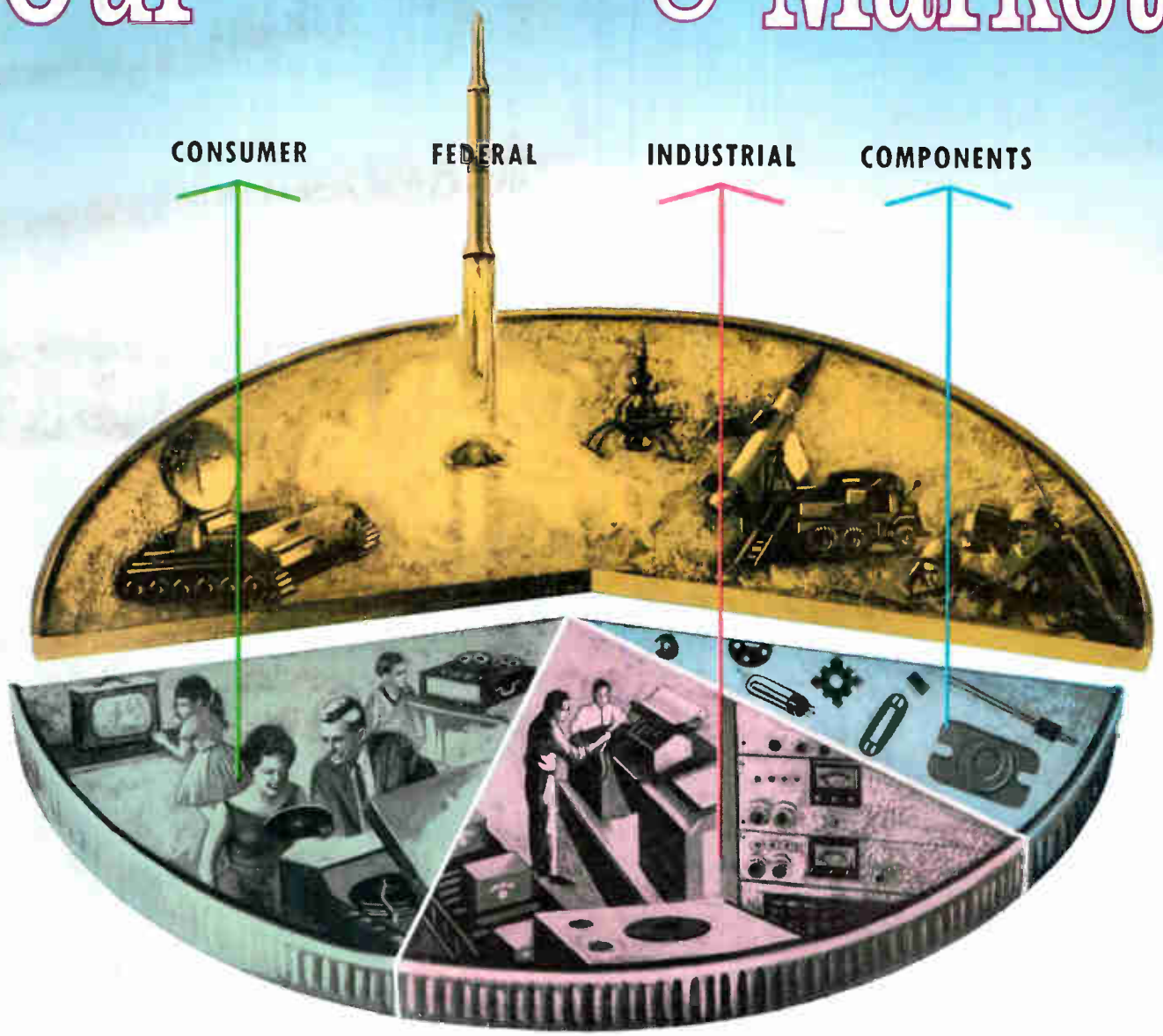
January 5, 1962

electronics

A McGraw-Hill Publication 75 Cents

Our Growing Markets



SPECIAL REPORT *An Analysis of the Present, and a Look Into the Future*

January 5, 1962

electronics

A McGraw-Hill Publication *75 cents*

Contents continued

electronics

January 5, 1962 Volume 35 No. 1

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CONTENTS continued

DEPARTMENTS

Not Too Far Too Fast

AMERICAN MANUFACTURERS, speaking generally, are opposed to reduction of tariffs. It is necessary that they be vocal in their opposition in order to counteract at least equally vocal proponents, and so suggest a compromise. This is our democratic way.

It seems certain that the argument about tariffs in Washington will be a long one. It also seems certain there will be reductions. For a sound argument can be offered that it is in our international political interest to facilitate trade with the common market. And a sound one can also be advanced that some protection of our internal market is still necessary. We think the first argument will take precedence, but not to the exclusion of the second.

While we too hope that American ingenuity can still compete in the export market, it is not easy. Cooperating European nations have considerable ingenuity of their own, and now also have modern production machinery to go with it. They frequently buy raw materials below our costs and, what is more important, their wage rates including fringe benefits are considerably less. Comparative productivity per man-hour can be argued, but not with us. Europeans work hard and well.

It is difficult to imagine how a sufficient number of conventional American products could be sold in Europe in the immediate future to compensate for the loss of internal business if European products of comparable nature came in here without restriction. Specialized items are another story, and can be sold in any market.

The reason for this very real clash between our international needs and our internal needs is the difference between living standards here and in Europe. European standards continue to rise rapidly. Assuming that they must rise still more in the free world's mutual interest, equalization will take time. That's why we urge, on this business of tariff reduction . . .

Let's not take it too far too fast.

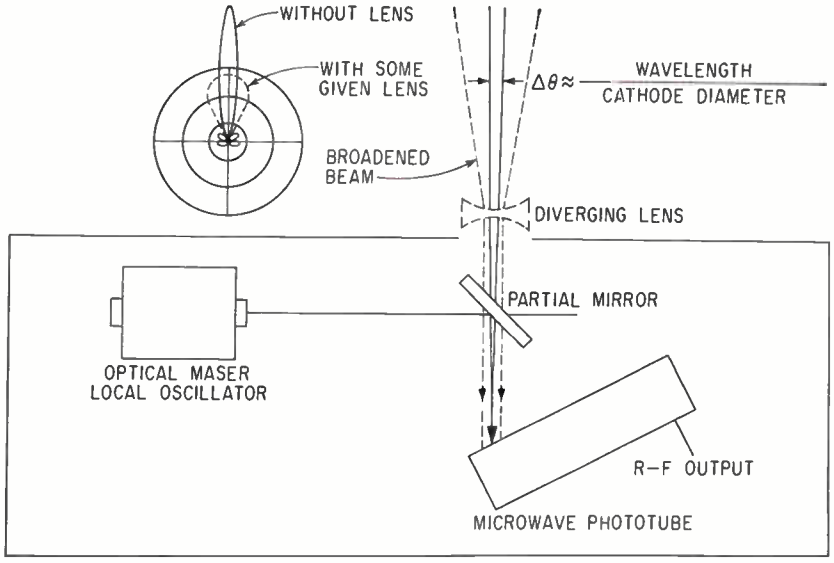
A Fresh Look

LONG-RANGE VIEW of the electronics industry's prospects and problems is difficult to acquire from following week-by-week happenings. Readers tell us that it is hard enough to keep up with technical and business developments in their own specific fields. If the industry were so mature—or so senile—that each man, each company, each product line comfortably filled its niche, it wouldn't matter. But electronics is a new world, not an old one.

Reflecting this need, each year at this time we make a fresh evaluation of the year's many developments and prepare a special market report on what has been happening and what is likely to happen in the electronics business. We don't own a crystal ball. But we do have an informed staff and friends in the industry willing to share their specialized knowledge.

This year's report, "Our Growing Markets" (p 35), shows, for example, that one of the major patterns emerging in the industry is a growing emphasis on specialized components and systems. Characteristic of this are the new military systems. Tied to this trend is a more vigorous search for industrial applications of products and components born in military R&D.

COMMENT



Optical Superheterodyne Receiver

I thought your articles on lasers [p 39, Oct. 27; p 40, Nov. 3; p 81, Nov. 10; p 54, Nov. 24] were very well done.

Your Sept. 15 issue (p 20) mentioned photomixing and optical superheterodyne experiments with an optical maser, carried on by B. J. McMurtry and myself at Stanford University. Since then we have continued this work, which is supported by the U. S. Army Signal R&D Lab., Ft. Monmouth, and the Phys. Sci. Div. of OSR.

In the drawing of the optical superheterodyne, $\Delta\theta$ is the angular width of the cone-shaped beam that carries the received signal to the cathode of the microwave phototube, and is equal to wavelength over cathode diameter, or over the diameter of the local oscillator light-spot on the photocathode, if the spot is smaller than the cathode.

The inset shows polar plots of gain vs angle, with and without an added lens to broaden the beam. Without the diverging lens, the receiving lobe would be very narrow, as the polar plot shows. In other words, as a receiving antenna it would have a very narrow beam, with extremely high antenna gain in the main lobe. If a diverging lens is placed in the beam almost anywhere beyond the partial mirror (the dashed lines show one located at the entrance to the box enclosing all the parts), the lens would broaden out the receiving pattern as shown. This will also reduce the gain within this broadened lobe.

As a matter of information, the reason the receiving beam is so narrow is that the signal and local oscillator lightwaves must arrive at the photocathode with their wavefronts parallel: the two light-beam wavefronts must have the same relative phase all across the cathode. The reason the nonparallel case won't work is that the two sides of the cathode will produce cancelling rather than adding beats, because of the 180-degree shift in relative phases of signal and local-oscillator waves. The situation is something like a distributed balanced mixer in the non-parallel case, but you're not providing the push-pull i-f input that a balanced mixer requires.

A. E. SIEGMAN
Stanford University
Palo Alto, California

East Is East

In your Electronics Newsletter of Nov. 24 (p 10), in the lower right-hand corner, reference is made to a $766,587 Air Force frequency counter contract that has been credited to Northwestern Engineering.

We would very much appreciate a correction to indicate that the contract was obtained by Northeastern Engineering.

DAVID S. KROMKA
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SAVE up to 40% in board space!..... *with unique design that offers*

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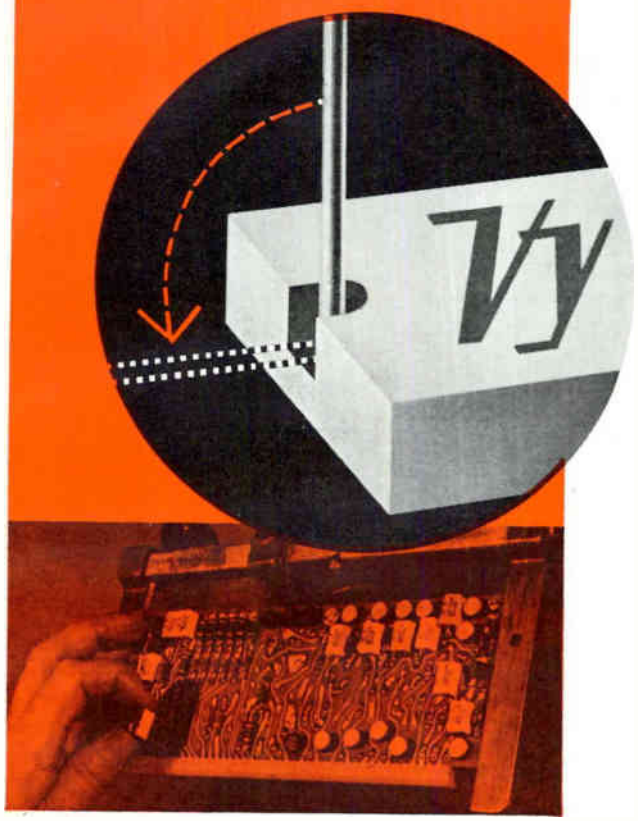
Plus Provision For Axial Lead Application



1/4" multiplied by the number of capacitors used on your circuit boards is the amount of space you can save by substituting "VY" Axial-Radial Capacitors for the axial units you may now be using.* Leads are *inboard* the body in radial configuration, yet may be moved to a *straight* axial position when required. Available in four sizes. 0.5 to 5600 mmf, 300 and 500 v ratings.

**Assuming minimum allowance of 1/8" for lead bend at each end of body for axial capacitors*

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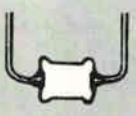
(No allowance necessary for lead bend)

VY 13 Axial Capacitor



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Board Space Required 5/8"

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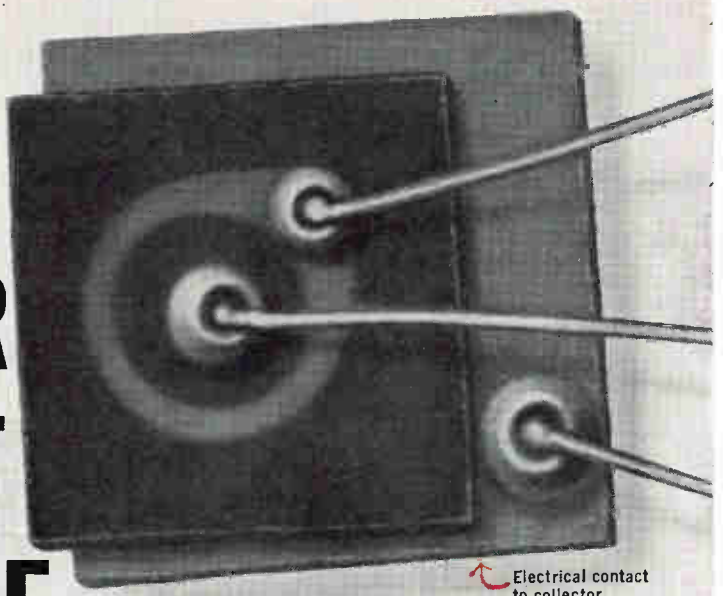
Photograph of a Fairchild Teardrop configuration transistor magnified 58 times. Approximate dimensions of actual unit: 50 mils square; 30 mils in depth.



Electrical contact to collector may be made by direct solder to molybdenum tab.

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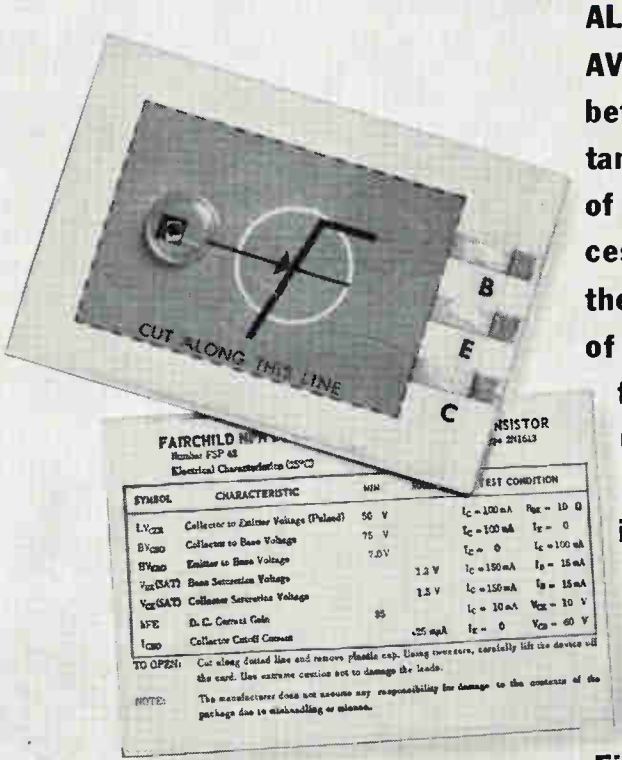
ALL FAIRCHILD PLANAR DEVICES ARE AVAILABLE IN MOLYTAB FORM. Never before has there been more dramatic or tangible proof of the natural superiority of Fairchild's Planar process. This process alone provides all the protection these devices need—through all stages of manufacturing and operation. Performance is unchanged by time, use or exposure to foreign matter. MOLYTAB Silicon Planar devices are ideal for many applications where small size and reliability are essential, such as thin film and potted work. For further information on specific devices, contact your local Fairchild Field Sales Office.



Actual size.
Units are delivered as shown for testing in container.
Specifications on back of each unit.

*MOLYTAB is a trademark of Fairchild Semiconductor, referring to any Fairchild Planar transistor or diode mounted on a gold plated, molybdenum substrate. Leadwires are gold for standard welding techniques.

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ELECTRONICS NEWSLETTER

Parts Supply Center Operational July 1

PENTAGON is setting up a Defense Electronics Supply Center at Gentile AFB, Dayton, Ohio, to handle purchasing, warehousing and other supply management functions for common-use electronic parts. It will become operational July 1. Consolidation of common-use components has been in the works for close to two years.

During its first year of operation, the center plans to reduce from 1.2 million to 680,000 the number of parts used by the services. Standardization, simplification and elimination of duplication will be used to cut down variety. The center will buy $143 million in parts the first year and about $198 million the next year. Electron tubes will be the first item handled for all the services.

The center will be one of several major units in the recently established Defense Supply Agency, which began operations January 1. It is in charge of a $3.2-billion inventory of commercial-type commodities. The bulk of military procurement, end items and specialized major components, will continue in the hands of the usual military agencies.

Report R-F Modulation By Organic Semiconductor

RADIO-FREQUENCY modulation capability in organic semiconductors (ELECTRONICS, p 68, Jan. 22, 1960; p 31, Apr. 28, 1961) was reported last week by Frank Alexander, head of the semiconductor physics group at American Viscose's research facility at Marcus Hook, Pa. He said polymer samples prepared by Morris Danzig have been used in simple nonlinear devices to audio-modulate r-f energy in the 500-Kc to 5-Mc range.

Laser Treats Tumor in Retina of Human Eye

PHYSICIANS at Columbia-Presbyterian Medical Center, New York, have been using a laser light source to treat an angioma in the retina of a patient there. The beam, produced by an American Optical Co. instrument called a laser retina coagulator, burns the tissue in microseconds. High speed is reported to decrease danger due to eye movement and heating. Operations performed by conventional high intensity light sources may require as long as a second.

Physicist Challenges Existence of Photons

PHOTON CONCEPT, which has figured in the development of physics since 1905 when Einstein used it to explain the photoelectric effect, was challenged last week at the American Physical Society meeting in Los Angeles.

James Deer, a research physicist for Iron Fireman Mfg. Company's Electronics division, said the concept can lead to incorrect predictions in certain experimental situations. He claims that atomic absorption and emission problems can be handled without quantizing the electromagnetic field and that a single transition in a source atom can produce multiple photoelectrons.

Deer offered a new theory, called statistical independence, and proposed experiments to test it. He estimated that experimental work would take two years.

Overseas Airline Will Use Doppler Navigators

TRANS WORLD AIRLINES plans to inaugurate full-scale use of doppler radar for navigation on its transoceanic flights. By agreement with the Transport Workers Union, TWA's 44 navigators will be phased out of their jobs after the automatic equipment goes into operation. United Air Lines uses doppler on flights to Hawaii, but only as an aid to navigators. TWA will place primary reliance on the system.

TWA is equipping 12 jets at a cost of $1.8 million with a system made by Bendix. Flight crews are now being qualified to use doppler and the air line expects FAA approval soon after Feb. 1. FAA approved the system in principle last September.

Tv Compression System Uses Digital Technique

LONDON — Television bandwidth compression system under development at the Imperial College of Science and Technology by Prof. E. Cherry is giving compression ratios of 10-to-1. Variable scanning method keeps transmitted frequen-

Does the Thing Have Any Master Points Yet?

MECHANIZED BRIDGE-PLAYING is being used to test Air Force research programs in voice communication with computer, pattern recognition, machine learning and voice synthesis techniques.

Air Force Cambridge Research Labs chose contract bridge because its problem-solving complications are applicable to military decision-making processes. It is expected that one result of the program will be a computer system that will know enough not to trump its partner's ace.

Actual play of the hand is now under study in an AFCRL program involving machine learning. With bidding and play worked out, final step will be coordination of these programs with spoken-word recognition. Vocal response may also be possible with techniques growing out of speech research

cies adjusted to a desired bandwidth. A detail detector analyzes the picture waveform, deriving digital and control data to define the picture. The digital signals are time-spread to make the most effective use of available bandwidth. Similar systems are under development for facsimile transmission.

Bank Will Automate All Its Transactions

MELLON BANK, of Pittsburgh, has ordered a battery of machines which will encode, in magnetic ink, all of its financial transactions. Paperwork will then be processed by the bank's computer.

The bank handles almost a million documents daily, including auto loans, bonds and coupons, checks and deposit slips. The encoding system, costing $250,000, was developed for the bank by National Cash Register.

Sensors Warn Motorists Slippery Bridge Ahead

WASHINGTON state highway department has installed an ice detector and warning system on the mile-long Nisqually slough bridge north of Olympia. Transducers are embedded in the pavement at one end of the bridge. When the pavement is wet and temperature falls to 33.5 F, warning signs are lit. The device is made by the Kar-Trol Signal Co., Houston.

Glass Protects Solar Cells From Radiation

ANALYSIS of solar cell performance data telemetered from the Explorer XII satellite shows that glass coatings will protect the cells from radiation belts in space, NASA reports.

Four banks of cells were carried. One bank, unprotected, degraded 50 percent on the first two orbits through the Van Allen belt, another 25 percent during the remainder of the satellite's 112-day life. Cells protected with 20-mil and 60-mil glass did not degrade and cells with 3-mil coatings degraded about five percent.

Among other experiments was one to measure the electron and proton concentrations in the outer Van Allen belt. Electron concentration is a thousand times less than previously thought. There are more protons, but their energy, below 1-Mev, is no hazard to manned space flight.

Britain Unfreezes Funds For Two Radiotelescopes

LONDON—Research grants for two radiotelescopes, suspended during the government credit squeeze last July, have been reinstated by the Department of Scientific and Industrial Research.

Cambridge University gets $1.2 million for a triple paraboloidal telescope, to be completed by 1964. Jodrell Bank, Manchester, was awarded $661,000 for a fully-steerable system to be built in 18 months.

The Jodrell Bank telescope will have an elliptical bowl measuring 125 by 85 ft and will operate at 21 to 3-cm wavelengths.

Project Defender Gets Another $15 Million

AIR FORCE has awarded MIT Lincoln Lab another $15 million for Project Defender, a missile defense study sponsored by Advance Research Projects Agency.

The lab's work on missile phenomena includes studies of reentry physics, measurements of pellets fired in a hypervelocity test range, radar and optical measurements of Trailblazer reentry test vehicles fired by NASA at Wallops Island, reentry measurements at the Atlantic Missile Range and technical direction of Project Press (Pacific Range Electromagnetic Signature Studies).

Army gave Raytheon another $1.4 million for Arpat, one of the antimissile studies in Project Defender. Raytheon heads a five-company team. Arpat has so far received $8.4 million.

In Brief...

LASER WELDING, machining and cutting systems are contemplated by the Air Force. Aeronautical Systems Division is preparing a list of companies with secret clearance that are capable of developing such a system. No proposals are sought yet.

ADMIRAL'S new 23 and 27-in. tv sets include a Compactron tube circuit to prevent picture distortion.

RUSSIA'S big radiotelescope (p 27, Oct. 27, 1961) will be used to study Jupiter and the sun's corona to a distance of 40 radii.

ANACONDA and Simplex Wire and Cable Companies will produce 1,560 miles—$7.9 million worth—of armored communications cable to link 150 Minuteman sites in South Dakota.

KOLLSMAN INSTRUMENT will develop optical and electronic instruments and guidance for the Orbiting Astronomical Observatory, under $1 million NASA contract. Chicago Aerial Industries has a $1.3 Army contract for reconnaissance drone and aircraft checkout equipment.

GROUND-BASED SYSTEM to track and guide reentering vehicles from distances of 3,000 mi to landing is under study at General Precision. It would use radar, tv, computer and communication subsystems and a world map display.

FMA, INC., reports it is in production on its electro-optical File-Search information storage and retrieval system and has sold one to the Navy. It costs about $125,000.

IWASAKI Communications Apparatus, of Japan, is negotiating with Solartron, of England, for manufacturing rights to the portable dual-beam oscilloscope made in the U. S. by Packard Bell.

OTHER LICENSING moves: Elliott Brothers, of England, gets rights to Acoustica Associates ultrasonic cleaners; Litton will make and sell Raytheon's microwave cooking components.

They said "PROVE IT"... AND WE DID!

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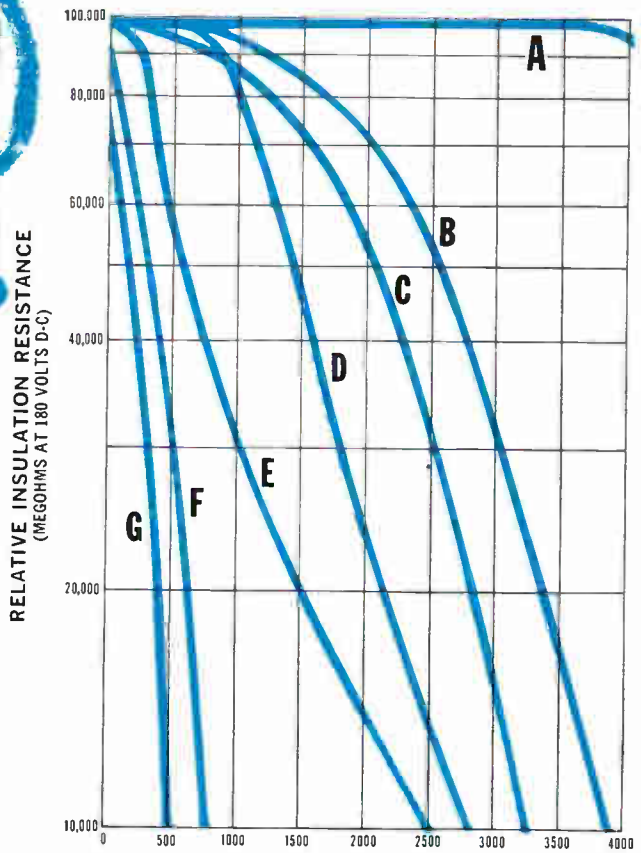
For complete technical data on Difilm Black Beauty Capacitors, write for Engineering Bulletin 2025 to Technical Literature Section, Sprague Electric Company, 35 Marshall Street, North Adams, Massachusetts..

MOISTURE RESISTANCE COMPARISON CHART
FOR TUBULAR CAPACITORS



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B. PAPER DIELECTRIC, solid impregnant, molded case
C. DIFILM DUAL DIELECTRIC (PAPER and POLYESTER FILM), solid impregnant, dipped coating
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G. PAPER DIELECTRIC, wax or oil impregnant, waxed cardboard jacket

You can get off-the-shelf delivery at factory prices of Replacement Type TM Capacitors (same construction as O. E. M. Type 160P) in pilot quantities up to 249 pieces from your local Sprague Industrial Distributor.

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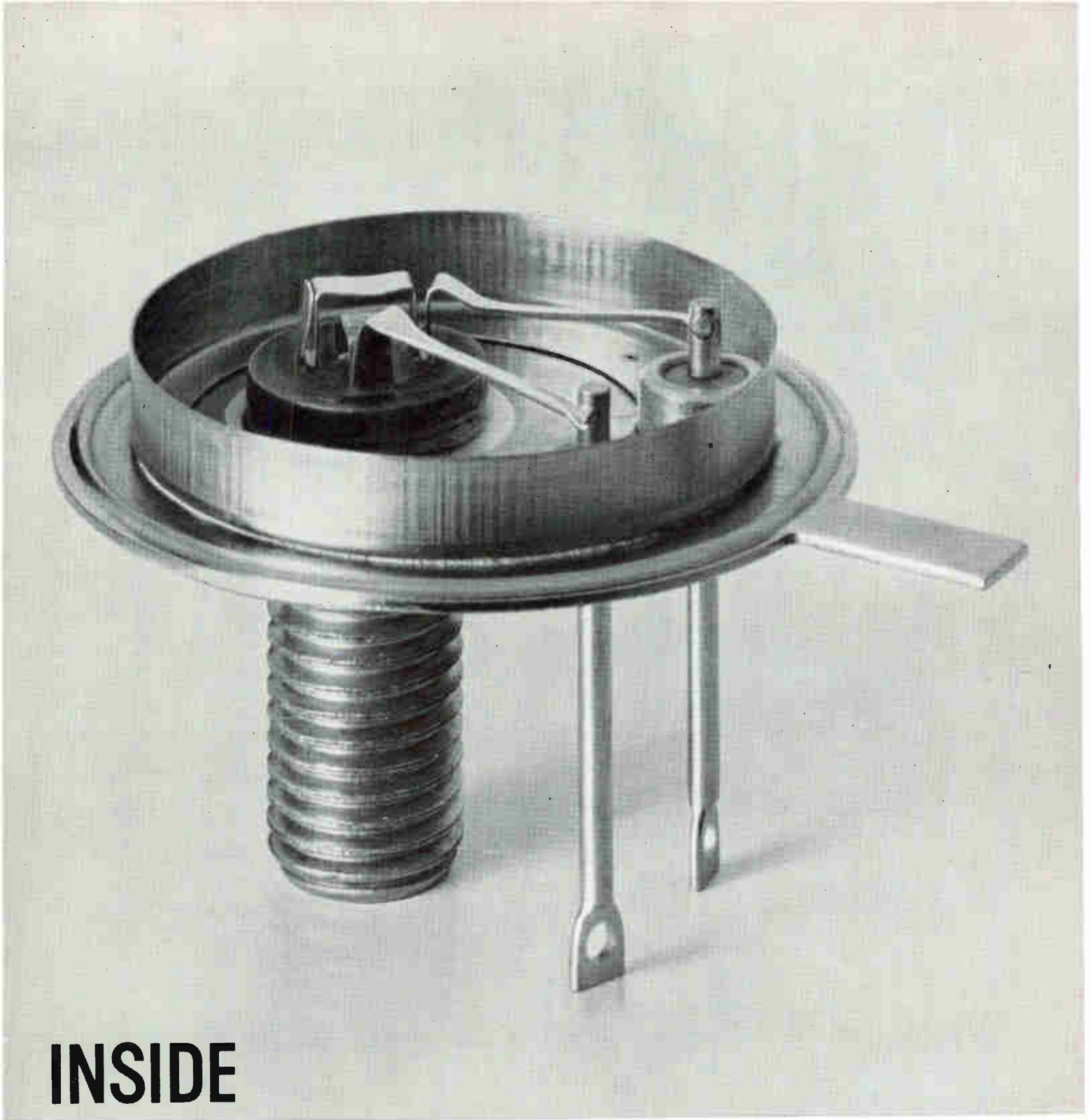

INSIDE

Quality Construction in Westinghouse 2N1015 and 2N1016 series of high-power silicon transistors is evidenced by: Exclusive alloyed bridging techniques which provide positive junction contact to insure reliability under severe vibration and shock. Bridge assembly welded to base and emitter pins for extra support and positive contact. Basic transistor hard-soldered in position to eliminate thermal fatigue. Protective junction coating that guards against moisture and further stabilizes electrical performance. These precision design features result in very low thermal impedance and high power rating. Upon completion every Westinghouse high-power silicon transistor is 100% Power Tested under full operating conditions to assure True Voltage Ratings.

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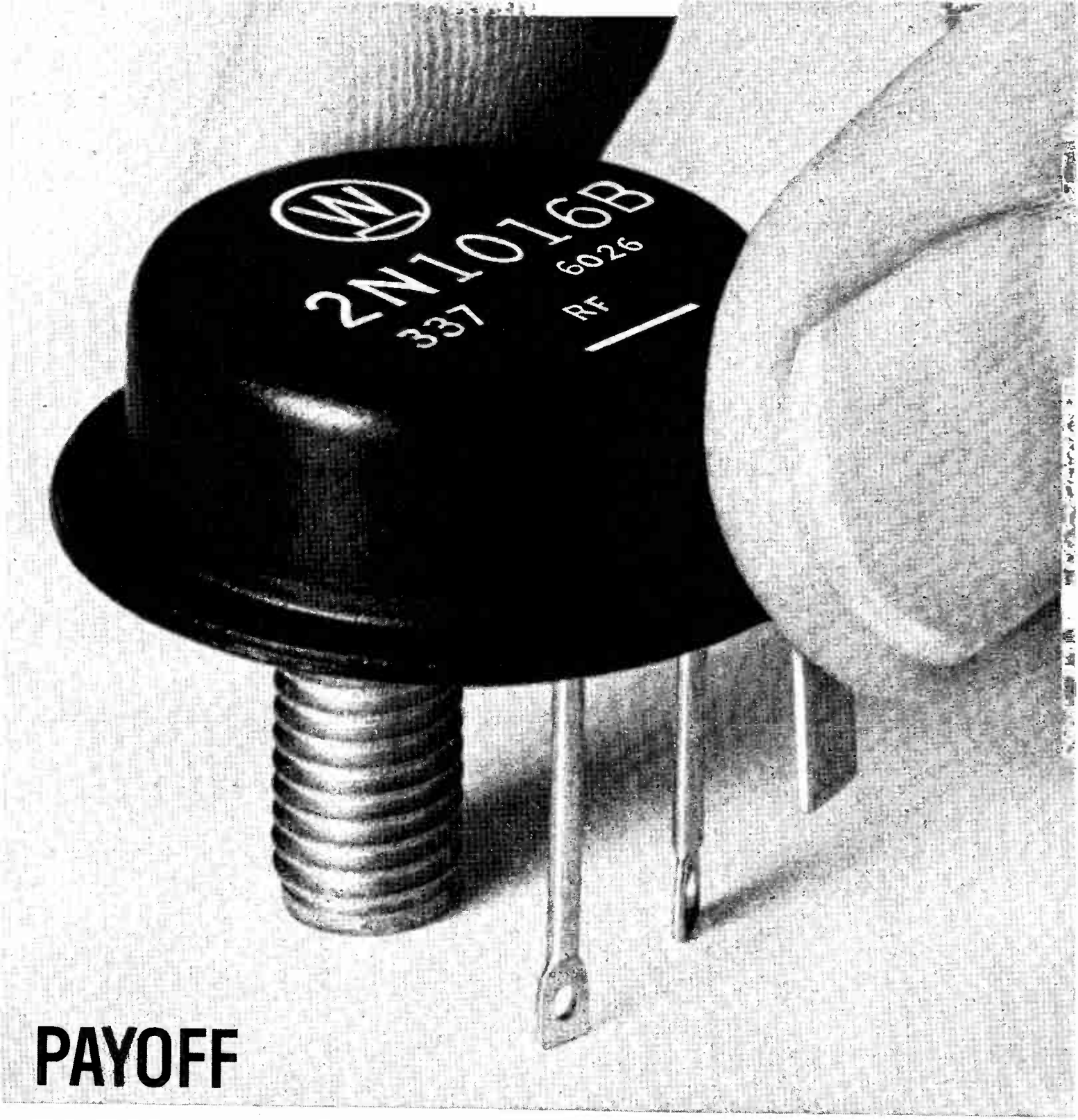

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Completely reliable performance of Westinghouse 2N1015 and 2N1016 series high-power silicon transistors . . . you can depend on: cooler operation, more safety factor in service, and twice the derating margin you can get in other types. High voltage ratings—up to 200 volts V_{CE}—mean an end to series connections of lower rated types. Also, you get the advantages of reduced inventory and convenient single-source purchasing. SC-1056

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WASHINGTON OUTLOOK

KEY ROLE IN SPACECRAFT rendezvous will be given electronics. When the first attempt to join in space a Mercury Mark II capsule and an Agena-B fuel cache is made in mid-1963, radar in the capsule and a transponder in the Agena-B will help bring them together. Infrared devices may bring the craft into proximity for the final approach. A two-foot long cone built on the spacecraft will be seated into the Agena-B rocket and locked into position when the final connection is made. Electrical connections in the cone will be mated with the fuel cache to relay command signals.

AIR FORCE PLANS to reequip the Navy's McDonnell F4H aircraft with a fire control system optimized for air-to-ground combat operations. The fiscal 1963 procurement schedule calls for large-scale purchase of the Navy plane. In the Navy version, the F4H's fire control system is optimized for the air-to-air interceptor operations.

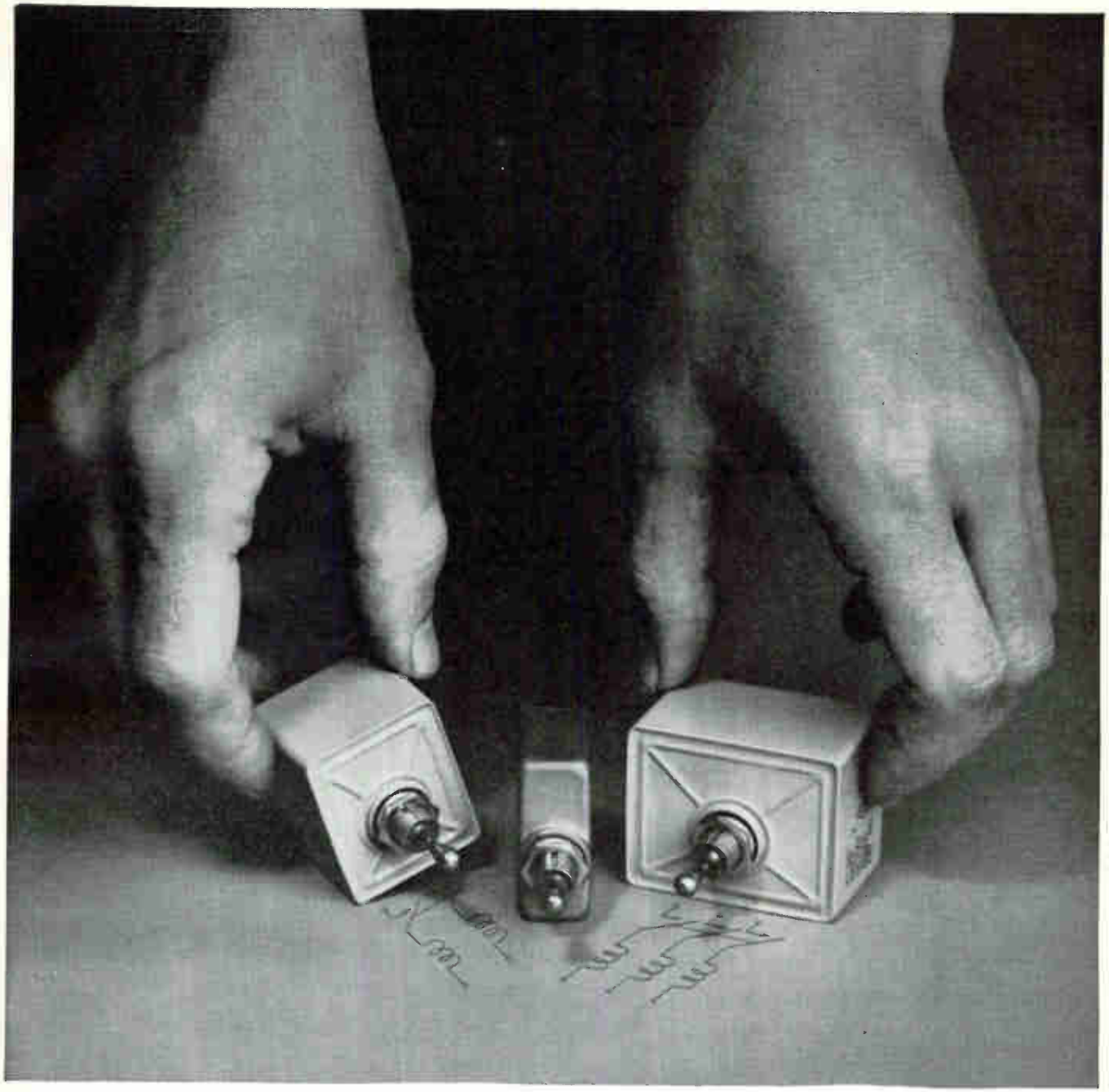
Air Force will presumably buy a modified version of the fire control system installed on Republic F-105 fighters. This includes General Electric's toss-bomb computer and North American Aviation's Autonetics search and range radar (Nasarr). Raytheon and Westinghouse are Navy contractors for the F4H fire control system. The Air Force estimates modifications of the F4H at roughly $500,000 each. But this estimate goes beyond the installation of new electronic equipment.

AEROSPACE INDUSTRIES ASSOCIATION estimates sales of aerospace products at roughly $14.8 billion in 1961, somewhat higher than last year. Unit production of military aircraft fell from 2,700 in 1960 to 2,500 in 1961. But rising expenditures for missiles and space vehicles partially offset the aircraft decline. Missile expenditures amounted to about $4.6 billion in fiscal 1961 ending last June 30.

AIA figures that sales for the 51 aerospace manufacturers showed a $500 million increase over 1960 to total $13.5 billion. Earnings for the firms are estimated at $240 million for the year, compared to $184 million in 1960. Sales in 1962 are forecast at about $15 billion. Commercial aircraft are about 15 percent of the volume.

FEDERAL AVIATION AGENCY officials will discuss with manufacturers at a Feb. 27 Washington conference new airborne equipment that will be required for a radar-oriented traffic control system. FAA has begun a five-year program to develop the new system in line with recommendations made two months ago by a presidential task force. The February conference will concentrate on radio-frequency, secondary radar and distance measuring equipment for the new system. Emphasis will be on equipment needs of private and business aircraft.

AMERICAN TRUCKING ASSOCIATION is making a concentrated effort to keep the nation's trucking firms informed about the availability and advantages of electronic accounting equipment for their operations. Association is now surveying 1,200 trucking companies with annual revenues exceeding $1 million to ascertain how much mechanical and electronic data processing equipment they now use, how much is on order, what accounting and statistical chores are now performed by such equipment and what functions users would like to have done by new equipment.



If you are designing for severe-environment service and need polyphase or multiple-circuit protection, these new subminiature two- and three-pole SM breakers can probably help you out.

Built to take rough going, they are designed to meet stringent specs for operation under conditions of shock, vibration, high humidity, sand and dust atmosphere, and salt-sea atmosphere. In addition, they will comply with requirements for explosion-proofing, fungus resistance, and high-altitude operation.

That's not all. The breakers are also temperature-stable (thanks to hydraulic-magnetic actuation). You don't have to derate them for high-ambient service. They will maintain nominal load capacity and calibrated trip points at any temperature from —40° to 100°C.

Now available in multi-pole models: Heinemann's rugged, Mil-type SM circuit breaker

And, nicely enough, you don't have to pay a weight or space penalty to get these capabilities. The two-pole SM weighs only 3¼ ounces, and measures just 1.5 x 1.25 x 1.9 inches (excluding handle). The three-pole model weighs 4½ ounces, measures 1.5 x 1.9 x 1.9 inches.

You can have both models in any integral or fractional current rating you need, from 0.050 to 20 amps, with either a "fast" or "slow" inverse time delay, or instantaneous trip. Both can be furnished in voltage ratings of 230V AC (max.), 60 or 400 cycles, or 50V DC (max.).

Our Bulletins 3502 and 3503 will give you complete technical information. A word from you will put them in the mail.

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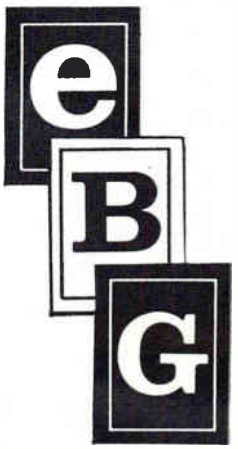

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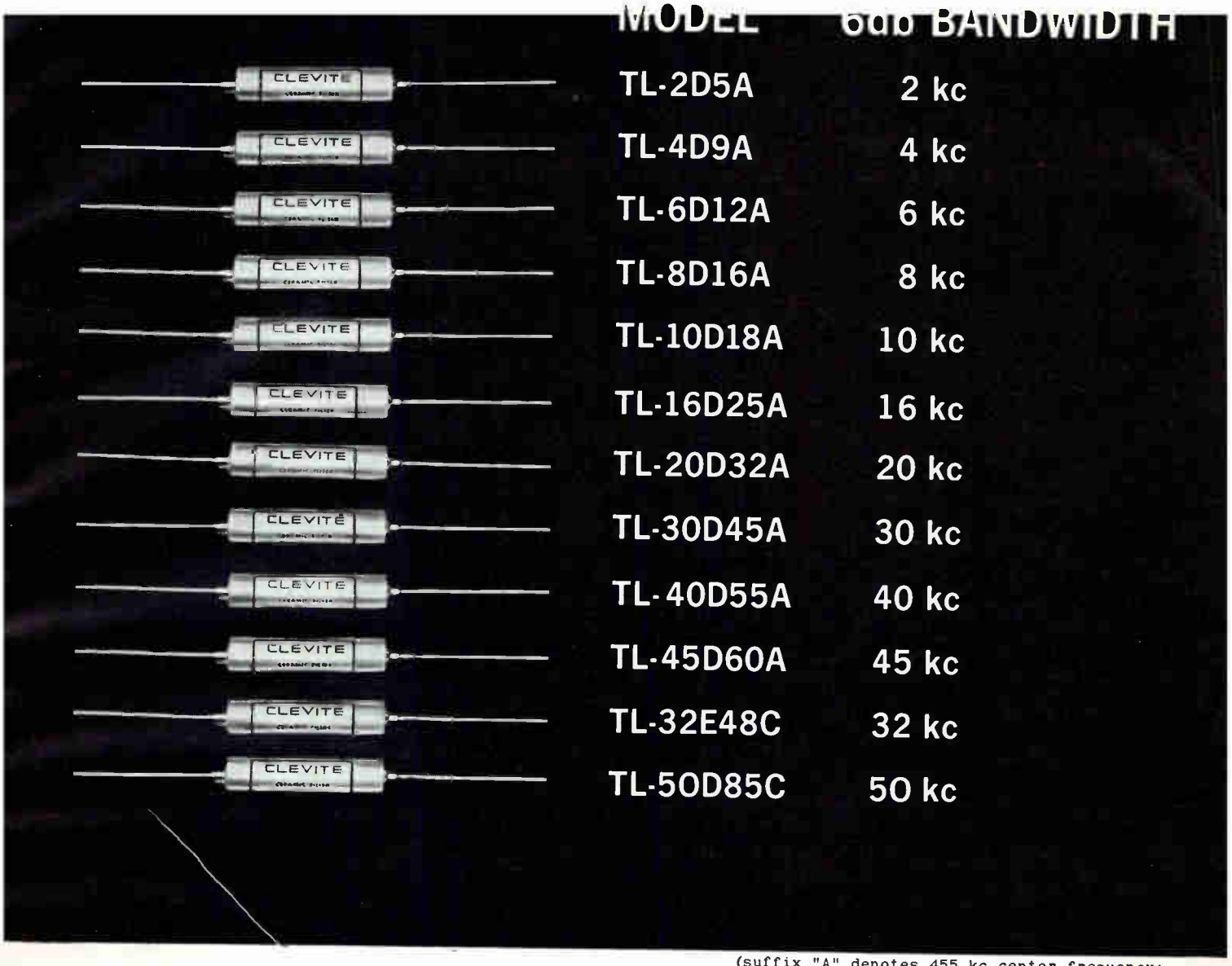

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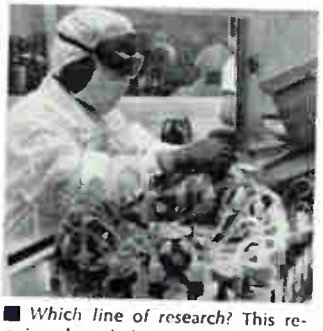

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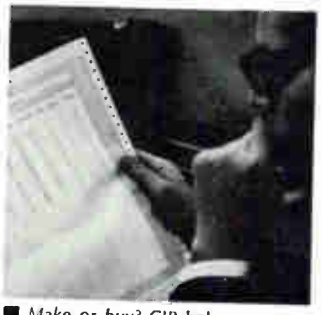

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1962 PREDICTION:

Competition Forces Careful Market Selection

Electronics executives generally agree that the way to bring profits back in line with volume is to sop up over-capacity with new markets

By THOMAS EMMA, Associate Editor

ELECTRONICS EXECUTIVES talk like deer hunters these days: it's hard to find a buck unless you know your woods. Company leaders are being more selective in the markets they aim at. Producing what the other fellow makes has led in many cases to more industry total volume, but less profit for the individual firm.

Other attitudes expressed generally in recent weeks include continuing reliance on research and development to develop new products and to remain competitive in developing fields. There appears to be a stepup in the trend away from heavy reliance on military and government business and toward industrial electronics.

Here, summarized, are comments on the state of the industry in 1962, as told to ELECTRONICS in recent weeks:

Turn the profit squeeze to advantage. With a general slowdown in the growth rate of new military systems, the entire industry is suffering from over-capacity. Developments have concentrated on the military market. To stay healthy and expand, the industry must turn its attention to other markets. The profit squeeze affecting all industries can benefit electronics companies able to devise aids to cheaper, better production. *D. W. Gunther, general manager, semiconductor dept., Westinghouse Electric.*

The day of the genius is over—at least for the electronics industry. The need now is for better marketing. Companies with strong marketing organizations are performing satisfactorily, indicating that technical competence alone is not enough. Overwhelming dominance of a company by scientists is the road to mediocrity. Except for space and military activities, the electronics industry competes with other businesses. For example, the company that produces an electronic computer to replace a mechanical computer is in the business machine field, not electronics. Newer companies will have to compete on that basis to survive. *Henry W. Harding, president, Laboratory for Electronics.*

New markets more difficult to define. Electronics grew in the past by creating and developing functionally new products and markets. Today, opportunities lie somewhat more in the direction of making the products of existing industries electronic. These new markets are more difficult to define and serve because of their diversity and fragmentation. The impact of developments on markets depends on how well products and services can be improved by performing functions electronically. Prime factors to watch: international developments and the ability of management to shape the direction of company R&D toward market opportunities. *Wendell R. Smith, vice president for marketing development, Radio Corporation of America.*

Sales high, profits restricted. Despite new highs in sales and orders, severe competition is putting the squeeze on profits. Developments to watch include new materials, miniaturization through molecular techniques, new electric and propulsion power sources. Advances in communications and data processing will be combined with new management techniques. Increased attention will be given technical and management help to underdeveloped nations. *Richard E. Krafve, president, Raytheon.*

More price competition ahead. The market is in an adjustment period which will continue with more price competition. Despite short term improvements in hardware demand, the emphasis on R&D will return when international pressures ease. Avoid upsetting price levels by over-engineering products that need not be complicated. Don't rush in to produce large numbers of a product for a small market showing some increase in demand. *Benjamin Katz, vice president, marketing, Monogram Precision Industries.*

Economies for the small company. Despite stiff competition and severe price cutting, progress will be made. Products designed within the past year account for 36 percent of this company's orders. The small company must affect time and labor savings by greater use of automatic and semiautomatic test equipment. *Elmer Gertsch, president, Gertsch Products.*

Cooperation between maker and user. Semiconductor markets will grow faster than the overall electronics industry. But dollar volume is lagging behind unit volume and must be expanded. The future will see more industrial business, more effect from microminiaturiza-

D. W. Gunther

H. W. Harding

W. R. Smith

R. E. Krafve

Benjamin Katz

Elmer Gertsch

Sidney Spiegel

Donald Boensel

George Singer

D. A. Potter

G. L. Haller

J. A. Kennedy

tion and integrated circuits. Semiconductor techniques can be improved by greater cooperation between maker and user. *Sidney Spiegel, vice president, marketing, Pacific Semiconductors.*

New power sources gaining importance. A factor for market growth will be new sources of electrical energy, such as fuel cells. Within the next four or five years there is likely to be a radical transformation in electrical generation and control equipment. Present opportunities are many because of missile and space programs, particularly in ground support gear. *Donald Boensel, vice president, Correlated Data Systems.*

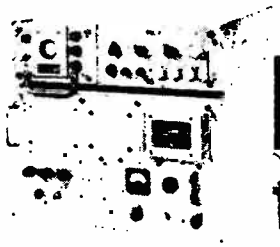
Short production runs favor small firms. Due to today's economy, there aren't too many major production runs. This puts the small company at an advantage. Companies organized for mass production runs are having a rough time of it. Since we are suppliers to larger companies, we can get into commercial markets as these large firms turn their efforts in such directions as commercial microwave. *George Singer, vice president, marketing, Rantec Corporation.*

Find new ways to finance R&D. The U. S. cannot afford national cutbacks in research and development spending, but the high cost of R&D programs take them beyond the scope of individual company problems. Automation may be the only way American industry can cut costs to compete abroad. The electronics industry is likely to remain intensely competitive for some time. Industrial markets provide more opportunities than the military market for developments in such fields as facsimile and cortation control. *Donald A. Potter, vice president and general manager, Stewart-Warner.*

Reinvest profits in R&D. To continue the rate of achievement that has characterized the industry demands a heavy reinvestment of profits in R&D. The general state of the electronics industry is one of rapid growth. Rising world population, mounting educational and medical needs are among factors in this expansion. *George L. Haller, vice president and manager, defense electronics division, General Electric.*

Refill the R&D bucket. Electronics can look ahead to market booms in consumer and some component areas. But it should pay particular attention to research associated with its own development. Industry should work with universities and research centers so it can be assured of the opportunity to return from time to time to refill the bucket for applied research. *John A. Kennedy, president, James Electronics.*

Market is good. The stepup in military aircraft procurement is helping component makers. The present state of the market is good and delivery schedules are more balanced. *Donald Duncan, president, Duncan Electronics.*



This is the CODE CONVERTER which takes Morse Code from the air at all speeds and odd rates and changes dot-dash to lengths of DC which are instantly locked and electrically stored 'til a word is complete on a digital board printer fed they come out code change automated language foreign or ours completely translated. all this from the house -that TRAK built

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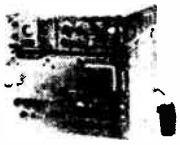

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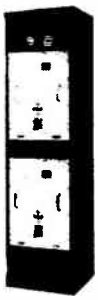

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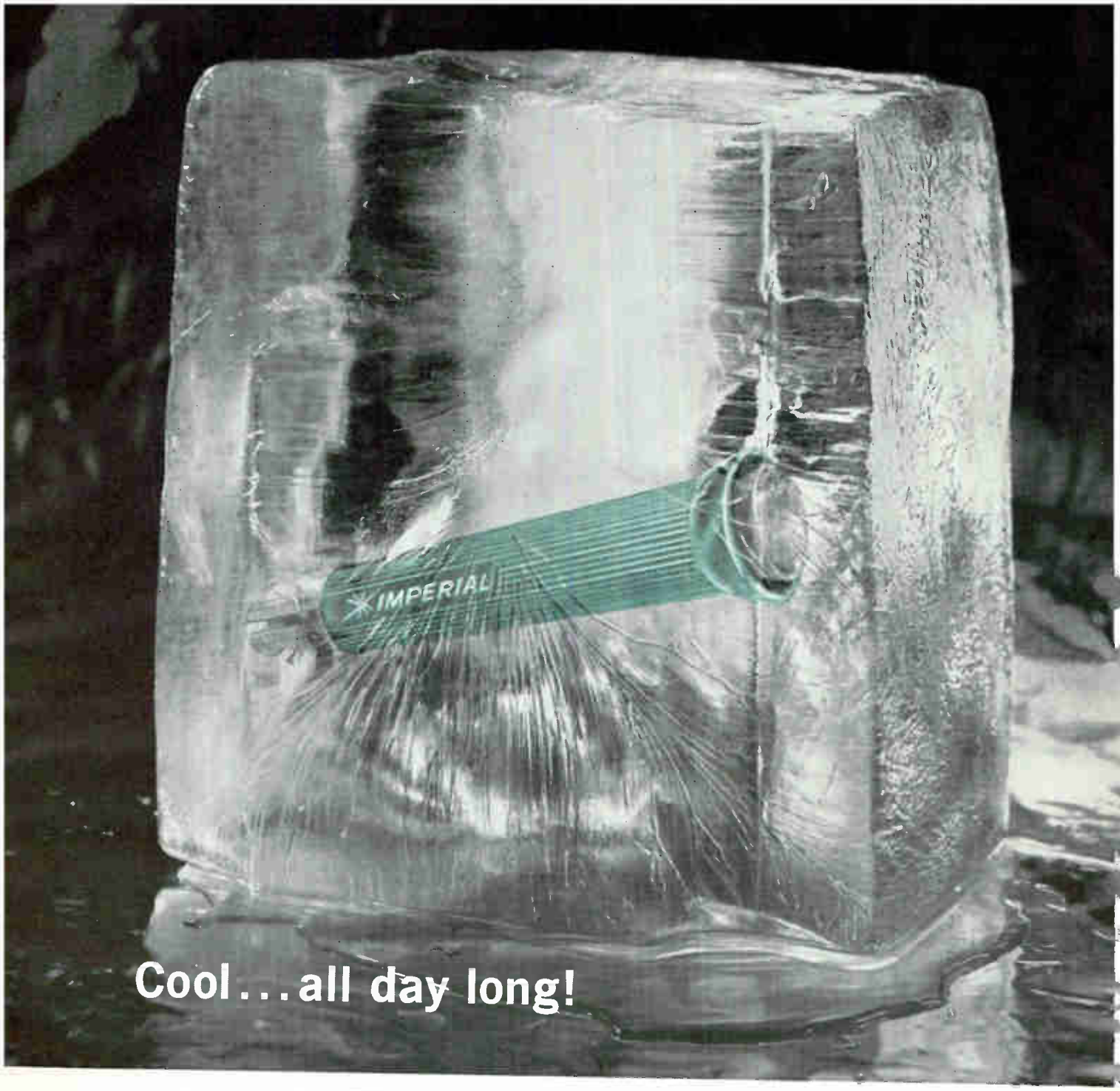

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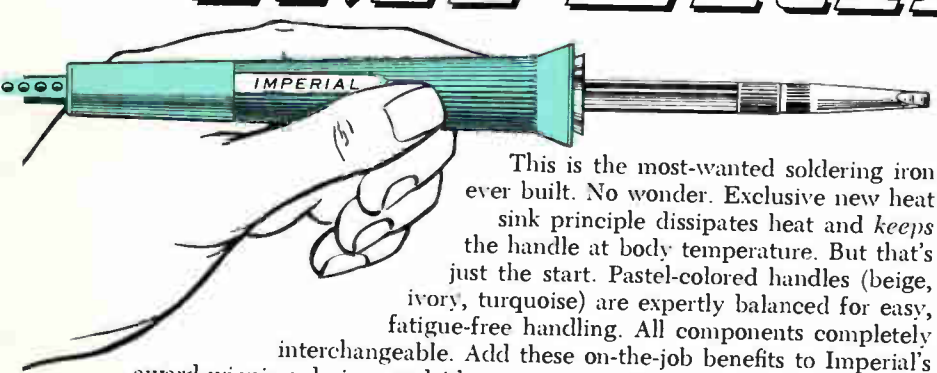

This is the most-wanted soldering iron ever built. No wonder. Exclusive new heat sink principle dissipates heat and *keeps* the handle at body temperature. But that's just the start. Pastel-colored handles (beige, ivory, turquoise) are expertly balanced for easy, fatigue-free handling. All components completely interchangeable. Add these on-the-job benefits to Imperial's award-winning design, and it's easy to see why this is the most popular soldering iron in the country. Mail this coupon today for all the facts.

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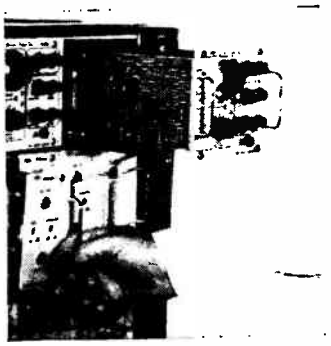


Modular concept extends instrument versatility, guards against obsolescence, cuts costs. Standard modules, designed to accomplish specific instrument and system functions, quickly plug into both front and rear of rack frames. Simplicity is highlighted throughout.

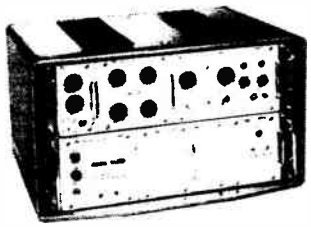
Take the numbers: 3450D, 2140A, 4550A, and 5510. Modify them, expand them, depend on them to provide you with the easiest, most flexible way to solve pulse instrumentation problems fast.

The secret: modular construction and adjustable pulse-forming controls—standard with all *Electro-Pulse* instruments. Interchangeable plug-in printed circuit modules quickly and economically extend instrument performance to meet a host of changing requirements. Integral front panels and controls achieve both electrical and mechanical standardization.

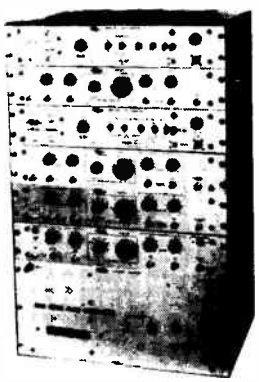
The popular "big four" shown here are only a few of the 33 cataloged instruments in Servo's broad *Electro-Pulse* line, which includes as many as 200 standard pulse and digital circuit modules (both tube and transistor types). Advanced pulse techniques and circuitry, coupled with traditional Servo instrument quality and reliability are another E-P plus.

Write for details...or for a Servo pulse specialist to discuss specific pulse instrumentation problems—and Servo solutions—with you.

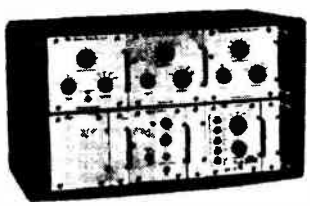
Modular flexibility...a Servo specialty...counters obsolescence, cuts pulse costs



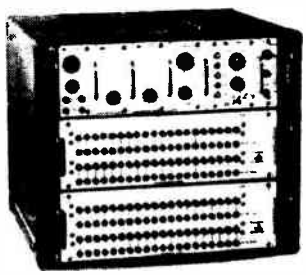
Popular 3450D general-purpose pulse generator quickly converts to six other standard pulse instruments. Versatility for production line or laboratory problems.



Precision 2140A double pulse generator provides separate or mixed output. Particularly adaptable to programmed operation in conjunction with semi-automatic checkout systems.



"Workhorse of the engineering lab," transistorized 4550A 10 mc pulse generator features wide range of rep rates, delay times, and pulse widths. Computer makers like its 10 nanosec rise time.



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Will The Russians Go Around the Moon

NASA favors the moon's equatorial belt, between 10 deg N to 10 deg S, for operational base. Ranger 3 will aim for the region between Kepler and Copernicus (top left). Soviet Prof Petrovich has said Soviets favor polar region for milder climate (USAF Lunar Reference Mosaic)

Although the U. S. moon flight program is gathering steam fast, aiming at circumlunar flight after 1965, the USSR may try it in early 1962

By JOHN F. MASON,
Associate Editor

RUMORS THAT the Soviets plan to send a man around the moon early in January have been persistent during the past few months.

According to a Reuters report, purpose is to study the moon's surface for a suitable automatic laboratory site. The spacecraft will be launched from Baikonur, about 100 mi east of the Aral Sea. A man will not land on the moon before 1964, Reuters said.

Radio Belgrade said a "lunanaut" on a five-day trip would study the moon's surface with an automatic astronomic observatory and photograph it with a special camera. According to Belgrade, Soviet long-range missiles launched to the Pacific in September tested the mechanism for the circumlunar spacecraft.

On Oct. 1, a Polish writer, Piekarowicz, predicted a Russian flight in 1962 or 1963. Trajectory would be similar to that Lunik III took to photograph the far side of the moon in 1959.

Whether the Soviets will attempt a lunar mission of any kind in January has not been formally announced by the USSR. If they should send a vehicle to the moon and try to recover it, it will probably not carry a man. Besides the chances of failure in guidance, control, deceleration, heating, and propulsion, there is also radiation.

Although eventually both the Soviets and the U. S. will achieve manned circumlunar flights, the philosophies behind the two missions may well be different. A manned circumlunar flight at this time would have more propaganda value than scientific. NASA regards this specific project as necessary practice for landing a man on the moon.

Circumlunar flight, manned or unmanned, is not the best way to survey the moon's surface. Even at 200 miles—the closest approach a circumlunar flight will probably achieve—camera resolution is not sufficient to survey a proposed landing site. Cracks and rock size, dust and flying debris could not be examined.

Such considerations, however, do not rule out a Soviet attempt to send a man around the moon. The Soviets are keenly aware of the value of propaganda.

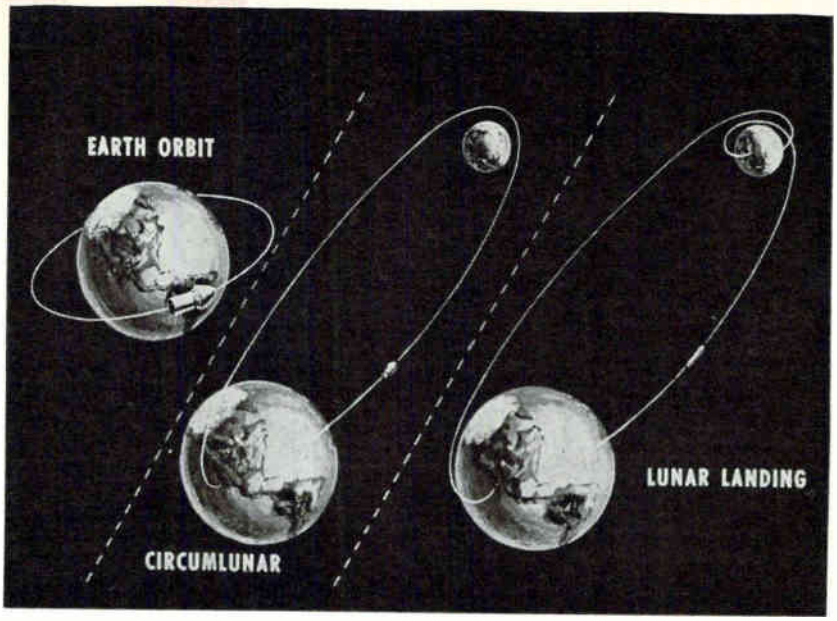
NASA plans to get a usable look at the surface by tv pictures transmitted back from the unmanned Ranger 3 as it approaches the moon for a crash landing early in 1962 (ELECTRONICS, p 24, June 23; p 20, Aug. 4). Six more Rangers will follow. In 1963 there will also be 10 Surveyor missions. They will orbit the Moon, make soft landings, and transmit tv signals, chemical analyses and other data. Besides locating a safe landing spot for men, these unmanned expeditions will provide engineering data for follow-on spacecraft.

For science, they will examine the lunar surface and subsurface for a possible answer to the origin of the solar system.

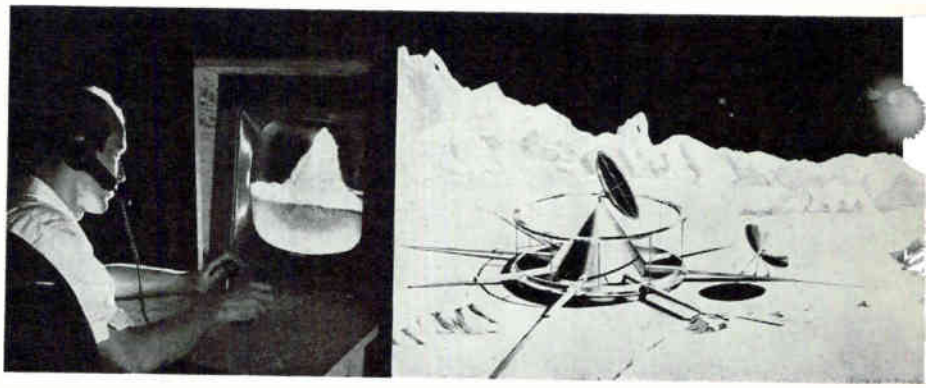
As a later preparation for manned landing, the Prospector spacecraft will land tons of supplies and equipment at a predetermined depot site, possibly including a jeep type vehicle, a small radiation shelter and rockets to return surface samples to Earth.

Soviet Prof. Petrovich described

This Month?



