stage and the new input shifted into the first stage by a periodic clock pulse; it is the plus-minus sequence shown at the top of the figure. The code is 50,000 elements long. These 50,000 range elements correspond to an unambiguous range of 800 miles, or the limit of the code setup. By phase reversal, the code modulates a continuous-wave sinusoid to yield a modulated c-w signal as shown in the second line of the figure. This signal, after translation to a radio frequency, is used as the transmitted signal. Received signals are translated down to the same intermediate frequency and are applied to the light modulator. The type of pattern on the disk is shown in the third line of this figure. A typical track consists of alternate transparent and opaque areas corresponding to the code. Each of the 50,000 code elements is composed of two bits, corresponding to the positive and negative portions of a sine wave, for a total of 100,000 bits in each doppler track. A total of 240 doppler tracks, plus a zero doppler track, is placed on the disk, each with a slightly different scale factor corresponding to a particular doppler element. The resulting correlation function at the bottom of the figure shows the envelope of the function and the fine structure underneath the envelope for two particular phases of the received signals. The width of the envelope at the half-power points is equal to the width of one element of the code, and represents a compressed pulse with a compression ratio of 50,000 to 1.

A photograph of a portion of the disk is shown in the figure on page 62. The disk itself is approximately 16 inches in diameter and is designed for a speed of 6,000 revolutions per minute. The continuous-wave oscillator track is shown as the upper track of this photograph. As the disk rotates, it yields a c-w sine wave. The pseudo-random binary phase code itself is shown as the next track and consists of alternate transparent and opaque areas corresponding to the plus-minus sequence of the code. In external circuitry, the code modulates the c-w signal to produce the coded transmitted signal. The third track, used for test purposes, is a repeat of the code in the second



Optical disk represents a bank of 241 doppler filters for each of 50,000 range elements, or a total of about 12 million doppler filters. The 16-inch diameter disk is a hundred thousandth the size of conventional doppler-filter implementation. Photomicrographs of disk patterns are at the right.

track but angularly displaced from it. The remaining tracks are the 241 doppler tracks, which are spaced over a segment of the disk only 1½ inches wide along the diameter. The average width of a line or space in each of the doppler tracks is approximately 400 micro-inches, representing a density of approximately 2,500 lines per inch. The disk is essentially a bank of 241 doppler filters for each of 50,000 range elements, or a total of approximately 12 million doppler filters. Comparing the volume of the disk alone with that which would be required by conventional doppler filter implementation yields a hardware size reduction of well over 100,000 to 1.

Components

Some of the components in the system are unique. One is the high-speed rotating glass disk, which bears the pseudo-random signals and generates and correlates the coded signals. After generation by a digital shift register, the code is recorded on paper tape, which is then used to control the exposure as each elemental area of the photosensitized disk is exposed to light. Step control of the exposure is accomplished with precision machine equipment.

If the speed of the disk varied, the jitter would destroy the time resolution of the resultant correlation function. A closed-loop servo system holds the speed to one part in 10 million. The mechanical Q or inertia of the rotating disk does the rest.

Light modulator requirements are met by using a short-persistence phosphor (P-16) on a cathode ray tube. As bandwidth requirements increase, the use of other light modulator materials such as potassium dihydrogen phosphate or cuprous chloride look attractive for applications where frequency responses above 20 megacycles will be required. Other possibilities are modulated semicoherent or coherent light-emitting diodes for higher-frequency applications.

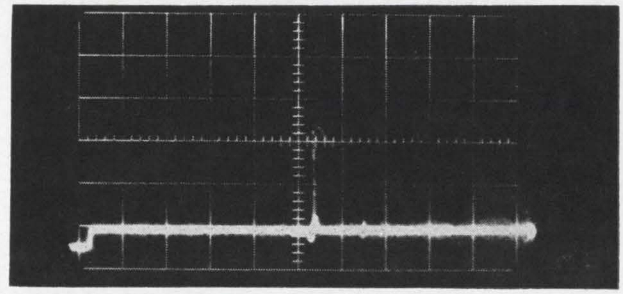
An image orthicon camera is used as an integration plane and as a read-out device displaying the correlation functions on a television screen display.

To permit photographing the correlation function on a television monitor, the field of view of a television camera is narrowed and a magnification of approximately 115 times is obtained. The field of view then embraces approximately 15 doppler channels and 150 range elements for a total of approximately 2,000 range-doppler elements. Range is measured along the horizontal axis, and doppler along the vertical axis. An A-scope display showing a horizontal scan through the target is shown at the top of page 63. The illustrated compressed pulse has a compression ratio of 50,000 to 1. For readout, the quantitative values of doppler and range are obtained from two counters—a doppler counter which reads out the location of the target in the doppler dimension, and a range counter which reads out the location of the target in the range dimension.

A block diagram of the experimental subsystem used for evaluation of these techniques is shown on page 63. The radar path block was simulated in various ways, including the utilization of an X-band transmitter-receiver system operated under a variety of jamming conditions. The results showed that the correlation gain and the large time-bandwidth of the system effectively improved signal-to-jamming noise ratio for several types of jamming signals.

Magnetic-optical processor

With a moving target, the correlation function will change position in range and doppler dimensions as the target moves. However, resolving the doppler dimension may be difficult with an accelerating or decelerating target. If the target's acceleration is appreciable during the integration time of the system, smearing will occur in the doppler dimension. This will show up on a monitor screen as a spreading of the light spot over many doppler tracks, with a decrease in light intensity. For targets with large acceleration, it may be impossible to determine the target's velocity or even its presence. Hence, it is desirable to incorporate a filtering process to determine and compensate for this acceleration.



Oscillogram of correlation functions has a pulse compression ratio of 50,000 to 1.

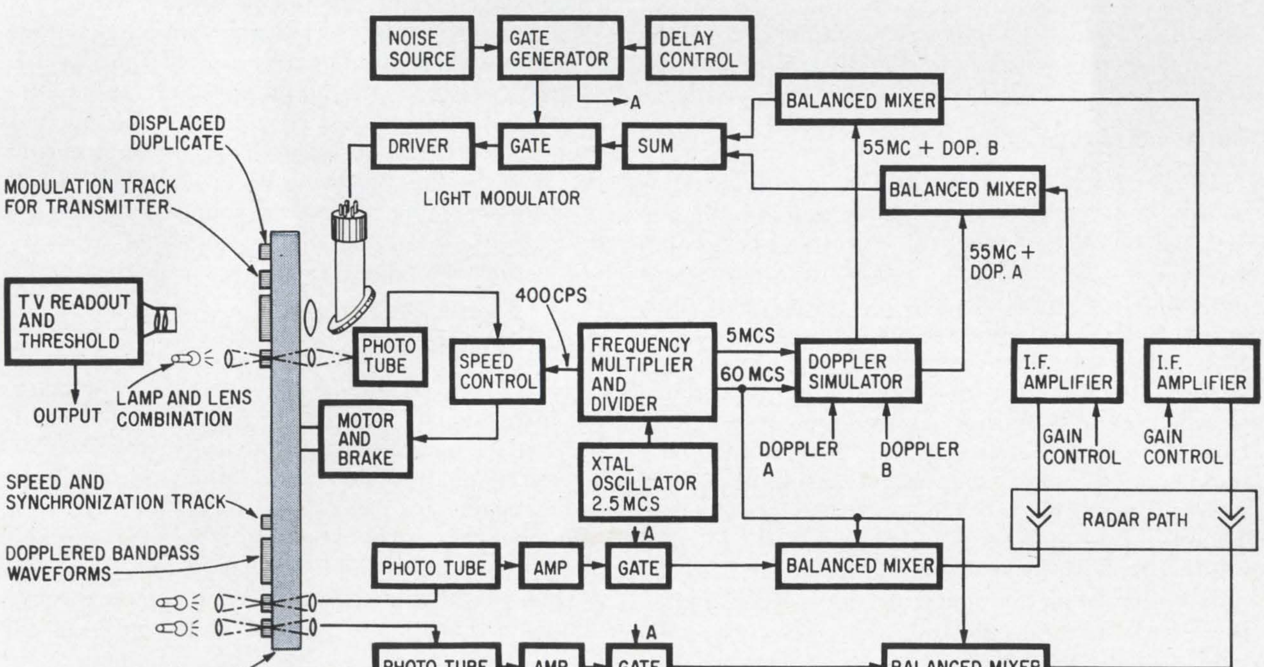
This problem led to investigations of rotary optical correlation for processing the two dimensions of velocity and acceleration, instead of velocity and range, as in the previous example. This system was intended for a coherent-pulse radar system, where coherent storage of the radar returns over the integration time of the system is required. The investigation centered on magnetic techniques for providing this storage capability as well as collating target returns by range elements, and processing of the range-gated stored returns by optical techniques for extracting velocity and acceleration information.

A concept diagram of the magnetic-optical processor is shown on page 64. A magnetic disk and an optical disk are mounted on the same shaft assembly and driven by a single disk drive and control. The upper part of the diagram is the magnetic storage portion of the system, and the lower part is the optical velocity-acceleration processor.

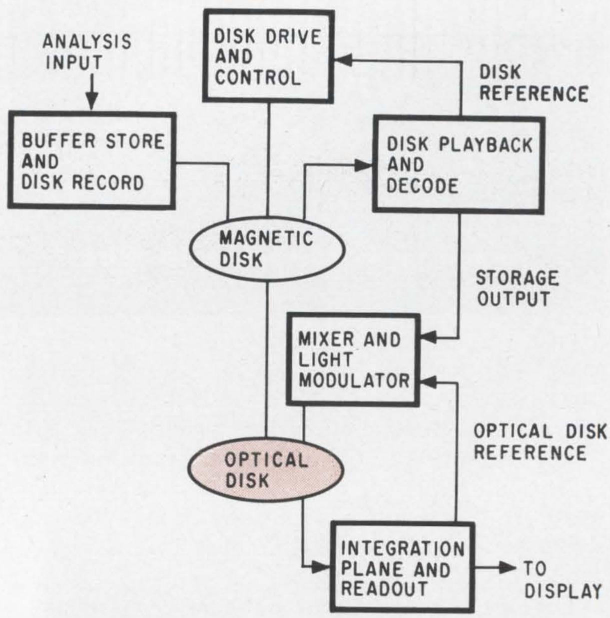
The magnetic part of the system operates as a conventional time-compression system. That is, the speed of rotation of the disk differs from the pulse-repetition frequency of the system by one pulse width. In this manner, successive radar returns are stored side by side on the disk for each range element.

The incoming data to be analyzed consist of radar target returns continuously recorded on the magnetic disk. The total storage time of the disk corresponds to the integration time of the system. As each subsequent signal is recorded on the disk the oldest signal is erased. The output of the magnetic disk is a signal representing the past history of the target returns in a particular range element, over the integration time of the system. This output is then fed to the optical velocity-acceleration processor.

The optical processor operates in a manner analogous to the optical correlator previously described, except that the two dimensions required are velocity and acceleration. The angular position



This experimental subsystem was used to show that the correlation gain and the large time bandwidth of the system improve the signal-to-jamming noise ratio.



Magnetic-optical processor has a magnetic disk and an optical disk mounted on the same shaft assembly. The upper part of the diagram is the magnetic storage portion of the system and the lower part is the optical velocity-acceleration processor.

of the disk is used for the acceleration dimension. This may be accomplished by combining the incoming signal from the magnetic system with an appropriate reference signal obtained from the optical disk. The frequency of the reference signal varies as the disk rotates. The combined signal is then applied to a light modulator which illuminates an area on the optical disk corresponding to the velocity-acceleration window to be monitored. The integrated product of the light-modulated signal and the patterns on the disk provide the resulting correlation function, whereby the radial position of the disk yields the velocity parameter and the circumferential position of the disk provides the acceleration parameter.

Corresponds to velocity

The manner in which this is accomplished is shown in more detail in the diagram at the top of page 65. The magnetically preprocessed input information is a c-w signal whose duration is proportional to observation time, or integration time, of the system, whose instantaneous frequency at any instant of time corresponds to velocity and whose rate-of-change of frequency is proportional to acceleration. A typical case is shown in the time-frequency plot of curve A. In this example, the doppler or target velocity is increasing at a fixed rate and represents a constant acceleration value. Therefore, the incoming signal is linearly increasing in frequency over the integration time and the rate-of-change of frequency, or slope of this curve, is proportional to acceleration. The reference signal with which this incoming signal is combined is chosen to be a quadratic time-versus-frequency curve—curve B. The combination of these two curves is curve C, a quadratic curve similar to curve B but shifted along the time and frequency axes. By proper choice of parameters it is possible to make this shift along the time axis proportional to acceleration, and the shift along the frequency axis proportional to velocity. The optical patterns which are placed upon the disk are multiple-radial tracks, each consisting of a quadratic time-versus-frequency curve. These are arranged on the disk so that when it is illuminated by a light-modulated signal corresponding to curve C, the correlation function is angularly displaced along the circumference of the disk by an amount corresponding to acceleration, and radially displaced from the center of the disk by an amount corresponding to velocity. By incorporating additional types of reference signals, it is possible to handle other than constantly accelerating targets.

Optical readout

One of the main advantages of optical processing is its inherently large information-handling capability. However, unless this great flow of information can be digested, a system bottleneck will soon develop.

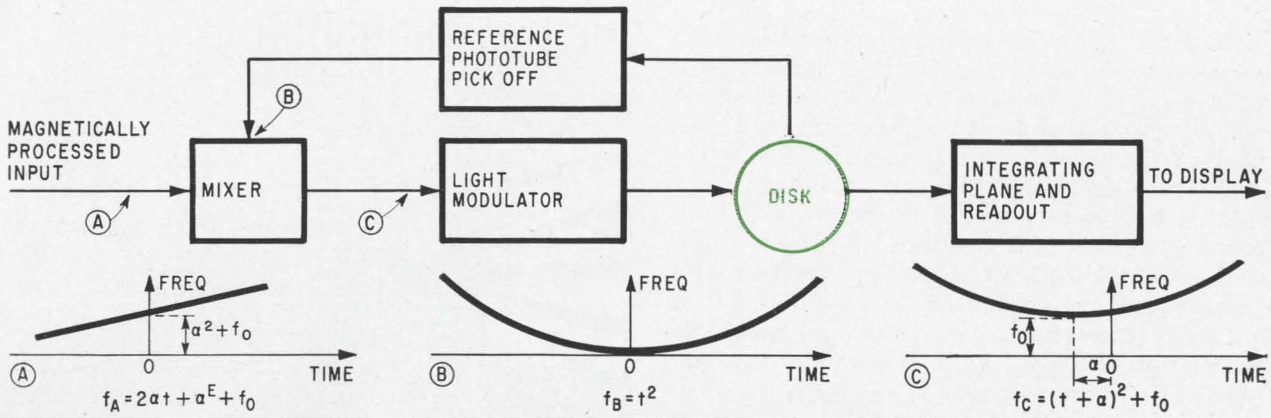
A television display, however, does not adequately solve the readout problem. In the first optical correlator described, over 200,000 resolution elements were simultaneously available for readout. At the present state-of-the-art this number can easily be doubled or tripled. If it were necessary to update this information many times a second, information bandwidths on the order of many hundreds of megacycles per second would be required.

To solve this problem, techniques are being developed for an optical readout system, shown on page 65. This diagram may be broken down into three main sections: the optical system, which consists of the scanning device, fiber optic light guides and phototubes; the electronic processing system, which consists of the amplifiers and thresholding units; and a high-speed coordinate buffer memory unit. In the diagram, the two-dimensional correlator field is the output integration plane of an optical correlator. For this application, the two dimensions are range in the horizontal direction of the correlator field and doppler in the vertical direction.

Feeds to phototube

The optical scanning device effectively causes an image of the correlator field to scan in the horizontal, or range, direction past a fixed slit. At the slit a separate fiber optic light guide feeds the optical signal for each doppler channel to a separate phototube. The resulting electrical signal is amplified and thresholded. That is, only the upper portion of the signal is allowed to come through, eliminating any noise present at its base. In this manner all doppler channels are scanned simultaneously.

At the time of threshold crossing, the line on which the threshold crossing occurs corresponds



At the top is an optical velocity-acceleration filter. In curve A, target velocity is increasing at a fixed rate, representing constant acceleration. The slope of the curve is proportional to acceleration. The reference signal which is combined with the input signal is the quadratic time-vs-frequency curve B. Curve C, a combination of A and B, is similar to B, but shifted along the time and frequency axes. The optical patterns placed on the disk are multiple radial tracks each consisting of a time-vs-frequency curve. When the disk is illuminated by a signal corresponding to C, the correlation function is angularly displaced along the circumference of the disk by an amount corresponding to acceleration, and radially displaced from the center of the disk by an amount corresponding to velocity.

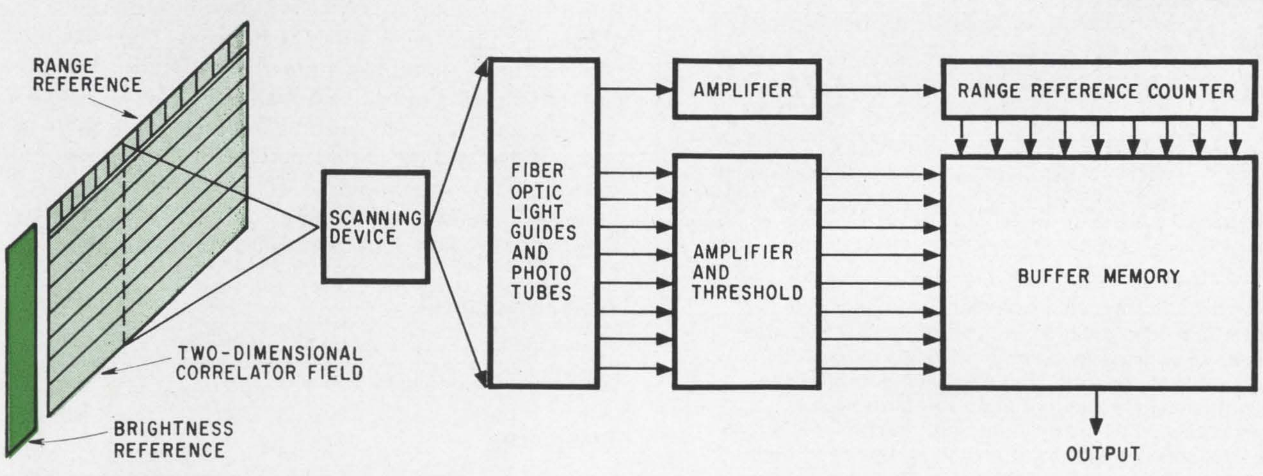
to the doppler of the target. At that particular instant the range is read from the range-reference counter. These two target coordinates are digitally stored in a buffer memory so that they can be read out in digital form at a smoothed rate. The effective readout rate, or output information rate, is then directly proportional to the number of targets present.

At the same time, the optical scanner also scans a range reference track. This is a precisely calibrated optical grating uniformly illuminated by a constant-intensity light source. This information is fed through a separate channel to a range reference counter, which is a fast propagation range counter specifically developed for data which vary rapidly. The output of the range reference counter at any instant of time is proportional to the position of the vertical line in the correlator field being scanned at that particular time. Also, at the beginning of each scan a calibrated brightness reference is provided for an automatic sensitivity control loop around each multiplier phototube. This feature compensates for effects of fatigue in the phototube, and stabilizes the gain of all the doppler channels.

The feasibility of this approach has been demonstrated by a combination of optical, electrical, and mechanical techniques. Future work must be on more efficient and compact devices and should emphasize greater adaptability and internal decision-making within the readout system.

Investigations have already been started to solve these problems with microelectronic and thin-film techniques. Although initial application is being made to the readout problem, these investigations are showing potential in other areas of optical processing such as replacing the rotating optical disk described earlier with optoelectronic components having no moving parts.

An example of this approach is the use of arrays of microelectronic photosensitive elements addressed by thin-film scanners.[1] The schematic in

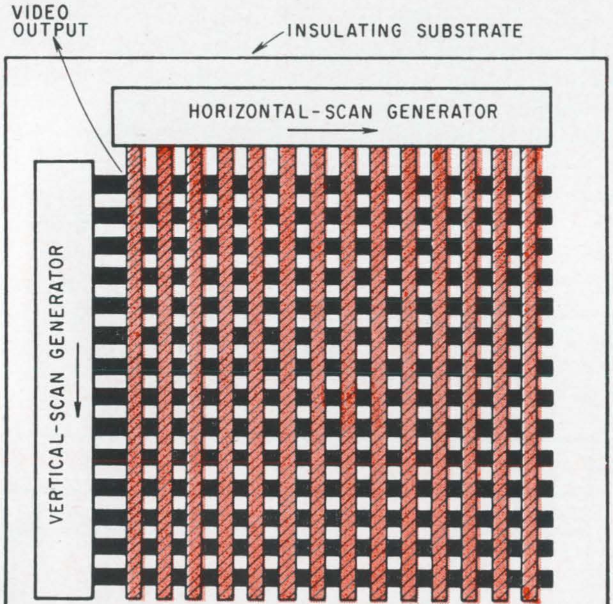


Optical readout system in three sections: the optical system, the electronic processing section, and a high-speed coordinate buffer memory unit. The two-dimensional correlator field is the output integration plane of an optical correlator. The dimensions are range in the horizontal direction of the correlator field and doppler in the vertical direction.

this column shows an experimental crossed-array, image-sensor panel driven by two thin-film scan generators. The photosensitive area is a crossed array of x-y coordinate strips deposited on a glass substrate. In the read-out application, this would be the time-integration plane of an optical correlator. At each intersection of the strips is a photosensitive element whose electrical output is proportional to the intensity of the light incident on it. Each element corresponds to a resolution cell on the integration plane. Also deposited along the periphery of the panel are two thin-film scan generators. These are essentially shift registers which permit selective scanning of certain areas within the array or programed scanning of the entire array. This can result in a considerable adaptive scanning capability by programing the scanning sequence in accordance with the target density on the array.

A diagram of a single line array and a thin-film scanner is shown at the right. A row of photo-elements is shown in the lower part of this diagram. This corresponds to one horizontal line of photosensitive elements shown in the previous diagram. The upper part of the diagram is a 30-stage deposited scan generator.

The row of photo elements consists of 30 photosensitive thin-film transistors. The center-to-center spacing between these elements is 12½ mils, and



A crossed-array, image-sensor panel driven by two thin-film scan generators. The photosensitive area is an overlay of x-y coordinate strips deposited on a glass substrate. The electrical output of the photosensitive element at each intersection is proportional to the incident light. Each element corresponds to a resolution cell on the integration plane of an optical correlator. On the edge of the panel are two thin-film scan generators which act as shift registers. They permit selective scanning of certain areas within the array or programed scanning of the whole array.

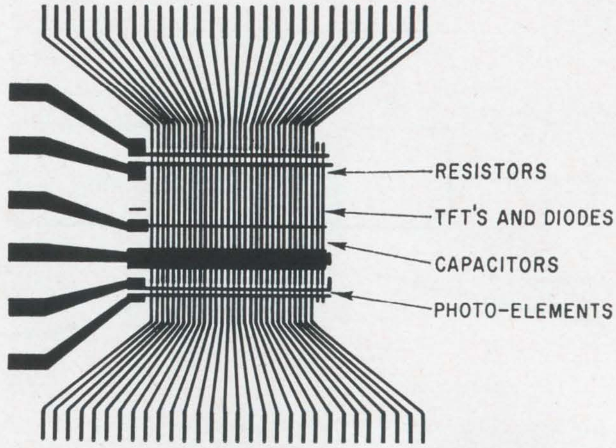


Diagram of a single line array and a thin-film scanner. In the lower part of the diagram is a row of photosensitive elements consisting of 30 thin-film transistors. It corresponds to one horizontal line of elements in the previous figure. The upper part of the diagram is a 30-stage deposited scan generator which contains 210 elements plus connections and crossovers. Extensions of this idea will provide two-dimensional arrays of thousands of photo-elements with digital logic control to address the individual elements.

present technology can greatly decrease this spacing. Above this row of photo elements is the 30-stage scan generator which consists of a row of 30 capacitors, 60 cadmium sulfide thin-film transistors, 30 field effect diodes, and 60 resistors. The length of each side of the scan generator, exclusive of the fan-out, measures approximately three-eighths of an inch or a total area of less than 0.2 square inch. Within this area there are a total of 210 elements plus numerous connections and crossovers. Adaptations will provide two-dimensional arrays consisting of thousands of photosensitive elements with address to individual elements provided by digital logic control.

Future of optical techniques

The techniques described do not require any critical light sources but use noncoherent light. With the availability of lasers having coherence in frequency and space, other techniques are possible. With either coherent or noncoherent light, depending on the methods used, optical systems can be utilized for functions normally electronic, such as radar pulse coding and decoding, two-dimensional filtering, steerable antenna array beam-forming and steering, analog computing and various similar forms of signal processing and data handling.

Acknowledgment

This work has been sponsored, in part, by the Bureau of Naval Weapons,[2] by the Rome Air Development Center,[3] and by internal RCA advanced development programs.

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Circuit design

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By D.J. Grover*

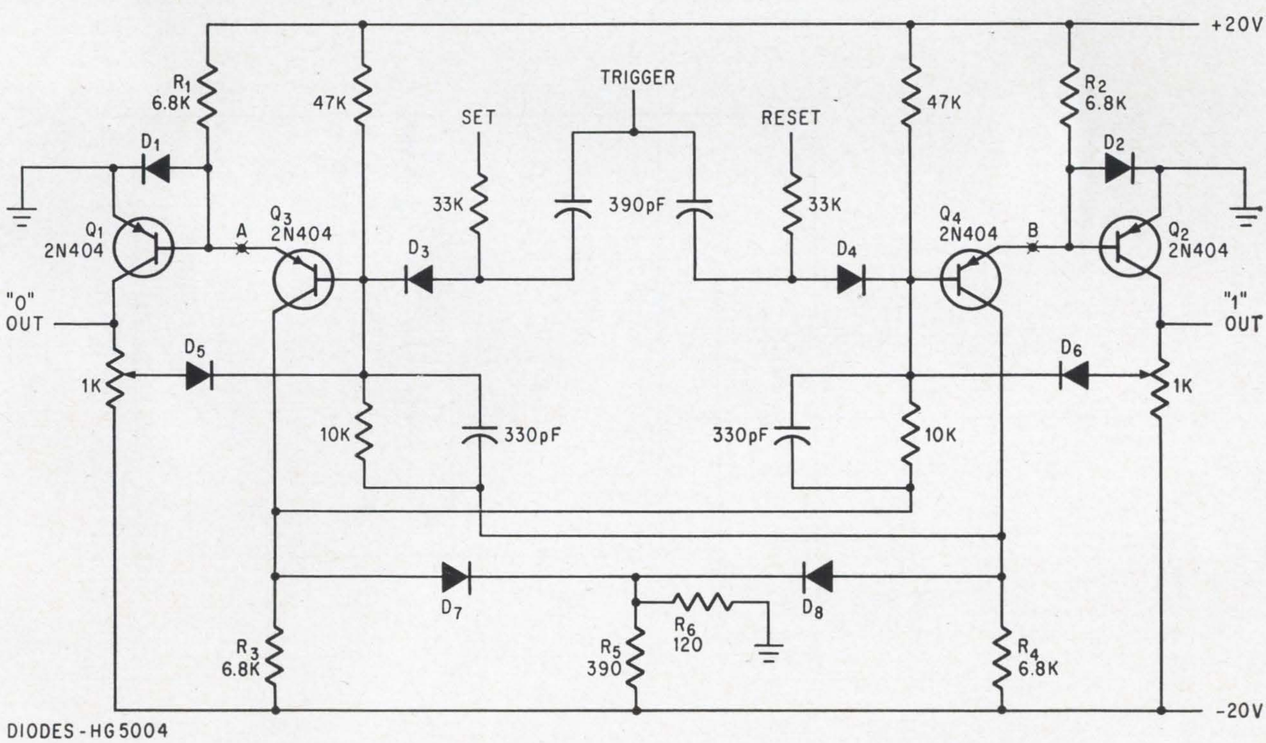
Marconi Instrument Ltd., St. Albans, England

Fan-out to as many as 60 other logic circuits is achieved with the flip-flop shown below by driving the bases of amplifier stages Q_1 and Q_2 directly from the emitters of Q_3 and Q_4. The circuit is a worst-case design allowing for a transistor current gain (β) as low as 15 and permitting at least 10% tolerance on component values and power supply levels. The circuit improves the fan-out capabilities of a conventional circuit designed on the basis of a worst case analysis by a factor of 4 to 1.

In a conventional circuit, the amplifiers would be connected to the collectors of the flip-flop through a coupling resistor and would be biased through a resistor divider connected between the supply voltages. The amplifier would turn off when the flip-flop to which it is connected is turned on. The problem is that the current available for back-biasing the amplifier is partially shunted by the divider network. When 10% tolerances on resistor values and supply voltages are considered, the loss in driving current can exceed 40% per stage. By connecting the amplifiers as shown in the schematic, Q_1 and Q_3 or Q_2 and Q_4 turn on and off together, and the only loss in driving current is the small amount shunted off by the bleeder resistors, R_1 and R_2. As a result, the fan-out may be increased by a large factor.

Change-of-state occurs when a positive pulse is applied at the trigger input. The output has a one-microsecond rise time, and will drive 60 gates—each with an input impedance of 24,000 ohms to —20 volts. If Q_1 and Q_2 are replaced by transistors with betas greater than 50, the fan-out

* Formerly with Standard Telephones and Cables, Ltd.



Directly coupled amplifiers, Q_1 and Q_2 improve current transfer efficiency when the tolerances on components and power supply voltages are large. As a result, the flip-flop can pulse 60 other circuits.

of the circuit can be increased to about 200. If the emitter leads of Q_3 and Q_4 are opened at points A and B and are then connected to ground, the inner circuit becomes a conventional flip-flop. The grounded emitter is simulated in the complete circuit by holding the emitter of Q_3 about 0.3 volt above ground, either by the diode D_1 (if Q_1 and Q_3 are not conducting) or by the base-to-emitter voltage drop of Q_1 (if Q_1 and Q_3 are conducting). The slight variation in voltage at the emitters of Q_3 and Q_4 reduces the efficiency of the flip-flop. This is compensated, however, by the improvement in current transfer to the bases of Q_1 and Q_2 which guarantees that the output stages will be saturated under worst case conditions.

The comparatively low values of R_1 and R_2 are necessary for reducing the turn-off time of Q_1 and Q_2. Components D_5, D_6, D_7, D_8, R_5 and R_6 prevent saturation of Q_3 and Q_4. If timing and triggering sensitivity are not critical, these seven components may be removed if the values of R_3 and R_4 are reduced to supply sufficient base current to Q_1 and Q_2.

Novel sweep circuit eliminates ramp pedestal

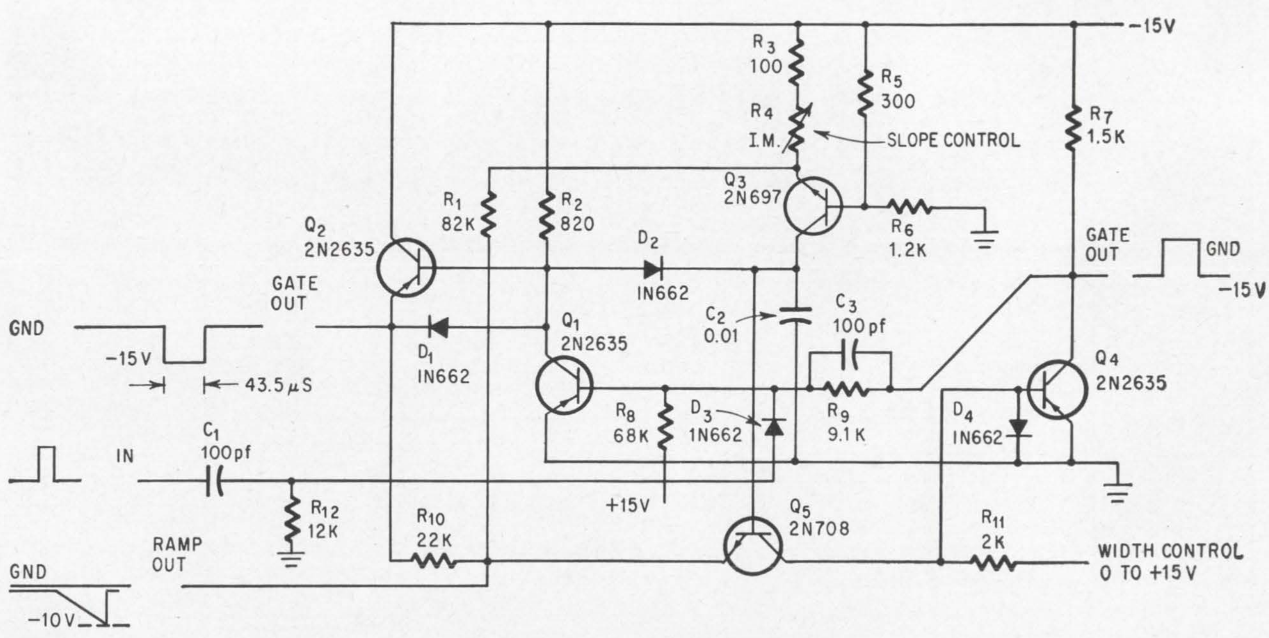
By Gilbert Marosi

General Precision, Inc., Sunnyvale, Calif.

Phantastrans, transistorized versions of phantastron sweep-circuits, are used extensively to obtain linear ramps and gating signals for timing circuitry. A standard phantastran has two disadvantages. The ramp begins on a voltage pedestal instead of at ground because the timing capacitor is connected to ground through the base-emitter junction of a transistor. The second disadvantage is that the slope of the ramp is limited to a range of 20 to 1 by the gain of a transistor in the circuit.

The modified circuit shown below eliminates the voltage pedestal by connecting the timing capacitor C_2 directly to ground. The slope is independent of the gain of Q_4, and may be varied through a range of 100 to 1 by adjusting potentiometer R_4. In addition, the width of the gating signal pulse may be varied from 1 to 500 microseconds. Furthermore, since the recovery time of the circuit is very short, the duty cycle can be as high as 98%.

In the stable state, Q_4 and Q_5 are off and all other transistors are conducting. Because Q_1 is saturated, the voltage across C_2 is about 0.7 volt negative with respect to ground. The emitter of Q_2 is almost at ground potential. A positive trigger at the base of Q_1 forces Q_1 to turn off and turns on Q_4 and Q_5. All other transistors continue to conduct.



Phantastran circuit provides a linear ramp and gating pulses. When repetitively triggered, the gating pulses at the two output terminals are complementary.

Because Q_3 is a high-gain transistor, its input impedance will be at least 10,000 ohms even if potentiometer R_4 is short-circuited. As a result, the resistance divider consisting of R_5 and R_6 is not loaded down by Q_3, and the voltage at the base and emitter of Q_3 remains constant at about —12 volts. Therefore the emitter current is constant, causing C_2 to charge linearly, resulting in a ramp at the emitter of Q_5. Its slope is inversely proportional to $(R_3 + R_4)C_2$. R_1 at the emitter of Q_3 is a bootstrap resistor needed to maintain linearity at slow-sweep rates.

The manner in which the circuit returns to the stable state is dependent on the currents I_{e5} in the emitter of Q_5, I_{b4} in the base of Q_4, and I_{11} flowing through R_{11}. Neglecting the voltage drop across the base-to-emitter junction of Q_1 and assuming the emitter of Q_2 is clamped at —15 volts, then

$$I_{e5} \approx \frac{15 - V_{c2}}{R_{10}} \approx I_{b4} + I_{11}$$

where V_{c2} is the voltage across capacitor C_2. Since the base of Q_4 may be considered to be at ground potential, I_{11} is a constant whose value is determined by R_{11} and the voltage on the width-control terminal. Therefore, from the equation, as V_{c2} increases, I_{b4} decreases. When $I_{b4} = 0$, Q_4 stops conducting and turns on Q_1. C_2 discharges very rapidly through Q_1 and D_2 and the circuit returns to its stable state.

Since the width-control voltage determines the magnitude of I_{11} it also determines the amplitude of the ramp because of the relationship between I_{11} and V_{c2} expressed in the equation. With the width-control voltage fixed, varying R_4 varies both the slope of the ramp and the width of the gate. With R_4 fixed, the slope is constant and varying the width control changes both the width of the gate and the amplitude of the ramp.

For the gate and ramp shown in the schematic, the value of R_4 is 1,000 ohms and the width-control voltage is 0.4 volts.

Gated multivibrator output provides constant pulse width

By Reed Newmeyer

Sperry Utah Co., Salt Lake City, Utah

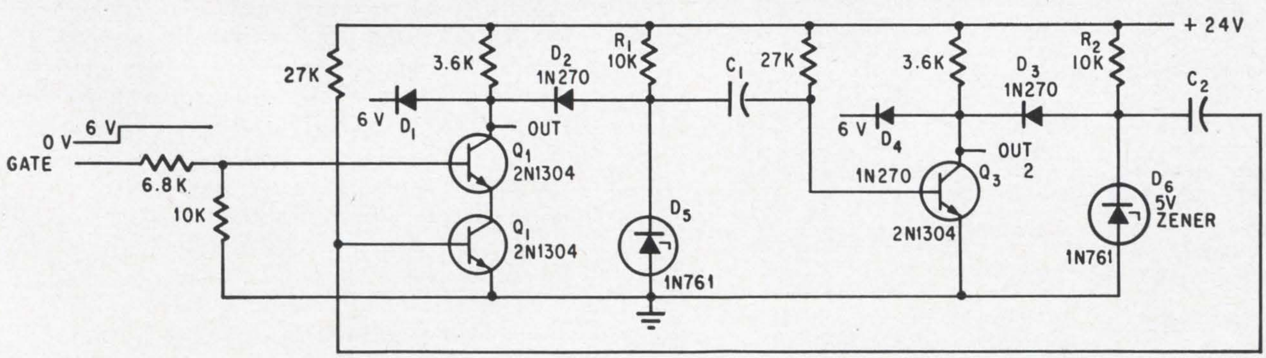
A train of pulses—all of constant width and free of transient spikes—are produced whenever a 6-volt gate is supplied to the base of Q_1 in the multivibrator shown below. The pulses may be used to drive stepping switches, to test circuit response and to operate counting circuits.

When the gate is applied, Q_2 and Q_3 are turned on and off as in a standard multivibrator. Since Q_1 and Q_2 are connected in series, they are either fully on or fully off at the same time. In a conventional circuit, the first few pulses will vary in width because the charge on the capacitor during standby is greater than the maximum charge that occurs during operation. In this circuit, zener diodes D_5 and D_6 maintain a constant pulse width by forcing the capacitor-charging cycle to start at 5 volts.

Standoff diodes D_2 and D_3 are back biased when Q_2 and Q_3, respectively, are not conducting. As a result, the outputs are clamped to either the 6-volt supply or to a few tenths of a volt above ground, depending whether the transistors are on or off.

Clamping diodes, D_1 and D_2, insure immunity to noise spikes. Because of the clamping diodes, the output pulses are about 6 volts. Larger pulses may be obtained by raising the clamp voltage or by removing D_1 and D_2 from the circuit.

If the gate is removed, the circuit will stop supplying pulses when Q_1 and Q_2 are turned off.



Complementary pulse trains appear at outputs one and two whenever a 6-volt gate is applied to the base of Q_1

Communications

Coding for error control: an examination of techniques

Through redundancy, a variety of code structures can detect and correct errors in digital communications. This second article in a series, describes the latest techniques and evaluates them for efficiency, complexity and cost

By Albert G. Franco and Mark E. Wall

Communications Systems Inc., Paramus, N.J.

Error-control coding is a technique that attempts to guarantee that a digital communication, despite any errors introduced by the transmission channel, will be received exactly as it was sent. Errors are detected and corrected through controlled redundancy inserted in messages.

The redundancy must spread the effect of channel disturbances over a number of interrelated bits. Using these interrelationships, a decoder checks the received message, finds errors, and corrects them to produce a message that exactly matches the original communication. The simplest example of encoding is replicate, or repeat, transmission, in which each bit of information is sent a minimum of three times to permit a majority decision. Any one bit in error can be corrected because of the simple relationship between successive bits. But, for the amount of error protection it offers, replicate transmission wastes channel capacity. Better coding structures provide more complex interrelationships, thus giving greater capability for the correction or detection of errors, and make more efficient use of channel capacity.

The authors

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Mark E. Wall carries out studies in digital communications and error control for CSI. He was formerly with the Astro-Electronics division of the Radio Corp. of America. Wall is currently pursuing doctoral studies at New York University.

Basic code construction

For the binary symmetric channel (one in which errors introduced by the channel are statistically independent with equal probability that either binary symbol will be transformed) the decoder uses an optimum decision scheme to select the transmitted sequence, x_j, most likely to result in the receipt of the sequence, y. Such a decoder is often referred to as the "ideal-observer" or "maximum-likelihood" decoder.

Maximum-likelihood decoding depends on the distance between code words. This distance is called the Hamming distance, after R. W. Hamming who proposed the concept. The distance between two n-bit binary sequences is defined as the number of bits that differ in the two sequences. For example, if $x_1 = 1001011$ and $x_2 = 1100010$, the sequences differ in the second, fourth and last digits, and the distance between x_1 and x_2 is 3. In maximum-likelihood decoding the decoder examines a received sequence y, and selects from a stored set of possible code words, that code word x which has the minimum distance from y. The maximum-likelihood decoder is therefore a "minimum distance" decoder.

An example might be the following bit sequences considered as a set of possible code words: $x_1 = 00000$, $x_2 = 10101$, $x_3 = 01011$ and $x_4 = 11110$.

Assume the received sequence is $y = 10001$. The minimum-distance decoder will decode y as x_2 since the distance between y and x_2 is one, while the distance between y and any of the other transmitted sequences is greater than one.

Maximum error-correction capability of a code is obtained by making the minimum distance between code words as large as possible for a given code length and redundancy. Error correction capability and minimum distance between code words are very simply related: that is, one, two, and up to e-errors in transmission can be corrected if the minimum distance between binary code words of length n is $\geq 2e + 1$. This is a theoretical relationship, which is not usually achieved in practice.

Code structures differ widely in their error-correction capability, redundancy, and their encoding procedures. The best error-control code has an encoding process that is simple in concept, easily implemented, and inexpensive.

In minimum-distance decoding, the decoder stores a "table" or "code book" containing all the allowable binary sequences of the specified code word. Each of the received sequences is assigned to the stored code word that most closely matches it. It follows that for the longer, more powerful codes decoders increase in complexity as they increase their storage capability.

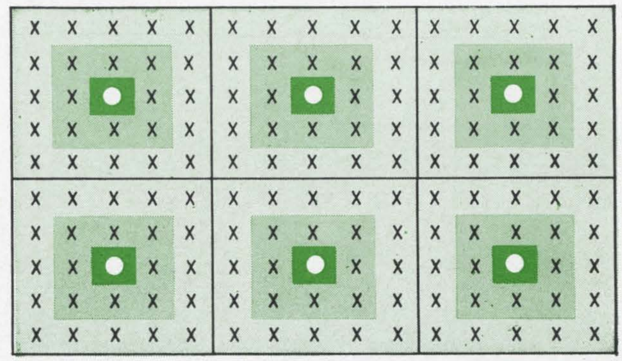
The problem of complex decoders for the longer codes has prompted development of the convolutional nonblock code, described later, which makes possible the construction of powerful code structures than can be decoded by simple decoders.

Thus far, the assumption has been that a code is used in the forward error-correcting (fec) mode. However, a code can also be applied in the error-detection mode, where error correction is obtained by requesting repetition of the code words detected in error (arq). The result is a considerably lower received-error rate. This is best understood from a geometric interpretation of the concepts of distance and minimum-distance decoding.

Consider the representation of a hypothetical code space, shown in the diagram above. The white circles represent six acceptable code words which will be received as a result of error-free transmission. The X's represent words received with errors. The code space is divided into subsets, just as it would be partitioned by a minimum distance decoder. All erroneously received sequences—the X's in a partitioned subset—are interpreted as the correct code word at the center of the subset.

The X's in the light red area represent sequences received with one error; in the paler area, two errors. For the partitioning shown, double error correction is possible because two errors result in a word still within the partition associated with the correct code word at the center. But sequences received with triple errors would be incorrectly decoded.

In error detection with repeat request, the only bit sequences that the decoder accepts are those



Hypothetical code space indicates distance between digital words. White circles represent correct code words. The X's in light red area represent same code word with one error, and X's in pale red area represent that word with two errors. For this code spacing, a minimum-distance decoder could not correctly decode a bit sequence with more than two errors.

depicted by the circles. The decoder rejects all other received sequences and initiates a request to repeat the transmitted code word. This decoding process can fail only if one acceptable code word is erroneously transformed into another acceptable code word. From the code space diagram it can be seen that there would have to be errors in at least five positions in a received sequence for such a transformation to occur. Such an event obviously occurs with less frequency than triple errors, thereby substantiating the claim of lower error probability when a given code structure is used for error detection rather than correction.

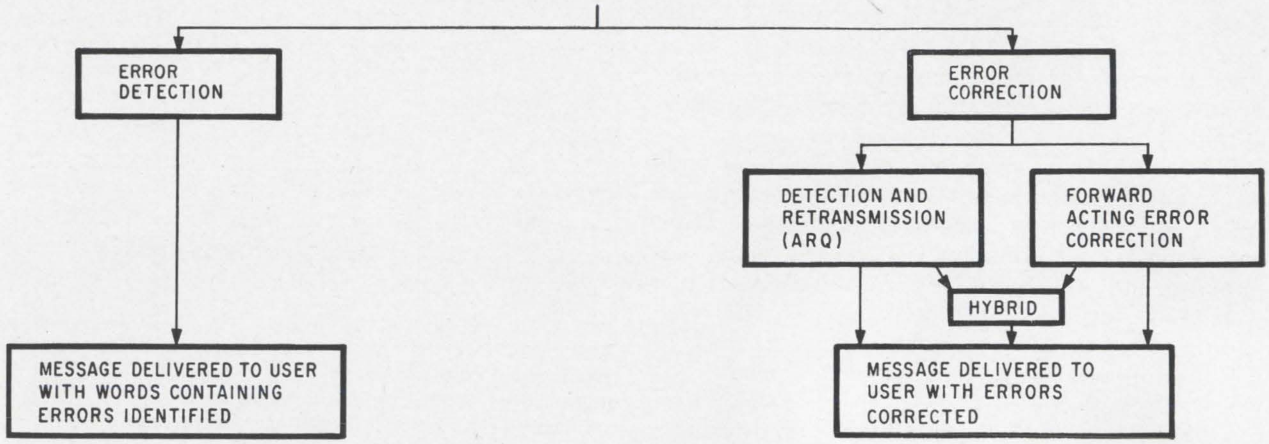
The selection of a mode depends on the user requirements, the nature of the digital traffic handled, and such factors as on-line data in which the data source generates a continuous bit stream with no provision for storage. The availability of a return channel will determine whether the arq mode of operation is possible.

1. Operational control techniques

Error-control systems fit into two basic classes: systems that detect and indicate to the recipient that a given character, word, or message contains errors; and systems that correct these errors. Further, the correction type systems operate by either of two methods: by detecting the error and requesting a repetition of the message from the transmitting end of the system; or by using a code structure that permits the correct characters to be determined from the received signals despite the errors.

Forward error correction

In forward error correction, redundancy is inserted into the transmitted bit stream and used at the receiver to correct errors that have occurred in transmission. The redundancy required for error correction is considerably higher than that for error detection, for the same degree of protection against



Classes of error-control systems. In error detection systems, the code words in error are identified, not corrected. Error-correction systems use various techniques to deliver error-free messages.

errors. Block or nonblock code structures may be employed in an fec system. Nonblock structures sometimes reduce the complexity of the decoder.

A continuous stream of data can be accommodated on a forward error-correction system. Since it isn't necessary to interrupt the data stream, a minimum of buffering, or temporary storage, is required. Synchronism between encoder input and decoder output is easily maintained. With nonblock code structures, bit-by-bit encoding can be utilized so that the form of the message needn't be confined to any specific structure. The delay introduced between input and output is a function of the path delay and the interval in bits required for the coding.

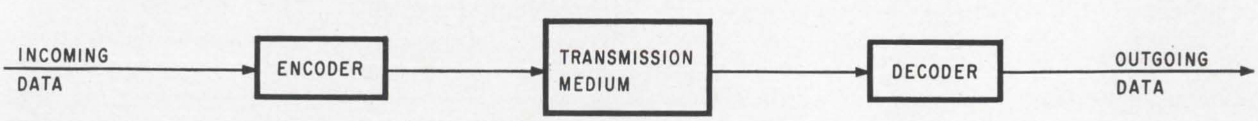
Error detection and arq

In this mode of operation, information is most conveniently encoded into blocks containing redundant bits. Upon detection of an error at the receive terminal, a request for repeat (arq) is sent to the transmit terminal via a return channel.

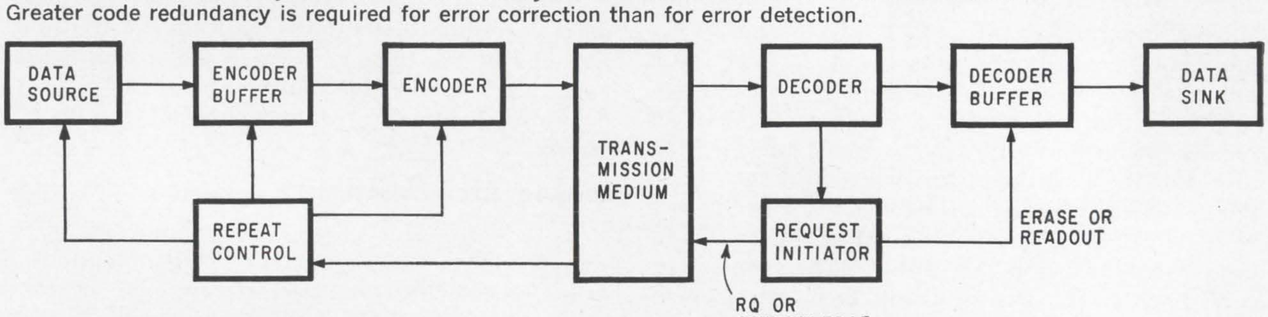
Often, arq system are designed so that successive information blocks are sent only after the transmit terminal gets an acknowledgment from the receive terminal. In such cases, only one block of information is repeated when necessary. A more efficient arq mode is one where continuous data is sent from the transmit terminal. Upon receipt of a repeat request in this instance, at least two data blocks are repeated. This happens because at least one block will be in the channel when the transmitter gets a request to repeat transmission.

With either arq mode, the data system is interrupted when repeat requests occur. As a result, synchronism cannot be maintained between the data source and sink without additional buffering. If buffers are used to provide an even flow of data, the data transmission rate must exceed the incoming data rate at the receiver so that the decoder buffer can continuously empty its contents. Otherwise, there is a certainty of buffer overflow during long messages, which results in lost data. Rate conversion equipment provides an even data flow for arq systems.

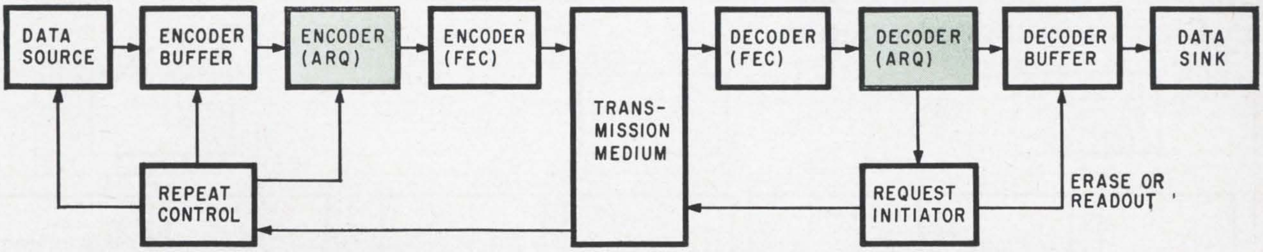
Interrupted data flow isn't a problem when transmitting between stores and sinks in which the data flow is controlled. Practical examples are the arq system in transatlantic Teletype service.



Forward-error-correction systems insert redundancy into the transmitted bit stream to correct errors. Greater code redundancy is required for error correction than for error detection.



Error detection with automatic repeat request (arq) inserts redundancy in the transmitted bit stream to detect errors. Correction is obtained by requesting a retransmission of any bit sequence in which errors are detected.



Hybrid error-control system has automatic repeat request, color, and forward error control in tandem. The combination lessens the probability of a repeat request and increases channel efficiency.

Both forward error correction and arq can be combined in a single code structure. The hybrid mode of operation may take either of two forms. One form has forward correction as the basic error-correcting technique, but can initiate repeat requests when the decoder fails. The other form includes a small amount of error correction in a block structure used in an arq system.

A hybrid technique that uses forward error correction in tandem with arq is shown in the block diagram above. Separate encoders and decoders are used for the fec and arq sections.

Hybrid systems generally exhibit characteristics similar to those of a simple arq system. Since fec lessens the probability of a repeat request, channel efficiency may be higher.

II. Coding structure classification

The choice of a coding structure depends on the user's error-control techniques, channel noise characteristics and resulting error probabilities, and the complexity and cost of the error-control equipment.

Code structures are categorized in the chart on next page. Block codes are formed by encoding information and check bits into blocks of n bits. For nonblock codes, each transmitted parity bit is continuously determined, to some extent, by all of the bits which have already been transmitted.

Constant-ratio codes

Constant-ratio codes consist of a block structure in which the number of zeroes and ones is constant. One such code is the three-out-of-seven arq code, which is used extensively in radio telegraphy. Its simplicity and effectiveness account for its use,[2] although there are others which outperform it.

In a 3/7-code each character has a block length of $n = 7$ bits (3 bits are ones). The number of characters that can be obtained from this code is

$$\frac{7!}{3!\ 4!} = 35$$

The maximum efficiency of this code word is the ratio of the information content in a 35-letter alphabet to that in a 7-bit word.

$$\text{Efficiency} = \frac{\log_2(35)}{\log_2(2^7)} = 0.733$$

Errors are detected by counting the number of ones, or marks, in each received word. It is a valid code word if it contains three marks. Because a single error will change the number of ones to either two or four, the code detects all single errors. All combinations of three, five, or seven errors can be detected.

But, not all of the even-numbered error patterns will be detected with constant ratio codes. For example, if there are two errors, one error changing a mark to a space and the other error changing a space to a mark, the number of marks will remain three. That pair of errors will pass undected as will four- and six-error patterns.

Another constant-ratio code is the IBM 4-out-of-8 code (IBM data transceiver code). It is an 8-bit code with 256 different bit patterns but only those with a fixed number of four ones and four zeroes are used to represent characters. The redundancy is the same as that of the 3/7 arq code and the same limitations prevail, although the number of characters is increased to

$$\frac{8!}{4!\ 4!} = 70$$

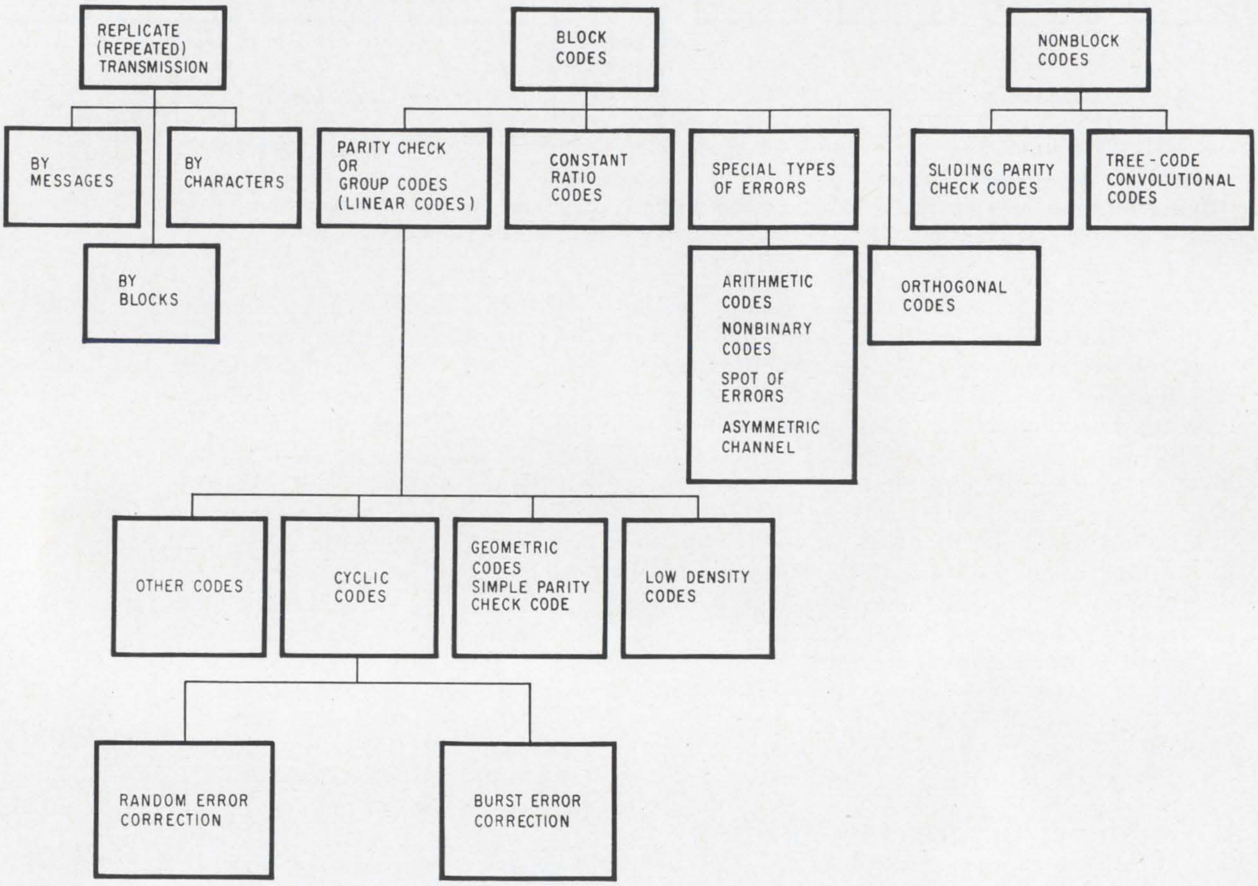
Despite their simplicity, constant-ratio codes have limited advantages. They can be used only for error detection and need higher redundancy than parity-check codes for equal detecting capability. Implementing the codes is difficult when the data source generates a random binary bit stream. The chief application of these codes has been in transmission of alphanumeric data, which, in any case, requires an arbitrary translation to digital symbols.

III. Parity-check codes

Parity-check codes are formed by algebraically relating a sequence of k information bits to a series of parity checks. Code words, or vectors, of k information bits and $(n - k)$ check bits are formed. They have the properties of mathematical groups and are therefore sometimes called group codes.

Essentially, all important block codes for error detection and correction are parity-check codes. Among them are the cyclic codes, which are principally random-error correction codes,[3,4] and those codes specifically designed to correct error bursts.[5,6]

Classes of code structures



The three basic code structures for error control are replicate block and nonblock code structures.

Replicate, or repeat, transmission is the simplest. It is a brute-force method in which each message is transmitted several times over the same channel or simultaneously over several separate channels, permitting a majority decision at the receiver; but channel capacity is not efficiently used.

The more efficient block codes are used in many error-control systems. Each message unit has a fixed block length—The important block codes—called parity-check codes—permit forward error correction by establishing a mathematical relationship between information bits and parity-check bits within a block, or code word. Cyclic codes, a class of parity-check codes, are derived from the fact that any cylic permutation of a code word results in another code word. These codes can be implemented with simple shift registers and can be formulated to correct either randum or burst errors. Geometric codes are parity codes used to detect errors on computer punched cards or tape, where the data is arranged in rows and columns. The parity checks are formed for a two-dimensional block of data. Constant-ratio codes are block structures in which the ratio ones to zero in the block is constant. These codes can only detect errors, therefore a return channel is necessary for error correction. Other block codes have been developed for dealing with special kinds of errors, such as multiple bursts, a cluster of errors in a two-dimensional array, correcting for a bit loss or gain, and errors occurring in the asymmetric channel.

The recently developed nonblock, or convolutional codes show great promise in reducing the complexity of decoders. These codes do not have a fixed block structure. The information bits are encoded one at a time, instead of in groups as in the block codes. With simple shift registers and logic circuits, a receiver can examine each bit to determine if it is in error.

Simple parity-check codes

The most elementary binary error detection code is the simple parity-check code. The parity-check digit is the sum modulo-2 (binary addition without carry) of all the bits in the block. Although the n-bit block, including the parity-check bit, can be received in 2^n different ways one, and only one, corresponds to the transmitted block. If an odd number of errors have been introduced, the parity check will indicate an error. Thus, half of all possible error patterns can be detected with just one check bit.

Adding more parity bits increases the redundancy and complexity of the code but the protection afforded is increased considerably. Many schemes have been devised for deriving the parity-check digits from the information digits, and each scheme results in a code whose error protection characteristics are unique.

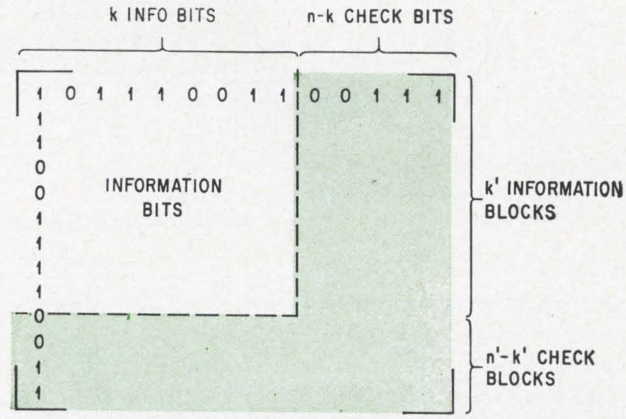
Hamming codes

The codes named after R. W. Hamming[1] correct single errors and detect double errors. They are based on the fact that a single bit error within a block of n binary bits, consisting of k information bits and $m = n - k$ check bits, can be corrected if the following relationship holds:

$$2^m \geqq n + 1 = m + k + 1$$

This relationship is derived from the fact that the minimum number of bits necessary to locate a position in one of n places is $\log_2(n)$. Adding a further restriction, (that is, the case where no errors occur), the number of bits required to correct a single error in n places is $\log_2(n + 1) \leqq m$ or, $2^m \geqq n + 1$.

Information messages consisting of four bits each, $k = 4$, provide a good example. The minimum value of m which satisfies the Hamming relationship for single error correction is $m = 3$. Therefore, a (7,4) code, in which the block length is 7 bits, must be used to correct single errors. With this code, there are $2^k = 2^4 = 16$ possible messages, each with four information bits.



Geometric code structures provide parity checks in two dimensions. The horizontal rows of information bits have parity-check bits, as in simple parity checking. But with geometric coding, the vertical columns are also appended with a parity-check sequence.

Cyclic codes

The concept of cyclic, or polynomial, codes is considered one of the major breakthroughs in coding theory. Their importance stems from the fact that they can be implemented easily.

Any cyclic permutation of a code word results in another code word. That is, if the sequence of bits $a_1a_2a_3 \ldots a_{n-1}a_n$ is a code word, then the sequence $a_2a_a \ldots a_na_1$ is also a code word and so is $a_aa_1 \ldots a_na_1a_2 \ldots a_{n-1}$. Such sequences can be generated rather simply by a system of shift registers and adders.

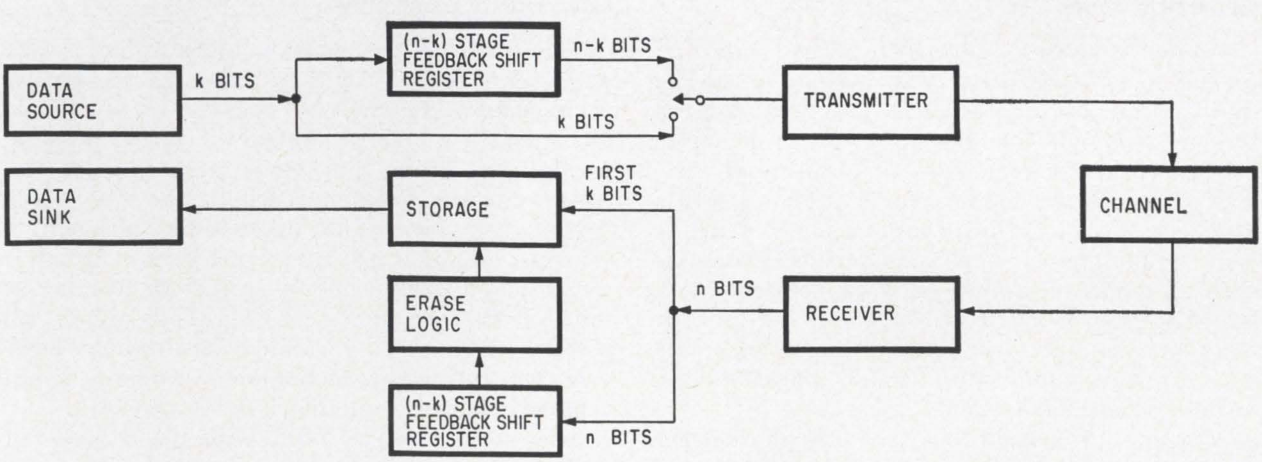
Cyclic codes can be generated by a shift register of length k, the number of information bits, or length $n - k$, the number of redundant bits. The latter type, which results in a shorter and cheaper shift register, is illustrated for an error detection mode in the diagram below.

To detect errors, the received block is checked for parity-check violations by a simple shift-register circuit similar to the one in the encoding equipment. If the received block is unacceptable, retransmission is requested. The probability of undetected errors can be made as small as desired at a relatively low cost in redundancy with longer block cyclic codes.

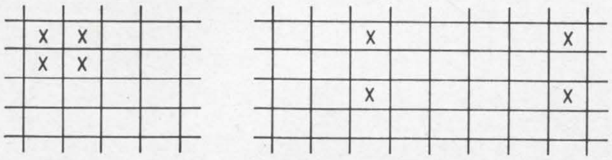
Some classes of cyclic codes, for example, the Bose-Chaudhuri code, are extremely powerful in correcting random errors. Certain other cyclic codes are effective in correcting error patterns confined to a single burst within a block. A shift register of length $(n - k)$ and simple logic circuits can correct an error burst whose length is one-third the number of redundant bits $(n - k)$ in a block. As with any block code, cyclic codes require a message buffer to store each received word until the error pattern and location are determined. Generally, burst decoders will fail to detect isolated errors beyond the confines of the burst limits.

Complex equipment is needed to correct random-error patterns by cyclic codes. The decoding complexity grows as a power of n for a fixed code redundancy.

On the other hand, for error detection and retransmission systems, these codes require a decoder that is as simple as the encoder. A feedback



Cyclic codes can be implemented easily. Each code word is a cyclic permutation of another code word. Typical cyclic encoding and decoding scheme shows a shift register that generates the parity-check bits. An identical register at the receiver recomputes the parity checks to determine if the code word should be accepted.



Rectangular error patterns, a possibility in geometric structures, could cause parity checks to look like correct bit sequences and errors would escape detection.

shift register of length (n-k) bits is required to encode and decode data for arq systems. At the receiver, k bits must be stored so that the complete n-bit code word can be received and checked for errors before it is released to the data sink.

The Bose-Chaudhuri code is a cyclic code designed to correct random errors. The number of errors it can correct depends on the distance between code words, which, in turn, is directly proportional to the redundancy. Therefore, the greater the redundancy, the larger the number of correctable error patterns. The longer B-C block structures have excellent capability for detecting burst errors as well. For example, a 255, 223 B-C code—255-bit block length having 223 information bits—has an efficiency of 87% under ideal channel conditions. This code, when confronted with a burst of pure noise input, (all bits are random ones or zeroes with probably of ½ for either) will fail to detect an error with a probability of less than 1×10^{-9}.

The Fire code[6] describes cyclic codes designed specifically for the detection or correction of burst errors. Basically, its encoding and decoding technique is similar to that of the B-C codes. Although the Fire code is capable of correcting single error bursts of much greater length than can a B-C code, it is vulnerable to only a few scattered errors within a block. For example, a Fire code that can reliably correct up to five bits in error in a single burst, might fail to correct two bit errors occurring more than five bits apart.

Fire codes and other burst correction codes can be extremely efficient when the duration and frequency of bursts are precisely defined.

Geometric codes

Geometric codes[7] are parity-check codes extended to more than one dimension. Considering the bit structure of previously described codes as forming a straight line, one can envision geometric codes as forming rectangles or even cubes.

These codes provide horizontal and vertical parity checks on a code word arranged in a plane, as well as the higher dimensional code structures, such as stacks of planes. A two-dimensional code structure with a single parity check for each dimension is simple to implement. Such codes have been extensively applied to data on computer cards or tape for error detection.

Although geometric codes are fairly efficient and easy to implement for the arq mode, cyclic codes are more practical for forward error correction. Geometric codes for error correction have been studied, but no good practical implementation has yet evolved. Higher dimensional codes for partial error correction and error detection have been analyzed and found to provide relatively efficient use of channel capacity but at the expense of considerable terminal storage requirements.

One of the most attractive features of geometric codes is the logical way in which standard information code formats may be grouped to form a block. By using a fixed number of code words for a row while varying the column depth, a rectangular block structure can be formed that adapts to changes in channel conditions without imposing format restrictions on incoming data.

An application of one such coding technique uses simple horizontal and vertical odd parity-checks on a punched card containing 80 characters, each with an information content of 8 bits. A repeat request of the entire card is initiated if any one of the parity checks is not satisfied. There is a possibility of undetected errors when the error patterns on the card are rectangular as shown in the diagram above. However, the probability of such an error pattern is very low.

Zierler codes

Zierler codes,[8] based upon the principle of encoding characters rather than bits, have been proposed but not yet implemented. One such structure, 2,040 bits long, and consisting of 255 symbols with 8 bits per symbol, seems fairly simple to implement. The basic construction of the code is similar to that of the B-C code but with 255 8-bit symbols in the block, instead of 255 bits per block. For a Zierler code, a variable number of check symbols, C, may be used. The result is that e or fewer symbol errors can be corrected, where $e = C/2$. The advantage of grouping bits into symbols is that longer block lengths are obtained with only a modest increase in decoder complexity. The efficiency of this technique lies in its ability to handle clusters of errors occurring within a code word; the number of random errors that can be corrected is limited.

Low-density block codes

A low-density parity-check block code[9] is one with a low ratio of ones to zeroes in the parity-check matrix. Low-density codes are often capable of correcting a high percentage of all the possible patterns of errors with moderately complex decoders. For the same block length, the greater the redundancy, the greater the number of possible error patterns that can be corrected. For instance, a typical (500, 250) code will correct almost all patterns of 30 errors and a (500,125) code, almost all patterns of 65 errors. It is important to note, however, that this coding technique is primarily applicable to relatively large block code structures.

Other block codes can deal with special kinds of errors. They include codes for error location, for correcting multiple bursts, for correcting a cluster of errors in a two-dimensional array, for correcting for bit loss or gain, and codes which can be adapted to an asymmetric channel.

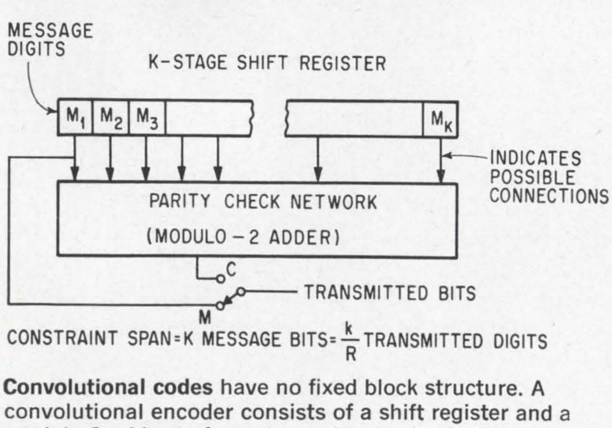
IV. Convolutional codes

Convolutional codes are widely used nonblock codes in forward error-correction systems because these nonblock structures can be decoded simply. They differ from the codes already described in that they have no fixed block structure. Information bits are encoded sequentially, with each information bit entering into the formulation of check digits for a period extending over k message bits or n transmitted bits. The length of this bit sequence is called the constraint length of the code.