Circumlunar trajectory will intersect moon's orbit ahead of the moon, then be swung around moon's field of gravity to an Earth-bound direction (NASA)



Moon-based station can televise surroundings to Earth-based receiver (AIL division of Cutler-Hammer)

Soviet plans for such a mobile station in the *Bulletin of the USSR Academy of Sciences*, according to Soviet news service Tass on Dec. 26, 1959. In Oct., Soviet scientist Mikhaylov announced development of an Earth-controllable, mobile moon-station with tv data link. Soviet writer Varvarov recently proposed a moon-based radio relay station to enhance moon-bounce signals.

To date, NASA has no plans for such a project. Bell Telephone Labs' J. R. Pierce does not feel the moon is suitable for such a relay station. It would be easier to put up a satellite.

The most important results of landing a man on the moon are probably those that can not be foreseen before man gets there. A known possibility is using the moon as a way-station for planetary missions. Piekarowicz predicted the Soviets would have a permanent moon-base for this purpose by 1970. NASA's John H. Discher, assistant director of Apollo spacecraft development, told ELECTRONICS such a concept is possible but that the first way-station to other planets might be man-made Earth orbital platforms.

According to Petrovich the Soviets favor the lunar polar regions for an operational base, seeking a milder climate than elsewhere on the moon. This, Petrovich said, was the best place for landing, for launching vehicles back to Earth and for storing fuel.

If Petrovich's views prevail the Russian and American expeditions to the moon may never meet.

NASA, Discher says, likes the region between 10 deg north and 10 deg south of the lunar equator, facing Earth. (See moon photo strip). The local surface appears desirable and heat and cold extremes are not considered insurmountable.

The phase of the moon is not important in timing a circumlunar flight, according to Discher. Even when the Sun is not shining on the moon, sunlight reflected from the Earth—earthshine—is sufficient for good viewing, as bright as an electrically lighted room.

NASA's first circumlunar manned flight will come after 1965, as step two in the three-step Apollo program. Step one, in 1964, will put three men in Earth orbit. The final Apollo objective in 1969 is landing men on the moon.

Apollo will have three modules: command-center module to house the crew, a propulsion unit, and lunar landing rockets.

In Earth-orbital flights the propulsion unit will return the craft to Earth. It will also be used for orbital maneuvers and rendezvous. North American Aviation will build this and the crew module (ELECTRONICS, p 14, Dec. 8).

For circumlunar flights, the propulsion module will return the spacecraft to Earth from any point along the lunar trajectory, provide midcourse and terminal guidance corrections, place the spacecraft into a satellite orbit around the moon and eject it from that orbit and return it toward Earth. For the lunar-landing mission, the same module will be the takeoff stage from the moon.

For circumlunar flights, Apollo will use a Saturn C-3 or C-4 which will include several F-1 engines in the first stage. NASA believes the C-3 will be capable of a simple figure "8" circumlunar orbit and return. The trip will take six or seven days. Distance from the moon at closest approach will be from 200 to 1,000 miles on the backside of the moon. It will not be at all close to the Earth side of the moon. The more powerful C-4 could put the craft into a 100-mi lunar orbit and later back into a trajectory toward the Earth.

A lunar satellite would have the advantages of proximity, good coverage and continuance. Obtainable data include surface, geo-

logical, magnetic field and mass distribution details.

A circumlunar trajectory is extremely sensitive. If the right initial velocity is not achieved an unguided ballistic trajectory would end up above or below the Earth, rather than on it.

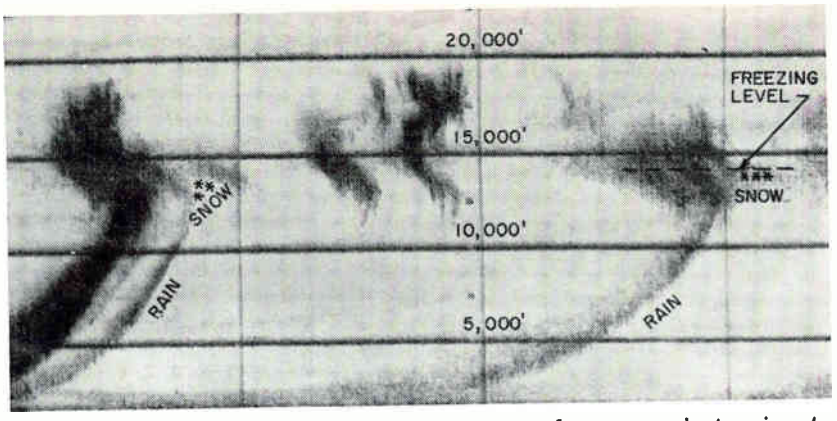
Due to the high possibility of errors in initial velocity and the unappealing consequences, corrections will be made during the Apollo flight. Guidance will be carried on board the craft. An inertial-accelerometer platform will be corrected by optical Earth-moon-star sightings made by the crew. Several corrections will be made on the way to the moon, none in its vicinity if the mid-course corrections were accurate, and several on the return to Earth. (There could be a very crucial moment in the vicinity of the moon. If the velocity is 100 fps too high, the moon's orbital motion and gravitational field could accelerate the vehicle out of the Earth-moon system and into a hyperbolic orbit around the sun.) At about ¾ of the way to the Earth, the pilot will make a guidance correction to align the craft with the narrow corridor through which he must approach the Earth.

Reentry into the Earth's atmosphere poses severe problems of guidance and control, deceleration and heating.

The craft will be entering at 25,000 mph. If it were a simple ballistic capsule it would have to enter a flight-path corridor with an accuracy of only 3½ miles above or below the trajectory. If the capsule undershoots, the occupants will be destroyed by the high deceleration forces or burn up in the atmosphere. If it overshoots, the vehicle will make another trip into the radiation belts, getting back to Earth several days later, if at all.

NASA is working to improve guidance systems to meet this severe accuracy requirement. The Apollo circumlunar craft, however, will not be ballistic; it will be semi-ballistic with some aerodynamic lifting capabilities. This will increase the permissible entry-corridor to about 40 miles thus alleviating the guidance problem and deceleration.

Once in the atmosphere, guidance instruments will include radar altimeters and bank-angle indicators.



Cloud height radar recording tells forecaster where snow is turning to rain. Slope changes as droplets fall faster

Global Weather Net Grows

WESTOVER AFB, MASS.—New ground radars and other equipment are being tested at this SAC base and at Hanscom Field, Bedford, as part of the gradual development of the Air Force's global weather system.

The 433L system will eventually be a high-speed network for weather data sensing, processing, forecasting and communications. New techniques will be incorporated without interrupting existing AF weather service.

System test beds at Hanscom and Westover combine radar, tv, computer and teletypewriter to speed data to SAC, TAC and other commands. Col. George A. Guy, of Electronic Systems Division, Hanscom, is managing the network's modernization. United Aircraft, program integration contractor, has set up a weather system center in Hartford, Conn.

Radar spots severe local storms approaching from as far as 100 miles

AN/FMQ-5 automatic weather stations are being tested at Westover and Hanscom. These convert sensor data into digital form, compute such parameters as runway visual range, and feed digital outputs to teletypewriters, printers, displays and communication circuits. Information goes to on-base meteorologists and user commands by closed-circuit tv and also is fed to the global system upon periodic demand from a control center.

FMQ-5 is built by Siegler's Olympic division, which also produced the AN/TPQ-11 cloud height radar (ELECTRONICS, p 62, Mar. 31, 1961). This radar, and a Curtiss-Wright storm detection radar, are the first two new devcies in 433L. They are expected to be operational in 1964.

A TPQ-11 has been installed at Hanscom. Working in the K_a band between 34.5 and 35.6 Gc, it profiles cloud density overhead. It detects cloud bases and tops at altitudes of 500 to 60,000 ft, for crt display and facsimile recording. One of its uses is in forecasting onset and dissipation of fog and precipitation. Information on cloud layers above the fog helps tell when the fog will burn off.

Operational versions of TPQ-11

are expected to use 0.5 μsec pulses at a rate of 1,000 pulses a second, twice the present rate. A circular-mode magnetron developed by SFD Laboratories under AF contract is in preliminary tests.

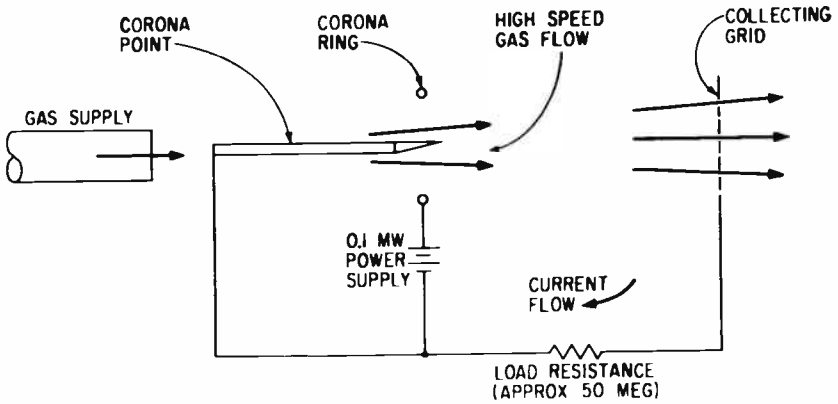
The storm detection radar, produced by Curtiss-Wright under Navy contract, is being tested at an AF Cambridge Research Lab site in Maynard, Mass. The main ppi scope uses a new storage and display tube developed by Skiatron and made by National Union Electric. Purple-on-white is used for persistent display. Conventional phosphor gives vertical display of storm intensity and height.

The Air Weather Service's Global Weather Central at Offut AFB, Neb., will have facilities to process and transmit information instantaneously to AF and Army units around the world.

Offut processes weather information in an IBM 7090. Graphs and charts, generated from raw data received by teletypewriters, are disseminated to users throughout the system. Teletypewriter speed may eventually be increased from 100 wpm, at present, to 2,000 wpm.

Tv sends teletypewritten forecast to user commands. Modified line feed displays 24 characters a line

Information from human observers can be fed manually into automatic weather station



Kinetic energy of high-speed gas is changed into electricity in GE's electrohydrodynamic generator

Gas Energy May Yield Power

ELECTROHYDRODYNAMIC GENERATION of megawatt power may result from investigations underway at General Electric's Missile and Space Vehicle dept. Using the arrangement shown, GE scientists recently reported generating 1.4 milliwatts at 170 v with 0.1 milliwatt being supplied externally.

This is significant, they claim, because it shows that such a system, derived from the electrostatic generator, can produce more electrical power than it consumes. In the GE device the kinetic energy of a moving gas is changed into electricity in a process termed electrohydrodynamics.

Present effort is aimed at developing a practical device for such applications as space vehicle ion engines.

In the experimental generator, which was developed under contract with the Air Force Aeronautical Systems Division, air is forced at near-sonic velocity through a corona discharge and ionized. The resulting electrons are drawn off in the area of the corona field while the ions are pushed down-stream by neutral atoms to a collecting grid where they recombine with the electrons.

Electron flow from the corona through the circuit to the collecting grid constitutes a current of approximately 10 microamperes. GE reports it is now investigating another method of ionization to get higher current.

For gases whose mobility is in the range of 1 cm a second per volt-cm, calculations show the system could yield 20 Kw a sq meter corona ring area. Efficiency would be low.

Gases or other substances, such as the aerosols, with lower mobility characteristics would give higher efficiencies. Marks Polarized Corp. is reported to have developed an aerosol generator for the Navy that shows promise of high efficiency.

GE reports it is looking at one system, which when used with the new ionization scheme might permit outputs on the order of several megawatts a cubic meter. Also under study are materials for preventing electrical breakdown at 10 Kv.

Because the device is potentially a simple, high-voltage power source, GE researchers see it as applicable to ion engines, which require potentials in the Kv range. It might also be useful for commercial power generation although power densities are not expected to exceed what might be produced by an MHD generator.

Multichannel Electronic Analgesic Is Offered

WEBCOR will offer to doctors and dentists next year a 10-channel magnetic recorder for analgesic use. The company says it will permit use of music and voice, for more effective results than white noise alone. The physician can superimpose his voice over prerecorded sound.

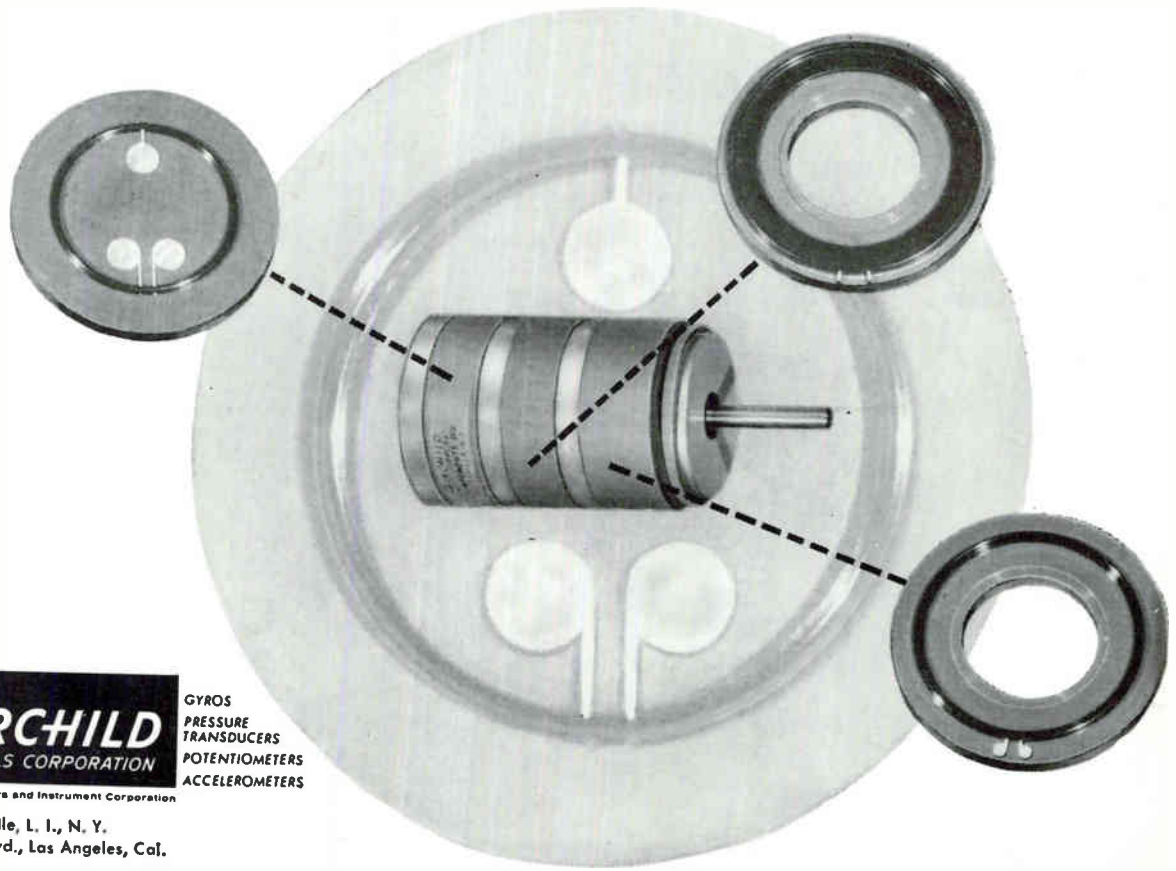
ANOTHER FINE PRODUCT OF FAIRCHILD RESEARCH

"FAIRITE" CONDUCTIVE PLASTIC POTENTIOMETERS

Fairchild, the leader in precision potentiometers, takes another giant stride in technological progress with infinite-resolution, conductive plastic potentiometers having Fairchild reliability "built-in" ■ "Fairite" potentiometers utilize a continuous track of specially prepared, conductive, high impact plastic co-molded with an insulating base of the same heat-resistant material to provide superior performance under temperature and humidity extremes ■ Temperature cycling tests of this advanced Fairchild design shows that resistance values are consistently reproduced ■ Resistance stability is maintained by Fairchild's unexcelled production skills which assure sufficient conductor bulk to virtually eliminate effects of wear ■ Low end-loss positive connections are achieved through co-molding of silver terminations with the conductive track. In addition, track geometry can be varied to obtain optimum functional conformity ■ Reliable operating life of many millions of cycles is assured through the resistance stability of Fairchild's "Fairite" conductive plastic potentiometers. For more information, write Dept. 53E.

FEATURES: INFINITE RESOLUTION/UNSURPASSED RELIABILITY/RESISTANCE STABILITY/CONSTANT RESISTANCE VALUES/LOW END-LOSS/LONG LIFE/COMPLETE RANGE OF SIZES

ELECTRICAL		ENVIRONMENTAL	
Resistance Range, ohms	2K — 50K ± 10%	Temperature Range	—65°C to + 150°C
Ind. Linearity	0.5% standard	Humidity	95% to 100% RH at 71°C
Resolution	Virtually infinite (less than .005°)	Vibration	10 G's to 2000 cps
Temperature Coefficient	Negative 3-400 ppm	Life	Over 10 million cycles at 600 rpm
Power Rating	2 watts at 20°C		



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MEETINGS AHEAD

RELIABILITY AND QUALITY CONTROL Symp., PGRQC of IRE, AIEE, ASQC, EIA; Statler Hilton Hotel, Wash., D.C., Jan. 9-11.

OPTICAL CHARACTER RECOGNITION Symposium, Nat. Bur. Stds., Dept. of Interior Aud., Wash., D.C., Jan. 15-17.

ELECTRICAL ENGINEERING Exposition for electrical-electronics industry, AIEE; N.Y. Colisium, N.Y.C., Jan. 29-Feb. 2.

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

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

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

APPLICATION OF SWITCHING THEORY TO SPACE TECHNOLOGY Symp., USAF, Lockheed Missiles & Space Division; at Lockheed, Sunnyvale, California, Feb. 27-Mar. 1.

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

MISSILES & ROCKET TESTING Symp., Armed Forces Communications & Electronics Association; Coca Beach, Fla., Mar. 6-8.

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

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

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

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

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

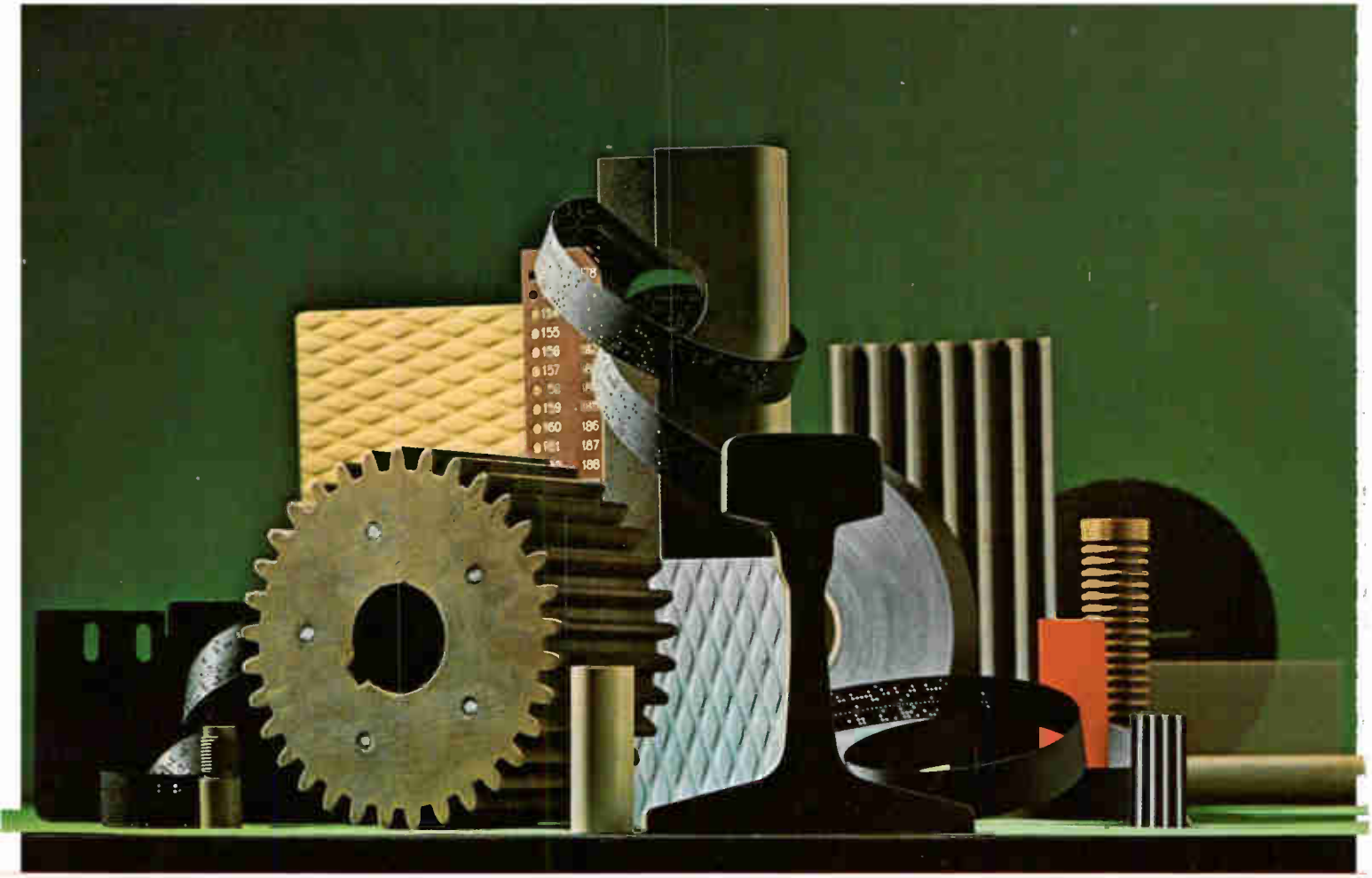
JOINT COMPUTER CONFERENCE, PGEC of IRE, AIEE, ACM; Fairmont Hotel, San Francisco, Calif., May 1-3.

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

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

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

MICROWAVE Theory & Techniques National Symposium, PGMTT of IRE; Boulder, Colo., May 22-24.



THIS remarkable plastic may trigger a new (or cost-saving) design idea for you

National Vulcanized Fibre is unique. It's a tough, cellulosic plastic—not mere paper or fiberboard. Vulcanized Fibre possesses an unusual combination of mechanical, electrical and thermal properties. For example . . .

It weighs one-half as much as aluminum, yet is one of the strongest materials known per unit of weight. It's tough, durable and cushions the shock of repeated blows.

Vulcanized Fibre has superior arc-resistance. It comes in standard and special grades, including a fire-resistant grade called "Pyronil." It can be machined, formed or deep-drawn into intricate shapes, and can be combined with other materials . . . aluminum, rubber, "Mylar," copper, laminated plastic, plywood, to name a few.

You can polish it, paint it, lacquer it, emboss it. And regardless of the finish, it resists oils, gasoline, fungi, most solvents. Most surprising is its low cost.

Find out for yourself why National Vulcanized Fibre is "the plastic with a million uses." There's a free sample kit waiting for you at a nearby NVF sales office. Check Sweet's Product Design File 2b/Na for the one nearest you. Or write directly to Dept. P Wilmington, Delaware.

116 Choices: One Source This is the latest count of the different plastics and grades NVF can offer in your search for the *one best material*. Add to this total *the* one special grade that can be developed from scratch to meet your particular need. This full range of materials is backed by complete engineering services . . . from application assistance up to and including the delivery of 100% usable, precision-fabricated parts . . . in any quantity, on time!

Call the NVF Sales Office near you. It's a direct line to single-source help on your current materials problem.

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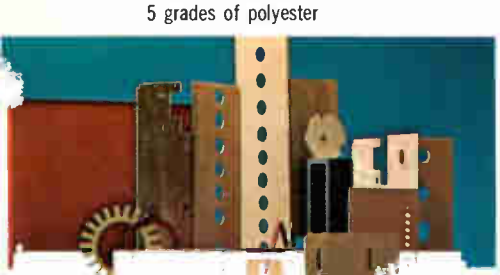
5 grades of polyester



85 Phenolite® laminates

3 thermoplastics . . . nylon, Delrin®, Penton®

There is a curious correlation between leading edge requirements and the state of the electronics art. Both have advanced together, and both move forward in discrete steps. Sixty cycle technology had its own attitudes, components and techniques. These were replaced when millisecond switching became important. Later on, rise times were measured in microseconds, and a corresponding set of components, techniques and attitudes made its appearance. Today, The Nanosecond Edge is the common and critical requirement. And a new generation of techniques has matured. All solid-state design is standard; performance is predicated on new orders of precision, speed and control; and the demands of a new and realistic concept of Reliability affect every design.

A new generation of Test Equipment has also made its appearance. It is typified by the Rese Model 203. This all solid-state, general purpose, pulse generator is *the basic* pulse instrument wherever the Nanosecond Edge has become important. It offers for the first time in the industry guaranteed linear rise and fall times over its entire range—20 nanoseconds to 2 μseconds with continuously variable controls over all the parameters of the pulse.

The design of the 203 is based on procedures normally followed in the computer field. All circuits are designed so that the components function at end-of-life values. Tolerancing is done on a worst case basis, and all transistor parameters are derated. The result is a superior instrument which provides that extra edge in Reliability, Controllability, Maintainability and Precision which the problems of design, maintenance and production demand.

For detailed specifications and the full story of the Model 203 contact Rese Engineering, Inc., A and Courtland Streets, Phila. 20, Pa.

THE NANOSECOND EDGE

pulse generator 203

rese

rese engineering, inc.

ELECTRONICS MARKET TABLES 1961 1962 1965

TOTAL ELECTRONICS INDUSTRY

	1961	1962	1965	1970
FEDERAL	7.56	9.6	12.37	10.0
INDUSTRIAL	2.63	3.0	3.9	6.5
CONSUMER	2.67	2.7	2.9	4.0
REPLACEMENT COMPONENTS	1.5	1.5	1.7	2.0
TOTALS	14.36	16.8	20.87	22.5

(Billions of dollars)

Sources: U.S. Department of Commerce, Bureau of the Census
Electronics Division, BDSA, U.S. Department of Commerce
Electronics Production Resources Agency
Electronics Industries Association

FEDERAL ELECTRONICS

	1961	1962	1965
	(Millions of dollars)		
FEDERAL ELECTRONICS TOTAL	7,560	9,622	12,370
Department of Defense	7,300	9,191	11,720
Procurement	4,300	4,971	6,220
R & D T E	2,000	3,000	4,000
Operations & Maintenance	1,000	1,220	1,500
National Aeronautics & Space Adm.	200	267	500
Procurement	100	67	200
R & D T E	100	200	300
Federal Aviation Agency	50	131	100
Procurement	25	74	50
R & D T E	25	57	50
Atomic Energy Commission	10	33	50
Procurement	4	13	25
R & D T E	6	20	25

CONSUMER ELECTRONIC PRODUCTS

	1961	1962	1965
	(Millions of dollars)		
R ELECTRONICS TOTAL	2,669	2,715	2,880
S TV TOTAL	1,125	1,130	1,140
White	1,050	1,030	1,000
	75	100	140
TS TOTAL	382	375	400
	240	165	130
	18	50	75
	120	125	125
	4	35	70
PHS TOTAL	487	495	500
	57	57	55
onic	430	438	445
RDERS			
l & Stereo)	56	60	75
TAPE	300	310	350
ITY TOTAL	67	70	80
s	14	15	16
	9	9	10
kers	12	13	13
s & Cartridges	10	10	11
	22	23	30
ECTRONIC	140	150	175
QUIPMENT (incl. CB)	65	70	80
	35	40	60
asure boats) TOTAL	12	15	20
	3	3	4
nders	3	3	4
phones	4	6	7
Finders	1	1	2
Alarms	1	2	3

The figures are listed so that the amount shown after each heading is the **total** of its subdivisions; all **totals** read upwards

electronics a McGraw-Hill Publication

COMPONENTS MARKETS

	1961	1962	1965
	(Millions of dollars)		
ELECTRON TUBES TOTAL	593	610	640
Receiving Tubes	331	330	296
Miniature	209	210	190
Subminiature	22	22	20
Standard Glass	86	85	75
Other	14	13	11
Power & Special Purpose	262	280	344
High Vacuum	61	60	60
Gas & Vapor	26	27	28
Klystrons	51	52	55
Magnetrons	39	42	50
Traveling Wave Tubes	26	31	70
Backward Wave Oscillators	13	18	26
Light Sensing, Emitting & Storage	31	36	40
Other	15	14	15
TV PICTURE TUBES	225	240	265
SEMICONDUCTORS TOTAL	606	672	939
Transistors	335	371	575
Silicon	106	107	225
Germanium	229	264	350
Diodes & Rectifiers	271	301	364
Silicon	114	120	150
Germanium	55	60	75
Selenium	18	20	19
Silicon Controlled Rectifiers	15	21	26
Microwave Diodes	6	8	10
Zener Diodes	38	40	44
Photo Cells (incl. infrared)	7	12	15
Other (solar cells, tunnel diodes)	18	20	25
RELAYS TOTAL	190	200	210
Electromagnetic (less coaxial)	100	102	104
Telephone Type	32	34	36
Coaxial	7	8	13
Crystal Can	12	13	13
Stepping	11	12	12
Thermal	5	7	8
Other	23	24	24

	1961	1962	1965
	(Millions of dollars)		
RESISTORS TOTAL	271	295	296
Fixed	128	144	137
Composition	54	58	56
Carbon	27	29	28
Metal Film	13	18	18
Wirewound	34	39	35
Variable	121	128	134
Nonwire wound	48	49	50
Wire wound	73	79	84
Nonprecision	13	14	17
Precision	60	65	67
Other (varistors, thermistors, etc.)	22	23	25
COMPLEX COMPONENTS [1]	33	35	50
CONNECTORS TOTAL	178	182	291
Coaxial (rf)	26	28	58
Cylindrical	66	66	75
Multiple Contact	47	47	68
Printed Circuit	13	14	38
Other (also fusion sealed)	26	27	52
QUARTZ CRYSTALS	26	27	30
TRANSFORMERS & REACTORS	174	185	191
ANTENNAS & HARDWARE	220	228	240
ELECTROLUMINESCENCE	6	7	8
MICROWAVE COMPONENTS (Less tubes & antennas)	94	96	105
MICROMINIATURE DEVICES	10	12	60
DELAY LINES	15	17	20
FILTERS	30	38	65

[1] Packaged components; two or more components packaged and shipped as a single unit but not a complete circuit function. Also includes modules which have several components packaged and shipped as a single unit, which comprise a complete circuit function.

	1961	1962	1965
	(Millions of dollars)		
TRANSDUCERS TOTAL	101	123	150
Accelerometers	11	12	15
Pressure	35	39	48
Displacement	30	33	40
Strain	18	20	24
Other	7	19	23
PRINTED CIRCUIT	33	36	45
FERRITE DEVICES	15	16	20
CAPACITORS TOTAL	286	316	345
Paper & Film Dielectric	101	103	90
Electrolytic, Aluminum	48	48	45
Electrolytic, Tantalum	62	70	80
Mica (incl. glass, vitreous enamel)	20	30	50
Ceramic	30	35	40
Variable (mica, ceramic, glass & air)	25	30	40
WIRE & CABLE TOTAL	228	235	251
Hookup Wire	78	75	70
Magnet Wire	60	63	70
Resistance Wire	10	12	15
Coaxial Cable	40	45	55
Other	40	40	41
THERMOELECTRIC MODULES	5	6	10
POWER SUPPLIES (subassembly)	25	27	30
TIMING MOTORS (Synchronous & nonsynchronous)	9	10	15
SERVOS & SYNCHROS TOTAL	46	60	80
Resolvers	3	5	10
Gyros	9	12	14
Servo Motors	12	15	20
Synchros	18	22	27
Rate Generators	2	3	5
Motor Generators	2	3	4

INDUSTRIAL ELECTRONICS

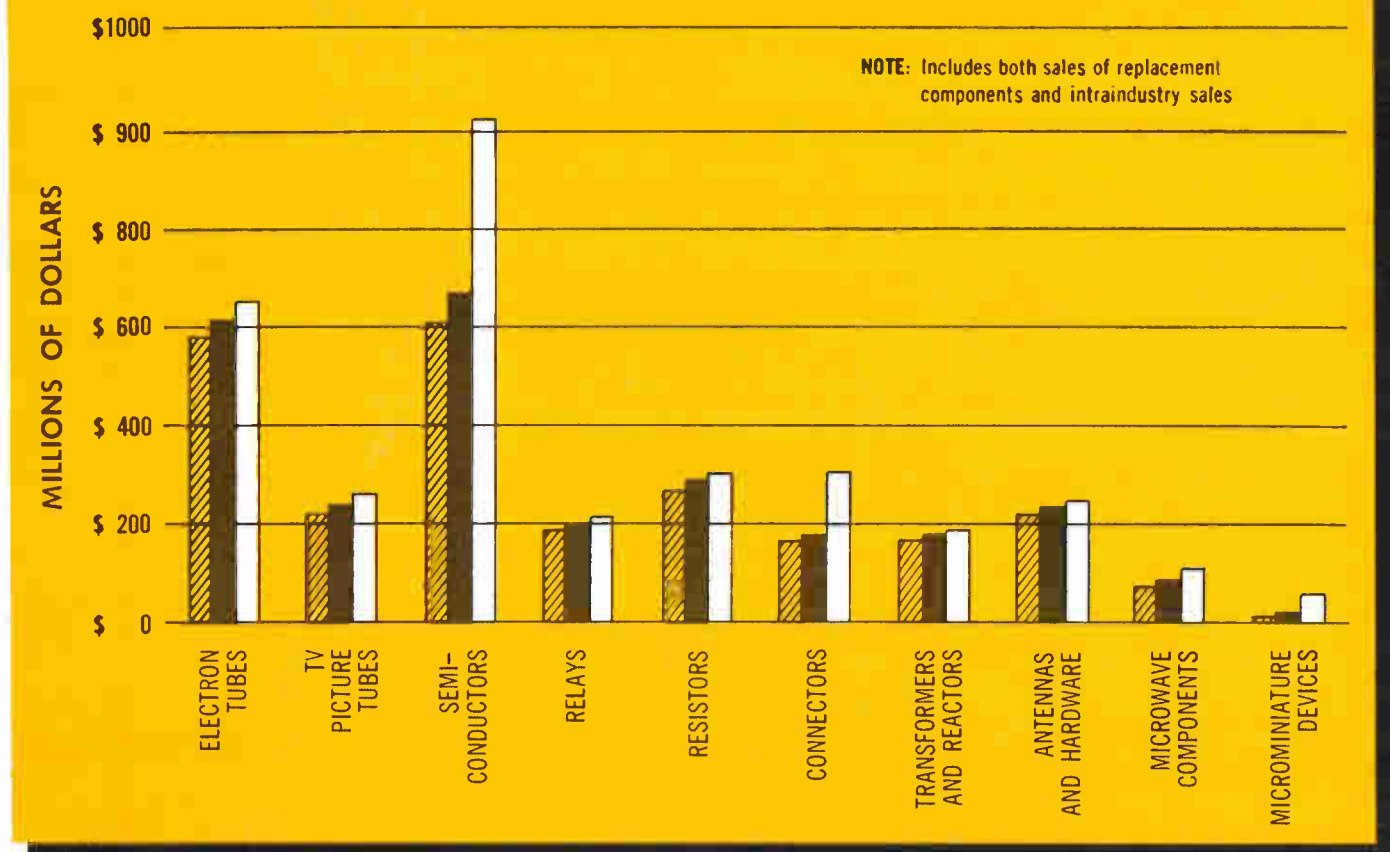
	1961	1962	1965
	(Millions of Dollars)		
INDUSTRIAL ELECTRONICS TOTAL	2,632	3,013	3,888
TEST & MEASURING TOTAL	449	513	683
Spectrum Analyzers	8	10	15
Signal Generators	50	60	75
Oscilloscopes, high-frequency	34	36	40
Oscillographs and Other Oscilloscopes	10	12	15
Voltage & Current & Power Measuring	15	16	20
Components Testers (tube, transistor, etc.)	17	17	18
Calibrators, Instrument	25	26	28
Electronic Timers	8	8	10
Bridges & Decades	10	10	10
Frequency Measuring	18	19	20
Waveform Measuring	18	20	21
Impedance & SWR	3	5	6
Frequency Meters	32	34	35
Recording Instruments	28	30	40
Engine Analyzers	25	27	30
Radiometers	3	5	10
Panel Meters, Indicating	18	21	30
Broadcast Test Equipment	2	3	5
Power Supplies, Laboratory	40	50	75
Active & Passive Networks	5	6	10
Microwave Test Equipment	15	17	20
Spectrometers	15	20	30
Infrared Detectors	20	25	50
Digital Readout Devices	30	36	70
NUCLEAR INSTRUMENTS & CONTROLS TOTAL	85.0	113	149
Gaging & Process Control	6.6	8	12
Portable Survey Instrument	6.4	8	10
Power Supplies	6.2	8	10
Detecting Heads	4.6	6	8
Monitoring Instruments	4.5	6	10
Pulse Height Analyzers	3.5	4	5
Amplifiers	3.2	4	5
Scalers	2.9	4	5
Dosimeters & Chargers	2.0	6	10
Radiation Sources	1.7	3	5
Counting Rate Meters	1.4	3	4
Reactor Controls	30.0	40	50
Particle Accelerators	12.0	13	15
INDUSTRIAL CONTROL SYSTEMS TOTAL	171	189	275
Numerical Controls	25	27	30
Infrared Ovens	16	20	55
Ultrasonics	18	20	30
Infrared Controls	30	22	30
Tv Remote Controls	6	10	20
Magnetic Tape Controls	10	12	20
Photoelectric Controls	6	8	10
Servo Remote Controls	60	70	80

	1961	1962	1965
	(Millions of Dollars)		
CLOSED CIRCUIT TV TOTAL	30	40	70
Industrial	25	32	50
Educational	1	2	10
Theater	1	1	3
Medical	3	5	7
MEDICAL EQUIPMENT TOTAL	63	75	98
Radioactive Tracer Equipment	2	5	10
X-Ray Equipment	5	6	10
X-Ray Accessories	2	3	5
Hearing Aids	40	42	45
Electrocardiographs	1	1	3
Monitoring Systems	1	3	5
Pressure Recorders	1	3	5
Ultrasonic Diagnostic	1	2	5
Other	10	10	10
COMMUNICATIONS EQUIPMENT TOTAL	733	785	918
Land Mobile	115	120	150
Microwave (pt to pt)	50	70	100
Terminal Equipment	30	40	50
Marine Commercial	9	10	15
Facsimile	16	16	20
Airborne	81	80	80
Carrier Current Equipment	10	12	15
Antennas	130	140	170
Intercommunication	23	25	30
Navigational Aids (Incl. Loran, Shoran, ILS, GCA, ATC, Tacan)	205	200	200
Vehicular Traffic Controls	15	17	20
Broadcast Equipment	49	55	68
Transmitters A-M	3	3	3
Transmitters F-M	2	3	5
Transmitters Tv	7	10	15
Consoles & Accessories	10	10	15
Tv Cameras, Color	10	12	15
Tv Cameras, Monochrome	17	17	15
TELEMETERING EQUIPMENT	50	60	75
TEACHING DEVICES	2	5	30
DICTATING DEVICES	85	95	120
COMPUTERS TOTAL	964	1,138	1,470
Digital [1]	800	950	1,200
Analog [1]	40	50	75
Peripheral Equipment	124	138	195
Converters A to D	20	20	25
Converters D to A	20	20	25
Converters, Card to Tape	4	6	10
Readers, Paper Tape	10	15	20
Digital Readout Devices	10	12	20
Magnetic Tape Equipment	50	50	75
Other Recorders & Readers	10	15	20

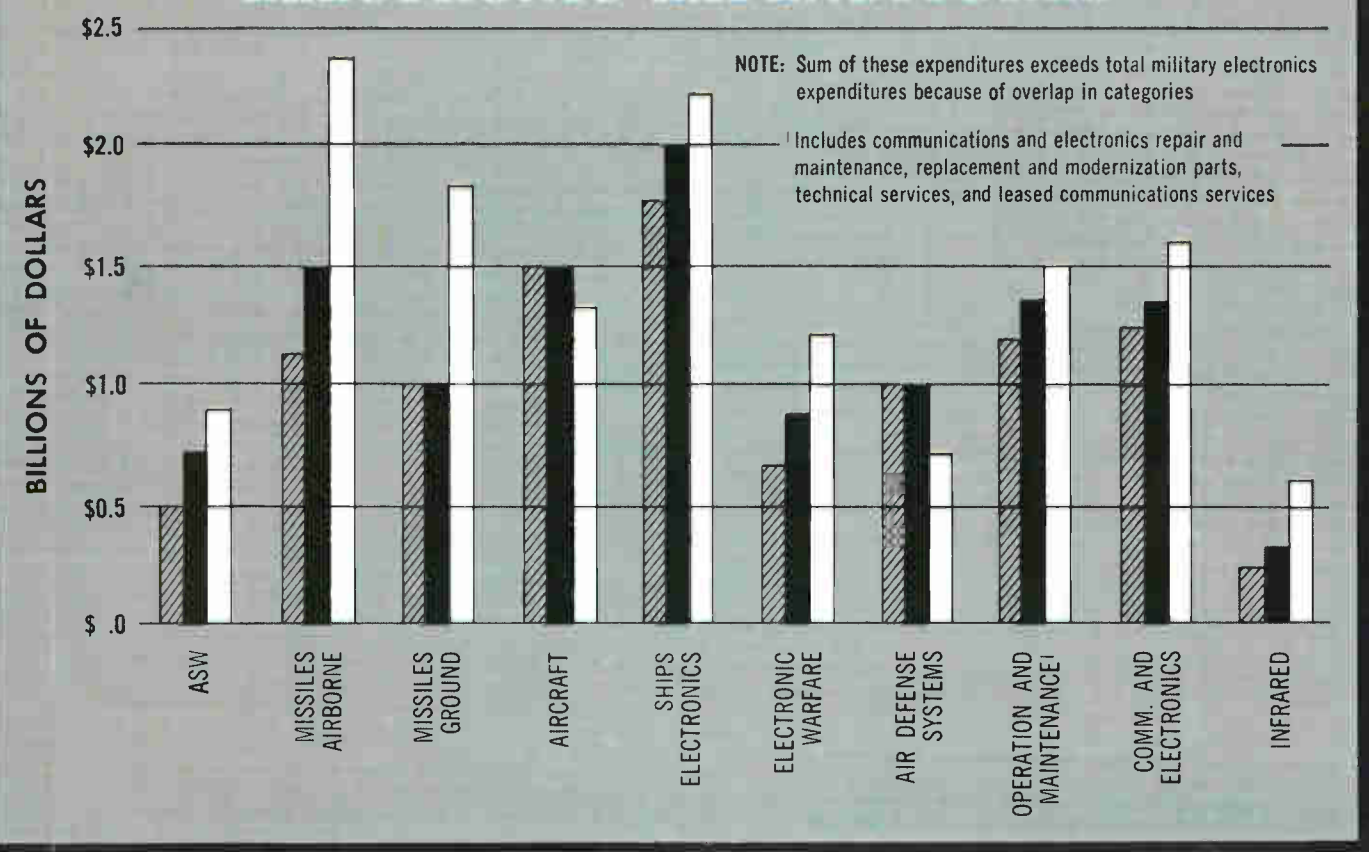
[1] Includes Industrial Controls

'61 '62 '65 '70 ELECTRONIC MARKET

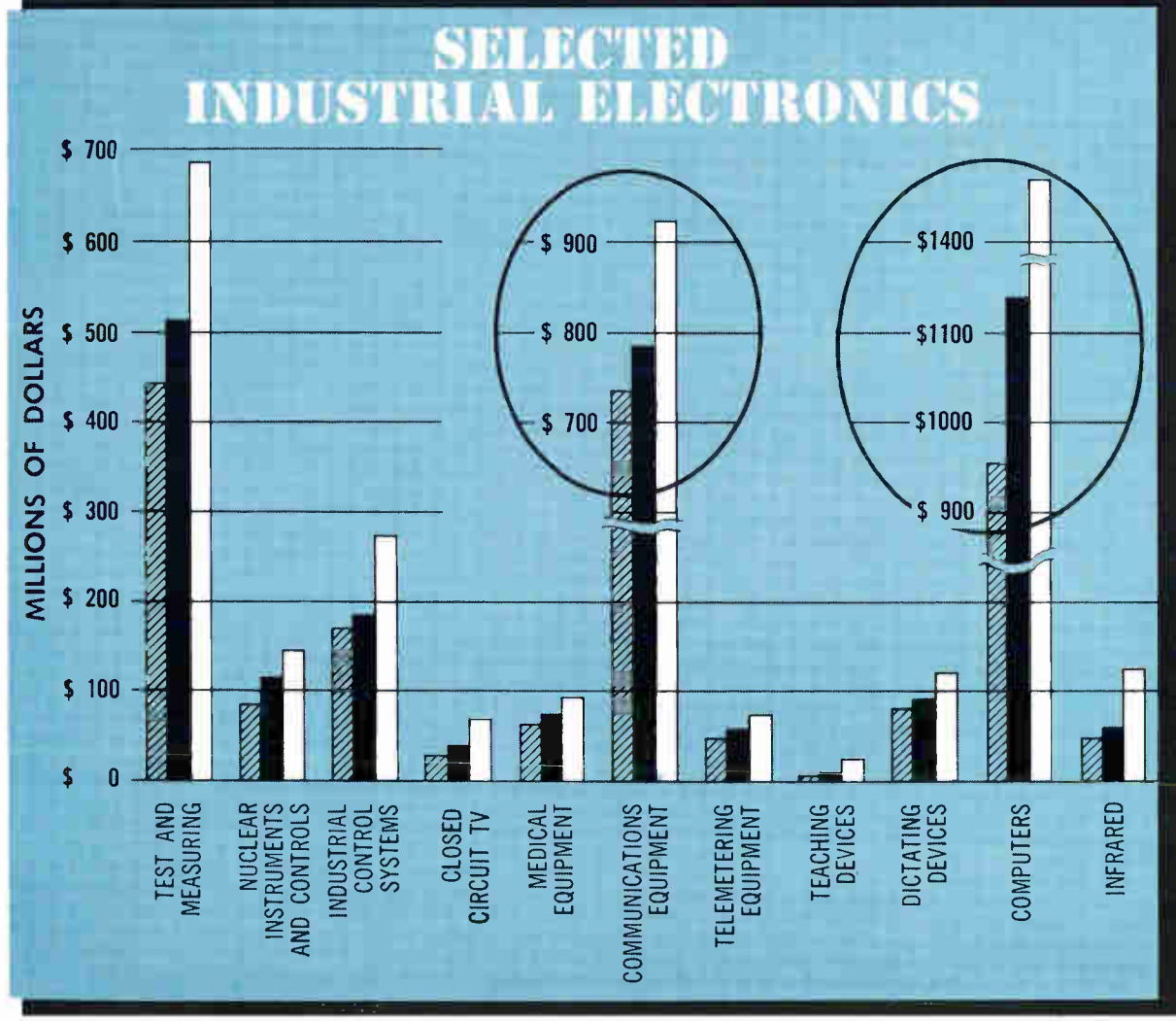
COMPONENTS' MARKETS



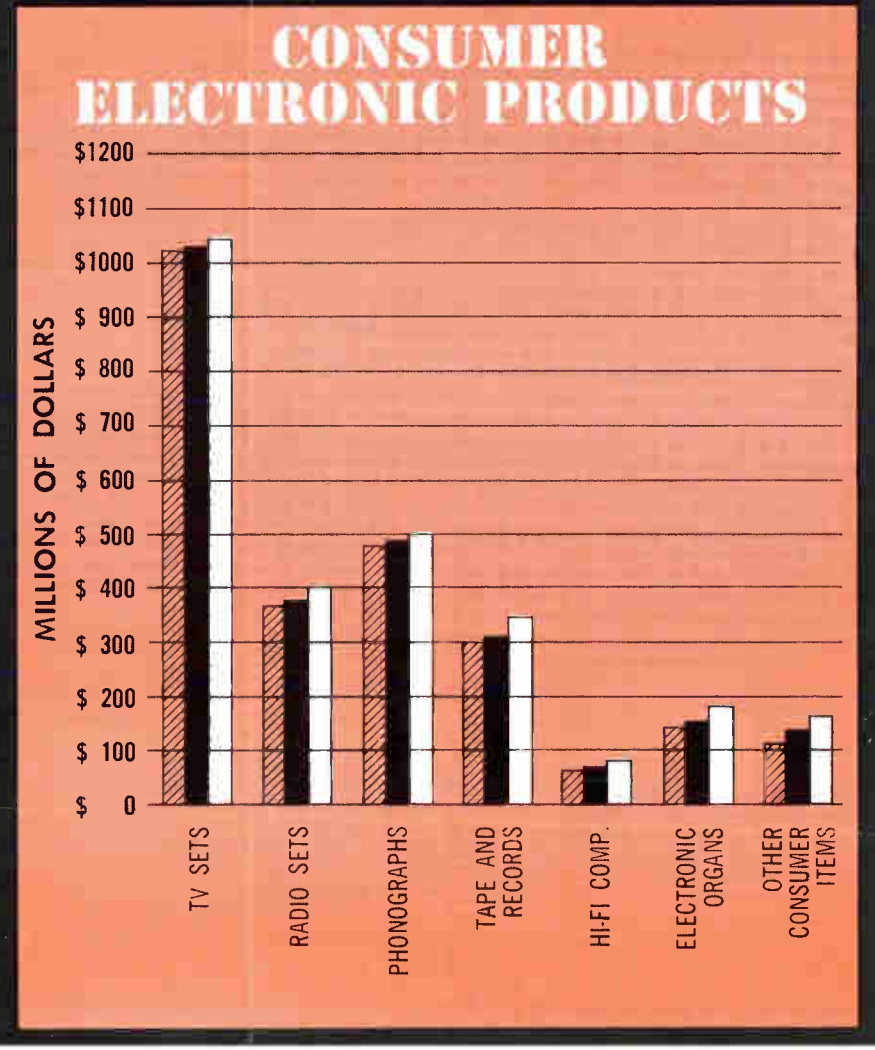
MAJOR MILITARY ELECTRONIC EXPENDITURES



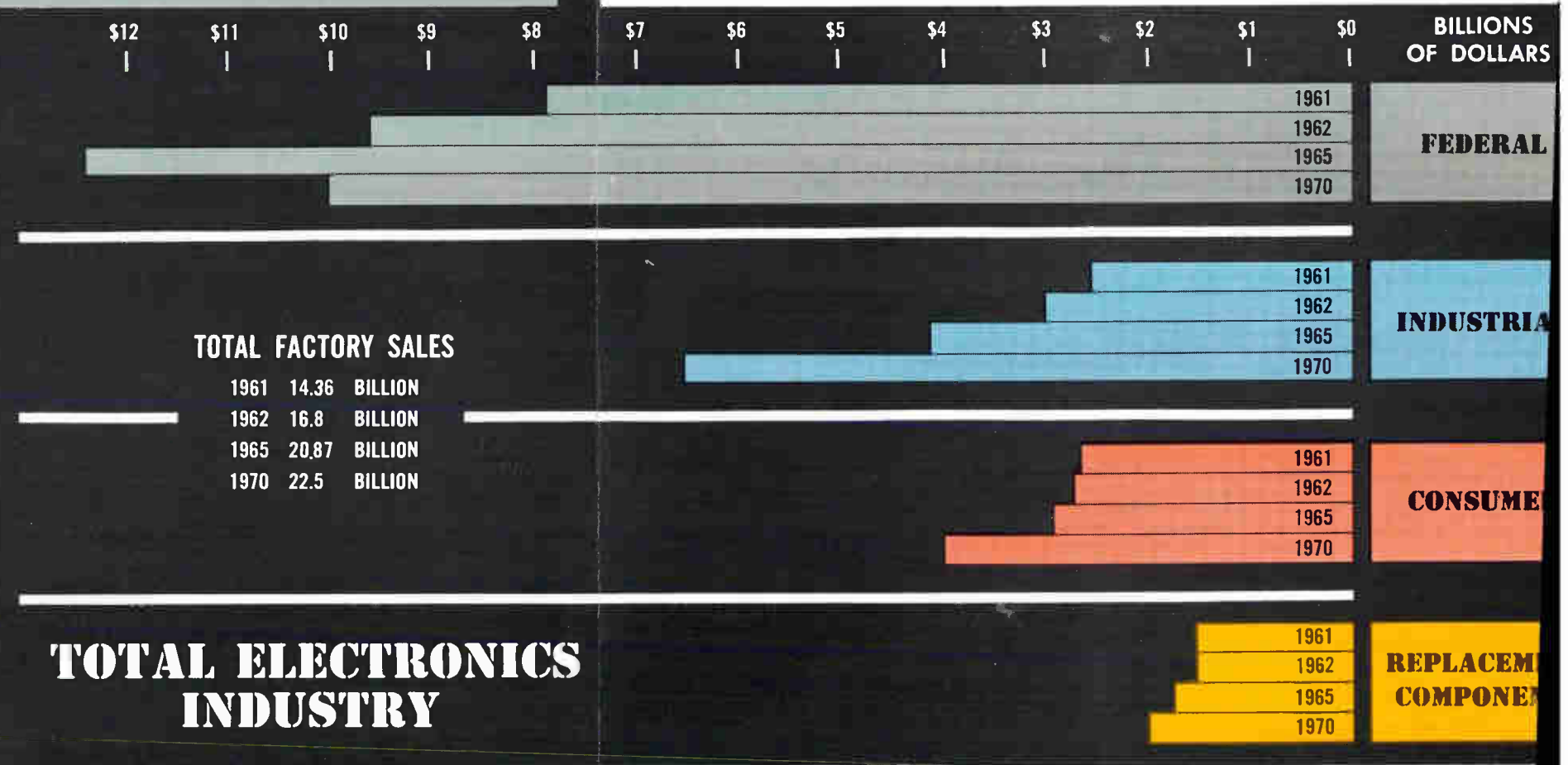
SELECTED INDUSTRIAL ELECTRONICS



CONSUMER ELECTRONIC PRODUCTS



TOTAL ELECTRONICS INDUSTRY



TOTAL FACTORY SALES

1961	14.36	BILLION
1962	16.8	BILLION
1965	20.87	BILLION
1970	22.5	BILLION

LEGEND: ▨ 1961 ■ 1962 □ 1965

electronics a McGraw-Hill Publication

AN ANALYSIS OF THE PRESENT, AND A LOOK INTO THE FUTURE

OUR GROWING MARKETS . . .

By THOMAS EMMA
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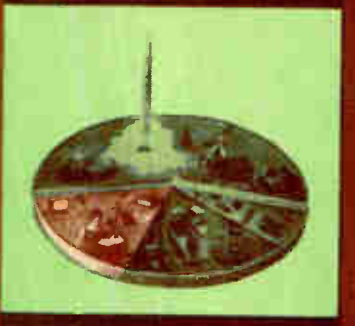
Mgr., Market Service Dept.

INDUSTRIAL MARKETS

Electronics is already important in commerce and industry, and more applications are coming

FEDERAL MARKETS

Changing patterns stressing research mean more money, but not necessarily more hardware

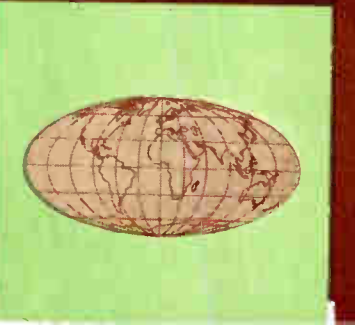


CONSUMER MARKETS

Still entertainment-oriented, but with more variety than ever before

COMPONENTS MARKETS

Some shakeouts, more new technology and increased demand for special items

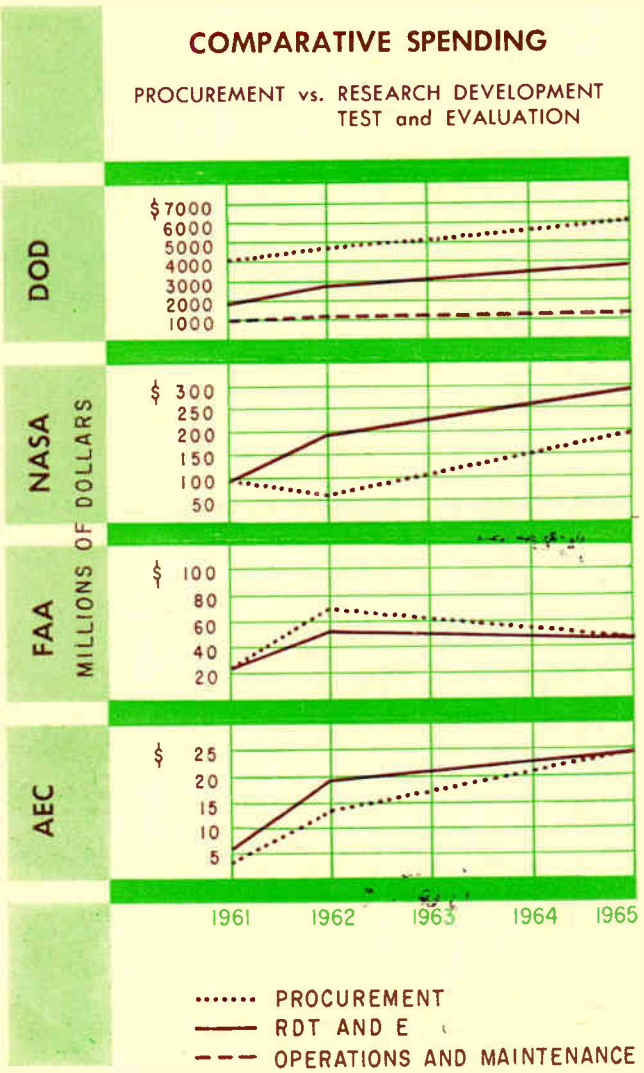


MARKETS ABROAD

Elsewhere in the world electronics is reaching major industry proportions, bringing new opportunities and problems

OUR GROWING

TODAY'S ELECTRONICS DOLLAR—
Major share is still from the military, but other parts are growing steadily



CONTINUED GROWTH against a background of changing patterns will be the main characteristic of the electronics market in the immediate future.

TOTAL INDUSTRY VOLUME of $14.7 billion in 1961 should reach $16.8 billion this year. By 1965 this figure will probably reach $20.87 billion, then climb to about $22.5 billion by 1970.

A major change in the composition of industry figures is already evident. Federal spending will continue to dominate the electronics industry, but increasing percentages of government expenditure will go for research, development, test and evaluation as opposed to direct hardware procurement. In addition, new demands by nonmilitary federal agencies will open additional markets for both goods and services.

DEFENSE DEPARTMENT spending last year stood at $7,300 million, National Aeronautics and Space Administration at $200 million, Federal Aviation Agency at $50 million and Atomic Energy Commission at $10 million.

It is reasonable to expect some leveling off in all four of these categories after 1965, barring a major change in the international situation. Major capital expenditures for major warning systems, electronic warfare complexes and other major installations could be completed or nearing completion. The already visible effects of DOD's shift in policy, giving limited warfare preparedness more attention, will probably be evident throughout the decade as more and more limited combat units are provided with electronic equipment.

INDUSTRIAL ELECTRONICS, holding perhaps the greatest promise for long-range future markets, now stands at $2.63 billion. As more industrial organizations

MARKETS

turn to electronics, however, this total will climb. This year's level will reach $3 billion and grow to perhaps $3.9 billion by 1965. By 1970, industrial electronics could climb to $6.5 billion.

A major portion of this growth will undoubtedly be in computers, which are already proving themselves industrially in data processing, control, analysis functions and a variety of other areas. Present levels of $964 million will go to $1,138 million by the end of this year and should reach $1,470 million by the end of 1965.

Communications equipment will go from a 1961 level of $733 million to $785 million this year. By 1965 a $918 million level could be reached.

Test and measuring equipment, rising in demand as aids to automation and better production methods, will show rapid strides. Last year's figure of $449 million will grow to $513 million by the end of this year and reach $683 million or more by 1965.

Other categories which will show increases are closed-circuit television, which should reach $70 million by 1965; medical electronics which should reach $98 million and nuclear instruments and controls which should go to $149 million by 1965.

CONSUMER ELECTRONICS is likely to show less increase in the next five years, but these are likely to be less spectacular than other segments of our industry. Last year's total was $2.67 billion. This year's will be about $2.7 billion. By 1965 the consumer market should be $2.9 billion and by 1970 it should grow to $4 billion. In television receivers, radios and phonographs, the shift in emphasis will be towards new developments . . . color in television and stereo in radios and phonographs. Black and white tv receivers, which will go to $1,030 million by the end of this year, may decline to $1,000 million by 1965. Filling the gap, however, could be an increase in color tv receivers, with a possible gain of $25 million this year over last year's $75 million, and a climb to perhaps $140 million by 1965. In a-m radio there will be a dropoff over the next five years, countered by a rise in the market for f-m receivers, particularly those equipped for stereo. Monaural phonographs should remain constant, while stereo record players will surely show at least moderate increases.

IN THE COMPONENT FIELD, both in the replacement and in the original equipment categories, a number of items will see leveling or declining markets as the pressure for smaller and more reliable assemblies makes itself felt. The general market picture for replacement components, standing at $1.5 billion in 1961, will remain about the same in 1962 as in 1961. By 1965 there should be a rise of $0.2 billion, and the total could go to $2 billion by the end of the decade.

Receiving tubes, both OEM and replacement will probably see declines in almost all categories as other devices and techniques supplant them, but stepped up requirements in communications and other areas will see a growing demand for special-purpose tubes. This market, which was $262 million last year will rise to about $280 million this year and to perhaps $344 million by 1965.

Semiconductors will continue to grow in importance. Last year's level of $606 million should climb to $672 million this year, reach $939 million by the end of 1965.

Selenium rectifiers, at $18 million last year, will go to $20 million this year, but will decline one million by 1965, but other types will show growth.

Filling a variety of demands in military and industrial applications will be microminiature devices of all categories. From last year's $10 million level, this year's figure will rise to at least $12 million and soar to perhaps $60 million by 1965.

OUR GROWING

THE INCREASING ACCEPTANCE of computers for process control, data reduction, and general office uses will lead an upsurge of industrial electronics markets during the next five years.

The introduction of communication systems to couple the output of data processing installations to multiple end-use points is improving the utility-cost ratio of these equipments. This factor, plus simplified programming of computers is aiding industrial acceptance of electronics.

Demand for test equipment, from single instruments to complete automatic checkout systems is increasing in industry. The use of X-ray equipment, both medical and industrial is growing. Teaching machines for education; and infrared equipment for industrial and railroad use are finding acceptance.

Electronic devices are gaining applications in oceanography, information storage and retrieval, highway control, automobile parking, aircraft safety, and materials testing. The newly invented laser (optical maser) is being groomed for many industrial applications, ranging from communications to medical.

The overview is one of increasingly active markets for well-managed firms selling to industry and business.

WHO WILL GAIN? The often predicted general shake out of small electronics firms and unprofitable larger operations is one of the half truths of the business world. Key men within the industry assert that any trend toward a shakeout that may occur in the future will be on a selective basis, and no more dramatic than the day-to-day problems in any highly competitive industry.

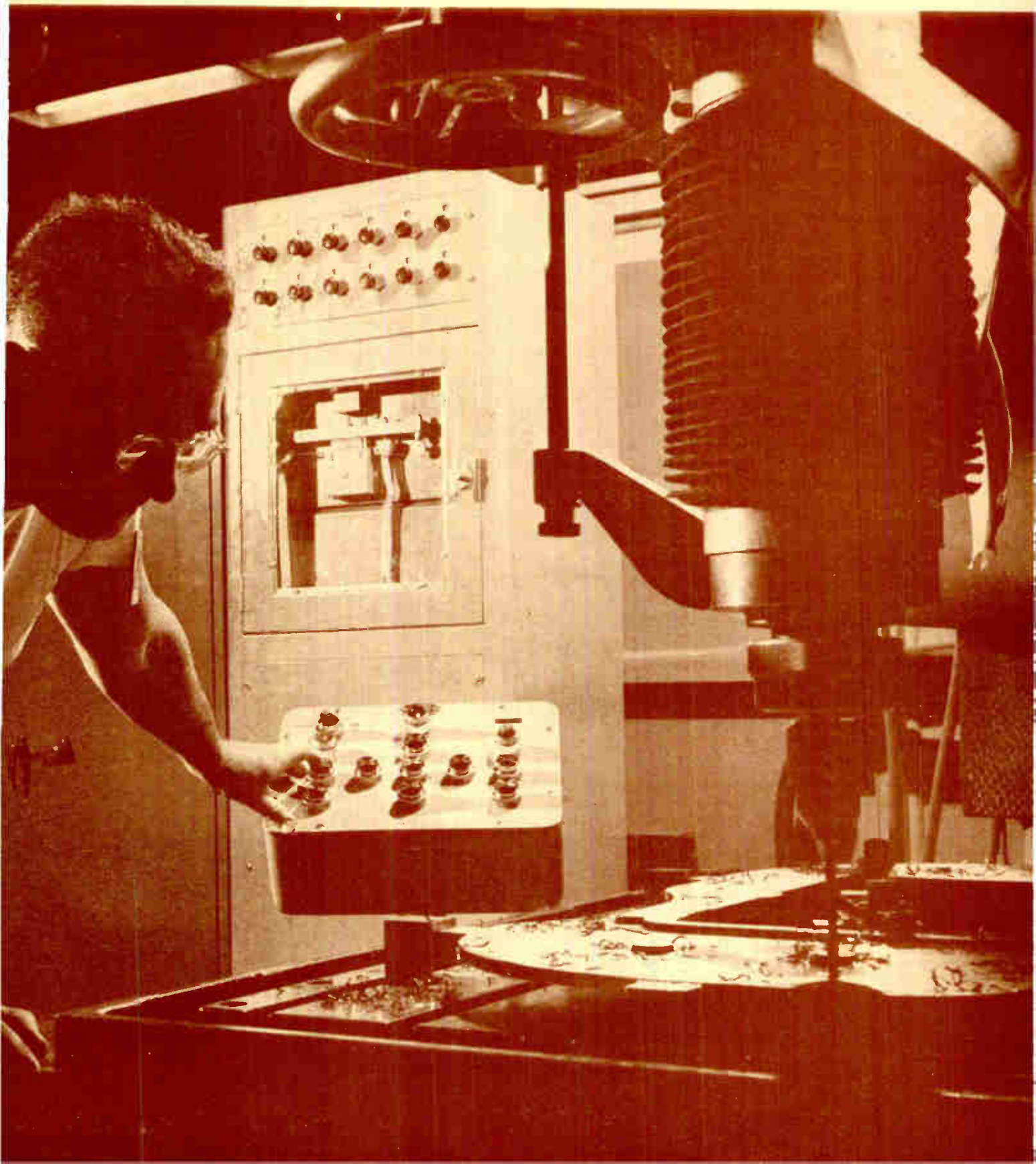
Multiple sources exist for most of the products and services supplied to industry and business by the electronics industry. This has imposed new demands on management. To run an electronics firm today requires a firm grasp of the same business practices that are used to succeed in other industries.

It has been suggested that the electronics management man of the coming decade would best be trained only in business; rather than engineering as the men who have for the most part led the field in the last decade, have been. In fact, however, the head man of an electronics firm must be expert in both areas to be fully effective. He requires a strong grasp of the technical problems encountered in developing and producing complex electronic systems, instruments, components, and providing related services.

Additionally an understanding of modern methods of

Control of six spindle turret drill press by prepunched tapes and closed loop feedback system uses ruggedized vacuum tubes. Sperry Rand Corp. equipment uses linear transducer, error detecting null circuit, valve driving amplifier for final hydraulic valve control of machine

INDUSTRIAL MARKETS



cost control, advertising, product planning, sales techniques and related skills is required.

COMPUTERS will advance sharply in sales to industry and office users in the next few years. Acceptance of the computer in many fields has already been achieved. The field of process control, where some computer control has been used with success for several years, should also show a substantial increase in computer applications in the next few years.