The convolutional encoding process is best described with the help of the diagram below. The sequence M_1, M_2, . . ., of information bits passes through a shift register k digits long. Each position in the register is associated with a bit in the parity check network. The transmitted check digits are computed by multiplying an information bit with its associated parity bit and forming the sum modulo 2 of the products.

In the case illustrated, the absence or presence of connections between the k-stage shift register and the parity network represents the multiplication between a code-structure bit sequence and the data. The entire process may be thought of as a convolution of the information bit stream with the code. Information bits and check bits are read out alternately according to a fixed procedure. The resulting sequence of modulo 2 sums interleaved with message bits is the transmitted message. The choice of connections into the modulo-2 adder is determined by a particular code.

Convolutional codes are still being formulated through heuristic procedures. At present, the two decoding methods are sequential decoding[10] and threshold decoding.[11] Sequential decoding is more powerful but information bits must be highly interrelated. Threshold decoding uses a rather loose structure to permit insertion of isolated parity checks in the bit stream.



Convolutional codes have no fixed block structure. A convolutional encoder consists of a shift register and a modulo-2 adder to form the parity checks. In this way, individual information bits enter into the computation of many check bits. Each parity check is interleaved between each information bit.

Sequential decoding

Sequential decoding was developed for convolutional codes of long constraint lengths.[10-13] Digits are decoded in sequence and each is tested to determine whether it's zero or one. Whenever a decision as to its value can be made with sufficient confidence a digit is read out of the decoder. The decision depends on the entire received sequence containing the symbol. Hypothetical sequences are searched out systematically and tested for distance from the received sequence. When a sequence within present limits of acceptable distance is found, the first symbol of the sequence is read out of the decoder and a new last symbol read in. If at first no acceptable sequences are found, or if two similar sequences corresponding to different alternatives are found, then the lengths of the sequences under investigation are altered until one alternative or the other becomes significantly more probable. At this point, an irrevocable decision is made and the next digit is examined.

Sometimes, due to excessive noise, the desired level of confidence cannot be reached. When this is anticipated, a procedure may include acknowledgment of a decoding failure and retransmission will be requested. As a result, the probability of reading a wrong symbol out of the decoder is very low.

One problem with the sequential method is the variable computation time needed to decode different symbols. Incoming data must be stored in a buffer during long computational periods. Whenever the buffer capacity is exceeded, a decoding failure is declared and retransmission is necessary.

Sequential decoding uses redundancy efficiently, and it adapts easily to changing channel conditions. Once an encoder and decoder are constructed for a given constraint length, the encoding structure may be varied within that constraint length by changing the logic procedures. The main disadvantages of sequential decoding are the large amount of equipment required because of the complex decision procedures, long constraint lengths, and the long decoding time which must be allowed.

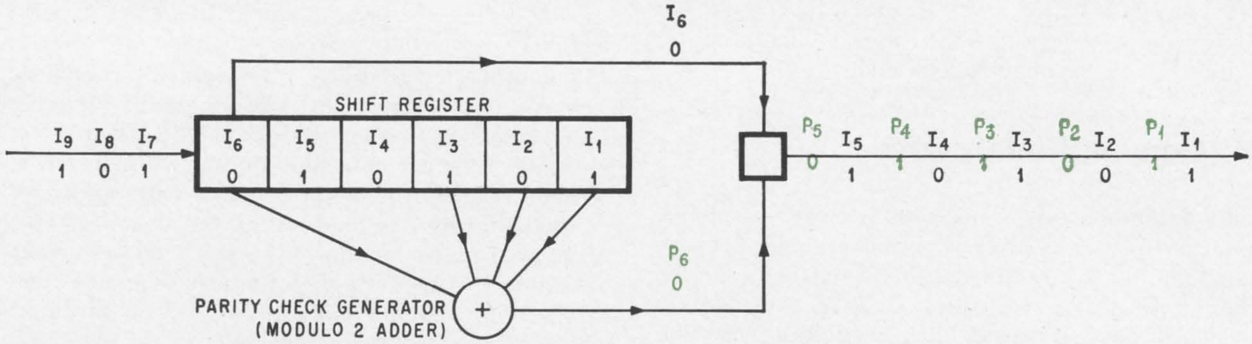
Threshold decoding

Convolutional codes can be decoded by a majority count of the parity-check bits associated with an information bit. This is called threshold decoding.

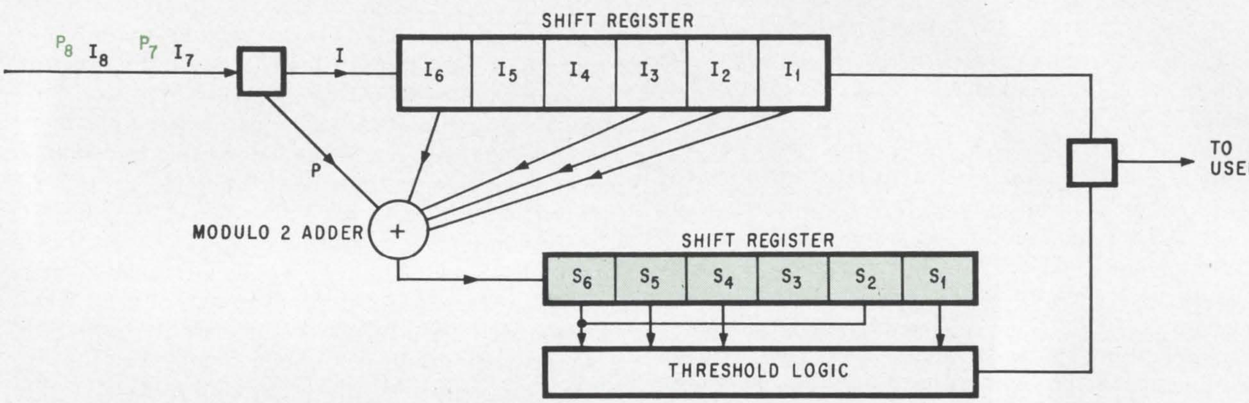
To understand this decoding technique, consider a specific convolutional encoder with threshold decoding. The code for this example is a ½ rate code, that is $k = n/2$. In this example $n = 12$ (p. 78, top).

A continuous stream of information bits is simultaneously fed into the shift register, the communication channel and the parity-check generator. The parity-check generator is a modulo-2 adder that sums the most recently introduced information bit with the previous third, fourth, and fifth information bits, and produces a parity-check bit.

This parity-check bit is transmitted immediately after its associated information bit (the most re-



Convolutional encoder for threshold decoding. Information bits are simultaneously fed into the communication channel, shift register and parity-check generator. The parity-check generator is a sum modulo-2 adder. It adds the most recently introduced information bit with the previous third, fourth and fifth information bits, to provide a parity-check bit (color) immediately after its associated information bit.



Convolutional threshold decoder. The data stream is separated into two streams—information and parity bits. These are fed to a shift register identical to the one at the encoder. The adder gets an additional input, the received parity-check bit. If there are no errors, the adder output is a parity-check bit added to itself, or zero. If there are errors, they will be produced as one's; they go from the adder to the lower shift register (color) to be corrected ultimately by the threshold logic circuits.

cently introduced bit). At the instant illustrated in the diagram, information bit I_6 is just entering the channel and its parity check P_6 is being determined. In the next bit interval, I_1 will be shifted out of the register and discarded. As an example of this technique, consider the 9-bit message 101010101 entered into the encoder from right to left. Assuming that the shift register initially contained all zeroes, the encoded form of this message reading from right to left would be:

$$P_9I_9P_8I_8P_7I_7P_6I_6P_5I_5P_4I_4P_3I_3P_2I_2P_1I_1$$
$$0\,1\,0\,0\,0\,1\,0\,0\,0\,1\,1\,0\,1\,1\,0\,0\,1\,1$$

At the receiver, the data stream is separated into two streams, one containing the original information bits and another the parity bits. The information bits are fed into a shift register identical to the one used for encoding. However, the modulo-2 adder at the receiver has an additional input, the received parity-check bits. If there have been no errors in transmission, the adder's output will be a parity-check bit added to itself, which is zero. A one in the output of the adder represents an error in transmission. The output of the adder is fed to a second shift register as shown in the diagram above.

The presence of one's in the second shift register can only result from errors. For example, consider the moment illustrated in the decoder diagram. The first six of the interleaved information and parity bits have already entered the decoder. The contents of the six stages of the shift register are given by

$S_1 = E(I_1) + E(P_1)$
$S_4 = E(I_1) + E(I_4) + E(P_4)$
$S_5 = E(I_1) + E(I_2) + E(I_5) + E(P_5)$
$S_2 + S_6 = E(I_1) + E(I_3) + E(I_6) + E(P_2) + E(P_6)$

where $E(I_j)$ or $E(P_j)$ is a one only if I_j or P_j is in error, and is zero otherwise.

The stages of the shift register, which are examined by the threshold logic circuit, are designed so that each logic equation formed will contain $E(I_j)$ once, while all the other $E(I_j)$ and $E(P_j)$ terms appear no more than once in the entire set of equations. In the example under consideration, the decoder is attempting to determine the correct value of information bit I_1. Assuming two or less errors in the eleven bits (6 information bits, the $E(I_j)$ terms, and 5 parity bits, the $E(P_j)$ terms) contained in these equations, a decision on the value of $E(I_1)$ can be made on the basis of the following rule: If three or four of the sums shown equal one, then $E(I_1)$ will be considered a one and bit I_1 will be considered in error.

The logic circuit is implemented to correct I_1 as it leaves the register and simultaneously correct all the S stages which contain $E(I_1)$. This threshold decoding scheme always gives a correct decision as long as no more than two errors are present in

Constraint length vs corrected errors

Efficiency (Rate)	Constraint length	Errors corrected
0.5	12	2
0.5	24	3
0.5	44	4
0.5	68	5
0.5	104	6

any 12 consecutive bits—6 information and 6 parity bits. However, it can correct some of the error patterns containing more than two errors.

Since the decoder is always examining 6 information bits and 6 parity check bits, this code is said to have a constraint length of 12. However, the principles illustrated in the previous example apply to codes with various constraint lengths and various rates. Some typical constraint lengths and the number of errors within that length that are guaranteed to be corrected are listed above.

These codes can be used in long-burst error correction by a method called diffuse convolutional coding.[14] It consists of taking a code like that just described and extending the constraint length over a long sequence of bits, only a few of which are used in computing the value of the parity-check bit.

The code can be extended to accommodate not only various burst sizes, but can handle various coding rates as well. The only limiting factor in the size of the burst that these codes can correct is the register capacity.

Probabilistic decoding

Unlike the coding methods previously described, probabilistic decoding is not a specific technique but a means of improving decoding techniques by bringing more information to bear on the decision process. The idea is to preserve some of the information usually lost in the demodulator when it assigns either of the values zero or one to a received waveform, and the probability for either value is nearly equal. Recapturing the lost information can be accomplished, for example, by recording the probability that each received digit was a one. This information is used in the decoder to determine the most likely code word. The process could also be considered one in which the demodulator makes use of the structure of the code to improve the reliability of its decisions. Actually, the result is to combine or interrelate the functions of the demodulator and the decoder.

An interesting example would be a threshold decoding scheme where the parity-check bits for a received sequence have the following probabilities of being one: 0.1, 0.2, 0.6, 0, 0.5, 0.8, and 0.9. This would ordinarily be demodulated as 0010111, assuming a decision rule that arbitrarily assigns the value one in cases of equal probability (0.5). With no further information, the decoder would merely detect the presence of an error for that parity check. But, with the probabilities available, it is possible for a decoder in conjunction with a logic circuit to change the least confident decision, namely, that regarding the value of the fifth digit where an arbitrary choice was made. This change could cause the majority logic estimators to decide that the correct value for the bit being decoded is one. Without the additional probabilistic decision process, an incorrect decision would have resulted.

This procedure uses the information in the received waveform more efficiently but its implementation requires complex equipment, including a device for storing probabilities.

Which code for what mode

For error detection the choice is limited to block codes. Among these, the Bose-Chaudhuri codes are preferred because of their relative ease of implentation, efficiency, and error-control capability. Geometric block codes perform almost as well in this mode and have desirable properties for formating, that is, the arrangement of the information bits within a block of binary bits.

When considering codes for forward error correction, nonblock structures become extremely attractive. Convolutional codes with sequential decoding are extremely effective for fec although the necessary equipment is complex and expensive. Although simpler equipment is required for threshold decoding, the error-correction capability for a particular code redundancy is reduced. Block coding structures are not usually used in the fec mode because the decoders required are prohibitively expensive. Zierler codes are the exception; they show promise of providing versatile error correction capabilities with decoders no more complex than sequential decoders.

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7.8 volts—operate
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Rate of Rise: 140 $\pm$ 20 KV/μ sec.
Pulse Width (current): 0.7 $\pm$ 0.05 μ sec.
Positive Backswing: 20% max.
Fall Time (current): max. 30% of pulse width
Ripple Detected RF: 14% max. on 711 magnetron
Overload Protection: 200% of protective diode current
Trigger Amplitude: 110 volts $\pm$ 10%
Trigger Pulse Width: 1 $\pm$ 5% μ sec.
Trigger Rise Time: 0.2 $\pm$ 10% μ sec.
Programming: 2 sec. delay
Inputs: DC voltage, system triggers, and AC filament voltages

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European
electronics markets—1966

By the editors of Electronics

In the first detailed statistical compilation of electronics consumption in Europe, the editors of Electronics predict the industry will grow 10 percent next year, to $7.8 billion. Consumer and industrial segments of the industry will grow the fastest; many countries expect a sharp decline in military electronics, which are already small in most countries, reflecting the completion of defense projects and the obstructionism of France in NATO.

Contents:

Intercoms & sound systems	3.3	22.5	20.3	6.5	5	4.2	2.7	49.0	113.5
Land mobile	1.1	25.4	20.0	8.8	3	1.7	.5	48.0	108.5
Microwave relay systems	2.7	30.0	23.5	9.0	4	2.8	.5	23.3	95.8
Navigational equipment, air & marine	40.0	139.0	125.0	53.5	32	32.0	40.0	175.0	636.5
Radar	2.5	58.0	35.0	15.0	6	2.9	2.2	69.0	190.6
Telemetry	3.0	19.5	23.5	2.0	*	1.5	1.8	8.5	59.8
Other communications equipment	12.0	24.0	18.0	5.5	11	6.5	2.4	28.5	107.9
Computers & related equipment, total	**45.9**	**234.0**	**250.6**	**99.2**	**51**	**40.6**	**33.3**	**302.5**	**1,057.1**
Analog and hybrid computers	3.9	19.0	20.5	6.4	3	1.8	1.5	12.0	68.1
Converters, A/D & D/A	2.8	16.5	14.0	4.6	2	1.7	1.1	17.5	60.2
Digital computers	23.0	130.0	155.0	64.0	27	25.0	20.0	165.0	609.0
Memories	2.2	18.5	16.5	6.0	3	2.0	1.7	17.5	67.4
Process control systems	8.0	15.0	18.6	4.4	8	4.8	5.4	20.0	84.2
Readers & readout devices	2.0	10.0	8.0	2.8	2	1.8	1.3	22.5	50.4
Other computer-related equipment	4.0	25.0	18.0	11.0	6	3.5	2.3	48.0	117.8
Nuclear instruments & equipment, total	**6.7**	**14.6**	**20.4**	**10.4**	**8**	**4.9**	**6.0**	**20.8**	**91.8**
Accelerators	.9	2.8	4.1	2.0	2	.7	1.3	3.9	17.7
Analyzers	1.4	2.2	3.5	1.7	1	1.2	1.0	2.8	14.8
Radiation monitoring equipment	1.3	2.1	2.5	1.5	1	1.1	.9	4.5	14.9
Reactor controls	1.3	2.8	3.6	1.2	2	.9	1.1	3.4	16.3
Semiconductor & other detectors	.6	.7	1.2	.7	*	.2	.3	1.2	4.9
Other nuclear instruments & equipment	1.2	4.0	5.5	3.3	2	.8	1.4	5.0	23.2
Production, control, & other equipment, total	**57.2**	**153.6**	**128.5**	**63.0**	**53**	**48.1**	**25.8**	**240.2**	**769.4**
Dictating machines	1.2	5.0	4.0	1.6	1	.7	.5	7.0	21.0
Industrial x-ray equipment	1.7	5.6	3.0	1.5	2	1.7	.8	10.0	26.3
Infrared equipment	3.3	16.8	14.7	4.3	3	2.8	1.6	25.4	71.9
Motor controls	8.0	13.5	12.5	5.0	7	5.5	3.5	23.5	78.5
Photoelectric devices	2.3	3.3	2.0	.8	1	1.1	.3	6.0	16.8
Power supplies (for production & control equipment)	10.5	18.0	23.3	9.5	11	9.5	5.3	21.7	108.8
Process controls, other	23.0	62.5	46.5	30.5	22	23.0	11.7	80.0	299.2
Welding equipment	.7	3.9	2.0	1.3	1	.5	.4	6.6	16.4
Other production & control equipment	6.5	25.0	20.5	8.5	5	3.3	1.7	60.0	130.5
Test & measuring instruments, total	**50.0**	**95.5**	**96.7**	**57.8**	**58**	**40.8**	**13.7**	**136.4**	**548.9**
Amplifiers, laboratory type	.3	1.5	2.0	.6	1	.3	.1	2.8	8.6
Calibrators & standards	3.1	3.9	4.0	2.6	4	2.2	.8	5.8	26.4
Components testers	2.0	3.6	4.0	2.5	3	2.0	.5	6.0	23.6
Counters	3.4	5.6	4.8	2.6	2	2.7	1.0	3.5	25.6
Electronic voltmeters & ammeters	3.3	5.3	5.2	3.5	3	1.2	.5	11.0	33.0
Microwave test & measuring instruments	7.4	9.2	11.1	5.7	9	5.6	1.7	13.8	63.5
Oscillators	1.6	4.6	4.5	1.9	2	1.2	.5	5.0	21.3
Oscilloscopes	10.0	19.5	19.5	11.9	10	9.0	2.5	22.0	104.4
Power supplies, laboratory type	4.5	7.5	9.0	5.5	5	3.5	1.1	9.7	45.8
Recorders	4.0	10.3	9.3	5.0	7	3.3	1.3	12.5	52.7
Signal generators	3.2	8.4	7.7	5.1	4	3.0	1.2	10.0	42.6
Spectrum analyzers	1.2	4.1	3.6	1.4	2	.6	.2	6.8	19.9
Other test & measuring instruments	6.0	12.0	12.0	9.5	6	6.2	2.3	27.5	81.5
ELECTRONICS INDUSTRY, grand total (millions of dollars)	371.6	1,814.8	1,668.2	760.2	439	343.2	250.7	2,257.7	7,905.4

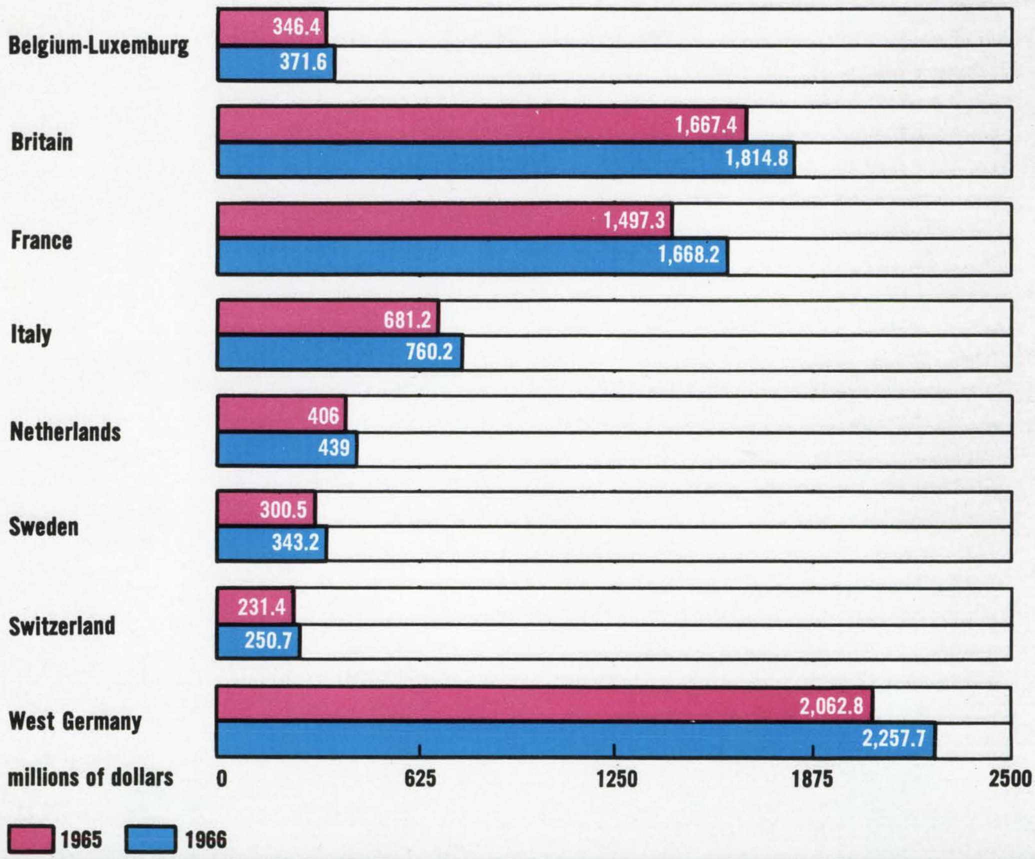
Blue section includes military, government non-military, commercial and industrial equipment consumption.

*0.5 million or less **doesn't include telecommunications.

European electronics markets—1966

	Belgium-Luxemburg	Britain	France	Italy	Netherlands	Sweden	Switzerland	West Germany	Total
Components, total (millions of dollars)	**90.6**	**558.7**	**458.9**	**176.7**	**152**	**94.1**	**53.3**	**612.4**	**2,196.7**
Antennas	2.5	22.5	16.0	5.0	3	5.0	3.8	39.5	97.3
Capacitors, fixed and variable	5.5	46.0	38.0	12.1	7	8.0	4.9	77.3	198.8
Coils (including IF)	1.0	14.5	13.5	4.0	2	1.5	.6	18.2	55.3
Complex components (including integrated circuits, printed circuits, subassemblies)	12.0	61.6	55.0	24.0	17	8.0	1.4	45.0	224.0
Connectors	2.3	31.0	18.0	9.0	4	3.2	2.5	21.5	91.5
Crystals & crystal filters	.6	7.2	5.5	1.1	1	.7	1.7	4.2	22.0
Delay lines	.7	2.2	1.3	.5	1	.6	.2	3.1	9.6
Ferrite devices	1.4	6.1	5.0	2.8	2	1.4	1.0	4.0	23.7
Filters & networks (except crystal)	.6	6.8	5.0	1.5	1	1.1	.5	7.6	24.1
Loudspeakers	1.9	8.6	9.0	3.0	6	1.3	.5	17.6	47.9
Magnetic tape	1.4	9.0	8.0	2.2	2	2.0	2.3	10.7	37.6
Potentiometers	1.1	9.5	6.8	3.0	4	2.7	1.1	17.0	45.2
Power supplies (OEM type)	2.3	21.5	17.5	7.0	7	3.5	2.2	22.2	83.2
Relays	3.5	28.4	23.0	11.5	6	6.2	3.5	21.6	103.7
Resistors, fixed	3.6	29.0	28.0	9.2	4	1.9	1.5	18.0	95.2
Semiconductors (except integrated circuits)	7.3	79.8	59.0	16.6	9	11.0	7.2	62.0	251.9
Servos & synchros	1.9	5.3	4.0	1.7	3	1.2	.6	8.0	25.7
Switches, manual	.8	4.5	3.8	1.1	1	1.7	1.2	10.5	24.6
Transducers	1.5	13.7	12.5	3.4	2	2.2	1.5	19.8	56.6
Transformers & chokes	7.7	25.7	21.0	9.5	11	8.5	5.3	42.8	131.5
Tubes, all	20.5	92.5	82.0	36.0	48	10.5	2.8	77.6	369.9
Wire & cable (for electronics)	4.0	22.0	18.0	8.0	6	5.4	4.8	31.2	99.4
Other components	6.5	11.3	9.0	4.5	5	6.5	2.2	33.0	78.0
Consumer products, total	**43.9**	**379.8**	**392.8**	**231.0**	**46**	**50.5**	**56.5**	**472.9**	**1,673.4**
Phonographs-radio combinations	5.8	27.2	26.3	16.5	5	6.5	8.5	32.5	128.3
Radios	8.6	60.8	51.5	30.0	8	7.0	8.5	125.0	299.4
Tape recorders (for home use)	1.3	9.8	10.0	4.5	2	3.7	2.2	16.0	49.5
Tv sets	24.7	260.0	285.0	175.0	27	30.0	35.0	274.4	1,111.1
Other consumer products	3.5	22.0	20.0	5.0	4	3.3	2.3	25.0	85.1
Medical equipment, total	**8.7**	**28.7**	**22.3**	**9.1**	**6**	**6.8**	**5.2**	**50.5**	**137.3**
Analytical laboratory equipment, electronic	2.0	5.0	4.2	1.8	1	1.4	1.1	9.7	26.2
Diathermy (short wave) equipment	.3	1.5	1.5	.3	*	.1	.1	3.0	6.8
Electrocardiographs & electroencephalographs	.5	2.3	2.0	.5	*	.3	.3	2.7	8.6
Hearing aids	1.4	5.4	4.1	2.0	1	1.1	.9	7.3	23.2
X-ray equipment, medical	2.3	9.5	8.0	3.0	2	2.2	1.7	17.3	46.0
Other medical electronic equipment	2.2	5.0	2.5	1.5	2	1.7	1.1	10.5	26.5
Communications, total**	**68.6**	**349.9**	**298.0**	**113.0**	**65**	**57.4**	**56.9**	**422.0**	**1,430.8**
Broadcast equipment	3.4	27.0	29.2	11.4	4	5.5	6.6	14.3	101.4
Closed circuit television	.6	4.5	3.5	1.2	*	[illegible]	[illegible]	[illegible]	[illegible]

TOTAL ELECTRONICS CONSUMPTION



EUROPEAN ELECTRONICS MARKETS

	1965	1966
Components	2,035.6	2,196.7
Consumer products	1,582.3	1,673.4
Medical equipment	127.6	137.3
Communications	1,309.3	1,430.8
Computers & related equipment	923.8	1,057.1
Nuclear instruments & equipment	79.9	91.8
Production, control & other equipment	647.0	769.4
Test & measuring instruments	487.5	548.9
Electronics Industry, total	7,193.0	7,905.4

Statistics were obtained by Milton Drake, director of market research, with additional reporting by McGraw-Hill correspondents in London, Paris, Bonn, Stockholm, Brussels, Zurich, Milan, Vienna and Copenhagen. This team interviewed representatives of more than one hundred industry associations, governmental agencies, banks, diplomatic sources and companies to obtain estimates of electronics consumption in each country. Statistical techniques were then applied to produce a consensus of these estimates.

European electronics market

The boom continues

Electronics' first European forecast indicates uninterrupted growth in all nine countries studied and in every major sector of the electronics field. Expenditures should total $7.9 billion in 1966

Western Europe's electronics markets will continue to expand next year with West Germany, Great Britain and France continuing as the biggest consumers, in that order.

Electronics' first European market survey indicates that sales will climb to $7.90 billion from $7.19 billion in 1965. Germany's booming economy will use $2.25 billion of electronics equipment, up from $2.06 billion this year. Sales in Britain will total $1.81 billion, compared with $1.66 billion this year; France will spend $1.66 billion on electronics, up from $1.49 billion this year.

Increases will cover all sectors of the electronics field: consumer, communications, computers, instrumentation and industrial equipment.

The consumer sector, although the second-largest and still growing, has cooled off slightly. Consumer products are expected to account for $1.67 billion in sales next year, up from $1.58 billion in 1965; but with the television market approaching saturation and color tv still at least three years off, sales of tv sets are not increasing as rapidly as in the past. The replacement market is not taking up all of the slack; however, sales of phonographs, radios and tape recorders figure to continue the fast growth experienced this year.

Industrial electronics, spurred by labor shortages and a demand for automation, continues to gain rapidly. In Germany, for example, only 5% of the factories have automation approaching that of American companies; this is expected to double in the next decade.

Also growing is the demand for computers. Sales are expected to exceed $1-billion for the first time next year; in 1965, sales of computers and related equipment totaled $923.8 million.

In communications, where European technology is pretty much keeping pace with that of the United States, expanding government budgets assure continued growth. Britain, for instance, spends $750 million a year on telecommunications. Electronic switching for telephone systems is being tested in Britain, West Germany, France, Sweden and elsewhere. Systems based on pulse-code modulation are due for delivery this year.

As in the United States the military market is uncertain. There are a few big contracts in the works, however—the French Mirage 4 bomber and Sweden's Viggen multipurpose warplane, to name two. Britain has been switching to American-made planes to reduce her defense costs, but the British expect to continue to supply much of the electronic gear.

The North Atlantic Treaty Organization also continues to buy electronic equipment, although its promise has not been fully realized.

West Germany is developing into a market for space electronics. Early this year the Ministry for Scientific Research estimated that it would spend $500 million by 1970.

West Germany

Industry rides on economic crest

The West German economy heads into 1966 at its strongest level since before World War II. And riding the crest of this economic wave will be the thriving electronics industry, the biggest in Europe; domestic consumption reached $2 billion in 1965 and is expected to total $2.2 billion next year.

Last year, West Germany satisfied its own domestic demand for electronic gear and ranked second only to the United States as an exporter of industrial electronic products. West German electronic equipment has found a worldwide market, from electronic telephone-switching equipment in Rome to automatically controlled tankers on the high seas.

Because of restrictions imposed on West Germany by the Allied occupation forces following World War II, the country's modern electronics industry is really only 10 years old. So West Germany has a long way to go to catch up with the United States in many advanced applications and advanced research and development. Many West German research workers eye the massive infusion of U.S. government funds into research and development with envy.

At the sprawling central laboratories in Munich of the giant Siemens & Halske AG, the largest electronics company in Germany, a research official says: "We cannot afford the wide-ranging projects that are possible in the U.S. In fact, less than 1% of our research and development budget comes from the government." But the West German electronics industry is hopeful that some year soon it will rank as a leading innovator in the field.

Government and defense

On its own and in cooperation with other European countries, West Germany is hard at work on such diverse projects as satellite-launching rockets, research and communications satellites, satellite ground-control stations, vertical/short-range take-off and landing (V/STOL) tactical fighters and transports, and helicopters. In 1966 and the coming years, these will represent a growing market, but a market in which the German electronics companies are going to fight harder than in the past.

Earlier this year, the West German Ministry for Scientific Research estimated the country's need for space projects funds at nearly $500 million for the next five years. And in the past year or so, a number of German companies have moved to strengthen their position in advanced applications by seeking ties with other companies, both domestic and foreign.

For example, Telefunken AG joined a consortium led by the Hughes Aircraft Co. to snag a North Atlantic Treaty Organization air-defense ground-environment (Nadge) contract. Siemens joined an opposing consortium led by the Westinghouse Electric Corp. AEG, Telefunken's parent, is working closely with the General Electric Co. in atomic power. Siemens produces some of the Radio Corp. of America's line of computers and sells them in West Germany.

Still, the U.S. is the major source for much of the electronic gear vital to West Germany's defense and is likely to remain so as long as the West German Army is considered only a part of NATO.

Last year, 30% of the radio equipment orders in West Germany were filled by the U. S. To change this, German companies are setting up more lucrative links with U.S. firms, tapping American know-how through licenses, exchanges or out-right acquisitions. An example of the latter is Telefunken's take-over of the majority interest in GE's subsidiary, Electronische und Luftfahrtgerate, GmbH, which services airborne electronic equipment.

Bucking this trend, though, are the subsidiaries of the U.S. companies actually manufacturing in Germany. For instance, 80% of the computers manufactured in Germany are made in American-owned plants, as are about 20% of all military and industrial electronics equipment and about 15% of consumer electronics.

Consumer electronics

The West German electronics industry is expected to show strength across-the-board except in some areas of consumer electronics. Sales of radio receivers will be stimulated when the West German broadcasting companies and the post office—which as in other European countries is responsible for radio and television transmission—begin stereo broadcasting around the end of 1966.

Although it will not be ready before 1967 at the earliest, color television is already far along in manufacturers' planning. The coming year will be a time for readying production lines to avoid the pinch the U.S. industry is now feeling because demand is far outstripping production.

But the West German electronics industry is in no real hurry to push color television into the marketplace. Sales of black-and-white sets are strong and more than 50% of the West German households now have at least one television set. By the end of 1966, this should reach nearer 70% and only then will the manufacturers feel the threat of saturation and the need for a new product. The domestic makers know they must be ready with color-television sets because a hefty 30% of the West German tv-set market now is filled by imports from other European nations. Without a competitive color set, this percentage might rise.

Sales are expected to rise in tape recorders and record-playing equipment and there are also great hopes for automobile tape recorders using easily changeable cartridges, a product introduced only this year.

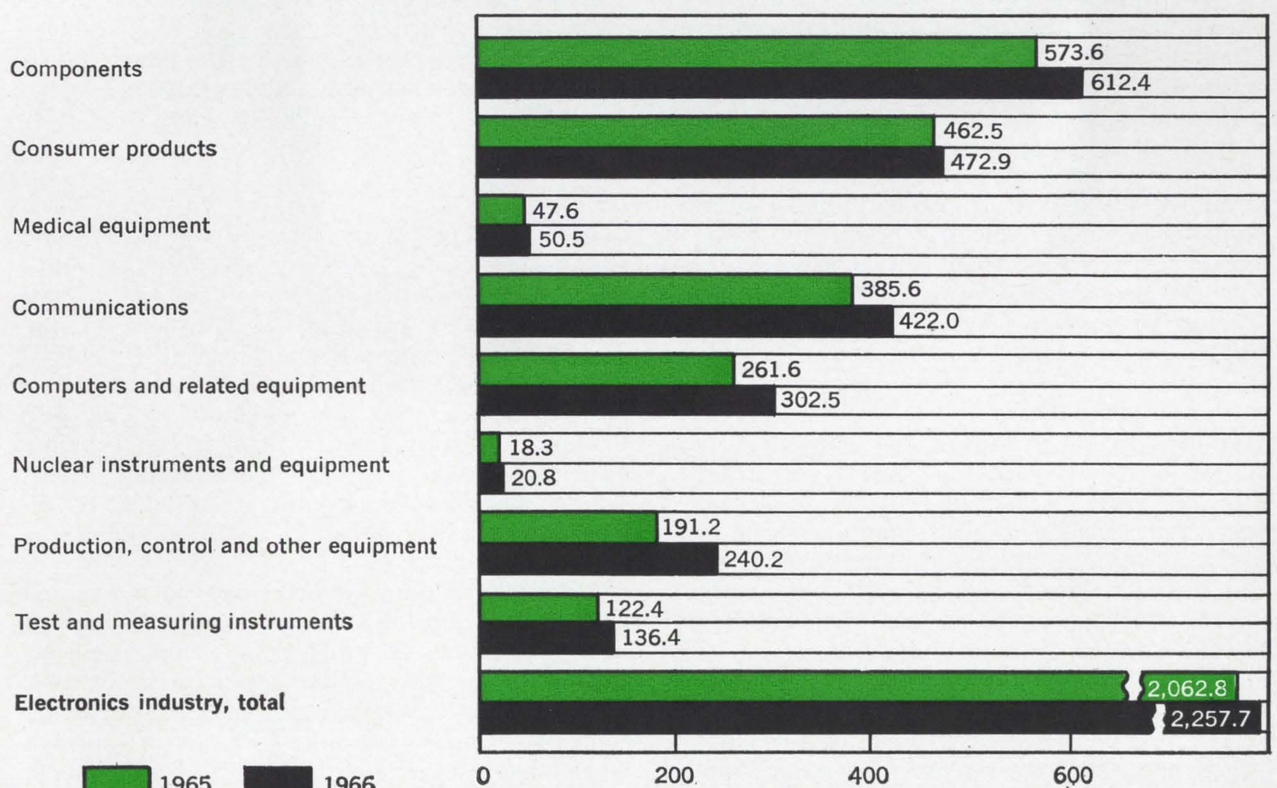
Industrial electronics

Electronics in the factory is gaining fast in West Germany as the demand from the country's prosperity outraces production capacity. A factor, too, is the chronic labor shortage that is being met—not always successfully—by the Gastarbeiter, as the foreign worker is called. Over 1.2 million strong, this labor force—recruited from Greece, Yugoslavia, Italy and England—is an important factor of many electronic plants.

So far, only about 5% of West Germany's factories including heavy industry have anything approaching the automation of American industry. The percentage is expected to double in the next

West German electronics markets

(millions of dollars)



five years, opening a large market for electronic-control, measuring and testing equipment.

Last year, nearly half of the control, measuring and testing instrument imports came from the U.S. Although the competition from the rest of Europe, especially in process-control computers is growing, the American position is expected to stay at a high level in 1966.

In just about every segment of West German commercial and industrial activity, sophisticated controls systems are being planned and electronic devices form their backbones. Numerical control is hurting the traditionally stolid West German machine tool industry. Not only has numerical control fathered a new generation of machine tools, but it is also pushing electronics into new areas—one of particular note in West Germany is the increasing automation of automobile design.

Next year will see several computer-controlled steel-rolling mills operating. One will be at the Fried. Krupp-owned Bochumer Verein in the Ruhr that was designed from the ground up for computer control. These mills have already triggered competition for new control systems both in the steel industry and elsewhere and 1966 should see an expansion of interest—and of orders—for electronic process control.

The fast-growing, and ultimately the most lucrative industrial market, is for process-control equipment, with the digital computer far and away the most attractive product. International Business Machines Corp. now supplies some 70% of the West German computer market, but Siemens—with a 6% share of the market—hopes to cut down IBM's near-monopoly in 1966. The West German company recently announced it planned expenditures of $125 million "within the next few years" to build up its electronic-data processing business.

Siemens intends to spend $10 million of that amount almost immediately by building a new computer development center in Munich. Another $5 million will be spent to expand already existing computer-production plants in that city. Siemens signed an agreement about a year ago with RCA to share licenses and sales facilities for RCA's Spectra 70 computer, which Siemens will distribute in Germany as the 4004 system. About 70% of the 4004's components are U.S.-made, but Siemens hopes to reduce this to about 30%.

Transportation is feeling the impact of electronics, too. Next year, this market will grow as both the railroads and the various government road agencies step up their programs for traffic-flow control. The Deutsche Bundesbahn, which runs the railroad network, has installed electronic controls in major train terminal switchyards and on some sections of the mainline right-of-way. The company is also looking at block control systems. Under the direction of a computer, these systems feed information back into the cab of a locomotive rather than just to the signals at trackside. Similar systems are being tested for subways in several West German cities.

And the West Germans, long-standing innovators in highway development, have installed computer-directed traffic control systems in the heart of West Berlin and Munich. West Berlin regulates traffic on the major road leading out of the city to the Hanover Autobahn. The control system, made by Siemens, employs a signal processor for routine work and a Siemens-Halske 303 process computer for tasks that require complex decisions. The machines cost a total of $250,000.

Siemens also has installed a control system, which uses radar detectors, in Neu-Ulm, in southern Germany. In a previous setup in Hamburg, the company used pneumatically operated strips to measure traffic flow and select a control program electronically. Munich installed a specialized computer made by a British firm, Elliott-Automation, Ltd. Costing $350,000, the machine will select programs from a repertoire of 40 that control the timing of traffic lights.

The telephone network in West Germany, as in the United States, is going through an evolutionary upheaval with direct distance dialing to many neighboring countries an accomplished fact and electronic switching systems appearing—both for central offices, such as one installed in Munich, and for private branch exchanges.

Some 30 to 40% of the market for West German telephone equipment is abroad, according to Siemens. So American companies can expect continuing competition in foreign markets from West German equipment, which is as advanced as American wares in many areas and in some—such as desk-top call director units—even more advanced. For example, one Siemens desk-top director has both a memory for each of its labeled buttons—addressed by punching the punch-button dial on the set—and also a temporary memory to store the last number called in case it is busy and there is a need to call again.

Components

In components, West Germany still lags behind the United States applying advanced products. As with many other electronic products, West Germany may be just a bit too late with its integrated circuits. Says a Siemens executive charged with semiconductor production: "So far, there is no real demand here for integrated circuit production. And what interest there is can be more easily—and more cheaply—met through licensing." Siemens is making integrated circuits for in-house use in the computers it makes under the agreement with RCA.

Besides being a market nearly ripe for integrated circuits from the U.S., West Germany can absorb healthy amounts of other components, such as advanced types of transistors, even specialty tubes. West Germany now purchases nearly 30% of her component imports from the U. S. and is expected to continue as a strong market for U. S. components next year.

United Kingdom

Gains expected in computer, military, communication sales

Increased spending for military electronics, telecommunications and computers should lift the British electronics market 9% to $1.81 billion in 1966 from $1.67 billion in 1965.

The military electronics industry had been hurt by the cancellation of the sophisticated TSR-2, a British fighter plane, in early 1965, but contracts are beginning to come through now for British-built equipment on planes bought from the United States. Contracts were awarded for the Hercules C-130, a turbo-prop heavy transport made by the Lockheed Aircraft Corp., and negotiations are going on now for supplying the electronics on the Phantom 2, a twin-engine attack bomber built by McDonnell Aircraft Corp.

In telecommunications, the British Post Office has announced an increase in the budget, from $500 million a year to $750 million annually over the next decade. Computer purchases are expected to climb to $234 million next year from $221.2 million in 1965. The component market is expected to grow to $558.7 million next year from $516.3 million in 1965.

The biggest puzzle for the electronics industry is the state of the British economy. The pound has been healthy since standby credits were arranged with foreign central banks in September. With luck, the government will achieve a balance of payments by the end of 1966 without the need of further deflationary measures and without a recession.

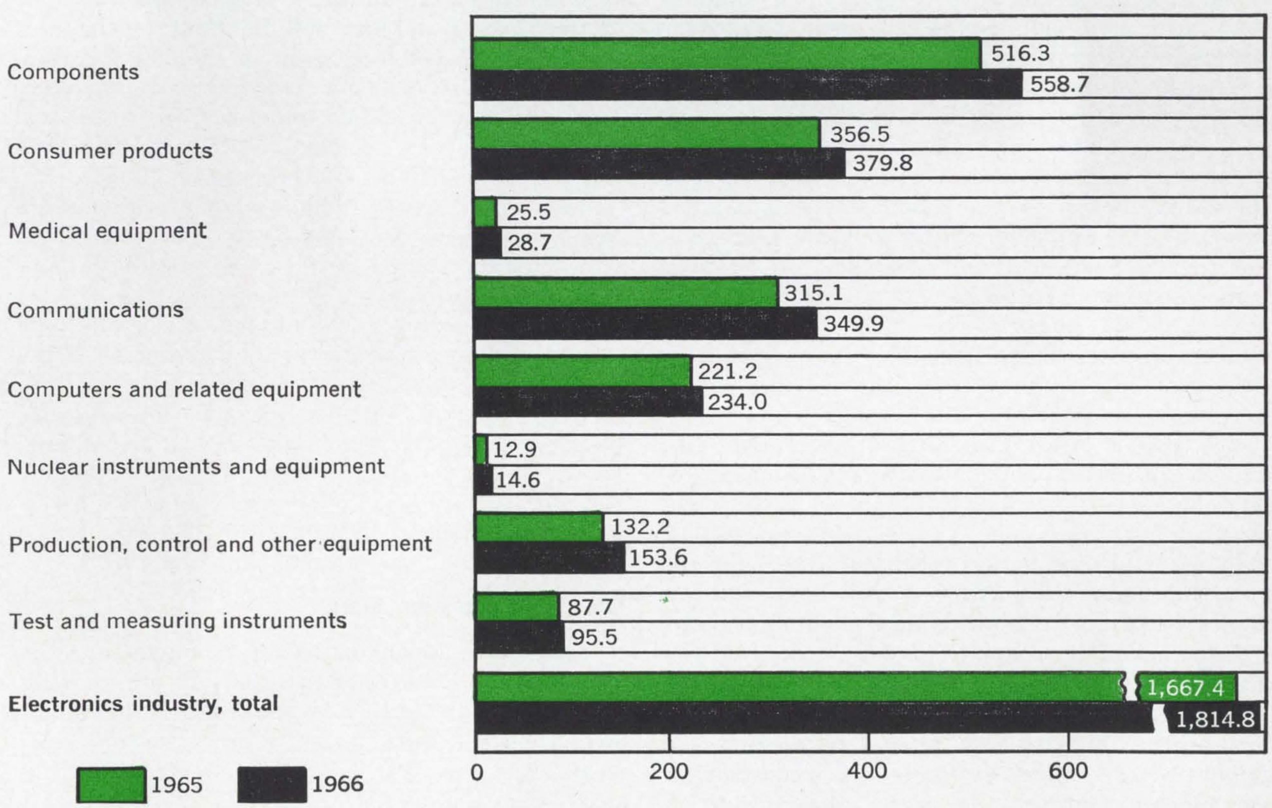
However, the deflationary measures taken in successive stages since November 1964 have had little effect. There is a labor shortage, and despite the government's price and income policy, wages are rising steeply—7% to 8% a year.

If wages continue to rise, foreign investors may get edgy again, the pound may weaken, and the government may be forced to further deflationary action. This could cause a recession. Deflationary measures adopted by the government in 1964 included a boost in the banks' basic interest rate to 7%, the highest level in modern times. The rate was lowered to 6% in June of this year. Sterling outflow was stemmed with an import levy of 15% which was dropped to 10%. Further government regulations may be necessary if exports lose their buoyance—they've risen about 5½% this year—and imports rise again.

There are some who say a recession will come

British electronics markets

(millions of dollars)



anyway as the government's measures—particularly the cutback in public capital spending—bite more deeply.

Two prestigious British economics groups have just predicted that the growth next year will be slow, with a rise of only 2% in production. They also say a recession will be avoided and by the end of 1966, trade should be about balanced.

A blow to the military market was the abandonment of the TSR-2 in 1965. When the plane contract was cancelled, about $33 million had been spent or committed by the British government for electronics. The total cost of the electronic systems would have been $90 million. Involved in the contract were firms such as Elliott-Automation, Ltd., Ferranti Ltd., and EMI Electronics, Ltd.

However, the industry expects contracts for American-built planes. The British Electronics Engineering Association, for example, worked out a deal with the Ministry of Aviation, to provide electronic equipment for the 75 to 80 Lockheed C-130 aircraft Britain is purchasing.

Negotiations are still under way for outfitting McDonnell's Phantom 2 with about $54 million worth of avionics and weapons system controls over the next few years.

Supplying the equipment for the C-130 will be Ekco Electronics, Ltd., weather radar; the Plessey Co., uhf/vhf communications; Marconi, Ltd., vhf communications, instrument landing and automatic direction finding; Ultra Electronics, Ltd., intercommunications equipment; Standard Telephones & Cables, Ltd., a subsidiary of the International Telephone and Telegraph Corp., radio altimeter; Decca Navigator, Ltd., Doppler equipment, navigational computers and display system; S. Smith & Sons, Ltd., autopilot; and A.C. Cossor, Ltd., identification equipment.

The Royal Air Force also has budgeted $132 million for radio, radar and navigational equipment for 1965-66. (The British defense budget's fiscal year begins in April.) About $44 million of this $132 million is being sent for the national computerized air-traffic control system. One computerized system is being installed at Britain's main air-traffic control center at West Drayton near London Airport. The $300-million system will be operational by 1969. Plessey has the contract for the computer complex, and Marconi is supplying the radar and traffic-control displays.

The British Army will be spending about $16 million for radars and supporting equipment for the Thunderbird-2 antiaircraft missile system and for manpack radios. The Navy has budgeted $69.2 million for electronic and electrical stores for the Polaris program. The Army is still bogged down in its studies of a tactical radio communications system, called the Hobart plan, which has been plagued by soaring costs—from an estimate about a year ago of $270 million for the forward line to $450 million this year. The Hobart plan covers the gamut of Army signals from complex headquarters exchanges to manpack sets in the forward units. A complete reappraisal is now being made, to reduce the cost by $180 million.

A decision on the British purchase of the General Dynamics F-111A, and another project, the Anglo-French Jaguar strike-fighter/trainer consortium, may come next spring, following a government defense review.

Expanding telecommunications

Between one-quarter and one-third of the Post Office's annual $750 million investment is earmarked for telephone exchange equipment and associated apparatus. Although barely a beginning has been made, a market is slowly developing for electronic telephone exchanges. D.A. Andrews, chief telecommunications superintendent of the Post Office, says: "We are progressing slowly from research to production."

Already operating are two experimental 200-line electronic switching units. One 800-line exchange will be installed next year, and contracts have been awarded for three more 800-line exchanges and a 1000-line exchange. A 3,000-line exchange is now being installed and will be ready for field trials in 1966. In these exchanges, which are space division multiplex systems, the reed relay is used for speech-path switching and certain control functions. The systems were developed by the joint electronics research committee, which consists of five telecommunication equipment suppliers. They are Associated Electrical Industries, Ltd., Automatic Telephones & Electric, Ltd., the L.M. Ericsson Telephone Co., the British General Electric Co. and Standard Telephone & Cables.

The country's expanding telephone system will also benefit makers of microwave equipment. Some 20 microwave stations will be built in the next three years. A 600-foot tower in London, the focal point of the national microwave system, was constructed this year. When in service, the tower will link the country's principal cities with those on the continent and in the U.S. via satellites.

Preparations for satellite communications are being made now. A second 85-foot antenna, which will allow the station to track two satellites simultaneously or provide a continuous communications service—by having each antenna track alternate satellites as they appear over the horizon—is being built at Goonhilly Downs.

In other aspects of the electronics industry, the mobile radio equipment market is also expanding. During the last four years, the number of mobile stations has nearly doubled from about 24,000 in 1961 to more than 44,000 in 1965. The Post Office expects the trend to continue into the 1970's.

Consumer question mark

What will happen to the television business is not so clear. Some industry officials are pinning their hopes on further expansion by the state-owned British Broadcasting Corp.'s second television channel—BBC 2. The channel, transmitting on 625-line uhf, is seen by about one-quarter of

British companies, such as Marconi Company, are working on research projects from lasers to microcircuitry.

Britain's population and is expected to reach 70% of them by the end of 1966. But sales failed to increase as expected when the service started early in 1965, and manufacturers found themselves with a surplus of sets. There's also the chance there may be a second commercial channel—625-line uhf. But the Post Office, which regulates television, hasn't made its position known.

Keith Miller, group marketing manager of Thorne Electrical Industries, Ltd., which produces more tv sets than its two largest competitors together, sees only moderate growth over the next few years.

He says industry output next year will be about the same as this year—about 1.85 million sets. Saturation is high—about 90% of the British homes have tv sets, either owned or rented. Miller says more tv sets can be sold by encouraging people to own two sets instead of just one.

Color television is seen as the bright hope to spur sales, but not this year. The government still has to decide on a system and when it will be introduced. However, the Television Advisory Committee has recommended to the Post Office that Britain adopt the West German PAL system. Because of the delay in deciding on a system, color tv cannot come to Britain before late 1967 or early 1968. "Even then," one official says, "there won't be any sudden rush of buyers because of the initial high price of color receivers," probably between $500 and $700.

Radio is having its problems, too, with the market for the less-expensive transistorized portable sets leveling off. Sales of very high frequency sets (a-m and f-m) will remain stable at two million. Most of the market for small, transistorized portable radios has been captured by imports from Japan, Hong Kong and Taiwan. About 1.5 million radios were imported in 1965, and 1.7 million in 1964.

Brisk computer business

The British computer market is a rarity: it's one of the few European countries not completely dominated by the International Business Machines Corp. in sales, although IBM does share the lead. Estimates vary, but most experts believe IBM commands 35 to 40% of the market as does International Computers & Tabulators, Ltd. The market is estimated at $234 milion in 1966, up from $221.2 million in 1965.

Efforts to counter the foreign influence are being made. ICT introduced the 1901 computer series, this year, and English Electric, Ltd., has announced the System 4 series, which uses integrated circuits in its processors. The System 4 will be rolling off the production lines early in 1967.

The computer industry has been an early recipient of the Labor Party's effort to help industry by initiating research in computer techniques. Computer firms have found it encouraging. One official commented: "It is the first time we have ever had interested civil servants talking the language of manufacturers."

Another effort to improve the competitive situation is being made in a joint effort by British and French electronics companies. They are seeking money from their respective governments for an Anglo-French computer consortium that would design a large computer by the 1970's that would reportedly dwarf the biggest present U. S. machine —Control Data Corp.'s 6600.

Growing IC market

British companies are also struggling for a foothold in the infant market of integrated circuits. This year, sales totaled about $3 million, a figure that will increase to about $8 million in 1966. The integrated circuits have been used mainly for military equipment and computers.

Although British companies are behind the U. S. in technology, they are developing a capability for IC production.

One of the most active companies is a microelectronics affiliate of Elliottt-Automation, Ltd., with about 200 people now working and plans under way for a $2.8 million plant. The company's efforts include thin-film, monolithic and metal-oxide semiconductor technology.

Marconi is producing a microelectronic computer called the Myriad, a real-time data processing computer.

Over-all, the British component market reached $516.3 million this year, and is expected to total $558.7 million in 1966.

France 

Big increase in military spending to aid electronics

President Charles de Gaulle wants more money spent on the military—more than is spent by any other Western European country. He'll have his way—and as a result will boost France's electronics market 11.4% to $1.6 billion in 1966.

De Gaulle's "force de frappe" provides a growing market. The military will pour $290 million into electronics, up 20% in a year.

Other segments of the electronics business also look for increases. Computer purchases are booming, and will reach $250 million, a 23% increase from 1965. The component industry will climb to $458.9 million. Sales totaled $426.0 million in 1965.

On the other hand the television market appears to be little more than marking time with sales of $285 million expected in 1966, a 5.5% increase which depresses the industry's total percentage of growth.

Complete capability

De Gaulle's efforts to build a complete defense capability in France has spurred French firms to develop new capabilities, and has protected them somewhat from foreign competition. However, because France is short of cash, the French military is still forced to buy many items on the world market on a low-bid basis.

Big military-oriented companies such as Compagnie Générale de Télégraphie Sans Fil (CSF), the largest electronics concern in France, have benefited from increases in electronics budgets. CSF, which does about two-thirds of its business in military electronics, builds both airborne and surface radar, and is working on phased-array radars. CSF produces air-defense radars operating on a wavelength of 10 centimeters, and long-range surveillance radars operating at 23 centimeters, with peak powers of two megawatts. CSF has the bombing-navigation radar for the Mirage 4, and supplies electronics for France's fledgling space program.

Electronique Marcel Dassault (EMD) supplies an analog type of computer for the Mirage 4 bombing-navigation system. EMD, which does most of its business with the military, also builds ground-checkout equipment for Mirage 4.

Compagnie IBM France, an affiliate of the International Business Machine Corp., is one of the exceptions to the "buy French" policy. The firm has a number of contracts including the computers and data processors for the new French air-defense system, Strida 2.

French firms are also putting their technology to work in civilian avionics. CSF, in work sponsored by the French government, is developing solid state airborne navigation and landing equipment, both for airlines and military use. CFS also is the prime contractor on a traffic-control simulator scheduled in 1966. Société Française d'Equipments pour la Navigation Aerienne makes aircraft gyro instruments and automatic pilots.

The French firms also manage to snare a share of the military business in other European countries. The Austrian air-defense system was reportedly built by CSF; Compagnie Française Thomson Houston (CFTH) served as technical adviser for the Western European Hawk missile program, and Laboratoire Central de Télécommunications (LCT) will build the European Space Research Organization's ESRO 1 polar ionosphere satellite. LCT is a subsidiary of the International Telephone and Telegraph Corp.

Thomson Houston, which has about 10% of its business in the military—mostly in ground and shipboard radar—is building high-power air-defense radar systems for Sweden.

Big in R&D

Although French firms complain about the lack of government dollars for research and development—and also say they are lucky to get $1 in R&D contracts for every $5 they invest on R&D—they are active in research, from communications to radar to lasers.

CSF has the most irons in the fire. It points to some $2 million to $4 million annually in research contracts from the United States Department of Defense.

CSF is working on a troposcatter system that it says will give the same or slightly better results as present quadruple-diversity systems but will cost about 30% less. Another effort is with a system to bounce communications signals off the ionosphere. Basically, the technique, which has been tested in a simulated ionosphere, would consist of mixing two transmitter beams in the ionosphere to produce a harmonic which would be stronger than either input beam. Tests in the ionosphere are scheduled for 1966.

CSF is also deeply involved in the development of lasers, solid state devices, the detection of clear-air turbulence by an infrared radiometer, and the use of holograms for data processing and automatic-reading machines.

Other companies working with lasers include Société Anonyme de Télécommunications, Compagnie Générale d'Electricité, and LCT.

LCT is also working on an experimental airborne computer using microcircuits, and will deliver to the French military in 1966 a scaled-down version of a pulse-code modulation system built with integrated circuits.

Another firm, Société d'applications Générales d'Electricité et de Mécaniques, which developed inertial guidance systems for the French ballistic missiles, reportedly is applying semiconductor microcircuits to its digital computer and inertial platform developments.

IBM France reportedly has studies under way for development of an airborne digital computer for use in the Concorde, the Anglo-French supersonic transport.

The emphasis on research has caused a boom in the market for laboratory instruments. Sales increased from $60 million to about $77 million in 1965 and are expected to rise another 26% to about $97 million in 1966. American companies have been getting about half of this business. Until recently there was a simple explanation for this: French companies, with their limited market, just couldn't afford to make the broad range of instruments offered by the American firms. However, as the market has grown so have the lines of French manufacturers until today they make just about all the equipment that their U. S. competitors do.

Some U. S. firms assemble instruments in Europe. For instance, the Hewlett-Packard Co., assembles many of the instruments it markets in France at its British and German factories but most of the components it uses come from the United States.

Gains in television

Television has been growing slowly, with an increase in sales of 5.5%, up to $285 million in 1966 from $270 million expected this year. About 40% of French homes now have tv sets. One reason for this relatively low percentage may be the strict governmental control of programing which has limited the entertainment value of television. The second set is almost nonexistent in French homes.

Radio sales are expected to drop from $52.6 million this year to $51.5 million in 1966.

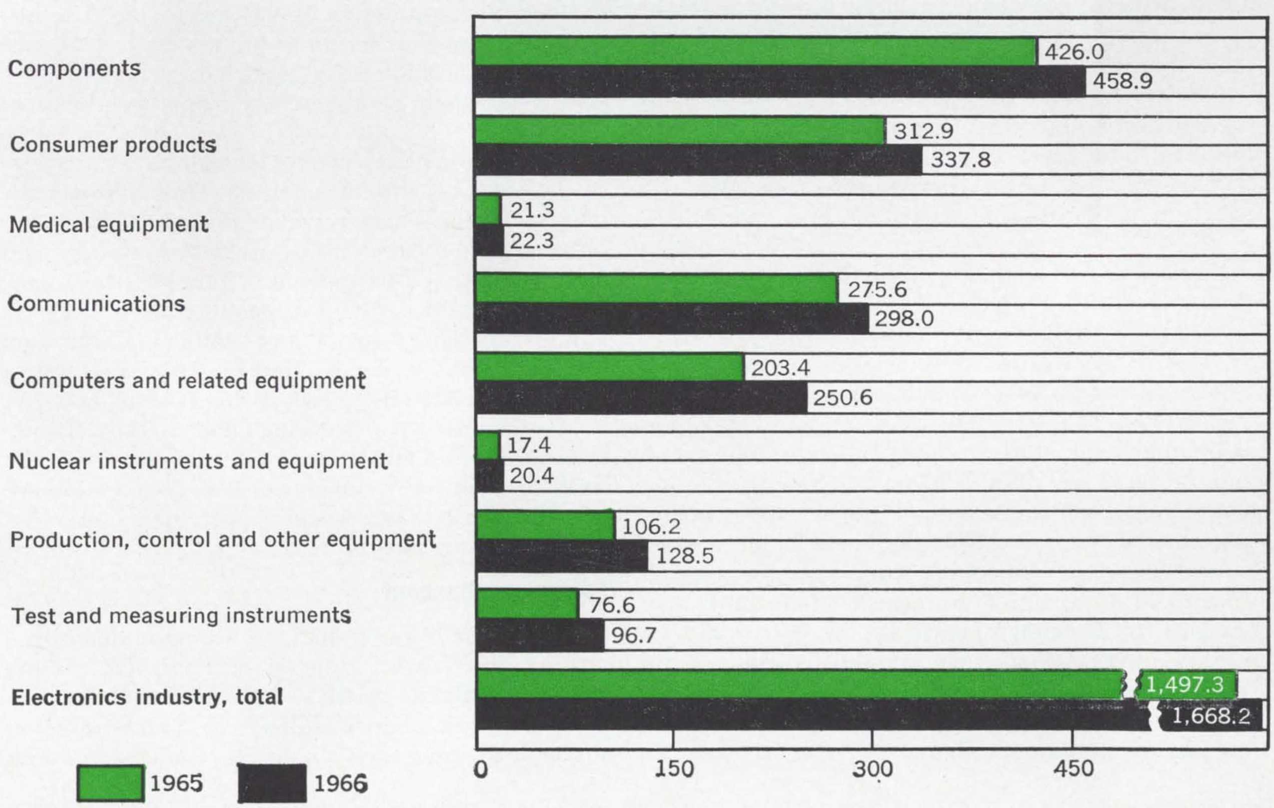
Like many other countries, France expects color television to boost tv sales, but not in 1966. France has an additional interest in color. The French color system, Secam, is being vigorously promoted throughout Europe. Compagnie Française de Télévision, a 50-50 affiliate of CSF and Saint-Gobain, the large French glass and chemicals firm, controls the process. The French government has strongly backed efforts in behalf of Secam.

Although on the surface not much has happened since last spring, when the Soviet Union announced its support of the French system, CFT has been busy behind the scenes lining up votes for Secam. It apparently has a long way to go before convincing the whole of Europe to adopt Secam, but CSF officials confidently declare that they have eliminated the American National Television Standards Committee (NTSC) system from the race. This leaves the West German PAL process, or some variation of PAL, in their view, as the main competition.

Alain Peyrefitte, the government's minister of information, says that regular color telecasts will start in September, 1967, a year earlier than planned. However, it will be several years after

French electronics markets

(millions of dollars)



that before color sales will become a factor.

CFT is now tooling up to produce a tube that might have a strong impact on the European, and eventually the world, color-tv market. It's a bright, easy-to-build color television tube that is expected to cost one-third less than present shadow mask tubes.

Rapid growth in computers

The growth rate of the French computer market is making the International Business Machines Corp. happy; IBM is generally understood to have installed three of every four machines in use in France. In 1966, sales are expected to shoot up about 23% to $250 million. This year sales were $230 million.

GE-Bull, an affiliate of the General Electric Co., is going after some 15% to 20% of the French market. Two French firms, CSF and Compagnie Général d'Electricité, have a joint entry in the computer field. The firm, Citec, is developing process-control computers and recently formed a consortium with two British firms which has applied to the French and British governments for financial backing to build a scientific computer.

Roger Aubert, CSF general manager for technical matters, predicts a growth of 300 to 500% a year in the process-control field during the next few years as French industry automates.

IBM and GE-Bull executives agree that process control has a big future in France, but plan to sell their general-purpose equipment to the market.

Although big growth is predicted, one problem is pointed out by Donald W. Pendery, IBM director of data processing for Europe. "The lack of trained people could become the really limiting factor in the growth of the computer market. Management is almost always behind the introduction of computers, but if they can't get people to run them this will be a pretty theoretical interest.

Pendery doesn't see anything else to prevent the European market from growing as did the U.S. market. "The growth rate, however, is probably that of the U.S. several years ago," he says.

IC production

France, like other European countries, has been slow in producing integrated circuits. Foreign firms with mass production were able to beat prices set by French companies despite the 15% duty the French apply on most semiconductor imports.

However, France's three largest semiconductor companies will start to mass-produce integrated logic circuits in 1966. They are CSF, La Radiotechnique, a subsidiary of Philips Gloeilampenfabrieken, N. V., of the Netherlands, and Societé Européene des Semiconducteurs (Sesco), a joint venture of Compagnie Française Thomson-Houston and the General Electric Co.

Texas Instruments Incorporated is the fourth largest semiconductor producer in France, and the Societá General Semiconduttori (SGS) of Italy has just opened a new plant.

Italy

Industry emerging from recession

Italy's electronics industry should emerge in 1966 from an economic recession that has dogged the entire country through 1965. Total domestic sales for the industry in 1966 are forecast at $760.2 million, about $80 million ahead of 1965.

Helping the electronics manufacturers shake off the recession will be a big boost in military sales: Italy has just signed a $170 million contract with the United States to buy 162 F-104's; the plane will be built in Italy.

The television market, though, is still in a slump. The gross national product is expected to climb about 4.5% in 1966 but manufacturers of tv sets point out that sales of consumer goods generally lag several months behind the over-all economic indicators.

One bright spot is the outlook for exports. Italian companies have recorded larger increases in export sales than in domestic sales.

Another hopeful sign is the increased research and development. Although Italy is far behind U.S. and Western European levels of research activity, a number of companies—often affiliates of U.S. companies—are building up their R&D efforts. An Italian company that might be a big winner in the R&D sweepstakes is Raytheon-Elsi, S.p.A., a subsidiary of the Raytheon Co. Elsi has signed a contract with Compagnie Française de Télévision to develop the production processes to build a picture tube for the Secam color tv system. If Elsi succeeds it could mean a bonanza because the company would be the world's only producer of the tube.

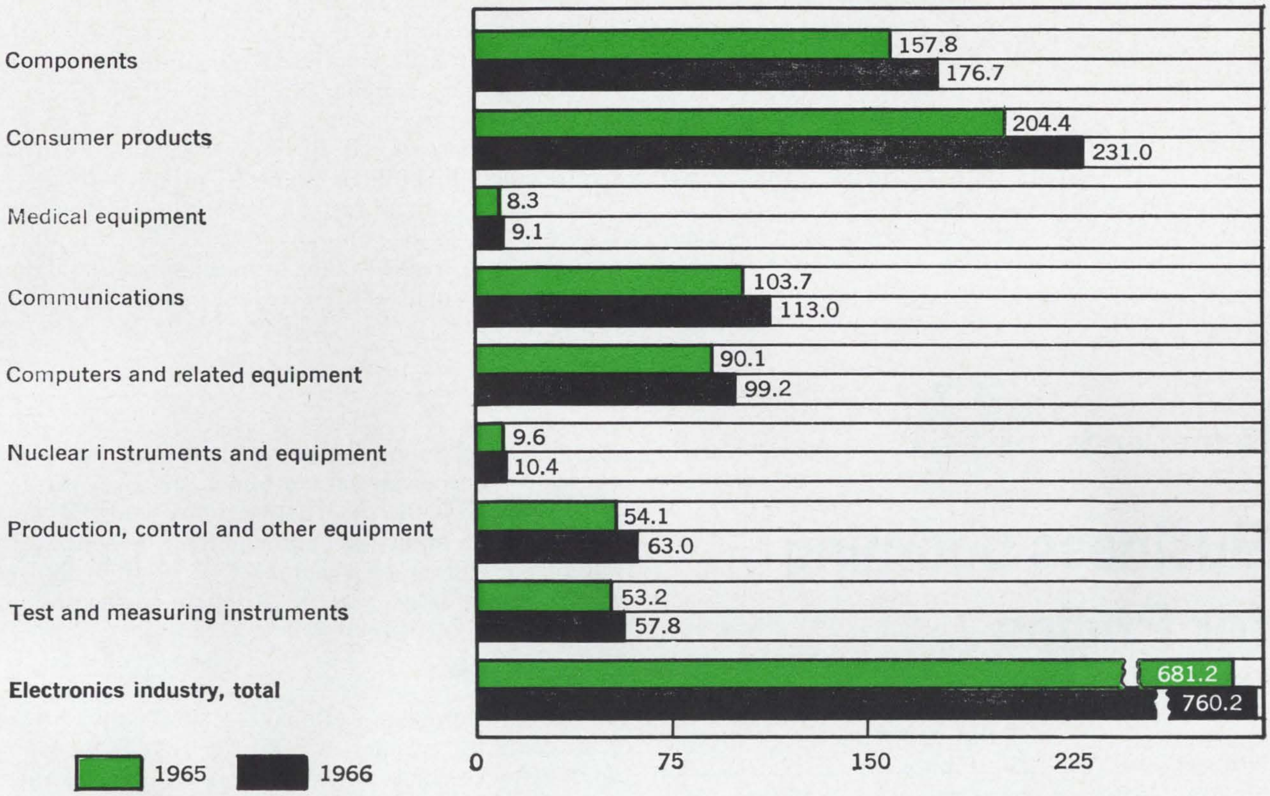
Because of Italy's technological backwardness, the industrial electronics market—stagnant over the past two years—won't make any spectacular improvement in 1966. Sales of advanced controls and instrumentation are expected to gain little headway. Numerical control (NC) for machine tools is a good example of what's happening. Although both Ing. C. Olivetti & Co., S.p.A., and Costruzioni Elettroniche Automatismi-Parego make NC equipment, only a handful have been installed in Italy. Guido Luccherini, Parego's commercial director, says his company sold only nine pieces of NC equipment over the past two years, and expects to sell no more than 10 in Italy next year.

Television shakeout

"Italy's television industry is seeing a shakeout," says Mario Malerba, director of Fabbrica Italiana Apparecchi Radio (FIAR)—GE's Italian television- and radio-producing subsidiary. He points out that although there are now about 58 producers turning

Italian electronics markets

(millions of dollars)



out 72 brands, eight hold 61% of the market.

During the first nine months of this year, 869,220 new television sets were registered with RAI, the government broadcasting monopoly; 774,500 were registered in the first nine months of 1964. Malerba believes the Italian industry is about where the U.S. industry was when its 1955-1958 shakeout came along. RAI is expected to start broadcasting in color in 1967. Sales of receivers, however, aren't expected to react for several years after that because tv set prices are expected to be high initially.

Telecommunications up

The telecommunications market totals about $32 million a year for electronics suppliers and is increasing at the rate of 7% to 10% a year. According to Virgilio Floriani, president of Telettra, the biggest purchaser of telecommunications equipment in Italy is the government's Societá Finanziaria Telefonica Per Azioni (STET) telephone group. But the Ministry of Post and Telegraph is another big customer. The military makes other, but smaller purchases. Next year should be a good one because the ministry is pushing a major expansion of its network.

Military business good

The industry is eagerly awaiting the signing of the F-104 Starfighter which is expected to pick up the slack left by the completion of the Hawk missile and the F-104 Starfighter programs this year. The new plane will be modified to handle the Sparrow air-to-air missile; this will involve adding a very precise fire-control system to the plane.

Work on a $20-million air-defense system for Italy will start in 1966. Italy is also expected to get a $15-million slice of the North Atlantic Treaty Organization's air-defense ground-environment system (Nadge).

Components growing

The component market will expand from $157.8 to $176.7 million in 1966. A good market for semiconductors is seen developing in television. Laurence Curry, manager of marketing services for Societá Generale Semiconduttori, a Fairchild Camera & Instrument Corp. affiliate, predicts that about 10% of the 1966 television sets will be transistorized.