Computer control of steel mills, power plants, cement plants, chemical process plants, have all been instituted. New inputs to the computer, such as supplied by X-ray equipment and other transducers, will provide added flexibility of operation.

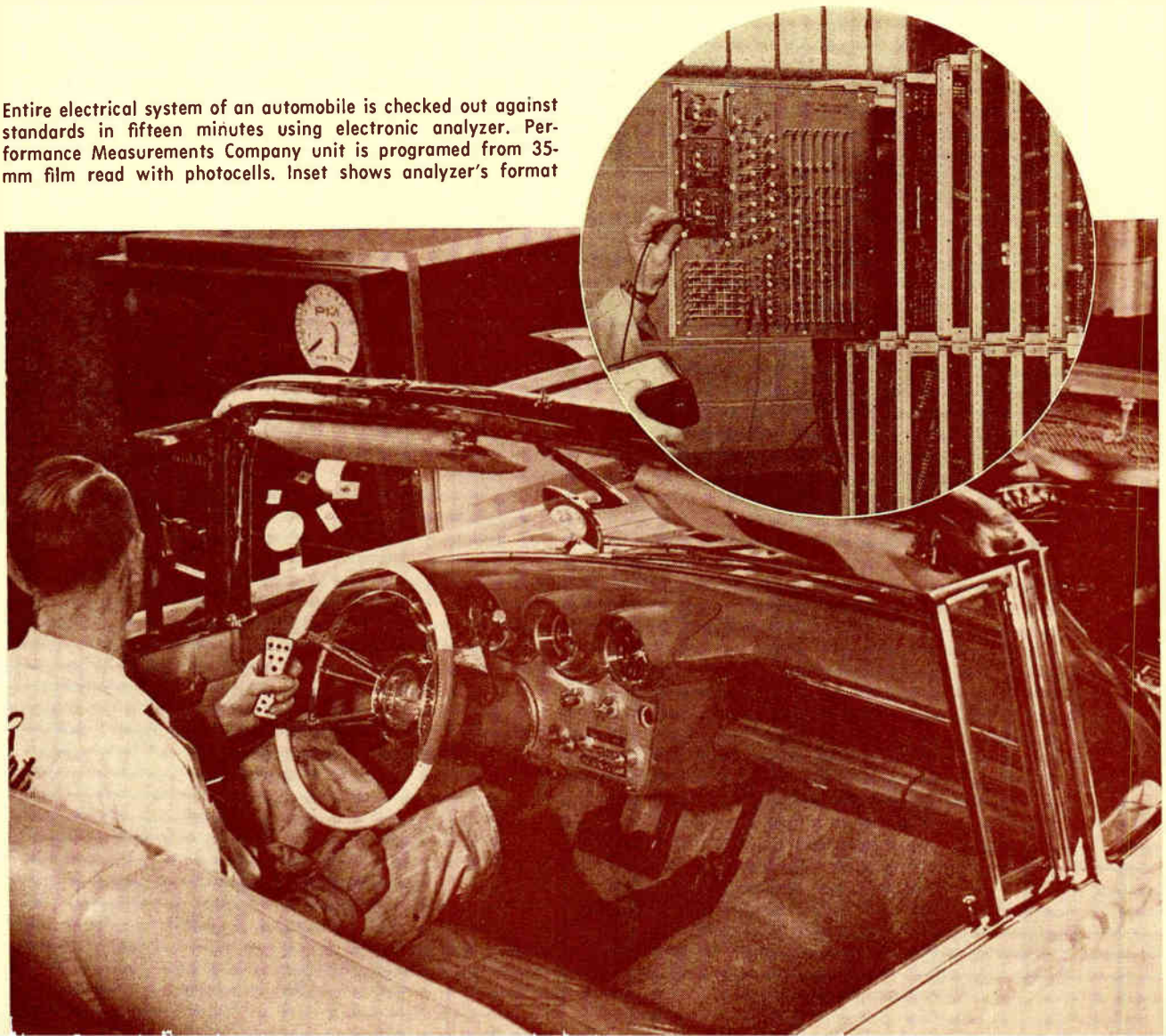
Automatic control in areas other than process control may find slower acceptance. There are many industry operations that could use computer control, but find it hard to justify the cost of installation. Others cannot quickly overcome the long existing dependence on manual or mechanical means of performing the job.

Also, the absence of skilled electronic technicians in many industries acts against acceptance of complex, computer-controlled installations. Improved reliability designed and built into the computer and its related electronic gear will help speed customer acceptance.

Thus, in the near future, sales of such items as computer-controlled automatic lathes using magnetic tape may move ahead at a conservative pace. However, in less complex machines such as drill presses run automatically, acceptance may be higher. In the same way, until the cost of installation drops, and clearcut proof of operating economies are given, computer applications such as control of highway traffic, will not increase startlingly. In computer applications, a help is expected from recent gains in the development of automatic programming devices, and related automatic readout systems. One objection to the use of computers in some applications such as data processing has been the lack of trained personnel to program and operate the equipment.

Input-output devices already in use range all the way from character or pattern recognition input equipment; to readout directly on a highspeed electric typewriter. As yet in rudimentary form is the speech programmer that would let the operator speak his request and data into a computer.

Computers are being used in jobs that would have appeared far fetched several years ago. An advertising agency is solving media selection problems with one, sociologists have predicted voting outcomes, a computer is being programmed to assist in diagnosis of diseases,



Entire electrical system of an automobile is checked out against standards in fifteen minutes using electronic analyzer. Performance Measurements Company unit is programed from 35-mm film read with photocells. Inset shows analyzer's format

and a computer has been used to simulate the entire human respiratory and circulatory systems.

The use of digital communication systems to transmit information in machine language between distant points over telephone lines is becoming widely used. It promises to increase the utility of a single data-reduction center, to permit its use by outlying offices of a firm that owns one main computer installation.

INSTRUMENTS—The market for test instruments is strong, and there is indication that firms in this field are in a position to experience continued growth. However, while industrial applications of test instruments are increasing, many test equipment sales are made primarily because the purchaser is tooling up upon receipt or in expectation of a government contract.

Automatic test equipment, in particular, is finding favor. This is true in automobile manufacturing and maintenance, where tests of ignition systems, engine performance and other functions can be made quickly by use of automated test equipment. Instruments for applications within the electronics industry itself are in growing demand, and should prove an expanding field in the next decade.

OTHER APPLICATIONS—The use of infrared devices such as the railroad hotbox detector for safety inspection, is expected to be a strong sales field.

Innovation of the laser, with its tight beam of high intensity radiation operating at optical frequencies, should in time lead to high data content communication systems for industrial applications.

Development of power modulators for the transmitter, light amplifiers and detector techniques for receivers, and a practical method of excluding atmospheric dust from the transmission path is needed. A land telephone communication system may be expected to evolve in time.

The laser is apt to find applications in the medical field, for its beam can be focused to micron dimensions, allowing it to sterilize small portions of tissue. Possible applications of the laser for use in computers are being researched. Mapping and charting may in time be done with laser-operated radar ranging systems, to an accuracy of fractions of an inch in distances of hundreds of miles.

Ultrasonics is finding a place in automobile counting problems, both in highway and parking field or ramp installations. The design of a counter that will not respond to a human, but will indicate the presence of an automobile even if it is not moving can be accomplished. Ultrasonic industrial cleaning uses are expanding.

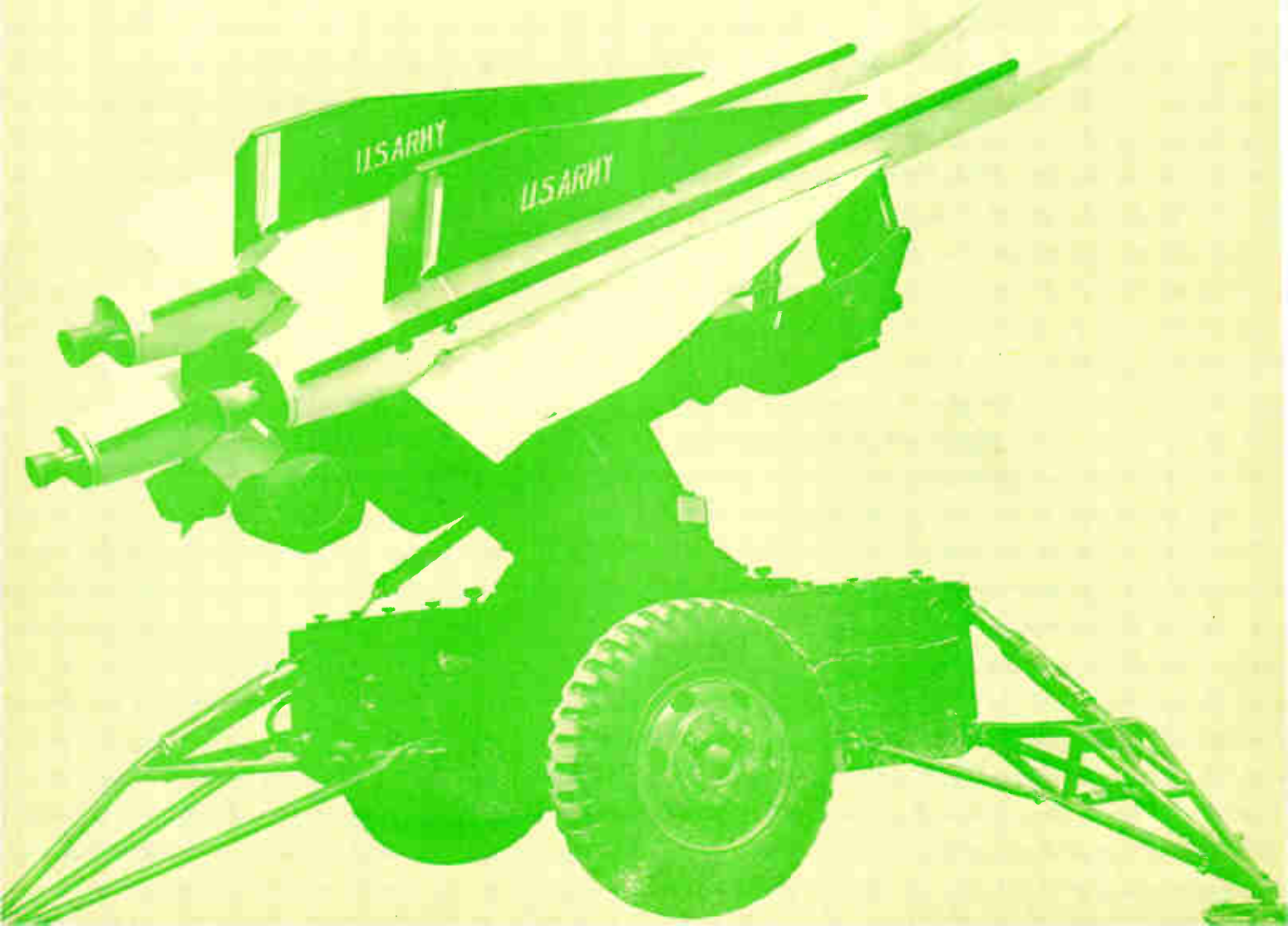
Doppler radar also has wide uses in the vehicular traffic field, and is finding application in automobile parking.

Medical probe contains radiation detector and microminiaturized electronics. Hughes Aircraft unit placed in 3-mm catheter can be inserted into human vein to measure radioactive isotopes in the blood stream

Ultrasonic measurement of liquid nitrogen level is made at cryogenic temperatures. Bogue equipment reads out digitally. Temperature is monitored to correct for speed of sound in medium. Piezoelectric transducer is used

OUR GROWING

Surface-to-air Hawk missiles now operational with the Army, on trailer-base launcher. Raytheon is the prime for this 20-mile range limited-warfare weapon. Electronics dollar portion of guided and homing type missiles is estimated at 65 percent



FEDERAL MARKETS

MILITARY—The changing problems of national defense have modified the concept of marketing to the military. It is no longer enough to study procurement lists of past years with only a partial awareness of research and development trends and changing world tensions.

The nation's need at this time for limited warfare weapons has created an increase in the market for electronics hardware already in production.

However, of increasing importance is the fact that military buying of goods as well as services is now being done, to an even greater extent, under the catch-all of Research, Development, Test and Evaluation.

Often a heavily funded project may result in only a few items of final hardware, but it will represent a large expenditure for electronic equipment and services, (engineering and other), during its research and development phases. Rapid obsolescence in weapon-systems and hardware is a hard reality in this decade of changing military positions and rapid technological advances in electronics. Limited production, or no production at all, as in the case to date of Army's Nike-Zeus antimissile missile, does not give a true picture of government electronic expenditures.

The amount spent by the military for the titular category of electronic procurement may decline in future years. However, money spent in the titular category of RDT&E should go up.

The Air Force's project leading to a manned maneuverable space craft, Dyna-Soar is an example of this. In fiscal 1961 a total of $58 million was spent on all aspects of the project. By now $185 million has been appropriated for fiscal 1962, on Dyna-Soar's RDT&E budget. The large electronic portion of this project will not then show up on procurement lists directly, and a yearend study of such lists will not reveal its total to the electronic industry.

Research and development holds the key to sales to the military in that they are constantly forcing new techniques into practical application, and discarding the old.

THE BUDGET—Congress has approved, at this writing, a $46.7 billion total defense appropriation for 1962. The exact portion of this figure that is electronic can only be estimated. The reason for this is that many projects of the Department of Defense, and the three military services are not broken down into their electronic portions. The government buys a missile, but has no pressing need to know exactly what amount of its cost is electronic. For some guided missiles, a number accepted for the electronics portion is about 70 percent.

Figures can be extracted with fair accuracy for major hardware procurement, and to a lesser extent for operation and maintenance.

However, in RDT&E such extraction of figures for electronics is not easy. Known and published government figures and statements do, however, give some good clues.

Part of this report includes a table of DOD electronic dollars, broken down for the calendar year 1962, as follows: procurement $4.971 million, operations and maintenance $1.220 million, and RDT&E $3.000 million.

In a statement by Senator Hubert H. Humphrey in the government publication, Coordination of Information on Current Federal Research and Development in the Field of Electronics, Sept. 20, 1961, an estimate of the electronic portion of RDT&E is given:

"A total of $9 billion is currently expended by the Federal Government for research, development, testing and evaluation. Not less than one-fourth of that sum is spent in the electronics field alone."

Security classifications on RDT&E projects prevents exact evaluation, but estimates in government and industry have ranged from two through five billion dollars, for the military electronics portion.

In the same publication quoted above, under Findings this statement is made:

"An inherent difficulty in managing the overwhelming bulk of information on electronics research and development is that such information tends to be 'buried' within the Defense Department data on weapon systems. This is the case because DOD is logically organized to achieve major security missions, i.e., develop weapon systems, rather than advance the state of the art of a field like electronics."

An example of this is then given:

"The significance of electronics in weaponry may be illustrated by its role in the Polaris program. This program is the Navy's largest research and development operation. Polaris is generally regarded as one of the foremost deterrents to World War Three. Through fiscal year 1960 the Navy had obligated $2.5 billion for the overall Polaris program. Of this amount, 27 percent was for electronic purposes—$705 million. Polaris has had 335 contractors and 10,000 subcontractors; of these totals, the electronics phase of the program has involved 112 contractors and 3,000 subcontractors."

To decide on the areas of electronics a firm may pursue in selling the military; its engineering and scientific resources must be considered. Projects are becoming increasingly intricate and technical, and demand a higher

level of ability to produce equipment and techniques acceptable to the military.

In a survey conducted by EIA and DOD it was found that of the estimated 155,000 engineers and scientists doing electronic work in the U.S., about 120,000 are in work supported by the government. Statements by DOD indicate a shortage of serious proportions is expected in the next five years.

It is possible to single out areas of future interest to the military in the field of electronics. This must be done within the restrictions of lack of data due to national security limitations; and the knowledge that an important international political change, or a sudden breakthrough in technology can change such areas from high to low interest.

ARMY'S electronic expenditure in the next year in large measure, will be for equipment already designed. The pressing Berlin situation and other similar trouble spots around the world has made buildup for limited war an immediate problem, and does not in all cases allow time for retooling or development of new designs.

However, where tactical requirements demand, and where time allows, Army is pushing developments in electronic instrumented weapons, and support devices. Electronics in applications ranging from infrared detection systems such as sniperscopes, through sophisticated surveillance techniques are receiving attention.

Communications, guidance systems, fire-control equipment and electronic warfare techniques are of interest. Missiles include types similar to the hand-launched, heat-seeking Redeye, the 20-mile Hawk, 75-mile Sergeant and others. One figure accepted in the industry for the portion of a guided missile (not ballistic) that is electronic is 65 to 70 percent. The exact type of guidance, and the mission capability determines the exact proportion, along with other variables. In an ICBM, some 30 to 35 percent electronics is estimated.

Army's interest in antimissile systems continues, including the still-not-in-production Nike Zeus, and other approaches to the antimissile problem.

One of the Army's needs is development of land-guidance systems. These would allow the positioning of vehicles such as tanks, missile launchers, jeeps and even individual soldiers to an accuracy of yards. It would allow correlation with known terrain features.

SURVEILLANCE—Passive systems of detection and identification are desired; these have the advantage of not revealing the user's position. Infrared devices and related techniques are of interest here. Surveillance systems able to operate at the longer infrared wavelengths would detect more of the output radiation of natural objects, and are of interest.

Infrared devices such as helmet-mounted night-driving binoculars, weapon sights, and hand-held binoculars, are being developed or are in production.

Additionally, active infrared surveillance equipment both pulsed and continuous, for long-range use is desired.

Devices that allow soldiers to detect enemy infrared sources are needed. Image-intensifier components and systems, to achieve improved vision capability in limited-light conditions, are being developed. Better phosphors, improved contrast, and lower voltage requirements for light amplifying tubes would be welcomed.

Radars for field surveillance with data-processing equipment built in could aid in tactical evaluation of enemy targets. Audio indicators now used for target indication to the operator, depend on ear sensitivity to an extent.

Power sources and supplies quiet both in the audible and electromagnetic sense are needed. Equipment ranging from miniature to full-sized units are desired to allow

less easily detected operation in tight field conditions. Fuel cells are of interest, as well as atomic fission devices. Means of improving batteries are also being studied.

The laser is an invention of interest to the Army. Lasers generate and amplify coherent light, at high intensity, and narrow bandwidth. The device shows promise for development of systems operating at optical frequencies and capable of increased resolution, accuracy and more compact design than their microwave equivalents.

Laser radars have already been developed by some firms, with ranges to 30 miles. They have a potential accuracy of fractions of an inch at these distances, and can be used for military mapping, target placement for fire control, and in surveillance systems able to trace an outline of the target and reveal if it is a man or a tank. However, production of such radars is some time away and hinges on further R&D.

As far back as July 1960 some scientists indicated belief that a death ray could be developed using the laser.

There have been reports of lasers burning holes in steel. A University of Michigan scientist stated that in the long run, lasers may find their widest application in devices making use of their high energy. He referenced the piercing of steel the thickness of ten razor blades by a laser beam.

Another scientist has said that a laser could be used without further development to blind enemy troops. Others feel that a true death ray is possible using high-power lasers able to pierce armor and devastate troop concentrations.

COMMUNICATION SYSTEMS using modulated laser beams are of interest to the Army because of inherent security characteristics obtained from the beam's low divergence. Spreading of less than one foot per mile can be obtained with a tightly focused laser light beam, making interception by the enemy difficult. A laser communication system for battlefield use might be more secure than telephone lines. A modulated laser beam will allow high information content, due to the wide bandwidth available at the high operating frequency of a laser.

Countermeasures and the directly related technology of counter-countermeasures is of interest to the Army. The need is to disrupt enemy communications and control and prevent them from doing the same to us.

Development of a ground radar able to overcome line of sight limitations for combat surveillance is desired. This would obviate the need for an above-ground system using an aircraft or other elevated platform. Right now, Army surveillance drones using varied sensory devices are in demand, as well as decoy and training drones.

Other Army needs include aircraft communication systems for distances of 50 to 200 miles, collision avoidance systems for aircraft, and airborne tv for combat surveillance.

Other needs include: satellite communication systems, automatic data-processing for field evaluation of tactical data in weapon control. Photographic techniques for surveillance, using electronic subsystems for processing, alignment, light control and other operations are desired.

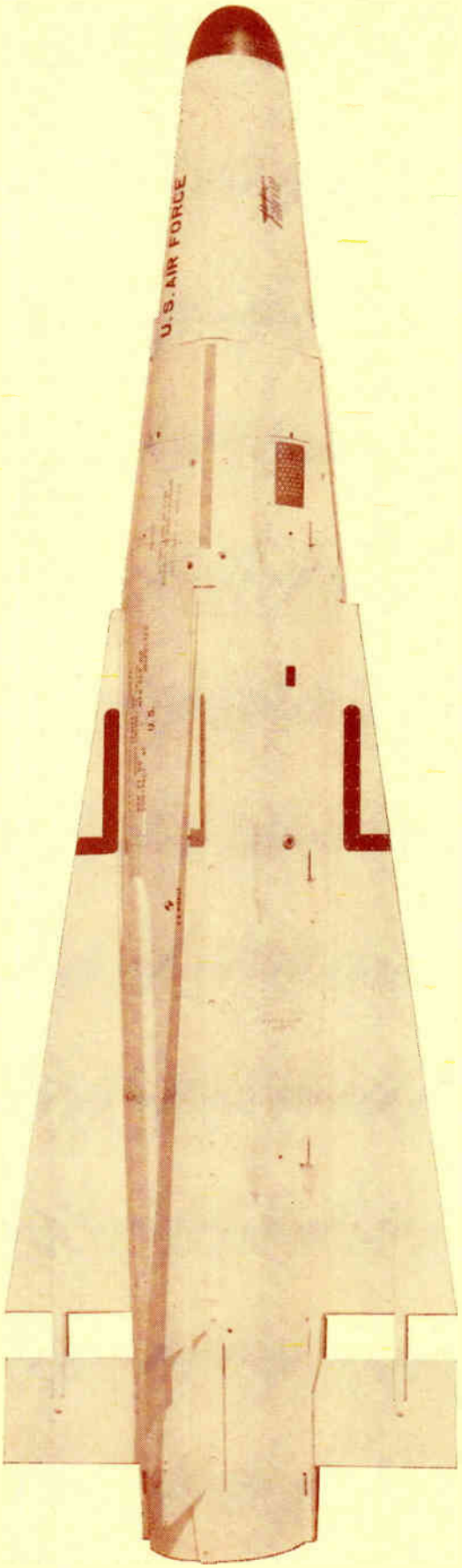
Electronic means of chemical and biological attack detection, and perhaps control, might be investigated.

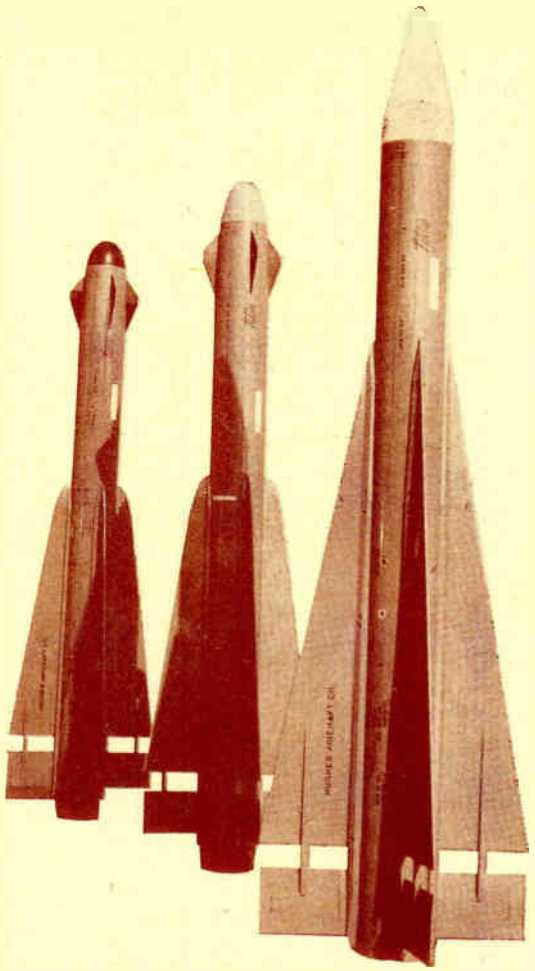
Side-looking radar for inspection of enemy territory while flying over friendly lines, with compatible recording equipment is sought.

A passive ranging system that will give distance to a target without revealing position, a color facsimile system for remote map reproduction and electronic equipment for location of water supplies are also in future warfare requirements.

THE AIR FORCE is faced with the need to develop mili-

Far left is an all-weather radar used by the Army to spot a single enemy moving a half-mile away, in darkness or fog. The unit, by Sperry Gyroscope, chonnels signals to the observer's headphone, is an example of the type of equipment Army and Marines require for limited warfare. In photo ot left Army helmet-mounted infrored binoculars ore used for night driving. Equipment configurotion allows free use of honds





Air Force air-to-air radar guided missile with nuclear capability (left) is the Falcon GAR-11 by Hughes Aircraft. Estimated range, 5 miles. Three smaller Falcon missiles at right are guided by (left to right) radar, infrared, radar

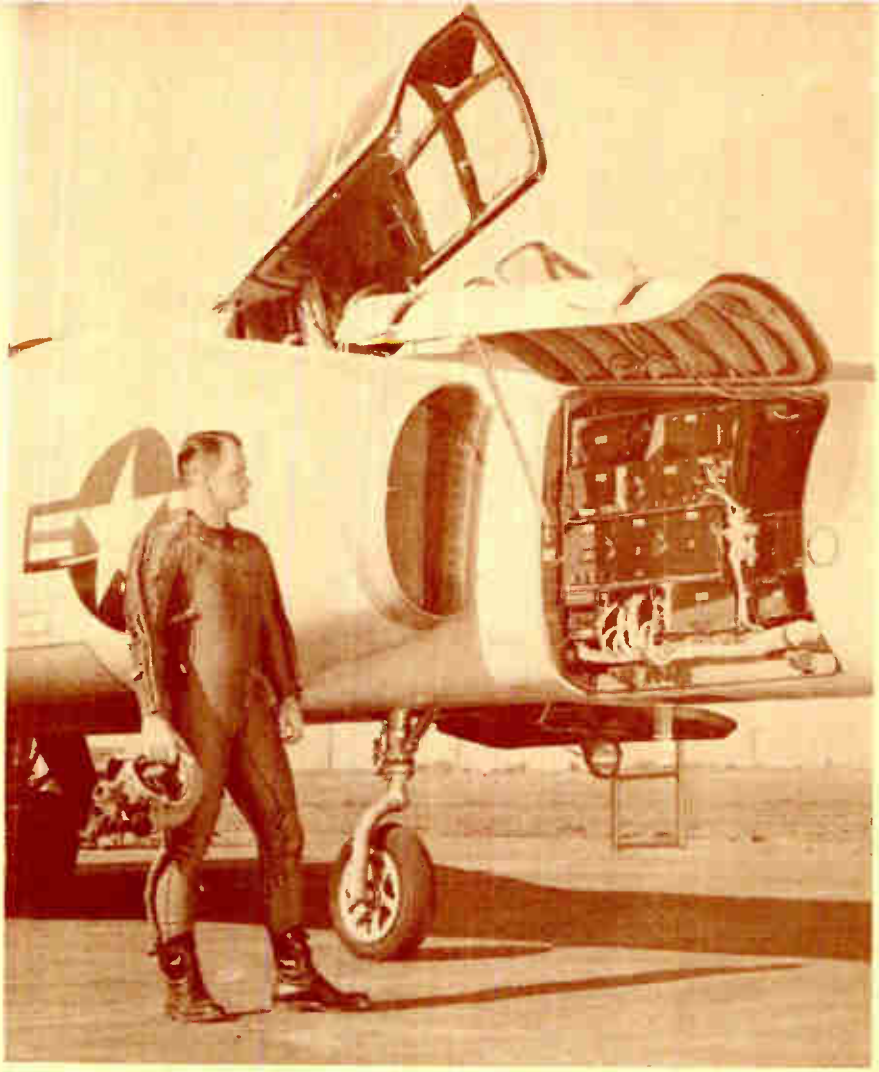
tary capability in space, as well as in its traditional atmospheric environment. In speeches and in hearings before the House of Representatives, Air Force officers and civilian experts have underlined this need.

The ability to attack from space is coupled with the need for surveillance and identification ability in detecting satellite and spacecraft launching and passage, and also anti-ICBM defense capability. Since any future war would be fought, at least in part, in space, ability to maneuver, navigate, communicate and rendezvous for maintenance and tactical reasons, must be realized in operating spacecraft of the Air Force.

The reliability demanded of electronic equipment for space operation is well beyond present concepts. Equipment must withstand extreme temperature variations, radiation exposure and heavy mechanical stress. In mean time to failure, 50,000 hours rather than 1,000 hours is sought. Space equipment must operate unattended. Even in the future when rendezvous ability is achieved, repair and maintenance of operating space equipment will be difficult and expensive.

The use of molecular electronics—the build up of circuits directly on surfaces by etching and depositing techniques—is being investigated by the Air Force as a means of achieving reliability. It can also reduce size and weight.

The Air Force has a unique communications problem brought on by the need to weld together a network of



Prototype test model of airborne digital computer, by Hughes. Unit is now in production for use in Air Force jet all-weather interceptor, can make almost 10,000 basic arithmetical calculations in one second

diverse weapons deployed throughout the world and in space. Identification and command decisions must be made at high speed, on any objects picked up by Air Force's early warning systems. This places a requirement of knitting together BMEWS, Saint (Satellite Inspector), Samos and Midas as well as future systems, along with manned aircraft on round-the-clock deployment, with government and Air Force command centers. A world-circling communications net, using communications satellites or otherwise immune to affects of nuclear blast in the ionosphere is required.

MANNED WEAPONS—The build up of ICBM capability by the Air Force does not preclude the use of manned bombers. The same is true of tactical missiles and fighter aircraft. Man can make judgments in a tactical situation beyond the ability of sophisticated machines. The manned bomber, unlike the ICBM can be recalled if a mission is eliminated after dispatch but before reaching the target. Such a craft will be the B-70.

To provide ability for electronic equipment buried in ICBM sites to withstand the effects of possible 100 megaton nuclear warhead detonations nearby, ruggedized manufacturing techniques will have to be employed in Minuteman and similar projects.

Other areas of interest to the Air Force include: power sources able to operate for long periods of time in space, such as nuclear equipment; navigation systems, mapping equipment, guidance devices and systems; and weather prediction systems using radar and electronic sensors of varied types. Bionics is of interest to Air Force, which is faced with control and computer technology problems that may be solved by bionics-type investigations.

There is a continuing need for electronic warfare (EW) equipment in manned aircraft, including jamming gear to blind radar, destroy communications and deter interception. EW equipment now used in missiles should increase in coming years.

The development of the laser should lead in time to space communication systems operating at optical frequencies. Gamma-ray systems are under study.

The low beam divergence, and large information handling capability of the laser's output, suits it to the coverage of space distances that will confront the Air Force. It has been estimated that in traveling the approximately 250,000 miles to the moon, the circle of light arriving there would be of the order of one mile across. Low power requirements are expected, compared to equivalent microwave systems.

The possible use of the laser's high intensity characteristic may suit it for use in an antimissile system. Requests for study proposals of the uses of the laser's high energy light beams have been sent to industry by the Air Force.

NAVY'S requirements for military undersea operations has made antisubmarine warfare (ASW) equipment

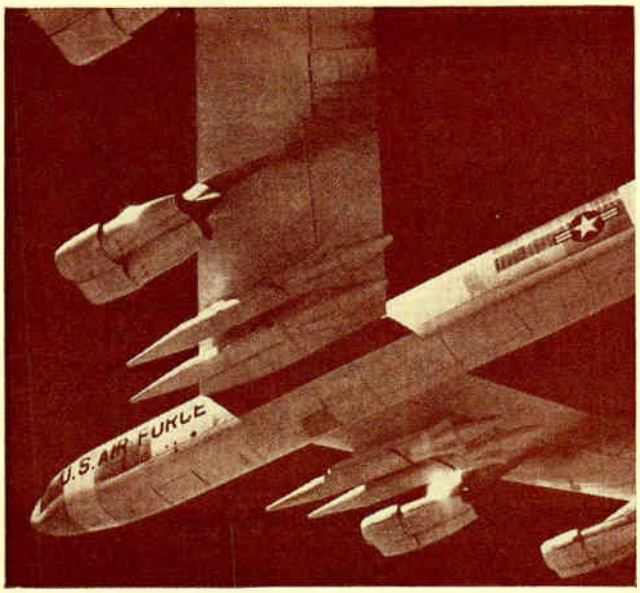
of prime interest. The total fiscal 1962 budget for ASW, just under two billion dollars for all phases including ship construction, is an indication of the magnitude of the problem. Navy undersea requirements for electronic equipment exist also in intensified oceanographic research work for military application, and in the well-funded Polaris missile launching and similar submarine programs.

With development of the snorkel submarine, which presents a small breathing apparatus above the surface for short periods of time, detection of the submarine became difficult. Radar was of use during periods of breathing for conventional submarines. Sonar for use against submerged submarines is limited in effectiveness.

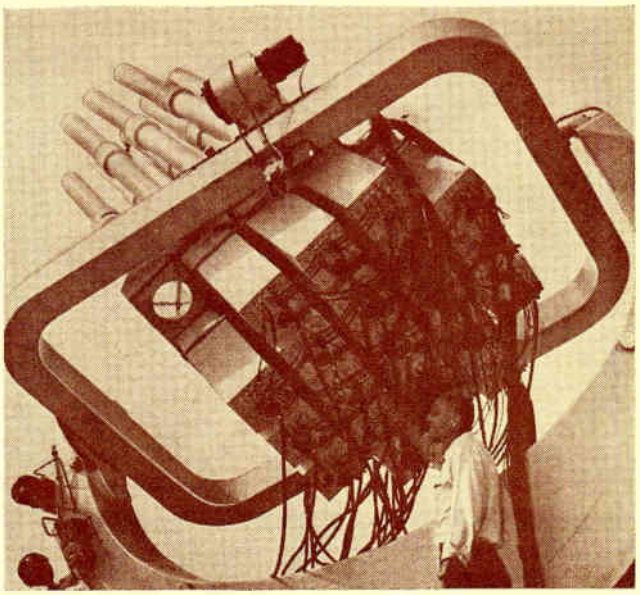
Upon development of the nuclear powered submarine, detection of the craft, which can remain submerged for months anywhere in the earth's 140 million square miles of ocean, reached the stature of an almost impossible task.

It is believed that the USSR has nuclear submarines, equipped with long-range missiles. It is not known if they can launch them from beneath the surface nor if all such missiles are ballistic, but their ability to approach our shores undetected is of prime concern.

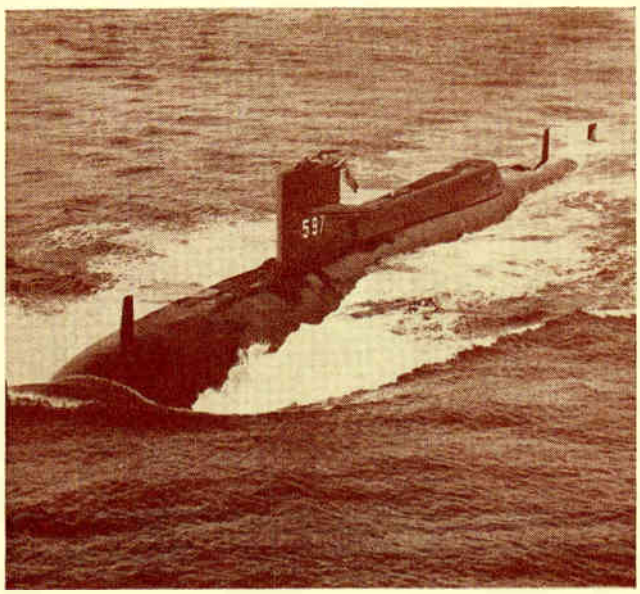
Long-distance penetration of the sea is achieved to a practical degree at this time only by sound. Thus sonar equipment and techniques are of interest to the Navy,



Air Force's air-launched Skybolt missile has over 1,000-mile range. Units are fitted to Boeing B-52H bomber. Douglas is prime for Skybolt



Missile and satellite tracking system for Air Force Systems Command. Facet-eye camera uses 19 refracting telescopes, provides output on image recording tubes



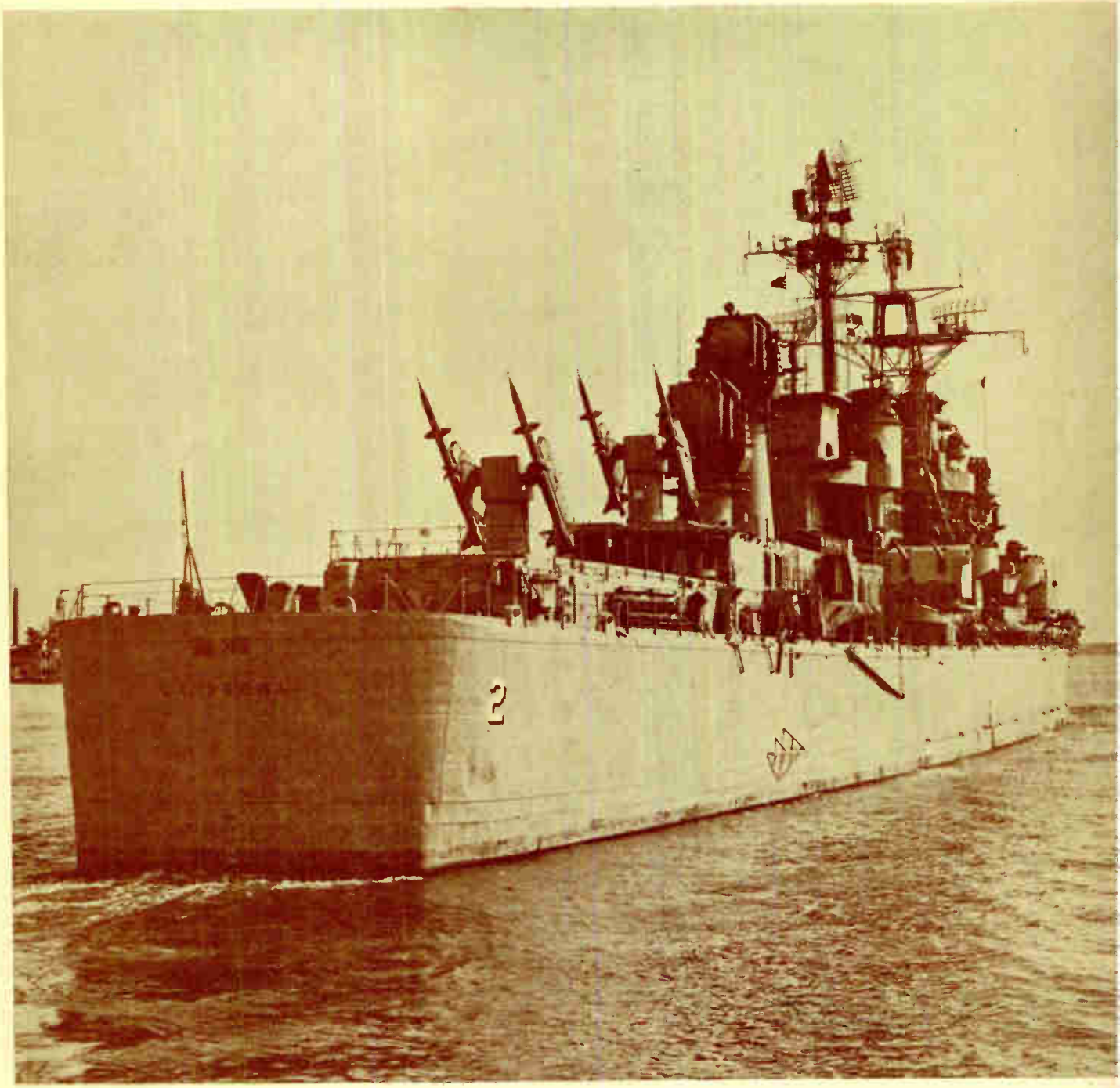
Navy submarine USS Tullibee, designed for antisubmarine warfare is nuclear powered. Vertical fins contain sonar gear. Navy is stepping up oceanographic research, in effort to develop new ASW weapons and techniques

Navy helicopter searches for submarines with sonar dome lowered into sea. Transducer may be lowered below sound bending thermal layers that would allow undersea craft to remain undetected

though Navy is eager to develop new approaches to the problem. Sonars with phased hydrophone arrays, for the passive pickup of moving submarines and high-power, active sonar are both being investigated. The formation of a network of long-range submarine detection stations, as in the recently declassified Artemis project, is an example of the steps Navy is taking in ASW sonar.

The system uses high-power sonar transducers able to project acoustical energy hundreds of miles, coupled with receiving hydrophones in scattered locations to fix the position of an echo-producing object, such as a submarine. Data-processing equipment is required to identify the target from among other possible echo-producing objects, such as whales, schools of fish, shrimp and decoys. Maximum range with sonar is obtained at low operating frequency. The effects of temperature and also pressure and salinity, cause bending of sound rays. Submarines can hide and operate under these layers of water variation. Means of overcoming this limitation are sought. Placing the transducer below the thermal layer is one approach.

NONACOUSTICAL METHODS—The Navy is interested in nonacoustical methods of submarine detection. One technique is the possible use of light undersea. By application of scanning techniques, and the development



Navy's guided missile cruiser, USS Canberra, equipped with long range, high altitude missile guidance radar, with antennas resembling huge searchlights. Sperry Gyroscope builds the radar, Convair is prime for Terrier surface-to-air missiles

of a high-intensity, coherent light source in the blue-green spectrum, reasonable ranges may be achieved. The development of a laser providing output at the blue-green wavelength is looked for as a useful breakthrough toward this goal. High definition would be achieved with any undersea light system and would make target identification easier.

A method in use is the magnetic-anomaly detector, which measures distortion in the earth's magnetic field due to the presence of a submarine.

The turbulence in water caused by a submarine's engines may allow development of a detection method based on this effect.

A wake of fluorescent material trails behind a submarine, and there are thermal gradients created by the passage of a sub. Infrared detection methods may be of use for the latter. Penetration of the ocean with radio frequencies is generally not practical, but recent observation of certain uhf windows shows some promise here. The rise in the surface of the ocean when a submarine passes may lead to high-definition radar equipment designed to detect this action.

Navy is pushing ahead the design and procurement of advanced sonar equipment, and seeks developments in everything from improved transducers, single-use hydrophones and projectors, sensitive low-noise amplifiers, through a range of equipment including data-processing gear and other specialized systems.

Using sonar, the Navy has developed the helicopter dip method, where a transducer is lowered into the sea from a hovering aircraft, and soundings made during a grid pattern of flight. Magnetic-anomaly detectors for use in aircraft are finding application.

To extend the weapon-delivery range in ASW to that of the detection methods, the Dash weapons system, using a remote controlled helicopter, has been developed. Extensive electronics is employed in control and operation of this drone.

Remotely controlled and homing torpedoes able to seek and destroy a submarine are of interest. The underwater, or surface-to-underwater missile, Subroc, is another example of an attack weapon used by Navy against subs.

Mines are considered effective, and updating World War II designs shows promise of further extending their usefulness. New types are also being developed, using acoustic and electronic sensors.

The navigation equipment used aboard the Polaris-launching nuclear submarines, includes gyroscopes and accelerometers in the inertial-navigation equipment, complex digital computers for course correction computation, and various input navigation aids. These submarines, being funded at an increased rate, demand precision navigation equipment to achieve accurate delivery of their 1,200-mile nuclear tipped missiles. Polaris missiles with 1,500 and 2,500 mile ranges are in the works.

Navy oceanography, part of the recently increased Federal spending in this area, demands advanced electronics ranging from sensors to data reduction systems. Included here are devices to measure wave motion, speed of sound in water, temperature gradients, turbulence, salinity, light transmission, sound propagation and reverberation, and a score of other ocean characteristics.

Sonar for fire-control use, as in the direction of depth-charge placement is being refined and applied in ASW work.

GENERAL—Automatic electronic checkout equipment is a must with the high complexity for modern systems. The defense agencies are driving toward more equipment of this nature, so that training skilled technicians becomes less of a problem. Reliability goes up, and the time required for readying equipment for use is cut down.

The use of value engineering, will continue to be pushed by the defense agencies, in an effort to remove frills from designs.

OUR GROWING NONMILITARY FEDERAL MARKETS

NONMILITARY FEDERAL spending for electronics is climbing fast with no leveling off in the foreseeable future.

One spur is the drive for space exploration which has absorbed into its efforts the combined resources of several nonmilitary branches of the federal government as well as segments of the Department of Defense.

NASA—The National Aeronautics and Space Administration, charged with the lead role in space exploration describes its programs as dependent on electronics.

James E. Webb, NASA chief, estimates that half of each dollar spent for space systems goes for electronics.

Of these dollars, many will go for research, development and testing rather than hardware procurement.

In fiscal 1960, the total NASA appropriation was $523,575,000. Of this $333,100,000 was for research and development. Last fiscal year's total appropriation was $964,000,000, of which $668,503,000 was earmarked for R&D.

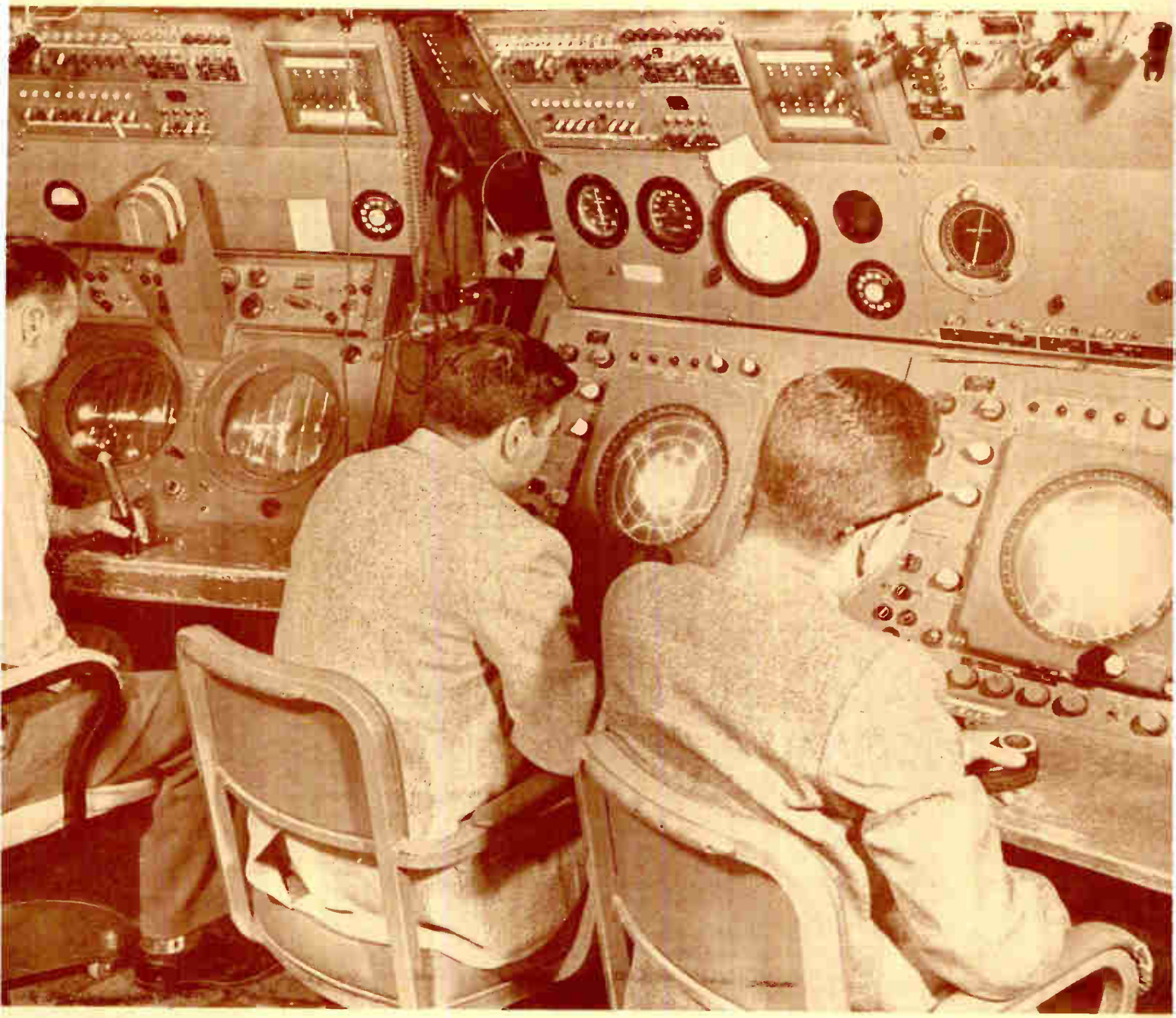
Plans for fiscal 1962 are still somewhat flexible, but show increases over 1961. Funds appropriated for NASA come to more than $1,784,300,000. Of this, some $1,-

300,000,000 will go for R&D. In the light of Administrator Webb's estimate, this will mean some $600 million or more will go for electronics.

Projects which will absorb NASA expenditures fall roughly into four areas: get a team of astronauts on the moon and back safely within this decade, step up development on program Rover, the nuclear rocket; accelerate the program to establish a world-wide satellite communication system and develop a world-wide satellite weather system.

In line with these objectives, NASA's Saturn program will account for heavy expenditures in research and development. The fiscal 1962 figure of $224 million represents about 17 percent of NASA's total R&D budget. Saturn's goal is to develop a multipurpose space vehicle using a modular approach for the upper stages to achieve a variety of configurations and functions. Earlier space research programs usually involved a vehicle tailor-made for each experiment. The Saturn concept will allow the same design to be modified to produce a family of vehicles to meet a variety of requirements.

Plans for long duration earth orbit flights, circumlunar flights and landings as well as returns are grouped by NASA under the Apollo program. The fiscal 1962



Typical information processing room at a Federal Aviation Agency installation at a large air terminal

R&D budget provides about $160 million for this purpose and represents some 12 percent of the R&D total.

Lunar and planetary exploration will account for about the same amount of money as the Saturn program. NASA officials expect this exploration program to present challenges in every branch of science. Probing the immediate area of space around the moon will call for specialized rocket control, high-level telemetry systems and a vast array of data-gathering devices. Surface exploration will impose even greater demands. Exploring the space environment and subsequently the surfaces of Mars and Venus will demand higher instrument performances than any present requirements. Wide-band infrared equipment, narrow-band spectrographic gear, data storing systems, long-range command systems and energy sources will all be called for.

Representing about 7.3 percent of NASA's fiscal 1962 R&D budget, communication satellite systems are being examined both in passive and active operation. Studies already conducted through Project Echo show a need for techniques for making rigid reflectors, techniques for ejecting more than one satellite into a predictable orbit and development of ground transmitting and receiving gear including equipment operating at optimum microwave frequencies.

NASA officials say studies indicate that with suitable ground facilities, about 60 Echo-type satellites at 2,000-mile altitudes could provide a world-wide system operable 99 percent of the time.

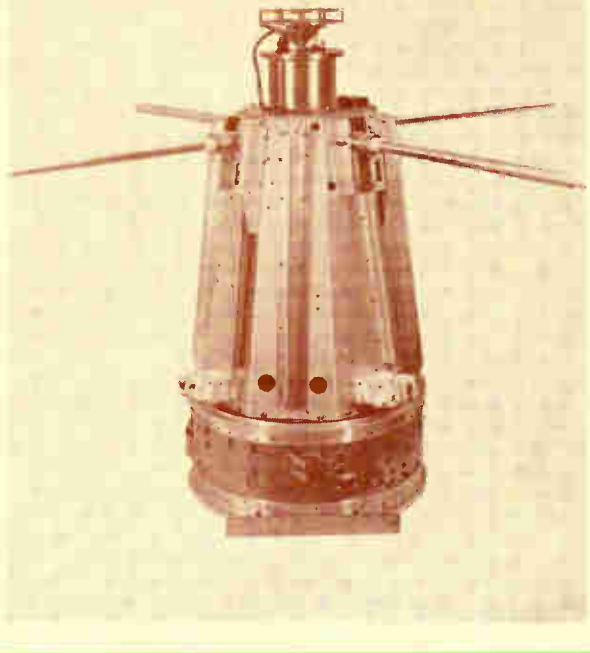
Development of long-lived components for active communication satellites is one area being probed by NASA. Inherent in this will be research on the behavior of components and systems in the space environment. On the ground, it is expected that an active satellite system will impose new demands on communications and tracking systems.

In addition to the markets for electronic equipment, and research and development that NASA programs are creating, a substantial amount of money will go for rental of electronic equipment, primarily of the data-handling variety. The growing complexity of the mathematical problems in space flight has created the need for some $5,700,000 worth of data reduction equipment in fiscal 1962 and for some $11,200,000 in analytical computation work. In addition, the business affairs of the Administration impose the need for some $2,100,000 worth of further expenditures for electronic computation. Most of these needs are being met through rentals of data-processing equipment.

FEDERAL AVIATION AGENCY expenditures over the next half decade may reach a leveling off period. One reason for this is that projects now being worked on anticipate future air traffic demands.

Some evidences of decline in spending are already evident in comparison of research and development budgeting of $78,400,000 in fiscal 1961 and of $71,600,000 in fiscal 1962.

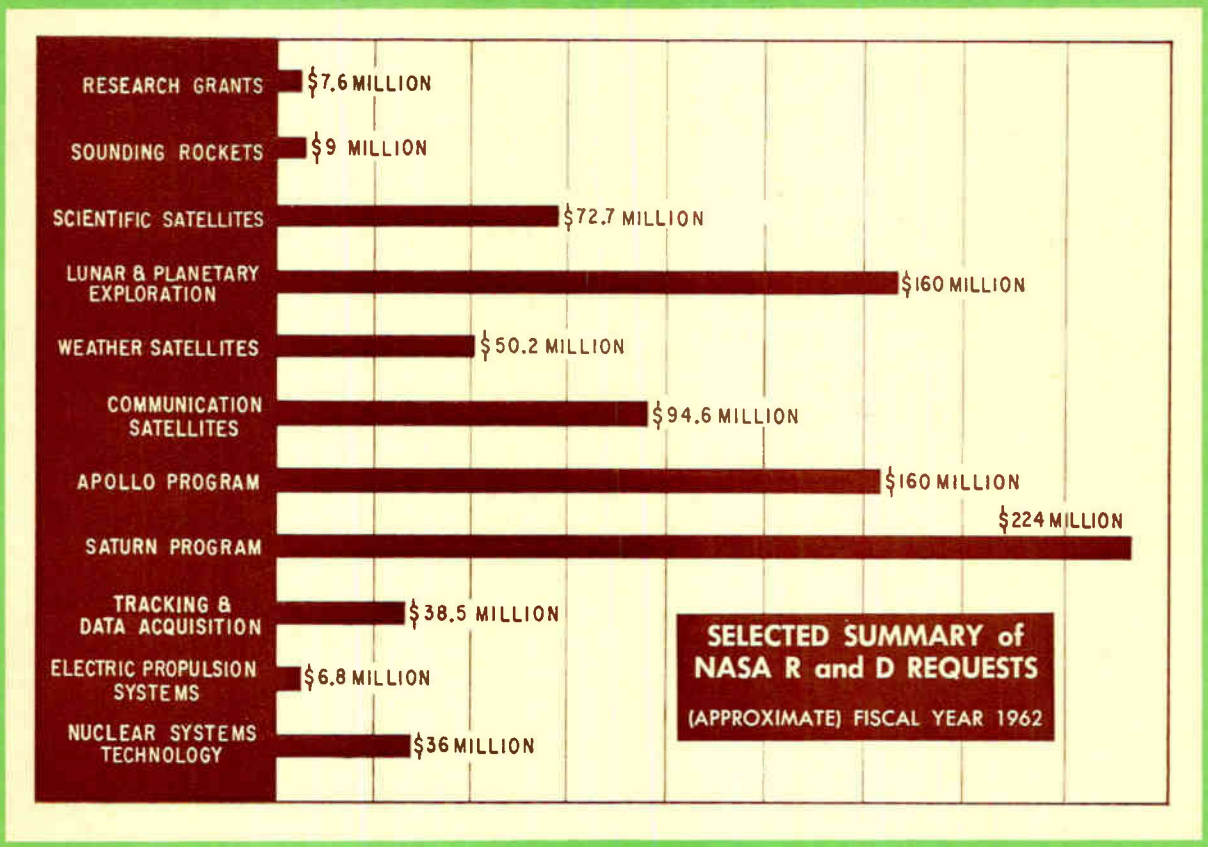
Expenditures last year as well as proposed spending in the immediate future may hinge on implementation of FAA's Project Beacon. This plan will utilize as much as possible the tools of automatic data processing, signaling and communications to control the growing amount of air traffic in U.S. skies. In addition to Beacon, plans are being worked on to complete a system of data-processing centers that will act as a nationwide air traffic control network.



Electron density profile probe developed by National Aeronautics and Space Administration to measure electron density at 4,500 miles up

NASA Appropriation Summaries FY-1960-62

	Salaries and Expenses	Research and Development	Construction of Facilities	Total
Fiscal Year 1960	$ 90,850,000	$383,100,000	$ 99,625,000	$523,575,000
Fiscal Year 1961	$170,760,000	$668,503,000	$124,737,000	$964,000,000
Fiscal Year 1962 (Requested)	$226,686,000	$1,295,539,000	$262,075,000	$1,784,300,000



Much of last year's contracting by FAA heads towards these twin goals. For example, thirteen long-range radar installations at about $2.4 million each are being built. Forty-one bright radar displays at about $405,000 each are contracted for as well as 14 radar beacon systems at some $293,000 each.

Thirty locations within the U.S. are being equipped with new teletypewriter facilities for delivery of weather data to the U.S. Weather Bureau, while the Alaskan teletypewriter circuit is being modernized. High-speed circuits are being installed in eight cities at an average cost of $342,000 and expanded weather data information services are being provided at 10 locations.

A good many FAA installations have been made at locations that are now primarily military rather than commercial in their aircraft operations. In most cases, these air facilities are in a state of changeover and may be used as commercial and civilian airports in the near future. As part of defense planning, however, present FAA-installed equipment is located at these sites to be compatible with possible future military needs.

AEC—Following reduced activity during suspension of nuclear testing, the Atomic Energy Commission spending for electronics appears likely to rise over the next five years.

From the present level of $10 million in calendar 1961, next year should see a rise to more than triple this amount as more and more control, monitoring and test electronics are needed to match general growth in atomic research and use. Additional thrust will come from AEC participation in Project Rover, aimed at developing a nuclear powered rocket engine, and Project Snap, aimed at developing on-board power units to supply satellites and space vehicles with internally produced electricity.

Weather Bureau spending for electronics will go mostly for data handling and transmission equipment, with other expenditures going for electronic devices and systems to gather meteorological information.

In matters related to meteorology, the Weather Bureau is participating with NASA in some space work. For fiscal 1962, funds have been allocated for spacecraft and launch vehicles. Command and acquisition stations are being built in Alaska and along the East Coast of North America. Total funds for these installations come to slightly over $12 million. Special-purpose equipment will amount to more than $3 million. Of this, a good portion will be in electronics. An additional $2 million will go into data processing and close to $300,000 will be spent for communications equipment.

OTHER FEDERAL AGENCIES such as Federal Communications Commission, Treasury Department, Bureau of Internal Revenue and Federal power projects and law enforcement agencies are also purchasers of electronics equipment.

OUR GROWING

THE POPULATION explosion and the rise in educational levels are bringing the high levels of purchasing power. Consumer desires are exploited to the point where they are confused with consumer needs, so that what was once considered a luxury item is, or will be, thought of as a necessity, A prime example is the television set, once a status symbol for the privileged few, and now the major source of entertainment.

But where are those increasing consumer dollars going? Television receiver sales, representing 40 percent of the consumer electronics market, have presently leveled off at a little over six million sets a year. Sales of phonographs and radios, each taking about 20 percent of the consumer market, declined somewhat last year as compared with 1960. A big surge may come in color tv, now that many set makers are represented in the market. Promising opportunities exist in the nonentertainment home electronics field, such as in electronic ovens, air purifiers and ionizers, and thermoelectric refrigerators and water coolers.

BLACK-AND-WHITE TELEVISION—Although 88 percent of U.S. homes have at least one tv set, and this figure may be close to the ultimate saturation percentage, the 1961 tv sales should be over 6.2 million sets, an increase over 1960 (5.9 million), 1959 (5.7 million) and 1958 (5.1 million). At least 6.4 million receivers should be sold every year for at least the next ten years, despite the approach of saturation.

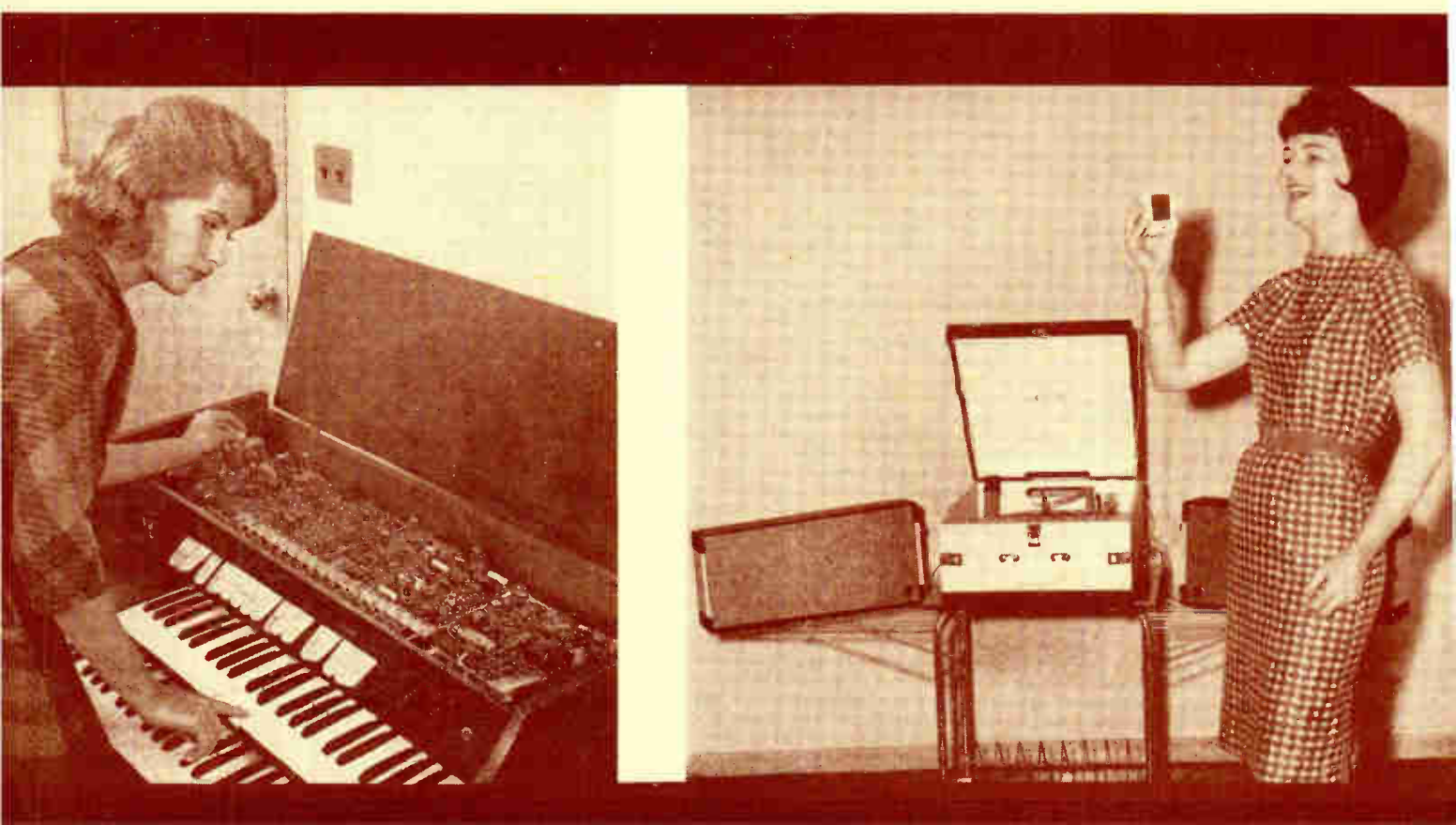
The future market will be largely replacements and extra sets. In 1959 the percentage of replacement sets to total sets in use exceeded substantially, for the first time, the percentage of sets to new tv homes. Last year, replacement sets totaled 3.8 million, or 6.8 percent of the total sets bought, while sets for new tv homes amounted to 1.1 million, or two percent of the 55.6 million sets in use at the beginning of the year.

Optimistic estimates place the yearly tv set sales at 8.5 to 9 million between 1962 and 1970, based on the population increase and a 14 percent replacement rate.

While the 19 and 23-inch picture tubes may dominate

Making an adjustment to the Schober build-it-yourself spinet organ, which has 88 keys in two manuals, 18 stops, 13 pedals, and weighs less than 100 pounds. Assembly time is estimated at 50 hours

This portable stereo phonograph by Admiral is aimed at the teenage market. When the microphone is plugged into a "sing-along" jack, sound from the microphone comes from the right loudspeaker



CONSUMER MARKETS

the black-and-white tv market in 1962, Admiral is stressing the 24 and 27-inch receivers. Sylvania considers the 23-incher to be an attractive size, but says there is a trend toward the larger sizes, particularly the 27-inch.

Although many purchasers stress portability of a tv set when buying one, especially an extra one, the set really doesn't get moved around in the home. Usually it remains in the bedroom, which is coming up fast as the most likely location of the second set.

Many U.S. manufacturers feel that battery-powered portable tv sets are impractical at present. Prices are high, and the picture size small for people who have become accustomed to at least a 19-inch screen.

COLOR TELEVISION—A dozen companies are offering color tv sets this winter. RCA, Packard-Bell, Emerson-Dumont, Magnavox, Admiral, Olympic, Sears (Warwick) and Philco have been joined this winter by Zenith, General Electric and Sylvania.

For the hi-fi enthusiast with an interest in short-wave reception, National Radio has styled the NC-105 to appeal to the audiophile as well as the amateur. The front panel provides a high-impedance tuner output

Westinghouse and Motorola both sold color tv receivers from 1955 through 1957, but neither has revealed plans for reentering the field at present.

Color sales have seldom gone over 100,000 sets a year, so that there are about 700,000 sets in use after eight years of sales.

Color sets are selling better than last year, and estimates by top industry people for this year's sales range from 250,000 to 500,000, with one guess of 750,000. The 1961 sales are expected to add up to 150,000.

Increased sales this season are partly due to more color programming. In the half-dozen largest U.S. cities, about 20 to 40 hours of color are broadcast weekly.

Prices of many color tv receivers are in the $600 to $700 range. The Sears Roebuck consolette lists for $450.

Hopes were once high for Paramount's single-gun Lawrence tube to lower prices, but a Lawrence tube set, when and if it is finally perfected, will cost, according to Paramount, about $400 on a mass-production basis of half a million sets a year.

Last fall a Japanese company brought out a $300 color tv set, using two single-gun tubes, and based on the two-color theory developed by Polaroid's Edwin H. Land. The theory was also substantiated mathematically by Huseyin Yilmaz of Sylvania.

RADIO—Sales of radio receivers have been rising steadily since 1958. Production, also on the rise since 1958, has for 1961 dropped some five percent below the previous year. Total radio production for 1961 should be 15 million sets, with f-m radios accounting for at least 720,000 units.

A substantial market is in sight for f-m stereo radio, backed by manufacturer support of stereocasting. The half-dozen largest U.S. cities have f-m stereo programming, although sometimes on a limited basis.