Philips Gloeilampenfabrieken, N. V., the Dutch electronics giant, sees the most important increase in semiconductor sales in Italy coming from power semiconductors, for such equipment as motor controls, d-c converters and welding machines. A few companies have started building prototype models of power converters using transistor power diodes instead of tubes.

Integrated circuits are slowly coming into use. For example, Telettra, using integrated circuits in its pulse-code-modulation multiplex telephone equipment, is now conducting field tests and expects to have the equipment in commercial use next year. Olivetti is said to have constructed a small computer in its laboratory, using integrated circuits, to measure transistor characteristics.

Exports becoming important

Hurt by the drop in the Italian market, a number of electronics firms have been trying to improve sales through exports. FIAR, which has been exporting tv sets for two years under other labels, now exports about 20% of its tv production. Magnadyne, another television firm, also exports about 20% of its output, with Germany, Austria and France the principal customers.

FIAR, which also enjoyed large exports because it built equipment for the Hawk and Starfighter military programs, is now pushing hard to sell tv repeaters outside Italy. It has already been working with government networks in Rhodesia and South Africa, and is now talking with buyers in Australia, Spain, Portugal and South America.

Italy has become the main export base for several companies. Calosi of Raytheon says that 50% of the sales of Selenia, another Raytheon affiliate and a major military supplier, are outside Italy.

Computers are becoming a significant export item and International Business Machines Corp. has decided to build a plant to produce its 360 Model 20 computer. Also in 1966 Olivetti-General Electric, S.p.A.—a company owned 75% by GE and 25% by Olivetti—plans to build about 300 data processing systems around the 4115 computer, two-thirds of which will be sold outside Italy.

Netherlands

Business booming for Philips

As Philips Gloeilampenfabrieken, N. V., of Eindhoven goes, so goes the Netherlands electronics industry. And for 1966, Philips sees a rise in sales of about 12% over the estimated $2.1 billion worth of business the company did worldwide this year.

Even if Philips' forecasts for the coming year —an increase of $252 million—turn out to be somewhat optimistic (hardly likely because of Philips' down-to-earth Dutch way of doing business), 1966 should nevertheless see an upturn in the company's sales curve. After three sparkling years of 12% increases, the sales gain slowed in 1965.

The slower gain came as no surprise to Philips' top brass; they had seen it coming. For one thing, 1964 sales of television sets got a strong fillip from the Olympic Games, relayed from Tokyo to Europe by satellites. Also during 1964, Philips delivered some whopping orders for military gear and telecommunications equipment that boosted sales figures. After a year like that, slowdown in sales growth is practically inevitable, even for a high-flying outfit like Philips.

But prospects now point to a strong upswing for the coming year. Philips' major market is Western Europe, where the company rings up slightly more than three-fourths of its sales. And for Western Europe, 1966 should be a good year. The Commission of the European Economic Community (EEC), for example, predicts the gross national product for the six Common Market countries will climb nearly 5%, a faster pace of growth than EEC turned in this year. The seven European Free Trade Area (EFTA) countries, led by Great Britain, should do equally well.

With that rosy general economic outlook as the background, Dirk D. Otto, manager of Philips' commercial planning department, predicts sales of electronics and electrical consumer goods in Western Europe will increase between 6% and 9%. In his opinion, industrial and military electronics equipment will do even better—15% or 16% above 1965 sales. A large part of this gain, he expects, will come from computers.

Scramble in tv

Like all European set makers, Philips will be scrambling for tv sales in a market that is becoming tougher to crack. Long gone are the days of the late 1950's and early '60's when consumers snapped up just about everything set makers could turn out. With 55 million sets in use at the end of 1965, the Western European market is between 50% and 55% saturated; the degree varies from 20% saturation in Spain to 80 to 90% in Britain.

Even so, Philips marketing men see a 5% yearly growth through 1970, which will boost the number of sets in use to 70 million and the over-all saturation to 73%. At the same time, the ratio of initial sales to replacement sales will just about flip-flop completely. Now, the ratio is 70% initial sales, 30% replacement sales; over the next five years it will swing to 66% replacement and 34% initial sales. That means a market much more sensitive to consumer whim.

The whim, of course, could well be changed to serious buying when color tv comes to Europe. But that advent seems at least three years off because of the hassle over which color-tv system the government-run networks of Europe should adopt as their standard. There was a standoff at this year's CCIR meeting at Vienna. CCIR is the International Radio Consultants Committee of the International Telecommunications Union, which represents countries on both sides of the Iron Curtain. The general feeling in the electronics industry is that Europe will wind up with two incompatible color systems—Secam in France and the Eastern European countries, and the West German PAL—an offshoot of the American NTSC system—elsewhere. Great Britain's recent swing to PAL has just about killed the chance for NTSC. Even so, Philips is continuing the experimental broadcasts in NTSC color it started last year.

Watching color

Philips' reading on the introduction of color tv in Europe now looks like this: 1967 or 1968 for Great Britain, West Germany and Italy; 1968 or 1969 for France, the Netherlands, Spain, Sweden and Switzerland; 1969-1970 for Austria, Belgium, Denmark and Finland. Until then, Philips—like other European set makers—can count only on a slowly growing black-and-white market while wistfully watching the color boom in the United States. There's some small comfort, though, in a second-set market starting to shape up now. To tap that market, Philips introduced late this year a fully transistorized set with a 14-inch screen and a vacuum-tube set with an 11-inch screen.

For the other major segment of the consumer electronics market—radios—sales for 1966 are expected to rise by 5% over this year's figure of 17.5 million sets, 13 million of them portables. To stem the Japanese invasion of the market, Philips will go to market with sets produced on automated lines, priced in the \$17 to \$26 range. With these, Philips says it can "fully compete with Japanese competition."

For the consumer goods that account for two-thirds of its total sales, Philips sees the wholesale introduction of microcircuits as "several years off." Still, 1966 will see the company's first move into the consumer market with microcircuits. The product: a hearing aid with a linear circuit.

Expanding in computers

Although Philips expects that computers will be a prime factor in the gain of 15% or 16% in sight for industrial and military equipment in 1966, its computer division won't be in the market in the usual sense of the term. True, the division now has under way design of a whole family of process-control computers based on integrated circuits, and Philips is well along in an effort to "computerize" a radio-set producing plant. But for the moment, the company sees itself as its own best customer for its recently formed computer division, which along with the basic computer hardware, turns out tape punch and memory units.

In the business computer field, Philips is getting its feet wet through a 40% holding in Electrologica, a small company based in The Hague. Despite its size, Electrologica has cornered a small part of the market in the face of competition from giants like the International Business Machines Corp. and Bull-General Electric, which is jointly owned by the Compagnie des Machines Bull of France and the General Electric Co. of the United States.

Military sales

The vagaries of the military market don't have too much impact on Philips since military sales add up to only about 5% of total sales. N.V. Hollandse Signaalapparaten, the subsidiary that ranks as the sole important Dutch producer of fire-control equipment, won't see its sales boom in 1966 but there's no slump in sight: the company has a substantial backlog of orders from NATO countries, South American countries, Sweden and Switzerland. Signaalapparaten will also deliver next year the phase 2 equipment for the air-traffic control system at the Amsterdam Airport plus a "free route" control system that will oversee traffic for the West German Air Force in the northern part of the country.

Belgium

Industry expecting drop next year

Champagne corks will not be popping when Belgian electronics companies greet the new year—business is expected to drop for them next year although the domestic market, in which imports are a big factor, will be up about 7% to \$371.6 million from \$346.4 million for Belgium and Luxemburg.

The main reason for the decline: military contracts—some \$80 million worth for the North Atlantic Treaty Organization's Starfighter and Hawk missile programs which had buoyed the industry over the past four years—have dwindled to practically nothing. But there is one major military contract that could help the industry, which is dominated by a trio of companies—Manufacture Belge de Lampes et de Materiél Electroniques (MBLE), Atéliers de Construction Electriques de Charleroi (ACEC) and Bell Telephone Manufacturing Co. (BTM).

Sales of television sets—expected to reach nearly \$24.6 million this year—should stay about the same at \$24.7 million in 1966, according to Jaques LaGrange, head of MBLE, the country's leading components manufacturer.

Military electronics

The contract Belgian electronics producers count on most is their \$11.8-million share of the \$280 million Nadge (NATO's air-defense ground-environment) project, scheduled for award this March. Nadge is NATO's plan for an integrated air-defense network stretching from Norway to Turkey.

The industry also expects a communications gear contract when Belgium buys 300 tanks from either France or West Germany probably early next year. Belgium will stipulate that its own firms get tank-equipment contracts amounting to just about the cost of the tanks.

MBLE also will have prototypes of a transceiver for paratroopers ready next year and hopes to produce them by 1967. BTM is now field testing pulse-code-modulation equipment for the Belgian Army. The circuit boards have both microcircuits and discrete components, but the circuitry was designed for an eventual switchover to microcircuits.

Space technology

All three companies are just starting in space projects through the European Launcher Development Organiaztion (ELDO) and the European Space Research Organization (ESRO). Belgian engineers will install the ELDO downrange guidance system in northern Australia next year. The system is currently being tested at Grimbergen Airfield near Brussels. MBLE was prime contractor for the system, but both ACEC and BTM supplied much of the equipment.

Industrial outlook

The lone bright spot in the outlook for next year is in industrial equipment, likely to pick up by about 15%. One possible shot in the arm for next year or 1967 is the instrumentation for three nuclear power stations Belgian public utilities have tentative plans to build.

Sweden 

Market booming for automatic equipment

The Swedish electronics industry expects a 14% boost in domestic business next year to $343 million, primarily because of a demand for automatic-control equipment by manufacturing companies—a demand prompted by a labor shortage and salaries that are the highest in Europe. The computer market is expected to expand to $40.6 million in 1966 from $35.4 million this year. The $40.6 million includes $4.8 million worth of process control systems.

"Everyone is using electronics—in power, instrumentation and process control," says Stephen Finta, managing director of Nordiska Elektronik AB, which represents a number of American electronics components manufacturers in Scandanavia.

The industrial business boost is expected to be large enough to offset a sharp decline in military electronics, deepened by a two-year delay in production of the Swedish Air Force's type-37 Viggen (Swedish for thunderbolt) aircraft. The new all-purpose defensive aircraft is now scheduled for service in 1971.

Some other healthy business signs:

- The consumer market, with television sales predicted at $30 million, is up $1.4 million over 1965. Most sales will be for replacement sets and will be made by three firms—Svenska AB Philips, Luxor Industri AB and AGA AB. Next year, the government is expected to announce the start of a second Swedish tv channel in 1968 and color telecasting in 1969.
- In communications, the major achievement will be the installation of an electronic telephone switching system by the L.M. Ericsson Telephone Co. The system, using space division, will serve 5,000 subscribers. Space division employs a separate wire path for each conversation. In time division, logic gates sample several conversations in rapid sequence, then switches connect pairs of telephones in sequence.
- The opening in Sweden, a country that imports most of its components, of a semiconductor manufacturing plant by Societá Generale Semiconduttori, of Italy in 1966.

Industrial growth

Saab Electronics, the civilian electronics sales division of the Swedish aircraft, automobile and electronics manufacturer, is typical of a number of Swedish companies moving fast to take advantage of industrial electronics growth. Jan Bakstrom, sales manager of Saab Electronics, says his firm's "main line is to develop and market products for automation for both Swedish and foreign industry."

In the process-control field, Saab has developed a system for automatic control of dyeing machines in the textile industry. Saab is also selling a new line of equipment, which can be controlled remotely by computers. Arenco Electronics AB, sees 1966 as the year of the big breakthrough for numerical control (NC) with between 50 and 100 systems being sold.

The industrial market is also being eyed by other firms, such as L.M. Ericsson. Although concentrating on communications, the company is watching the industrial control field, says Christian Jacobaeus, chief technical officer.

Military need slowing down

In addition to the delay in producing the type-37 Viggen aircraft, there's been a general slowdown in the military market, according to Frank Hammar. Hammar is the managing director of Standard Radio & Telefon AB, which is the Swedish subsidiary of International Telephone and Telegraph Corp. "The order books are filled because of previously heavy orders, but new military orders are down about one-third from what they have been," he says. "We look at the future with some concern." He expects Standard Radio's business to be up in 1966 though, partly because of its export sales in air-traffic control equipment. The company recently delivered a traffic control system to Arlanda International Airport outside Stockholm.

Spokesmen see no strong improvement next year in the price war in components, which has affected the Swedish agents and the American, British, French and German manufacturing companies which supply the market.

Switzerland

Market growing

Although the Swiss are renowned for their precision work in watchmaking, machine tools and instruments, their country is regarded as "a bit backward" in electronics. A leading electronics researcher says Switzerland is interested in applications rather than new directions.

Electronics sales totaled $231.4 million this year and are expected to climb to $250.7 million in 1966.

Military electronics is concentrated narrowly. Contraves AG, in Zurich, develops special equipment for the Swiss Army and sells military systems to other countries. One product, a mobile radar fire-control system called the super-fledermaus, is sold to members of the North Atlantic Treaty Organization. Contraves is also participating in a satellite prospect of the European Space Research Organization satellite.

Communications is a growing area. Albiswerk AG of Zurich is installing a semielectronic telephone switching system. It's a time-multiplex system with an electronic logic unit. This year, the government's telephone and telegraph agency has spent about $100 million for telecommunications equipment; next year's expenditure is expected to reach $120 million.

Philips AG produces about 60% of the television sets sold in Switzerland. About 59,000 sets were sold this year, and the same number is expected to be sold in 1966. The population of Switzerland is 5.8 million.

Generally, consumer electronics is not attractive to Swiss industry because of high tariffs in exporting to Common Market countries. However, Switzerland is a prime market for such imports as instruments and computers, thanks to a labor shortage. Until recently the economy depended largely on foreign labor; one out of every three wage and salary earners was a foreigner. However, the Swiss government has ordered a reduction in immigration of 5% this year and a similar percentage in 1966. For Swiss manufacturing and service industries, this has resulted in automation. Scientific and industrial instruments and equipment are reported to be expanding at a rate of 10% to 20% a year.

Switzerland is building one nuclear electrical plant with a capacity of 250 to 300 megawatts of energy, with another plant being planned. Also being considered are electronic steering of reactors and a wide range of electronic equipment.

Although Switzerland is light on electronics research, two American companies operate research centers in Switzerland: the International Business Machines Corp. at Ruschlikon and Radio Corp. of America in Zurich. RCA has an ambitious materials program that includes fundamental work in ferroelectrics and dielectrics.

Austria

Fast rise in imports

Imports are becoming increasingly important in Austria's electronics industry. The country of seven million people is growing in prosperity and becoming a more inviting market as protectionist measures fade as a result of Austria's participation in the European Free Trade Association together with Denmark, Norway, Portugal, Sweden, Switzerland and Great Britain.

The consumer market is growing slowly. Sales of radio sets next year are expected to remain at the 1965 level, but the cost per set is expected to increase, increasing the dollar total to $15.3 million from $14 million in 1965.

The television market is expected to grow slightly in 1966 from the $12.6-million level of this year. Imports have been making big gains, to about $7.2 million this year 1965 from $1.7 million in 1964. Most imports come from West Germany, Sweden and Denmark.

The Postal and Telegraph Administration has expansion plans, but has been hampered by a shortage of funds. It recently bought $2 million worth of coaxial application equipment from Standard Telephones & Cables, Ltd., a British affiliate of the International Telephone and Telegraph Corp.

Another trend in Austria is importing of computers to be leased to Communist countries in Eastern Europe. One Viennese dealer has computers on lease in several Soviet-bloc countries.

Denmark

Seeking buyers abroad

Danish electronic companies, most of which have fewer than 500 employees, are facing a severe labor shortage, tight credit and high taxation.

Last spring, to control inflation the government restricted credit and, as a result, reduced consumer spending. Many producers of television, radio and hi-fi equipment are burdened with heavy inventories. Some are turning to exports; some say as much as 95% of their output is sold outside the country. Credit restrictions are expected to continue 18 months more.

Almost all companies report an increase in business with the Communist countries of Eastern Europe, including the Soviet Union. Some companies say their Soviet-bloc sales have climbed 20% to 25%. Czechoslovakia is the biggest market, followed by Hungary and Rumania.

Russia

No threat seen to West in sale of electronics

The Soviet consumer electronics industry is far from primitive; however, for the foreseeable future the Soviets will offer no competition to Western producers. In fact, Russians will remain hungry, even starved, for Western imports.

This is the image emerging through the static of military secrecy and statistical reports in which electronics is not treated as an industry at all.

Recently, a Soviet official, asked if there was any computer larger or faster than the Minsk-22, then on display at an international showing, replied: "Yes, but they're beyond the Urals." That's Russian slang for "military secret."

And in the USSR's annual book of vital statistics, running to more than 700 pages, nowhere is there to be found a figure relating to electronics in any useful way. Electronics production figures are wrapped up heavily in the military budget, which in turn is hidden behind headings such as "machine building" or "gross chemical output." (In fact, the old Ministry of Medium Machine Building was a code cover for the Soviet nuclear weapons production authority.)

Space program opened the door

It was the Soviet space program that released some facts on the country's electronics industry. Manned sputniks, moon shots, and deep-space probes told much that was new.

It's been demonstrated that the Soviets no longer are counting on the cushion that large booster rockets gave them in the early days of space exploration. The move is clearly toward denser electronic packages, though not necessarily toward American-style microminiaturization. The Soviets, apparently, will always favor the big power pack.

This year the Russians brought back 1,100-line pictures of the far side of the moon from a distance of several hundred thousand miles. Earlier they orbited a communications satellite with 40 watts of power, or ten times that of Early Bird. They claim they'll be able, shortly, to broadcast directly from an orbiting satellite into community television antennas.

And they've announced their soft-landing Luna package which contains radar plus a computer complex to measure distance to target, compute optimum time for retro-fire, and give the firing order.

Increasing complexity of the Soviet space effort indicates substantial solid state computing power on the ground, though it is apparent that none of this hardware has become available to the civilian industry.

The Russians continue to claim superiority in computers, but they make no secret of their desire to buy Western models. Recently a group of visiting American businessmen were asked to evaluate the possibility of holding an American computer and industrial electronics exhibition in Moscow. British companies, led by Elliott-Automation, have been selling industrial-process computers and instrumentation to the Soviets for several years, and the general belief is that relaxation of controls by the West would lead to a flood of such sales.

Meanwhile, the Russians are showing signs of putting heftier budget sums into civilian electronics research. Last summer Moscow sponsored a month-long exhibit of Soviet and East European information equipment at which it was learned that progress has been substantial. The Soviets are now working hard to develop a common computer language and common components standards for Eastern Europe, and within a few years they may achieve success.

In their civilian applications the Russians have now reached the point of full transistorization with modular sections, but they have yet to apply molecular or integrated circuitry. They appear to be about one generation short of Western achievements. They've developed random-access retrieval systems along the lines of American devices of 1959 and 1960.

Consumer electronics

On the purely consumer electronics front, progress has been much swifter, relatively. Within the past 12 months the Soviets have put transistor radios, modern-styled television sets, and portable phonographs on the market. Now they've agreed to use the French Secam color-television system, with "commercial" broadcasts scheduled in 1967.

Radio and phonograph production actually declined between 1963 and 1964, from 4,800,000 to 4,750,000. Television-set production inched up from 2,470,000 to 2,920,000.

The production for 1965 increased slightly. For the first three quarters, tv set production was up 22% and radio and phonograph production up 7% according to official statistics.

The Russians don't import any consumer electronics, and have no plans to do so.

Exports decline

Electronics export figures show that the Russians are caught up in worldwide price trends. Exports of 72,400 radios in 1963 were valued at just over $3 million, or $40 each. But last year 111,300 radios exported cost an average of only $20 each, for a net decline in foreign exchange of about $800,000 —on nearly 60% volume increase.

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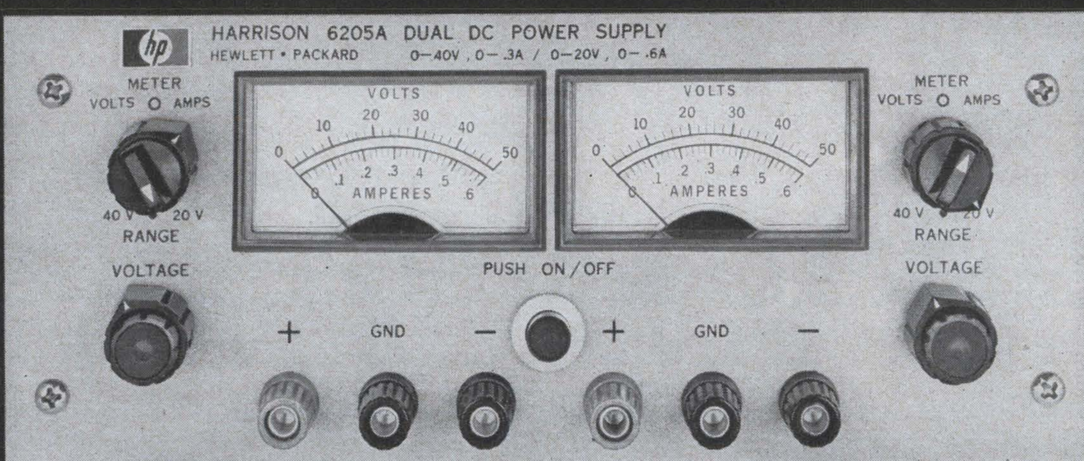

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Probing the News

Consumer electronics

Anxiety amid affluence: why color-tv makers worry

With demand for their product outstripping plant capacity by 30%, 13 major companies are rushing into transistorization. Some are doing it reluctantly, under the pressure of competition

By Louis S. Gomolak

Chicago News Bureau

Makers of color-television sets are worried. Although demand is 30% ahead of their ability to produce receivers, they fear technological obsolescence.

With transistors working their way into color tv, and integrated circuits beginning to appear in design rooms, can the producer afford to stand pat with his present designs?

Last June, when the Philco Corp. announced plans to build hybrid 19-inch sets late this year—with 32 semiconductors and 16 vacuum tubes—its competitors' initial reaction was: "Who needs another technical advance? Changing to a rectangular picture tube from a round one is enough for one season." But every major producer put its engineers to work designing solid state circuits for color tv.

And last month, when it was disclosed that the Admiral Corp.—which ranks third in color-tv sales—plans to use an integrated circuit to demodulate the color signal in a 15-inch portable, the activity intensified in design rooms and in executive suites. Even companies that oppose the shift now, on technical grounds, are among the 13 big concerns that plan to introduce semiconductors in early models. Many agree with Admiral, which considers transistorization necessary, beyond technical reasons, to maintain what one official describes as "the company's image as a progressive force in the consumer market."

I. Reluctant innovator

At the Zenith Radio Corp., J. E. Brown, vice president for engineering and research, warns: "Degraded performance, starting with the tuner, is all you'll get" in changing to transistors. "There isn't a radio-frequency transistor on the market as free of cross-modulation phenomena as the vacuum tube you want to get rid of," he declares. Brown concedes that one solution may be the field effect transistor, a high-impedance device whose characteristics resemble those of a vacuum tube. But these are not being produced in great enough volume, he adds.

Yet Zenith is planning to offer hybrid receivers next year. So is Setchell-Carlson, Inc., despite the fact that its chief engineer, Fred G. Melius, agrees with Brown's technical objections.

One of the transistor's strongest advocates is Raymond L. Osborn, director of tuner engineering at the Oak Electro-netics Corp., the biggest supplier of tv tuners. "We've produced over 100,000 transistorized color-tv tuners since the second quarter of this year," he

Admiral Corp.'s Leonard Dietch, believes transistors should be used wherever they are economically possible. Admiral plans to transistorize everything but the high-voltage deflection circuits. It will also use an integrated circuit.

says, adding, "the noise and gain figures are competitive with tube tuners."

Oak's vice president for marketing, Paul W. Wheaton, adds that the transistorized tuners are also competitive in price with tube tuners.

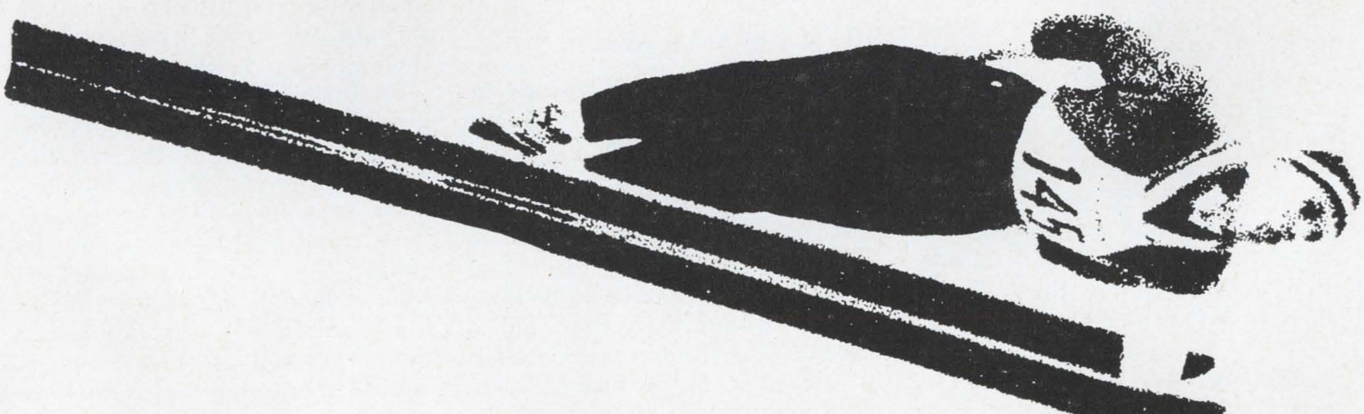
Little by little. Some companies plan to ease into hybrid design by transistorizing the least demanding spots first—the low-level processing and control circuits. Theodore S. Zelazo, assistant chief engineer at Muntz Tv, Inc., thinks the best place to start transistorization is in the sound and synchronization circuits. C. J. Dumas, a research manager at the Hoffman Products Corp., thinks reliability would be doubled if all low-level circuits were transistorized. Both companies are designing 19-inch hybrids.

But Admiral's manager of color tv engineering, Leonard Dietch, believes transistors should be used now wherever they are economically possible. Admiral plans to transistorize everything but the high-voltage deflection circuits. The use of transistors to this extent, Dietch says, "doubles set reliability, shrinks package size and cuts power consumption." The company's 19-inch hybrid will consume 160 watts, he says, compared with 265 watts for Admiral's comparable all-tube set.

All the way. Sylvania Electric Products, Inc. opposes hybridization; the subsidiary of the General Telephone and Electronics Corp. expects to have a fully transistorized receiver ready by 1967. W. D. Shuster, engineering manager in the entertainment products division, says, "It makes more economic and performance sense than just going half way."

The Wells-Gardner Electronics Corp. and Warwick Electronics Corp. have both confirmed plans to build hybrid sets, but will not disclose the extent to which they will use transistors. Warwick sells its receivers under the Sears Roebuck Corp.'s Silvertone label and Wells-Gardner supplies tv's for the W. T. Grant Co., the J. C. Penney Co. and the Western Auto Supply Co.

Four manufacturers, all reported to be designing hybrid sets, will not talk about it. The General Elec-



tric Co. is said to be working on both hybrid and completely solid state versions of its 11-inch Porta Color set. The Radio Corp. of America, the leading producer of color-tv sets, is reported to be designing 15- and 19-inch hybrids; Motorola, Inc., a 19- and possibly a 21-inch set; and the Magnavox Co., a 21-inch set.

II. Deflection circuits?

All the companies interviewed, except GE, agree that transistorization of the high-voltage deflection circuits is impractical now for technical and economic reasons.

"There is no single economical device that can handle 25,000 volts," says Warren C. Letsinger, customer assistance manager at the General Motors Corp.'s Delco Radio division. "One transistor, the experimental 2N2580 could, but one of them costs $100." Two Delco DTS 423's in series, which cost about $8 each at the distributor, could also do the job. But these transistors would be operating so close to their maximum ratings that their switching times would have to be perfectly matched.

Delco, along with Texas Instruments Incorporated and Motorola, is working on a single device to solve the deflection problem. Delco's unit, similar to its DTS 423, but with a higher rating, is believed to be the farthest advanced.

Despite its reluctance to discuss its plans, GE seems to have solved the deflection-circuit problem. Peter Humeniuk, engineering manager at the company's tv-receiver department, says, "Devices are available to transistorize the entire set, from tuner to deflection stages. The somewhat higher cost is to be expected."

Economics. How much will the consumer be willing to pay for the more expensive solid state components?

Zelazo, at Muntz, says, "The magic pulling power of the word transistor is worth a price differential of $30 or more in the market." John H. Schumacher, head of Warwick's design engineering, says, "Between $15 and $25 retail." Dietch, of Admiral, Humeniuk of GE, Pierce of Wells-Gardner and Melius of Setchell-Carlson, generally agree that hybrid sets should only cost 5% to 10% more than present tube sets do.

Dietch adds that increased component cost for hybrid sets could be somewhat offset by the labor-saving techniques by which the sets could be fabricated.

Brown, of Zenith, believes that improved styling, resulting from smaller components, will support higher prices. Brown believes hybrids will cost $50 or $60 extra, but he says the public will pay it. Second generation sets, he adds, will cost less because of lessons learned while producing the first generation.

Philco is recommending a retail price of approximately $450 for its 19-inch hybrid tv. The Philco 21-inch all-tube set now sells for about $370.

III. IC's in 3 to 5 years

Although Admiral is already introducing an integrated circuit into its sets, most producers don't expect widespread use of IC's for three to five years. Dumas, of Hoffman, sees "very good possibilities for an IC set by 1968." Brown, of Zenith, says, "A minimum of three years, but more likely five." Philco sees 1972 as the big year for IC's in color tv. "We estimate six to eight (integrated) circuits will be used per set," a spokesman says. "By 1972, from 20 million to 25 million circuits will be needed to meet production needs." He declines to predict the dollar volume of the requirement because "the same wild pricing that affected transistors has already engulfed integrated circuits."

Admiral is keeping IC's out of the video strip at present, Dietch says, "because transistors do the job there and cost less." The company is using an IC in the color demodulator in its 15-inch hybrid "because the frequency-range requirements are low, and one IC replaces many tubes or transistors in one shot," he explains. The IC replaces all the components previously used in the color demodulator, also two other transistors and their associated circuitry.

Hoffman Electronics may be the next to use IC's. The company believes, according to Dumas, that "any low-level circuit handling from 20 to 50 volts can be replaced by IC's now." Dumas says this includes the video i-f amplifiers, color demodulator, sound circuits, f-m amplifier, synchronization processing and amplifying stages, vertical integrator and automatic-gain-control (agc) stages.

Military electronics

Discriminating Press

Study seeks to analyze the fiery signature of warhead during reentry

By Thomas H. Maguire
Boston Regional Editor

On the Kwajalein atoll in the Marshall Islands, 2,000 miles from Hawaii, sites were being prepared this week for new radar and optical systems to increase the capabilities of Project Press (Pacific range electromagnetic signature studies)—the six-year old program to find out how defense radars and other sensors can pick out a genuine warhead in a blizzard of decoys and penetration aids.

Since 1959, the Advanced Research Projects Agency of the Department of Defense has spent $160 million on Project Press. Press is part of Project Defender, ARPA's over-all program to explore defense against missiles and satellites and for development of penetration aids for United States missiles.

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Model	VDC	I MAX. AMPS[1] 40°C	50°C	60°C	71°C	Price
LM 201	0- 7	0.85	0.75	0.70	0.55	$ 79
LM 202	0- 7	1.7	1.5	1.4	1.1	99
LM 203	0-14	0.45	0.40	0.38	0.28	79
LM 204	0-14	0.90	0.80	0.75	0.55	99
LM 205	0-32	0.25	0.23	0.20	0.15	79
LM 206	0-32	0.50	0.45	0.40	0.30	99
LM 207	0-60	0.13	0.12	0.11	0.08	89
LM 208	0-60	0.25	0.23	0.21	0.16	109

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LRA 3—5¼" Hgt. by 3" Depth Price—$35.00

LRA 4—3½" Hgt. by 14⅛" Depth [for use with chassis slides] Price—$55.00

LRA 5—3½" Hgt. by 3" Depth Price—$35.00

Package B
3³⁄₁₆" x 4¹⁵⁄₁₆" x 6½"

Model	VDC	I MAX. AMPS[1] 40°C	50°C	60°C	71°C	Price
LM 217	8.5-14	2.1	1.9	1.7	1.3	$119
LM 218	13-23	1.5	1.3	1.2	1.0	119
LM 219	22-32	1.2	1.1	1.0	0.80	119
LM 220	30-60	0.70	0.65	0.60	0.45	129
LM B2	2 ±5%	3.4	3.0	2.3	1.4	119
LM B3	3 ±5%	3.4	3.0	2.3	1.4	119
LM B4	4 ±5%	3.4	3.0	2.3	1.4	119
LM B4P5	4.5±5%	3.3	2.9	2.2	1.4	119
LM B5	5.0±5%	3.3	2.9	2.2	1.4	119
LM B6	6.0±5%	3.2	2.8	2.2	1.3	119
LM B8	8.0±5%	3.0	2.7	2.2	1.3	119
LM B9	9.0±5%	2.7	2.5	2.1	1.3	119
LM B10	10.0±5%	2.6	2.4	2.1	1.3	119
LM B12	12.0±5%	2.4	2.3	2.1	1.3	119
LM B15	15.0±5%	2.1	1.9	1.7	1.2	119
LM B18	18.0±5%	1.8	1.6	1.5	1.2	119

All models in grey are new.

[1] Current rating is from zero to I max.
Current rating applies over entire output voltage range.
Current rating applies for input voltage 105-132 VAC 55-65 cps. For operation at 45-55 cps and 360-440 cps derate current rating 10%.

Package C
3³⁄₁₆" x 4¹⁵⁄₁₆" x 9⅜"

Model	VDC	I MAX. AMPS[1] 40°C	50°C	60°C	71°C	Price
LM 225	0- 7	4.0	3.6	3.0	2.4	$139
LM 226	8.5-14	3.3	3.0	2.5	2.0	139
LM 227	13-23	2.3	2.1	1.7	1.4	139
LM 228	22-32	2.0	1.8	1.5	1.2	139
LM 229	30-60	1.1	1.0	0.80	0.60	149
LM C2	2 ±5%	4.9	4.2	3.5	2.4	139
LM C3	3 ±5%	4.9	4.2	3.5	2.4	139
LM C4	4 ±5%	4.9	4.2	3.5	2.4	139
LM C4P5	4.5±5%	4.9	4.2	3.4	2.4	139
LM C5	5 ±5%	4.8	4.1	3.3	2.4	139
LM C6	6 ±5%	4.6	4.0	3.1	2.4	139
LM C8	8 ±5%	4.4	3.8	3.0	2.0	139
LM C9	9 ±5%	4.2	3.6	3.0	2.0	139
LM C10	10 ±5%	4.0	3.5	2.9	2.0	139
LM C12	12 ±5%	3.8	3.3	2.8	2.0	139
LM C15	15 ±5%	3.4	3.2	2.7	1.8	139
LM C18	18 ±5%	3.0	2.8	2.5	1.7	139
LM C20	20 ±5%	2.9	2.7	2.4	1.7	139
LM C24	24 ±5%	2.5	2.4	2.2	1.5	139
LM C28	28 ±5%	2.3	2.1	2.0	1.4	139

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tion and velocity of its target and conversion of the world's largest-aperture spectrometric telescope. The new optical instrument is designed to track a missile and measure its radiation during reentry.

I. Design is aided

Performance details of Press are classified, but DOD officials say the program has greatly increased our knowledge of reentry phenomena and has aided missile-systems design, for both attack and defense. Unarmed missiles are being used.

Lincoln Laboratory of the Massachusetts Institute of Technology is scientific director of Press. C. Robert Wieser, assistant director of the Laboratory, heads a 120-man Lincoln force working at Kwajalein and at the Lexington, Mass. laboratory, where all of the data is flown after each mission for analysis and interpretation.

The scientists working on the program describe Press as a study of physical effects—recorded at optical, infrared and radio frequencies—which occur during the flight of a ballistic missile, especially during reentry. Press is the full-scale field measurements part of the program, building on results of laboratory and model measurements of reentry.

Says a member of the Press team: "We would like to be able to base the identification of an incoming missile on immutable physical laws—not on things which an enemy can change like size, shape or speed of the object. We are looking for something in the physics of the atmosphere that tells us something specific about an object hurtling through it."

Press explores the potentials of atmospheric filtering as a means of identifying a warhead. What kind of special signature does a ballistic missile write during reentry? What does a warhead do to the atmosphere, and vice versa, that will enable defense radars to sort it out from dummies, and decoys?

"These are controlled measurement experiments, not war games," says Wieser. "Of course," he adds, "you cannot tell sheep from goats unless you have both there." So the firings down the Pacific range include both missiles and decoys.

Nike-X link. Although Press is a reentry measurements program and not directly involved in development, a close relationship is maintained with the Kwajalein test site of the Nike-X antiballistic missile program. Pointing data from the Press computer is fed to the Nike-X site, where tests are under way for an operational ABM system. Information is interchanged with Western Electric Co., developer of Nike-X.

Whenever a ballistic missile is fired from Vandenburg Air Force Base down the 4,500-mile Western Test Range to the Kwajalein impact area, Press's computer-directed network of ground-based and airborne optical sensors is trained on the warhead as it reenters the atmosphere.

II. Second generation radar

The new radar, called Altair for ARPA long-range tracking and instrumentation radar, will be installed on Roi-Namur Island at the northern tip of the atoll. It will be used by some 50 American scientists, who commute daily by air from their living quarters on Kawajalein Island.

Altair will provide improved resolution and sensitivity, also a greater versatility of frequencies and waveforms than the Tradex radar now being used. Tradex, for target resolution and discrimination experiments, is a modified version of the AN/FPS-49 designed for the ballistic missile early warning system. It was the first trifrequency radar.

Like Tradex, Altair will locate the reentry vehicle for the other sensors. It will then provide data on the object for subsequent analysis. Many characteristics of an object in space—size, shape, orientation, materials of construction—can be determined through radar signal returns measured in terms of amplitude, polarization, phase relationship, and doppler shifts. The measurements are modified by the atmosphere, by ionization layers, the earth's magnetic fields and other factors. For the purposes of Press, the radar gathers as much raw data as possible about the object and its immediate environment.

When the Altair installation is completed, it will take over the uhf and vhf capabilities now performed by Tradex. If Tradex is kept at all, it will perform only as an L-band radar.

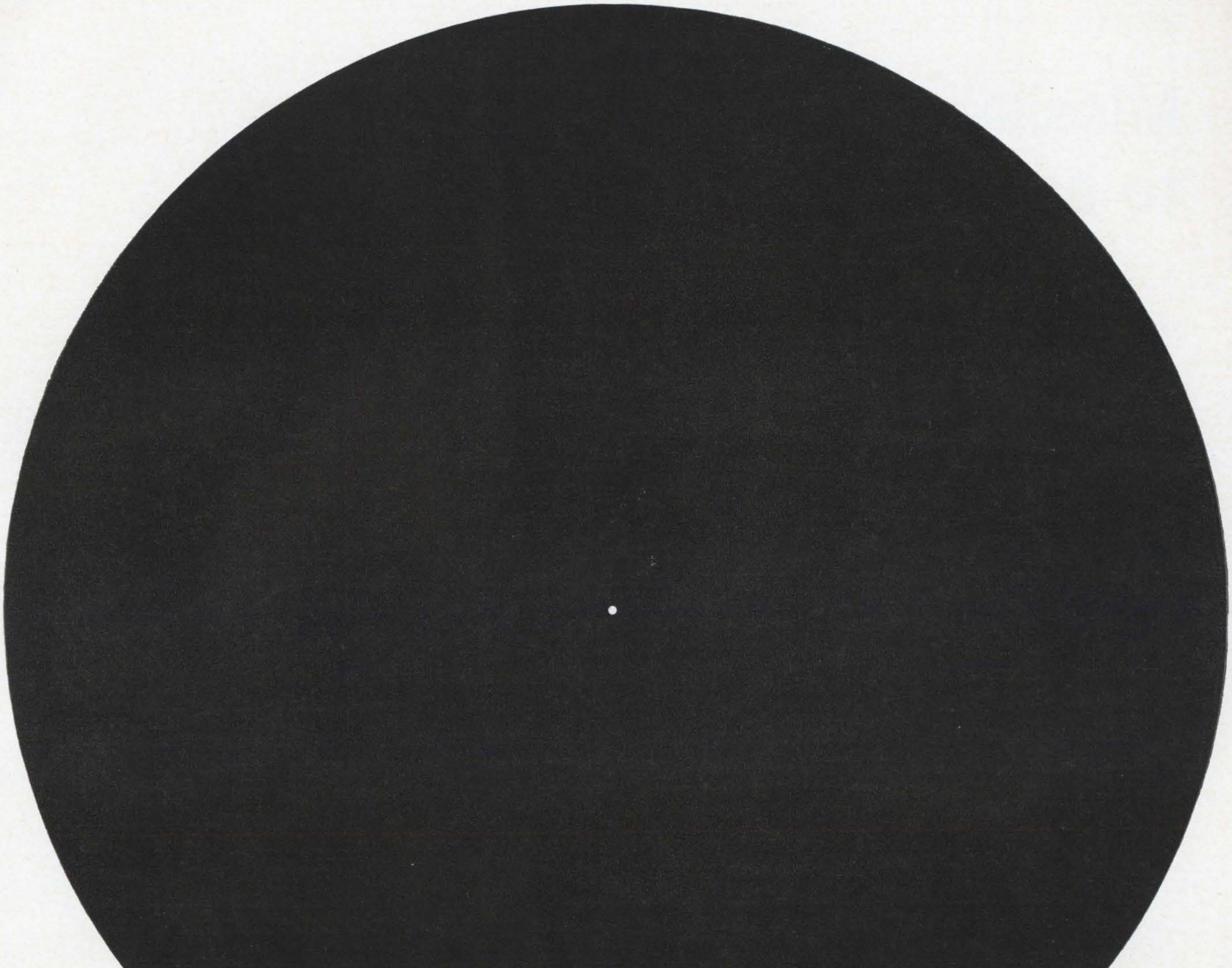
Until Altair is ready, Tradex's uhf capability (425 megacycles) will be used for target detection, acquisition and tracking. This transmitter has a peak power of four megawatts, with 300 kilowatts of average power coming from the triode amplifier. The L-band radar provides signals for detection, display and target analysis at 1,320 Mc, with a klystron providing five megawatts peak power. The vhf radar operates at 60 Mc.

Under a $16.2-million contract from ARPA, Sylvania Electric Products, Inc., a subsidiary of General Telephone and Electronics Corp., is designing Altair. Radiation, Inc. will build the steerable parabolic reflector. Continental Electronics Manufacturing Co., a subsidiary of Ling-Temco-Vought, Inc., will supply a vhf transmitter; and Energy Systems, Inc., the uhf. Hazeltine Corp. has the subcontract for pulse compression equipment; and the Computer Control Co. will furnish a digital computer for real-time control of the system.

III. The telescope

A site is also being prepared at Roi-Namur for the new spectrometric tracking telescope with a 48-inch aperture that will be shipped to the Pacific early next year from Lincoln Laboratory. The telescope was built for field studies of small reentry vehicles fired from Wallops Island, Va., [Electronics, May 10, 1963, p. 16]. It is being converted at Lincoln for tracking and measurement of radiation from full-scale

Another ARPA-sponsored program aimed at upgrading Press capabilities is a satellite that aids in testing the sensitivity of radars, particularly their ability to analyze reentry signatures. Developed by Lincoln Laboratory, the satellite is a carefully machined aluminum ball whose radar backscattering cross section is precisely known. Since its position is also known at all times, the correct radar return is easily determined [Electronics, May 17, p. 18]. Lincoln Laboratory plans to launch additional spheres at orbit altitudes especially suited for Press radar as soon as payload space is available.



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Missile's sea cruise to be business trip

Shipboard trials will test range, reliability, accuracy, and reaction time of the Standard missile that will replace extended-range Terrier and medium-range Tartar

By Gerald Parkinson

Los Angeles News Bureau

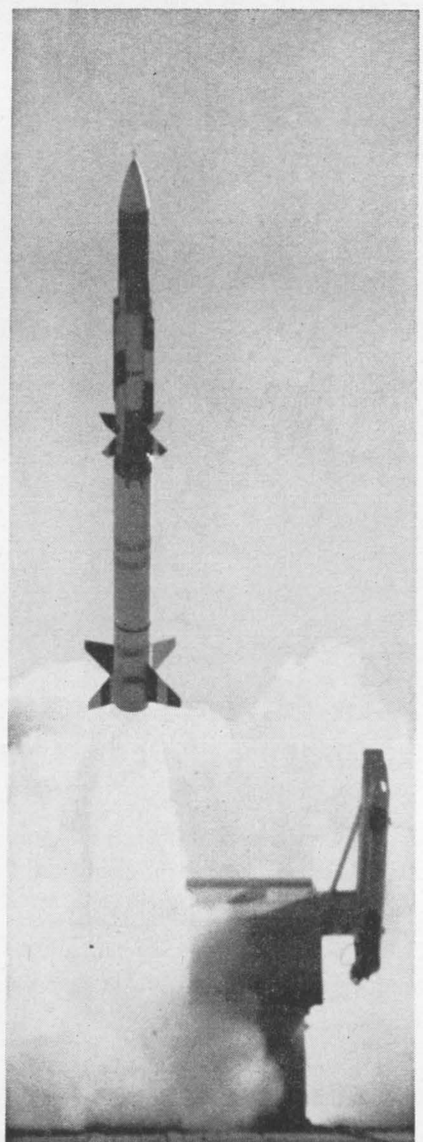
Before March, the Navy's new Standard missile will blast off the deck of a destroyer in hot pursuit of an F-9F jet drone streaking along at 500 knots. If all goes well, the missile will overtake the drone within a few seconds, passing close enough for the Standard's killer warhead to destroy the plane—if the missile were armed.

Preparations for the shipboard tests have been under way for several months at the Naval Ordnance Test Station in China Lake, Calif. Ground and flight tests have been 70% successful—a high percentage, the Navy says, for a developmental system only one year old.

The Navy's Bureau of Weapons is so satisfied that it doesn't plan any design changes. And the General Dynamics Corp.'s Pomona division, the prime contractor, is making only minor package improvements from lessons learned during the tests. The Standard missile will replace two surface-to-air missiles, Tartar and Terrier—known as the two T's. The two T's have had so many problems they are often called the "terrible T's."

I. No shipboard maintenance

Primarily an antiaircraft defensive weapon, the Standard represents a new generation in defense as well as in electronics technology. It is a better weapon because of its increased range, accuracy, reliability, ease of maintenance and reaction time. Reliability failures have been cut in half and maintenance aboard ship has been eliminated. Standard-carrying vessels will not even carry test equipment; the missiles will be tested only every three to five years. Warm-up time on the launcher before firing is only one second, another improvement over the two T's, which required 20 seconds. The same launch and control systems for the two T's, with minor modifications, will be used for Standard. The system automatically selects missiles from the ship's magazine, loads them on the launcher, trains them on the target and fires them.



Extended-range Standard blasts off the launch pad at White Sands, N.M. The missile will soon go to sea for testing.

The missile. The Standard is being developed in two versions, one to replace Tartar and the other for Terrier, both also built by General Dynamics.

The medium-range replacement for Tartar uses one solid-fuel rocket and will have a range "a good deal more than Tartar's 10 nautical miles," according to Capt. Lewis J. Stecher Jr., project manager. The extended-range missile replacement for Terrier will use one solid-fuel rocket and a sustainer rocket with a range "a lot more than 30 miles," Stecher says.

The medium-range missile is 14 feet long and weighs 1,200 pounds —about a foot shorter and 100 pounds lighter than Terrier. The diameter of both Standards is just over one foot.

The Standard can also operate as a surface-to-surface weapon against enemy ships; the two T's could not.

Guidance. Standard, like its predecessors, is guided by a semiactive homing system. A large shipboard radar blankets the target with radio signals, and the missile picks up the reflected signals and homes in on the target. Although the principle is the same as that for the two T's, the Standard's system is designed so the missile can penetrate an enemy's electronic countermeasures more efficiently.

The Standard system's signal-to-noise ratio is also better than the

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This revolutionary selective plating technique can reduce gold requirements over 60%, with no adverse effects on contact reliability, durability or electrical performance. Cinch puts the gold plating only where you need it—at the area of contact. (A gold "flash" may be applied to the rest of the connector if desired.)

The new Cinch .045" square tail connector (patent pending) utilizing this selective plating, combines the contact reliability of a flexing bifurcated contact with the stability of a rigid .045" square tail. This is achieved by inserting a wire core into the tail section and forming the flexible contact material into a .045" square tail with the sharp corners so necessary for reliable wire wrap attachments.

For additional information of this connector, with selectively plated contacts, write to Cinch Manufacturing Company, 1026 S. Homan Avenue, Chicago, Illinois 60624.

CM-6509

CINCH

DIVISION OF UNITED-CARR

Circle 113 on reader service card

Terrier and Tartar systems—so much better that the signal can distinguish a ship from the sea and operate as a surface-to-surface missile; the two T's could not.

Another innovation that makes Standard more effective against surface vessels is a contact fuse. The two T's, which had been using a proximity fuse only, are now being equipped with the contact fuse developed for Standard as well.

II. Solid state circuits

Standard has a number of component improvements over Tartar and Terrier. Standard uses solid state circuits, rather than a mixture of tubes and transistors. Some of the components are made with integrated circuits, but the use of IC's is limited to areas where their advantage has been proved. One example is in the timers, where IC's save space and money and the application is simple enough to assure reliability.

"We don't have enough solid information on IC shelf life, decay rates, and reliability under service conditions," says Stecher, explaining the Navy's limited use of IC's.

But, future versions of the Standard missile will probably make wider use of IC's. According to Joe Benish, Standard project manager, IC's are "definitely applicable" for greater use in the missile. Pomona has preliminary designs of missiles like Standard "using up to 90% IC's," Benish points out.

Packaging. Standard's electronic system will be about 50% smaller than that in the two T's, thanks to a more compact type of assembly. Welded-wire modules will be used instead of the five wheel-shaped, soldered assemblies, whose rims form the skin of the system in the two T's.

Although Standard is shorter and lighter than the two T's, the 50% reduction in space required for electronic gear has left more room for a larger rocket motor, a different warhead and for even more electronic equipment if the Navy should decide to improve on the Standard.

Another benefit of the switch from soldered to welded construction, says the Navy, is the higher reliability of the welded joints. The Navy learned this from its experience with welded-wire modules in the Polaris missile's guidance and control systems.

III. Adaptive control

The autopilot on Standard "is the first truly adaptive autopilot for an antiaircraft missile," Benish declares. The autopilot, developed by General Dynamics, is designed to adjust to a wide range of dynamic pressures.

Actuator. In its adaptive control, the autopilot makes use of an electric actuator developed by GD to drive the tail of the missile. This tail, like the ailerons and rudder of an aircraft, controls the missile's movement. The actuator also enables the Standard to use an all-electric control system: all the power comes from a silver-zinc primary battery. This eliminates any need for hydraulic systems—used to steer Terrier and Tartar—which are less reliable and less efficient because they leak and require more energy.

The actuator is a bistable, nonlinear device with a d-c motor to drive the missile tail. The d-c drive is operating constantly at full speed. Special clutches are continually engaged and disengaged to drive the tail rapidly in either direction. The tail vibrates rapidly during flight and takes an average position, depending on the required maneuver. Benish says he thinks this is the first time a clutch system has been used for missile guidance. Steering is accomplished by four independently actuated control surfaces on the aft section.

The autopilot continuously monitors the vibration or, "dithering," of the tail, which reacts differently according to speed and altitude. Thus, when a change in course is signaled, the autopilot knows how much to move the tail to make the change.

The system requires no more circuitry than that for the autopilot in Terrier and Tartar, Benish says. The Terrier-Tartar autopilot obtains air-density readings from a static pressure probe in the nose of the missile, and has a complicated system of sensors to pick up information about dynamic pressures. This is expensive and not as reliable as the adaptive autopilot.

The autopilot contains a roll-free gyro and a roll-rate gyro to stabilize the roll loop, and rate gyros to control pitch and yaw, with accelerometers for stabilization.

In the Standard, the autopilot is immediately in front of the rocket motor and behind the battery. In Terrier and Tartar, it is behind the guidance system at the front of the missile. Benish notes that it is more desirable to have the autopilot farther back so the warhead can be as far forward as possible. However, in Terrier and Tartar, the autopilot is mounted forward to minimize wiring between the autopilot and associated instrumentation.

IV. Contracts

General Dynamics is now one year into the three-year development program, and is just getting into pilot-line production. The work is being carried out under a fixed-price-incentive contract, an arrangement that works out well, Stecher says, if the contract has been drawn up carefully. The fixed-price-incentive, Stecher says, is undoubtedly a trend and will become more prevalent. Also, making one contractor responsible for the entire program has made for a smoother operation.

Benish says it is too early to make a judgment on the contract from General Dynamics' viewpoint, because incentives for deliveries and missile performance will not become important until about the middle of 1966, during pilot-line production.

The company is doing all development and production work on Standard, buying only components. The warhead and rocket motors—the same as those used for Terrier and Tartar—are government furnished.

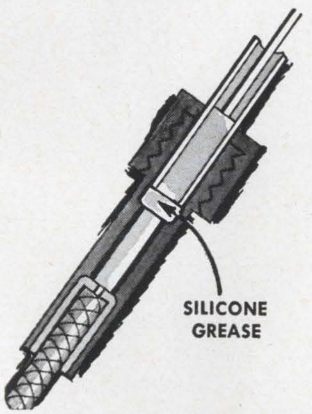
Competitive bids. Full production is scheduled for fiscal 1967, when the Navy plans to put the contract up for competitive bidding. When manufacture starts, the two T's will begin to be phased out of production.

The two T's are on more than 60 U. S. ships, plus some French, Italian, Australian, Japanese and Dutch vessels.

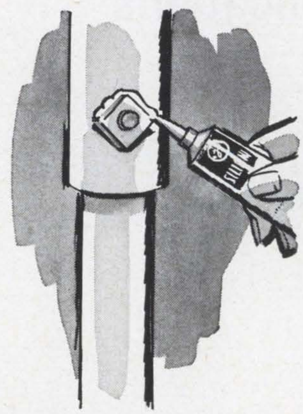
General Dynamics has commitments through 1968 for installing missiles on 26 more ships. Tartar usually goes on destroyers and Terrier on frigates, cruisers and aircraft carriers.

Silicone greases solve unique problems of moisture, corrosion, temperature and contamination

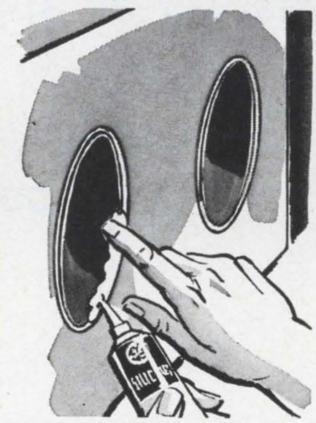
Silicone greases have many unique properties that make them perform when other types of greases fail. Silicones are chemically inert and therefore compatible with most materials. They are also usable from −100°F to 450°F, and maintain the same viscosity without solidifying or melting. They are hydrolytically stable and water repellent. Silicones also resist oxidation and gumming. And they exhibit low evaporation and bleed loss. Here are some examples of how industry takes advantage of these unique silicone properties:



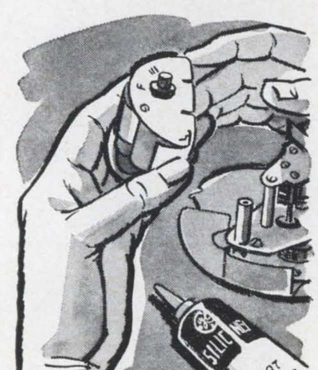
Inert silicone grease fills joints of explosive separation system for space vehicles. Prevents entrance of liquid air if seals or bonds leak. Grease is easily applied.



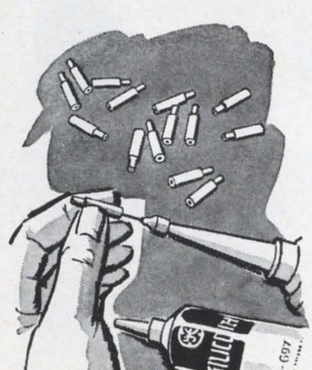
Outdoor lighting fixtures used galvanized bolts that corroded badly in a year. Thin coat of silicone grease resulted in zero corrosion, permitting bolts to be removed.



Grease film is applied to organic rubber O-rings on gloved box. Box must be leak-tight to prevent spread of radioactivity. O-ring life doubled, saving replacement work.



Rotor for a watt-hour meter is permanently lubricated with silicone grease. Six years and one million meters later, not one case of failure due to grease breakdown has occurred.



A small amount of silicone grease is used to fill connector plugs for down hole oil well equipment. Petroleum greases failed at 400°F and washed out. Silicones protect against salt water.

Silicone grease is applied to the cutouts in the thrust bearings of a turbo drill. The grease prevents adhesion to a rubber surface and also provides corrosion protection in service.

Silicone Products Department, Waterford, New York

GENERAL ELECTRIC

Silicone Greases are available from these distributors:

ALABAMA
ARGO and COMPANY
7 — 18th St., SW, Birmingham

ARIZONA
ELECTRICAL SPECIALTY COMPANY
120 S. 29th St., Phoenix
R. V. WEATHERFORD COMPANY
9310 N. Central Ave., Phoenix

CALIFORNIA
ELECTRICAL SPECIALTY COMPANY
2820 E. 12th St., Los Angeles
ELECTRICAL SPECIALTY COMPANY
213 E. Harris Ave., S. San Francisco
R. V. WEATHERFORD COMPANY
6921 San Fernando Rd.
Glendale 1
R. V. WEATHERFORD COMPANY
3240 Hillview Ave., Palo Alto

COLORADO
ELECTRICAL SPECIALTY COMPANY
2026 Arapahoe St., Denver 5

CONNECTICUT
R. H. CARLSON COMPANY, INC.
7 Bruce Park Ave., Greenwich

DISTRICT OF COLUMBIA
READ PLASTICS, INC.
317 Cedar St., NW, Washington 12

FLORIDA
GULF SEMICONDUCTORS, INC.
129 Almeria Ave., Coral Gables 34
2733 Scarlet Rd., Winter Park

ILLINOIS
FEDERAL INSULATION
549 W. Randolph St., Chicago 7
J. J. GLENN & COMPANY, INC.
605 W. Washington Blvd.
Chicago 7

INDIANA
HYALINE PLASTICS CORPORATION
1019 N. Capitol St., Indianapolis

IOWA
PLASTIC SUPPLY INC.
512 S.W. 9th St., Des Moines
P.O. Box 1482

KENTUCKY
GENERAL RUBBER & SUPPLY CO.
3118 Preston Hwy.
Louisville 40213

MASSACHUSETTS
NORTHEAST CHEMICAL COMPANY
581 Boylston St., Boston 16

MICHIGAN
F. B. WRIGHT COMPANY, INC.
9999 Mercier St., Dearborn

MINNESOTA
D. A. SCHULTZ COMPANY
801 S. E. 8th St., Minneapolis

MISSOURI
D. A. JAMES COMPANY
911 St. Charles St., St. Louis 1
REGAL PLASTIC SUPPLY COMPANY
1735 Main St., Kansas City

NEBRASKA
REGAL PLASTIC SUPPLY COMPANY
2324 Vinton St., Omaha

NEW YORK
CHAMBERLIN RUBBER COMPANY
455 E. Main St., Rochester 14604
CHAMBERLIN RUBBER COMPANY
210 Marcellus St., Syracuse 4
PUNT, INC.
160 Woodbine Ct., Box 99
Floral Park

OHIO
THE PHILPOTT RUBBER COMPANY
2077 East 30th St., Cleveland 15
PARKWAY PRODUCTS, INC.
1230 W. 7th St., Cincinnati 45203

OREGON
ELECTRICAL SPECIALTY COMPANY
2360 N.W. Quimby St., Portland 10

PENNSYLVANIA
SMITH OF PHILADELPHIA
Second & Somerset St.
Philadelphia 33
SPECK-MARSHALL COMPANY
P.O. Box 110, Nichol Ave.
McKees Rocks 15136

TEXAS
HOUSTON INDUSTRIAL SUPPLY CO.
P.O. Box 52507, 1902 Bell Ave.
Houston 52
LAWRENCE ELECTRONIC COMPANY
P.O. Box 20676, 3422 Cridelle,
Dallas 20

WASHINGTON
ELECTRICAL SPECIALTY COMPANY
2442 First Ave., S., Seattle

WISCONSIN
R. J. WITTENBURG COMPANY
1338 W. Atkinson Ave.
Milwaukee 53206

Circle 117 on reader service card

Power control and conversion technique

Voltage regulator using a new type of variable indicator offers advantages over ferroresonant transformer

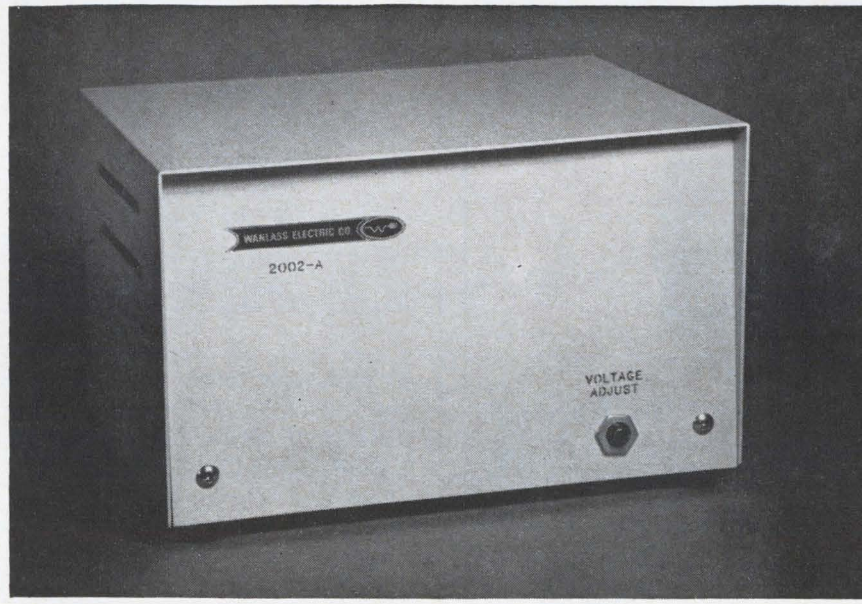
Voltage regulators featuring a new type of variable inductor have been put on the market by the Wanlass Electric Co., of Santa Ana, Calif. These are the first instruments produced by the infant company.

The regulator's advantages over the common ferroresonant transformer, Wanlass says, are that it is insensitive to frequency changes between 40 and 70 cycles, produces an adjustable output, and can regulate the voltage at the load. The ferroresonant transformers, the company admits, are a lot cheaper. To meet price competition, Wanlass has also introduced an economy line which is less sensitive.

The heart of the regulator is a new type of variable inductor, which Wanlass will not discuss, except to say that it uses no mechanical or solid state elements. Application for a patent are now in process. It is the voltage drop across the variable inductor which controls the output voltage.

Input voltage is stepped down by an autotransformer and then fed to the variable inductor. A transistorized circuit senses the output voltage and feeds it back to the inductor through a servo unit containing a zener reference.

The regulators will handle both line and load changes over a range of 95-130 volts. If the load is constant, a change in input voltage would cause a corresponding change in output voltage. But any change in output is detected by the sensor and fed back to the servo. The zener actuates the control winding of the inductor and modifies the inductance so that the voltage change across it exactly matches the change that would otherwise occur in the output voltage. A similar correction is applied if changes in the load cause the voltage to change.



If the load is connected, at a remote location, voltage drops in the line may be a problem. In this case the load can be included in the feedback loop, to insure regulation at the remote terminals.

Voltage regulation generally includes some form of waveform distortion. Constant voltage transformers, Wanlass says, tend to produce a square-wave output, which is characterized by a flat output near the peak of the waveform. In contrast, the Wanlass transformer has a small dwell time around zero voltage, but is more sinusoidal over the remainder of the cycle. As a result the Wanlass transformer may be used to drive motor loads which are generally subject to overheating when fed by a square wave.

The regulators come in three lines:

- R-1000, a precision 0.1% line and load regulator with output filtering which reduces waveform distortion to 3%.
- R-2000, a 0.5% regulator which operates under varying line, load, and frequency conditions.
- R-3000, a 1% regulator which controls line fluctuations under relatively fixed load conditions.

The difference in the three types is mainly in the sensors. Wanlass offers three kinds: root mean square, for most a-c applications, average, for a combination of a-c loads and d-c power supplies; and peak, for d-c power supplies with capacitive output filters.

Wanlass expects to use its variable inductor principle to make d-c power supplies, d-c to d-c converters and d-c to a-c inverters.

Specifications

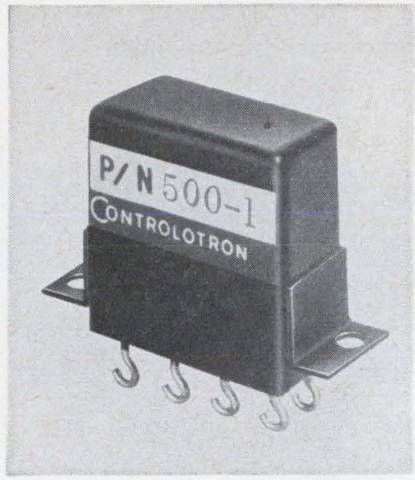
Series	R-1000	R-2000	R-3000
Capacity (kva)	1-10	1.2-10	0.5-10
Frequency (cps)	50-60	50-60	50-60
Nominal input voltage	115	115	115
Line regulation in volts for ±15-volt input variation	±0.1	±0.5	±1
Load regulation in volts from zero to full load	±0.1	±0.5	Fixed load operation
Response time (milliseconds)		30—100	
Remote sensing	Yes	Optional	No
Standard sensor	RMS	RMS	Peak
Price	$375	$100	$49

Waveform filters, average sensors, line isolation and other options are available.

Wanlass Electric Company, 2189 South Grand Ave., Santa Ana, Calif.

Circle **350** on reader service card.

Tiny relay works fast and long



A solid state relay, said to be the smallest of its type available, provides high speed and reliable operation, according to Controlotron Corp., of Hicksville, N. Y. The relay, known as a series 500 is hermetically sealed in a standard MIL-R-5757D case, the size of a crystal can. The smallest unit is a bit over an inch high.

The relay has an operating speed of 1 microsecond and possesses the reliability inherent in silicon transistorized devices. Although not primarily intended for interchange with electromechanical relays, the series 500 offers in relay applications the advantages of long life and ability to meet military environmental specifications.

Like its electromechanical counterpart, the solid state relay provides isolation between actuating and switching circuits. Models are available with actuating voltages from 1 to 70 d-c or 6.3 to 115 a-c. Since the relay does not exhibit a hysteresis effect, its pull-in and drop-out ratings are the same. Switching current ratings range from 1 to 15 amperes and the devices are available in spst, spdt and dpdt configurations.

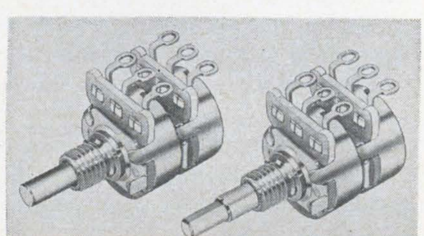
Available as an option is protection against overvoltages, transients, and short circuits. The short-circuit protection feature requires no series element in the load circuit.

Specifications

Size	MIL-R-5757D crystal can
Operating speed	1 microsecond
Sensitivity	1 ma at 4 volts a-c minimum 10 millivolts d-c
Control ("coil") ratings	1, 6, 12, 26.5 and 70 volts d-c or 6.3, 28 and 115 volts a-c
Transistor switch ("contact") ratings	1, 3 and 15 amperes
Transistor switch configurations	Spst (normally open or normally closed), spdt or dpdt

Controlotron Corporation, P. O. Box 535, Hicksville, L.I., N.Y. **[351]**

Variable resistor fits in limited space

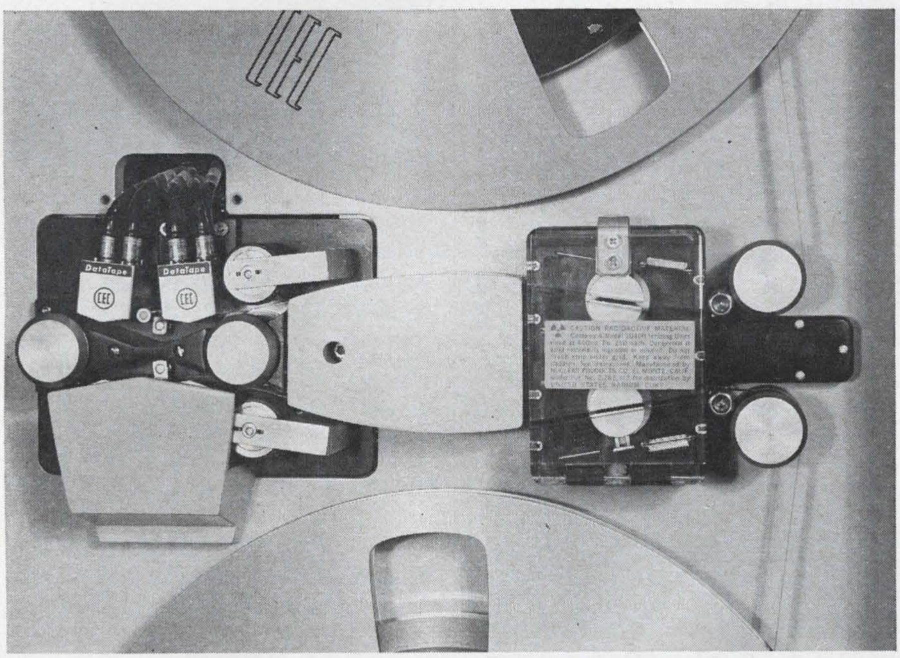


A ¼-watt, ⅝-in.-diameter, series 200 variable resistor is now available in tandem construction with straight (type 2-200) or concentric (type C2-200) shafts. In addition, newly designed solder lugs are now available on all 200 series controls.

The 200 can be furnished with rear-extended or conventional shafts in 0.125 in. or 0.156 in. diameter, with ear or bushing mounting, and with various associated switches when desired, and can be mounted with shaft perpendicular or parallel to the panel. Printed-circuit terminals and single construction are also available. The composition element has been proven in over one billion field applications. Resistance range is 200 ohms through 5.0 megohms.

Price in quantities of 3,000 to

CEC's VR-3600 establishes new record for head life



It is not news that the VR-3600 is the most advanced of all magnetic tape recorder/reproducers. This has been proved in countless telemetry and laboratory applications. But what *is* news, is the remarkable durability of the instrument's recording heads.

All reports have shown that CEC's head life guarantee of 1000 hours is not only realistic but very conservative, since in virtually every case the new recording heads have surpassed this figure with little sign of wear. Compare the 1000 hour achievement with the performance of the VR-3600's closest competitor, and the savings to the user become significant indeed.

Reason behind the performance: these CEC recording heads are of a unique material and solid metal pole-tip design which completely eliminates the weaknesses of conventional head lamination or other solid-tip designs.

Result: a head that both provides superior performance at frequencies to 1.5 mc and reduces head wear and cleaning to a minimum.

Other advantages of the VR-3600 include . . .

1 **Bandwidth switchability.** With a mere flick of a switch, the operator may instantly change from wideband to narrow band, and back again — thus *doubling* the unit's capability with *no change* of components required. (On special order.)

2 **Constant flux recording** for assured machine-to-machine compatibility at all frequencies and tape speeds (with IRIG standards).