PHONOGRAPHS—Factory sales of phonographs will show little change in the near future: a rise of less than two percent is anticipated in stereophonic models. The present ratio of stereo to mono, about 15 to 2, will increase to about eight to one in 1965.

ELECTRONIC ORGANS—In 1961 retail sales were about $140 million. The 1962 estimate is $150 million, indicating a healthy rise in electronic organ sales. Since only a few percent of the market potential has been tapped, several more companies may soon climb aboard the electronic organ bandwagon.

Interesting sidelights are that the electronic organ has not become a status symbol, and that while most people buy a piano for their children, they buy an organ for themselves. One organ maker claims that more new

organs are now bought nationally than new pianos.

Transistor keying is a feature of the Conn organs, which use vacuum tubes for tone generation, as do most organs. Transistor tone generators are used in organs by Allen, Gulbransen, Magnavox, and Thomas. The lower-priced market is aimed at by organs in the $500 range, made by Electro-voice and Estey.

ELECTRONIC ORGAN KITS—Although over a dozen companies share the home organ market, the do-it-yourself organ kit business is largely split between two companies, Schober Organ Corp. of New York, and Electronic Organ Arts of Los Angeles.

Schober Organ markets a concert model at $1,200, a consolette at $800, and, to compete with the low-priced ready-made organs, a recently introduced spinet at $550. The spinet uses neon oscillators. This fall Schober plans to bring out a table-top organ for about $200, with a single manual, divided for accompaniment and melody.

Electronic Organ Arts once offered a dozen kit models, and had a tendency toward selling completed organs. After this company was bought by Dorsett Electronics, the emphasis has been on kits, and the models have been reduced in number with prices beginning at $1,300.

AMATEUR RADIO—The existence of 230,000 amateur radio stations makes the amateur communications market a sizable one. An increasing percentage of radio amateurs build receivers and transmitters from a kit, or buy them ready-made.

The citizens band group is a fast-growing communications field, with well over half a million c-b transmitters in use. The variety of citizen's band equipment is mounting rapidly, and so many c-b stations are already crowding the airwaves that the FCC may soon have to take further steps to stop general rag-chewing.

ELECTRONIC KITS—Although the do-it-yourself builder can save up to 50 percent of the cost of ready-made equipment, many kits are assembled by people who could easily afford the finished equivalent. It is the "pride and satisfaction of personal accomplishment," as one manufacturer puts it, that makes a man spend $30 for a six-transistor radio kit when he can buy a transistor radio at less than half the weight and price.

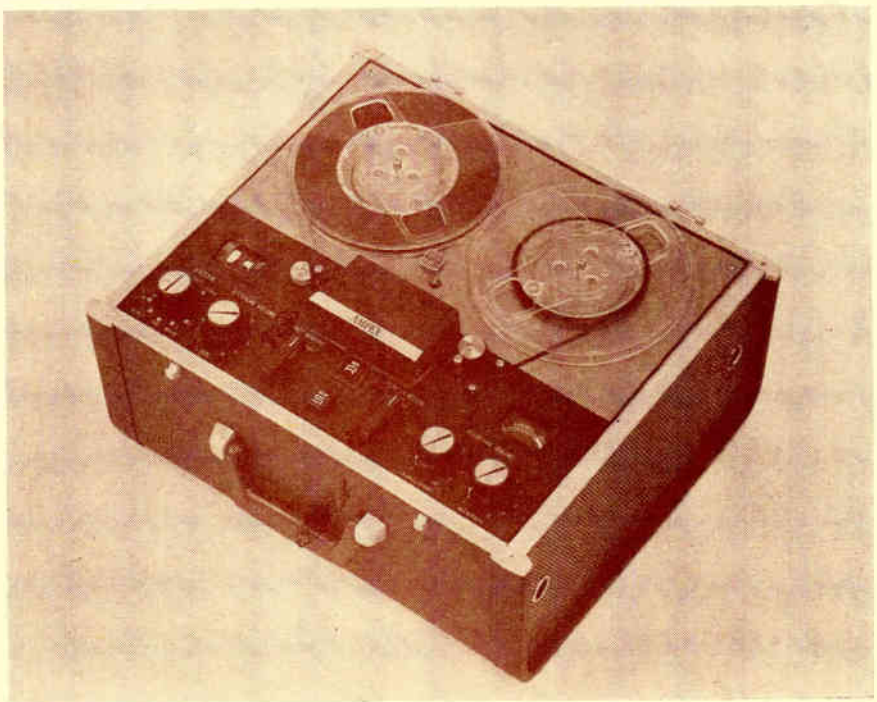
The new Daystrom line, made by the Heath company, is sold through dealers. The Daystrom circuits are similar to those in the Heath kits, but there are differences in design, price and packaging. To make the Daystrom kits simpler to assemble, and thereby appeal to a wider audience, tube sockets are riveted to the chassis, critical circuits come partially assembled, more circuit boards are used, resistors and capacitors are laid out in numbered sequence.

Heath uses a tunnel diode in their latest model grid-dip meter.

ELECTRONIC TOYS—The electronic portion of most ready-made electronic toys consists of a simple transistor amplifier, such as in a portable voice amplifier. That the price of electronic toys comes high is indicated by the $10 list price of the portable amplifier, and by the $30 list price of an infrared phone, which even at cut rates is still about $20.

Many of the toys that use tubes or transistors are the do-it-yourself kits, variously called electronic workshops (Heath), science kits (GE), or electronics engineering sets (Lionel). The kits are of two types: for building a single item, or making several. For the single item, the price is often high: $18 list for a GE transistor radio kit. The multiple-project kits cost an average of a dollar per project, and most use solderless connectors, so that a circuit can be set up in a few minutes.

An estimated $8 million worth of build-it-yourself electronic kit toys will be sold in 1962, and $20 million in 1971.



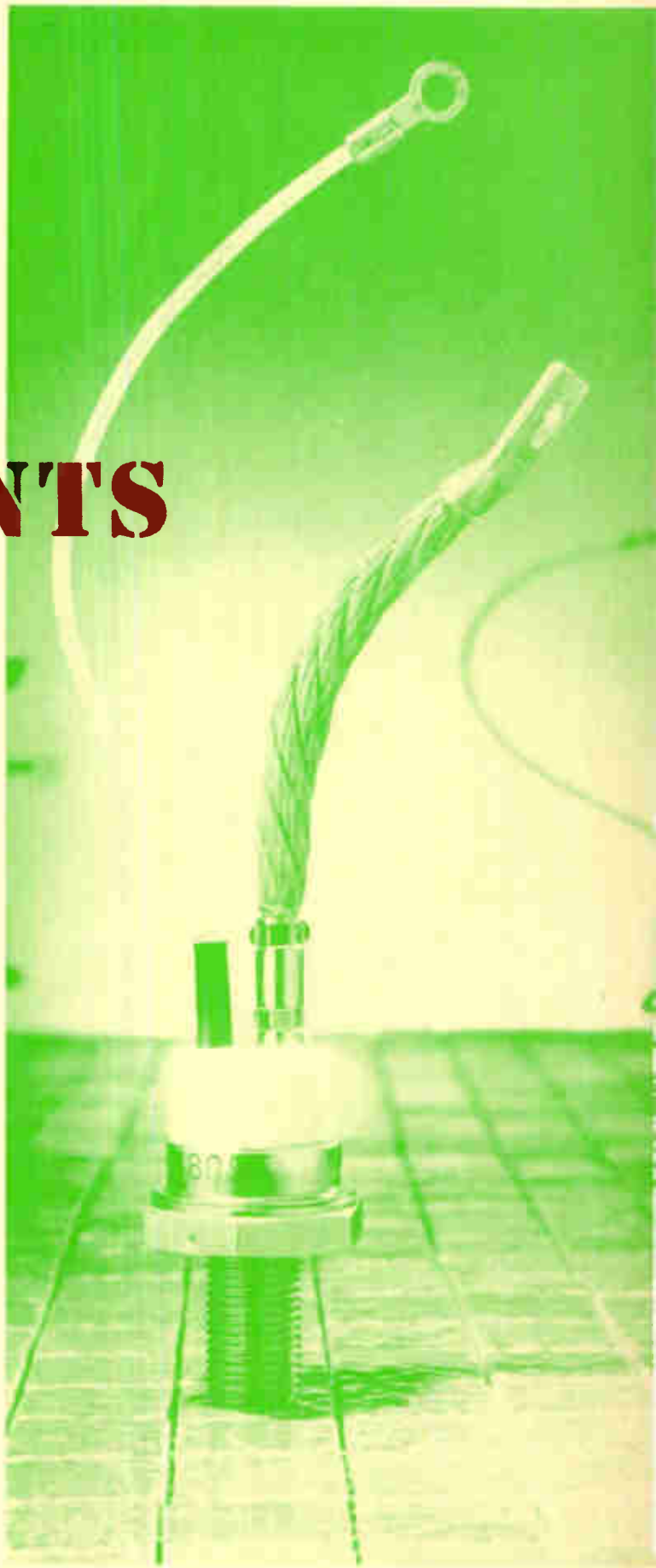
Portable model 1260 four-track stereo and monaural tape recorder and player by Ampex permits separate erasure of each of the four tracks, and uses a three-pole erase head that erases the tape twice

OUR GROWING COMPONENTS MARKETS

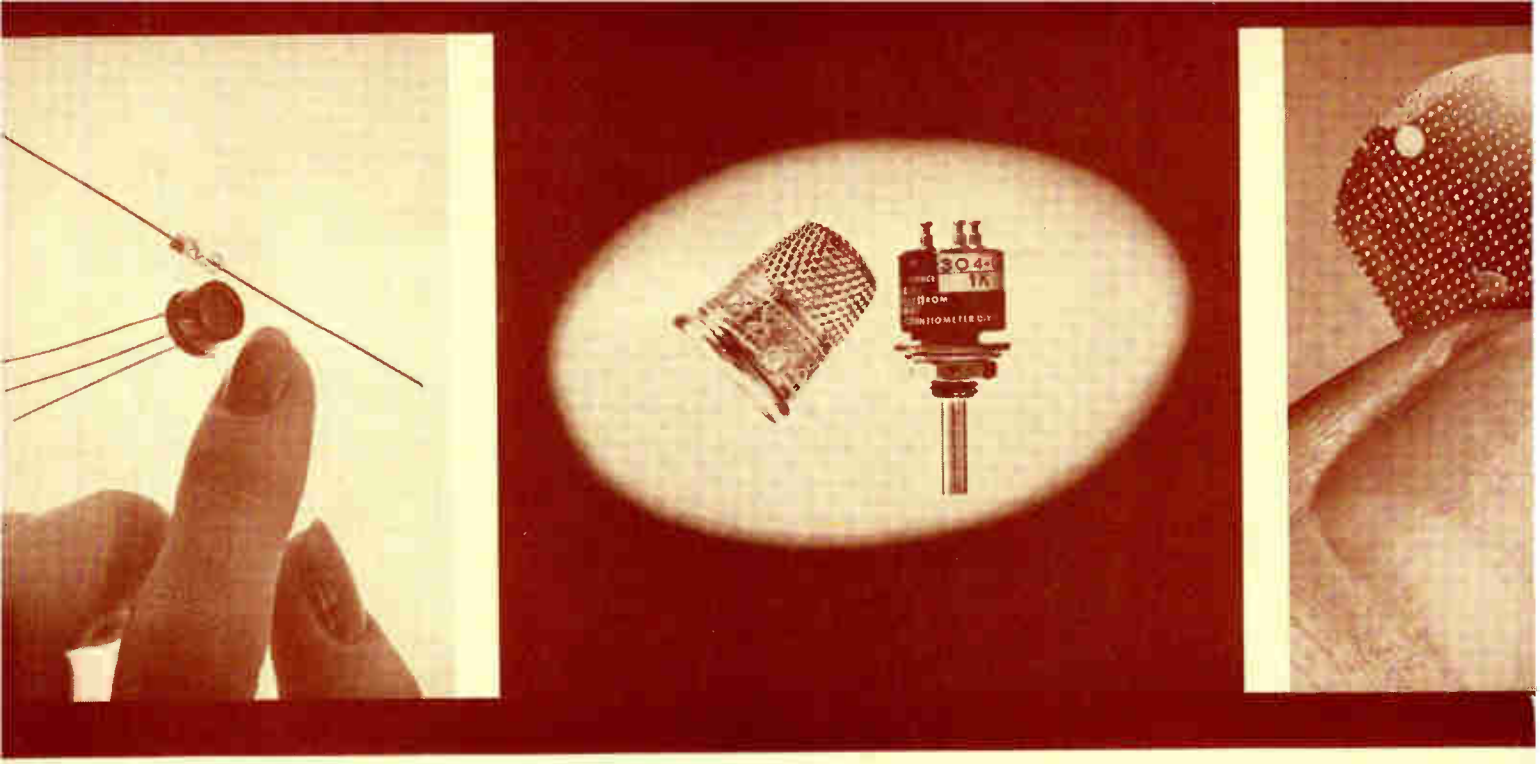
COMPONENT MAKERS are for the most part optimistic about the future, despite the problems of imports, price-cutting and heavy competition. Sales and profits for the first quarter of 1962 should be about the same as for last year.

Sprague Electric's vice-president of sales, Carroll Killen, sees a modest increase in the components market in 1962, and says "we are just now beginning to see results of the release of military orders in the past couple of months. The industrial components market will just hold its own in 1962. Industrial customers, especially computer manufacturers, overestimated their needs in 1961, and so they have over-healthy inventories. The military will start to let some contracts in 1962 for microminiature modular packages with discreet components and component groups. This will gradually build into a big market, since the so-called molecular circuitry is still far away. Also, the modular approach is less costly, and does not force circuit-design standardization."

ELECTRON TUBES—Although semiconductors are increasing in use, and heavily in some applications, electron tubes are by no means on the way out. The output of electron tubes of all types is expected to rise two to three percent this year over the 1961 estimate of $593 million in factory sales. Although receiving tubes may decline two to three percent yearly, this should be offset by a seven-percent rise in the factory sales of power and special-purpose tubes. Traveling-wave tubes are expected



Silicon controlled rectifier by Westinghouse handles up to 300 volts and up to 50 amperes



to increase 20 percent; backward-wave oscillators will experience a 40-percent rise.

Two factors are important in the continued existence of electron tubes. One is increased reliability. For example, the failure rate for the average of 16 different Sylvania subminiature tube types was lowered from 5.5 percent per 1,000 hours in 1952 to 0.5 percent per 1,000 hours in 1960. For some tube types, a failure rate of 0.1 percent per 1,000 hours is forecast by Sylvania within the next two or three years.

Tests by Arinc Research Corp. aboard naval vessels show a combined tube removal rate of 15 percent per thousand hours in 1954, which dropped by 1960 to 1.2 percent for miniature tubes and to 0.19 percent for subminiature tubes.

The increased reliability was brought about, not by startling breakthroughs, but by many small innovations, such as changing the bulb design to reduce glass cracking, lint control to eliminate foreign matter, and heater-coil redesign for more uniform coating. Even greater reliability will result in the future if heater burnout is minimized or eliminated. Greater control of saturation emission and interface resistance also should improve the uniformity and long-life stability of electron tubes.

The second factor supporting the tube market is resistance to nuclear radiation. Radiation can radically alter the characteristics of most transistors and similar solid-state devices, and possibly cause circuit failure. Although the effects of radiation on electron tubes range from a reduction of emission current to causing fissures in the tube envelope or breaking the glass-to-metal seals, tubes are resistant to radiation.

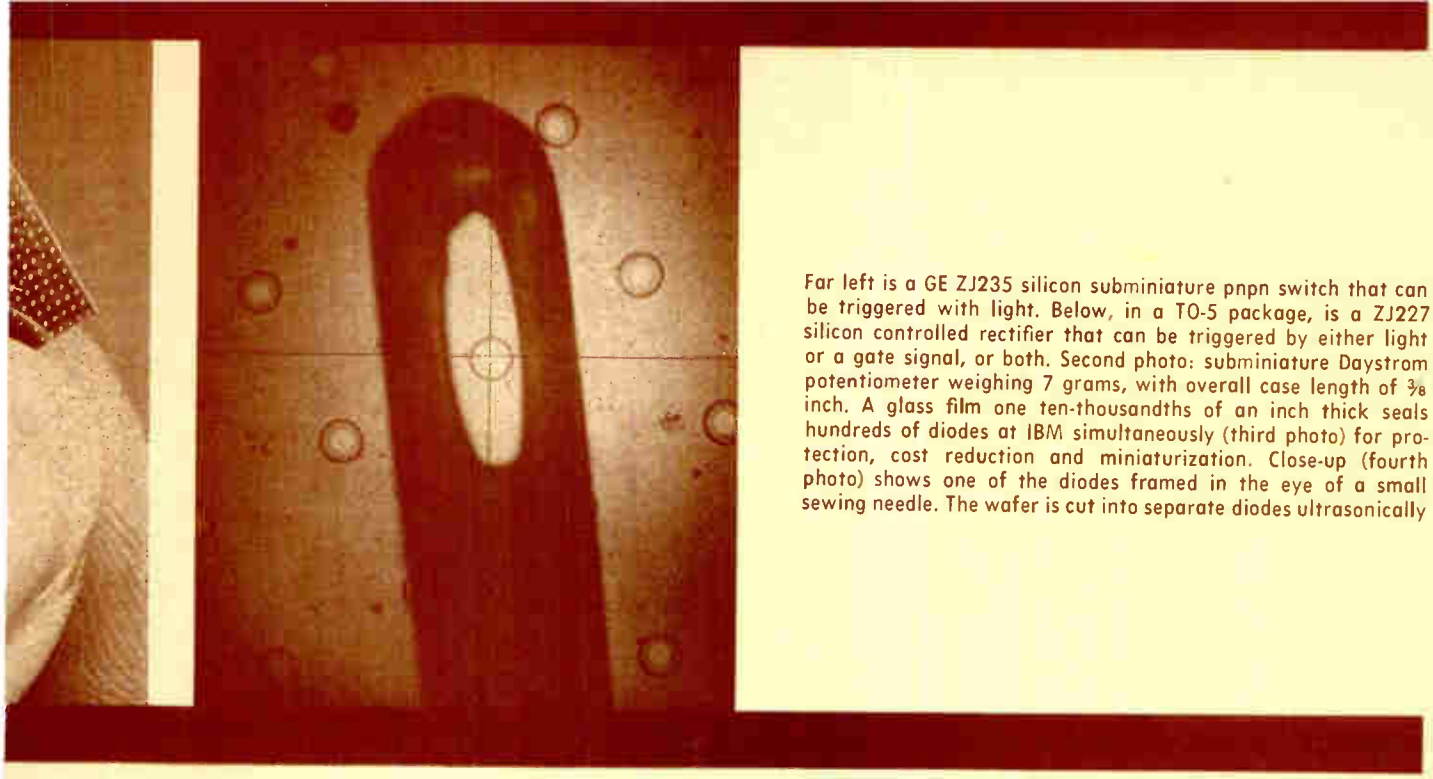
According to B. W. Sauter, general manager of Westinghouse's electronic tube division, the downward trend in receiving tubes over the last several years could reverse itself and begin to increase in the next few years. He referred to the way radio sales have held up in the past, and anticipates that the tube replacement market will exist at a substantial level for a long time. Color tv sets, for example, have an average of twice the receiving-tube complement of present black-and-white tv receivers.

New types of electron tubes show promise for the future. The General Electric multipurpose Compactron tubes will be used by Muntz TV to make a television set with only eight tubes plus the crt, at a retail price of $100. The Compactron is already in some tv sets of other manufacturers. The nuvistor, RCA's thimble-sized tube, is featured in their current line of tv sets, both color and black-and-white, because of its low noise factor, and is also used in tv cameras, radar sets, and test equipment.

The marketing manager of Raytheon's industrial components division J. Dorfman, says 1962 will be better for tubes than 1961, because pressure to cut prices will diminish. "In 1961, too many customers were using their suppliers as inventory warehouses. The buildup of inventory has begun," he adds.

Dorfman doesn't see a decline for the electron-tube market, and states "There are two plus-factors for entertainment components in 1962. One is that color tv is beginning to crawl, and will soon walk. The second is f-m multiplex stereo. New industry standards make a healthy picture for everyone concerned with hi-fi and f-m generally. Overall, the receiving tube business is in a stable condition, for both the industrial and military market, and adjustments have already been made for the effect of solid-state advances. As for light-emitting tubes, they are part of the display field, which is already launched on expansion and will continue in 1962. Printer tubes, storage tubes and other electronic readout devices should find expanding applications and a bright market in 1962."

Among the expected General Electric developments is an integral tube-cavity combination using a planar triode receiving tube that oscillates at 10 gigacycles, according to W. F. Greenwood, marketing manager of the GE receiving tube department. Two or three major systems applications for GE's thermionic integrated micromodule



Far left is a GE ZJ235 silicon subminiature pnpn switch that can be triggered with light. Below, in a TO-5 package, is a ZJ227 silicon controlled rectifier that can be triggered by either light or a gate signal, or both. Second photo: subminiature Daystrom potentiometer weighing 7 grams, with overall case length of 3/8 inch. A glass film one ten-thousandths of an inch thick seals hundreds of diodes at IBM simultaneously (third photo) for protection, cost reduction and miniaturization. Close-up (fourth photo) shows one of the diodes framed in the eye of a small sewing needle. The wafer is cut into separate diodes ultrasonically

(TIMM) circuits, plus several small black-box applications, should develop in 1962. The company also plans to make TIMM components commercially available for development work by systems designers. Greenwood predicts that growing needs for radiation-tolerant electronic systems should increase the usage of small ceramic receiving tubes. It is expected that radiation tolerance ratings for glass tubes will be established in 1962.

POWER AND SPECIAL-PURPOSE TUBES will find the military market showing continued growth. The market growth-rate will be further affected somewhat by NASA and other space budget increases.

During the past few years, equipment and defense systems have become more complex. The field of radar systems is an example. This trend to complexity is expected to continue, and as a result, the cost per installation will tend to increase. the number of projects decrease. Such programs will require tubes with higher output and a higher degree of reliability. The emphasis will be on shorter run, complex, highly reliable tubes designed for specific application.

In 1962 the evolution to space-age requirements for radars for search, surveillance, guidance and communications will bring about the need for higher-power tubes with 10 to 100 times the power output of existing designs. One device to meet these requirements is the multiple-beam klystron (MBK) now being developed by General Electric. Historically, higher outputs have been obtained by using multiple externally linked units, but systems costs in dollars per kilowatt may favor a single, highly reliable unit such as the MBK. Because large blocks of power are required for many systems installations, increased emphasis on efficiency improvement of high-power microwave tubes is anticipated.

Increasing demands for intelligence transmission at high rates, and improved counter-countermeasures techniques, will see further development of wider-bandwidth microwave devices such as voltage-tunable magnetrons, klystrons and traveling-wave tubes. Multioctave broadband requirements can be met by microwave tubes now in advanced development, provided that requirements become well-defined and funds are allocated.

The market for traveling-wave tubes is expected to grow rapidly. There will be a continued reduction of noise figures for types used in receivers. Improvements in tube designs can be expected to drop the noise figure of existing types an additional 1 to 3 db in the next year.

In the fields of secure communications and deep-space probes, there is not expected to be any rapid change to light beam devices. Stimulated market activity is expected for wide-band, low-noise voltage-tunable magnetrons (VTM) because of greatly improved low-noise characteristics. Further improvements in VTM efficiencies and packaging should increase their use for space applications.

Single-purpose phased-array radar requirements should stimulate the market for microwave tetrodes because of their phase stability. In this area. the needs for broad banding may be solved by integral cavity designs up to low S-band. Ring-bar and other microwave structures now being developed will play an important role in higher-frequency multipurpose phased-array radar systems.

Due to a growing concern with problems of radio-frequency interference. a steady increase in the market for high-power microwave filters is expected.

The military radar tube replacement market will increase. Some observers see the replacement market evolving into a repair business for expensive high-power tubes. Many present tube designs can be repaired instead of replaced, making possible considerable savings to the military.

Economic recovery in many industrial fields should have a favorable effect on the market activity for power and control tubes. This includes ignitrons for electronic steel-mill drives. The European steel-mill market, in its build-up since World War II, has made wide use of

electronic drives. Electronic drives for U. S. applications are expected to increase.

Another growth area is the metal fabricating industry, which includes the automotive industry. Here resistance welding equipment is important.

In public transportation, further developments in the design and use of railway multiunit cars, now being considered, could stimulate market activity for water-cooled and air-cooled ignitrons for motor speed control. In general, the replacement market for industrial tubes should increase modestly.

The rate of growth in the broadcast and communications market will depend largely upon FCC rulings regarding vhf-uhf television. If an upward frequency shift becomes mandatory, a revival of the high-power tube market is expected. Otherwise, the increase rate of new stations is expected to stay at its present nominal level.

Only small gains in the broadcast station replacement tube market are expected.

No significant penetration has yet been made in the consumer market by high-power tubes. One possible exception is the application of magnetrons for electronic cooking. Any acceleration of present activity now being conducted by some range builders could be the stimulus for wide use. Any appreciable market is likely to be several years away.

TV PICTURE TUBE markets should increase, according to B. W. Sauter of Westinghouse, for some of the same reasons affecting receiving tubes. Obsolescence of tv sets, new families being formed, two and three-set homes and picture-tube innovations are contributing factors in the future of this market.

Black-and-white picture tubes of the 19 through 21-inch sizes enjoyed high factory sales from 1953 through 1959. In 1961, factory sales of 22 through 25-inch sizes finally pulled ahead of the 16 through 18-inchers. In 1961, EIA changed its tube-size groupings. The 1961 figures show that factory sales of 18 through 20-inch tubes were double the 1960 sales, sales of 21-inch tubes were halved, sales of 22 and 23-inch tubes did 50 percent better, and sales of tubes over 24 inches were about the same.

The only color tv picture tube in general commercial use today is the RCA round three-gun tube. Sales of these tubes are linked directly to the market for color tv sets. Motorola has a rectangular color tube that is said to require a less bulky cabinet, but as yet there is no indication that it will be used in a color receiver. Nor is the Lawrence single-gun tube, owned by Paramount, about to be incorporated in a commercial set.

Although work is being done on flat picture-on-the-wall tubes, they are still not out of the woods. Pictures have been obtained with flat tubes in the laboratories, but as one manufacturer put it, "don't ask us what kind of a picture we've been getting." Sometime this year the Navy may release information on a flat nonvacuum-tube electroluminescent panel developed by Lear for aircraft instrument readout, although it may be some time before a lower-cost panel would be developed for tv use.

SEMICONDUCTOR unit sales will rise in 1962, but price-shaving will continue, so that the net result will be little change in the dollar volume, according to Henry Schunk, marketing manager of the Raytheon semiconductor division. He adds that there will be no market zoom in 1962 for new devices such as tunnel diodes, integrated circuits, avalanche transistors or controlled rectifiers.

Prices have bottomed and are now starting upward, Schunk says. "Inventory buildup has started because customers no longer have barrels of them in stock. Price stabilization is already starting on germanium alloy transistors. In general, entertainment-grade semiconductors will have a stabilized market and price. High-speed types such as mesa, planar and epitaxial, pose question marks. It looks like the supply potential is greater than the actual market."

One trend seen in 1962 is a decrease in special semiconductor type designations.

The price cutting once common in the electron-tube field is now found in the semiconductor business.

Factory sales of semiconductors are expected to rise about eleven percent in 1962, with a 1965 figure of $939 million, an increase of over 50 percent from the 1961 estimate of $606 million.

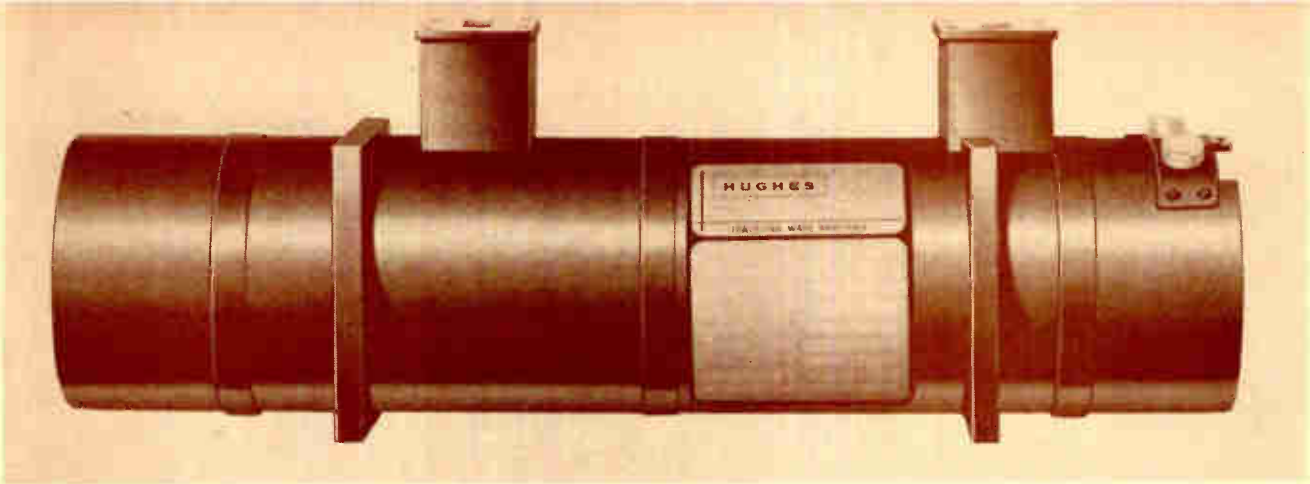
The glamour of the transistor has attracted over 90 U.S. companies to semiconductor production, with a resulting overcapacity. Mergers and dropouts are not uncommon. Among the larger companies, Raytheon, which acquired CBS Electronics' semiconductor business, later bought Rheem Semiconductor.

Westinghouse feels that the rapid price reductions experienced in 1961 should diminish during 1962. However, they believe there is a trend developing toward product simplification and lower costs in high-volume product techniques in the semiconductor industry. It is expected that new emphasis will be placed on markets now using conventional electrical devices, in an effort to supplant these devices with solid-state components. Specific growth components include power-switching devices, represented by silicon transistors and controlled rectifiers; thermoelectric devices for cooling as well as for power generation, and molecular electronics in which functional electronic blocks will be extensively used in commercial products. Some manufacturers believe that germanium devices in general may have a limited future, particularly low-power diodes and transistors. Tunnel diodes have not developed as rapidly as some early predictions had indicated.

Tunnel diodes, although of interest in microwave and special applications, may find less use in computer logic circuits than in small, fast memories, for which they are well-suited by their high speed and low noise.

TRANSISTORS this year should see factory sales of about $371 million, with an annual increase of 15 percent bringing sales up to $575 million by 1965. Silicon transistors are expected to more than double in sales by 1965, while germanium transistor sales will increase by only 50 percent during that time.

Transistors are being used widely in the armed services. A high increase in military sales, which now account for almost half the total industry sales, seems unlikely in the near future. The Air Force, which went to transistors as soon as possible because of weight and



Wire-band PPM (periodic permanent magnet) focused 1-Kw traveling-wave tube by Hughes covers the X-band, with a 40-db gain and a 2-percent duty cycle

size limitations in airborne equipment, is fairly well transistorized. The Navy, which has more room on its ships, uses tubes or transistors as the situation demands, stressing transistors only in such space-limited areas such as submarines, and for reliability. The Army hasn't time to transistorize much of its existing designs in these days of limited-war potential, since it needs the equipment as soon as possible. Much of the limited-warfare equipment is being made to older designs; transistorization is being applied to new types of equipment.

The computer business, which may expand greatly in the second half of this century, uses transistors widely. The IBM 702 used 10,000 tubes and RCA's Bizmac I contained 30,000 tubes. The Philco 2000 contains 56,000 transistors and IBM's Stretch computer uses 200,000 transistors.

SEMICONDUCTOR RECTIFIER sales in 1962 are expected by GE to show an increase of 12 percent, which will boost the industry volume $17 million over the $140 million estimated by the company for 1961. Continued price pressures and vigorous competition will continue to characterize 1962.

The silicon controlled rectifier should approximate its 1961 performance by doubling sales in the coming year, GE says. "New product introductions will add impetus to the SCR in 1962, particularly in the low-current lead-mounted and high-current areas."

Low-cost product categories in both rectifier and SCR lines will become more attractive to manufacturers of consumer products. Also anticipated, is increased industrial volume in the high-current rectifier area.

Hoffman Electronics has an optimistic outlook for 1962, and feels it can develop applications for control rectifiers in the commercial market. It sees a large potential in commercial applications of 1-amp and 5-amp control rectifiers, is thinking of branching out into higher-power rectifiers. Although some companies feel that the price war is coming to an end, they see more competition in quality for 1962.

VARIABLE RESISTOR prices of precision potentiometers have been on the decline since 1958, and Beckman Instruments among others sees no chance of them going up, but feels that there will be a stabilization.

Beckman sees sales growth in the development of new or upgraded products and is branching into different product areas. It sees a market shift in potentiometers. For example, they make a two and a three-inch type, and feel there will be a need for the smaller one-inch type; hence their intention to enter that area. They are also going into specialized components developed to order. Beckman is introducing a Cermet potentiometer, both rotary and rectilinear.

CONNECTORS of all types will see larger sales volumes through 1965.

Microdot among other companies expects an increase in sales for this year, and has opened a new facility with a connector department.

Microminiature multipin connector design is beginning to make progress. Miniaturization will be a big trend this year. Microdot attributes the step-up in hermetic seals to tighter requirements.

TRANSFORMERS will see more sales and the need for more reliability. "There will be a components shakeout in 1962," says Sylvania's A. H. Plaisted, product sales manager. "Reliability is stirring the pot. Up to now, there has been no feedback on transformer reliability unless it was a catastrophic failure. Sophisticated reliability requirements are now being written into contracts." Another trend in 1962, Plaisted says, will be more sales of transformers that use a conformal coating technique, with epoxy as a sealant, rather than hermetic sealing in a can.

ELECTROLUMINESCENT PANELS probably need a major breakthrough before they can challenge cathode-ray tubes in the entertainment market as a basic display device. Although high brightness can be obtained by raising the frequency or voltage, the life of the device is shortened considerably. So for the present electroluminescence will be limited to readout devices, instrument panel lighting, highway road signs and night lights.

MICROCIRCUITS, one of the hot fields in components today, is called by Motorola integrated circuits, Texas Instruments refers to them as Solid Circuit microelectronics, Westinghouse names them molecular electronics

or molectronics, and Fairchild Semiconductor uses them for their Micrologic circuits.

Fairchild's Micrologic circuits were introduced as a production item at the IRE Show last March. Six logic elements have been put on the market so far, with a seventh coming out shortly. The introductory price of all the elements is $120 each in small quantities, but Fairchild anticipates an ultimate price of less than $10 each in large quantities. Fairchild expects that there will be in operation by the end of 1961 a prototype computer built by one of their customers with Micrologic elements.

Motorola received a $1.5 million Air Force contract last June for the study of compatible techniques for integrated circuit functions. This speeded up their two-year old program to the point where they expect to have practical circuits available within the first quarter of 1962, although not on a large scale for another two years or so.

Texas Instruments exhibited last fall, jointly with the Air Force, a general-purpose digital computer using 587 microelectronic circuits, with a weight of 16 ounces and a volume of 6.3 cubic inches. These circuits were the basis for the development of the current TI line of six Solid Circuit logic networks. The Solid Circuit SN 502 flip-flop cost $450 in March of 1960, when it was introduced. An improved flip-flop, the SN 510, cost $95 in sample quantities last Fall. A volume price of $5 is predicted within five years. Another series of TI Solid Circuits, for radio and instrumentation, is almost ready for introduction.

Westinghouse, with two Air Force feasibility contracts totaling $4.3 million, was scheduled to deliver a molectronic communications receiver to the Air Force last month. Westinghouse has a program for invading the consumer market with molectronics. The program includes plans to mass-produce several molectronic circuits by the end of 1961, and to introduce both industrial and consumer molectronic products in large volume and at prices competitive with conventional items. This would mean circuit prices of no more than a couple of dollars apiece.

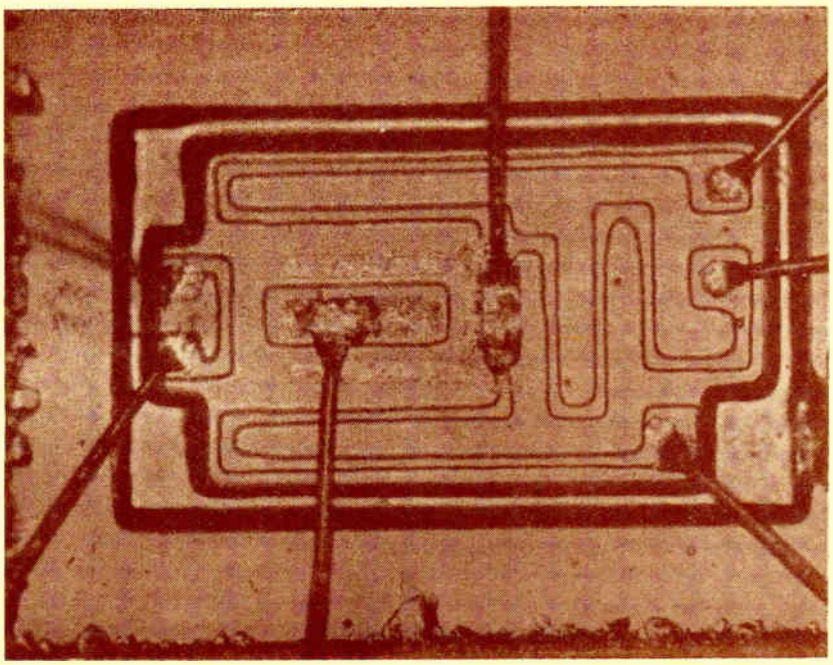
CAPACITORS may see some sweeping changes in the future. Mylar-film dielectric capacitors will continue to replace paper in high-reliability applications, particularly in military equipment, according to the Good-All Electric Company, a division of Thompson Ramo Wooldridge. "This trend is closely tied in with presensitization of military equipment and the result is a need to go to higher densities in component packaging. The projected increase would be about the same as last year."

Tantalum capacitors will increase about the same rate as last year, about 15 percent, Good-All says. "Tantalum is primarily an electrolytic-type capacitor and is used where there is a need for bulk capacitors, in bypass and coupling applications or computer areas. Also, there is much use of tantalum in the Minuteman program."

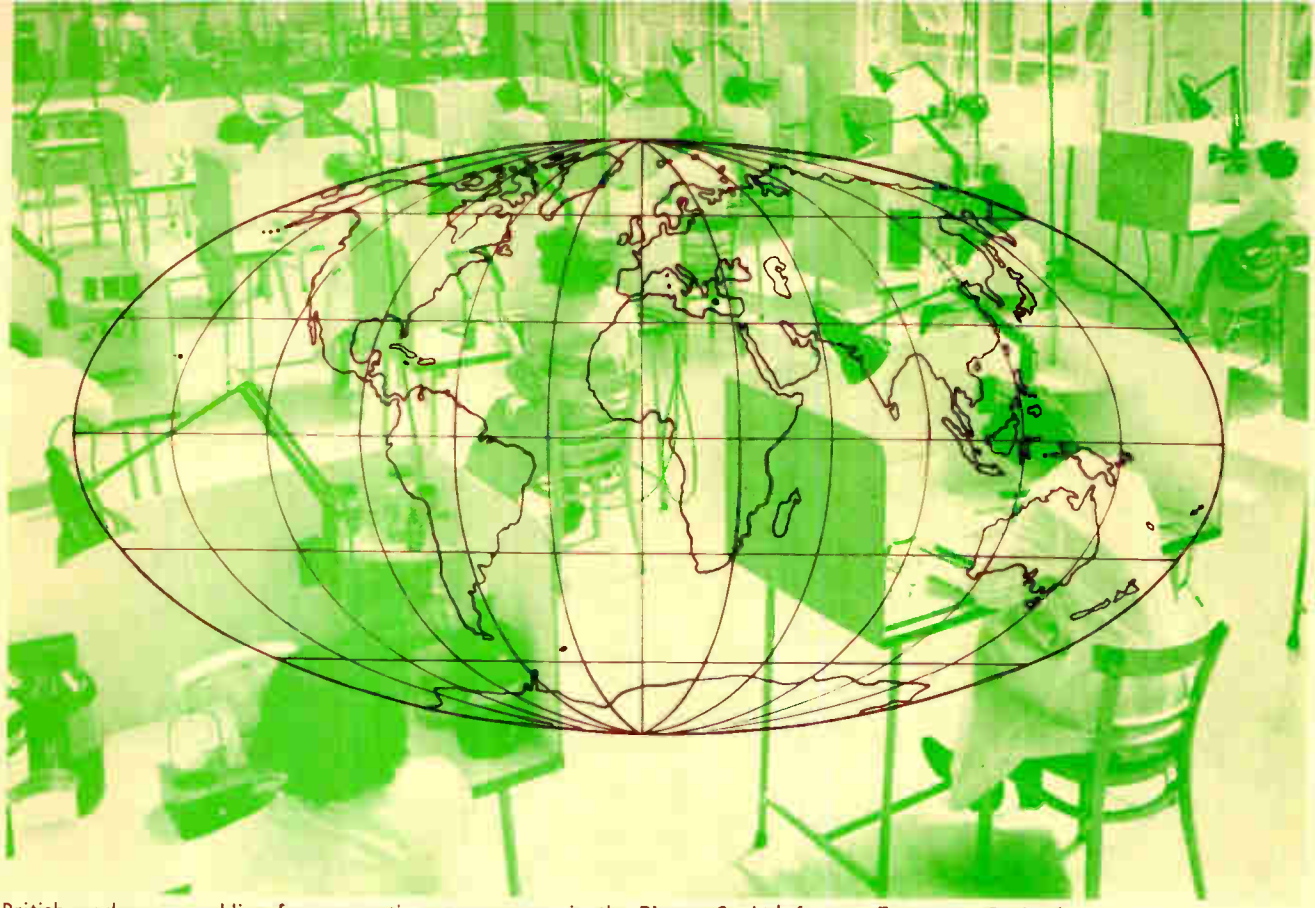
Capacitor pricing should hold up well, particularly in military applications. Industrial users as well as the military are pressing hard for miniaturization. Emphasis continues to be for more and more quality. Both industrial and military users are pressing for life testing data. There has been no pronounced price-cutting so far.

In an effort to upgrade their quality and to increase longevity, many entertainment-grade users are going after better quality in capacitors. For example, just a few years ago, electronic organs were using dielectric capacitors, and now they are using epoxy potted Mylar capacitors.

There may be a nominal price increase in variable capacitors over the next year or two, due to the new labor rates and also possibly because of the cost of materials, according to Thompson Ramo Wooldridge. "The sales curve for variable capacitors is linked closely to the communications business and primarily to consumer industry."



Integrated Motorola circuit prototype of a NOR logic element



British workers assembling ferromagnetic memory cores in the Plessey Co. Ltd. factory, Towcester, England

GROWING MARKETS ABROAD

WESTERN EUROPE—A population of over 300 million, a gross national product between $400 and $500 million by 1970 and a high living standard is the environment in which Western European electronics will flourish.

Presently the 18-nation complex resembles the U.S. economy as it was in post World War II years.

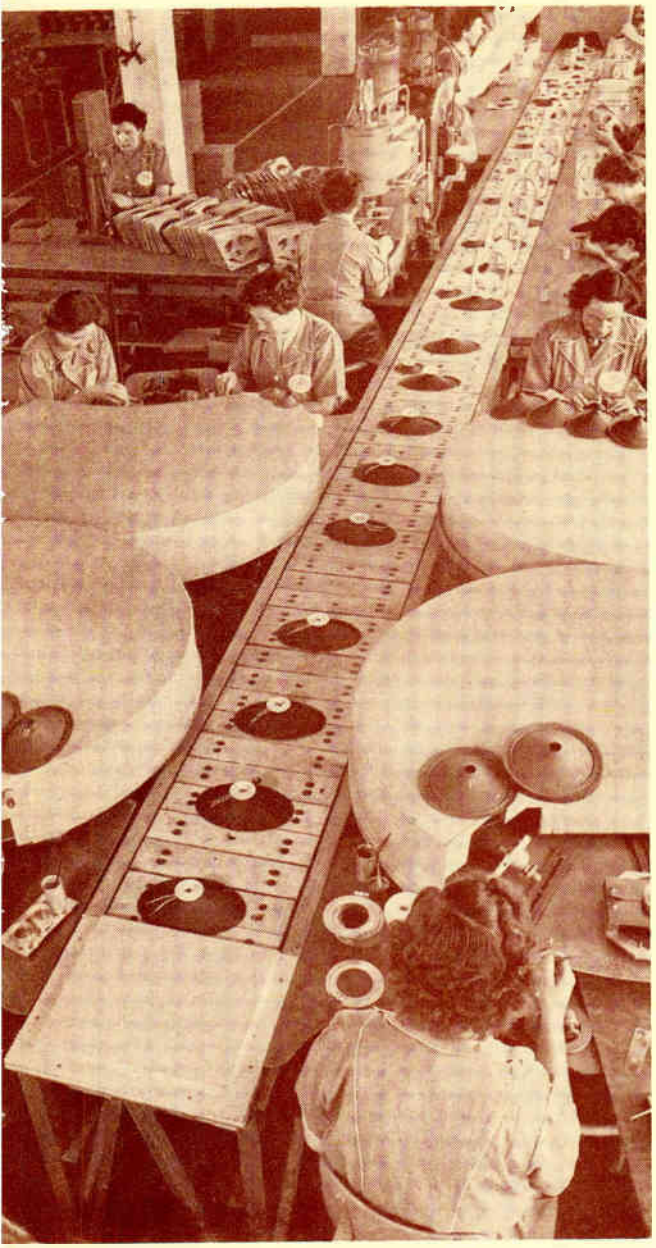
A MAJOR DIFFERENCE with the U.S. electronics industry as it was 15 years ago, however, lies in the amount of technical information available to European scientists and engineers. Research conducted in America while Europe was digging out of war ruins is for the most part available to the Continent. In addition, there is a general availability of investment capital.

These two factors make electronics in Europe more than a radio/tv business. Coming up fast is specialized component manufacture, industrial electronics, instruments and many other aspects of electronics.

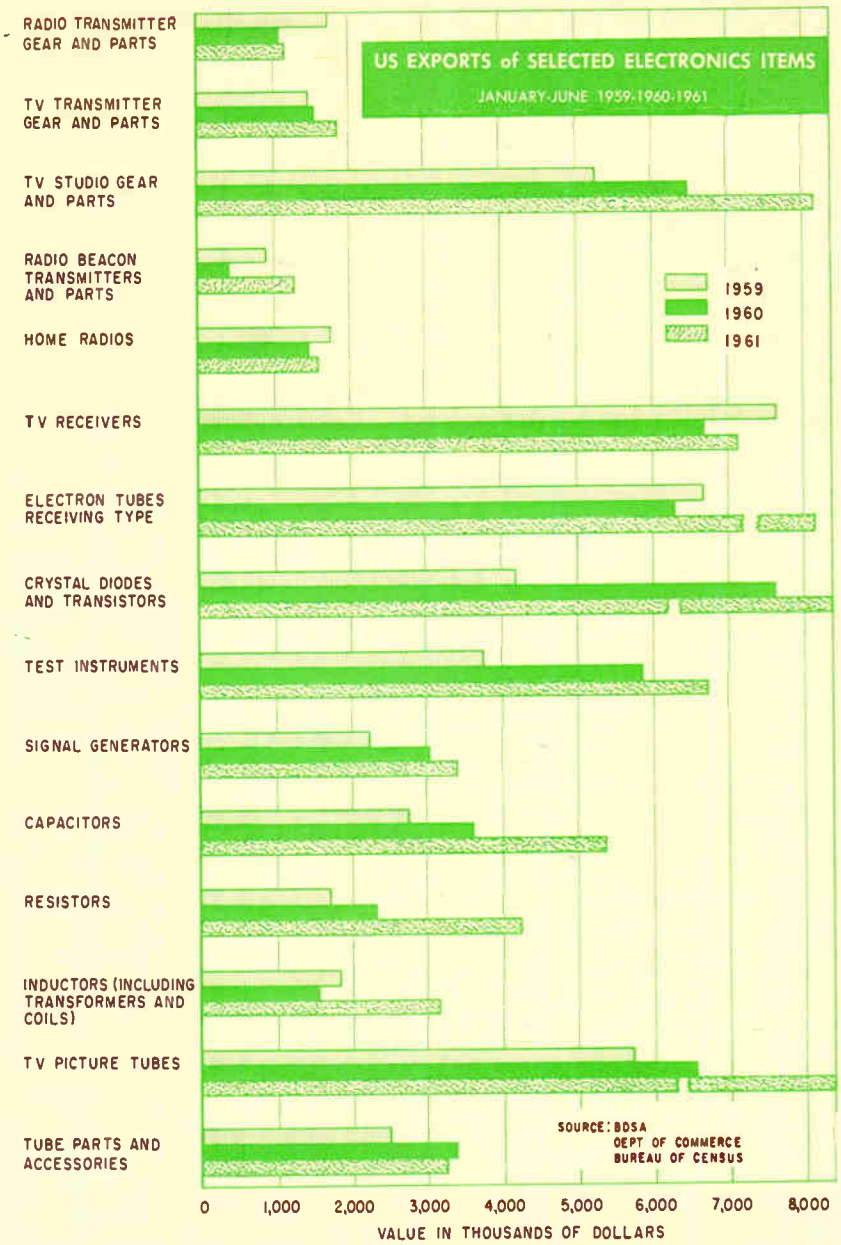
Underlying this growth potential is the increasing importance of the European Economic Community and the European Free Trade Association. The philosophies and accomplishments of these blocs are already cementing Europe together commercially. It appears more and more evident that commercial interests outside these groups may have to join in by establishing facilities that make them an integral part of these economic entities.

Some signs of the health of Europe's electronics industry can be seen in the changing balance of trade. Once almost all of Europe's electronics requirements were filled from imports. Now there are a growing number of items being exported and competing on world markets.

BRITAIN'S ELECTRONICS INDUSTRY exceeds $750



German facility of ITT producing high fidelity loudspeakers



million, over ten times its prewar level. Exports last year were almost $170 million.

There are about 500 electronics companies in more than 750 plants in England. Also, firms classified in other industries produce a certain amount of electronics goods.

Three British electronics firms have more than 10,000 employees. Forty companies have more than 1,000 employees and produce about 75 percent of the nation's total electronics output. About 300 companies have over 25 employees each. Although many firms are subsidiaries of electrical machinery producers, the number of independent companies is rising.

About half of England's electronic output is in radios, phonographs and tv sets. Last year 2.5 million radios and radiophonographs were produced. After 1957 more tv sets than radios were made. In 1960, however, popularity of transistor radios put the balance in favor of radios once more and raised unit production to record levels. Curtailed installment buying may have damaged tv sales in recent years.

Electronic capital goods, rising steadily since the war exceeded $165 million in 1960, with a good share going for computers. There are more than 300 digital computers in use. These along with associated computer equipment are mainly at work in industrial uses. Domestic computer sales top $17 million. Tube and component production last year exceeded $90 million.

British electronics exports rose to $169.5 million in 1960 from some $90 million in 1954, mainly in such non-consumer goods as navigational aids and communications gear. The former saw some $50 million in exports last year.

Tube and component exports amounted to $60 million. Radio receivers, in a slump between 1955 and 1958 are once more showing export gains.

Britain's customers last year were Canada, U.S., Netherlands, Sweden and Australia.

Rising British imports are also noted. In 1954, electroncis imports were about $24 million. Last year they

were $72 million. Of this, $21 million was in capital goods.

A feature of British electronics is the amount of effort it puts into research and development. A recent survey shows about 12 percent of net industry output goes back into R&D. Over seven percent of British scientists and engineers working in industry are in electronics. Of these, two-thirds are in research and development.

BELGIUM'S growing electronics industry ranks eighth among the nation's business activities. It employs some 30,000 workers who produce about $200 million worth of equipment, mainly components and subassemblies. Also produced is electronic automation equipment and communications gear.

In components manufacture, the emphasis is on high-quality industrial items rather than mass numbers of commercial pieces. Semiconductors are an important portion of the output and the quantity and quality of transistors has grown steadily. Tube production is high though steady with growth in quality rather than numbers. Emphasis is on the industrial rather than entertainment types. Resistors are produced with the same market in mind and include nonlinear ceramics, photoresistors, varistors and thermistors.

Subassembly work includes a certain amount of miniaturization, but relies primarly on communications equipment, data transmission and telephone gear.

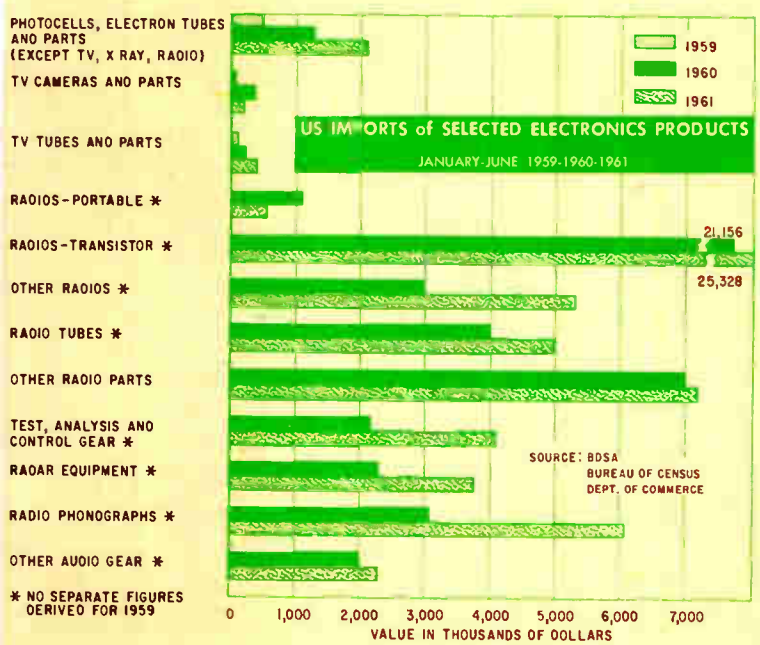
WEST GERMANY, bases its electronics industry heavily on radio, tv and communications. Growth is evident, however, in electronic machine tool control, component manufacture and other areas of electronics.

During 1960, West Germany produced 4.8 million radios of all types valued at more than $190 million. Almost half of the radios were for export. Television sets, including units packaged with radios, phonographs or both, numbered 2.8 million at about $335 million. About 26 percent of these were exported.

Component manufacture in 1960 is estimated at more than $150 million. Included in this figure are $34 million in resistors, $61 million in capacitors, $14 million in coils, filters and transformers. About one-quarter of West German component production went to the export market.

German consumer products incorporate a considerable amount of modernity. Some 95 percent of all German tv receivers have 24-in. picture tubes. Thirty percent of the radios are equipped for stereo, 10 percent are cordless and 75 percent can receive on four bands. Half of the new tape recorders are four-track types and over one-third are made for compatible stereo.

There are about a dozen firms producing radar and communications gear. Three of these are U.S. subsidiaries. Production is largely for internal uses in such applications as harbors and air terminals.



FRANCE, long involved in radio research, supplied some of the know-how that went into the initial development of microwave radio some 50 years ago. Today, the nation is doing its share to aid the growth of electronics. There are close to forty good sized electronics companies in France and as many of smaller size. A directory of French electronics companies shows a diverse selection of electronics areas ranging from radio receivers to specialized semiconductors.

France has a favorable balance of electronics exports. Imports run to about 3 percent of total French electronics production, while exports run to about 8 percent. This balance is aided by shipments to French zones of influence as well as general world markets.

ITALY is seeing some growth in electronics, though perhaps less than some of the more highly urbanized neighboring countries. Most manufacturing is done in central and northern Italy although a considerable amount of foreign capital and Italian funds are being expended in stepping up the pace of electronics manufacture in the south. As is the case with most other continental nations, Italy's electronics industry is concerned primarily with radio and television. Some component manufacture, however, has been started.

NETHERLANDS is known in Europe as a supplier of components for a variety of applications. Electron tubes and semiconductors are produced almost exclusively by one company, but in such quantities as to dominate a good bit of Europe's trade. Most of the output goes into equipment by the same firm both within Holland and in other countries. Both exports and imports of tubes and semiconductors have been rising steadily in the Netherlands. Electron tube imports in 1950 were valued at $1,561, exports at $12,496. By 1959 imports were $30,858, while exports came to $53,955. Recently, Dutch authorities have discontinued publication of import-export figures, but until 1957, Belgium was the main Dutch source of tube imports, with West Germany and Britain following.

A good amount of Holland's communications equipment is made internally. Radiotelephone and telegraph equipment, broadcast gear for radio and tv, studio equipment for television, navigational aids, radar and remote control aparatus are all available from internal suppliers. A certain amount of microwave equipment is imported from West Germany and some mobile radio gear from Denmark. Electronic test equipment and laboratory

New research center nearing completion outside Tokyo by Tokyo Shibaura cost more than $5¼ million

gear from the U. S. enjoys a significant sales volume.

JAPAN relies heavily on electronics exports for its economic health. Short on such heavy items as coal, iron ore and other major natural resources, manufacturing industries are the mainstay of the economy, and outside markets are essential to maintain these industries.

Japan's electronics industry has grown by leaps and bounds since the early 1950's when television broadcasting began on the islands.

In 1960 Japanese electronics output totaled more than $1,600 million as compared with $932 million in 1959 and some $240 million in 1956.

As is the case with most nations, consumer electronics accounts for the major share of the industry. Fifty-seven percent of Japan's 1960 total was in consumer electronics. Television receivers accounted for $394 million. This was a rise of 18 percent over the preceding year. Between 1958 and 1959, however, tv sales went up 118 percent.

During 1960, production of radio receivers with three or more transistors came to $169 million, receiving tubes to $86 million, tv picture tubes to $70 million and transistors to $54 million. Values of commercial, industrial and component output also rose during the 1958–60.

Japan's balance of trade has been dropping since May of 1961 with imports greater than exports. Because of this and other factors, a tighter money policy is prevailing in Japan which will affect capital expansion. This could mean that production levels will not continue climbing at their present rates. Already, the Japanese government has asked manufacturers to voluntarily curtain capital goods spending. Some idea of how this move affects Japan's electronics industry is given by Yamaichi Securities, one of the nation's leading financial houses. Tokyo Shibaura's expansion program calls for more than $74 million this year, Matsushita plans more than $17 million, Nippon Electric $22 million and Hitachi close to $10 million. It is likely that these and other electronics companies will observe the government request.

Despite this possible production plateau in the short-range future. Japanese electronics is certain to continue its over all expansion.

Present equipment produced extends into virtually every area of electronics from simple transistor radios to computers. Much of this production is and will continue to be in cooperation with foreign companies.

The Finance Ministry of Japan at mid-year 1961 announced that 1,440 technical licensing agreements had been signed with foreign firms. A similar check a year earlier placed the number at 1,090. Of the 1,440 agreements of last year, 350 were in the electrical machinery category which includes electronics.

LATIN AMERICA represents a growing volume of the overall world electronics market. Most electronics expenditures in the vast region between the Rio Grande and Tierra del Fuego are for radio and television sets and for communications gear.

Latin America's general average economic activity has doubled in the past 20 years. It is estimated that the total gross national product of Latin America is rising at the rate of five percent annually.

Radio and television are viewed as ideally suited for communicating educational, political and other types of information. It is this factor, perhaps more than any other, which has contributed to the growth of broadcasting in Latin America. Each of the nations has at least one television broadcast station and many have several. Brazil has more than two dozen.

Receivers are made locally for the most part to circumvent the difficulties of foreign currency exchange, tariffs and other obstacles. General set costs run to about $500 and for the average resident, they are purchased on the installment plan, often under three-year purchase periods. The receivers are of recent or modern design and include many 19-in. and some 23-in. models.

While the tv receiver market is still a long way from saturation, there is a high percentage of radio receivers in Latin America. These too are produced locally for the most part and are usually equipped to receive short wave in addition to a-m.

It is in the field of communication that great promise for Latin American electronics lies. Jungles and other natural obstacles make the region ideal for microwave net works. Growing air traffic is imposing its needs, and a population increasing both in numbers and education will increase the demand for telephone systems.

The competition for markets is evident. In most Latin American nations, the U. S. still maintains a good hold on the market, but West Germany, Netherlands, Japan and United Kingdom companies are developing markets which in some nations exceed those of the U. S. In Uruguay, for example, radio component imports from the Netherlands exceed U. S. shipments. In Colombia, Netherland components run a close second to U. S. with United Kingdom imports trailing closely.

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18 — 26 V DC	SP22-50 $820.00	SP22-30 $590.00	SP22-20 $525.00	SP22-10 $450.00
10 — 20 V DC	SP15-50 $820.00	SP15-30 $590.00	SP15-20 $525.00	SP15-10 $450.00

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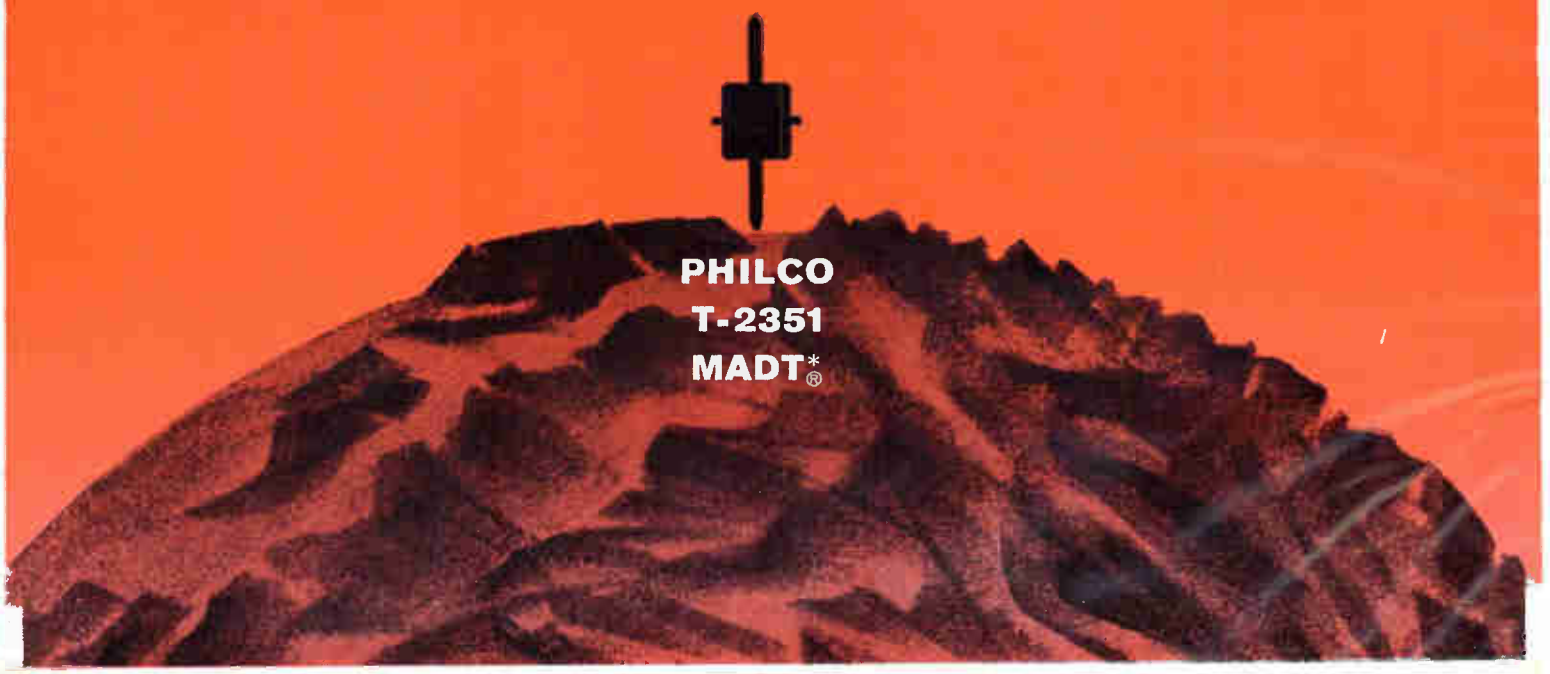

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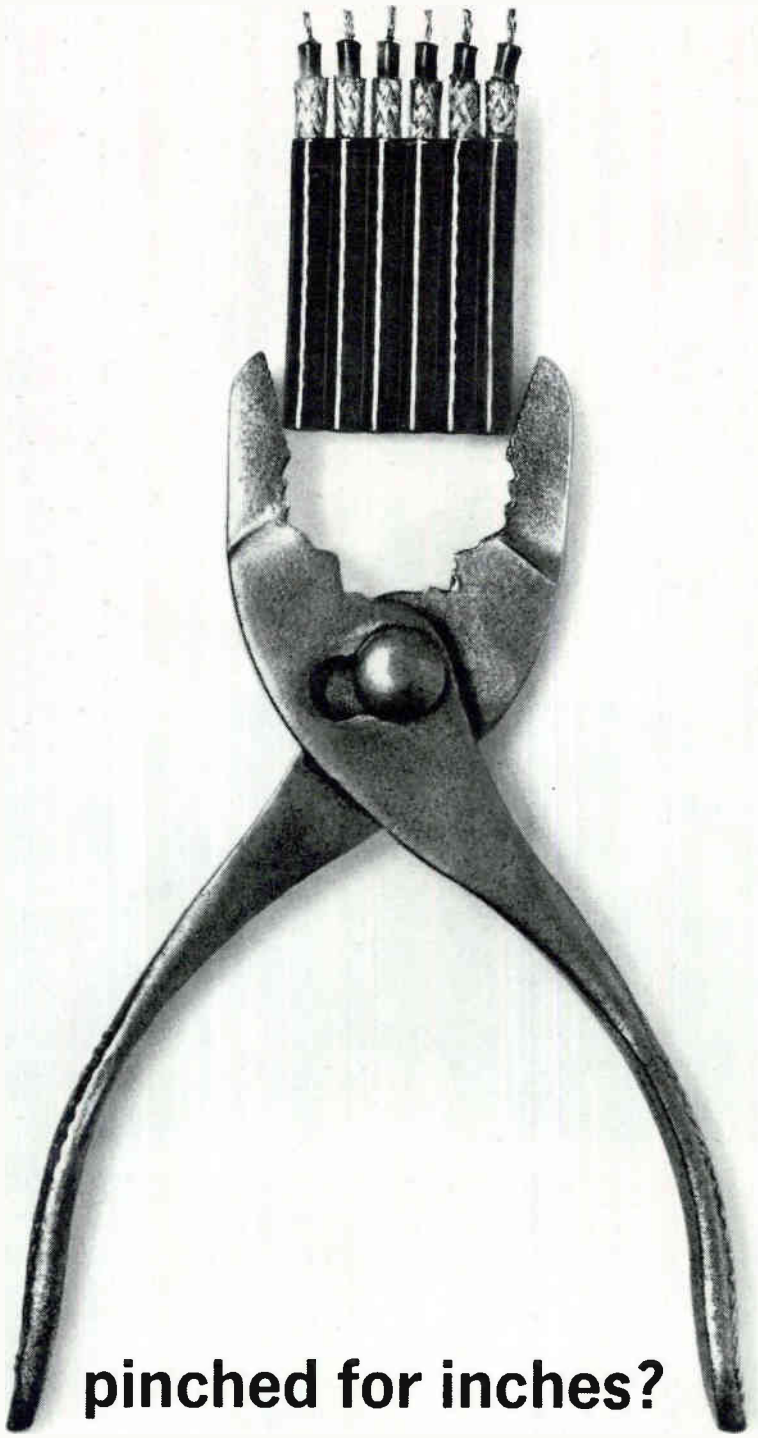

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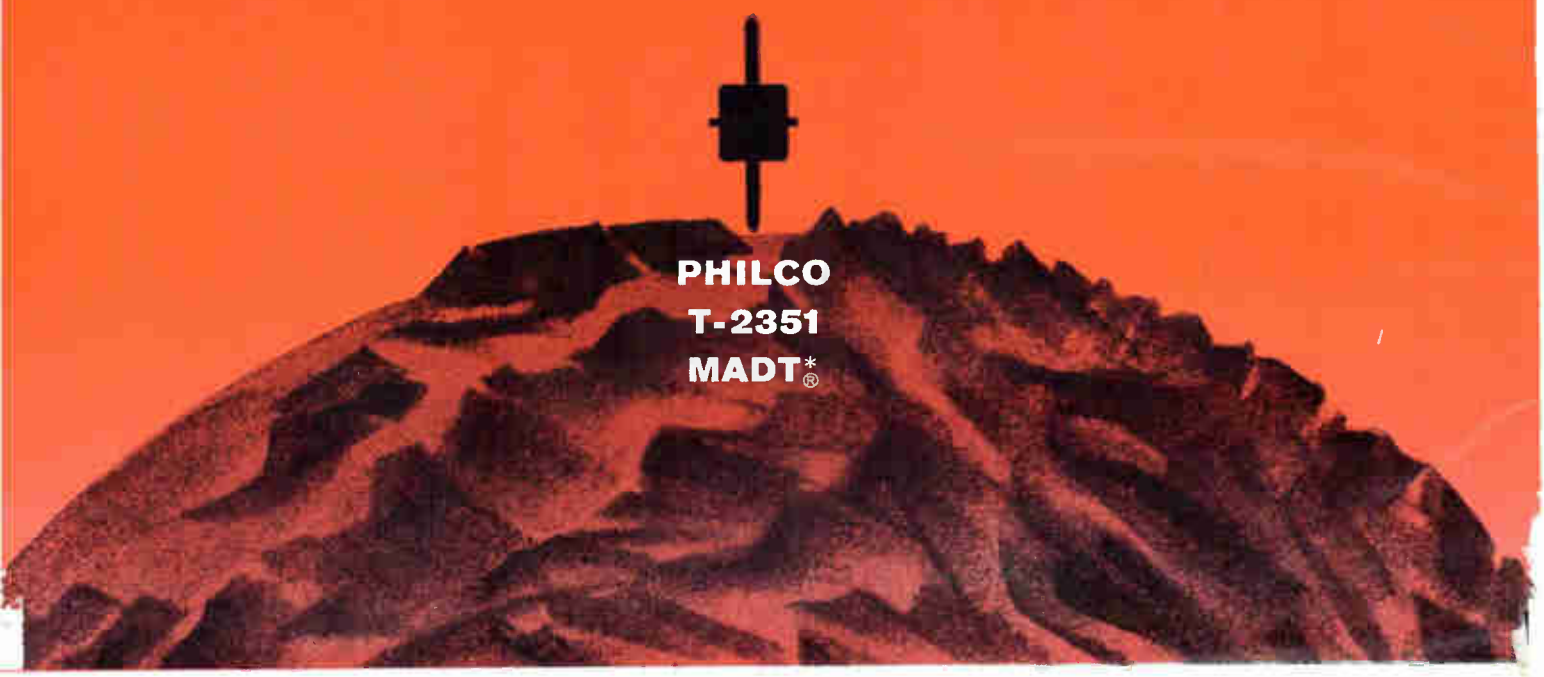

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electronics
January 5, 1962

Review of problems associated with vertical registration of characters in high-speed optical scanning equipment. Design of a vertical locator for automatic registration is presented

Authors Milbradt (left) and Bauldreay check out automatic registration

SOLVING REGISTRATION PROBLEMS

In Optical Character Recognition

By J. BAULDREAY
E. MILBRADT,
Engineering Dept.,
Farrington Electronics,
Inc., Alexandria, Va.