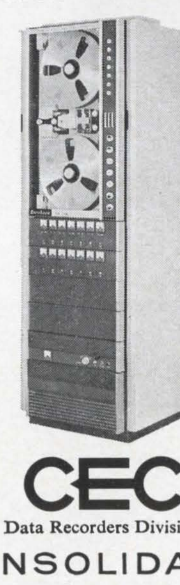
3 **Six speed switchable video FM** — d-c to 500 kc.

4 **Single source responsibility.** All components are designed and manufactured by CEC . . . including the video FM!

Important features:

- Pushbutton selection of *six* transport speeds along with associated electronics.
- Each of the VR-3600's 7 or 14 record/reproduce channels can be used for data storage in the 400 cps to 1.5 mc or d-c to 500 kc frequency range.
- Automatic end-of-reel sensing stops tape without leaders; transfer switch provides start command for nearby recorder and 30 second overlap of recorded data between machines — at no extra cost.
- IRIG or 18.24 kc AM servo system or time expansion/contraction servo system using common assemblies mean low cost for any version or combination of servo systems.
- Tape is constantly cleaned by optional vacuum/ionization; tension controlled, in all modes, by closed-loop servo control.
- Individual plug-in equalizers (6 per amplifier) meet all specifications simultaneously. Buy only those required, then set and forget.
- Record and reproduce amplifiers are solid state; the direct system fully amplitude- and phase-equalized.
- Tape transport skew is less than 0.5 μsec; complete cumulative flutter less than 0.30% p-p at 120 ips.
- The system may be supplied in single or dual rack configurations, with or without a dolly.

For *all* the facts about the VR-3600, call CEC or write for Bulletin 3600-X23.



CEC

Data Recorders Division

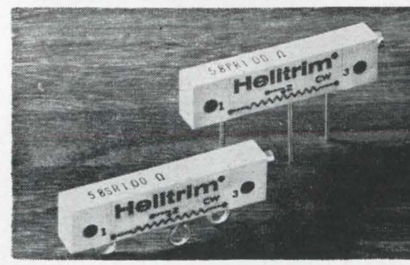
CONSOLIDATED ELECTRODYNAMICS

A SUBSIDIARY OF **BELL & HOWELL**/PASADENA, CALIF. 91109
INTERNATIONAL SUBSIDIARIES: WOKING, SURREY, ENGLAND AND FRIEDBERG (HESSEN), W. GERMANY

New Components

9,999 is under 20¢ each for bushing-mounted controls, and approximately 16¢ each for ear-mounted controls. Delivery is 3 to 6 weeks.
CTS Corp., Elkhart, Ind. [352]

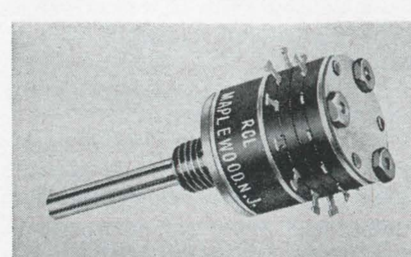
Thin, rectangular trimming pot



Model 58 is a thin, rectangular trimming potentiometer offered with either printed circuit pins or solder lugs. It is said to be the industry's only trimmer with a slim RJ12 style plastic housing and terminals staggered in RJ11 configuration. The unit is less than 0.200 in. thick and requires only two-thirds the board space of an RJ11 trimmer.

The new trimmer features a cermet resistance element with essentially infinite resolution and standard resistances from 10 ohms to 2 megohms. Power rating is 1 watt at 85°C, and the total operating temperature range is —65° to 175°C.
Helipot Division of Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, Calif., 92634. [353]

Miniature switch is easy to disassemble



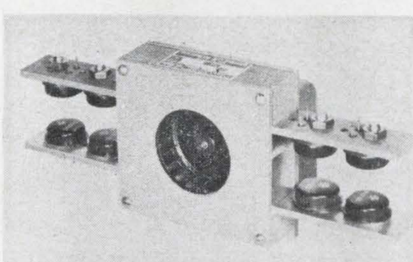
A half-inch rotary switch is being produced with a new "wire easy" construction. This construction allows the operator to disassemble the switch at the work bench, facilitating wiring by allowing switch connections to be made on a flat surface, instead of in a hard-to-reach assembly, closely surrounded by other components. Disassembly is accomplished by removing only three units.

With up to 12 positions per deck, and as many as 6 poles per deck, shorting and nonshorting poles may be grouped on one deck, in any combination. Since all individual deck parts are self-contained, and are permanently molded into place, assembly is said to be foolproof because decks cannot be assembled incorrectly. There are no loose parts to be misplaced or lost during reassembly.

Life expectancy of the switch is 200,000 operations. Contact resistance is an average of 0.0025 ohm, with a current-carrying capacity of 0.75 amp at 28 v d-c. A positive stainless-steel, roller-type detent snaps from position to position.

RCL Electronics, Inc., 2 Hixson Pl., Maplewood, N.J. **[354]**

Heat dissipator for semiconductors



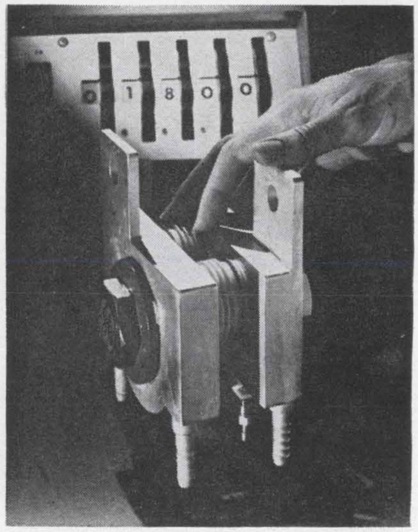
A forced-air heat dissipator is available for semiconductor cooling. The basic unit is 6½ in. long x 4¾ in. high x 4 in. wide and dissipates approximately 800 watts. The thermal resistance is approximately 0.25°C/watt. The unit mounts 12 semiconductors, more when stacked. It has a built-in heavy-duty blower and built-in air flow switches, and is thermostat-controlled.

Units may be modified to suit customers' specific needs. Delivery is 2 to 4 weeks. Price is approximately $75, depending on customer specifications.

Vemaline Products Co., Franklin Lakes, N.J. **[355]**

New Semiconductors

Scr handles 1,800 volts



A silicon controlled rectifier, capable of switching up to 1,800 volts and high currents, is available from the General Electric Co. Until now, such switching required using several units strung in series. GE's new unit, containing a pair of water-cooled scr's mounted between two heat sinks, dramatically increases the power-handling capacity of solid-state switches by incorporating extra-large silicon pellets in a configuration that permits cooling on both sides of the pellet, thus preventing thermal fatigue.

The unit, which does not yet have a GE type number, can handle up to 1,800 volts, 1,200 amperes root mean square of continuous current and permits switching of 1.5-megawatt loads.

One advantage of the new unit: it can be operated directly from a-c distribution lines, such as the 480-volt and 550-volt lines now becoming more popular for powering heavy industrial equipment. It can also be used in 600-volt, d-c motor controls, battery-charging equipment, welding controls, high-power plating power supplies, and industrial lighting controls.

To achieve the high-voltage capabilities of the new device, GE increased the pellet size of its 1,200-volt, 470-ampere scr by 55%, and altered the pellet geometry.

GE plans to bring out an air-cooled version of the 1,800-volt unit during 1966. The present water-cooled assembly measures six inches square and five inches deep.

The units are being produced at GE's Philadelphia facility. The company will begin delivering samples during the first quarter of 1966. Prices have not been set yet but a company spokesman said the initial price will probably be around $500.

Specifications

Blocking voltage	1,800 volts
Surge current	7,000 amperes
Rms continuous current	1,200 amperes
Thermal resistance, junction to water	0.11° C/watt
Water flow	2 gallons per minute
Availability	90 days

General Electric Co., Auburn, N. Y. **[371]**

Operational amplifier offers high gain

The μA709 monolithic operational amplifier is designed for use as a general purpose amplifier in d-c servo systems, high-impedance analog computers, and low-level instrumentation applications, and for the generation of special linear and nonlinear functions.

The new circuit, which uses non-Darlington input to achieve low offset and to minimize thermal drift, offers performance comparable to the best discrete component designs; it is exceptionally stable over the full military temperature range. It is constructed using the standard patented Planar epitaxial process.

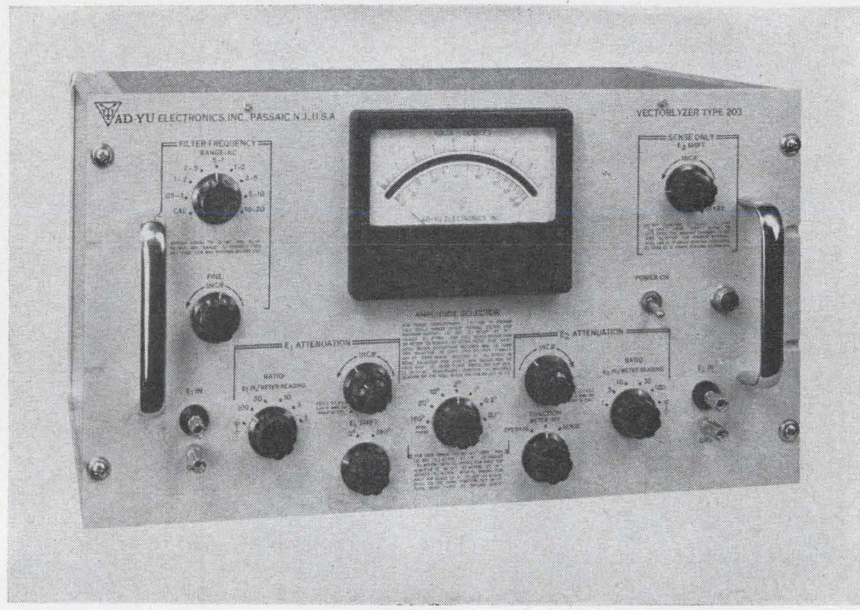
The μA709 features a voltage gain of 45,000, an output swing of $\pm$14v, and an input voltage common mode range of $\pm$10 v. Other features include an offset voltage of 1 mv, power consumption of 80 mw, and thermal drift of 3 μv/° C. The unit is guaranteed over the full military temperature range of −55° to +125°C.

Prices are $50 for 100 to 999; $60 for 25 to 99; $75 for 1 to 24.

Fairchild Semiconductor, a division of Fairchild Camera and Instrument Corp., 313 Fairchild Dr., Mountain View, Calif. **[372]**

New Instruments

Phasemeter 98% accurate costs $998



A phasemeter that is said to be the most accurate and sensitive in the moderate price range has been introduced by Ad-Yu Electronics, Inc. The instrument measures the phase relationship of two voltages.

The Model 203 Vectorlyzer has an accuracy of ±0.004°, or ±2% of full scale, at any range from 50 cps to 20 kc, and its lowest full scale range is 0.1°, which gives the best resolution in any phasemeter.

Its price—$998—is about one-half that of other instruments of comparable performance, according to Paul Yu, president of Ad-Yu.

Input to the Vectorlyzer may be two voltages whose phase relationships are unknown, or one input may be a precisely established phase reference. The circuit is designed so that when the magnitudes of the two input voltages are made equal, the output of the circuit is directly proportional to the sine of the angle between the two inputs. This technique reduces the complexity of the circuitry required, and results in lower cost.

The inputs to the Vectorlyzer are applied one at a time. A rough adjustment of each is first made with a step attenuator, and the final adjustment with a continuously variable attenuator. The magnitude of the first signal is varied until the output meter reads full scale. The second signal is then applied and its magnitude adjusted until the meter reading is nulled. The meter is then switched to lower ranges until the operator achieves the desired resolution, and the phase-angle difference read directly from the output meter. A rectifier bridge circuit is the phase difference detector. Cathode followers in each signal channel provide impedance matching between the signal sources and the attenuator circuits.

Since the instrument was designed to measure small phase-angle differences, differential amplifiers are used to provide high gain. Further signal clarity is achieved by including an adjustable bandpass filter to isolate harmonics and noise.

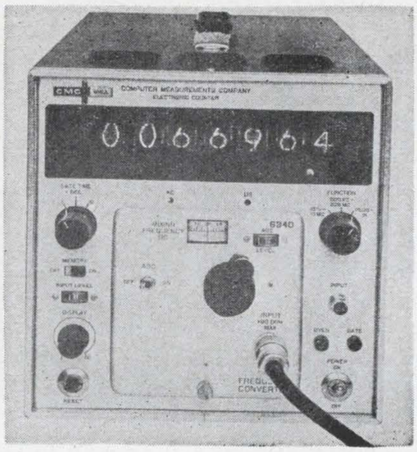
The range scale may be extended from 180° to 360° by an additional control on the front

Specifications

Frequency range	50 cps to 20 kc
Full scale deflection	Seven ranges: 0.1°, 0.2°, 1°, 2°, 10°, 20° and 180° (180° switch adds 180° to above scales for angles to 360°)
Accuracy	±0.004° or ±2% of full scale on any range
Input impedance	20 pf in parallel with 1 megohm

panel. Another feature allows the operator to determine whether the phase relationship between the two signals is leading or lagging.
Ad-Yu Electronics, Inc., 249-259 Terhune Ave., Passaic, N.J. [381]

Frequency meter gives readings to 225 Mc



A frequency meter using silicon semiconductors provides direct readings to 225 Mc. The half-rack model 616A is designed for rugged field use and is operative at temperature ranges of —20° to ±65° C. It is especially valuable for communication-system trouble shooting and calibration.

The instrument measures frequency directly from 10 cps to 10 Mc. A direct reading up to 225 Mc can be achieved by prescaling the input signal. An optional frequency converter plug-in, model 634D, provides increased frequency measurement range through 322 Gc by use of heterodyne techniques. Additional plug-in units are being planned to increase frequency measurements to 12 Gc.

Measurements are displayed on a 7-decade in-line readout, with an eighth decade optionally available. Automatic decimal point and memory are standard.

Model 616A is designed to be compatible with the company's model 410A printer through the installation of an optional data output connector. The 616A and 634D are available at a price without optional equipment of $2,185 and $825 respectively.

Computer Measurements Co., 12970 Bradley Ave., San Fernando, Calif., 91342. [382]

Printer is simpler, costs less

Mechanical printers are usually very complex, and consequently very expensive. The Potter Instrument Co. says its Model 3502 is fast, reliable, and low in cost because of simple design. It sells for one-quarter to one-sixth the price of other printers running at similar speeds.

Among the fastest impact printers on the market (excluding electrostatic and photographic units) are several models in which the type slugs are mounted on an endless chain running past the surface of the paper. These printers have a hammer for each position to be printed across the paper—usually between 100 and 150 positions. Each hammer strikes the rear of the paper just as the slug bearing the character to be printed passes on the other side. The need for each hammer to strike quickly and at exactly the right moment, so the moving slug will not blur or smudge, requires complex mechanical and electronic design.

Engineers at Potter say they have solved this problem using only 90 mechanical parts and 110 electronic parts. There are only half as many hammers as positions in the printed line; each hammer spans two print positions. The type slugs on the chain are arranged so that there is never more than one slug opposite a hammer.

The "chain" is a neoprene-nylon belt of the type used as timing belts in some new automobile engines; these belts are so tough that the pulleys wear out first. The metal type slugs are attached to the belt.

The normal alphabet, or font, holds four sets of 48 characters each, arranged around the length of the chain. Chains are also available at lower speeds, two 96-character fonts or one 192-character font.

The printer can be equipped with a line buffer. Without the buffer, the computer must retain the data to be printed, and cannot continue with its program until the line has been printed. With the line buffer, the computer can store a whole line at electronic speeds, and continue the program while the printer works.

The line buffer, and the timing logic that continually compares the characters on the chain to the characters that are to be printed, are built wholly of integrated circuits—another reduction in cost and complexity.

The Model 3502 is Potter's first attempt to market a purely commercial printer; their printers have been used by the military, notably in Polaris submarines.

Specifications

Printing speed	600 lines per minute (48-character font) 190 lines per minute (192-character font)
Printing format	6 lines per inch vertical 10 characters per inch horizontal
Line length	128 characters maximum
Transfer rate to buffer	250,000 characters per second
Characters on chain	4 fonts of 48 characters 2 fonts of 96 characters 1 font of 192 characters
Paper speed	17½ inches per second
Price	\$5,800 basic \$12,140 with line buffer

Potter Instrument Co., 151 Sunnyside Blvd., Plainview, N. Y. **[401]**

Epoxy-encapsulated FET amplifiers

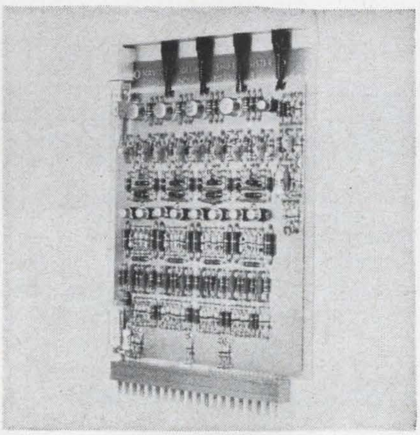
Two new all-silicon, epoxy-encapsulated operational amplifiers exhibit ultrahigh input impedance.

Models 1553 and 1953, which use field-effect input transistors, feature 10^{12} ohms input impedance and 100-kc bandwidth at the rated output of $\pm$ 10 v at 20 ma.

Other specifications include a gain of 106 db and a small signal bandwidth of 1.5 Mc. The 1953 measures only 1.2 x 1.8 x 0.6 in. Unit prices are: 1553, $165; 1953, $185.

Burr-Brown Research Corp., Box 11400, Tucson, Ariz. **[402]**

Shift register module is a 4-bit unit



Model 08 shift register module is one of a complete new line of 1-Mc system logic functions, available in both germanium and silicon versions. It is a complete 4-bit shift register, designed for parallel-to-serial and serial-to-parallel conversions. Pedestal gates are provided for transferring data into the register, and each flip-flop has its own neon indicator for readout of the data, for checkout purposes.

The modules can be cascaded to form shift registers of any length. The shift input has its own pedestal gated amplifier to simplify control of the shift operation and to provide minimum loading on the shift command. Inputs to a master reset bus are provided in both d-c and pedestal gated forms.

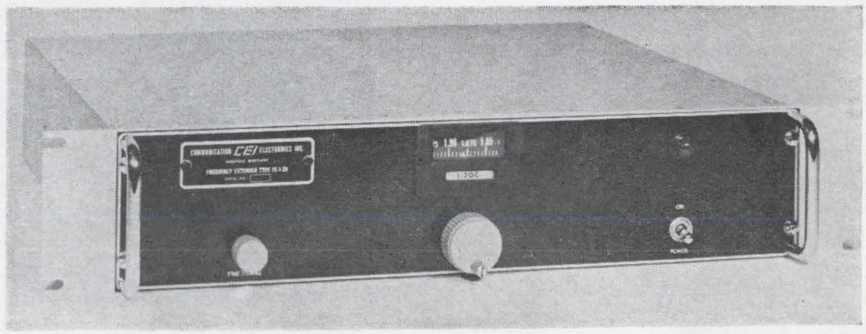
A clamp voltage supply is incorporated on the module to supply the necessary clamp voltage on the flip-flops. The presence of this supply on the card itself eliminates the problem of susceptibility of a flip-flop to noise on a clamp supply bus.

Price is $103; delivery from stock.

Navigation Computer Corp., Valley Forge Industrial Park, Norristown, Pa. **[403]**

New Microwave

2-Gc extender is YIG-tuned



A frequency extender that allows receivers to operate in the 1-to-2 gigacycle range for radio-frequency surveillance, telemetry, or radio-frequency interference measurements has been developed by Communication Electronics, Inc. Designated FE-1-2A, it converts the input r-f to a 160-megacycle intermediate frequency. The extender was developed for military applications and is now the only one commercially available at frequencies above 1 gigacycle, according to the company.

The FE-1-2A has a four-section YIG (yttrium iron garnet) preselector that makes it electronically tunable over the frequency range; it is not mechanically tuned. The preselector design also reduces unwanted radiation from the local oscillator back to the antenna to less than 75 microvolts.

The tuning frequency is critically dependent on the regulation of the power supply. So, the power supply was designed to have a total noise and ripple voltage less than 1 microvolt.

The noise figure throughout most of the r-f range is 16 decibels; in the upper 11% of the r-f range, it rises to 18 decibels.

Except for the ceramic triode in the stable local oscillator, all other active devices are solid state. As a result, the FE-1-2A is compact—requiring only 3.5 inches of rack space—and consumes only 25 watts.

On special order, the FE-1-2A can be built to convert to a 24.1 megacycle i-f, instead of 160 Mc.

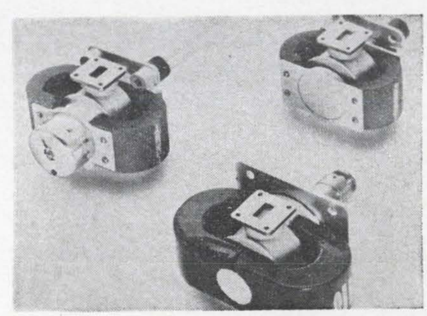
Price is $4,000; delivery within 45 days after receipt of order.

Specifications

Image rejection	70 decibels minimum
I-f stability	50 parts per million per °C
Operating voltage and frequency	115 volts, 50 to 400 cps
Weight	20 pounds
Front-end bandwidth	8 megacycles

Communication Electronics, Inc., 6006 Executive Blvd., Rockville, Md. **[421]**

Coaxial magnetrons operate at Ku-band



A line of light-weight, coaxial magnetrons is announced for operation at Ku-band. The units—the QKH-1302, 1325, and 1368—are designed for airborne radar applications requiring high efficiency, frequency stability, and small size. They will meet the most rigorous airborne environment conditions.

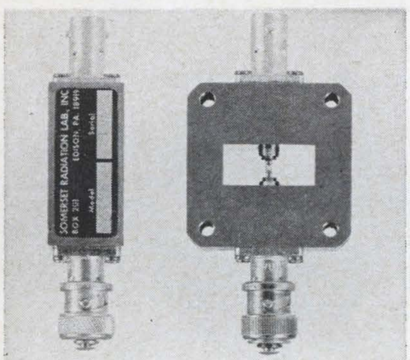
The QKH 1302 is tuned mechanically over the 16.6- to 17.1-Gc frequency range. The QKH1325 operates at a fixed frequency of 16.5 Gc, and the QKH1368 at a fixed frequency of 17.2 Gc. Peak output power for the QKH1325 is 65 kw; for the other two units, 35 kw.

These coaxial magnetrons have

integral stabilizing cavities incorporated in the resonant structure of the tubes. This design is responsible for lower push-pull figures, longer tube life, and higher reliability than in conventional magnetrons.

Raytheon Co., Microwave & Power Tube division, Foundry Ave., Waltham, Mass. [422]

X-band oscillator uses silicon diode



A planar epitaxial silicon diode produces strong oscillations at X-band in the model X910 oscillator. Output in X-band is obtained with a back bias voltage of 80 v and a reverse current of 4 to 7 ma. The bias supply is pulsed to produce a steady shf output that permits making ordinary laboratory frequency and power measurements.

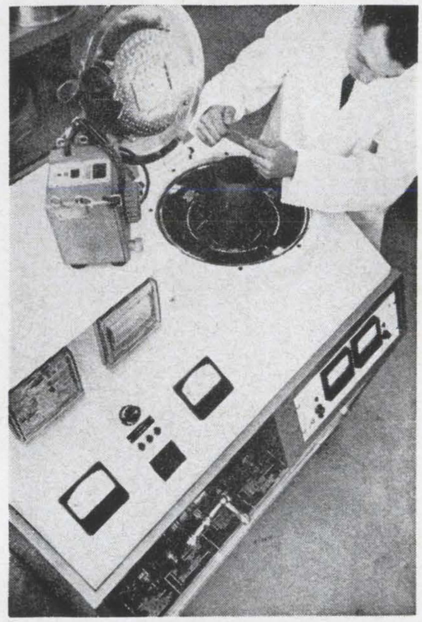
Model X910 oscillator consists of a silicon diode mounted in a short section of X-band waveguide. BNC receptacles at both ends of the diode and waveguide matching assembly allow an external bias load resistor to be conveniently connected. Either polarity of the diode can be selected, depending on the polarity of the available power supply. Operational data and test setup instructions are included with each unit.

Power output is typically −25 dbm at 9.0 Gc; bias voltage, 80 v maximum pulsed at 1,000 pulses per sec; reverse bias current, 8 ma maximum; maximum diode power consumption, 500 mw; waveguide, 0.900 x 0.400 i-d (8.2-12.4 Gc); waveguide length, 0.75 in.; weight, 4 oz.

Price of the model X910 is $80; delivery, from stock.

Somerset Radiation Laboratory, Inc., P.O. Box 201, Edison, Pa. [423]

High-temperature vacuum furnace



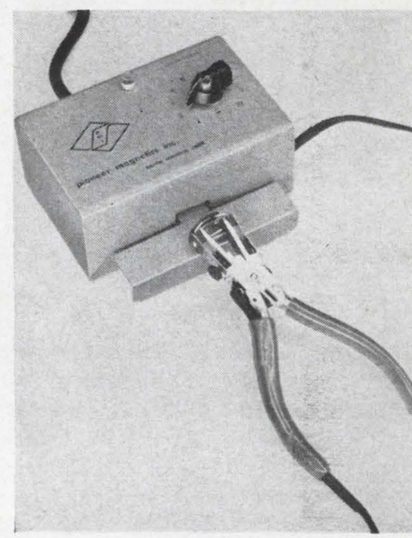
A high-temperature vacuum furnace called HotVac has been introduced for small-scale production and development processing at temperatures up to 4,000°F. Applications include sintering tantalum capacitors, carbides, nitrides and borides; heat treating of refractory and reactive metals; homogenizing refractory alloys; diffusion bonding; emissivity studies; thermocouple calibration; and high-temperature environmental testing.

Features included in the series 3400 model 612 HotVac are said to be those most often specified by users. A heating element measuring 6 in. i.d. by 12 in. high is of expanded tantalum mesh, providing 340 cu in. of loading volume. A balanced, 3-phase input power supply provides 30 kva output, stepless, controlled by a saturable core reactor. The 100% stainless steel, full-opening, double-wall chamber is electropolished for operation at hard vacuum levels. The pumping system, which uses full-bore manifolding to match the 7-in.-i.d., 1500-liter/sec diffusion pump, employs a gate valve with chevron multi-coolant baffle and bellows-sealed roughing and foreline valves. When specified with Viton seals, available at no extra cost, the furnace will perform in the 10^{-8} torr range.

The furnace is priced below $12,000 complete, including demonstration and certified performance test data.

Vacuum Industries, Inc., 34 Linden St., Somerville, Mass., 02143. **[451]**

Thermal wire stripper produces clean cut



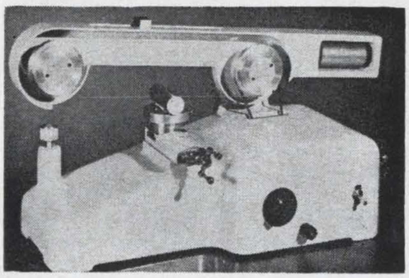
Model PM1056D thermal wire stripper features the "no nicking" patented action that allows the operator to sever, strip and remove the insulation slug from the wire in one combined operation. Recent improvements in the special alloy heater wires reduces build-up of carbon deposits and produces an exceptionally clean cut. All thermoplastic insulations, including Teflon, DuPont H Film and Raychem No. 44, are handled with the same tool.

The PM1056D is particularly useful for coaxial cable. The fine heater wire eliminates high-potential test rejections between the conductor and shielding of the co-ax since it is virtually impossible to overheat the shield in normal operation.

New cushion-grip, non-slip plastisol handles have been added for additional operator comfort and convenience. The Teflon-covered guide guard provides maximum protection against scratching of the stripped bare wire as it is withdrawn from the stripper. The guide also prevents accidental burns to insulation of adjacent wires, and offers additional safety to the operator.

Pioneer Magnetics, Inc., 1745 Berkeley St., Santa Monica, Calif., 90404. [452]

Lab instrument slices and dices crystals



A crystal slicing and dicing instrument is announced for pilot-plant work and laboratories. Model 5D-12 will slice and dice a variety of crystals including silicon, quartz, indium antimonide, gallium arsenide, barium titanate and germanium. It slices from 0.006 in. thick with no more loss than a 0.006-in. kerf per cut.

The instrument employs an endless wire blade within an abrasive slurry, which laps its way through the crystals. The cutting arm maintains a perfect balance and is equipped with adjustment of cutting pressure. Due to the use of the abrasive slurry, the finished wafers are exceptionally smooth and uniform.

Dicing is easily accomplished on the mounting table, which rotates a full 360°. A wafer is mounted and cut in one direction and then rotated 90° to complete the dicing operation.

Motor, speed control and splash guard are integral parts of this compact instrument. It is supplied with calibrated indexing on the work station, variable blade speed, interchangeable mounting plates and calibrated cutting pressure. The unit is finished in enameled aluminum and measures 10 in. high x 22 in. long x 9½ in. deep. It weighs 25 lb and the power supply is 110 v a-c.

Evans Equipment Co., Pleasant Rise, Brookfield, Conn., 06804. [453]

New Books

Heat dissipation

Cooling Electronic Equipment
Allan D. Kraus
Prentice-Hall, Inc., 390 pp., $16

Cooling electronic equipment successfully requires understanding of basic principals of conduction, convection, and radiation. Kraus deals nicely with these fundamentals and goes on to describe their application in the design of extended surfaces and heat exchangers.

The book adequately covers most aspects of thermal design. However, some chapters lack thorough handling and concise presentation. The work-sheet approach, though effective in describing the particular solutions presented, fails to provide the designer with guidelines applicable to a variety of systems. There is also one striking deficiency: physical data and heat-transfer parameters are not presented.

However, the over-all treatment of cooling methods is good. Equipment designers will appreciate the chapter on network analogy: analogies between the concepts of heat transfer and the principles of circuit analysis familiar to the electrical engineer are emphasized. This chapter also should help clarify, for those with an electrical background, the mechanisms of effective heat transfer.

Kraus starts with an explanation of the basic modes of heat transfer; he puts sufficient emphasis on fundamentals so that a reader with only a modest understanding of the subject will be informed. The ensuing development is sufficiently detailed and logical so that the practicing engineer should have no trouble following it.

The chapters on extended surfaces and component cooling are important to those directly involved in cooling electronic equipment. The illustrations point up applications of the basic principles of the preceding sections. The author describes most of the classic solutions for extended surfaces of various cross sections and offers a mathematical formulation of the optimum physical dimensions of the more common profiles.

He considers the primary mechanisms involved in cooling transistors, vacuum tubes, and microwave components. Although the chapter on change-of-phase cooling does not go into great detail, the information is more than sufficient to stimulate the thermal designer to consider the use of this often-disregarded mechanism.

Other well-presented topics include discussions of thermoelectric coolers, cold plates, and thermal considerations in design of space vehicles. The importance of the various techniques are summarized and some of the advantages and disadvantages are considered in the chapter on system optimization and trade-offs. This is worthwhile for those involved in optimizing payloads in terms of weight, efficiency, or some other particularly critical parameter.

The book also contains an excellent bibliography of the heat-transfer literature.

As a whole, the book is a well-organized guide and source of reference material for design of cooling systems and should be a valuable addition to the library of any one involved in this field.

John H. Sununu
Chief Engineer
Astro Dynamics, Inc.
Burlington, Mass.

Recently published

Structural Synthesis of High-Accuracy Automatic Control Systems, M.V. Meerov, Pergamon Press, Inc., 340 pp., $15

Principles of Technical Writing, Robert Hays, Addison-Wesley Publishing Co., 324 pp., $6.50

The Doppler Effect, T.P. Gill, Academic Press, Inc. 149 pp., $6.50

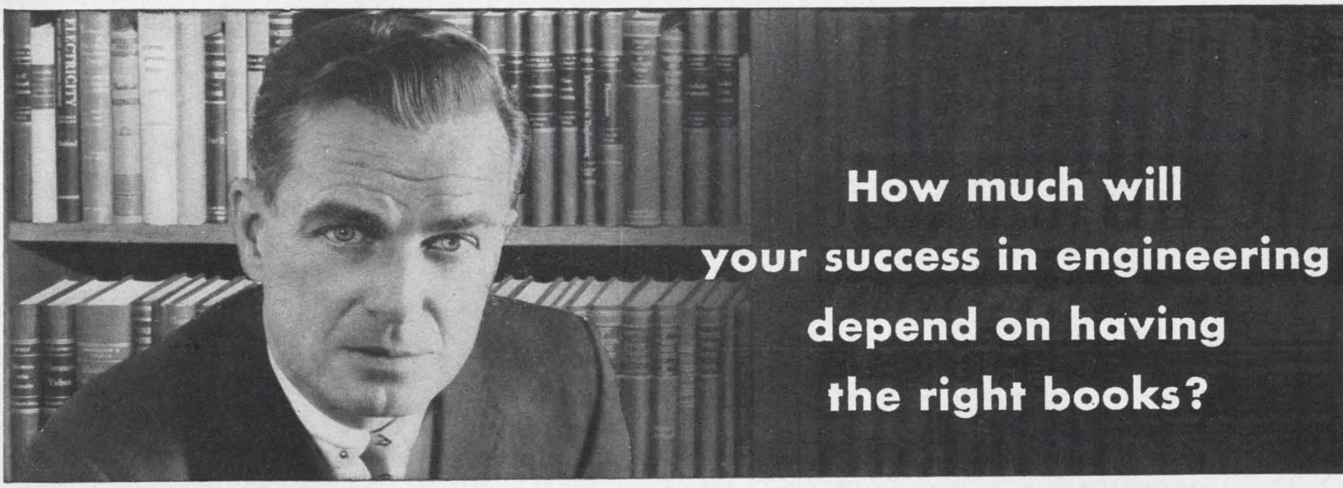
Communication Processes, NATO Conference Series, Vol. 4, Edited by Frank A. Geldard, Pergamon Press, Inc., 299 pp., $14

Ten-Decimal Tables of the Logarithms of Complex Numbers, Mathematical Tables Series, Vol. 33, Pergamon Press, Inc., 110 pp., $7.50

Optical and Electro-Optical Information Processing, Edited by James T. Tippett, et. al., The Massachusetts Institute of Technology Press, 780 pp., $30

Analogues for the Solution of Boundary-Value Problems, International Tracts in Computer Science and Technology, and Their Application, Vol. 13, Translated from Russian, Volynski, V.E. Bulchman, Pergamon Press, 460 pp., $15

Principles of Communication Engineering, J.M. Wozencraft, I.M. Jacobs, John Wiley & Sons, Inc., 720 pp., $11



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Electronic and Radio Engineering by F. E. Terman. 4th Ed. Helps solve modern problems in the electronic and radio engineering fields.

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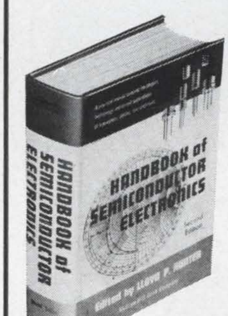

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Technical Abstracts

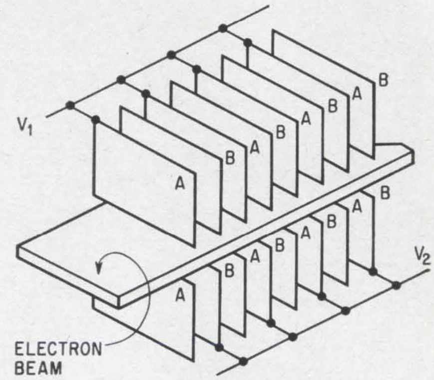
Low-cost, tunable amplifier

A low-noise transverse wave electrostatically focused backward-wave amplifier for ultra-high frequency.
Peter Everett
Zenith Radio Corp., Chicago, Ill.

Recent interest in inexpensive, voltage-tunable amplifiers for radar has prompted a reexamination of the transverse-field interaction that was first proposed when the conventional, longitudinal-field, traveling-wave tube (twt) was developed in the 1940's. The basic focusing structure of a transverse-field tube consists of two rows of parallel plates as shown in the sketch. All the plates marked A are connected to a positive potential, V_1, and the plates marked B are connected to another positive potential, V_2. As a result, the plates form a series of two-dimensional electron lenses in which the potential alternates at each succesive lens. When an electron travels rapidly through the slot between the two rows of plates, the transverse impulse from the lens field is averaged into a single force. This force acts in the direction of the axis and may be used to cancel the self-repulsion of a beam of electrons.

A single electron traveling near the axis will undergo a simple harmonic motion at frequency f_p, defined as the focusing frequency. When a beam of electrons passes through the structure, the electrons have an average drift velocity along the axis and a transverse oscillation at the focusing frequency. At any frequency there is a fast and slow wave, each of different wavelengths and phase velocities, and of positive and negative kinetic energies.

As in any beam tube, noise is associated with the waves because of the random positions and velocities of the electrons. If a converging electron lens is placed near the cathode, electrons with the same velocity will cross the axis at the same point. If a narrow slit is placed at the crossover point to intercept electrons that have the wrong velocity, the velocity fluctuations—and consequently the noise temperature—of the beam will be reduced. For a dispenser cathode at



Basic focusing structure of a transverse field twt is a series of electron lenses.

2,000°K with a beam thickness of 5 mils at the cathode and a slot that intercepts 90% of the beam, the noise temperature is less than 300°K over a frequency range from 450 to 900 megacycles.

To make this tube act as a backward-wave amplifier, inductances are connected across the plates. The equivalent circuit of this structure is an iterated bandpass filter comprising series capacitors and shunt resonators. In this circuit, the instantaneous phase increases in the direction of the load. This means that the direction of phase velocity is from the load to the generator. Because the power flows from the generator to the load, the phase velocity and group velocity are in opposite directions. As a result, a backward wave is sustained at the tube.

The first experimental tube designed to test this theory used an old, low-noise gun developed at the Zenith Radio Corp. in the early 1950's. Because the gun operated with low-current densities, a number of compromises had to be made in the design: spacing between focusing disks was large; noise figures were around 5 db; and the beam voltage had to be varied from 100 to 1,000 volts to linearly control frequency from 350 to 700 Mc.

Another tube was designed to optimize operation over the 450- to 900-Mc band and to reduce the required tuning voltage. Both of these factors were obtained by reducing the space between the parallel focusing plates; however, this also required reducing the slot between the two sets of parallel plates. This posed a problem of mechanical tolerances and set a practical limit for reducing the size of the tube. In this tube, the tuning voltage was only 50 to 500 volts.

Presented at the IEEE International Electron Devices Meeting, Washington, Oct. 20-22.

Guiding star

Sensor problems in space and interplanetary navigation,
Hans D. Heyck, Aircraft Armaments Inc., Cockeysville, Md.

Space missions near earth are controlled by networks of ground radar and radio command stations. But deep-space probes do their own navigating, and like the ancient mariners, must look to the stars to guide them.

Successful space travel requires extremely precise information on a vehicle's trajectory. Six degrees of freedom must be known and controlled:

- Angular acceleration, velocity and position (or altitude) must be found in three axes: pitch, roll and yaw.
- Linear acceleration, velocity, and position also must be known in three axes: fore and aft, up and down, and left and right.

The Mariner spacecrafts, in the Venus and Mars fly-by missions, used the sun and one of the brightest stars, Canopus, as direction references. The difficulties Mariner 4 had in finding Canopus, and staying locked on, indicated need for improved sensors.

Typical accuracies of sensors today are: direction 0.001° to 0.01°; attitude 0.1° to 0.5°; acceleration 0.001 G to 0.01 G; velocity 10 feet per second to 100 feet per second; position 1.0 to 10 miles.

The shortcoming of today's sensors are described by Heyck. He then tells of proposed equipment which may help. One instrument is a space velocity meter based on angular star aberrations. The device would use single telescopes with fused-silica prisms in front of the receiving optics. Heyck also discusses design of optical rendezvous systems, which, because of their light weight and low power consumption could replace bulkier microwave radar.

Twelfth Annual East Coast Conference on Aerospace and Navigation Electronics Baltimore, Md., Oct. 27-29.

New Literature

Telecommunications organization. The Ericsson Corp., 100 Park Ave., New York 10017. A new edition of the comprehensive data file on the worldwide Ericsson Group of telecommunications companies contains basic information on the group and its operations, arranged and indexed for quick reference. Circle **461** on reader service card.

Diamond tools for substrate processing. Aremco Products, Inc., P.O. Box 145, Briarcliff Manor, N.Y., 10510. Product bulletin 107 describes a line of diamond tools for drilling glazed alumina ceramic substrates for thin film circuits, and for scribing fragile single crystals of silicon and germanium for semiconductor devices. **[462]**

Low-pass filters. Gulton Industries, Inc., 212 Durham Ave., Metuchen, N.J., has issued bulletin H-16b on a series of miniature, high-frequency, low-pass filters which effectively reduce or eliminate radio-frequency interference and feedback in low power circuits. **[463]**

Electron beam gun technology. Microperv, Inc., 1384 Pompton Ave., Cedar Grove, N.J. A six-page, illustrated brochure summarizes the theory of electron beam gun technology and its application to commercial research and production tools. **[464]**

Silicon varistors. Victory Engineering Corp., P.O. Box 187, Springfield, N.J., 07081. Technical bulletin MSV111 describes diffused-junction silicon varistors which consist of a pair of parallel-connected, matched, oppositely poled silicon diodes. **[465]**

Coaxial switches. Electronic Specialty Co., 4561 Colorado Blvd., Los Angeles, Calif., 90039, has published a 12-page catalog describing 23 types of hermetically sealed coaxial switches. **[466]**

Lead forming tool. Davey Products Co., Box 567, Fairfield, Conn., offers a two-page bulletin on a low-cost, caliper-like component lead forming tool. **[467]**

Kelvin double ratio set. Leeds & Northrup Co., 4907 Stenton Ave., Philadelphia, Pa., 19144. Data sheet A11.1222 describes a six-dial Kelvin double ratio set that compares shunts, standards and other resistances of 10 ohms and less to one or a few parts per million. **[468]**

Vibration isolator. Robinson Vibrashock division, Robinson Technical Products, Inc., Teterboro Air Terminal, Teterboro, N.J., 07606. Bulletin CS 65-2 describes an all-metal, vibration- and shock-control mount for airborne, vehicular and industrial applications. **[469]**

Precision pots. Bourns, Inc., Trimpot Division, 1200 Columbia Ave., Riverside, Calif. Short-form catalog No. 3 is a six-page brochure giving specifications and prices on 25 types of precision potentiometers. **[470]**

Data acquisition system. Dana Laboratories, Inc., Irvine, Calif., 92664. Data sheet DL-488 contains a complete description and specification information on the model 8001 data acquisition system that measures d-c volts, a-c volts, millivolts, and ratios. **[471]**

Electromagnetic equipment. Westinghouse Electric Corp., Hendy Ave., Sunnyvale, Calif., 94088. A six-page illustrated publication covers the types of custom-built magnetic equipment the company can supply to meet the needs of science and industry. **[472]**

Printed-circuit design. Lockheed Electronics Co., 6201 E. Randolph St., Los Angeles, Calif., 90022, has published a brochure to aid engineers in the design of producible, reliable and economical printed circuit boards. **[473]**

Trimming potentiometers. Helipot Division of Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, Calif., 92634, has available a short-form catalog describing 20 different models of Helitrim Mil spec and commercial trimmers. **[474]**

Subminiature sensors. Pickering & Co., Sunnyside Blvd., Plainview, N.Y., 11803, has available a two-page product data sheet detailing a subminiature linear variable differential transformer series capable of ultrasensitive measurements. **[475]**

Furnace control instrumentation. General Electric Co., 40 Federal St., West Lynn, Mass., 01915. GEA-8192 is a 12-page booklet describing a line of instrumentation for diffusion, vacuum, and heat-treating furnaces. **[476]**

Full-wave chopper. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif., 91343, offers a two-page bulletin on the model 171 transformer-coupled full-wave chopper. **[477]**

Analog-to-digital converter. Stellarmetrics, Inc., 210 E. Ortega St., Santa Barbara, Calif. Model ADC-1 data sheet gives specifications for an analog-to-digital converter designed to meet the unique requirements of telemetering signals. **[478]**

IC logic modules. Scientific Data Systems, 1649 Seventeenth St., Santa Monica, Calif., 90404. A line of high-speed, integrated-circuit logic modules (series SDS T) is described in a six-page brochure, 64-51-02A. **[479]**

Electronic-grade chemicals. Nitine, Inc., 45 S. Jefferson Rd., Whippany, N.J., has available a catalog listing over 200 chemicals commonly used in semiconductor processing for etching, doping and cleaning, with individual analyses and prices for commercial and laboratory quantities. **[480]**

Spur gearmotors. Globe Industries, Inc., 2275 Stanley Ave., Dayton, Ohio, 45404. Two-page bulletin B-1742 supplies data on 28 standard concentric spur gear ratios from 2.56:1 to 16,833:1, rated to 50 oz-in. output. **[481]**

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Volume 38, 1965

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ELECTRONIC COMPONENTS DIVISION

GENERAL ELECTRIC

December 27, 1965

Electronics Abroad

Volume 38
Number 26

Soviet Union

Surgery calling the computer

A Moscow hospital has given a crucial task to a small, slow digital computer: it must make a diagnosis on every patient who is to undergo surgery. Officials at the Vishnevsky Institute of Surgery say their system gives a correct diagnosis 91% of the time and is never wrong; the worst it can do, they say, is reply "no diagnosis."

The institute specializes in the treatment of rheumatic virus diseases and of diseases of the heart and liver. Its diagnostic system is limited to these diseases.

Physicians explain that automatic diagnosis often relieves them of time-consuming research into a case; this is important in a country like the Soviet Union, which has a severe shortage of doctors. It also spares some patients painful tests, such as those requiring drawing of large amounts of blood or spinal fluid.

Simple hardware. In contrast with the West, where real-time computers are used widely in medical research and in data-handling at some hospitals, the Russian institute employs an almost-primitive computer to perform a simple task. The heart of the Soviet system is a Ural 2, a vacuum-tube machine with a memory of only 2,040 bits and a speed of only 8,000 operations a second.

With this computer and its peripheral equipment, together with machines that punch and sort cards, the institute has constructed a system with adaptive features, incorporating probability thresholds for identifying diseases and equipped with a medical "library" of 1,500 cases so far. About 200 cases are added to the archives annually.

The interview. When a patient checks into Vishnevsky, a doctor asks him hundreds of questions and enters the yes-or-no replies onto a four-page questionnaire. Digital answers must be either 1 or 0; in the category "femaleness," for example, the doctor writes 1 for yes or 0 for no.

Health officials in the United States estimate that one diagnosis requires an average of 600 yes-or-no answers.

After the interview, the patient's condition and symptoms are reduced to a stack of punched cards and fed into the computer. The Ural 2 makes a probability comparison between each symptom and a given disease, eliminating "impossible" diseases. For instance, if a patient's systolic and diastolic blood pressure are within certain limits, diseases of certain parts of the heart can safely be eliminated.

M. L. Bykhovsky in his lab

The computer's memory is programed with a series of thresholds, so that equivocal results can be evaluated. If a positive diagnosis is impossible, the doctor is given a list of possible diseases for further investigation.

Probability. A supplementary system, to determine the probability of a diagnosis, is called phase-interval analysis. Soviet physicians have developed lists of symptoms common to more than one disease, and mathematical measures of any symptom's "distance" from the "center," or positive identification, of the disease. The distance is not an absolute measure, but a comparison with distances of that symptom from other disease centers.

This analysis gives the probability of a specific disease being present in any group of symptoms.

Phase-interval analysis requires the handling of about 10,000 bits of information and the computation of many integrals. Because of the Ural 2's limited capacity, this requires several runs in the computer.

Digital to analog. Dr. Mikhail L. Bykhovsky, director of the institute's computing center, expects to switch to analog computers. Experiments with a pair of analog machines, each containing 30 amplifiers, have convinced him and other doctors that the digital approach is too elaborate.

He notes that accuracy to 2% is sufficient for the electronics in a diagnostic system—because the doctor's role is still crucial—and that a good analog machine can give this accuracy. "After all," Bykhovsky continues, "diagnosis is, in the final analysis, an art. What the doctor needs is help in evaluating a large number of symptoms simultaneously, and in locating previous cases of the disease."

An analog computer can do just as good a job, he says, and do it less expensively than a digital machine.

The next step, according to Bykhovsky, may be a master computer system with a series of satellite analog computers. The system would be based on manufactured "memory blocks" that would be distributed to local clinics and updated at a central institute.

Other approaches. Elsewhere in the Soviet Union, computers are performing other medical tasks. The Leningrad Polytechnical Institute claims to have developed an analyzer algorithm that permits computer diagnosis in 10 to 15 minutes, based on deviations in norms for pulse, heartbeat, encephalograms and other measurements.

At Yerevan, in Armenia, researchers have developed a program that is said to permit a computer to analyze electrocardiograms for as many as a dozen parameters.

France

Space mail

To Arthur C. Clarke, radio engineer and science writer, communications satellites are the fulfillment of a prediction made two decades ago. Clarke, who is generally credited with being the first to write about communications satellites in precise technical terms, is still looking into the future—and seeing wonders wrought by the switchboards in the sky.

At a week-long meeting of Unesco—the United Nations Educational, Social and Cultural Organization—in Paris this month, Clarke predicted direct satellite-to-home radio and tv broadcasts in five years. He also saw:

- Mail transmitted by satellite across the Atlantic as quickly as it travels between cities in the same country.
- A nationwide newspaper for the United States, whose international editions would be printed around the world from type set on orders relayed by satellite.
- Worldwide educational television.

Phone rates. Other participants predicted that satellites would effect reductions in long-distance telephone rates, but nobody would say how much. They pointed out that present rate structures are based on distance, but that a satellite doesn't care whether a call is going 500 miles or 5,000. Some suggested a flat rate some day for calls anywhere on earth.

Other speakers stressed the problems that will accompany the benefits—problems such as frequency allocations, equipment compatibility, priority of satellite use, control of receiver facilities, government versus private ownership, and competition among different satellite systems.

Studies in space

Ten days after the French A-1 joined American and Soviet satellites in space, France's first scientific satellite sailed into orbit on the nose of a Scout booster Dec. 6 and began to analyze the wave field produced by radio transmitters operating on the ground at very low frequencies—16 to 25 kilocycles per second. The FR-1 satellite was launched in California by the United States National Aeronautics and Space Administration.

The 132-pound satellite is collecting information about five components of the very-low-frequency electromagnetic field. Loop aerials are gathering data in the ionosphere about three magnetic components, and dipole aerials are collecting data about two electric ones.

Ground transmitters. FR-1 most resembles two Lofti satellites, launched by the United States in 1961 and 1963. These also studied wave fields produced by signals from the ground. The French transmitters are at Sainte-Assise near Paris and at Balboa, Panama Canal Zone.

The French satellite amplifies the signals on board, and transmits the amplitudes back to earth by telemetry link, on command from ground stations in the United States' Stadan network and the French five-station Iris network. The data will help to learn the basic characteristics of the field—its intensity, polarization and direction of polarization—and of the medium through which the field operates—its refractive index and electron density.

Satellites in the American Explorer and the Anglo-American Ariel series studied ionospheric characteristics with transmission originating on the spacecraft. The Canadian satellite Alouette 1 is transmitting sound waves from the top of the ionosphere to the bottom; these waves never reached the ground, but made it possible to study the ionosphere's upper layers, which are difficult to probe in any other way. The Soviet Union also has conducted atmospheric studies with satellites, but details are skimpy.

Japan

Radar on the rails

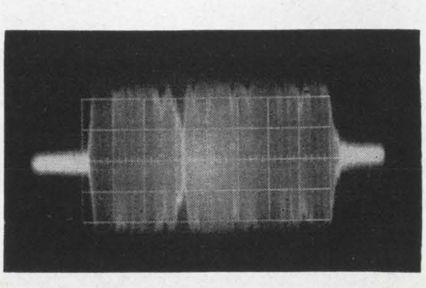
Radar is preventing collisions in the air and at sea; now the Japan National Railway, operator of the 125-mile-an-hour Tokaido Express and other lines, is studying a microwave system designed to detect obstacles in the path of its swift locomotives.

The system, developed jointly with Hitachi, Ltd., transmits pulses along leaky waveguides and monitors the return signals. Short (17-nanosecond) pulses are sent through a low-loss circular waveguide adjacent to one rail. As the energy leaks out through a longitudinal slit along the waveguide, a parabolic reflector directs it across the track to another waveguide. The energy then travels back toward the transmitter, but along the opposite rail, and is detected by a receiver.

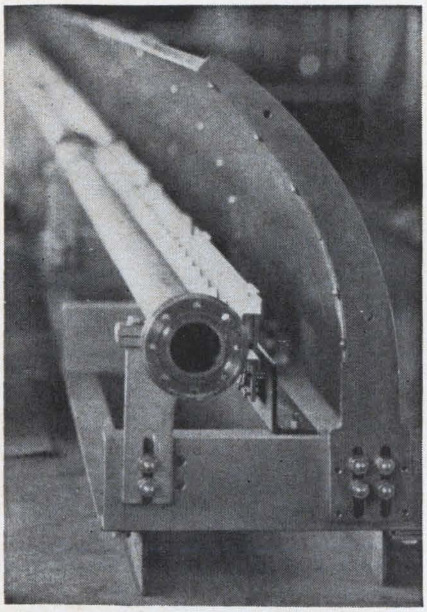
Spotter. When an obstacle is on the track between the transmitted signal and the receiving waveguide, it reflects some of the signal's energy, thereby reducing the signal's amplitude at the receiver. This decrease shows up as a deep notch on the oscilloscope display.

In the waveform shown below, the notch was caused by a man standing on the track. The system will also detect a log, a large piece of machinery or any other kind of obstacle that may have fallen onto the track.

A circular waveguide with a helical coil along its inner surface was chosen because it supports the TE_{01} mode, which has the lowest loss of any waveguide; at 50 gigacycles per second its loss is only



Notch in output waveform is caused by a man on the track.



Leaky waveguide has loose-pitch helix on inner surface. Energy leaking out of longitudinal slit in waveguide is directed across track by a parabolic reflector.

4.8 decibels per kilometer. The principal source of loss is the coupling between the transmitter and receiver lines—90 db per meter of separation.

Cost obstacle. The Japanese probably will install it only on high-speed lines and possibly at busy terminals and yards. Because the system also provides position information, it would be a useful adjunct for existing monitoring equipment.

In the United States, no comparable system is known to be under study. Cost is the big drawback, according to Irwin Goldstein of the T. J. Kauffeld engineering firm of New York, a specialist in engineering for railroads. "The costs resulting from damage to railroad equipment due to obstacles on the track is very small," he declares.

Another video recorder

A second Japanese company is preparing to compete for the United States market in video tape recorders for the home. The Shiba Electric Co. says it will offer two types next spring: a helical-scan recorder for about $500 and a linear-scan for about $300.

The only recorders sold in America for private use are helical-scan units. The Ampex Corp. offers one for $1,095 and the Sony Corp.—Japanese concern—has a recorder-monitor combination for $995.

Helical vs. linear. A helical-scan recorder achieves high head-to-tape speed by moving the recording head past the tape rapidly; linear-scan machines move the tape past the head. The heads on a helical-scan recorder are mounted on a fast-revolving drum over which the tape moves slowly—7.5 inches per second in Shiba's unit.

A linear-scan recorder is similar to a standard audio recorder except that the reel-to-reel tape speed is very fast—60 inches per second for Shiba's—to allow recording at video frequencies. Linear machines have limited bandwidth and resolution, use vast amounts of tape, and often produce noisy, jittery pictures.

In Japan, another company—the Matsushita Electronics Corp.—says it will sell a helical-scan tape recorder there next spring for about $500.

West Germany

Semiconductor battleground

Bavaria is about to become a battleground for United States semiconductor companies. Factories are planned by West German affiliates of Texas Instruments Incorporated and of the Fairchild Camera & Instrument Corp.

In February, TI expects to begin production of silicon transistors and diodes at a 10,000-square-foot building in Freising, 22 miles northeast of Munich. The company has an option to buy 25 more acres adjacent to its present 3-acre plot. Initial manufacturing will be done by 35 to 40 employees, but TI says the work force should expand to 200 by the end of the year.

Fairchild's affiliate, SGS-Fairchild GmbH, plans to make silicon planar semiconductor elements in epoxy packages, later adding a line of integrated circuits, a spokesman says. The plant will be in Wasserburg, 30 miles east of Munich.

Why Bavaria? Freising and Wasserburg are in an area that has good transportation and training facilities, and a supply of skilled manpower in a country that suffers from an acute labor shortage. More important, perhaps, is the large concentration of electronics companies in Bavaria, putting the two new plants close to a big chunk of their market.

I. Milton LeBaron, general manager of TI's affiliate—Texas Instruments Deutschland GmbH—predicts that the German company will become the country's biggest manufacturer of semiconductor products. The parent company's sales are expected to exceed $400 million this year.

Bottleneck alert

The 2,000-mile autobahn system in West Germany, long the international standard for highway excellence, is succumbing to the international problem of traffic proliferation. But before expanding its highway-modernization program to build new stretches of autobahn, the government is taking a hard look at an electronic system designed to warn motorists of bottlenecks ahead.

Developed by Telefunken AG in cooperation with the government's traffic ministry, the early-warning system provides for information to be transmitted to vehicles either via an attachment to the car radio or by means of a self-contained receiver in the car. Two miles from each exit, a driver would receive one of 24 prerecorded messages. Depending on what he hears, he may decide to turn off onto an alternate route.

No interference. A broadcast is triggered when a vehicle passes over a wire embedded one inch below the road's surface, in the expansion joint between concrete slabs. The wire is the start of an inductive loop enclosing an area two miles long and two lanes wide.

By limiting broadcasts to the area inside a loop, Telefunken permits several messages to be sent without interference on the same frequency—70 kilocycles per second—on adjacent stretches of road. In this way, vehicles passing in opposite directions can receive different messages.

The loop is fed by a 40-watt transmitter coupled with a 24-track continuous tape recorder.

The cost. The warning system would be expensive—$20 million to $25 million for installation, according to a Telefunken official, plus about $15 for each attachment to a car radio. But that's still a lot cheaper than building new roads.

Traffic information for broadcast would come from police cars, helicopters and perhaps traffic-sensing devices consisting of similar induction loops in the roadway but smaller than the two-mile ones for radio messages.

The Telefunken system is strictly for the open road so far. In its present form it cannot cope with city traffic because of the length of the loops—long enough for the motorist to receive the full message three times while traveling 60 miles an hour. Even at a 20-mile-an-hour speed in the city, a comparable loop would have to cover 15 streets in an area where traffic conditions might change from street to street.

The Netherlands

Electronic eye on the sky

Legend has it that a wooden-shoed moppet once saved Holland from a flood by plugging a leaky dike with his finger. With this tradition of digital control, it's not surprising that this country is a leader in applying digital computers to the control of air traffic.

A bigger reason, probably, is that the tiny Netherlands is the home of one of the world's biggest electronics companies, Philips Gloeilampenfabrieken, N.V. The Dutch system of air-traffic control, which is getting increased attention in other countries, is called Signaal after a Philips subsidiary, N.V. Hollandse Signaalapparaten, in Hengelo.

Three steps. Signaal's phase-one equipment has been operating since 1961 at Schiphol, Amsterdam's airport. Since then, Signaal has received orders for phase-two gear for Schiphol and for a more advanced system for the West German Air Force. Signaal calls its basic system Satco, an acronym for Signaal automatic air-traffic control.

Satco's phase one performs automatic processing of flight-data strips. Phase two, scheduled to go into operation in February, will process the flight-control boards automatically, giving the controller information for setting his control patterns. The third phase will add a plan-position indicator. The system for Germany will compare radar inputs with flight-plan information to conduct, automatically, a continuous search for collision courses.

Progress strips. Satco's phase one processes flight plans, coverting them into 900 flight-progress strips a day to help air-traffic controllers keep track of planes flying into or out of the Amsterdam airport. But by February the printed strips will be on their way out as the phase-two equipment starts to take over.

The big difference in appearance is the method of display. The phase-two equipment provides an automatic alphanumeric indication on progress boards. These are made up of electromechanical indicators developed by Signaal. Rather than cathode-ray tubes, the designers wanted devices that would retain the last available flight information for the controllers in case of a power failure.

The phase-two gear will also move closer to automation of flight control. The computer automatically will check for a conflict every time a new flight plan is fed into the system. If the check shows that two planes are scheduled to reach the same place at the same time, a warning light will flash.

Free-route system. Even more sophisticated will be the Satco system to be installed next year in Bremen. It will control five military airports in West Germany, serving aircraft whose routes are not fixed as with commercial aircraft.

For this "free route" system, inputs from a radar system will be used together with flight-plan data to aid in the continuous search for collision courses. To correct position data, the controller can compare a plane's actual position on a plan-position indicator (PPI) scope with a display of its calculated position. A "rolling ball control" on the controller's console brings computed and actual positions together, constantly changing the data stored for the aircraft in question. The system going to West Germany will have capacity in its flight-data memory to store the flight plans of 200 planes at a time.

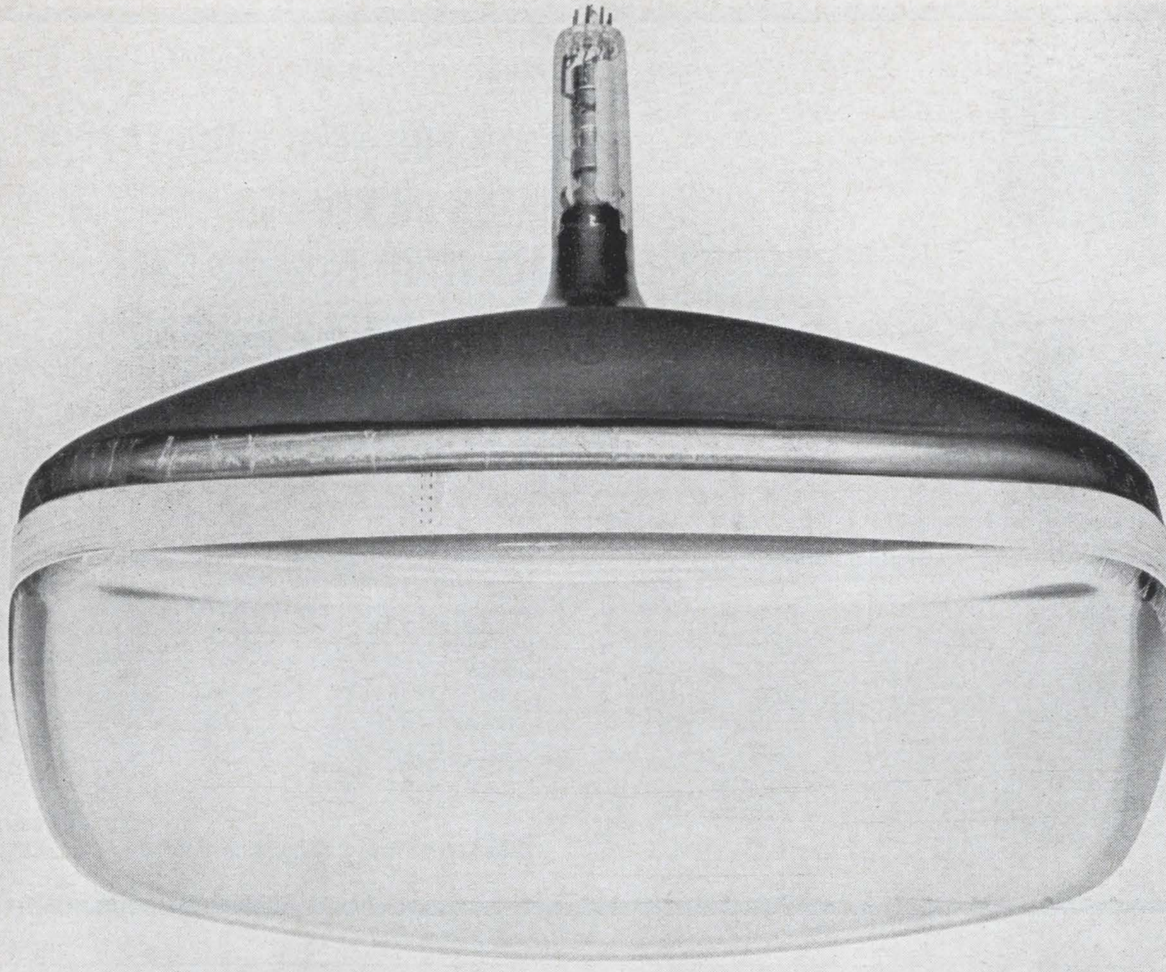
Around the world

Great Britain. A closed-circuit television network to serve 1,000 schools is being considered by the Inner London Education Authority. It would begin operation in 1970.

Israel. In 1968, France and Israel will be linked by an 1,800-mile submarine cable through the Mediterranean Sea. The 96-channel cable will carry telephone and telegraph messages as well as some data. It will cost $17 million, and be built by a new Franco-Israeli company owned 60% by the Israeli Ministry of Posts and Telecommunications and 40% by France Cables et Radio.

Saudi Arabia. Britain has outbid United States companies for a $300-million agreement to supply arms to Saudi Arabia. Most of the money will go for supersonic Lightning fighter-bombers; a big share also will go for American-made antiaircraft missiles. The Lightnings will be armed with Hawk missiles, and the sale will include radar gear.

India. A plant to manufacture electronic equipment for atomic-energy programs may be built soon by India's Atomic Energy Establishment, according to H. J. Bhabha, chairman of the agency. The plant would be near Thumba Beach, site of India's rocket-launching center for atmospheric studies.



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December 27, 1965

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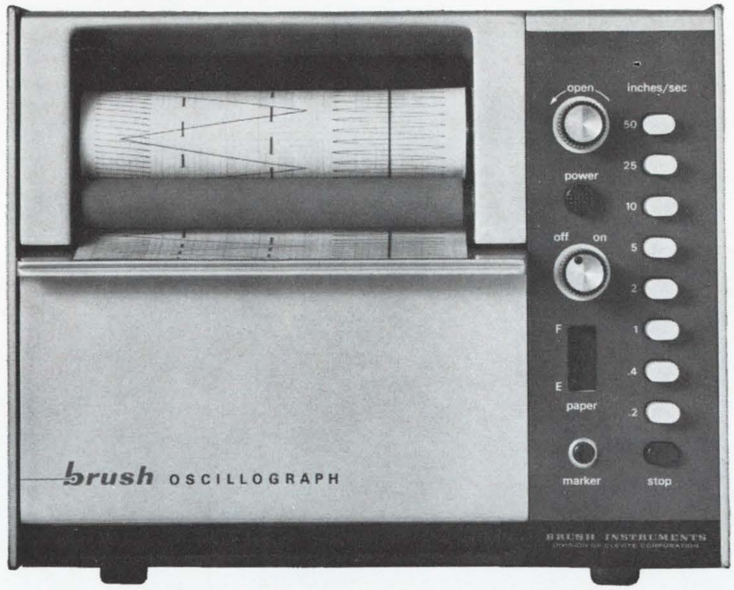

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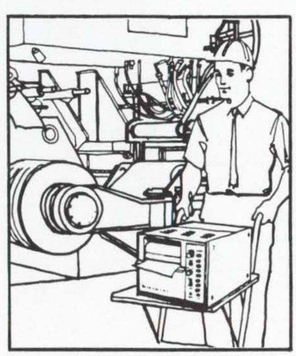

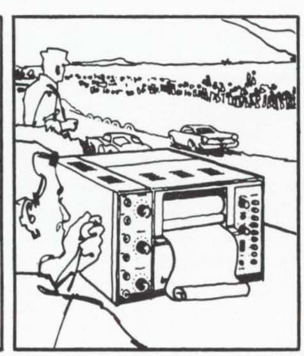

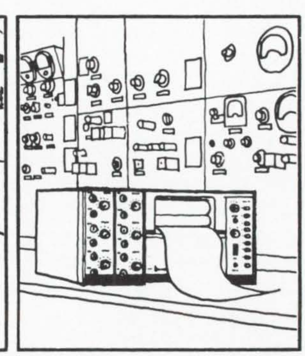

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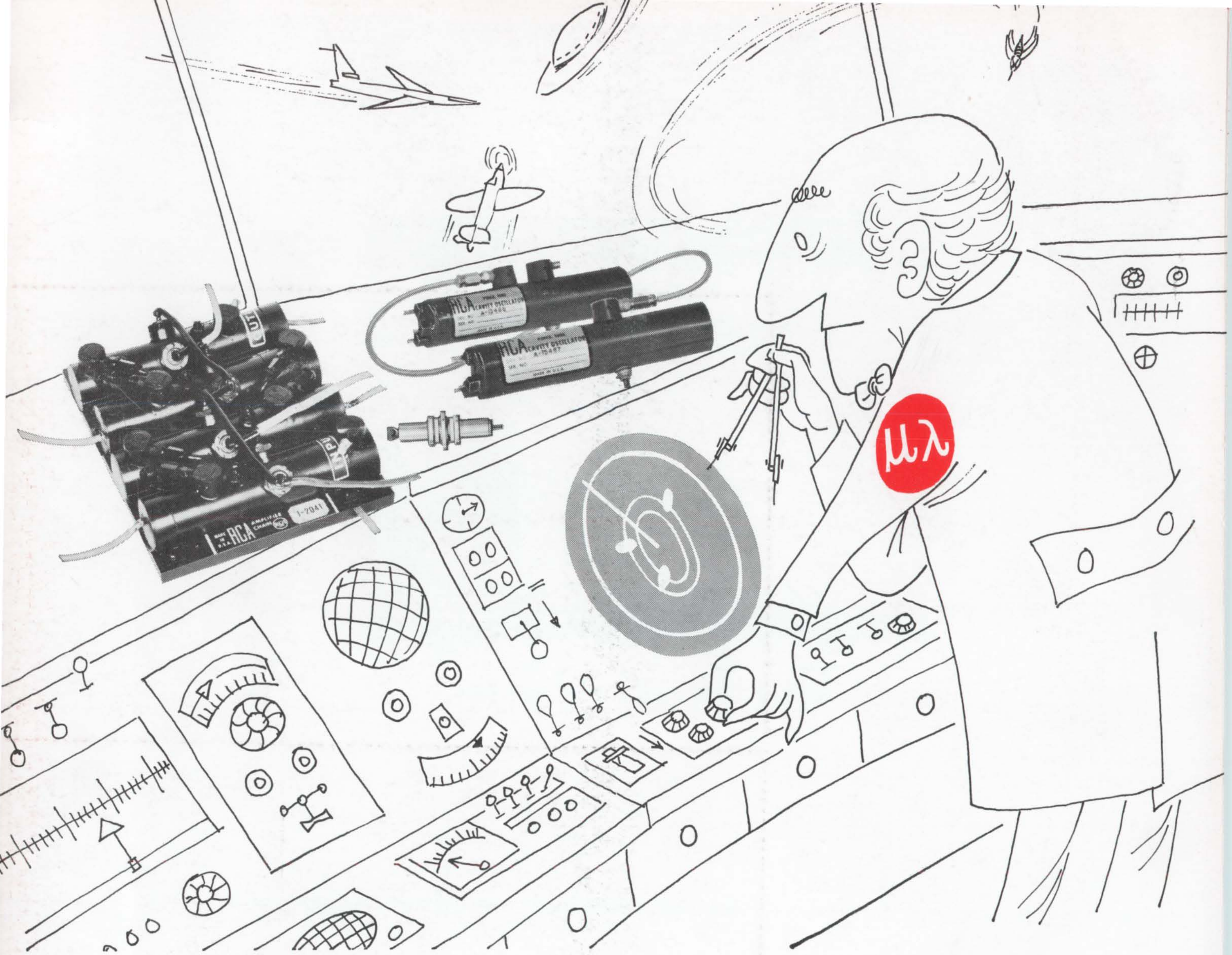
Circle 901 on reader service card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