A PROBLEM common to all character reading systems is that of irregular registration resulting from human inconsistency and from mechanical imperfections in typewriters, stamping machines and high-speed printing machines. Rarely does a line of printed characters have perfect horizontal and vertical registration, that is, consistent horizontal spacing and a common vertical datum. In general, horizontal registration poses a lesser problem in that character pitch is fairly consistent in most popular type fonts, print wheels are maintained at precise distances apart. Stylus heads are also rigidly spaced. Once the first character in the line is encountered, its foremost point can be used as a reference to time and locate all following characters. There is one exception—the Executive type font with proportional spacing.

In the vertical direction, the whole line may be misplaced from its ideal position; also, individual characters may be offset one from another. This latter effect is fairly common with wheel printers, sometimes with chain printers, and with maladjusted typewriters. To detect the traits of a character and determine their physical relation to one another, some reference is usually established to measure time or distance and fix the specific points at which these traits should appear. The machine might then conclude

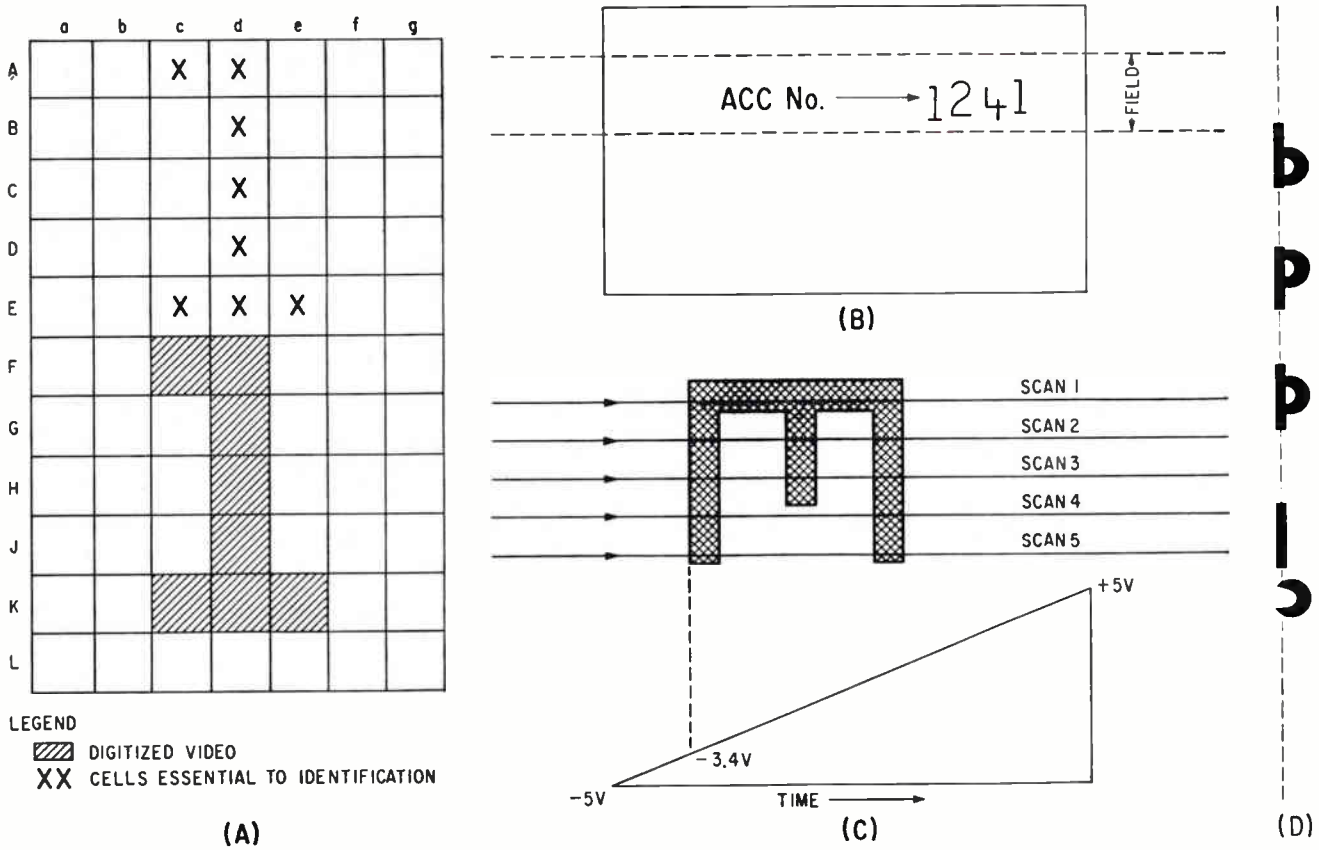

FIG. 1—Matrix identification (A); how scanning field relates to characters on document (B); sweep-locator relation (C); registration and character composition (D)

their combination to represent a particular character and thus establish a recognition. The position of a character cannot be determined accurately if the reference point is poorly defined. It is common to use as a reference either the top or bottom of each character, whichever is more convenient.

Two methods are now used to overcome imperfections in vertical registration: the video pattern is previewed and then shifted to an area where it can be recognized and identified; the character is viewed as it develops during successive scans, and its edge is used as a datum line for recognition decision making. This latter method has, for several years, been used in Farrington Optical Scanners.

The first method is employed by Solartron, Ltd., of Thames Ditton, England.[1] A preliminary reading is made to obtain a registration error, that is, the difference between actual and ideal vertical character position. This error is then fed back to correct the optics of a flying-spot scanning system so that on a second reading the character will appear in the correct position within the scanning field for identification. A somewhat similar approach is employed by Standard E.L.A.G. of Stuttgart, Germany,[2] who first enter their digitized video into a shift register matrix, and then shift the static pattern vertically to a position where it can be compared with other predetermined character configurations. They tackle horizontal registration by a sideways shift, possible since it is a 2-dimensional shifting matrix. Some machines made by the Rabinow Engineering Co. also appear to use the electronic vertical shift. Both approaches are illustrated with Fig. 1A, which shows how the numeral 1 would be held in a matrix-type storage had the relative positions of the numeral and reading field been as shown in Fig. 1B. Assume, for example, that a character which occupies cells Acd, Bd, Cd, Dd, and Ecde (Fig. 1A) would be recognized as a numeral 1. The Solartron attack would be to lower the upper limit of their optical scan by 5 cell heights, bringing the character up and into registration. S.E.L.A.G. would shift the stored character pattern up 5 cell heights to the top of the matrix where the top and one side would be used as an electronic reference, and the shifted pattern would coincide with the predetermined configuration for the numeral 1. Whether this must be an exact match or a best match varies from machine to machine, but best match methods are the most common.

To appreciate the operation of the vertical locator circuit, it is first necessary to be acquainted with the essentials of recognition used in Farrington optical scanners. The area being scanned is highly illuminated and, by a flying aperture,[3,4] each character is scanned vertically as it moves past the reading station and is broken down into twenty or more vertical samples. The combination of these provides adequate intelligence to permit recognition. Assume that the letter E is broken down into 5 successive scans as shown in Fig. 1C. At the main reading station, the height of the scanning field is about three times that of a character. In general, a greater printing registration error will require a larger scan height in relation to character size. A sawtooth voltage, beginning at −5 volts and

ending at +5 volts, is generated in coincidence with each successive scan such that each black crossing can be marked with a potential proportional to the time that it is encountered after the beginning of the scan: hence, the sawtooth is an analog representation of scan distance from the beginning of the reading field. The vertical locator is concerned only with the first such crossing or earliest video marking the lowest point of the character. This point will vary with any vertical misalignment. As shown in Fig. 1C, the bottom of the letter E is at −3.4 volts or at 15 percent of the field scan height. The vertical locator detects and holds this position in field so that it can be used as a datum point for character interpretation.

This datum point is needed for fixing the relative positions of constituent criteria. Suppose that a fixed scan of adequate height were employed such as to ensure that all characters would be seen, and allowing for a reasonable vertical misalignment from character to character. Fig. 1D shows that confusion would exist in determining whether the letters P, b, the numeral 6, or just extraneous strokes have been seen, since the vertical arrangement of the two strokes could yield a large number of configurations. By using the upper or lower edge of a character as a reference relative stroke position as well as vertical misalignment from character to character is accommodated.

The letter E in Fig. 1C is shown perfect in every detail. However, commercially available reading machines are designed to cope with character and background imperfections such as incomplete characters or specks of dirt which could be mistaken for print. These are practical problems for which equally practical solutions have already been found by builders of reading machines. It would be futile to worry about background interference and character imperfection if one could not decipher perfectly formed characters with a consistent background.

The operation and design of the circuit to locate a line of printed characters and automatically provide a common continuous vertical datum can be analyzed with the aid of the simplified schematic and waveforms of Fig. 2A and 2B. A sawtooth sweep voltage is compared with the earliest video encountered in each vertical sweep and the storage capacitor (Fig. 2A) is charged to a potential which is an analog marker of the distance from the bottom of the scanning field (3.4 volts for the letter E in Fig. 1C). This voltage is available directly for analog purposes and is also used as a reference to trigger a logical output signal. The circuits between the storage capacitor and the logical output are buffers so that current drawn by the output will not reduce the capacitor voltage.

The locator circuit may be used to mark either the top or bottom of a character depending on design preference. Sweep direction is from bottom to top of the scanning field when marking character bottom; top to bottom when marking character top. Fig. 2B shows the waveforms from scanning the letter E in Fig. 1C. As soon as the video from the bottom of the left hand tall vertical stroke of the E is detected, Q_5 of the long tailed pair Q_5, Q_6 will begin conducting, since the base of Q_6 will be at −3.4 volts of the positive-going sawtooth while the base of Q_5 (point D) is at the reset level of +5 volts. The potential at point A is essentially the same as that of point D. Conduction of Q_5 will result in a positive voltage feedback to the input AND gate (when Q_6 is nonconducting) and thus allow the storage capacitor to discharge through Q_1. The rate of discharge is determined by the AND gate output potential, the current gain (Beta) of Q_1, and the divider (R_2, R_3) feeding its base. When the discharge is such that the falling voltage at point D equals that of the rising sawtooth, then Q_5 and Q_6 will switch differentially, the input AND gate will close, and discharge of the storage capacitor will cease. This continues in the following scans with the discharge period getting shorter and shorter and the logical signal coming earlier and earlier in the scan until, in the fifth scan, the successive approximations yield the answer of −3.4 volts at point A. With this potential on the storage capacitor, the logical output then switches in coincidence with the earliest video which is, in the ex-

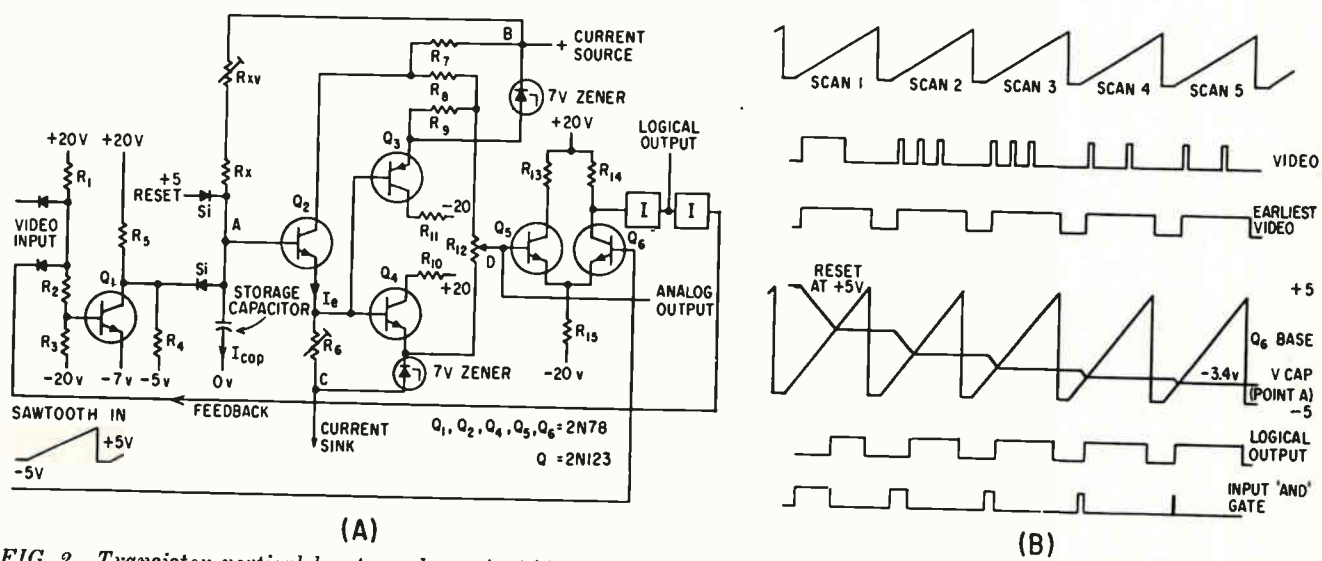

FIG. 2—Transistor vertical locator schematic (A) and locator waveforms (B)

ample of Fig. 1C, the bottom of the letter E. In actual usage, the location is essentially complete after 2 or 3 scans early in character.

The transfer of a change in potential from point A to point D, the switching of Q_5, Q_6 and transmission of this fact to stop the discharge of the storage capacitor takes roughly one microsecond. Compensation for this is accomplished by slightly offsetting the level at point D below that of point A and thereby causing Q_5, Q_6 to switch just before the capacitor voltage equals that of the sawtooth, thus preventing any overshoot. Transistors Q_3 and Q_4 with voltage limiters R_{11} and R_{10}, respectively, are emitter followers between points A and D.

To maintain the reference voltage (−3.4 volts in the example) once established, point B is at all times 7 volts positive with respect to point A. Similarly, Q_2 I_e will be constant at $7/R_6$ milliamperes (when R_6 is in kilohms). The two silicon diodes in a cutoff condition can be ignored so that the current into the storage capacitor can be expressed as: $I_{cap} = I_{r2} - (I_b - I_{co})$. If this current flow can be adjusted to zero, the storage capacitor will hold its charge indefinitely.

The first term (I_{r2}) is as constant as the potential between points A and B, and to keep this potential as stable as possible the 7-volt zener diode is fed from a constant-current source. While these diodes exhibit their lowest incremental impedance at 7 volts, it is still finite and current changes would cause changes in zener voltage. Additionally, 7-volt zeners are close to the zero temperature coefficient of 5.5 volt zeners. The same reasoning applies for the potential A to C.

The second term ($I_b - I_{co}$) is equal to $I_e/B - I_{co}$, both of which are temperature dependent. While I_e is held constant, beta increases roughly ¾ percent for each degree centigrade temperature rise and I_{co} doubles in 7 deg C. It was decided, therefore, to keep the quantity $I_e/B - I_{co}$ to a small value initially so that any variation due to a change in temperature would be small. It was for this reason that the 2N78 was chosen with a typical I_{co} of 0.7 microampere and the high beta at low currents which is characteristic of rate grown junction transistors. The 2N78's used as Q_2 have an I_{co} of less than 0.3 microampere and beta of greater than 70.

Having these characteristics of Q_2, R_{x2} is then adjusted so that 3 microamperes flow through R_3 into point A, and R_6 is adjusted so that 3 microamperes flow into the base of Q_2; $I_e/B - I_{co}$ should then be (3.3 − 0.3 microampere) at 25 deg C and 3.1 − 0.7 microampere at 35 deg C or a change of −0.6 microampere over this 10 deg C temperature variation. If the storage capacitor is chosen typically to be 0.5 μF, then the rate of gain of voltage will range from zero at 25 deg C to

$$\frac{1}{c}\frac{dq}{dt} = \left(\frac{1}{0.5 \times 10^{-6}}\right)\left(\frac{0.6 \times 10^{-6}}{10^{-3}}\ \frac{\text{volts}}{\text{ms}}\right)$$

which equals approximately 1 mv per ms or a drift of 10^{-4} of the field height (of 10 volts) per millisecond. Since characters are scanned typically in a few milliseconds, the drift in capacitor potential is negligible.

The locator circuit is not limited to this operation. It is sometimes desirable to have a prelocation signal that gives a logical output at some point earlier in scan, beneath the main locator. In some applications, after an initial fast location, the locator must follow only gross deviation from alignment or a steady drift in outline such as would result from a sloping line of characters. This slowing down of the locator can be effected by loading the junction of R_1, R_2 to limit the base current of Q_1.

When it is known that the characters to be read may be erratic in their vertical registration, it may be of advantage to introduce a positive drift at point A so that upon leaving one character, the locator will automatically look for the next to be positioned slightly later in scan.

Some machines use two locator circuits. The first locator previews each character, and the resulting logical output is then fed as a video input to a second locator. This secondhand input is a much better starting condition than the reset level and, therefore, enables a faster and more accurate location by the second or main locator.

Presently, the locator is used as the heart of another circuit which enables a machine to read characters of varying height and obtain a measure of this height in analog terms so that, subsequently, we are able to measure and position set fractions of a character height.

One application of the locator is in an experimental mail sorter making a two-way sort on letter mail. A more advanced, nearly operational, transistor model for the Post Office Department is being tested. Since the bottom line of the address on an envelope can be almost anywhere within limits, a forward reading station locates the bottom line of the address. The analog output of the forward reading locator is then fed to a position servo mechanism coupled to a mirror in the optical path to the main reading station. By the time the envelope has reached this main station the mirror has been moved so that only the bottom line is presented to the recognition logic. When reading addresses typed with the first letter upper case but following letters lower case, use is also made of a prelocator looking below the main locator. This is of value when dealing with the letters, g, j, p, q, and y, which hang below the main body of a word. Additionally, since the height of the characters varies considerably, the circuit that measures and stores this height is also used on this machine. For example 12-pitch type is about 0.085 in. high and 8-pitch type is about 0.130 in. high.

Figures 3A, 3B and 3C were taken from an oscilloscope tv-type presentation obtained by feeding the sawtooth waveform to the Y deflection plates and blanking the tube cathode with the signal to be viewed or its derivative.

Figures 3A and 3B show an envelope as seen by the forward reading station. The derivative of the locator logical output shows how the locator lowers into the bottom of the bottom line; close examination will show it to be cutting through the e in Research, F in Farrington, 7 in 7019 and the A in Alexandria.

Figure 3C shows the same envelope in the main reading station where only the bottom line of the address is seen. The locator upward drift between words can be seen, with the prelocator duplicating it a little way below.

In another application, a page reader, the vertical locator is used to perform two separate functions.

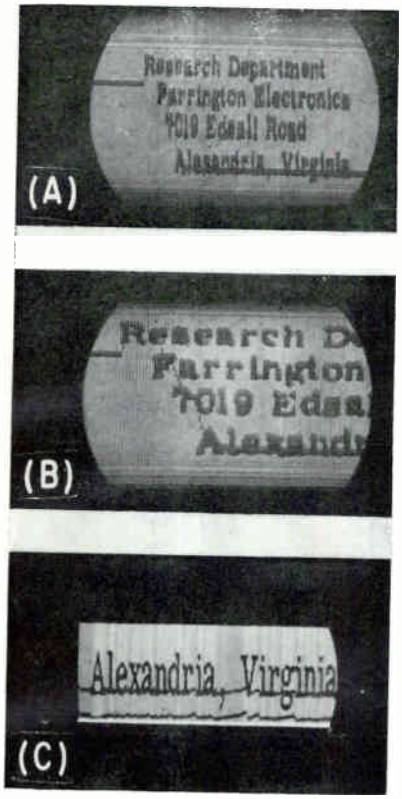

FIG. 3—Oscilloscope presentations

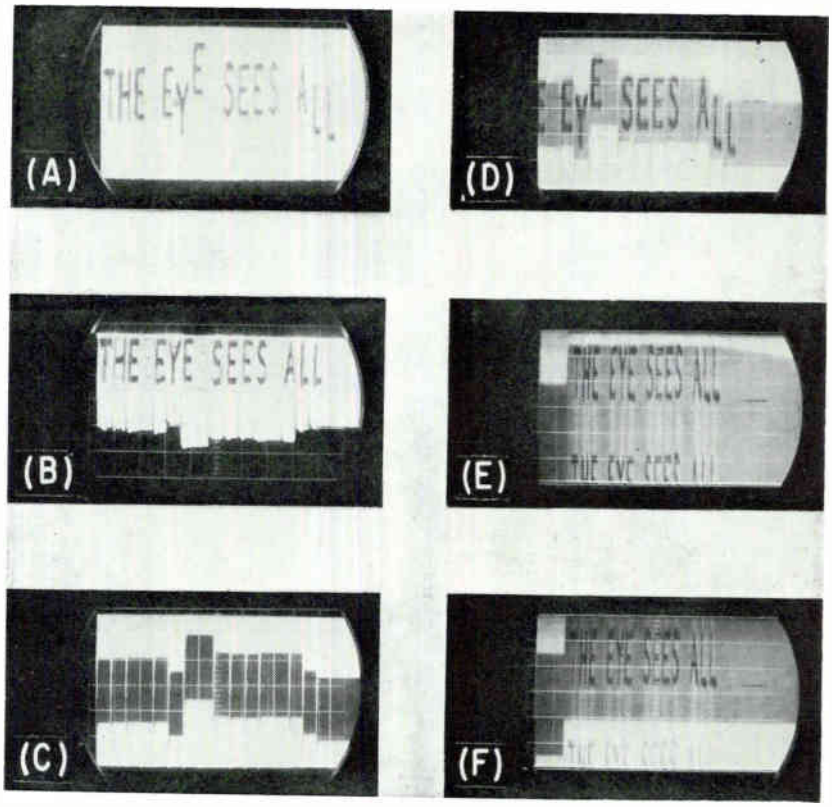

FIG. 4—Operations of vertical locators are traced in these tv presentations

The first function is what might be called the general purpose function of the locator and that is to locate each character to be read vertically within the read zone. Two locators are used as is generally the case. The first locator is allowed to sample recognition pulses from a pre-read station, which is one character space ahead of the main read station. This locator will set to the earliest recognition seen in the scan zone, which is the top of the character when scanning from top to bottom. During the time that it takes the character to pass from the pre-read station to the main read station the position of the first locator, now set to the top of the character, is transferred to a second locator. This second locator continues to mark the position of the top of the character in each scan until it is reset and then set again for the next character. The output of the second locator is used in the recognition program to zone the character vertically. After the second locator is set to the first locator the latter is reset and then allowed to set again on the next character in line.

Figure 4A shows a line of characters where some of the characters are vertically out of registration. Figure 4B shows the same line with all characters vertically aligned electronically, using the locator. Figure 4C shows how the second locator is used to zone an area within the scan zone in which recognition is allowed to be seen. Figure 4D shows the characters within this zone. All other recognition within the scanning zone, but not in the shaded area, is gated out and is not allowed to confuse the identification of the characters being read. With a page reader, when reading lines of information single-spaced and six to the inch, more than one line is seen in the scanning field. The problem then is to gate out all information other than the line to be read. This is the second function of the locator.

A third locator with a prelocator is used to find and locate on the line to be read. Once the locator has set to the top of the line being read, the prelocator gates out all other recognition except this line. Figure 4E shows how the third locator locates on the top of each character in the top line. Figure 4F shows how the prelocator zones around this line and gates out the second line. The third locator is not reset after each character, but is allowed to drift down in order to compensate for any vertical misalignment of the line. This can be seen to the right hand side of Fig. 4E.

An apparatus has been described in the literature[5] that has sidestepped the problems associated with vertical registration, but it needs the backing of a matrix method before it can successfully read digits. It is probable that in the future more sophisticated recognition techniques will be developed that will, in themselves, inherently accommodate both character size and registration.

The authors acknowledge the aid of John O'Rosky in preparing this article.

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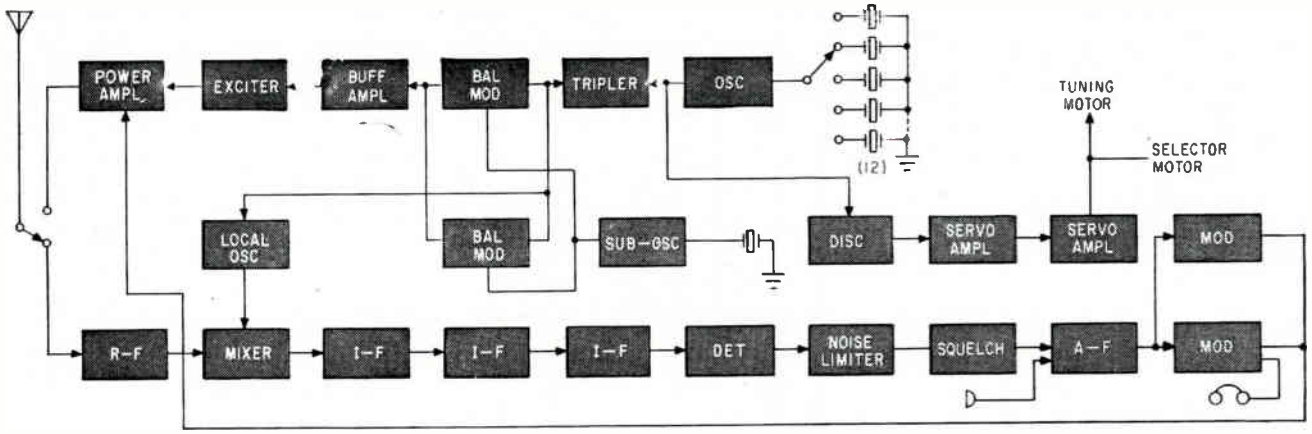

FIG. 1—Model TA-1640 airborne transceiver

SERVO-TUNED TRANSCEIVER for Airborne VHF Communications

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AIR-TO-GROUND vhf communications are indispensable in civil air traffic control to keep airplanes in contact with ground stations. Ground control approach equipment cannot be used without vhf communication to guide a pilot to a safe landing in bad weather.

Installation of vhf ground stations are the obligation of every country in the international air routes. To make contact with these scattered ground stations, airplanes must be equipped with airborne vhf radio equipment, having multi-channel frequencies to communicate with ground stations.

This transceiver has 12 crystal units normally, but the transmitting and receiving frequency is chosen between 118 Mc and 145 Mc by replacing crystal units; this does not require presetting the tuning system.

The r-f output power of the transceiver is 8 watts and its total power consumption is below 200 watts. Power input is 28v d-c. Voice signals are applied to the r-f carrier as amplitude modulation and the maximum modulation is 95 percent or more.

The receiving sensitivity for 50 mw audio frequency output is below 3 microvolts input. A mechanical filter provides selectivity for the 50-Kc channel separation.

A block diagram of the vhf transceiver is shown in Fig. 1. The receiver is a single superheterodyne with one r-f stage and three i-f stages. The audio output from the detector is coupled to the audio output amplifier (also the modulator), then a noise limiter, avc and squelch circuit and the headphones. Local crystal oscillator output is multiplied by 2x, 3x and 3x multipliers to be injected into the mixer.

In the transmitter, the output of the crystal oscillator is multiplied by 2x and 3x and mixed with a 3.8333-Mc suboscillator signal in a balanced modulator. The output of the higher sideband of the balanced modulator is then frequency multiplied by a tripler. The r-f power amplifier is amplitude-modulated by a push-pull amplifier, which is the receiver audio amplifier and also as the servo-amplifier.

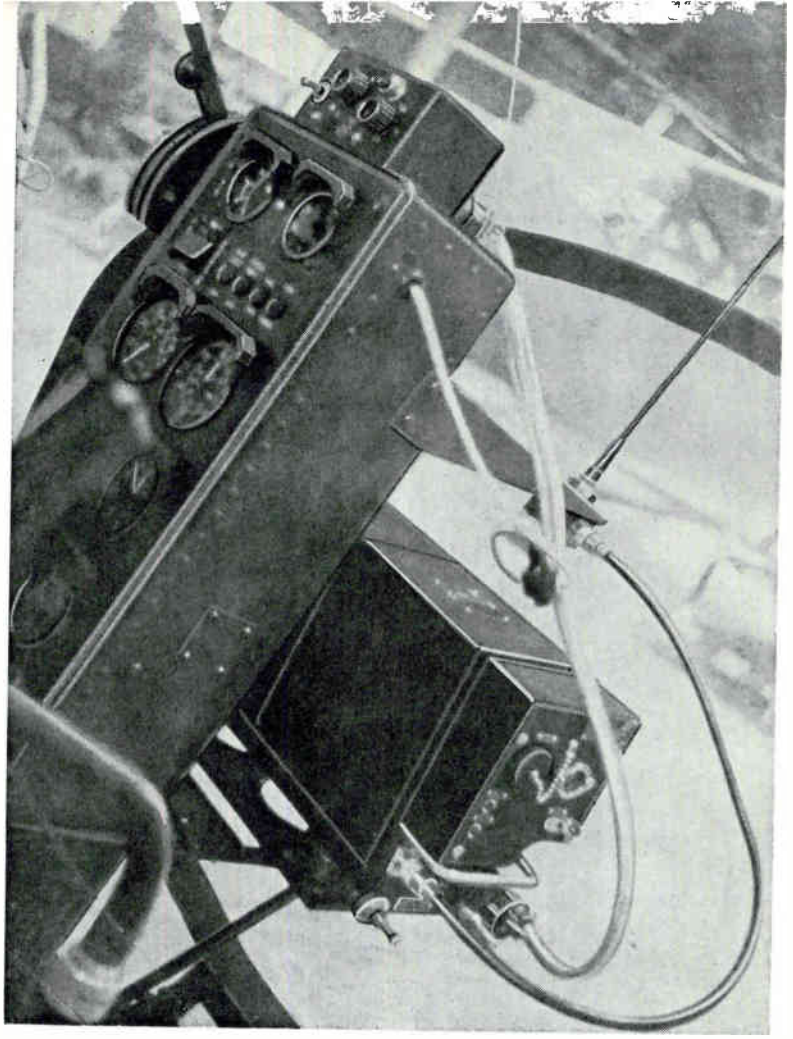
Up to ten headsets can be connected to the receiver; all can be used at the same time.

Conventional tuning systems of airborne vhf equipment may be classified into five categories:

In the switching system, a separate crystal unit and tank circuit are installed for each frequency, and channel-switching is by selector switch. There are several transmitter and receiver crystals and the switch selects one unit. Only the crystal unit is changed as the tank circuit is wide-band.

In the manual tuning system, the tank circuit is manually tuned with a flexible shaft. Remote control is by motor and servomechanism.

Transceiver TA-1640H installed behind the instrument column of a Bell 47G helicopter



Transmitter tunes itself automatically to any of twelve operating frequencies by unique servo system. Receiver features a noise limiter with a 1,000-to-1 signal-to-noise ratio

In the mechanical preset system, several cams, driven by ratchet gears and relays, rotate the tank circuits to a preset tuning point. A motor selects the cam to rotate the mechanical tuning circuits to the exact tuning point.

In the decade selecting system, any frequency channel of the band, with intervals of 100 Kc, can be constructed in decade order.

In the electronic automatic tuning system, after the crystal unit starts oscillating, rotation of the mechanical tuning circuit of a later stage will be stopped at the peak of exciting current at the last stage of the transmitter and the receiver local oscillator. The tuning circuits are stopped by a servomechanism, energized by the sensed output of a frequency discriminator circuit.

Each of these systems has advantages and disadvantages with respect to dimensions, weight, number of channels, stability, electrical performance and accessibility. Therefore no distinctive evaluation is possible, but the automatic tuning system has become common.

The mechanical preset system has been popular because of its compactness, light weight and simplicity of construction. However, the number of frequency channels is limited due to the obtainable accuracy of the mechanical parts. Since the cams and wheels are subjected to impulsive force and wearing, false actions of the tuning mechanism are likely to occur. Moreover, presetting this equipment in the airport maintenance shop is not easy.

The decade selecting system, which combines the crystal oscillator output with the i-f frequency, is one in which a required frequency is built up by combination of crystal oscillators at 1 Mc and at 0.1 Mc. This type of transmitter or receiver can handle 280 channels with about 24 crystal units, even though it is complicated both mechanically and electrically, and the entire equipment becomes heavy and bulky. Therefore, this type is applicable for large airplanes.

The electronic automatic tuning system, using the grid current of the amplifier stage, has the advantage that it is not necessary to preset the tuning circuit even if the frequency of any channel is changed by replacing the crystal unit. But it has the disadvantage that clutch slipping often causes mis-tuning and strains the mechanical parts, by functioning as a brake.

The difference between the two types of electronic automatic tuning systems is that discrimination, or determination of the tuning point, is not by amplifier grid current, but by a frequency discriminator. When the tuning mechanism passes over the null point of the discriminator, the servo output voltage will change its sense, and reverse the motion toward the true tuning point until the entire circuit is correctly tuned.

One of the features of this transceiver is its system for changing channels with a servo-tuning mechanism. When the automatic tuning system is used, it is necessary only to change the crystal. This means that an airplane flying a

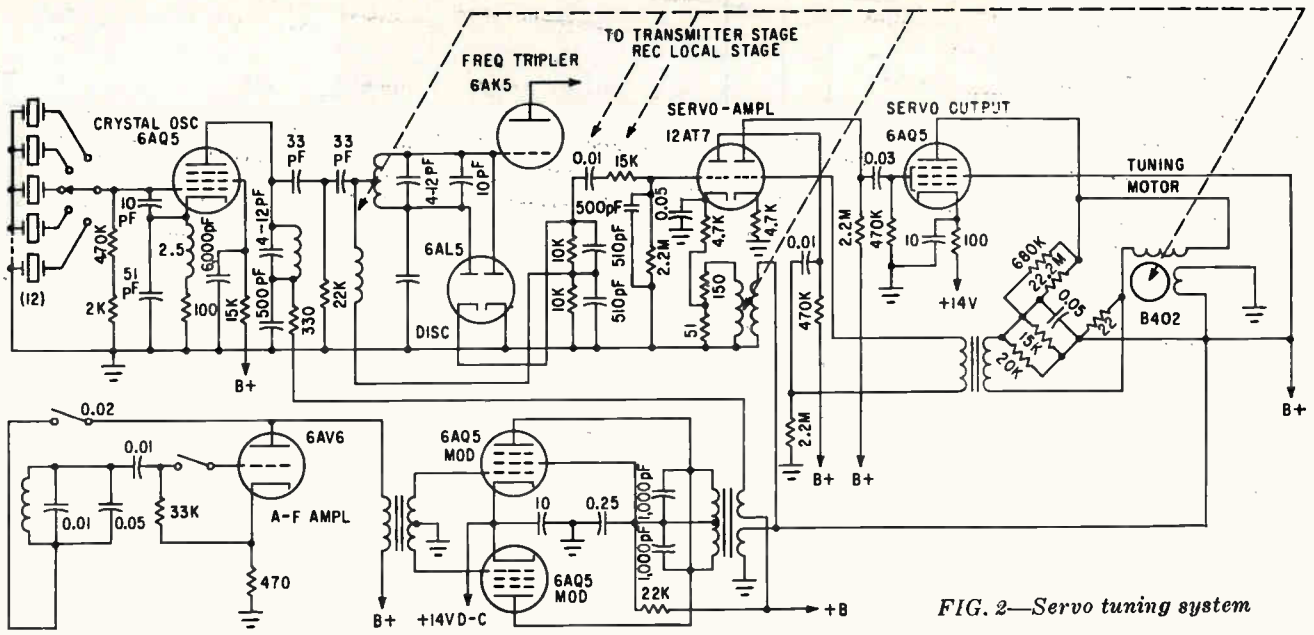


FIG. 2—Servo tuning system

long distance has only to furnish the crystals for the number of frequency channels for the next flight plan. No maintenance nor presetting in the ground shop is needed.

Since the tuning range of the tank circuits of the transmitter and receiver units is wide, a tuning mechanism using carbonyl-slug cores and metal rings is used to vary the inductance. This construction of variable inductance coils is compact, lightweight and reliable during vibration and other ambient conditions. Moreover, variation of inductance is frequency-linear, to make it easy to tune many circuits concurrently. The moving part of the servo is designed for low inertia to avoid any unnecessary hunting motion of the mechanical part.

This slug-tuning system has proved to be more favorable than that of the variable capacitor system, it is easily accessible for maintenence.

The schematic the servo tuning circuit of the transceiver is shown in Fig. 2. The crystal oscillator output is frequency discriminated by a tuning circuit, which is mechanically connected with all other tuning circuits by a servomotor. Since the crystal oscillator is amplitude-modulated by 400-cycle signal during automatic tuning action, the output voltage of the frequency discriminator is a 400 cps signal, whose amplitude is zero at the true tuning points, and whose relative phase angle will change its sense at the tuning point.

Variation of amplitude and phase in regard to the position of the tuning circuit is shown in Fig. 3. The phase of the discriminator output changes from positive to negative at the tuning point, showing whether the circuit is positioned lower or higher than the true tuning point. This makes it possible to sense the direction of rotation of the servomotor regardless of the previous position of the tuning system.

The output of the frequency discriminator is amplified by a servo-amplifier, and the control winding of the servomotor is energized by an amplified 400 cps signal.

In servo theory, this is a first-order system. Therefore, it would be possible to stop at the point of zero error voltage, but for better stability of the servo system, it is advisable to use a negative feedback proportional to the motor speed.

A tachometer is usually used to obtain this negative feedback voltage in similar servo systems. However, in this transceiver, negative feedback voltage is picked off the winding of the servomotor, whose impedance changes by the slip of the two-phase induction motor. When the motor rotates, the impedance changes proportionally with the speed of servomotor, and the increment can be obtained by a bridge circuit in which one arm is the control winding of the servomotor. Omission of the tachometer contributes to the miniaturization of the equipment.

The amplifier of this servo system has high amplification to obtain enough voltage to excite the servomotor at full revolution for the lower voltage output part of the discriminator when it is out of tune. Hence, as seen in Fig. 2, the servomotor is excited by a nearly equal voltage in all ranges except a certain region near the tuning point, and thus the total servo system is one type of ON-OFF or relay servosystem.

Steepness of the characteristic of the discriminator circuit near the tuning point, together with the high amplifier gain, often cause hunting and deteriorate the stability of the system. When the tunable frequency range of the transceiver is wide and consequently the minimum discriminator voltage is small, the amplification of the servo amplifier should be increased; therefore the frequency discrimination circuit should not have too steep a characteristic near the center. An important point in designing this transceiver is to obtain both stability near the tuning point, and higher discriminator voltage at the far end of the tuning range, where the circuits are greatly off-tuned. To cope with the decreased discriminator voltage at the off-tuned range and to get rid of the spurious effect of harmonic or parasitic tuning of the discriminator circuit, a 400-cps bias voltage is superposed on the discriminator output. This bias voltage is induced by magnetic pick-up coils

built in the servo.

The 400-cps a-c power for the servo-system is generated by the transmitter modulator, because this transceiver is intended for installation in small airplanes, which have no 400-cps source. Upon completion of automatic tuning, the 400-cps voltage source is cut off and the relay is released to halt the automatic tuning. The disciminator output becomes zero just when the center frequency of the discriminator circuit coincides with the frequency of crystal oscillator. The turn-off relay is delayed in operation for a period during which the overshooting of the servomechanism corrects itself.

Because of the high gain amplifier and the high gradient of the discriminator near the center frequency, the accuracy of stoppage is high; error is less than 0.1 percent. Temperature compensation is used in the tuning circuit of the discriminator. This tuning system is compact and lightweight and permits an increase in the number of channels by providing the required number of switches to change the crystal.

Special considerations against external noises such as engine noise and acoustic noise are required for airborne equipment. The aircraft antenna is often exposed within the intense field of impulse noises caused by engine ignition.

In modern aircraft the spark plugs are double-shielded, the power source is insulated from ground and shielding covers are almost perfect. However, these measures cannot prevent noise from being generated. The level of noise sometimes reaches hundreds or thousands of times that of the received signal. Even in the presence of such impulse noises, this transceiver is designed to be able to perform satisfactorily.

The cabin of the airplane is filled with equipment and accordingly the receiver is subjected to noise from this equipment. When carried on a small helicopter, this equipment was placed amid an impulse noise field of 100μv per meter, owing to imperfect shielding of sparkplugs, and it was necessary to receive a weak signal on the order of 2μv per meter. The engine noise, being impulsive, contains some carrier-wave component, so that it can be used to energize the noise-elimination circuit.

A conventional noise-limiting circuit is shown in Fig. 4A and the improved noise-limiting circuit in Fig. 4B. In the improved circuit, the R-C time constant is large and the plate of the detecting diode is negatively charged by the detected input signal. Its voltage is kept steady by capacitor *C*. Even if the signal includes audio modulation, the voltage at point *A* will be equal to half the peak value of the carrier signal, and its fluctuation will amount to half the modulation of the signal. When impulse noise is introduced to this detector circuit, the potential at point *P* will not change, according to the time constant of the circuit, but the voltage at point *A* increases positively and the limiting diode shuts out the noise by its rectification characteristics. No audible noise can pass this limiter, even if the impulse noise has hundreds of times as large a voltage as the carrier wave.

If the conventional noise limiter (Fig. 4A) is used, strong impulsive noise will leak through the filter circuit that determines the plate potential. Other than the performance of limiter circuit for impulse noise, the characteristics of the avc circuit, which is charged to peak value by strong noises, often cause the decline of sensitivity. The avc circuit should also be designed so as not to be effected in its voltage by the impulse noise. This noise limiter can suppress electrical noise up to approximately 1,000 times that of the signal level with only a slight trace at the audio output.

When noise limitation is insufficient, the clarity of the received signal is deteriorated by cross modulation between signal and noise in the audio-frequency amplifier. With the new noise-elimination circuit, the transceiver gives better sensitivity and articulation than other vhf equipment, even if it is mounted in a poorly shielded airplane.

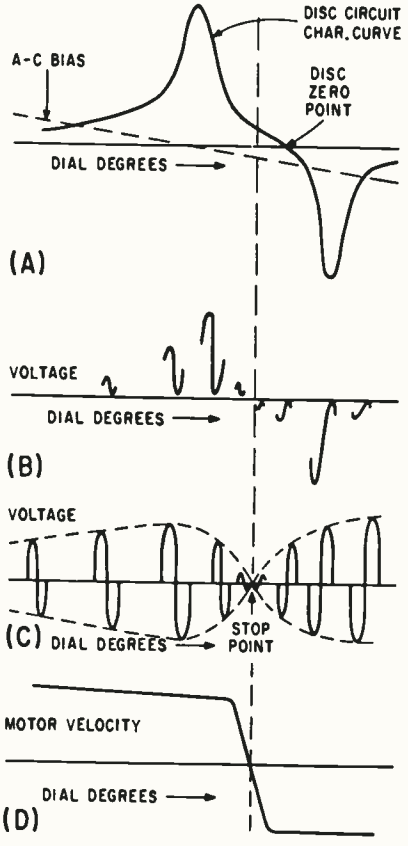


FIG. 3—Operation of the servo tuning system: discriminator circuit static characteristic (A); servo-amplifier input voltage, using a modulated oscillator (B); servo-amplifier output motor control voltage (C); and motor velocity (D)

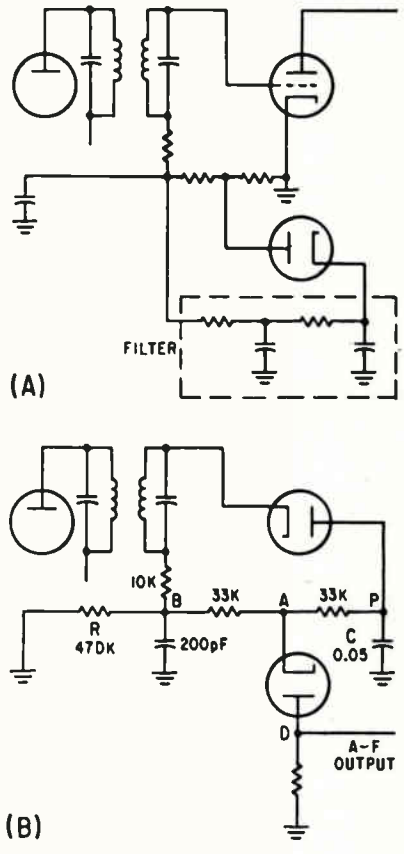
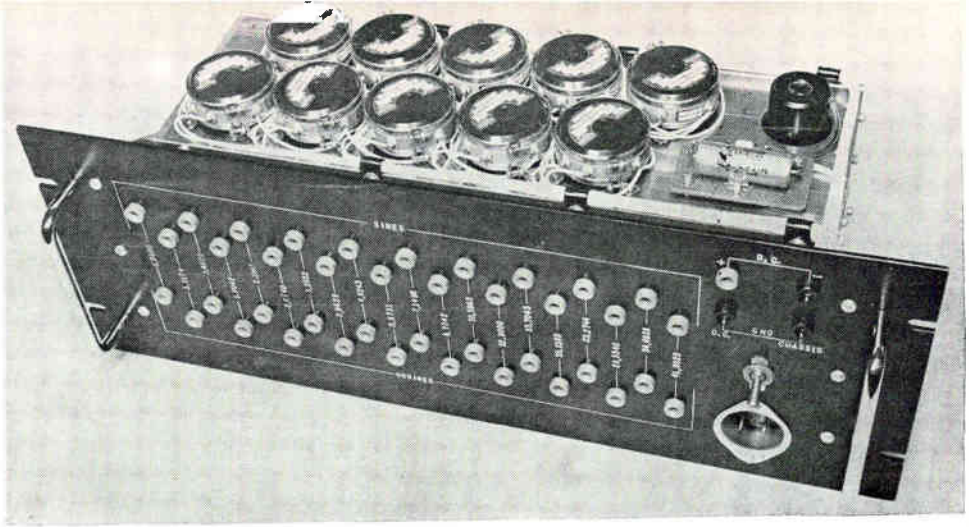


FIG. 4—Conventional noise-limiter circuit (A) and authors' noise limiter circuit (B). In conventional filter, suppression capability is 10. New circuit has capability of 1,000 times with only slight leakage into audio output



Sine-cosine potentiometers are driven by low speed clock motor to generate low-frequency white-noise signal

White Noise Signals

Pseudo random signal generator is useful for simulating, testing and analyzing low-bandpass control systems. A flat amplitude-spectrum and statistically invariant signal with 420-component frequencies is generated with sine-cosine potentiometers

By N. D. DIAMANTIDES,
Goodyear Aircraft Corp.,
Akron, Ohio

RANDOM SIGNALS of analytically known and time invariant statistics are indispensable during control loop and systems design. A random signal value in controls and communications is the so-called white noise. White noise lends itself to a manageable analytical treatment and simplifies the design of filters required to shape it to the degree needed to solve problems.

White noise is composed of an infinite number of sinusoidal signals having the same amplitude but random phases with constant packing density per unit interval on the frequency axis resulting in a signal of a constant power spectral density. On the other hand, a signal within a certain frequency band composed of a finite number of nonharmonic and phase-incoherent sinusoids of the same amplitude has some of the features of white noise, including computational convenience. This signal can be endowed with power spectral density invariance since sinewave generators can be made frequency and amplitude stable. A desirable property of such a device is that the discrete frequencies can be packed close enough that their separation remains beyond the frequency-resolving power of the system subjected to the composite random signal.

An important application for signals of this type is in the field of human psychomotor-response studies. Here not only should the amplitude of the input signal components maintain its value throughout a range of experiments, but knowledge of phase relationships is often needed as well. In addition, the composite signal rules out predictability on the human subject's part, a factor of basic importance in response dynamics. A constant-noise signal generator is also useful in deriving the transfer function of control systems, and in studies of the dynamics of processes and plants; other applications include studies of dynamic systems such as airplanes and missiles, land vehicles and ships. Information can be obtained by applying the constant noise signal directly to the sys-

THE ARGUMENT OF PERIODIC TERMS

	r^0	r^1	r^2	r^3	r^4	•
r^0	$2r^0$	$r^0 \pm r^1$	$r^0 \pm r^2$	$r^0 \pm r^3$	$r^0 \pm r^4$	•
r^1	$r^1 \pm r^0$	$2r^1$	$r^1 \pm r^2$	$r^1 \pm r^3$	$r^1 \pm r^4$	•
r^2	$r^2 \pm r^0$	$r^2 \pm r^1$	$2r^2$	$r^2 \pm r^3$	$r^2 \pm r^4$	•
r^3	$r^3 \pm r^0$	$r^3 \pm r^1$	$r^3 + r^2$	$2r^3$	$r^3 \pm r^4$	•
r^4	$r^4 \pm r^0$	$r^4 \pm r^1$	$r^4 \pm r^2$	$r^4 \pm r^3$	$2r^4$	•
•	•	•	•	•	•	•

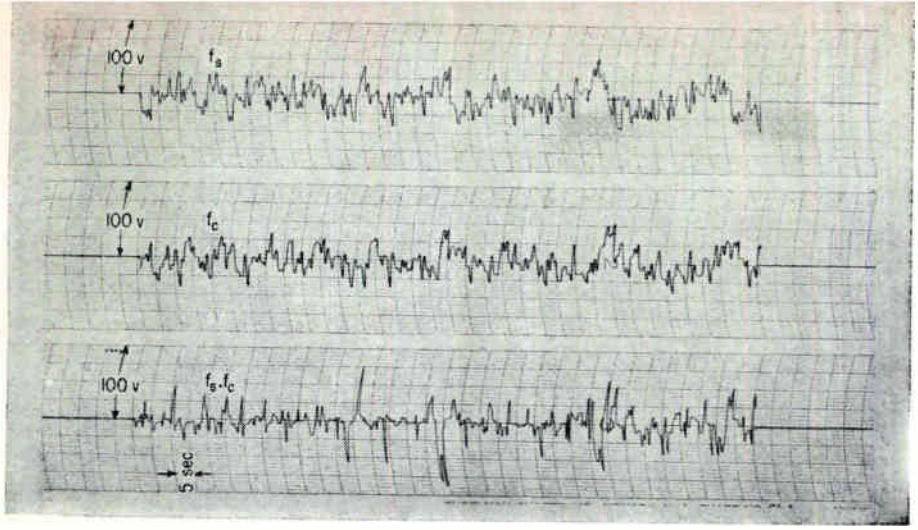


FIG. 1 — Samples of white noise signals produced by generator. Random signal would not begin to repeat for 10^{22} years

Aid Systems Analysis

tem under study, as in constant response studies and in control loops; or the signal can be applied to a simulated system, as in large plants, aircraft and weapons.

The constant noise signal generator shown in the photograph consists of 20 wirewound, sinecosine potentiometers of one-percent accuracy. The potentiometers are driven from a single, constant-speed, a-c motor at nonharmonic angular frequencies through successive gear trains; the gear trains reduce the speed of rotation from one shaft to the next by the same ratio. The value selected for the fixed gear ratio is

$$r = 23/28 \tag{1}$$

When the potentiometers are biased symmetrically by voltages ± A, and the outputs from the sine and cosine wipers are summed separately, the generator produces two signals, one a sine function, f_s, and other a cosine function, f_c

$$f_s(t) = A \sum_{n=0}^{19} \sin (r^n \omega_0 t + \phi_n) \tag{2}$$

$$f_c(t) = A \sum_{n=0}^{19} \cos (r^n \omega_0 t + \phi_n) \tag{3}$$

Either of two basic frequencies can be selected by a gear shift

$$f_0 = f_{\max} = \frac{\omega_0}{2\pi} = 1 \text{ or } 2 \text{ cps} \tag{4}$$

For $f_0 = 1$ cps, which will be assumed throughout this article, the lowest frequency component will be

$$f_{\min} = \left(\frac{23}{28}\right)^{19} = 0.0238 \text{ cps} \tag{5}$$

Typical samples of the signals $f_s(t)$ and $f_c(t)$ are shown in Fig. 1.

The minimum number of revolutions required by the fastest shaft to allow the other shafts to go through an integral number of revolutions is given by the factor 28^{19}. This is the least multiplier that

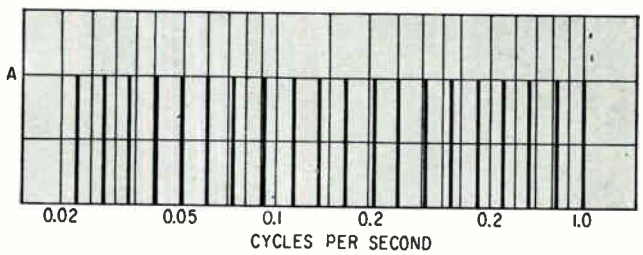


FIG. 2—Spectral density of the signal $f_c(t)$

changes into integers all terms of the series.

$$1, \left(\frac{23}{28}\right), \ldots, \left(\frac{23}{28}\right)^{18}, \left(\frac{23}{28}\right)^{19}$$

When this value is reached, the signal will start repeating. Since each revolution takes one second, the repetition period is

$$T = 28^{19} \text{ sec} \cong 10^{22} \text{ years} \tag{6}$$

The spectral density of either one of the signals $f_s(t)$ and $f_c(t)$ is shown in Fig. 2.

The full value of the constant noise generator is realized when advantage is taken of some basic properies of trigonometric functions and computer components are available that are capable of implementing the functions.

One valuable function is obtained when $f_c(t)$ is squared and subsequently added to two more signals in the following manner

$$F_1(t) = [f_c(t)]^2 + A f_c(t) - 10A^2$$

$$= A^2 \left[\sum_{0}^{19} \cos (r^n \omega_0 t + \phi_n)\right]^2 + A^2 \sum_{0}^{19} \cos (r^n \omega_0 t + \phi_n) - 10A^2 \tag{7}$$

The series part gives rise to terms of the forms

$$A^2 \cos^2 a = \frac{A^2}{2} + \frac{A^2}{2} \cos 2a \tag{8}$$

and

$$A^2 \cos (a) \cos (b) = \frac{A^2}{2} \cos (a + b) + \frac{A^2}{2} \cos (a - b) \tag{9}$$

The constant terms of components like those in Eq. 8 are neutralized by the term $10A^2$ in Eq. 7.

The periodic terms arising from the products of Eq. 9 are diagrammed in the table, where each term is represented by the respective value of the multiplier of the basic frequency ω_o.

As shown in the table, (p 86) each term appears twice in symmetrical locations about the main diagonal cancelling the factor 1/2 shown in Eq. 9. On the other hand, the terms along the main diagonal appear only once, thus retaining the factor 1/2. Hence

$$F_1(t) = \frac{A^2}{2}\sum_{n=0}^{19}\cos(2r^n\omega_o t+2\phi_n)+A^2\sum_{n=0}^{19}\cos(r^n\omega_o t+\phi_n)+$$
$$A^2\sum_{n=0}^{19}\sum_{m=0}^{19}\cos\left[(r^n+r^m)\omega_o t+(\phi_n+\phi_m)\right]_{m\neq n}+$$
$$A^2\sum_{n=0}^{19}\sum_{m=0}^{19}\cos\left[(r^n-r^m)\omega_o t+(\phi_n-\phi_m)\right]_{m\neq n} \quad (10)$$

The first two sums comprise 20 terms each, while, as shown in the table, the result of each double summation is equal to the sum, s, of an arithmetic progression having 19 terms (columns), the first of them equal to 19, the last equal to 1, and the ratio also equal to 1; therefore

$$s = \frac{19}{2}(19+1) = 190$$

Thus, the number of frequencies contained in $F_1(t)$ is 420; the highest frequency is

$$f_{max} = 2r^0\,\omega_o/2\pi = 2 \text{ cps} \quad (11)$$

and the lowest (nonzero) corresponding to the smallest difference is

$$D = r^n - r^m = r^n(1-r^{m-n}) \quad (12)$$

Since $r < 1$, D is smallest when both

$$\begin{matrix} n = \text{maximum and} \\ m-n = 0 = \text{minimum} \end{matrix} \quad (13)$$

Both these conditions are satisfied when $n = 18$ and $m = 19$; therefore

$$f_{min} = (r^{18}-r^{19})\,\omega_o/2\pi = 0.0052 \text{ cps} \quad (14)$$

The only disadvantage of the signal $F_1(t)$ is that it contains 20 components, $(2r^n\omega_o)$, having amplitudes half as large as the rest of the 420 components.

It can be shown that

$$F_2(t) = [f_s(t)]^2 - 10A^2$$
$$= -\frac{A^2}{2}\sum_{n=0}^{19}\cos(2r^n\omega_o t+2\phi_n)+$$
$$\sum_{n=0}^{19}\sum_{m=0}^{19}\cos\left[(r^n+r^m)\omega_o t+(\phi_n-\phi_m)\right]_{m\neq n}-$$
$$\sum_{n=0}^{19}\sum_{m=0}^{19}\cos\left[(r^n+r^m)\omega_o t+(\phi_n+\phi_m)\right]_{m\neq n} \quad (15)$$

Consequently, between Eq. 10 and 15

$$F(t) = F_1(t) + F_2(t) + Af_c(t)$$

or

$$F(t) = 2A^2\cos(r^n\omega_o t+\phi_n)+$$
$$2A^2\sum_{n=0}^{19}\sum_{m=0}^{19}\cos\left[(r^n-r^m)\omega_o t+(\phi_n-\phi_m)\right]_{m\neq n} \quad (16)$$

This signal contains only 210 different frequencies between $f_{max} = 1$ cps and $f_{min} = 0.0052$ cps, but it possesses an absolutely flat spectrum and sharp cutoff. An additional characteristic of the signal $F(t)$ is that it contains no harmonic frequencies.

Figure 2 shows a sample of the product

$$[f_c(t)]\,[f_s(t)]$$

and Fig. 3A is the circuit diagram for generating $F(t)$.

Figure 3B shows the packing density of the component frequencies of $F_1(t)$ over intervals 0.1 cps wide. Since the power in each frequency band is proportional to the number of the components within it, the curve represents the power spectral density of $F_1(t)$.

The gearing ratios may be selected to obtain any desired mode of frequency separation instead of the geometric progression used here. In certain applications other types of rotary sine-generators may be more suitable than potentiometers.

The author is grateful to J. O. Rhodes of the Advance Systems Predesign Department of Goodyear Aircraft Corp. for supervising the electromechanical design and fabrication of the random-function generator.

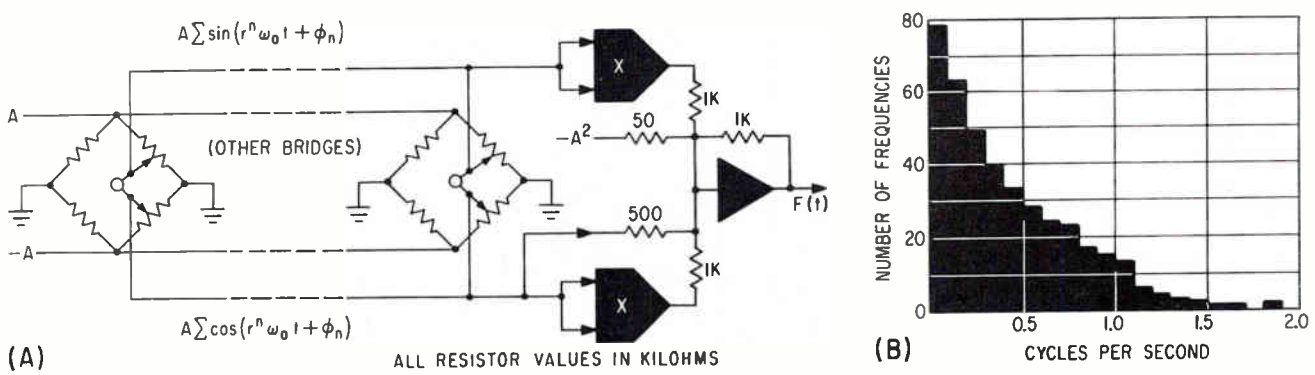


FIG. 3—Motor-driven sine-cosine potentiometers generate nonharmonically related signals from which F(t) is obtained by computer operation (A). Packing density of component frequencies of $F_1(t)$

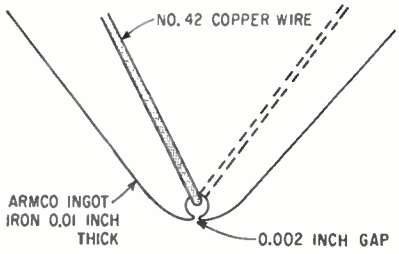
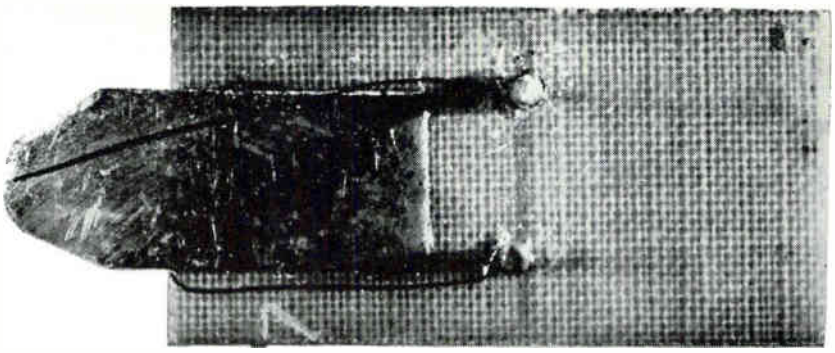


FIG. 1—One turn of wire over magnetic material forms simple recording head



Single-turn head has cost and manufacturing advantages but requires large write current

Single-Turn Recording Heads

By H. J. Kump,

International Business Machines Development Lab., Endicott, N. Y.

A BIT RECORDED with the single turn recording head of Fig. 1 is the same as that recorded by any ring head: two poles similar in shape and amplitude, but opposite in polarity. This is in contrast to the concentric poles recorded by stylus heads, where the outer pole is considerably weaker than the inner pole.

A given volume of magnetic material will produce the highest field in a given air space when the induction B in the material is that for which the energy product BH is a maximum. ("Ferromagnetism", R. M. Bozorth, p 348, D. Van Nostrand.) Considering the recorded bit to be the volume of magnetic material, optimum recording can be expected to occur when the self-demagnetization of the bit equals that necessary to produce the maximum energy product in the recording surface. This does not assure that read-back will be optimum. That is to say, a recording surface thickness must exist, for each size bit, for which the fields above the bit will be maximum. To ascertain this thickness for the single-turn head, the head was pulsed with a 50 amp, 2.5 μsec pulse above various thicknesses of NiCo plated drum surfaces. The results are plotted in Fig. 2A. Optimum recording is obtained for a coating of NiCo 0.0005 inch thick. (While Fig. 2A shows results for a head-to-drum gap of 0.001 inch, the curve is approximately correct for gaps from 0.0005 to 0.005 inch.)

When the head-to-drum gap is varied, using the optimum NiCo plating of 0.0005 inch, the curve in Fig. 2B results. The asymptote indicates that the NiCo surface is saturated at a head-to-drum gap of 0.001 inch. The maximum value of the vertical component of magnetic field, over the bit, is 155 oersteds.

When the write current is varied, with head-to-drum gap constant on the same 0.0005 inch thick surface, the curve in Fig. 2C is obtained. Here, the asymptote indicates saturation of the write core. The head-to-drum gap of 0.003 inch allows operation in a near linear region of the curve of Fig. 2B while avoiding surface saturation. The curves shown are all interrelated to some degree; thus, while a total of 4 db of loss exists at 30 amperes with a gap of 0.003 inch, there is probably no loss when the gap is 0.0005 inch.

Although the single-turn head has cost and manufacturing advantages, it has not been used extensively because of the large (5 to 50 amp) drive current necessary. Related heads are discussed in British patent specification 806,288 (1955), filed by the Clevite Corp.

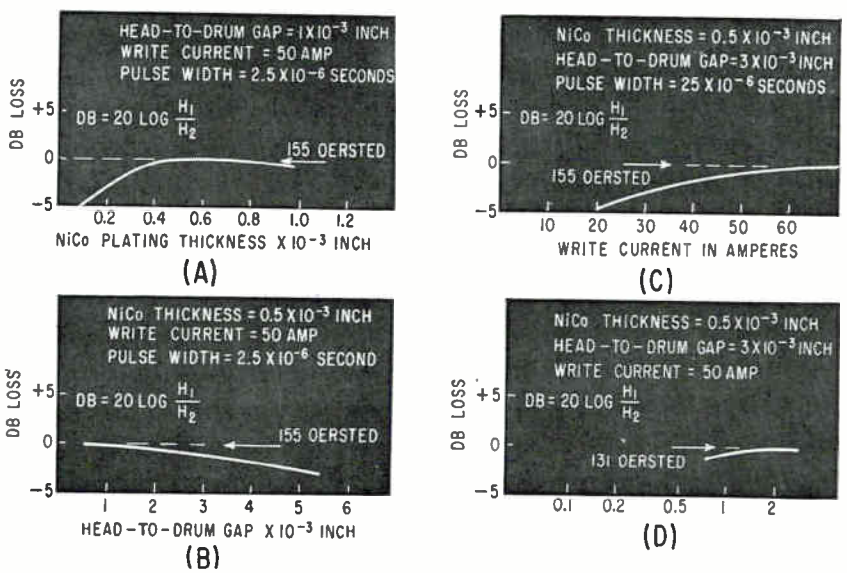
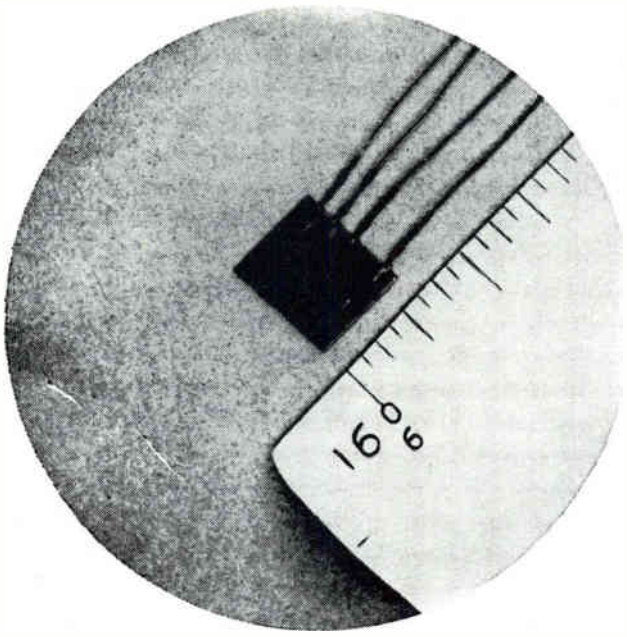


FIG. 2—Optimum plating thickness for single-turn head is approximately 0.0005 inch (A). Optimum thickness saturates for head-to-drum gap of 0.001 inch (B). Asymptote in (C) indicates saturation of writing head rather than surface. Pulse response (D) shows no losses to eddy currents or inductance for 1.5 μsec pulses

Developing the Hall



Synthesized Hall generator

The Hall generator's inherently small size confers application flexibility and makes the device especially adaptable as a measuring probe

By J. W. MOTTO, JR.
Semiconductor Department, Westinghouse Electric Corp., Youngwood, Pa.

WITH A NEW DEVICE such as the Hall generator, an important step in obtaining extensive application of the device is to supply the circuit designer with an equivalent circuit. This will provide insight into how the device functions and will permit at least semi-quantitative calculations into possible applications.

The equivalent circuit for the Hall generator is synthesized by noting the basic phenomena that take place, describing these phenomena in mathematical matrix form, and finally combining the individual parts by appropriate matrix manipulation into the equivalent circuit. Using this phenomenological approach, the parameters will all have physical meaning.

The current gain, voltage gain, and input impedance will then be derived in terms of the equivalent circuit parameters to illustrate the use of the equivalent circuit in Hall generator applications.

Multiplier—An electric current and magnetic field existing simultaneously in a semiconductor produce a voltage described by

$$V_h = \frac{R_h \times 10^{-8}}{d} (\bar{I}_c \times \bar{B})$$

where V_h is the resultant Hall voltage, I_c is the current through the semiconductor, B is the magnetic field, d is the thickness of the material in the direction of the magnetic field, and R_h is the proportionality constant termed the Hall constant. This voltage V_h is the Hall voltage, discovered by Edmund Hall in 1879[1], and is directly proportional to the vector product of the control current and the magnetic field.

The property of the Hall generator to multiply its pair of inputs defies representation by conventional circuit components. The closest conventional component would be an ideal transformer having a variable turns ratio directly proportional to magnetic field as shown in Fig. 1A.

The Z parameter matrix for an ideal transformer is nonexistent, but the A parameter matrix takes the form

$$[A]_m = \begin{bmatrix} a & 0 \\ 0 & \frac{1}{a} \end{bmatrix} = \begin{bmatrix} KB & 0 \\ 0 & \frac{1}{KB} \end{bmatrix}$$

Gyrator—The Hall generator is a linear passive device, and yet it has the additional property of not being bilateral. This has been termed in literature as a gyrator, and has symbol shown in Fig. 1B.

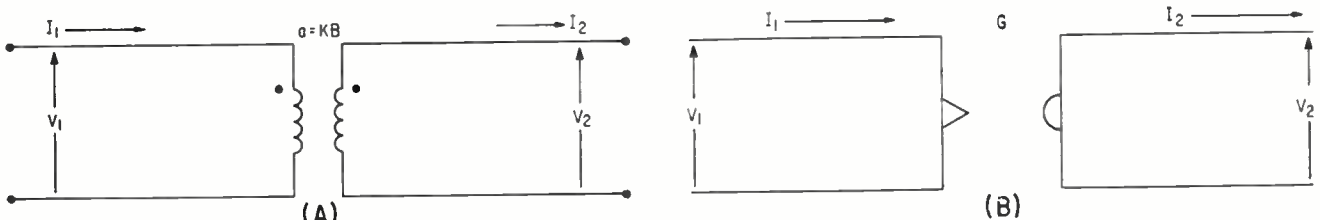


FIG. 1—Transformer with turns ratio proportional to a magnetic field represents the Hall generator's ability to multiply (A); gyrator symbol (B) indicates that although the generator is a linear passive device it is not bilateral

Generator Equivalent Circuit

equivalent circuit reduces cut-and-try approach in circuit design

The Z parameter matrix for an ideal gyrator is given by

$$[Z]_G = \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$$

The A parameter matrix would be given by

$$[A]_G = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$$

Internal Resistance—The Hall effect is a solid-state analogy of the magnetic deflection of an electron beam in a cathode-ray tube. This Hall effect takes place in a block of conducting material and the resistance of this material must be taken into consideration. There are two internal resistances: the resistance to the flow of control current, r_c and the resistance to the flow of output current, r_H.

Unfortunately, these resistances are also a function of the magnetic field. The increase in resistance with the magnetic field is termed the magnetoresistive effect and is proportional to the square of the carrier mobility[2]; it is therefore large in Hall generators incorporating high-mobility materials. The exact theory for this resistance change is complex; it can, however, be described for the type 803 Hall generators by the empirical equations

$$r_c(B) = R_c(0) + 0.03B^{1.6}$$
$$r_H(B) = R_H(0) + 0.03B^{1.55}$$

Where r_c (B) is the control terminal internal resistance in ohms, r_H (B) is the Hall terminal internal resistance in ohms, B is the magnetic flux density in kilogauss, R_c (0) is the control terminal internal resistance with $B = 0$ in ohms, and R_H (0) is the Hall terminal internal resistance with $B = 0$. For most calculations, an exponent of 1.6 could be used for both r_c (B) and r_H (B).

The A parameter matrices for these simple resistance circuits are given in Fig. 2A.

The four parts of the Hall generator are the control-terminal resistance, multiplier, gyrator and Hall terminal resistance. These are effectively in cascade as shown in Fig. 2B.

The two-port equivalent circuit of several individual two-port circuits in cascade may be found by multiplying the A matrices of the individual two-port A matrices[2].

$$[A]_{eqv\ ckt} = [A]_{rc(B)}[A]_m[A]_G[A]_{rH(B)}$$

$$[A]_{eqv\ ckt} = \begin{bmatrix} 1 & r_c(B) \\ 0 & 1 \end{bmatrix}\begin{bmatrix} KB & 0 \\ 0 & \frac{1}{KB} \end{bmatrix}\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}\begin{bmatrix} 1 & r_H(B) \\ 0 & 1 \end{bmatrix}$$

$$[A]_{eqv\ ckt} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} \frac{r_c(B)}{KB} & \frac{r_c(B)r_H(B)}{KB} + KB \\ \frac{1}{KB} & \frac{r_H(B)}{KB} \end{bmatrix}$$

Transforming the A equivalent circuit matrix to the Z equivalent circuit matrix.[3]

$$[Z]_{eqv\ ckt} = \begin{bmatrix} \frac{A}{C} & \frac{|A|}{C} \\ \frac{1}{C} & \frac{D}{C} \end{bmatrix} = \begin{bmatrix} r_c(B) & -KB \\ KB & r_H(B) \end{bmatrix}$$

The two generator equivalent circuit in the Z parameters is shown in Fig. 3A.

The Hall generator equivalent circuit in terms of the Hall generator parameters can be obtained by

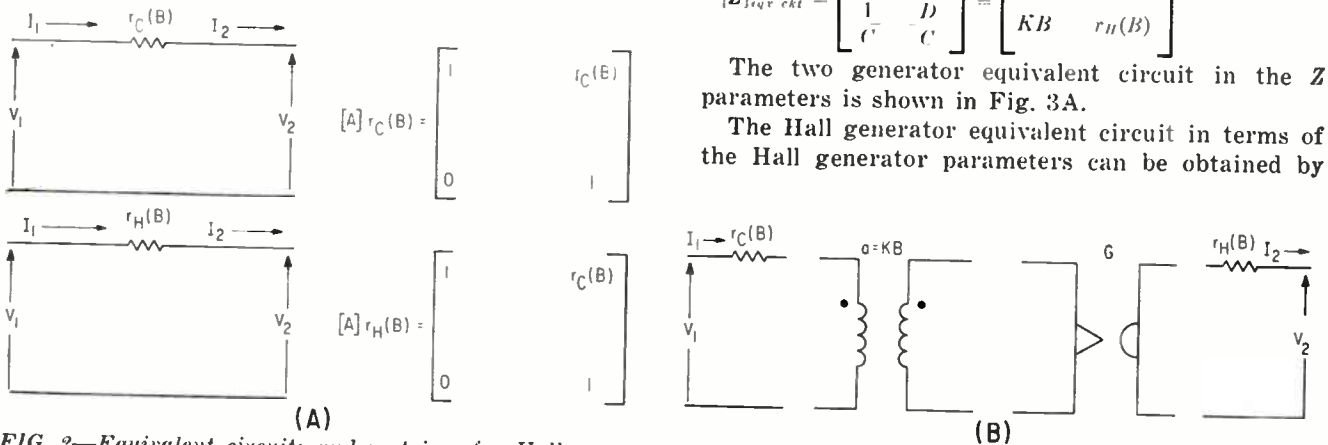


FIG. 2—Equivalent circuits and matrices for Hall generator input and output resistances (A): the four basic parameters: control terminal resistance, multiplier effect, gyrator and terminal resistance are cascaded in (B) to simulate the overall Hall generator effect

direct substitution as shown in Fig. 3B.

The terms used in the Hall generator equivalent of Fig. 3B are defined as follows: voltage V_c is the voltage across control terminal, I_c is the current through control terminals, V_H is the voltage across Hall terminals, I_H is the current through Hall terminals, B is the instantaneous magnetic field density component that intercepts the Hall generator perpendicular to the plane of its control current.

Resistance r_c (B) is the control terminal internal resistance and is a function of magnetic field that can be described with reasonable accuracy by r_c (B) = R_c (0) + $0.03B^{1.65}$. Resistance r_H (B) is the Hall terminal internal resistance. It is also a function of the magnetic field as described by r_H (B) = R_H (0) + $0.03B^{1.55}$.

Coefficient K_h is the Hall constant: R_H/d, where R_H is the Hall coefficient, d is the thickness of the Hall generator, and K_h (I) is the inverse Hall constant.

The equivalent circuit shown in Fig. 3B indicates bilateral operation. In normal operation a current passing through the control terminals generates a Hall voltage at the Hall terminals; however, the Hall generator may be used in the inverse mode of operation, that is, a current passing through the Hall terminals generates a Hall voltage across the control terminals.

The equivalent circuit presented will be most applicable to the specific design problems of a given experimental or developmental Hall generator application.

The following are three examples of how it may be used. It has been shown in many texts that using the Z parameters, the current gain, voltage and input impedance can be expressed as shown in Eqs. 1, 2, and 3

$$A_I = \frac{Z_{21}}{Z_{22} + Z_L} \tag{1}$$

$$A_v = \frac{Z_{21}Z_L}{\Delta + Z_{11}Z_L} \tag{2}$$

$$Z_{in} = \frac{\Delta + Z_{11}Z_L}{Z_{22} + Z_L} \tag{3}$$

where

$$\Delta = Z_{11}Z_{22} - Z_{12}Z_{21}$$

The Z matrix for the Hall generator equivalent circuit is

$$Z_{eqv\ ckt} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} = \begin{bmatrix} r_C(B) & -K_h(I)B \\ K_hB & r_H(B) \end{bmatrix} \tag{4}$$

Current Gain—For the Hall generator, the forward current gain (Eq. 1) becomes

$$A_I = \frac{K_hB}{r_H(B) + R_L} \tag{1a}$$

$$AI\Big|_{R_L=0} = \frac{K_hB}{r_H(B)} \tag{1b}$$

Voltage Gain—For the Hall generator, the forward voltage gain (Eq. 2) becomes

$$A_v = \frac{K_hBR_L}{r_C(B)r_H(B) + K_H^2B^2 + r_C(B)R_L} \tag{2a}$$

$$A_v\Big|_{R_L=\infty} = \frac{K_hB}{r_C(B)} \tag{2b}$$

Input Impedance—For the Hall generator, the input impedance formula is

$$Z_{in} = \frac{r_C(B)r_H(B) + K_h^2B^2 + r_C(B)R_L}{r_H(B) + R_L} \tag{3a}$$

$$Z_{in}\Big|_{R_L=0} = r_C(B) + \frac{K_h^2B^2}{r_H(B)} \tag{3b}$$

$$Z_{in}\Big|_{R_L=\infty} = r_C(B) \tag{3c}$$

The input impedance increases when the output is short-circuited owing to the gyrator action of the Hall generator

$$Z_{in}\Big|_{R_L=0} > Z_{in}\Big|_{R_L=\infty}$$

Inverse Operation—For inverse operation, the derived formulas are changed to replace r_c (B) with r_H (B); r_H (B) with r_c (B); and K_h with K_h (I) resulting in

$$A_I(I) = \frac{-K_h(I)B}{r_C(B) + R_L} \tag{1c}$$

$$A_v(I)\Big|_{R_L=\infty} = \frac{-K_h(I)B}{r_H(B)} \tag{2c}$$

$$Z_{in}(I)\Big|_{R_L=0} = r_H(B) + \frac{K_h^2(I)B^2}{r_C(B)} \tag{3d}$$

The equivalent Hall generator circuit is capable of predicting the characteristics of actual Hall generators in action. This facility is useful in developing existing Hall generators applications and will help inquiries into new applications.

Three circuit parameters were derived to demonstrate the use of the equivalent circuit in Hall generator circuit design.

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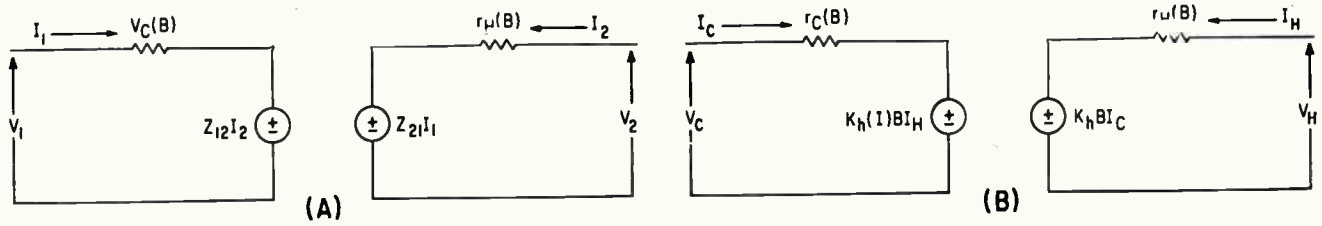

FIG. 3—Two-generator equivalent (A) is a simplification by matrix multiplication while the final equivalent circuit (B) synthesizes all 4 individual components of Fig. 2B

Archytas of Tarentum (428-347 B.C.), Greek philosopher and mathematician, is credited with being almost the first to bring mathematics to human uses. His invention of a wooden pigeon that actually flew is an example of his ingenuity in this respect.

Though we do not know today what means Archytas used to make the wooden bird fly –whether it was a heavier-than-air machine or whether it utilized gases—the concept was definitely original and successful.

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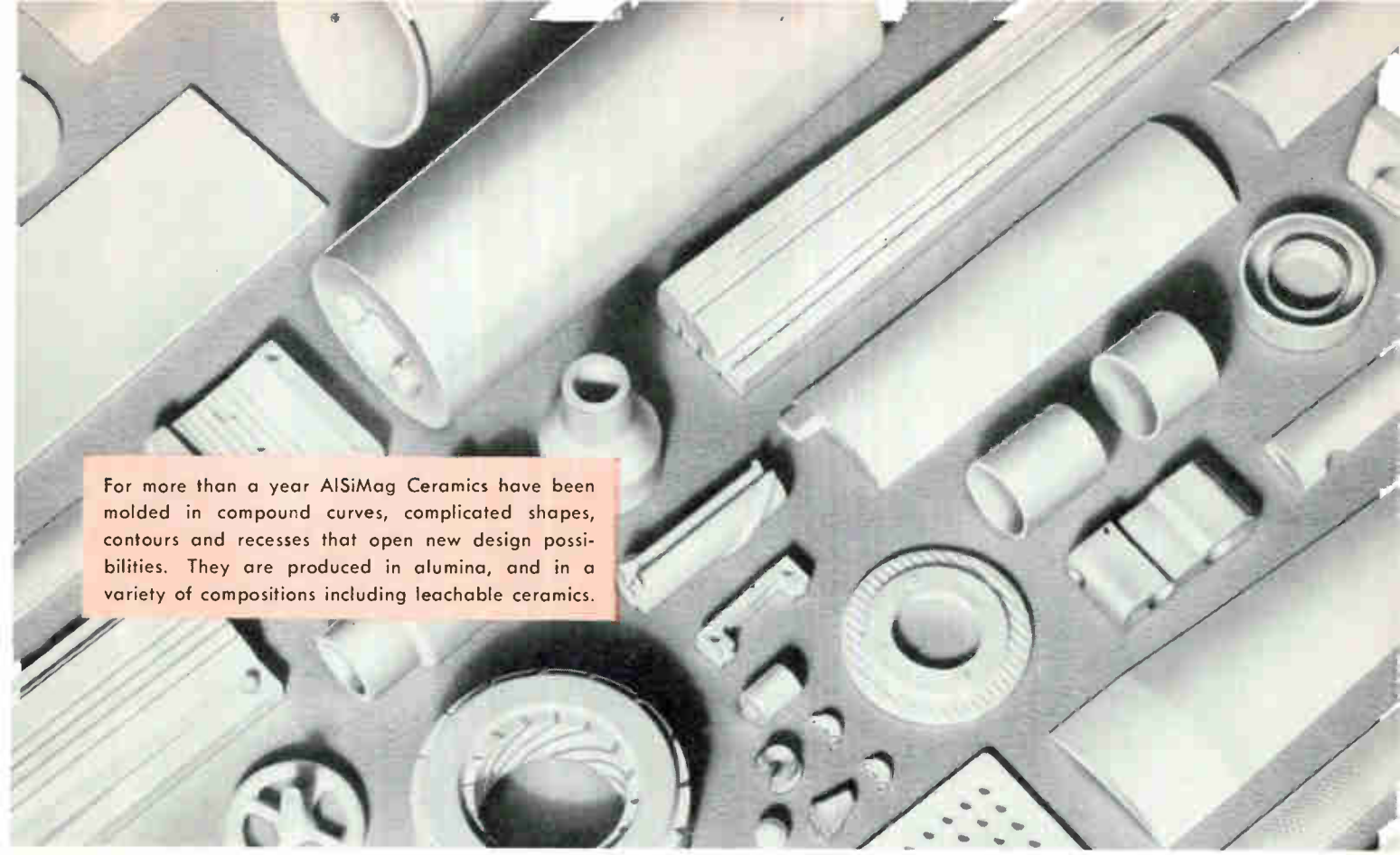

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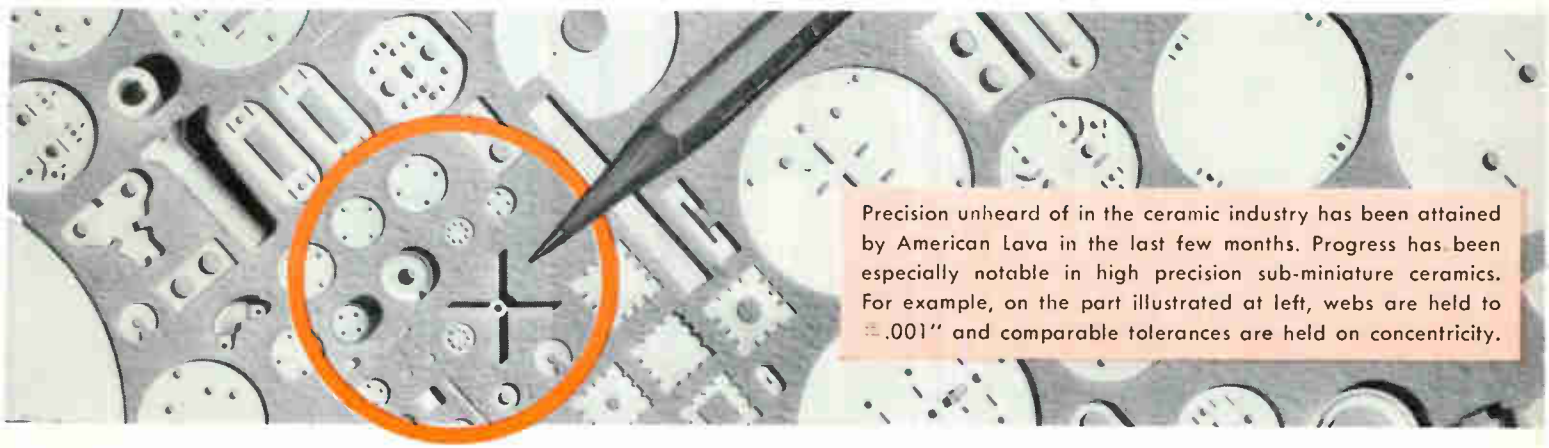

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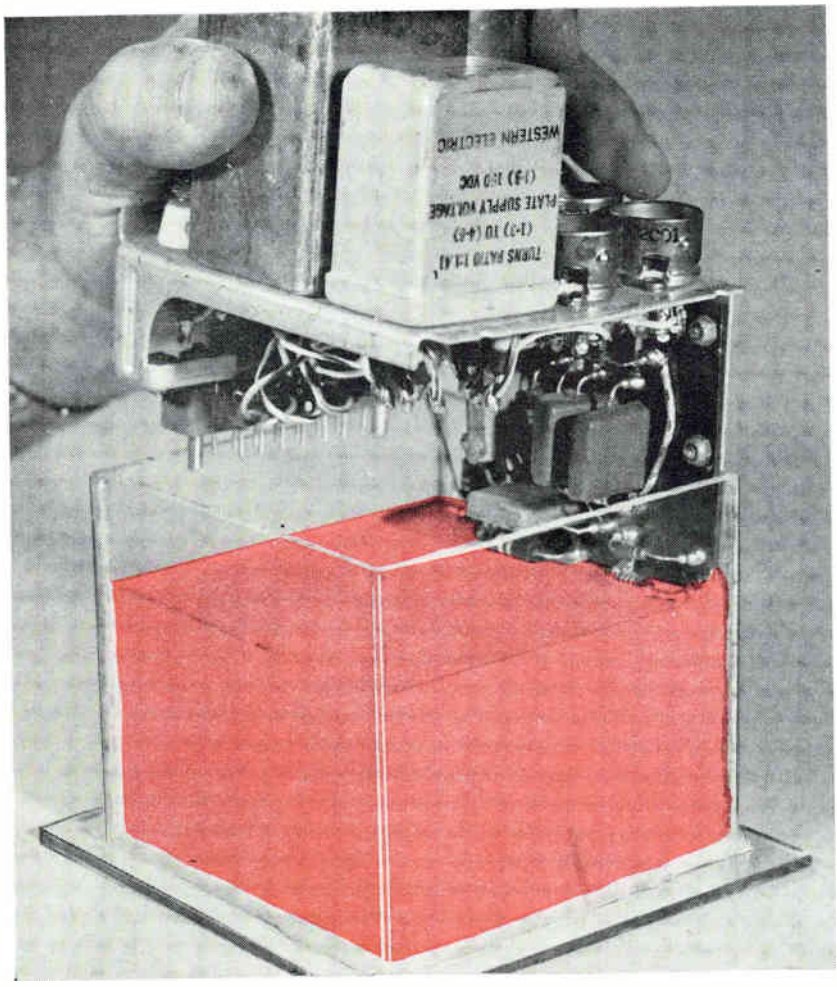

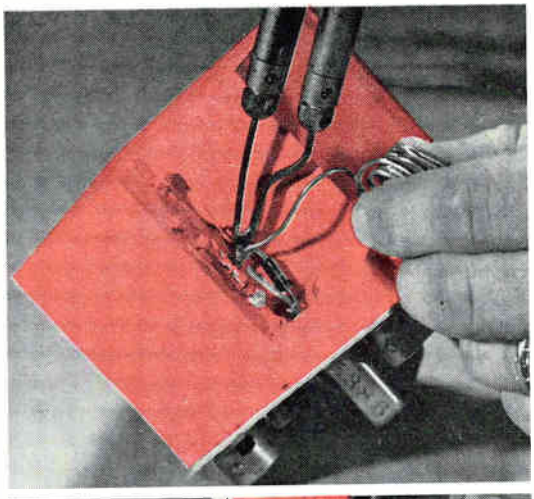

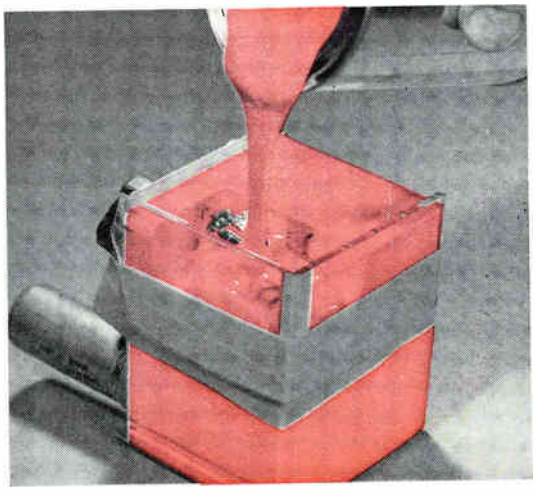

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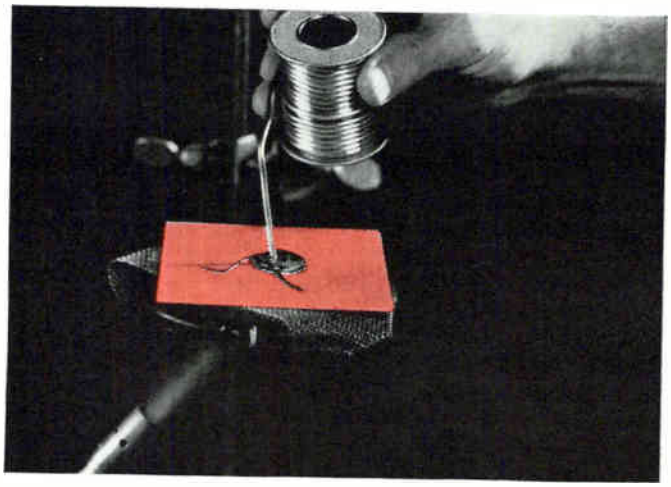

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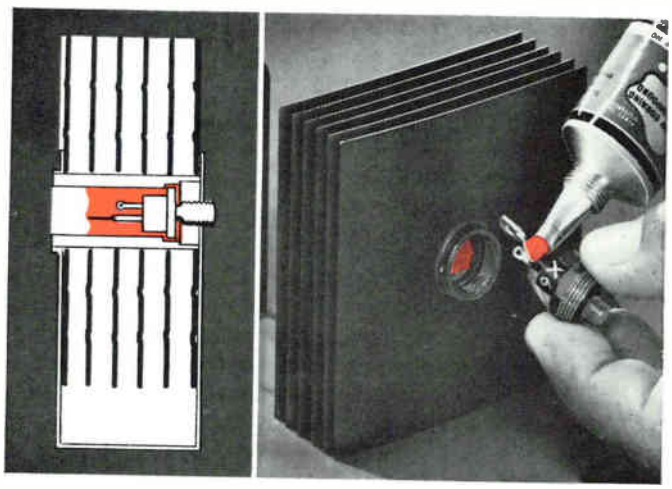

Silicone compound for heat sink seal

Heat sinks built by Fairfield Controls, Inc., Stamford, Conn., combine pure copper fins with Dow Corning 3 Compound to assure full load operation of silicon control rectifiers within the maximum allowable junction temperature of 125 C. Dow Corning compound with its petroleum jelly-like consistency, provides excellent heat transfer between the 25.5 amps diode shown here and the metallic parts of the heat sink assembly. The operating portion of the rectifier is inside the heat sink, with silicone compound to facilitate heat transfer from the entire diode body to the heat sink proper. At the same time, moisture and contaminates are sealed from the diode lead connections.

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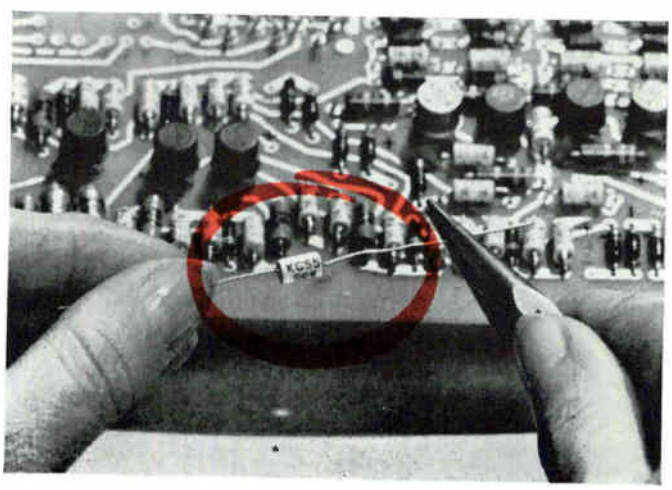

Key to stability — silicone fluid

Dow Corning silicone fluid is used in a new line of hermetically sealed precision film resistors developed by Key Resistor Corporation of Gardena, California, to "provide the ultimate in long term life and stability." According to Key engineers, "the unique silicone fluid filled construction results in excellent heat dissipation characteristics — minimizes effects of severe overloads." Dow Corning silicone fluids are used as filling and cooling media in numerous electronic and electro-mechanical applications because they maintain initial viscosity over a wide temperature range, are stable at high temperature, are excellent dielectrics . . . offer numerous other advantages.

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Free 12-page manual, "Silicones for the Electronic Engineer". Write Dept. 4201, Dow Corning Corporation, Midland, Michigan.

Thermocouple Compensating Circuit Design

By J. BRUCE BROWNWOOD,
Chief Engineer, Transducer Group,
Servomechanisms, Inc.,
El Segundo, Calif.

TEMPERATURE-COMPENSATING circuit permits high-accuracy temperature measurements in missile flight testing. The circuit eliminates the need for controlling temperature of one of the two junctions in a thermocouple. It is practical for use in missiles, providing fast response in the rapidly changing environment and consuming limited power.

The extreme heat generated in missile flight requires temperature measurements in all vital areas. Temperature measurements are needed to determine critical aerodynamic surfaces, structural failures caused by extreme heat and engine hot spots. They can also locate over-protected areas where weight can be reduced by eliminating or using less temperature-protective material.

The Seebeck Effect

An electromotive force is produced in a thermocouple by the temperature differential at the hot junction where temperature is being measured and at the cold junction where the dissimilar metal terminates into the measuring device. To measure voltage accurately at the hot junction, temperature at the cold junction must be either known or controlled.

In laboratories, the cold junction is usually immersed in an ice bath at zero degrees C, where could junction emf is zero volts and output is proportional only to hot junction temperature. However, this method is not practical for missile flight testing.

In early missile flight tests, thermocouple junctions were immersed in a constant-temperature oven. Although results are accurate, temperature must be maintained above the ambient temperature operating range. Therefore this method is limited to applications where a finite warmup time and adequate power are available.

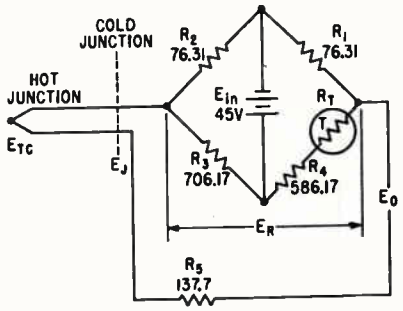

FIG. 1—Bridge output cancels voltage developed at cold junction

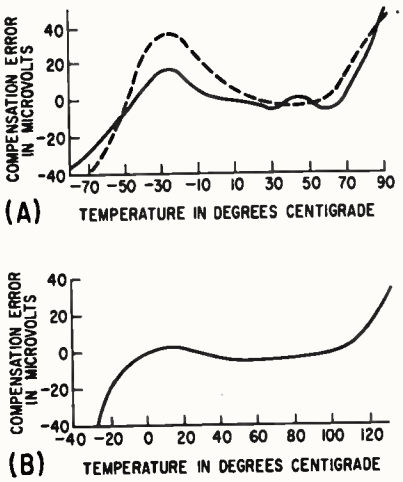

FIG. 2—Actual and calculated values (A) are compared for temperature-compensated system and sample calculations (B) are plotted

TABLE I. THERMOCOUPLE OUTPUT AND TEMPERATURE-SENSITIVE RESISTANCE

Temp in deg C	Thermocouple voltage in mv	Temperature sensitive resistance in ohms
−60	−2.2	79.76
−40	−1.5	92.76
−20	−0.77	106.16
0	0	120
20	0.8	134.52
40	1.61	149.8
60	2.43	165.9
80	3.26	182.83
100	4.1	200.64
120	4.92	219.34

The temperature-compensating circuit developed at Servomechanisms, Inc. provides a voltage to compensate cold junction emf. In Fig. 1, E_{tc} is developed at the hot junction (connection of thermocouple wire) and E_j is developed at the cold junction (connection of thermocouple wires to copper wire). A Wheatstone bridge provides E_r to cancel E_j.

The bridge consists of supply voltage E_{in}, precision resistors with negligible temperature coefficient and temperature-sensitive resistor R_t. A temperature-sensitive resistor of any material may be used and precision windings of chemically pure annealed nickel wire is used in this case because of its relative price.

The general equation for output voltage with an infinite load is $E_o = E_r - E_j + E_{tc}$. If $E_o = E_{tc}$, voltage $E_c = -E_j$. To approximate $-E_j$ with E_r, the equation $E_r = E_{in}\, R_1/(R_1 + R_4 + R_t) - E_1\, R_2/(R_2 + R_3)$ must be solved for various values of R_t. For three-point compensation, it can be solved for T_a with $R_t = R_a$ and $E_r = E_a$, for T_b with $R_t = R_b$ and $E_r = E_b$, and for T_c with $R_t = R_c$ and $E_r = E_c$.

The bridge circuit is defined by the resulting equations: $R_1 + R_4 = (QR_c - R_b)/(1 - Q)$, $E_{in}\, R_1 = (E_b - E_c)\,(R_c - R_b)Q/(1 - Q)^2$, $1/(R_2 + R_3) = 1/(R_1 + R_4 + R_a) - E_a/E_{in}\, R_1$, and $Q = [(E_c - E_a)/(E_b - E_a)]\ [(R_a - R_b)/(R_a - R_c)]$.

Finding Circuit Values

Typical specifications might include: an alumel-chromel thermocouple, zero degrees C reference junction temperature, zero to 100 degrees C temperature compensation range, 500 ohms maximum output impedance and common mode rejection. Referring to NBS Circular 561, Table 6, of the U. S. Department of Commerce and to Edison Co. Temperature Resistance Table 7 for Chemically Pure Annealed

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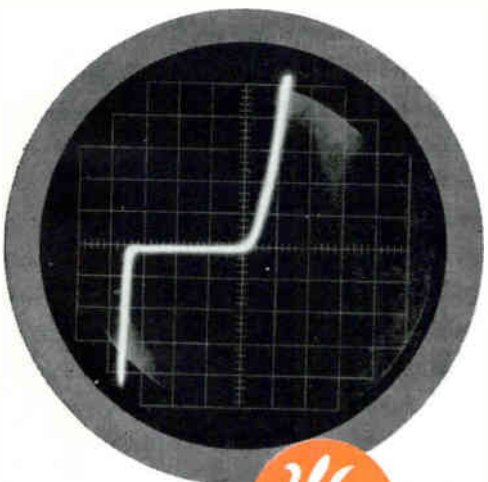
1N746A	1N749A	1N752A	1N755A	1N758A
1N747A	*1N750A	1N753A	1N756A	1N759A
1N748A	1N751A	1N754A	1N757A	

*1N750 is also qualified to MIL-E-1/1238 (Sig C)

plus **MIL-E-1/1238 (SIG C)**

1N709 1N716 1N718 1N720 1N722



MIL-S-19500/117 (NAVY)

Type	Zener Voltage (Volts) Nominal	Test Current (mAdc)	Dynamic Resistance (Ohms)[1]	Dynamic Resistance (Ohms)[2]
1N962B	11	11.5	9.5	700
1N963B	12	10.5	11.5	700
1N964B	13	9.5	13.0	700
1N965B	15	8.5	16.0	700
1N966B	16	7.8	17.0	700
1N967B	18	7.0	21	750
1N968B	20	6.2	25	750
1N969B	22	5.6	29	750
1N970B	24	5.2	33	750
1N971B	27	4.6	41	750
1N972B	30	4.2	49	1000
1N973B	33	3.8	58	1000
1N974B	36	3.4	70	1000
1N975B	39	3.2	80	1000
1N976B	43	3.0	93	1500
1N977B	47	2.7	105	1500
1N978B	51	2.5	125	1500
1N979B	56	2.2	150	2000
1N980B	62	2.0	185	2000
1N981B	68	1.8	230	2000
1N982B	75	1.7	270	2000
1N983B	82	1.5	330	3000
1N984B	91	1.4	400	3000

Forward Current: @ 1.5 Vdc 200mA min @ 25°C

1. R_D measured at test current with 10% of test current superposed (60 cps rms).
2. R_D measured 0.25 mAdc with 25μA superposed (60 cps rms).

NOTE: Suffix "B" indicates 5% Zener voltage tolerance; suffix "A", 10%; no suffix, 20%.

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Nickel Wire, Table 1 can be established.

Three points within the temperature range are T_a = 0 C, T_b = 40 C and T_c = 100 C. Substituting these values into the equation for the bridge circuit, the computed parameters are: Q = 0.9411, $R_1 + R_4$ = 662148 ohms, $E_{in} R_1$ = −3434 volt ohms and $R_2 + R_3$ = 782.48 ohms.

To simplify the equation for E_r, it is assumed $R_1 = R_2$ so that the equation with the values substituted can be rewritten as $E_r = -3434\ [1/(662.48 - R_t) - 1/782.48]$. Values of R_t from Table 1 were substituted into this equation and these values are compared with the thermocouple voltages of Table 1 in Table 2.

Computation accuracy results in an uncertainty of 5 μv in Table 2 but the tracking error is less than 5 μv or less than ⅛ degree C from 0 to 100 C. Since deviation outside the range increases rapidly, design parameters must be chosen for each temperature range.

Any desired values can be used for bridge resistors and voltage. Since E_{in} must usually be an isolated d-c supply, E_{in} is the controlling factor. In this case, it is assumed that any voltage range is available. The limiting conditions are imposed by output impedance and common mode rejection. If the thermocouple is grounded and the circuit operates into an isolated input like a d-c amplifier, unequal line impedance may cause excessive noise generation because of ground loops.

Common Mode Rejection

To provide common mode rejection, R_5 is inserted in the lower line. If R_5 is made equal to the resistance of the parallel combination of the bridge circuit, any noise generated because of the grounded thermocouple is attenuated equally on both lines as it appears at the input of the next component. With an isolated d-c supply, both input lines see the same a-c noise bias. A properly designed d-c amplifier will amplify only the difference in potential between the input lines, thus providing common mode rejection. Output impedance then is $R_o = R_1 (R_3 + R_4 + 134.5)\ (3.53)\ (10^{-3})$ ohms if the lines are balanced and $R_1 = R_2$.

TABLE II. BRIDGE AND COLD JUNCTION OUTPUTS

Temp in deg C	E_r in mv	E_j in mv	$E_j - E_r$	Equiv temp error in deg F
−60	−2.48	−2.2	0.28mv	12
−10	−1.58	−1.5	0.08μv	3.6
−20	−0.70	−0.77	0.03μv	0.9
0	0	0	0	0
20	0.8	0.8	0	0
40	1.61	1.61	0	0
60	2.13	2.13	0	0
80	3.26	3.26	0	0
100	4.1	4.1	0	0
120	4.94	4.92	−0.02μv	0.9

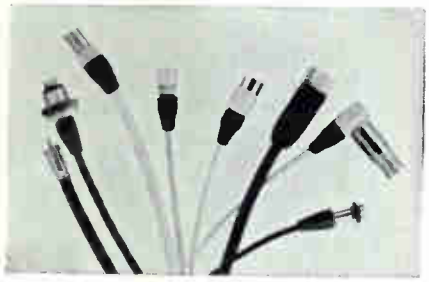
Using a 45-volt battery, the values in Fig. 1 can be derived and R_o = 340 ohms.

Although accuracy is limited to ⅛ degree C, it is generally determined by the tolerance of other parameters, accuracy of thermocouple wire, temperature-resistance characteristics of the nickel resistor, temperature difference between the cold junction and the temperature-sensitive resistor, and the regulation of E_{in}. Accuracy better than ½ degree C over the 100-degree range can be obtained with careful design.

Measurements with a temperature-compensated system are compared with calculated values in Fig. 2A. The system is designed for a temperature range of −65 to 165 F with required accuracy of ±3 F. The three points dictated by design parameters are −35 C, 20 C and 70 C. Results of the sample calculations are plotted in Fig. 2B.

The care required in selecting the three points is indicated in Fig. 2. Generally two of the points are chosen near the temperature extremes. For example, while the theoretical compensation for the sample calculation from 0 to 100 C in Fig. 2B is quite close, at −60 C the error is about 12 degrees F. In Fig. 2A, the system using points −40, 20 and 70 degrees C compensates within ±2 degrees F from −65 to 100 C.

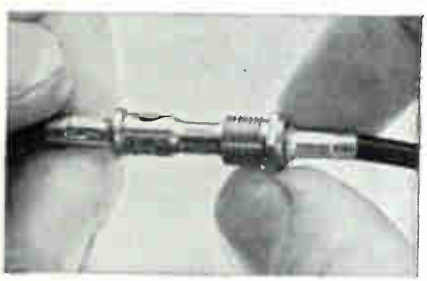
Microminiature Coaxial Connectors



Microdot's microminiature connectors —including the world's smallest 50-ohm coax connectors—are available in over one million combinations. Plugs are available in straight or angle screw types and slide-on versions. Receptacles include printed circuit and bulkhead feed-thru types. Only highest quality materials are used. Conductors are of silver-plated copperweld or cadmium bronze, center contacts are of gold-plated coin silver. Housings are silver-plated brass to assure minimum electrolysis with aluminum panels. "Teflon," "Kel-F," polyethylene, and neoprene are used as dielectrics, jackets, bend relief caps, and pin protectors.

Microdot Inc., 220 Pasadena Avenue, South Pasadena, California

Crimp-type Connectors



These solderless, coaxial connectors are available in a variety of mounting configurations, including snap-locking versions. Male and female connectors may be mounted interchangeably. Mated length is $1\frac{13}{16}$". Working voltages: 1,000 V. maximum, at sea level; 500 V. maximum, at 60,000 feet. VSWR; less than 1.2 up to 2,000 mc. Life; 5,000 matings, minimum, without electrical deterioration. Tensile strengths of the crimps exceed the breaking strength of the cable. Hard gold plated Beryllium copper and TFE plastic are extensively used to assure optimum reliability.

Microdot, Inc., 220 Pasadena Avenue, South Pasadena, California

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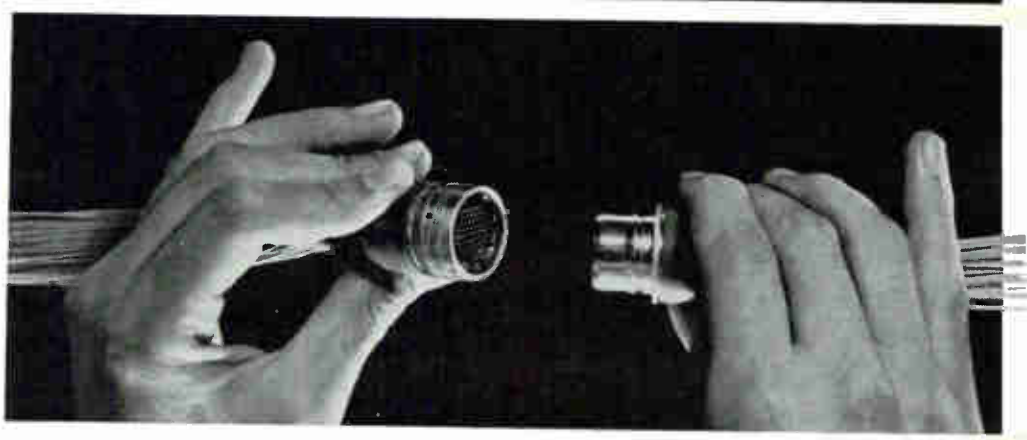
MICROMINIATURE MULTI-PIN CONNECTORS



Visualize 61 contacts in the diameter of a dime . . . think of slashing connector weight requirements by 33% . . . estimate the dollar savings in time and inventory of a connector with complete interchangeability of parts. This unique combination of advantages—and more—are built-in features of Microdot's new multi-pins.

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SIZE DESIGNATION	PLUG O.D.	NO. OF COAXIAL CONTACTS	NO. OF POWER CONTACTS
A	$\frac{3}{4}$"	up to 7	up to 19
B	$1\frac{5}{16}$"	up to 12	up to 37
C	$1\frac{1}{8}$"	up to 19	up to 61

Microdot Multi-Pins are available in disassembled "kit" form or, if you prefer, factory assembled with Microdot cable.

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7.5 cm
6 cm
5 cm
4.5 cm
3.5 cm
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2 cm
8 mm
4 mm
2 mm

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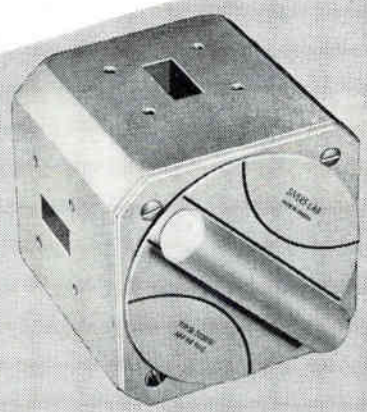

Waveguide Switches
These waveguide switches are ideal for switching in both high and low power microwave systems
- **manual and motor-driven types**
- **cross-talk attenuation > 80 dB**
- **VSWR < 1.05**
- **switching circuits:** and

a much – enlarged microwave programme

Philips have taken over the world-wide sales and service (outside Sweden) of the Sivers Lab microwave equipment, well-known for its advanced design and high quality. The Sivers programme includes a number of frequency bands which were not represented in the Philips microwave range.

As a consequence, the integrated Philips-Sivers microwave programme offers an exceptionally wide choice of microwave instruments and components for all wavelengths between 25 cm and 2 mm.

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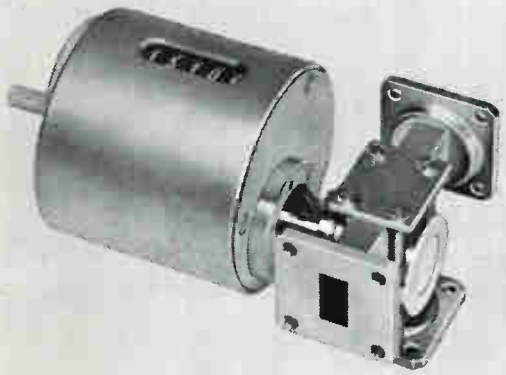
programme

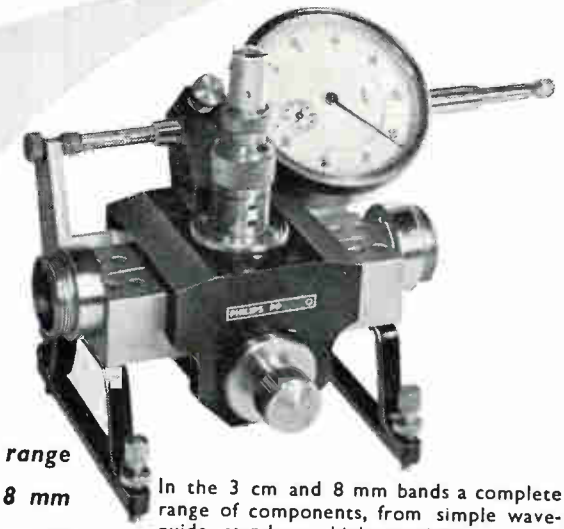


Direct Reading Frequency Meters

The frequency meters are suitable for experimental hook-ups as well as for panel-mounting in permanent equipment. The cavities can be combined with different coupling elements in order to obtain the required coupling circuits.

- **direct readings in Mc/s**
- **accuracy ± 0.1% (with correction curve < 0.05%)**
- **basic coupling elements:**

End-connected waveguide		*Passing coaxial*	
Passing waveguide		*Crystal diode mount coaxial*	
End-connected coaxial		*Lid*	

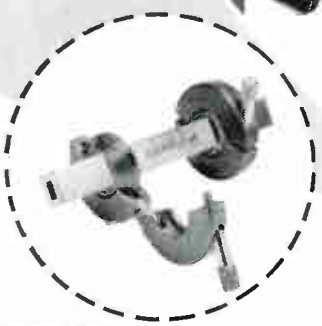


A complete range of 3 cm and 8 mm components

In the 3 cm and 8 mm bands a complete range of components, from simple waveguide stands to high precision standing wave detectors are available. The components can be easily arranged and re-arranged to produce a variety of set-ups.

2 – and 4 mm components

For the generation, propagation and measurement of microwaves in the 2 – and 4 mm bands the Philips Research Laboratories developed a klystron and a complete range of components based on many new electrical and mechanical principles. They are important tools in plasma physics, spectroscopy, solid-state research, radio astronomy etc.



For coupling 2 and 4 mm components Philips designed the claw flange, which is the only type officially approved by the International Electrotechnical Commission (I.E.C.) for the frequency range from 50 to 120 kMc/s.

instruments: quality *tools* for industry and research

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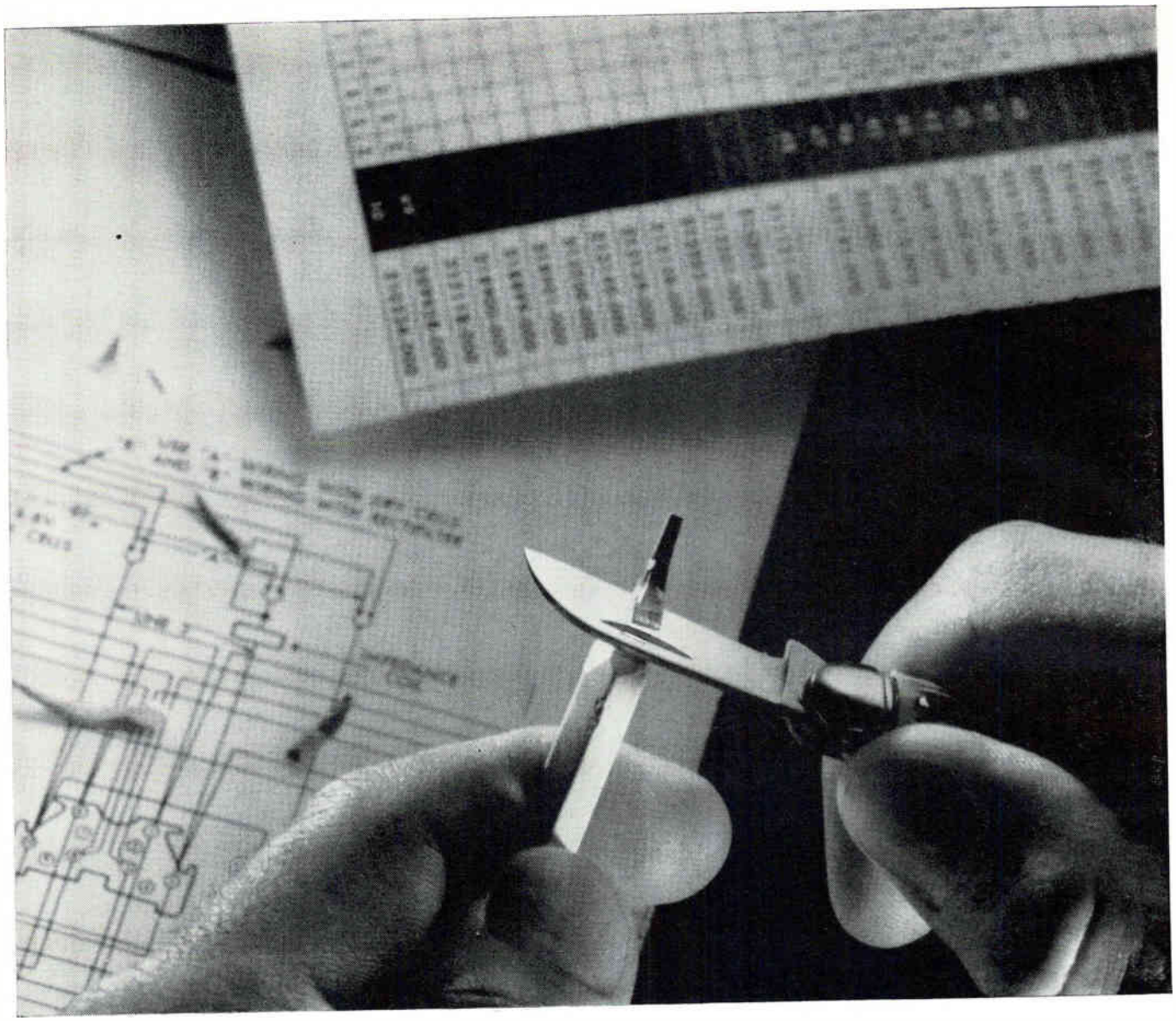

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N (Meets Mil-R-10509D)	60 65 70	10 to 133K 10 to 499K 10 to 1 meg.	3%
C (Meets Mil-R-22684)	20 32 42S	51 to 150K 51 to 470K 10 to 1.3 meg.	5% (plus purchase tolerance of either 2% or 5%)

That's what our new *Corning Design Tolerances* are all about. They give you a percent deviation from nominal that includes the purchase tolerance, maximum ΔR due to TC, and maximum load-life drift. They're based on extended performance at full power and 70°C. ambient for over 30,000 hours.

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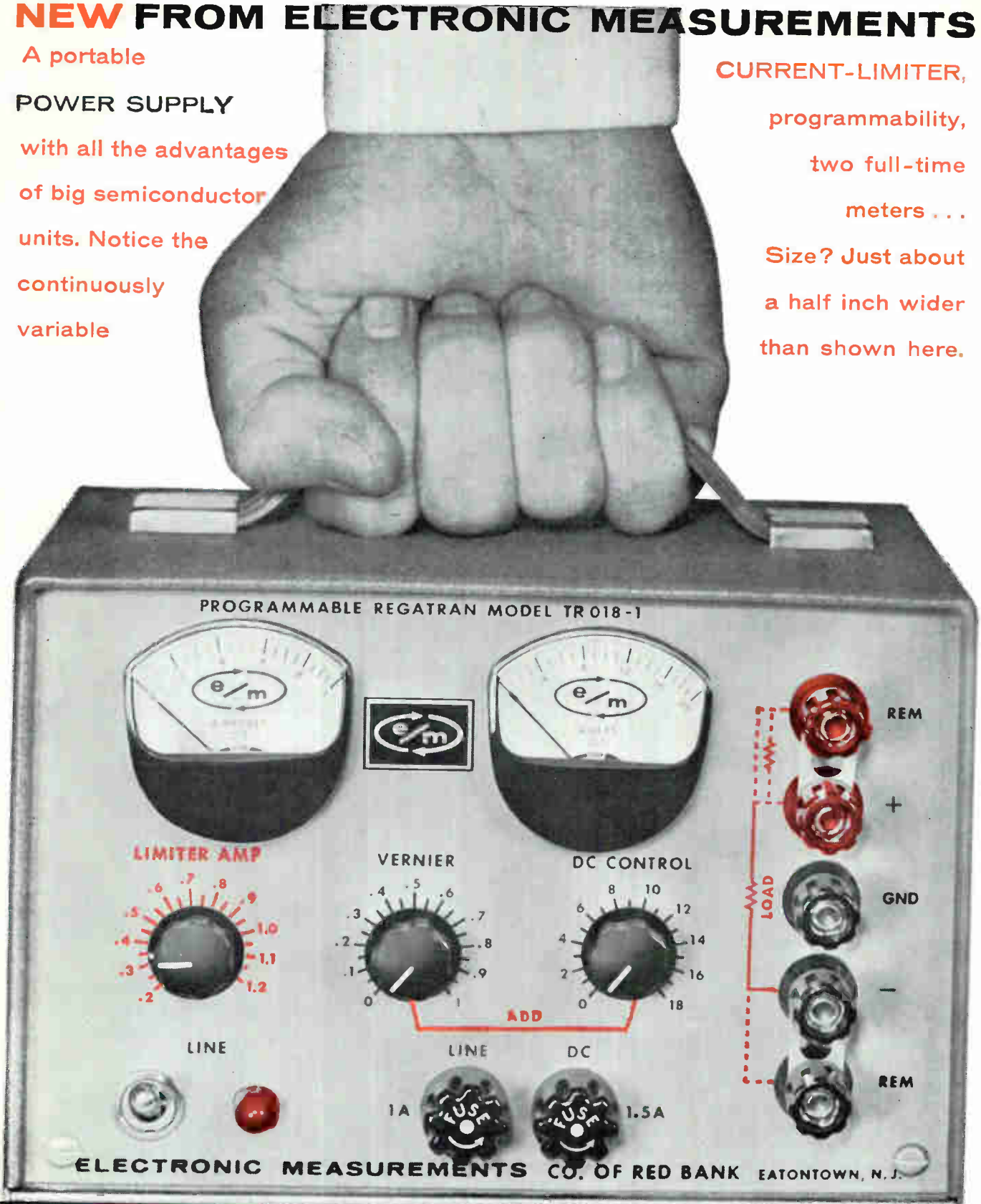

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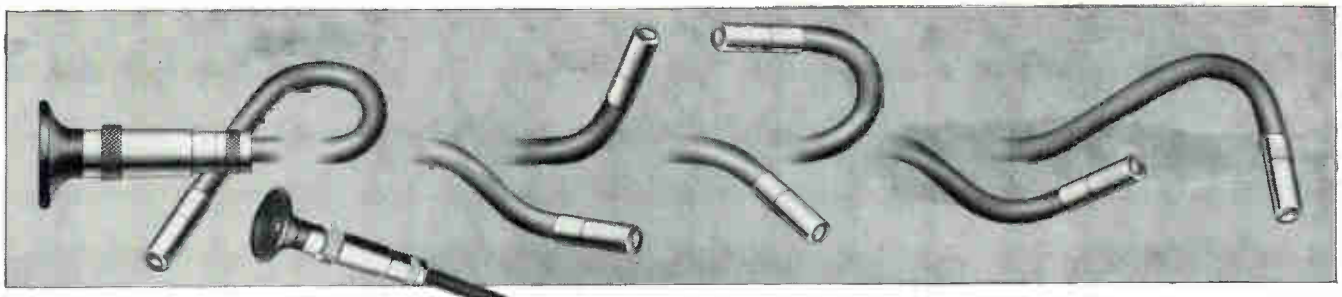

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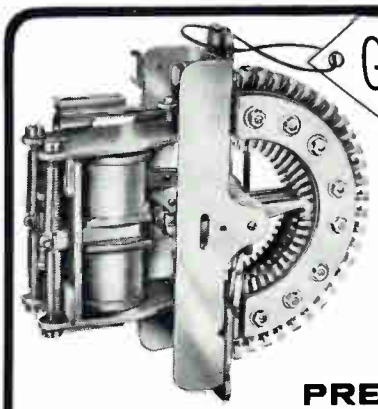

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9 years apart... exactly what are the differences?

As you can obviously see, the modern version has had a bit of face-lifting; but that's not all—the main differences lie in improved modulation capabilities; now—the best in the business. For example, internal square wave was 40-4,000 pps, *now* 10-10,000 pps; pulse width was 0.5-10, *now* 0.3-10 μ sec.; pulse repetition rate was 40-4,000 pps; *now* 10-10,000 pps; pulse delay was 2.5-300, *now* 2-2,000 μ sec. But oddly enough, we're proud of both the changes and the lack of changes. The changes have certainly made the MSG-1R and 2R a more sophisticated instrument—a better buy than ever. But the lack of really basic change means the 8-year-old version is far from obsolete – it's still a highly competitive unit – it still possesses unusually high stability and accuracy; its direct-reading frequency and power, UNI-DIAL® control and other convenience features save important time and insure accuracy in either the lab or the field. Moreover, the fundamental retention of the *essential* design, after eight years, means that these instruments are the most *tried and proven* design that ever came down the pike. Concrete proof of Polarad's policy of "features for the future." Write for a copy of Notes on Microwave Measurements.

own line of spectrum analyzers which includes 40- and 480-filter analyzers as standard products. Spectra as wide as 50 kc/s can be analyzed. In addition, frequency analysis instrumentation, covering a wide range of spectra and resolutions, is available on special order.

Spectran frequency analyzers also incorporate important electronics features. For example, new solid-state filter-drive circuitry has been developed. This utilizes a transistorized balanced mixer and low-pass filter which increases carrier suppression, reduces extraneous noise, lowers resultant thermal drift, and generally increases dynamic range. The new drive circuits are capable of full 20-watt output and can drive an entire 480-filter bank simultaneously, thus permitting distortionless analysis of complex signals covering the full frequency range.

Spectran instrumentation engineers are presently developing varied means of information readout to allow broader application of their analyzers. Custom instrumentation capabilities are available at Spectran for the adaptation of versatile magnetostriction devices to the problems of frequency selection and analysis.

ergy, they will not heat up or burn, thereby permitting higher pulse output and more rapid repetitive rates. The threshold energy levels required are lower because of the reduced losses.

The high-efficiency background coatings are obtained through vacuum deposition of multiple layers of films less than one micron thick with techniques similar to those used by Infrared Industries in the manufacture of Fabry-Perot optical interference filters. The 99.6 per cent reflectance is close to theoretical limits. Best that can be achieved with metallic or mirrored coatings is believed to be around 96 per cent.

The new dielectric coatings also have the advantage of being selec-

company's development departments.

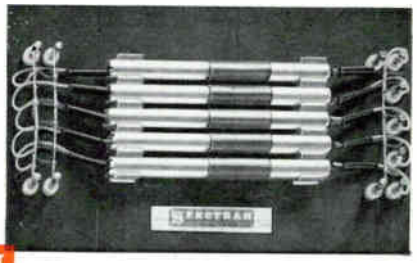
The first orders for the automatic telephone system have come from the Swedish Telecommunications Administration and from the Copenhagen Telephone Company. The Swedish order is for a suburban exchange outside Stockholm with an initial capacity of 4,000 lines, while the Danes have ordered an exchange for the center of Copenhagen, initially for 12,000 lines

Ceramic Tubes for UHF

A TINY ceramic receiving tube for microwave and space communications, developed by Toshiba, will be utilized in computers and automa-

for improved

MAGNETOSTRICTIVE DEVICES



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for frequency reference, analysis, and signal selection

Nearly indestructible Spectran filters are available with center frequencies ranging from 20 kc to 425 kc, and bandwidths from 1 cps to 170 cps. Input and output impedances can range from a fraction of one ohm to several thousand ohms. Skirt slope is 6 db per bandwidth octave for single filters, 12 db per bandwidth octave for dual filters, etc.

Through advances in both design and processing, Spectran filters offer several important advantages. Composition of filter material has been modified and techniques of metallurgical treatment improved to yield a reduced temperature coefficient of 4 parts per million per degree C over the ambient range of —20° to 50° C. This is approximately one half the coefficient previously obtainable and, over certain temperature ranges, the coefficient has been reduced to as low as 1 ppm/°C.

Improvements in Spectran coil design have resulted in more efficient magneto-mechanical transduction, and thus in lower insertion loss. In addition to single elements, Spectran filters are available in arrays having substantially zero differential-temperature coefficients. This assures the holding of constant frequency relationship among elements in a filter array.

MAGNETOSTRICTIVE DELAY LINES

for use in digital computers, radar and communications systems

The magnetostriction line achieves long delays in compact physical space and with low signal loss, and it does so in a structure that is physically rugged and relatively inexpensive. Spectran materials exhibit a low temperature coefficient in Young's modulus, resulting in constant delay times over a wide range of ambient temperatures.

MULTIPLE-FILTER SPECTRUM ANALYZERS

for instantaneous analysis of sonic and electromagnetic waveforms

The precise spacing of single filter elements to form extended-coverage multiple-filter arrays is a special capability of Spectran. Technicians can provide superior filter arrays because of unprecedented control of temperature and humidity in the Spectran assembly area.

Spectran manufactures filter arrays to customers' specifications and also incorporates them into its own line of spectrum analyzers which includes 40- and 480-filter analyzers as standard products. Spectra as wide as 50 kc/s can be analyzed. In addition, frequency analysis instrumentation, covering a wide range of spectra and resolutions, is available on special order.

Spectran frequency analyzers also incorporate important electronics features. For example, new solid-state filter-drive circuitry has been developed. This utilizes a transistorized balanced mixer and low-pass filter which increases carrier suppression, reduces extraneous noise, lowers resultant thermal drift, and generally increases dynamic range. The new drive circuits are capable of full 20-watt output and can drive an entire 480-filter bank simultaneously, thus permitting distortionless analysis of complex signals covering the full frequency range.

Spectran instrumentation engineers are presently developing varied means of information readout to allow broader application of their analyzers. Custom instrumentation capabilities are available at Spectran for the adaptation of versatile magnetostriction devices to the problems of frequency selection and analysis.

for additional information on Spectran products and capabilities, address domestic inquiries to the factory address below, export inquiries to Microwave International Corporation, 36 West 44th Street, New York 36, New York.

SPECTRAN ELECTRONICS CORP.

146 MAIN STREET MAYNARD, MASSACHUSETTS

(Area code 617) TWinoaks 7-8881

CIRCLE 111 ON READER SERVICE CARD

HOW POLARAD'S GENERATORS GUARD

1953
MSG-1 and 2
950 to 4600 mc

1962
MSG-1R and 2R
950 to 4600 mc

9 years apart... exactly what are the differences?

As you can obviously see, the modern version has had a bit of face-lifting; but that's not all—the main differences lie in improved modulation capabilities; now—the best in the business. For example, internal square wave was 40-4,000 pps, *now* 10-10,000 pps; pulse width was 0.5-10, *now* 0.3-10 μ sec.; pulse repetition rate was 40-4,000 pps; *now* 10-10,000 pps; pulse delay was 2.5-300, *now* 2-2,000 μ sec. But oddly enough, we're proud of both the changes and the lack of changes. The changes have certainly made the MSG-1R and 2R a more sophisticated instrument—a better buy than ever. But the lack of really basic change means the 8-year-old version is far from obsolete – it's still a highly competitive unit – it still possesses unusually high stability and accuracy; its direct-reading frequency and power, UNI-DIAL® control and other convenience features save important time and insure accuracy in either the lab or the field. Moreover, the fundamental retention of the *essential* design, after eight years, means that these instruments are the most *tried and proven* design that ever came down the pike. Concrete proof of Polarad's policy of "features for the future." Write for a copy of Notes on Microwave Measurements.

MICROWAVE SIGNAL YOUR INVESTMENT

Which Polarad Generator Solves Your Problem?—500 to 50,000 mc.

Model PMR
500 to 1,000 mc

Interchangeable FM or pulse modulators. FM modulator provides low distortion wide-range, sine-wave deviation. Pulse modulator provides pulse, square wave and sawtooth FM. (10-10,000 pps). Calibrated power output: 1 mw

All Polarad Signal Generators (500 to 21,000 mc) offer:

Continuously variable attenuators calibrated directly in —dbm.

Internal pulse, FM and square wave modulation, external pulse and multi-pulse modulation.

Delayed and undelayed sync outputs.

UNI-DIAL® tuning with direct-reading frequency dials accurate to ± 1%.

High stability non-contacting klystron cavity chokes for noiseless tuning and accurate calibration.

Model MSG **950 to 4,600 mc**

	Frequency	Calibrated Power Output	Internal Pulse Modulation: Internal Square Wave	Width in μ sec.	Pulse Repetition Rate in pps	Delay in μ sec.	FM deviation in mc minimum
MSG-1	950-2,400 mc	1 mw (0 dbm)	40- 4,000 pps	0.5-10	40- 4,000	2.5-300	±2.5
MSG-1P*	950-2,400 mc	10 mw (+10 dbm)	10-10,000 pps	0.3-10	10-10,000	2-2,000	±2.5
MSG-1R	950-2,400 mc	1 mw (0 dbm)	10-10,000 pps	0.3-10	10-10,000	2-2,000	±2.5
MSG-2A	2,000-4,600 mc	1 mw (0 dbm)	40- 4,000 pps	0.5-10	40- 4,000	2.5-300	±2.5
MSG-2R	2,000-4,600 mc	1 mw (0 dbm)	10-10,000 pps	0.3-10	10-10,000	2-2,000	±2.5
MSG-2P*	2,000-4,600 mc	10 mw (+10 dbm)	10-10,000 pps	0.3-10	10-10,000	2-2,000	±2.5

*Attenuator Accuracy: ±3 db between 0 and +10 dbm. ±2 db below 0 dbm.

Model PMX
4,450 to 8,000 mc
6,950 to 11,000 mc

Two interchangeable r-f generator units.

Internal pulse and square wave modulation (10-10,000 pps); 0 to —127 dbm power output.

Model KSS
GENERATOR SOURCE
1,050 to 11,000 mc
In 4 tuning units

Power output: 14 to 400 mw, depending upon frequency; internal square wave 10-10,000 pps; external pulse, square wave or FM modulation; adjustable attenuator.

Model MSG-34
4,200 to 11,000 mc
In one instrument

Internal pulse and square wave modulation (10-10,000 pps); 0 to —127 dbm power output; DIGITAL frequency indicator.

Model CSG
SWEEP GENERATOR
1,000 to 16,000 mc
In 5 interchangeable tuning units

Provides high-power microwave signal adjustable from single frequency to 2:1 frequency range; .001 to 100 cps sweep rate; internal modulation: 1,000 cps and 456 kc square wave; external modulation: square wave, FM and pulse.

Model PMK
10,000 to 21,000 mc
in 2 tuning units

Two interchangeable generator units.

Calibrated power output: + 10 dbm (10 mw); internal pulse and square wave modulation (10-10,000 pps); DIGITAL frequency indicator.

EHF SIGNAL GENERATOR AND SOURCE
12,400 to 50,000 mc

Units in this range provide cw signals, 1,000 cps internal square wave, external modulation provisions, accurate frequency calibration. EHF SIGNAL GENERATOR 18,000 to 39,700 mc, 7 plug-in units. Accurate power calibration. EHF SIGNAL SOURCE 18,000 to 50,000 mc, 9 plug-in units. High power output.

Model B
CODE MODULATOR MULTI-PULSE GENERATOR
950 to 10,750 mc
in 4 interchangeable tuning units.

Provides 5 independently adjustable pulse channels, each with variable pulse width and delay. Built-in precision oscilloscope.

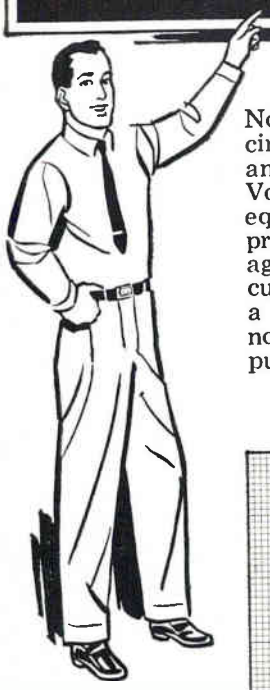
Because each of these fine test instruments has something special about it, a feature or capability that can suit your test requirements exactly, check through this ad—then get complete specifications from your local Polarad representative.

POLARAD
ELECTRONICS CORPORATION
43-20 34TH STREET, LONG ISLAND CITY 1, NEW YORK

FREE LIFETIME SERVICE

Acme Electric

CONSTANT VOLTAGE STABILIZERS PROTECT THEMSELVES AGAINST OVERLOAD!



No need to "fuse" the output circuit against overload when an Acme Electric Constant Voltage Stabilizer is part of the equipment. These stabilizers provide automatic protection against overload or short circuit. When load current reaches a critical point in excess of normal operating load, the output voltage is reduced to zero.

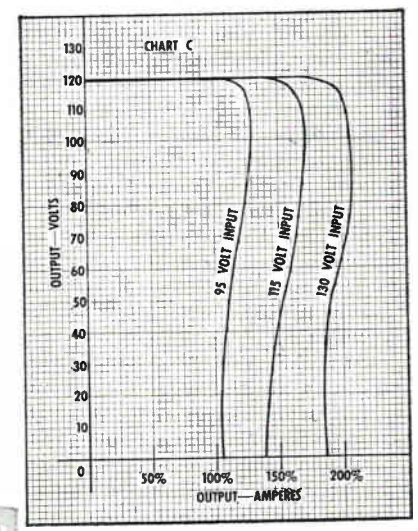
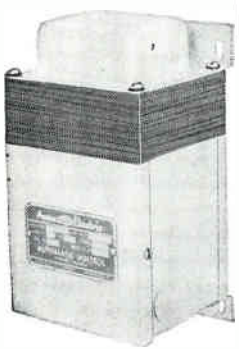


Chart shows performance curves under various voltage inputs and current overload conditions. This current limiting is accomplished automatically.



If you have ever observed the "quickness" of two cycles. 1 30 second, then you'll appreciate the speed with which these stabilizers respond to a fluctuation in line voltage.

Available in sizes from 15 to 2000 VA. Input voltage ranges 95/130, 190/260. Output voltages stabilized at 6.3, 120, 240 volts. *Write for catalog 09-B01.*

ACME ELECTRIC CORPORATION

311 Water St. Cuba, N.Y.

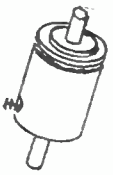
In Canada: Acme Electric Corp. Ltd., 50 Northline Rd., Toronto, Ont.

SAA3515/1967

Acme Electric

114 CIRCLE 114 ON READER SERVICE CARD

DRY PARTICLE INSTRUMENT CLUTCHES & BRAKES



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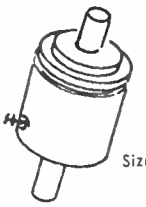

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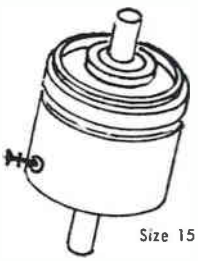


Size 15

Cone Clutch

Life: 1000 hours and/or 1,000,000 cycles

Response Times: 2½ to 5 milliseconds

Torque Ranges: 0-100 oz. in.

High Torque to Inertia Ratios

Fixed Field Design

Zero Backlash

Vibrac's Clutches and Brakes, designed to meet the environmental conditions of MIL-E-5272A are available in standard servo sizes.

Ultra smooth operation during continuous slip conditions and independence of torque from rotational speed combine to make Vibrac Clutches and Brakes ideal for servo and tape transport mechanisms.

The miniature Cone Clutch is designed to protect rotary components from excessive torque loads. The conical slipping surfaces have a constant coefficient of static and kenetic friction and operate smoothly during the slip condition: The Cone Clutches can be calibrated through torque ranges from 0-160 oz. in.

Full information available upon request.

VIBRAC CORPORATION

281 BILLERICA ROAD, CHELMSFORD, MASSACHUSETTS

CIRCLE 202 ON READER SERVICE CARD

THUMBWHEEL SWITCHES

TABET U.S. Patent 2,841,660

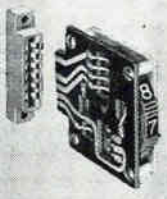
Binary & Digital **Meet MIL-S-22710.** C·D·I

- **For Critical Reliability Applications.**
- **Available with internal lighting MIL-L-25467A.**

Permanent wafer type, Series TSD-P. Only ½" panel space needed per module. Also available in multi-deck series TM.

Removable wafer type, Series TSD-R. For continuous operation applications where interruptions must be held to an absolute minimum.

Permanent wafer type, Series TSB-P. Available in 8, 10, 12 or 16 positions, up to 36 switches per assembly.



Removable wafer type, Series TSB-R. For applications where maintenance time is valuable and rapid servicing a necessity.

CHICAGO DYNAMIC INDUSTRIES, Inc.

C·D·I PRECISION PRODUCTS DIVISION

1725 Diversey Blvd., Chicago 14, Illinois

Phone: WEllington 5-4600

CIRCLE 203 ON READER SERVICE CARD

NEW FROM SORENSEN

Compact
Fully Transistorized

DC POWER SUPPLY

0 to 40 V DC at 0 to .75 Amp.

The compact new Sorensen Model QR40-.75A is one of the latest additions to Sorensen's line of outstanding products. It features extremely low ripple, precise regulation, programmable output voltage, adjustable current limiting and provisions for remote sensing. Typical applications include powering computer circuits, test and instrumentation equipment, and communications equipment. Negligible on-off overshoot provides protection for transistor circuits. Write for complete specifications and literature.

SPECIFICATIONS

INPUT VOLTAGE RANGE	105-125 V AC at 50-400 cps.
OC OUTPUT VOLTS	0 to 40 V OC
OC OUTPUT CURRENT	0 to .75 Amp.
VOLTAGE REGULATION (Line & Load Combined)	±(0.01% + 1 MV)
RIPPLE (RMS) AT 60 CPS	150 Microvolts
CURRENT REGULATION (Line & Load Combined)	±0.15%
RIPPLE CURRENT	10 Microamps.
RESPONSE TIME	50 Microseconds
CABINET SIZE	8¼" x 9" x 5¼"
RACK HEIGHT	5¼"

Unit is available for dual rack mounting.

WIDE RANGE TRANSISTORIZED DC SUPPLY

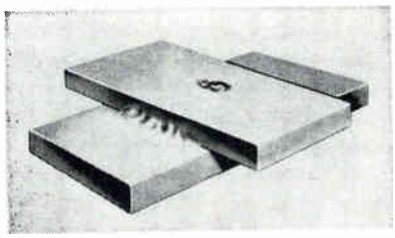
The QR150-1A is a completely self-protected, transistorized DC Power Supply. Output voltage range: 0 to 150 V DC at 0 to 1 Amp. output current. Combined line and load regulation is ±(0.02% + 4 MV). Ripple is 1 MV RMS. *Circuit Design and protective features prevent damage to transistors under overload or short-circuit conditions.*

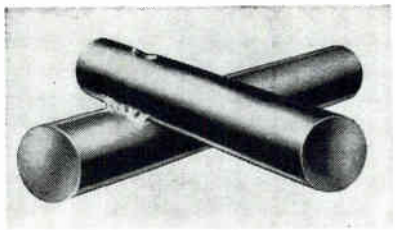
A UNIT OF RAYTHEON COMPANY

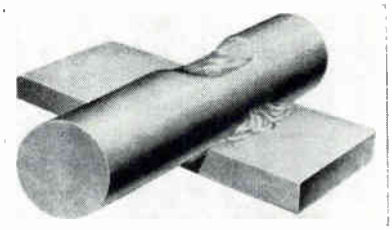
Sorensen

RICHARDS AVENUE • SOUTH NORWALK • CONNECTICUT

CIRCLE 115 ON READER SERVICE CARD







Examples of good welds—A highly reliable weld is obtained when the wires to be welded are clean and positioned correctly, and when electrode force and weld energy are optimized for the materials being welded. A significant amount of metal has melted in each of these welds, indicating that the base or core metals are fused, not just the tinning or coating

How to Make Reliable Welds

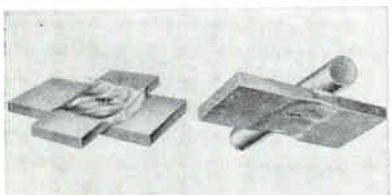
By E. J. MESSNER
Raytheon Co., Newton, Mass.

TO OBTAIN MAXIMUM reliability from welded connections, all the usual welding procedures must be followed and, in addition, inspection of the materials to be welded must be even more stringent with respect to contamination and nicks in wire and ribbon. Also, the material in the leads of each lot of components is inspected at Raytheon spectrographically, since the optimum weld-energy cycle depends on the materials being welded. Component manufacturers, because of changes in manufacturing methods, a change in the source of supply, or for other reasons, sometimes change lead materials from one shipment to the next. Changes of lead material are usually of no importance in soldered circuits but they are in welded circuits.

In the welding operation itself it is not enough merely to have good equipment and an efficient set-up. The electrical path of the welding current is subject to considerable variation in resistance because of the cleanliness and tightness of cable connections and electrodes, and the parallelism and surface condition of the electrodes. These factors can change available weld energy by as much as 25 percent.

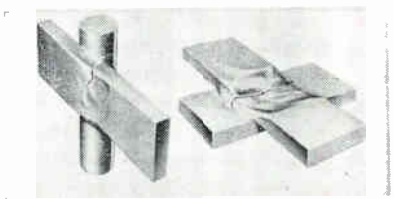
One of the biggest variables in making reliable welds is placement

DEFECTIVE WELDS

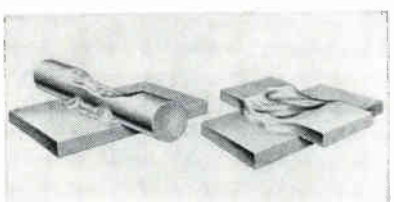


Burned hole in weld reduces weld strength and has poor appearance. Burned holes can result from dirty material, misaligned work pieces, improperly positioned electrodes, improper welding sequence

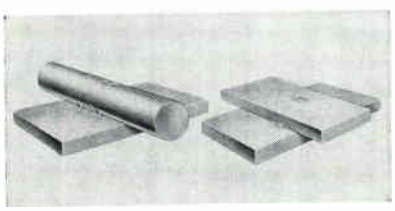
Blow holes or deep pits cause weakness. Blow holes can develop if the electrode force is removed before the weld is actually made, if the material is dirty or contains a large amount of impurities



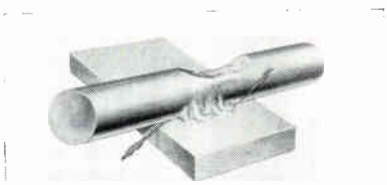
Cracked welds typically result when most of the available electrode force is used to bring badly fitting parts together. Cracks reduce fatigue strength and lower resistance to shock



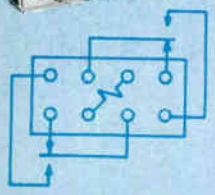
Burned weld has low strength, increased electrical resistance, poor appearance. Welds of this type are caused by improperly aligned electrodes, wrong electrode force, wrong energy for the materials being welded, dirt in the weld area, improper sequence of electrode force and welding current, improperly positioned wires



Inadequate weld is weak and has increased electrical resistance. Causes are improper positioning of materials, using materials having low electrical resistance (welding energy too low for the material), improper follow through during the weld cycle, dirty materials, and presenting parallel paths for the welding current (shunting)



Splashed welds are short circuits waiting for a chance to happen. They are caused by dirty materials, too high a weld current, low electrode force, improper weld sequencing. A splashed particle is particularly likely to break off if its base is small with respect to its length and to the largest portion of its cross section



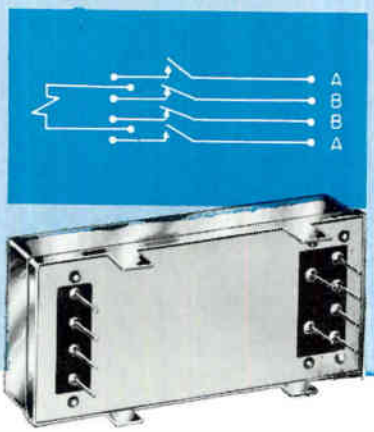
CRYSTAL CAN MINIATURE REED RELAY

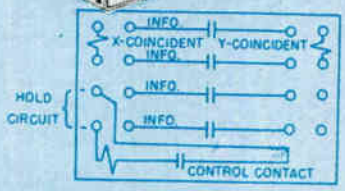
Only 1.25" x .80" x .40", Dunco MRR2A2B magnetically shielded reed relays replace crystal can types in many applications requiring long life and extreme contact reliability on dry circuit and light load switching. They are highly resistant to shock and vibration. Unit illustrated has 2 Form A and 2 Form B break-before-make contacts. Other contact combinations available.

Non-magnetic terminals provide convenient printed circuit mounting without disturbing operating characteristics. Reed switches separately sealed in glass eliminate contact contamination. Write for Information Bulletin MRR-2.

GENERAL PURPOSE REED RELAY FOR PRINTED CIRCUITS

Encased in magnetically shielding steel enclosures, Dunco RR2A2BS reed relays have terminals of non-magnetic tin-coated copper wire. Thus they minimize the effects of external magnetic fields; the changing of relay characteristics by cutting or bending magnetic terminals; and eliminate terminal soldering difficulties. Unit illustrated contains 2 Form A and 2 Form B break-before-make reed contacts. Other combinations available. Inherently stable switching characteristics may be utilized fully without special care in applying the relays. Ask for Dunco Information Bulletin RR-2.





MINIATURE REED CROSSPOINT RELAY

Designed for coordinate network switching arrays, Dunco Crosspoint Relays feature fast operation; long contact life; excellent contacting reliability; low operating power; and convenient printed circuit card mounting. Five reed switches encased in 3 coils are magnetically shielded in an enclosure only 1.75" x .80" x .40". Simultaneously energizing X and Y coordinate coils closes the contacts. These remain closed until the holding coil is interrupted or a single coordinate coil is reverse pulsed. Ask for Dunco Bulletin MRR-1.

Here's Reed Relay Progress!

Struthers-Dunn developments like these are helping engineers and designers utilize the full advantages of reed relays . . . *with a minimum of special attention in applying them.* Each basic type is adaptable to numerous modifications and contact combinations. Write for Data Bulletins indicated or send application details for reed relay recommendations. Address: *Struthers-Dunn, Inc., Pitman, N. J.*

STRUTHERS-DUNN

Pioneers of Space Age Relay Reliability

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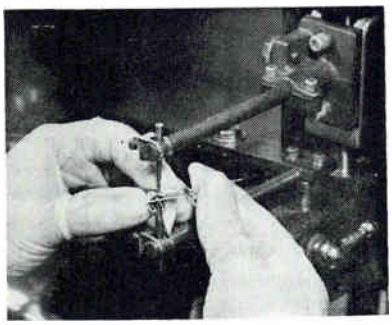
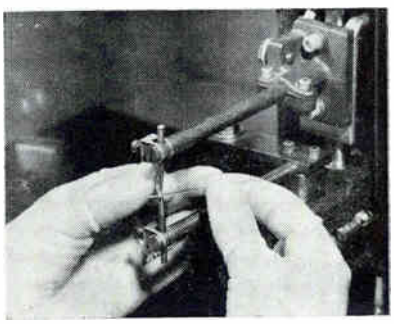
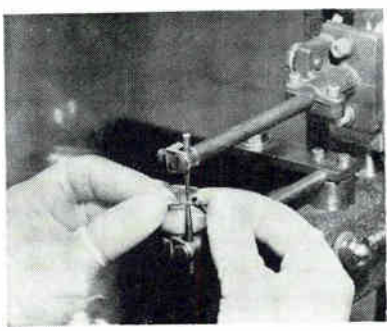
WELDING MISTAKES



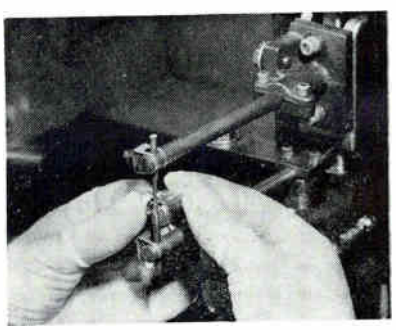
A spot of foreign matter on a lead will usually cause a bad weld



The two leads to be welded are not properly centered on the axis of the electrodes



Welding on a kink or bend will always produce a weak joint. The two materials being welded should be brought into close contact before the weld cycle is started

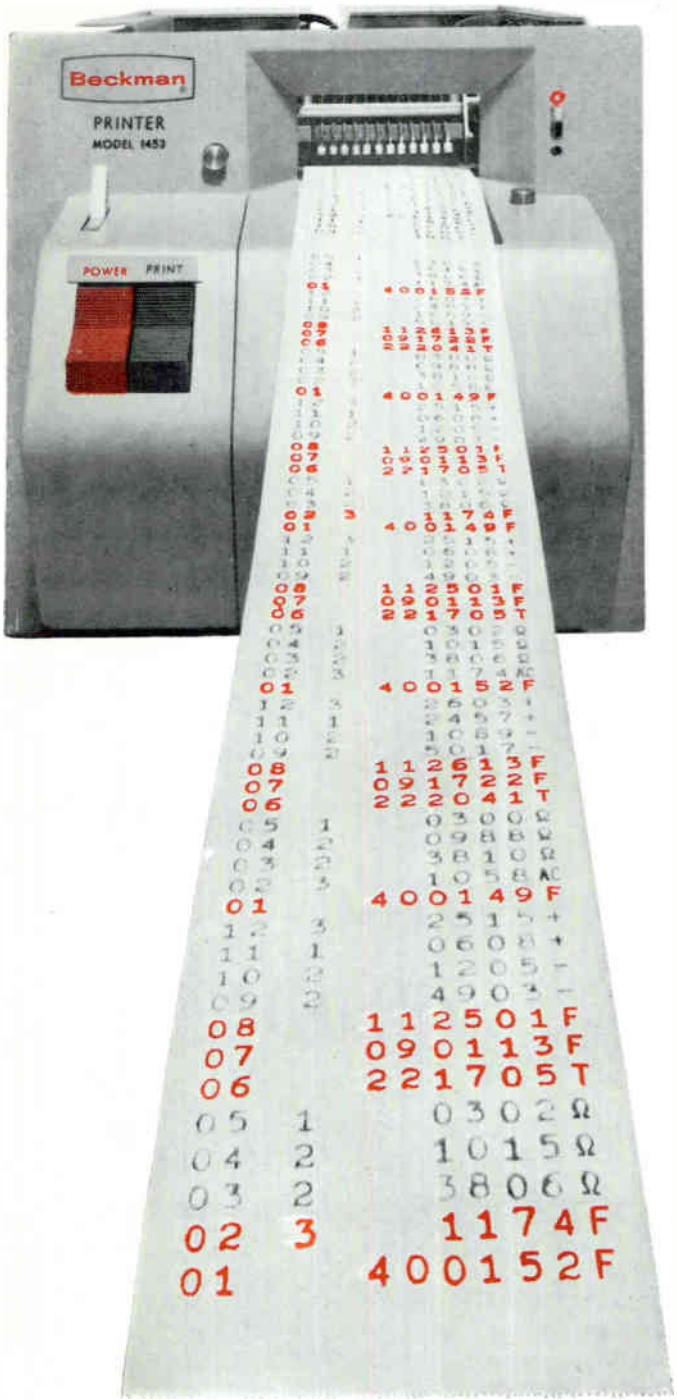


Two transistor leads are touching the bottom electrode. Weld current will be partially shunted through the transistor and may destroy it

of parts during the welding operation and the electrode pressure the operator applies. Strength tests on welds made with mechanical or air operated electrodes show improved weld consistency. Holding fixtures can be used for part placement in some cases and these fixtures will become more practical when welded modules are designed for automatic production.

Parts placement is of particular importance when connections to semiconductor devices are made. If two or more leads touch one of the electrodes, the parallel path for the welding current can destroy the device (ELECTRONICS, p 72, Sept. 22, 1961).

Welded joints have already achieved a mean-time-before-failure of over 500,000,000 hours on one computer module made at Raytheon and it is expected that this figure can be improved substantially. The present goal for soldered connections is 20,000,000 hours mtbf; a projected future goal for soldered connections is 100,000,000 hours mtbf.



SOLID-STATE PRINTER WITH NEW CAPABILITIES

With this solid-state 7 to 12 digit printer, you can feed in 4-line BCD data in either a 1-2-2-4, 1-2-4-8, or 1-2-4-2 code configuration *without changing components or interrupting operation.*

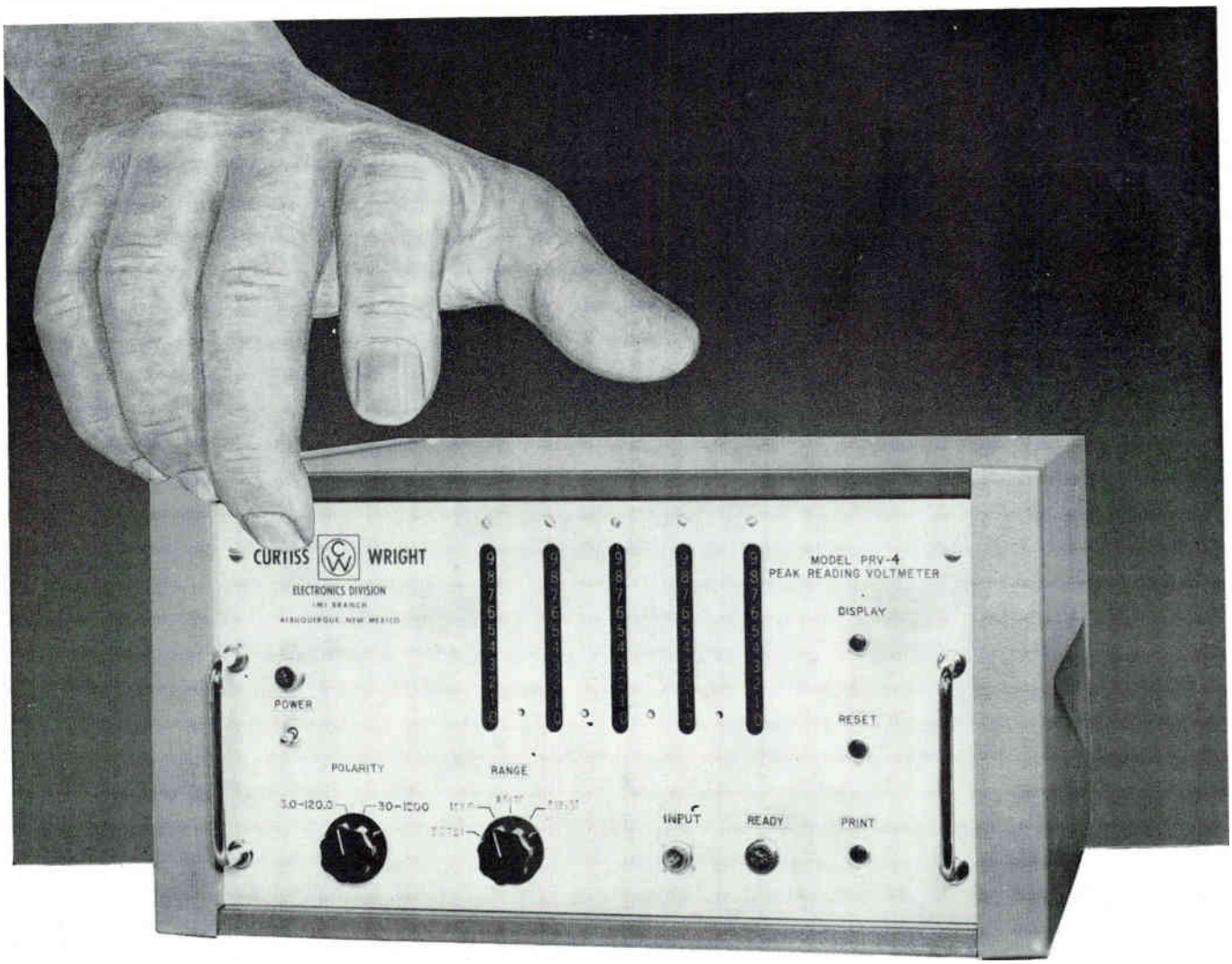
Each digit-column of this parallel-entry printer is controlled by a separate solid-state plug-in code module connected independently to the data source. Thus, you can easily pre-arrange digit-columns in any order and into specific groups. Using optional plug-in code modules—which can be interchanged or combined with standard modules—you can apply 10-line *and* 4-line BCD data *simultaneously.*

The Model 1453 can automatically print in black or red to indicate different input sources or off-limit readings. Reliable solid-state circuits and time-proven Burroughs printing mechanism assure you of trouble-free operation.

If you can only spare about 8″ x 8″ of panel space for a completely self-contained printer, then the compact half-rack Model 1453 is the answer.

Standard 7 digit printer is only $975. For complete information write for Brochure A1453.

Beckman® INSTRUMENTS INC.
BERKELEY DIVISION
RICHMOND, CALIFORNIA



Capture...then Read

THE FIRST PEAK OF ANY VOLTAGE

Single Transient Peak Reading Voltmeter

FOR: Blast Studies — Shock Studies — Transient Voltage Measurements on Aircraft Power Busses — Measurement of any single transient phenomena which may be characterized by a voltage pulse.

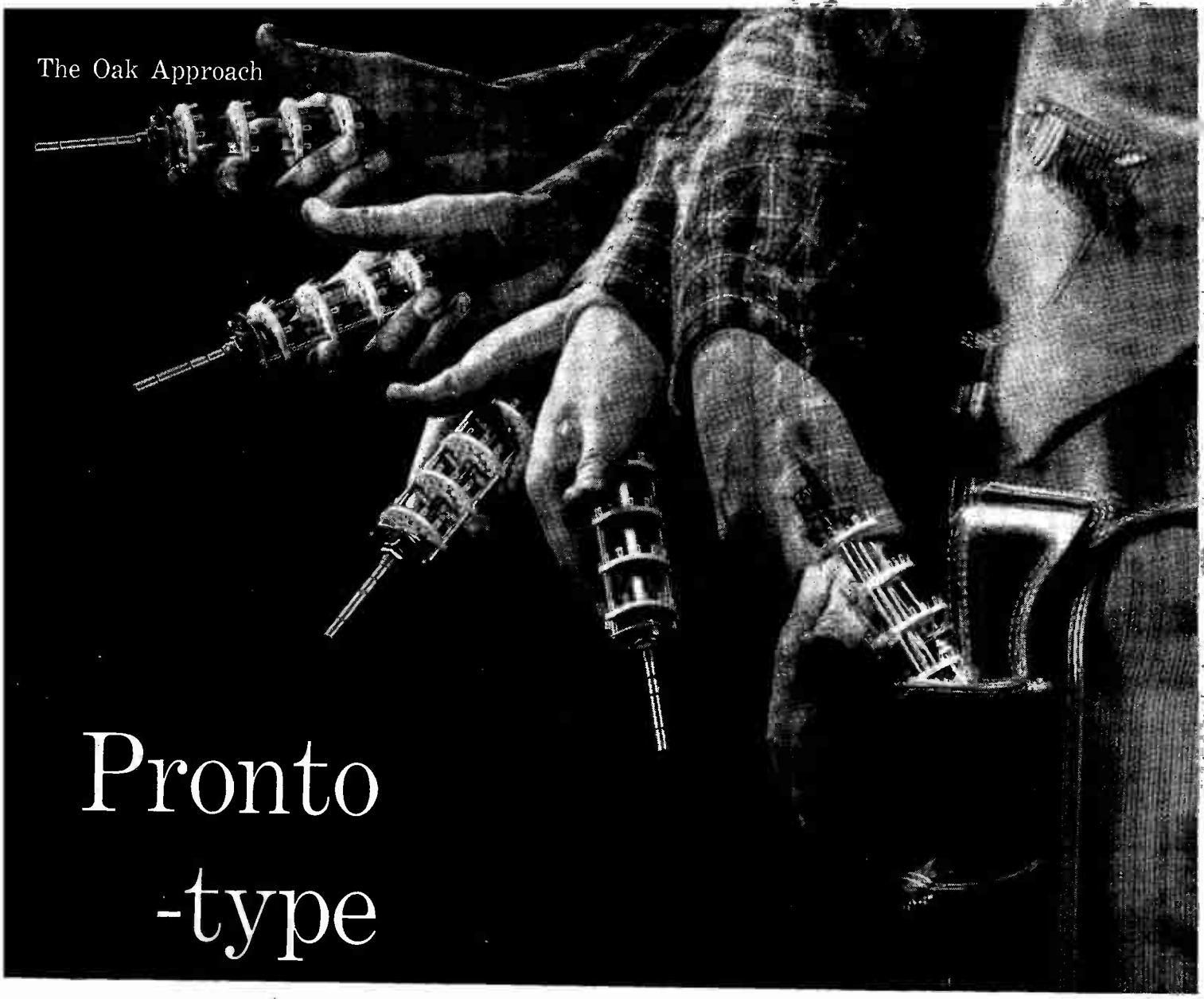
The Model PRV-4 Single Transient Peak Reading Voltmeter is designed to accept and display the first value of a *positive* or *negative* voltage pulse of arbitrary shape within specified limits. Readout is provided as a four digit decimal value directly in volts with a fifth digit for over-range indication. First peak voltage detected blocks further input values until reset. A four line 1-2-2-4 coded output line is provided for external printout. The PRV-4 will read out peak amplitude of rectangular pulses of one microsecond or greater pulse width. Readout cycle time, 1 millisecond with accuracy of 0.5% of absolute or 10 counts. Range 30 MV. to 1000 V.

Write to Intermountain Branch for complete specifications on the PRV-4 and other models, or for information on custom units available for unique requirements.

ELECTRONICS DIVISION INTERMOUNTAIN BRANCH

CURTISS-WRIGHT CORPORATION

P.O. BOX 10044 • ALBUQUERQUE, N. M. • PHONE: 345-1661 • TWX: AQ-69



service on prototype switches

Go ahead and draw! Just send us your sketch and we'll do the rest. OAK has initiated the fastest delivery cycle in the industry for prototype rotary switches — your switch is completed within *three* days after receipt of your drawings.

That's pretty fast on *your* draw. It's speed made possible by a completely equipped and integrated department devoted to prototype orders *only*. These special jobs are immediately separated and hand tended through all production stages. Four daily "switch runs" to O'Hare International Airport make sure you get your switch on time.

Layout sheets are available at no cost to help in diagraming your switch. For information on prototype service, products and production scheduling, contact us or your nearest OAK representative.

OAK MANUFACTURING CO.

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Cable: Oakmanco. • Plants in Crystal Lake, Illinois • Elkhorn, Wisconsin
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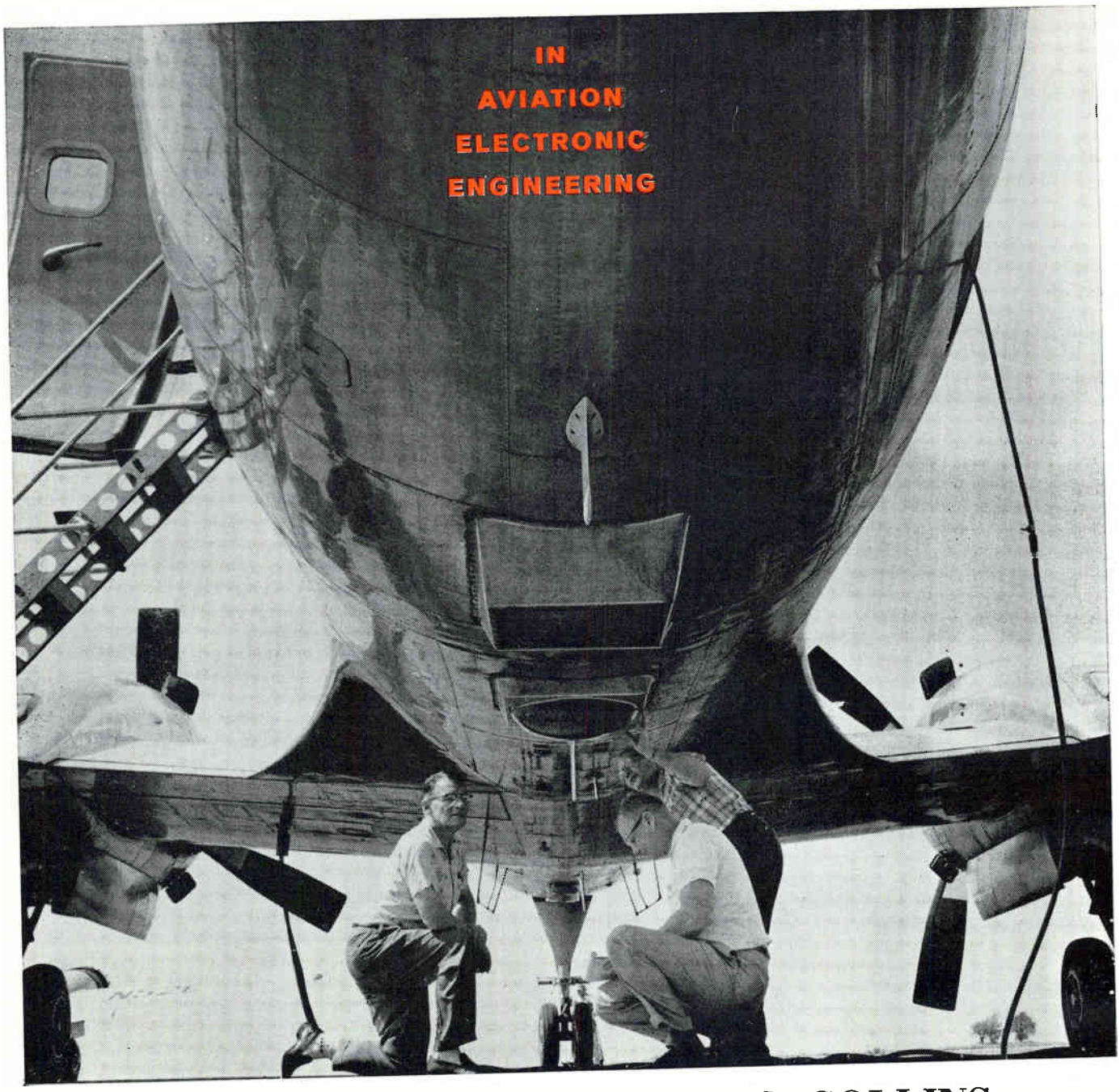
ROTARY AND PUSHBUTTON SWITCHES • TELEVISION TUNERS • VIBRATORS • APPLIANCE AND VENDING CONTROLS • ROTARY SOLENOIDS • CHOPPERS • CONTROL ASSEMBLIES

CIRCLE 121 ON READER SERVICE CARD 121



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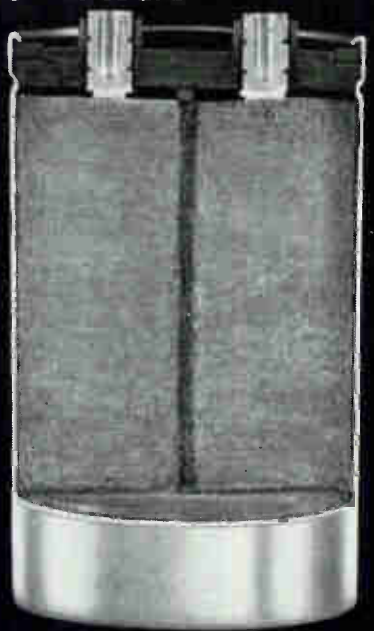
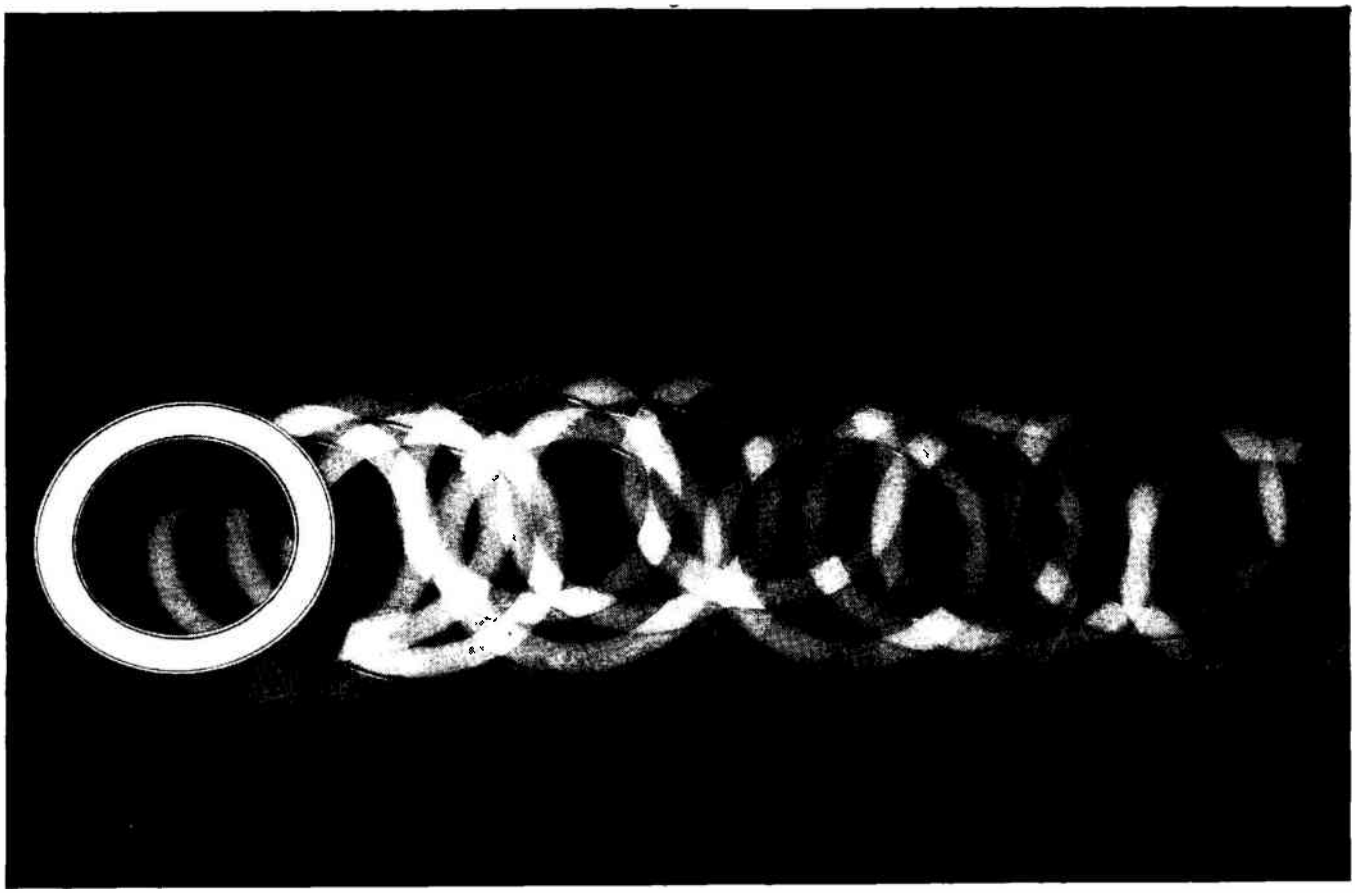
CIRCLE 123 ON READER SERVICE CARD→

Exclusive ionic "bath" increases electrolytic reliability



Inside General Instrument Electrolytic Computer Capacitors is aluminum foil that has been "taken to the cleaners" to improve its reliability. ■ The etched crevices in aluminum capacitor foil often harbor acidic residues of the etching process. These carriers of corrosive action frequently escape detection in testing, only to show up, embarrassingly, after the capacitor has been in use a while. Chemical baths remove some of them. But only General Instrument — of all manufacturers of electrolytic computer capacitors — passes the foil through a unique ionic cleaning procedure before etching to assure the type of etch that minimizes the potential danger of deep-pocketed crevices. ■ All General Instrument tantalums, micas and paper-films get similar extra care. If you care, specify General Instrument Capacitor Division. Write for engineering bulletin EL-8 and the booklet "Inside General Instrument Capacitor," to Department 200C, General Instrument Corporation, Darlington, S. C.

GENERAL INSTRUMENT CAPACITORS



the strong case for Centricores®

When you're considering magnetic cores it pays to get down to cases. The sturdy aluminum case for Centricores assumes special importance where impact, vibration, heat or mechanical pressure could cause trouble in a control loop you're designing, or where you want to miniaturize an inductive component.

The case is ruggedly rigid, so that you can apply your circuit windings without danger of distorting the core's magnetic properties. And the case is absolutely leakproof. You can vacuum-impregnate Centricores without danger of their damping oil leaking out or foreign matter leaking in. The tightly sealed case also guards against leakage in applications where high ambient temperatures are present, or where Centricores are used in rotating equipment.

Here's a tip on miniaturization. The rugged design of the Centricore case permits use of a thinner gage aluminum that shaves fractions of an inch off their size—fractions that can add up to precious inches where you want to scale down component dimensions. *Centricores are the slimmest magnetic cores on the market.*

Centricores are the most uniform. They give the exact performance you want, from core to core and lot to lot. Their remarkable consistency in insulation, dimensions, squareness, thermal stability and gain is the product of unique quality controls that begin with the very selection of raw materials and extend through final testing.

Write for complete data. Centricores are available from stock from our East and West Coast plants in all standard sizes and magnetic qualities, and in both aluminum and phenolic cases. We will match them within 5 per cent over the entire voltage-current loop, in sets, units or in multiples up to twelve. Write for detailed specifications today.

MAGNETIC METALS

MAGNETIC METALS COMPANY
Hayes Avenue at 21st Street, Camden 1, N.J.
853 Production Place, Newport Beach, California
transformer laminations • motor laminations • tape-wound cores
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Model 440
$250

Widest range-highest stability!

Improved NARDA Solid-State POWER METER –portable unit with rechargeable battery– measures rf power (0.1 to 10 mw) within 3%!

Compensated or not—you can't buy a more stable Power Meter for lab use than the new, improved version of Narda's Model 440! Self-balancing, it provides accurate direct reading measurements of either CW or pulsed power. Fully transistorized and powered by a nickel-cadmium battery (rechargeable overnight), it provides complete freedom from deviations due to line voltage fluctuations. Moreover, zero-set controls have been especially re-designed for fine resolution and ease of control on lowest scales.

The 440 may be used for any frequency range for which there are bolometer or thermistor mounts, and provides up to 18 ma bias current. In addition to the five standard scales up to 10 mw, the 440 provides 0.001 to 0.01 mw and 0.003 to 0.03 mw scales (bolometer use only; 4.5 ma preferably) to provide the widest power measuring range available. And in addition, you get all this with an accuracy of ±3% of full scale reading!

Call your local rep or write us for more complete specifications. Ask, too, for our free catalog of over 600 microwave instruments and components. Address: Dept. E-1-16.

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Plainview, L. I., New York
Area Code 516 GE 3-9000

FOR DC-to-15 MC APPLICATIONS

Tektronix Types 515A, 516 Oscilloscopes

These two compact Tektronix Oscilloscopes ideally suit most general-purpose measurement applications in the dc-to-15 mc range. They display bright traces with excellent definition.

You may prefer the Type 515A Oscilloscope if you work exclusively with single-trace applications in the laboratory, in the field, or on the production line. Or, you may prefer the dual-trace facility of the Type 516 Oscilloscope. It offers you four operating modes and independent controls for each amplifier channel—enabling you to position, attenuate, invert input signals as desired.

Regardless of your selection of either of these precision tools, you will find your Tektronix Oscilloscope easy-to-operate and easy-to-keep-operating.

CHARACTERISTICS

VERTICAL AMPLIFIER

Frequency Response from dc-to-15 mc (at 3 db down). *Risetime* of 23 nanoseconds. Sensitivity from 50 mv/cm to 20 v/cm in 9 calibrated steps, continuously variable uncalibrated from 50 mv/cm to 50 v/cm. *Constant Input Impedance* at all attenuator settings.

SWEEP RANGE

Linear Sweeps from 0.2 μsec/cm to 2 sec/cm in 22 calibrated rates, continuously variable uncalibrated from 0.2 μsec/cm to 6 sec/cm. *5X Magnifier* to extend calibrated sweep rate to 40 nsec/cm.

TRIGGERING FACILITIES

Automatic or Amplitude-Level Selection (preset or manual) on rising or falling slope of signal, with AC or DC coupling, internal, external, or line—also high-frequency sync to 20 mc.

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5-inch crt with 6-cm by 10-cm viewing area and 4-KV accelerating potential.

AMPLITUDE CALIBRATOR

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All critical dc voltages electronically regulated. *Power Requirements* of 105 to 125 volts or 210 to 250 volts, 50 to 60 cycles—with special models using dc fan motor and operating from 50 to 400 cycles also available.

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13½" high by 9¾" wide by 21½" deep—approximately 45 pounds.

Type 515A Oscilloscope (50-60 cycles)	$800
Type 515A MOD 101 (50-400 cycles)	835
Rack-Mount Models also available	
Type 516 Oscilloscope (50-60 cycles)	$1000
Type 516 MOD 101 (50-400 cycles)	1035
Type 516 MOD 108B (significantly improved writing rate at 6-KV on 6 div by 10 div viewing area—each div equals 0.85 cm)	1075

U.S. Sales Prices f. o. b. Beaverton, Oregon

For a demonstration of these or any of over fifty other Tektronix Oscilloscopes, call your Tektronix Field Engineer.

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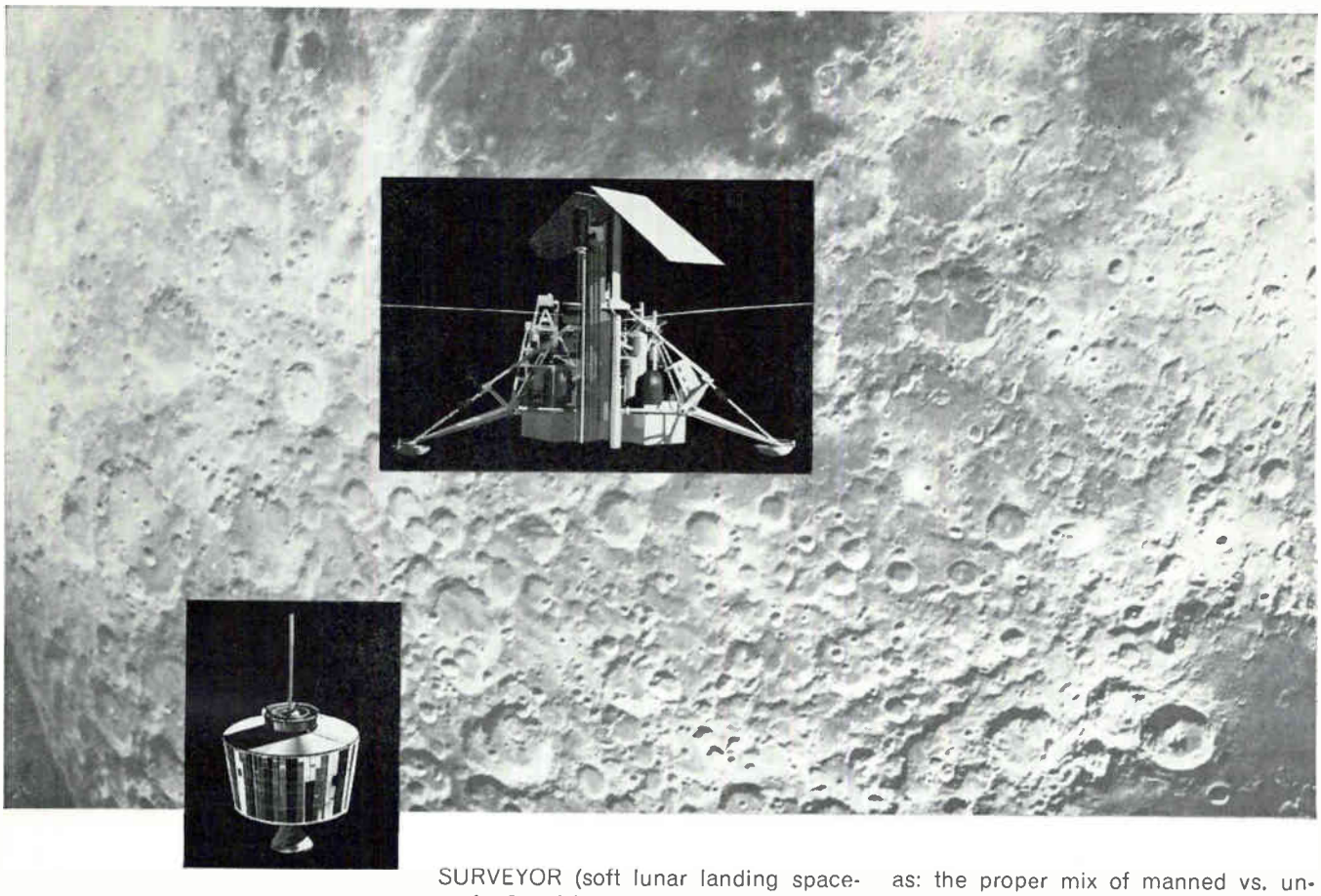
European and African countries, the countries of Lebanon and Turkey, please contact TEKTRONIX INTERNATIONAL A.G., Terrassenweg 1A, Zug, Switzerland, for the name of your local engineering representative. Other Overseas areas, please write or cable directly to Tektronix, Inc., International Marketing Department, P. O. Box 500, Beaverton, Oregon, U.S.A. Cable: TEKTRONIX.



systems analysts:

Quantify the complex on important projects at Hughes!

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

Because of these projects and others important to the nation's defense, preparedness and space effort, Hughes offers more opportunities to Systems Analysts than ever before.

Involved with these positions are the consideration of many basic problems such as: the proper mix of manned vs. unmanned satellites; the requirements of manned space flight; IR systems requirements for high speed strike reconnaissance systems or unmanned satellites; analysis of weapon systems from conception through development, test and customer use; and many others.

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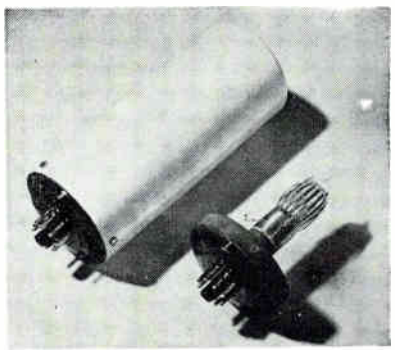
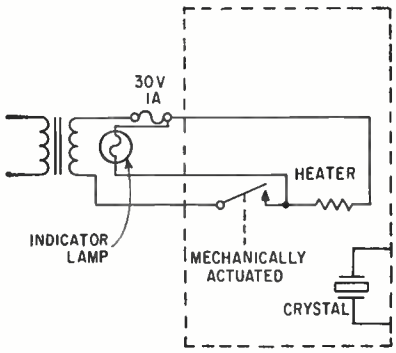
DESIGN AND APPLICATION





Crystal Oven Has No Thermostat

USES LATENT HEAT OF FUSION

MARCONI INSTRUMENTS, 111 Cedar Lane, Englewood, New Jersey announces a new crystal oven which eliminates temperature fluctuation arising from thermostatic control. Melting point of crystalline napthalene at normal atmospheric pressure serves as a standard. When the napthalene is partially melted, and a layer of liquid is in contact with the solid layer, boundary temperature is at melting point temperature and the property of latent heat of fusion prevents temperature variation. A thin layer of solid is maintained around the crystal chamber by making use of the change in volume accompanying change of state. Volume change operates pressure-sensitive switch controlling power to heater. Type F3006 stabilizes at 79.5 C although further types will stabilize at 48 C. Cyclic temperature variation is claimed at less than ± 0.0014 C.

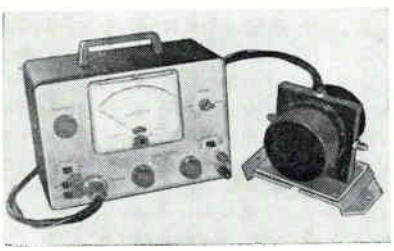
CIRCLE 301 ON READER SERVICE CARD

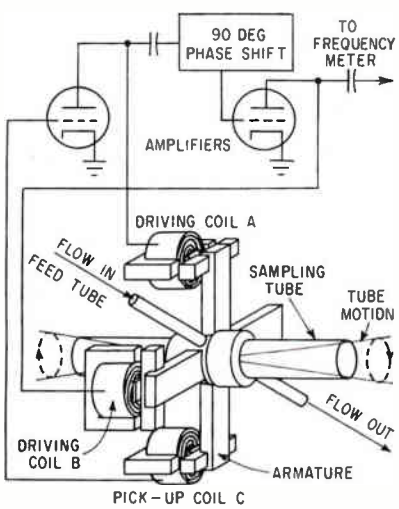
New Fluid Density Meter

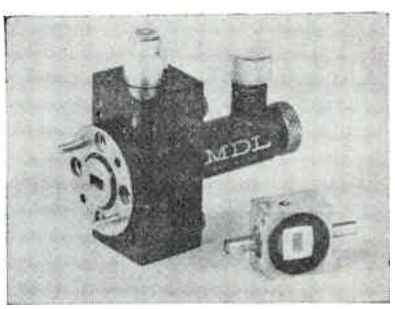
USES MASS-CONTROLLED OSCILLATOR

CO-ENGINEERING COMPANY, Box 194, Boonton, New Jersey announces the DENSITOR for measuring the density of fluids, mixtures and suspensions. The device uses an electromechanical vibrating tube as the measuring element. It is supported by a spring suspension and is caused to vibrate at its natural frequency by electromagnets. Two electromagnets driving at right angles cause the vibrating tube to move so that any material within the tube is subjected to unidirectional rotation. A baffle within the tube insures complete exchange of material with flow. The sensing element has three armatures and the sampling tube is suspended by springs within the frame. Excitation will cause the system to vibrate at its natural frequency. Pickup coils are mounted adjacent to the armatures. If the output of pickup coil *C* were amplified and fed to driver coil *A*, oscillations would occur in the vertical plane. If the output signal is shifted 90-degrees and applied to driver coil *B*, the ends of the sampling tube will trace a circular path. A nutating motion is achieved in which all portions of the tube and contents follow a circular motion. When the sampling tube is filled with fluid, mass will be different, thus altering natural vibrating frequency. Density of fluid is determined by vibration frequency. Maximum full-scale sensitivity is 0.1 specific gravity unit, and will withstand fluid pressures from −15 to +500 psi. Can also be used to measure finely divided soils.

CIRCLE 302 ON READER SERVICE CARD







Crystal Holders

RUGGED, LIGHTWEIGHT

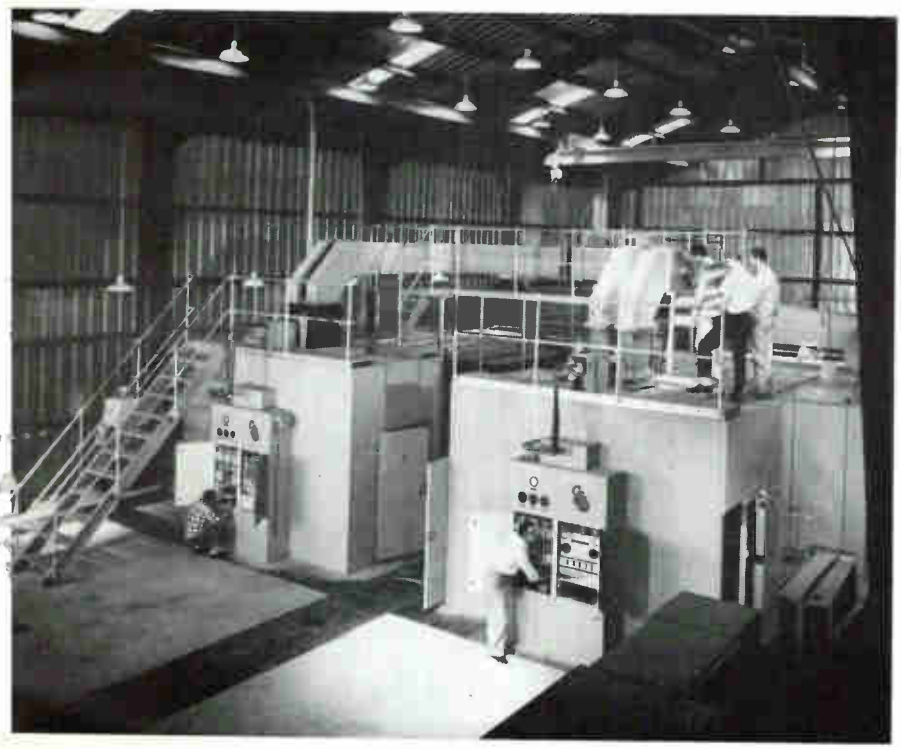
MICROWAVE DEVELOPMENT LABORATORIES, INC., 15 Strathmore Rd., Natick, Mass. A WR15 crystal holder, model 15DH16, incorporates compact design and superior performance, making it suitable for microwave system design. Covering the frequency range 68.0-72.0 Gc, unit uses a 1N2792 crystal.

CIRCLE 303 ON READER SERVICE CARD

Precision Eyelets

RAMCO MFG. CO., 540 Westfield Ave., W., Roselle Park, N.J. Eyelet sizes in an o-d range of from 0.046 to

CIRCLE 129 ON READER SERVICE CARD→



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Powerful radars with an accurate range of thousands of miles can detect incoming ICBMs minutes after launching. The transmitters for this defense system are being built by Continental Electronics . . . specialists in super power transmitting equipment.

Provided under sub-contract to General Electric and R.C.A., these transmitters from Continental Electronics are another contribution to our country's defense.

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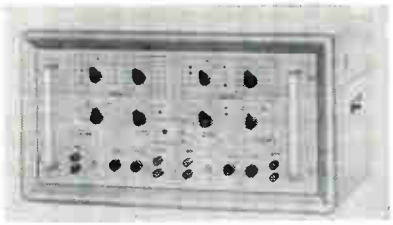
ENGINEERS . . . FOR STIMULATING WORK ON THE ELECTRONICS FRONTIERS OF TOMORROW WITH A DYNAMIC, CREATIVE ORGANIZATION, SEND RESUME TO DIR. OF PERSONNEL.

0.100 in. are available in stock sizes for applications in electronic tubes, printed circuitry and other components and devices.

CIRCLE 304 ON READER SERVICE CARD



Filter
RESPONSE TO D-C

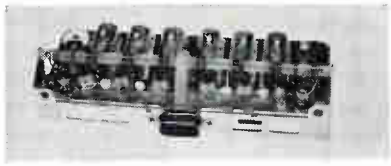
DYTRONICS CO., 5485 N. High St., Columbus 14, Ohio. Model 722 filter offers two separate variable frequency filters in a single package. The two filter sections may be used in separate circuits as individual filters or may be cascaded to produce more desirable response characteristics. Each section may be operated as either a low-pass or high-pass filter with the cutoff frequencies adjustable from 1 cps to 100,000 cps. As a low-pass, it offers response to d-c; as a high-pass, frequency response extends over 1 Mc.

CIRCLE 305 ON READER SERVICE CARD

Subminiature Switch

U.S. SWITCH CORP., 7 Jefry Lane, Hicksville, N.Y. Model 710 high current switch has a rated life of over 1 million operations; temperature range, −100 to 250 F; contact arrangement, spdt.

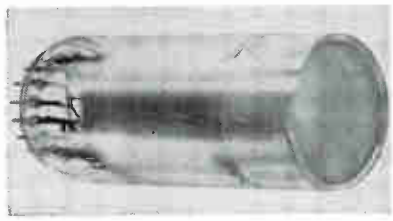
CIRCLE 306 ON READER SERVICE CARD



VHF Amplifier
BROADBAND

MOTOROLA INC., 8330 Indiana Ave., Riverside, Calif., has available a low-cost MIL-E-5400 broadband vhf amplifier. Model LPD01 weighs less than 6 oz and occupies less than 12 cu in. Unit provides 9 db gain over the entire 30 Mc to 300 Mc range. The amplifier is designed as a plug-in module that can be readily cascaded ahead of a tuned receiver, or used as a crystal video receiver by employing a crystal detector.

CIRCLE 307 ON READER SERVICE CARD



Photomultiplier Tube
LINEAR OUTPUT

EMI/US, 1750 N. Vine St., Los Angeles 28, Calif. The 9637B tube is recommended for general purpose scintillation counting applications where gain stability and good output linearity are required. It has a 44 mm diameter end-window photo-

cathode and six venetian-blind type cesium-antimony dynodes. It has a 15 pin glass base, and is supplied with a matching low-loss Teflon socket.

CIRCLE 308 ON READER SERVICE CARD

Germanium Switch

TEXAS INSTRUMENTS INC., P.O. Box 5012, Dallas 22, Texas, has introduced the TI 2N797 high-speed *npn* germanium mesa switch.

CIRCLE 309 ON READER SERVICE CARD

Summing Amplifiers
TRANSISTORIZED

MELCOR ELECTRONICS CORP., 48 Toledo St., Farmingdale, L.I., N.Y. Transistorized summing amplifier provides quadrature rejection at the null point in a servo loop. Model 1060 features 150: 1 quadrature rejection ratio, operates at 400 cps, and has low noise characteristics. It has a summing accuracy of ±0.05 percent and 200,000 v input impedance.

CIRCLE 310 ON READER SERVICE CARD

R-F Calorimeter
DRY LOAD

MELABS, 3300 Hillview Ave., Palo Alto, Calif., offers a dry load calorimeter for precise and accurate power measurements over the frequency range of 50-75 Gc. Sensitivity is 50 μw or better and power range extends to 100 mw. Power can be determined from supplied calibration curves or obtained to high accuracy by utilizing the built-in d-c calibrator. Price is $1,550, delivery 60 days.

CIRCLE 311 ON READER SERVICE CARD

Epoxy Casting System

THERMOSET PLASTICS, INC., 4015 Millersville Road, Indianapolis 5, Ind. Resin No. 609 clear colorless epoxy casting system is designed to cure in two hours or at temperatures at low as 175 F.

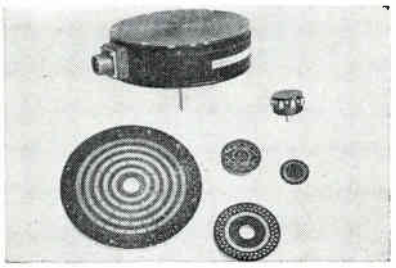
CIRCLE 312 ON READER SERVICE CARD

R-F Connector
CLOSED ENTRY CONTACT

THE DEUTSCH CO., Municipal Airport, Banning, Calif. Subminiature

coaxial connector featuring closed entry contacts is designed for complete environmental performance. It has a retention spring housed within the barrel of the socket inner-conductor. The connector has been tested to a vswr rating below 1.2:1, up to 4 Gc, and is available in 6 alternate key way positions to prevent mismating in multiple connector applications.

CIRCLE 313 ON READER SERVICE CARD



Rotary Switches
CONDUCTIVE PLASTIC

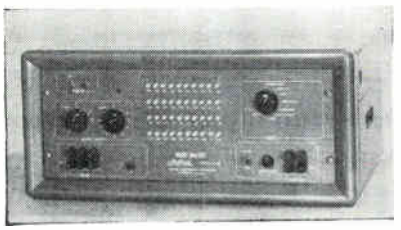
MARKITE CORP., 155 Waverly Place, New York 14, N.Y., offers a line of precision rotary switches for controls and instrumentation. Incorporating completely molded and flush switch plates, the switches achieve elimination of stick-slip phenomena. They offer long wear-life capabilities, with good signal-to-noise ratios when switching light to moderate signals, even under environmental extremes.

CIRCLE 314 ON READER SERVICE CARD

Solid State Sensor

MICRO SYSTEMS INC., 319 Agostino Rd., San Gabriel, Calif., announces series DO1, a semiconductor displacement transducer for structural test applications.

CIRCLE 315 ON READER SERVICE CARD

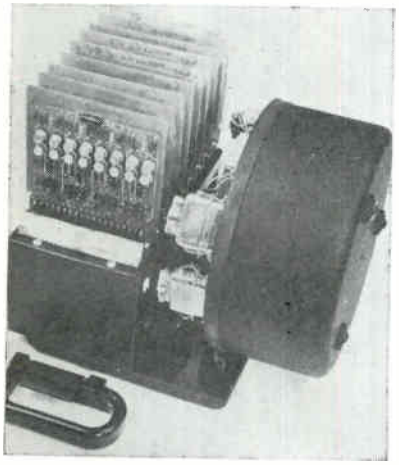


Word Generator
AND DISPLAY

DIGITAL ELECTRONICS CORP., 161 Sullivan Lane, Westbury, L.I., N.Y. Two all-transistorized Word Mas-

ters operate as a word generator and display. They operate from 0 to 500 Kc and 500 Kc to 5 Mc with word lengths up to 40 bits. The versatile model 1040 Word Master has provision for input and output synchronization to other equipment, choice of pulsed or NRZ output with amplitude control and a choice of automatic or manual key input. Output amplitude and sync signals are variable from 1 to 20 v. Prices start at $1,950.

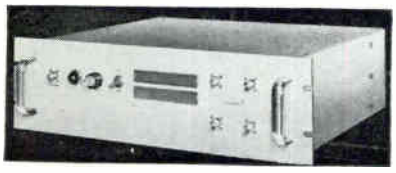
CIRCLE 316 ON READER SERVICE CARD



Magnetic Storage Drum
HIGH SPEED

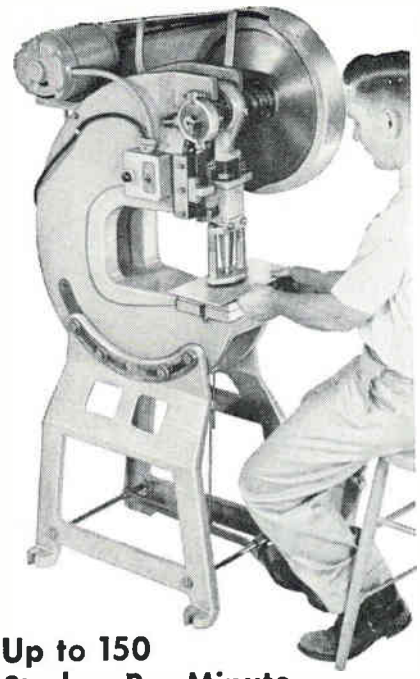
COGNITRONICS CO., Briarcliff Manor, N.Y. Featuring high frequency recording and high pulse densities, the low-cost, small-space model 4-20 provides a high speed drum access storage component for data reduction and processing systems, with pulley and belt drive permitting selected drum speeds to 25,000 rpm. Drum has capacity of up to 50 tracks with individually adjustable heads, employing a record current of approximately 100 ma through either coil.

CIRCLE 317 ON READER SERVICE CARD



Multicoupler
BROADBAND

APPLIED RESEARCH, INC., 76 South Bayles Ave., Port Washington, N.Y. True broadband coverage from 500 to 1,000 Mc with a better than 10 db noise figure is available with model



Up to 150 Strokes Per Minute...

NEW DI-ACRO OPEN BACK INCLINABLE PUNCH PRESS NO. 5

This new bench type punch press has five tons of power for punching, forming, shearing, marking, riveting, staking or embossing. Single stroke cycling, 150 s.p.m., or continuous operation, 210 s.p.m. Deep 12 inch throat allows working to center of 24" sheet. Spring loaded material stripper—easy to set up—ideal for women operators or inexperienced help. Standard equipment includes motor, brake, flywheel guard, all electrical connections, punch holder, stripper assembly and die holder.

HAND OPERATED PUNCH PRESSES— Di-Acro Punch Presses No. 1 and 2 both provide 4 tons of power that will punch holes up to 4" round in 16 ga. mild steel using punches with shear. No. 1 has 6¼" throat depth and No. 2 a 12¼" throat depth. Both model come with short handle, long handle fo heavier materials, punch and die holders turret stripper, back and side gauges.

PRECISION PUNCHES AND DIES— Over 500 sizes of single station Di-Acro punches and dies are available from factory stock, plus adjustable punches and dies for multiple punching in one operation.

For complete information consult the yellow pages of your phone book under Machinery: Machine Tools for the name of your nearest distributor or write us.

Find Us Fast in the Yellow Pages

pronounced "die-ack-ro"

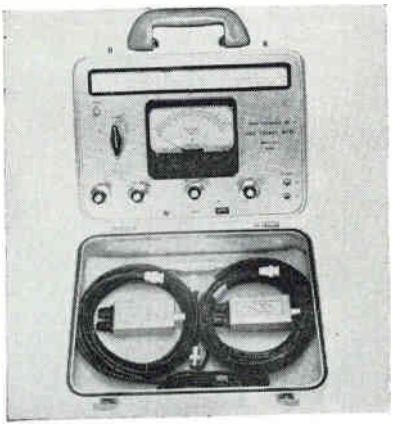
See complete Di-Acro line in Sweet's Machine Tool Catalog

di-acro PRECISION METALWORKING EQUIPMENT

DI-ACRO CORPORATION
formerly O'Neil Irwin Mfg. Co.
431 8th Avenue
Lake City, Minn.

HFM-6(A)50100-4 multicoupler. Unit has four isolated outputs at 50 ohms. Gain, overall, from the 50 ohm input to any output is 10 db minimum. It draws approximately 75 w total from a 115 v line.

CIRCLE 318 ON READER SERVICE CARD



Field Strength Meter
PORTABLE UNIT

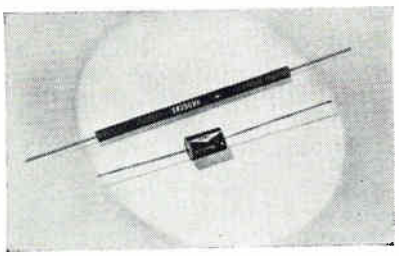
SMITH ELECTRONICS, INC., 8200 Snowville Road, Cleveland 41, O. Model SM-1 field strength meter is a self-contained, gain stabilized radio receiver of high quality and metered output, reading in both voltage and decibels. It tunes continuously over a vhf range from 52 to 220 Mc and a uhf range from 450 to 900 Mc.

CIRCLE 319 ON READER SERVICE CARD

Waveguide

BART MFG. CO., Newark, N.J., has produced a lightweight, high accuracy waveguide with electroformed nickel.

CIRCLE 320 ON READER SERVICE CARD

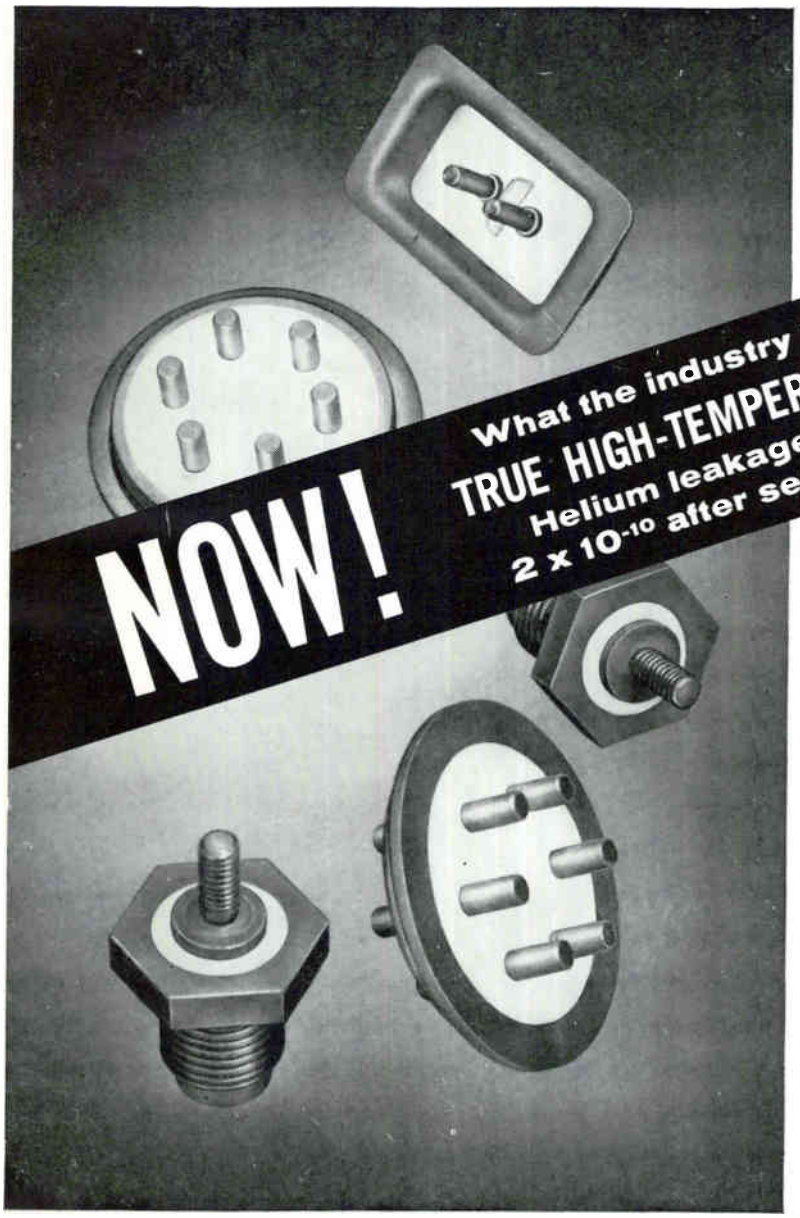


Selenium Rectifiers
CARTRIDGE TYPE

ELECTRONIC DEVICES, INC., 50 Webster Ave., New Rochelle, N.Y. A line of h-v, insulated-case, selenium cartridge rectifiers is suited for compact packaging. Available in ratings from 50 to 25,000 piv, the

BIG NEWS in high-temperature precision-molded insulation

SUPRAMICA® 620 "BB" ceramoplastic



Need a precision-molded insulation material with total dimensional stability under the most adverse thermal cycling, operating to 1200°F. . . . or a material with previously unattainable combination of properties? Check these facts about new SUPRAMICA 620 "BB" ceramoplastic:

- **Maximum temperature endurance of material 1200°F. (unstressed). Heat distortion temperature of material 1100°F. (ASTM D648-264 PSI)**
- **SUPRAMICA 620 "BB" ceramoplastic can be precision molded to most intricate geometries with gauge-like tolerances.**
- **SUPRAMICA 620 "BB" ceramoplastic will not carbonize.**
- **Absolute hermetic seals achieved directly during the molding cycle. Components meet a helium leakage rate of less than 2 x 10^{-10} cc/sec., after the following environmental tests:**
  1. Samples heat shocked a total of 20 cycles from boiling water for 30 minutes directly to ice water for 10 minutes.
  2. Samples heat shocked a total of 5 cycles, from 350°C. for 1 hour directly to room temperature for 10 minutes, to -70°C. for 1 hour, to room temperature for 10 minutes.
  3. Samples heated to 500°C. for 4 hours and directly to room temperature.
- **Thermal expansion factor matches many metals and alloys.**
- **New SUPRAMICA 620 "BB" ceramoplastic features a dielectric strength of 270 volts/mil, 1/8" thickness per ASTM D-149.**

WRITE for Information and Engineering Data Sheets on
SUPRAMICA 620 "BB"
and other **MYCALEX®** glass-bonded mica
or **SUPRAMICA** ceramoplastic insulations.

General Offices and Plant: 120 Clifton Boulevard, Clifton, N. J.
Executive Offices: 30 Rockefeller Plaza, New York 20, N. Y.

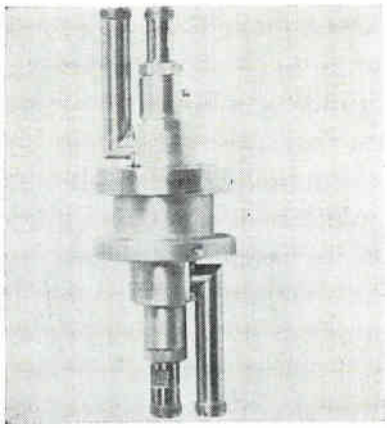
World's largest manufacturer of ceramoplastics, glass-bonded mica and synthetic mica products

THE FIRST SYNTHAMICA® SYNTHETIC MICA
SINCE 1919 MYCALEX® THE INSULATOR
THE FIRST SUPRAMICA® CERAMOPLASTIC

MYCALEX
CORPORATION OF AMERICA

rectifiers have o-d's from $\frac{3}{16}$ to $\frac{5}{8}$ in. and are $\frac{3}{4}$ to $9\frac{1}{4}$ in. long. D-C output current ratings at 40 C ambient are 1 ma, 3 ma, 5 ma, 7 ma, and 10 ma. Units have very low forward voltage drop and reverse leakage.

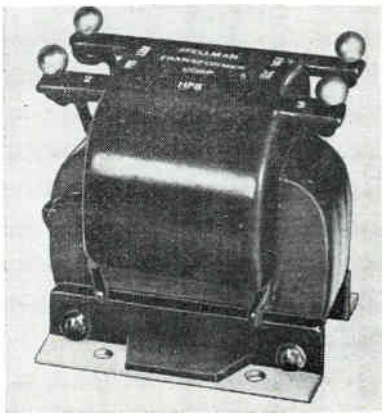
CIRCLE 321 ON READER SERVICE CARD



Coax Rotary Joints
DUAL-CHANNEL

GENERAL ELECTRONIC LABORATORIES, INC., 18 Ames St., Cambridge, Mass. Two compact dual-channel coaxial rotary joint assemblies with broad-band frequency characteristics are available. The couplers feature low vswr's and minimal insertion losses with negligible wow. The inner channel of each coupler uses direct contact to allow performance over the frequency range from d-c to 11 Gc. Outer channel is non-contacting and designed to cover approximately an octave band in the S and C frequency ranges.

CIRCLE 322 ON READER SERVICE CARD

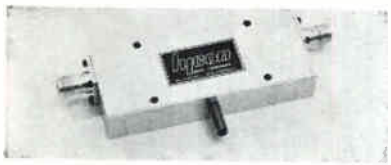


H-V Transformer
110 V 60 CPS INPUT

SPELLMAN HIGH VOLTAGE CO., INC., 1930 Adee Ave., Bronx 69, N.Y., announces model HP-8 high voltage transformer with output of 8 Kv

rms, 10 ma. Suitable for use in 20 Kv doubler circuit. Unit is 5 in. wide by 5 in. high by 4¼ in. deep. Price is $30 net.

CIRCLE 323 ON READER SERVICE CARD



Variable Attenuators
1.3 TO 4.0 GC

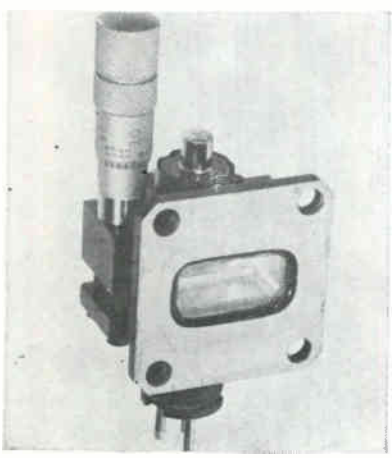
HYCON MFG. CO., 700 Royal Oaks Drive, Monrovia, Calif. Continuously variable attenuator provides a means of attenuation of power from 0 db to greater than 30 db. Unit contains an easily adjusted minimum backlash attenuator blade and is supplied with TNC coaxial connectors at the input and output. Special microwave lossy material was used to obtain 30 db attenuation minimum in the 4-in. long unit at 1.3 Gc.

CIRCLE 324 ON READER SERVICE CARD

Transducer

TRANS-SONICS, INC., P.O. Box 328, Lexington 73, Mass., has available a thermocouple transducer which provides its own cold-junction reference compensation.

CIRCLE 325 ON READER SERVICE CARD



X-Band Klystron
TUNABLE

METCOM INC., Salem, Mass. Model MXK-26 X-band klystron features a micrometer tuner, an integral cavity, a waveguide output, and a 3-pin Pee-Wee phenolic base. It is

tunable over a range from 8.1 Gc to 12.1 Gc; has a minimum power output of 100 mw and the resonator voltage is 500 v. Reflector voltage is −20 v min to −1,000 v max. Available from stock for $225.

CIRCLE 326 ON READER SERVICE CARD

Delay Lines
MAGNETOSTRICTIVE

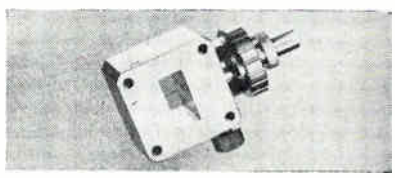
COMPUTER DEVICES CORP., 6 W. 18 St., Huntington Station, N.Y. Series of standard magnetostrictive delay lines cover the entire range from 2 to 5,000 μsec in 7 space-saving package sizes. They feature temperature coefficients of delay of better than ± 10 ppm/deg C; signal to noise ratio of better than 7 to 1; delay trim range of ±4 μsec from nominal delay; digital bit rates or frequency response up to 1 Mc for delays up to 2,000 μsec, ¾ Mc to 4,000 μsec, and ½ Mc to 5,000 μsec.

CIRCLE 327 ON READER SERVICE CARD

Miniature Servo

GENERAL PRECISION INC., Librascope Division, Glendale, Calif. Model 100-2 is a miniature servo for use in both analog and digital systems.

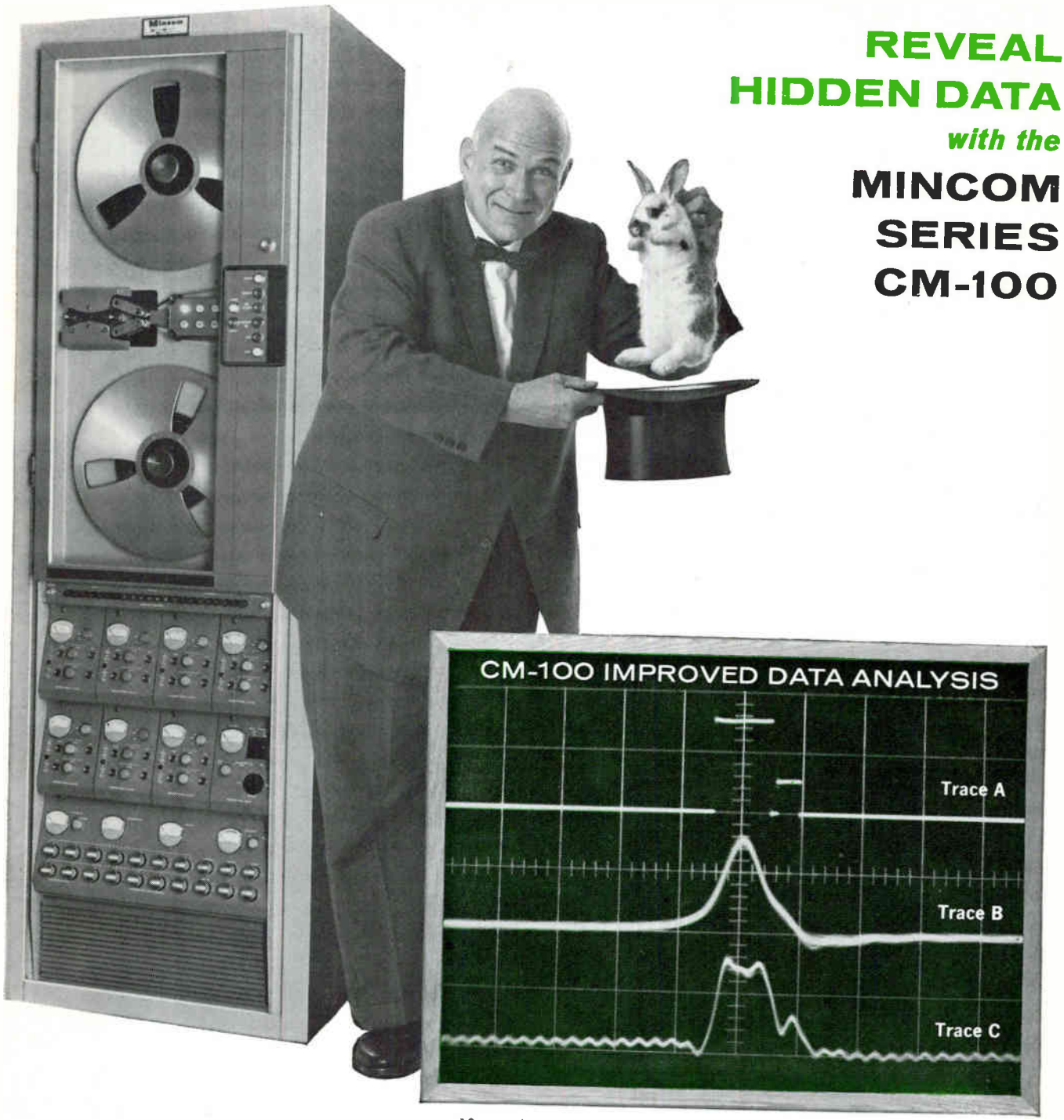
CIRCLE 328 ON READER SERVICE CARD



Slotted Line
FOR X-BAND

SOMERSET RADIATION LABORATORY, INC., 192 Central Ave., Stirling, N.J. Model X103 fixed waveguide slotted line has a stability that permits system as well as laboratory

REVEAL HIDDEN DATA *with the* MINCOM SERIES CM-100



10 μs pulse separated from 4 μs pulse by 1.2 μs space. Trace A: 100-kc system input. Trace B: 100-kc output. Trace C: CM-100 output. Sweep Rate: 10 μs/cm. Vertical Deflection: .5v/cm.

Pulses recorded on any standard 100-kc system reveal previously undisclosed data when played back on the Mincom Series CM-100 Video Instrumentation Recorder/Reproducer. At 60 ips, a prerecorded tape from a standard 100-kc recorder will present on the CM-100 an improved frequency response of 200-220 kc ± 4 db with a practical limit of 250 kc. CM-100's superior playback heads and phase-compensating electronics produce better rise time, correcting for phase shift and overshoot. This recovery of hidden data is only one of the advantages of the CM-100, a 7 or 14-track 1-megacycle system which is now performing predetection recording/reproducing on an operational basis—in FM/FM modulation, PCM and PCM/FM. Write for specifications.

...WHERE RESEARCH IS THE KEY TO TOMORROW

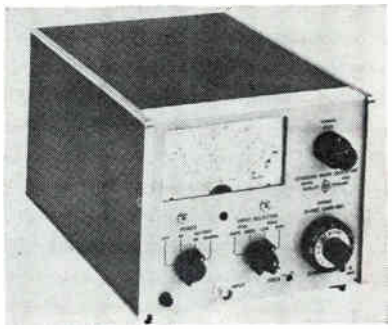
Mincom Division 3M MINNESOTA MINING & MANUFACTURING CO.

LOS ANGELES 25, CALIFORNIA • WASHINGTON 4, D.C.

CIRCLE 141 ON READER SERVICE CARD 141

applications over the entire X-band (8,200 to 12,400 Mc) range. Residual vswr is 1.01:1 maximum. Insertion length is 1.0 in. Temperature range is −55 to +200 C.

CIRCLE 329 ON READER SERVICE CARD



SWR Meter
HIGH RESOLUTION

HEWLETT-PACKARD CO., 1501 Page Mill Road, Palo Alto, Calif. Model 415 C standing wave indicator provides pinpoint resolution for precise r-f attenuation measurements. It is essentially a high gain (greater than 100 db), low noise audio amplifier coupled with an output voltmeter to read swr or db directly. Amplifier is tunable from 980 to 1,020 cps, and the variable 15 to 100 cps bandwidth permits the meter to be used for both high-sensitivity and swept-frequency applications. Price is $325.

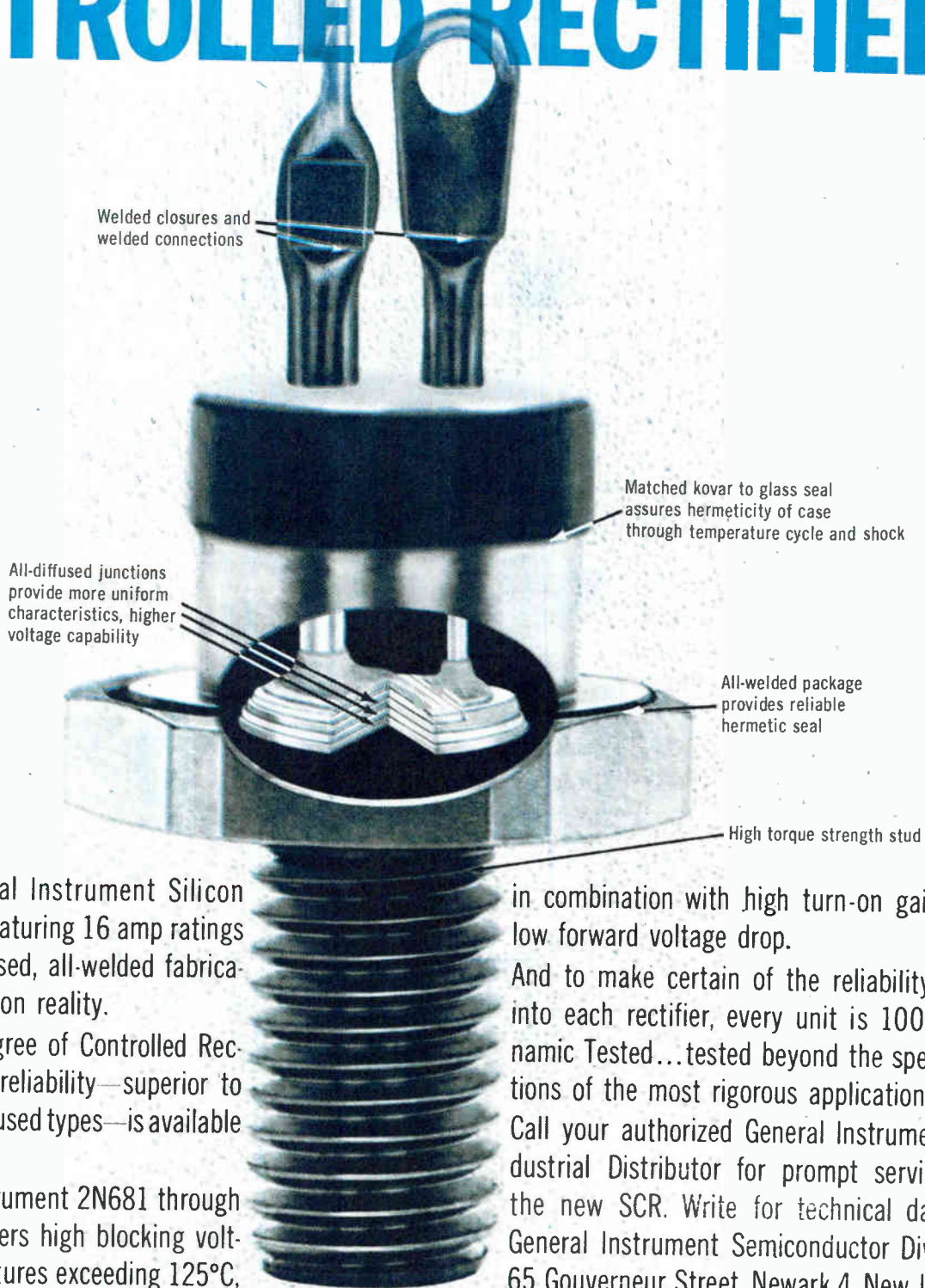
CIRCLE 330 ON READER SERVICE CARD

Ultrasonic Cleaner
9-GALLON UNIT

GULTON INDUSTRIES, INC., 212 Durham Ave., Metuchen, N.J. Model MU-1101 mobile ultrasonic cleaner is designed for cleaning medical and

CIRCLE 143 ON READER SERVICE CARD→

AVAILABLE FROM GENERAL INSTRUMENT...
FIRST 16 AMP., 500 VOLT TRIPLE DIFFUSED SILICON CONTROLLED RECTIFIER!



The exclusive General Instrument Silicon Controlled Rectifier, featuring 16 amp ratings to 500v, and all-diffused, all-welded fabrication, is a full-production reality.

The result: A new degree of Controlled Rectifier uniformity and reliability—superior to conventional alloy-diffused types—is available to you right now.

This new General Instrument 2N681 through 2N689 SCR series offers high blocking voltages even at temperatures exceeding 125°C, in combination with high turn-on gain and low forward voltage drop.

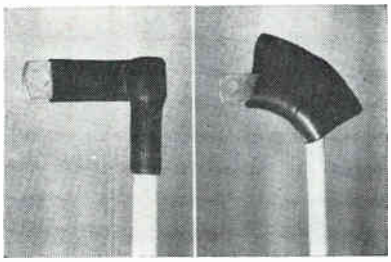
And to make certain of the reliability built into each rectifier, every unit is 100% Dynamic Tested...tested beyond the specifications of the most rigorous applications.

Call your authorized General Instrument Industrial Distributor for prompt service on the new SCR. Write for technical data to General Instrument Semiconductor Division, 65 Gouverneur Street, Newark 4, New Jersey.

GENERAL INSTRUMENT SEMICONDUCTOR DIVISION
GENERAL INSTRUMENT CORPORATION

surgical tools. It has an automatic timer, is constructed of stainless steel and weighs 340 lb. Cleaning tank measures 19¾ in. long by 11½ in. wide by 10 in. deep.

CIRCLE 331 ON READER SERVICE CARD



Flag Boots

HEAT SHRINKABLE

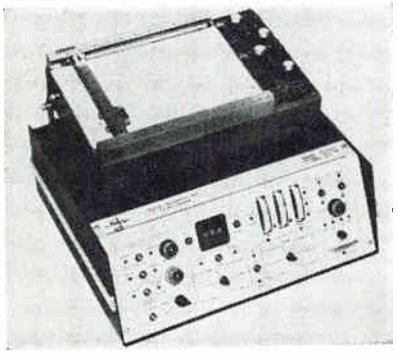
RAYCLAD TUBES INC., Redwood City, Calif. Thermofit heat shrinkable flag boots are supplied in an expanded shape to be easily slipped in place over the flag termination. Upon heating in excess of 250 F for a few seconds, the boot shrinks forcibly toward a predetermined shape and size, tightly grasping the cable and flag terminal. The resulting product is a tough, moisture resistant, compact, homogeneous insulation produced at a significant cost reduction.

CIRCLE 332 ON READER SERVICE CARD

Transistor Tester

MOTOROLA SEMICONDUCTOR PRODUCTS INC., 5005 E. McDowell Road, Phoenix, Ariz. Computer-controlled automatic transistor tester can test, select and sort 56,000 transistors per 2-shift day.

CIRCLE 333 ON READER SERVICE CARD



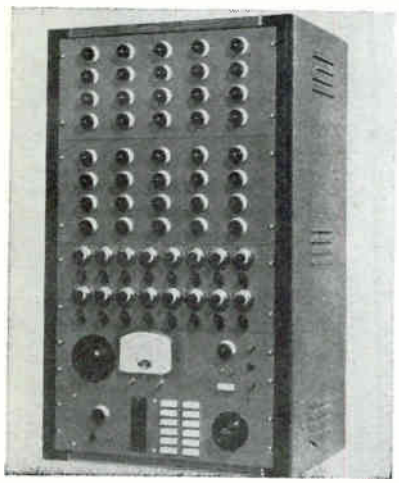
Dynamic Analyzer

ANALOG RECORDING

NUCLEAR INDUSTRIES, INC., 10 Holland Court, Valley Stream, N.Y. Model 121A is a compact, single

channel, general purpose counting system for recording and analysis of static or dynamic variations in nuclear activity. Fully transistorized, it uses advanced digital to analog conversion techniques. It includes methods of direct analog recording of digital events per unit time or time per unit event. Information is recorded in linear or logarithmic form on an X-Y plotter or strip chart recorder accessory. Price is from $2,700.

CIRCLE 334 ON READER SERVICE CARD



Transformer Tester
GO/NO-GO

MESUR-MATIC ELEC. CORP., Bradford, N. H. Model TT-1-P56 is designed for precision evaluation of 50 and 60 cycle power transformers in the 1 to 1,000 v a-c range. Under actual operating conditions, each winding is tested against every other winding and the frame to preset inspection tolerances. The voltage accuracy of each secondary and tap is individually indicated by go/no-go lights.

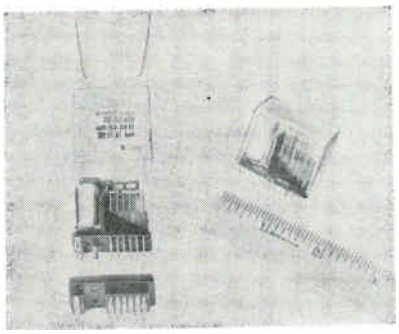
CIRCLE 335 ON READER SERVICE CARD

Time Delays
ADJUSTABLE

LOGITEK, INC., 54 Rome St., Farmingdale, L.I., N.Y., has available fixed or variable delays to operate

from 50 μsec to 500 sec at standard accuracies of 2, 5 and 10 percent over any combination of 18 to 31 v d-c and −55 C to +125 C. Timing of variable units may be adjusted over a 30 to 1 range by using external resistors or potentiometer adjustment. Units may be turned on or off before, during or after the timing cycle, held off or externally synchronized, permitting logical operation.

CIRCLE 336 ON READER SERVICE CARD



Six-Pole D-C Relay
VERY SMALL HOUSING

ALLIED CONTROL CO., INC., 2 East End Ave., New York 21, N.Y. The T-154 commercial 6pdt relay has 2-amp resistive d-c contacts as standard and low-level or 5-amp contacts on request. It features more than 200 million operations without mechanical failure. Average nominal operating power is 1.5 w. An operate time at +25 C of 15 millisec or faster at nominal voltage is obtained; release time is 6.0 millisec max at nominal voltage. Housing measures 1⅜ in. high by 1⅝ in. long by ⅞ in. wide excluding terminals.

CIRCLE 337 ON READER SERVICE CARD

C-Band Radar Beacon
COMPACT SIZE

GENERAL INSTRUMENT CORP., Andrews Road, Hicksville, L.I., N.Y. The RB-200 is a lightweight, solid-state, subminiature unit designed for operation as a tracking device to assist radar operators to follow and

10MC FREQUENCY COUNTER/STANDARD

A NEW CONCEPT IN PRECISION MEASURING

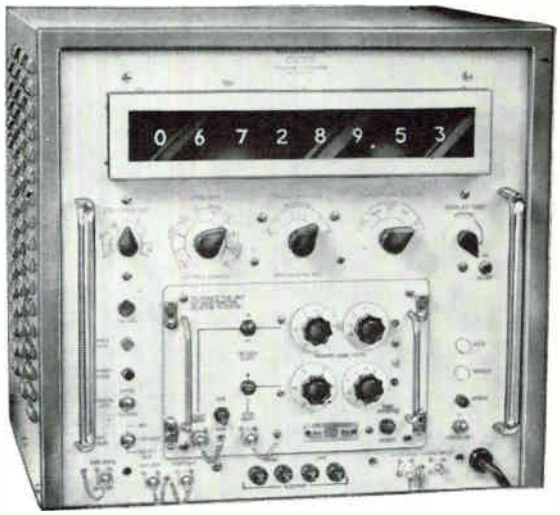
The Model 14-20C 10MC Frequency Counter/Standard combines the features of a precision counter and a high stability frequency standard into an advanced design unit. Specifications are as follows:

- Simultaneous and independent use of both frequency standard and counter.
- Stability of $1x10^8$ per day and $5x10^8$ per week calibrated by the primary time-standard "Atomichron."
- Nine standard decade output frequency steps of 0.1cps to 10mc provided by frequency synthesizer. Gate time from 1 millisecond to 100 seconds.
- Counts any one of nine decade frequencies from 0.1cps to 10mc for period and time interval measurements.
- Self checks counting and gate circuits at any of these frequencies in all combinations of available gate times.
- Operates within all ratings over a temperature range of −20° C to +55° C, and humidities up to 95%.
- Operates from an external 100KC or 1mc reference frequency.

Other features include:

Frequency range 10cps—10.1mc
Period DC— 100KC
In-line readout 8 place
Input power 115/230v, 50-60 cps (400 cps opt.)

PRICE $2,200



NORTHEASTERN ENGINEERING INCORPORATED

DEPT. 1C, MANCHESTER, NEW HAMPSHIRE
AFFILIATE OF ATLANTIC RESEARCH CORP.

CIRCLE 207 ON READER SERVICE CARD

For Integrated Communications Systems

BUDELMAN

Microwave and Carrier Offers Greatest Value!*

- UHF and Multiplex Radio
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Write for free BEC Spec File Today!

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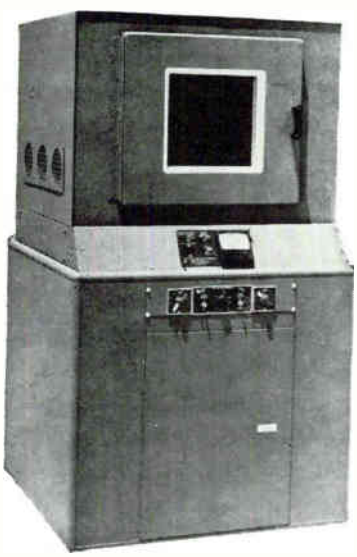
375 Fairfield Avenue — Stamford, Connecticut

* Because Budelman equipment performs better, costs less to buy and maintain.

CIRCLE 208 ON READER SERVICE CARD

PINPOINT PRECISION

THROUGHOUT LARGE VOLUME



MODEL 1060B
Temperature Chamber
Cabinet Optional

20" x 20" x 25"

LOWER GRADIENTS:
±1° C. over large portion of test volume

RANGE:
−100° F. to +600° F.

CONTROL ACCURACY:
± ¼° F.

HEATING TIME from 70°:
13 minutes to 350° F.
28 minutes to 500° F.

COOLING TIME from 70°:
6 minutes to −65° F.
9 minutes to −100° F.

Call Delta representative or write direct for specifications

DELTA DESIGN INC.

3163 ADAMS AVE. SAN DIEGO 16, CALIFORNIA
ATWATER 3-3193 • CABLE: DELTA • TWX: SD 6488-U

CIRCLE 147 ON READER SERVICE CARD

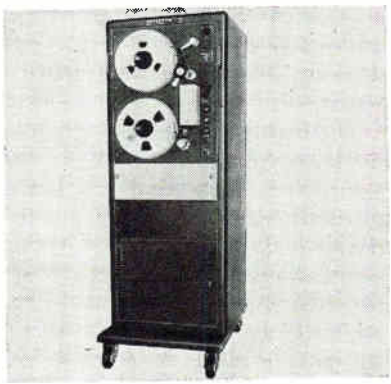
identify in-flight missiles, aircraft or space probes at distances greatly exceeding the normal reflective path of a ground radar. It includes a transmitter capable of emitting a power output well in excess of 10 w, and a receiver with a sensitivity exceeding −45 dbm. Beacon can operate over the 5,400-5,900 Mc range.

CIRCLE 338 ON READER SERVICE CARD

Power Supply

RAYTHEON CO., 225 Crescent St., Waltham 54, Mass. Power supply stores and releases precise welding energy of 20 to 225 watt-sec to permit 50 to 120 spot-welds per minute.

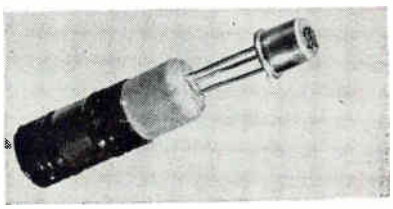
CIRCLE 339 ON READER SERVICE CARD



Data Recorder
TRANSISTORIZED

SANBORN CO., 175 Wyman St., Waltham 54, Mass. Model 2000, a 7-channel, 4-speed Sanborn/Ampex magnetic data recording system is priced at $6,800. Tapes are interchangeable on IRIG standard machines. Recorder uses ½ in. tape and has 3¾, 7½, 15 and 30 in./sec speeds. Direct recording bandwidth is up to 50,000 cps and f-m bandwidth is up to 5,000 cps.

CIRCLE 340 ON READER SERVICE CARD



Epitaxial Switches
ULTRA-HIGH-SPEED

TEXAS INSTRUMENTS INC., P.O. Box 5012, Dallas 22, Texas, announces

six new germanium epitaxial transistors for all ultra-high-speed switching applications from 3 ma through 100 ma. Types 2N960 through 2N962 and 2N964 through 2N966 combine high dissipation, low I_{CBO}, and rugged mesa construction with the epitaxial benefits of low storage time and low $V_{CE(sat)}$. There is no compromise of high breakdown or high beta.

CIRCLE 341 ON READER SERVICE CARD

SPST Diode Switch

CONSOLIDATED MICROWAVE CORP., 850 Shepherd Ave., Brooklyn 8, N. Y. Model X110 high speed diode switch operates in the range of 8.2 to 12.4 Gc with typical isolation of 20 db at 9 Gc and insertion loss of 1.3 db.

CIRCLE 342 ON READER SERVICE CARD

Power Supply
AMPLITUDE-REGULATING

GENERAL RADIO CO., West Concord, Mass. New model of the type 1236-B amplitude-regulating power supply provides 1-Kc square wave modulation from an internal generator. Designed for operation with uhf and vhf oscillators, the instrument maintains the oscillator output amplitude constant as the frequency is varied. The square-wave modulation feature permits the use of a tuned audio amplifier following the detector, thus achieving high sensitivity with a simplified setup.

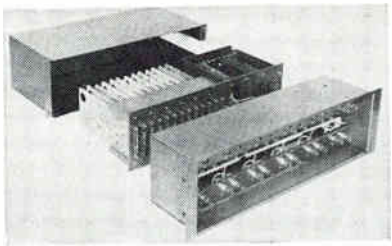
CIRCLE 343 ON READER SERVICE CARD

Transient Indicator
DIGITAL READOUT

REGENT CONTROLS, INC., Harvard Ave., Stamford, Conn. Model TD-761M2 automatic maximum voltage

indicator is a reliable instrument designed to detect and measure voltage levels. Of particular use in semiconductor electronics, it is fully transistorized, battery operated, and completely portable. Voltage range: 2,000 v maximum. Transient duration: 1 μsec minimum to d-c.

CIRCLE 344 ON READER SERVICE CARD



Annunciators
TRANSISTORIZED

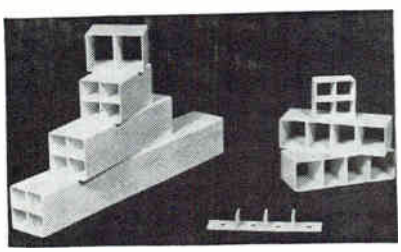
ROCHESTER INSTRUMENT SYSTEMS, INC., 273 N. Union St., Rochester 5, N.Y. Completely solid-state, the model AN-100 annunciator circuits are packaged in interchangeable, plug-in modules. Unit is available in four standard sequences, ranging from a simple automatic reset to a momentary alarm and ringback. It operates from either 120 v a-c or 125 v d-c, and is actuated by normally closed or normally open relay contacts or 10 and 0 v d-c at 1 ma.

CIRCLE 345 ON READER SERVICE CARD

Indium Antimonide

MICRO STATE ELECTRONICS CORP., 152 Floral Ave., Murray Hill, N. J., is producing single crystal indium antimonide suited for use in high mobility devices such as Hall effect isolators, gaussmeters, and ammeters.

CIRCLE 346 ON READER SERVICE CARD



Multiple Barrier Tubes
FOR CIRCUIT PACKAGING

STEVENS TUBING CORP., 86-88 Main St., East Orange, N. J. Formed in multiples of 2, 3, 4 or more at a

time, multiple barrier tubes are available in a variety of square or rectangular arrangements in lengths up to 18 in. Materials include glass silicone, epoxy, polyester, and melamine, for high temperature applications in Class H and Class B. Short pieces are useful as potting forms, or as separators in multi-packaged components

CIRCLE 347 ON READER SERVICE CARD

Test Jacks

TEFLON INSULATED

SEALECTRO CORP., 610 Fayette Ave., Mamaroneck, N. Y., announces Press-Fit Teflon-insulated test jacks for use in threaded receptacles. The SKT-43-B1 test jacks are designed to accept a 0.070 in. diameter by 0.250 in. long probe, and have a turret-type terminal. Designed for metal tubes, with threading, the extra-bulk Teflon body presses into the tube, resulting in a very high pull-out strength installation. The Teflon insulation permits a wide operating temperature range, and provides excellent dielectric strength.

CIRCLE 348 ON READER SERVICE CARD

Variable Delay Line

NARROW-RANGE

GENERAL RADIO CO., West Concord, Mass. Type 301-S104 variable delay line weighs 1½ oz and has a total range of from zero to 25 nsec ± 10 percent. The line affords a resolution of 0.06 nsec and a pulse rise time of approximately 2.4 nsec at maximum delay. Characteristic impedance is 200 ohms ± 20 percent, and the d-c resistance is 5.5 ohms ± 20 percent.

CIRCLE 349 ON READER SERVICE CARD

PRODUCT BRIEFS

GRAPHIC RECORDER miniaturized. Assembly Products, Inc., Chesterland, O. (350)

LITHIUM ION DRIFT DETECTORS active area: 5 mm by 5 mm. Solid State Radiations, Inc., 2261 S. Carmelina Ave., Los Angeles 64, Calif. (351)

BALANCED MIXER for space environments. Hycon Mfg. Co., 700 Royal Oaks Dr., Monrovia, Calif. (352)

COOLING MODULES for semiconductors. Deltron Inc., 4th & Cambria Sts., Philadelphia 33, Pa. (353)

D-C AMPLIFIER self-compensating. Netherlands Consulate General, Commercial Div., 10 Rockefeller Plaza, New York 20, N. Y. (354)

R-F FILTERS and capacitors. RF Interonics, Inc., 15 Neil Court, Oceanside, L. I., N. Y. (355)

A-C POTENTIOMETER military type. Perkin-Elmer Corp., Norwalk, Conn. (356)

FREQUENCY STANDARD compact, low weight. American Time Products, Div. of Bulova Watch Co., Inc., 61-20 Woodside Ave., Woodside 77, N. Y. (357)

DIGITAL PATTERN GENERATOR versatile instrument. The Magnavox Co., Urbana, Ill. (358)

VOLT BOX extends pot range. Central Scientific Co., 1700 W. Irving Park Road, Chicago 13, Ill. (359)

TRANSMITTING TUBES for mobile use. Radio Corp. of America, Harrison, N. J. (360)

MICA CRYSTALS man-made. Molecular Dielectrics, Inc., 101 Clifton Blvd., Clifton, N. J. (361)

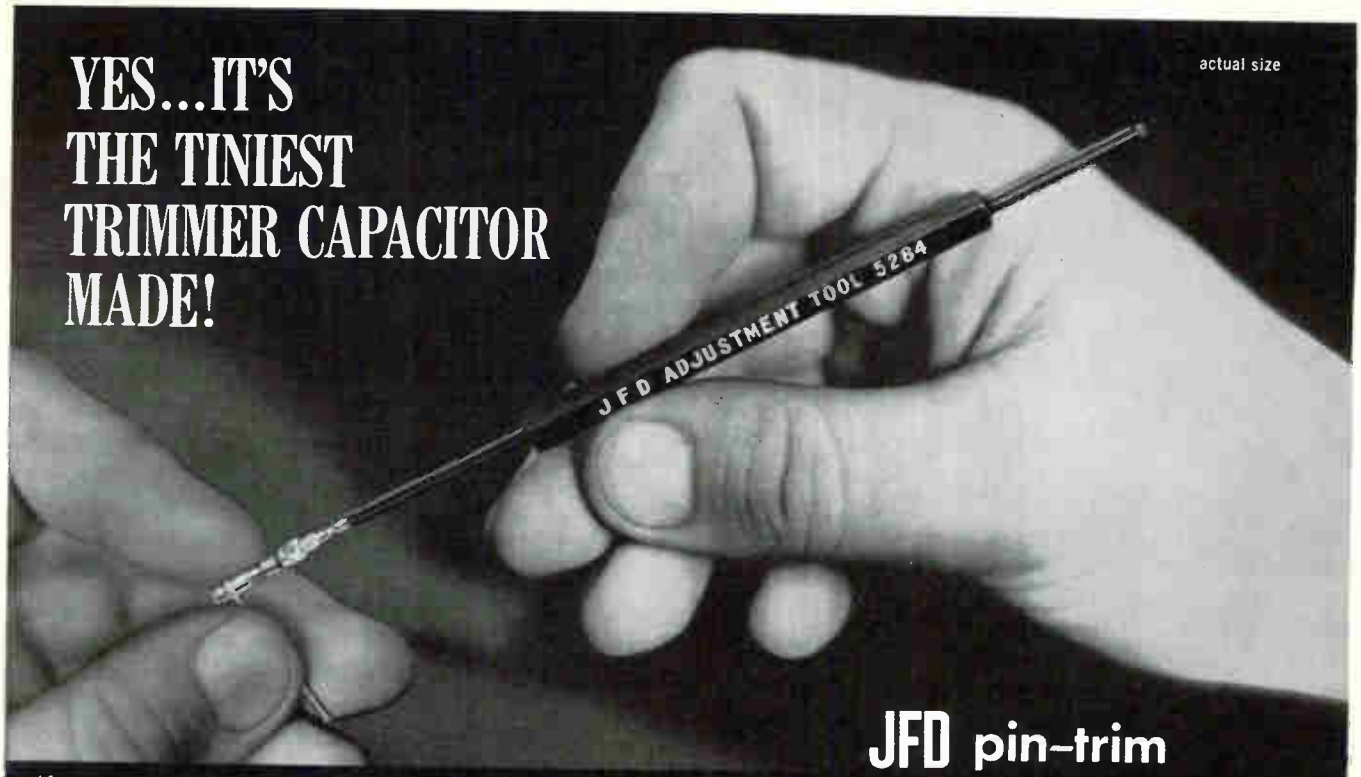
FREQUENCY SENSOR automatic reset. Jordan Electronics, 121 So. Palm Ave., Alhambra, Calif. (362)

VARIABLE RESISTORS with metal-ceramic element. CTS Corp., Elkhart, Ind. (363)

BACK DIODES for nsec switching circuits. Micro State Electronics Corp., 152 Floral Ave., Murray Hill, N. J. (364)

SILICON MESA TRANSISTORS medium power. Clark Semiconductor Corp., Walnut Ave., Clark, N. J. (365)

YES...IT'S THE TINIEST TRIMMER CAPACITOR MADE!



JFD pin-trim

If you are designing for missile environments or applications requiring more capacity in less space, look in to the Pin-Trim. It provides a practicable solution to the challenge of end-product miniaturization with high operational stability.

The new Pin-Trim delivers: (1) more capacitance per cubic centimeter than any other conventional piston trimmer; (2) 75 per cent less weight and 50 per cent less volume than JFD's own miniature trimmers; (3) greater sensitivity; (4) finer adjustment.

If you are looking for maximum compactness between stacked circuit boards, or less stray capacitance in a given area, check the JFD Pin-Trim specifications for your subminiature trimmer applications.

For further data, call your local JFD Field office or your JFD franchised Industrial Distributor.

- Overall diameter: 1/8 inch. Overall length above panel: 3/8 inch to 1 inch.
- Double the sensitivity of JFD standard trimmers. Special adjust mechanism provides 102 turns per inch for extra fine adjustment.
- Increased maximum to minimum capacitance ratio per unit (minimum: 0.5 pf.).
- Operating temperature −55° to +125°C.
- Low temperature coefficient of capacitance.
- Anti-backlash design for precise tuning resolution.
- Low inductance for high frequency use.
- Ultra linear tuning assures accurate alignment—absolute repeatability. Standard slotted end for screwdriver adjustment.
- Rugged shock and vibration resistance.
- 500 V. DC working voltage.
- 10^4 megohms insulation resistance.
- Q factor of 500 (measured as per JFD #5178).
- 0.5 inch ounce tuning torque.
- Meet or exceed applicable performance requirements of MIL-C-14409A.

JFD Adjustment Tool No. 5284 (illustrated) available at 85¢.

Model*	Capacitance Range MMF Measured Per JFD #5177 Min.	Capacitance Range MMF Measured Per JFD #5177 Max.	D.C. Working Volts	Dielectric Strength Measured For 5 Seconds at 50% R.H. at Max. Rated Cap.	Insulation Resistance Measured After One Minute at 500V. D.C. and 50% R.H.	Q Factor Measured Per JFD #5178	Unit Weight Grams	Dimen.** Max. ±1/32
PT901	0.5	2.0	500	1000	10^6 Megohms	500	0.62	3/8"
PT902	0.5	3.0	500	1000	10^6 Megohms	500	0.64	1/2"
PT903	0.5	5.0	500	1000	10^5 Megohms	500	0.79	3/4"
PT904	0.5	7.0	500	1000	10^6 Megohms	500	0.94	1"

*These units are also available in the same capacitance values for printed circuit boards in models TT911, TT912, TT913 and TT914.
**Length front of panel.

JFD

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Literature of

SILICON DEVICES Electronic Devices, Inc., 50 Webster Ave., New Rochelle, N.Y. Three catalog data sheets cover glass subminiature silicon diodes, silicon Zener diodes, and silicon rectifiers. (366)

ASSEMBLY MACHINE Kulicke and Soffa Mfg. Co., Inc., 401 N. Broad St., Philadelphia 8, Pa. Catalog sheet illustrates and describes a precision multi-tool assembly machine designed for microcircuitry research and production. (367)

INDUSTRIAL ANALYZERS Weston Instruments Div., Daystrom, Inc., 614 Frelinghuysen Ave., Newark 14, N.J. Bulletin 06-207 discusses the features and specifications of four models of circuit analyzing instruments. (368)

POWER SUPPLY Perkin Electronics Corp., 345 Kansas St., El Segundo, Calif., has issued a bulletin on a 125 v, 25 amp silicon rectifier power supply. (369)

MICROELECTRONICS Varo Inc. Microelectronics Div., 2201 Walnut St., Garland, Texas, offers literature describing representative pieces of equipment in its microcircuits and microcomponents line. (370)

SUBMINIATURE PLUGS Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif. Catalog D-8 lists and describes characteristics of a series of subminiature, rectangular D plugs. (371)

TRANSFORMER SIMULATOR Electronic Research Associates, Inc., 67 Factory Place, Cedar Grove, N.J., has available a catalog sheet describing the model TS460 transformer simulator. (372)

CIRCUIT PROGRAMMING SYSTEMS Virginia Electronics Co., Inc., River Road & B.&O. Railroad, Washington 16, D.C. Brochure describes a wide variety of sizes in circuit programming systems. (373)

MOISTURE MONITOR Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif. Four-page brochure describes type 26-303 moisture monitor. (374)

ENERGY DISCHARGE CAPACITORS Sangamo Electric Co., Springfield, Ill. Electrical and mechanical design criteria on energy discharge capaci-

tors are summarized in a state of the art publication. (375)

TRANSIENT VOLTAGE DETECTOR Halmar Electronic Products Co. Ltd., 1550 W. Mound St., Columbus 23, O. Brochure illustrates and describes an all-solid state transient voltage detector. (376)

HALL EFFECT DEVICES Siemens, N.Y. Inc., 350 5th Ave., New York 1, N.Y., announces a booklet about Hall effect devices for all problems of modern electronics. (377)

F-M ANTENNAS Andrew Corp., P.O. Box 807, Chicago 42, Ill., has published catalog B on its Multi-V f-m antenna system. (378)

REMOTE MONITORING CompuDyne Corp., 400 S. Warminster Road, Hatboro, Pa. Four-page folder describes Alertra model 901 remote monitoring system. (379)

SILICON DIODES National Transistor Mfg., Inc., 500 Broadway, Lawrence, Mass. Catalog B-101 covers a line of silicon double diffused alloy diodes. (380)

SERVOMOTORS Helipot Division of Beckman Instruments, Inc., 2500 Fullerton Rd., Fullerton, Calif. Data sheet covers size 15 and 18 servomotors, inertia and velocity damp servomotors, and servomotor-rate generators. (381)

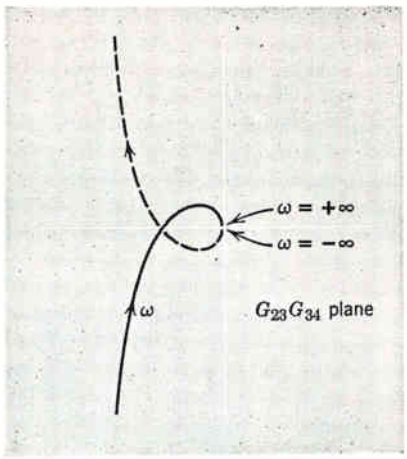
ELECTRONIC SOLDER Alloys Unlimited Solder, 2101 43rd Ave., Long Island City 1, N.Y., announces a brochure on its line of electronic and industrial solder. (382)

BUTTON CELLS Yardney Electric Corp., 40-50 Leonard St., New York 13, N.Y. Rechargeable Silcad button cells are described in a technical data sheet. (383)

RADIATION DETECTORS Molēchem, Inc., a subsidiary of Hamner Electronics, Inc., P.O. Box 531, Princeton, N.J. Technical information on surface barrier silicon radiation detectors is contained in a 4-page bulletin. (384)

SURVEY METER Kleber Laboratories, Inc., 2530 N. Ontario St., Burbank, Calif., has available a specification sheet on the model 20 radiation survey meter. (385)

NEW BOOKS



Introduction to Feedback Systems

By L. DALE HARRIS

John Wiley and Sons, Inc., Philadelphia, Pa., 1961, 360 *p*, $10.50

A COMPREHENSIVE treatment of feedback, based primarily on the pole-zero, root-locus rather than the sinusoidal approach. Also included is a considerable amount of the pertinent mathematical techniques, including appendices on Laplace transforms and transfer function analysis. Linear oscillating systems are dealt with in a separate chapter.

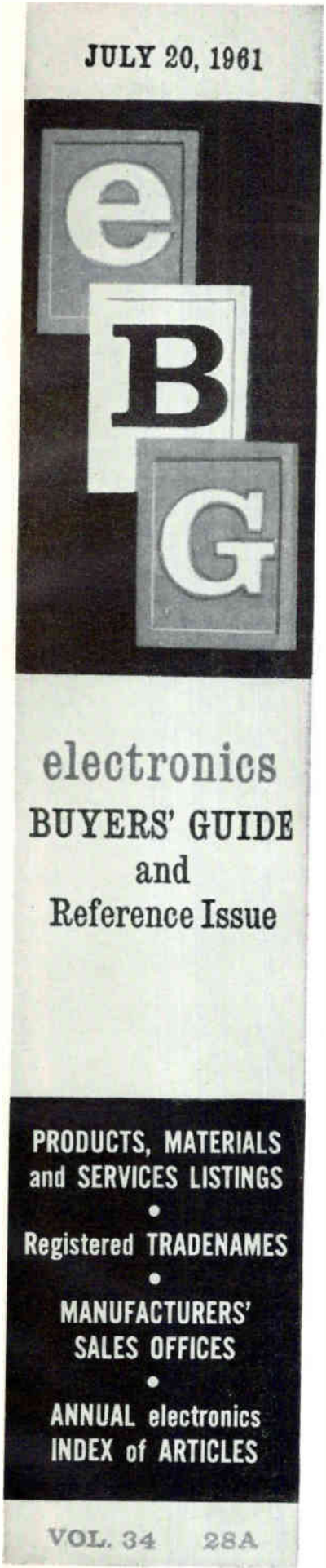
The book is intended as a text for the engineering student, and provides a solid base in feedback theory that is then applicable to a large variety of problems. Adequate problems are supplied, but there is no bibliography. G.V.N.

Electronic Amplifier Circuits, Theory and Design

By J. M. PETTIT and M. M. McWHORTER

McGraw-Hill Book Company, Inc., New York, 1961, 319 *p*, $9.75

STARTING WITH the general theory of amplification, the authors develop analytic techniques for deriving equivalent circuits of amplifiers and interpreting characteristics of the main classes of amplifiers. Tubes and transistors are treated in parallel, and a number of modern techniques for optimizing amplifier performance are discussed. Special consideration is given to stagger-tuning, interstage design



and noise aspects. Examples and problems appear throughout.

The book is written on a senior-student or graduate level, and will serve as a useful handbook to the design engineer. G.V.N.

Electronic, Radio and Microwave Physics

By D. E. CLARK and H. J. MEAD

The Macmillan Co., New York, 1961, 521 *p*, $25

INTENDED to be a reference work for experienced engineers, teachers and students, this volume places greater stress on fundamentals than applications. Fifteen chapters cover the important principles in the fields of electronics and microwave physics. Parts of this material can be used to supplement primary textbooks for students in these fields. The subject matter is up to date and includes many references. L.D.S.

Induction Heating

By P. G. SIMPSON

McGraw-Hill Book Co., Inc., New York, 295 *p*, $11.50

THIS PRACTICAL and theoretical volume describes design of coils, power systems and generating equipment for typical applications of induction heating. Fundamental electromagnetic and heat-flow theory are reviewed as a basis for practical designs.

Linear Circuits, Part I: Time—Domain Analysis

By RONALD E. SCOTT

Addison-Wesley Publishing Company, Inc., Reading, Massachusetts, 510 *p*, $6.75.

THIS FIRST part of a two-part book covers the basics of linear circuit theory. Major sections are resistive circuit theory and transients in the time domain.

Prepared as as text for a first course in Electrical Engineering, the book treats circuits as idealized models. For those engineers out of school a few years, the book provides an idea of present course content. Answers to all problems are given, making the text usable as a

self-refresher course.

Part II (not reviewed) covers frequency domain analysis. — M.M.P.

Magnetic Tape Instrumentation

By G. L. DAVIES

McGraw-Hill Book Co., Inc., New York, 1961, 263 *p*, $8.50

THIS "attempted exposition of the principles and equipment, their character and limitations" of magnetic tape recording and reproduction of data, as distinguished from voice and music, encompasses almost all phases of instrumentation, and data acquisition and processing systems.

The Consulting Engineer

By C. M. STANLEY

John Wiley & Sons, Inc., New York, 1961, 258 *p*, $5.95.

NONTECHNICAL aspects of the consulting engineer's professional life are covered in this book. Topics include organizing a consulting firm, typical accounting and billing procedures, contracts, ethics, and relations with clients and colleagues. This is a useful guide for a consultant getting started or an engineer contemplating striking out on his own. J.C.

Basic Radio

By MARVIN TEPPER,

John F. Rider Publisher, Inc., New York, 1961, 776 *p*, $13.85 (*soft covers*), $14.85 (*cloth covers*).

THE LATEST in the Rider "pictured text" series, these six volumes represent a surprisingly detailed coverage of basic radio communications, with separate texts on d-c electricity, a-c electricity, electron tube circuits, a-m and f-m receivers, transistors, and a-m and f-m transmitters. Featuring a well-planned drawing on each page, an absolute minimum of mathematics, and a clear writing style at the technical institute level, these books make an interesting introduction to radio or a rapid brush-up on its fundamentals. S.B.G.

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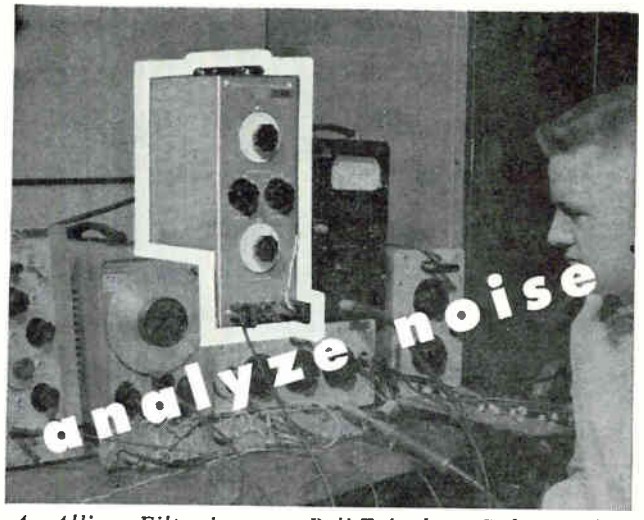
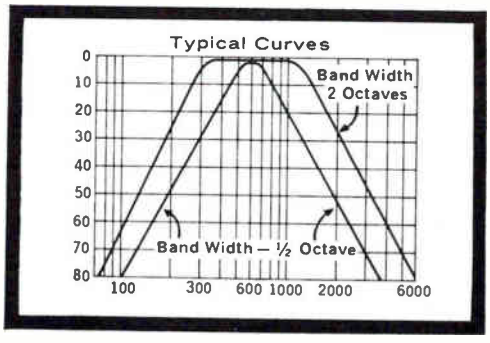


An Allison Filter in use at Bell Telephone Laboratories

Allison Variable Filters cover a frequency range of 1 cps to 640 kcps

Here's the answer for a general purpose, tunable, audio-frequency filter . . . an Allison Variable Filter. Allison Filters may be used as high cutoff, low cutoff or band pass filters. Requiring almost no maintenance, these passive network filters have a dynamic range in excess of 120 db. They are excellent for the analysis of transient noises since they have no internal noise and negligible ringing effect. 11 filter models . . . portable and rack mount . . . direct reading...prices start at $345.00...write today for attenuation curves, complete specifications, and prices.



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Charles E. Beck

David B. Smith

Donald G. Fink

Henry F. Argento

Philco Realigns Organization

ORGANIZATION alignments and personnel appointments for Ford Motor Company's new subsidiary, Philco Corp., have been announced by Charles E. Beck, president.

The new corporation is organized by staff and operating functions. Staff functions include finance, legal, engineering and research, government product planning and marketing, industrial relations, public relations, and organization and executive personnel planning. There are nine operating divisions.

Beck said Paul J. Miller, controller; William R. Wilson, treasurer; and Fred G. Reiter, president of Philco Finance Corp., will report to Gene McCormick, vice president-finance. Ernest E. Bareuther, assistant controller, will report to Miller.

The former Philco Research Division has been redesignated the Philco Scientific Laboratory. Donald G. Fink was appointed director reporting to David B. Smith, vice-president-engineering and research.

The former Government and Industrial Group has been reorganized. Henry F. Argento was appointed vice president-government product planning and marketing. Beck said the following executives of the former Government and Industrial Group will continue to report to Argento: Joseph M. Hertzberg, John B. Hunt, Harold E. Rice and A. P. Hill. James E. Leeper, manager of the corporation's Washington office, also will report to Argento.

The following general managers of operating divisions will report to Beck—Henry E. Bowes, Consumer Products Div.; Robert F. Herr, Techrep Div.; Harvey Williams, International Div.; William J. Peltz, Lansdale Div.; Clarence E. Burke, Computer Div.; Frank E. Stehlik, Communications and Weapons Div.; Elmer B. Garland, Communications Systems Div.; Oscar T. Simpson, Western Development Laboratories; and Willard Feldscher, Sierra Electronics Div.

Elect John Graham ITT Vice President

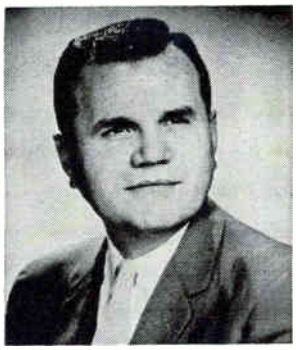
ELECTION of John J. Graham as a vice president of International Telephone and Telegraph Corp., New York City, is announced. He will also serve as executive assistant to the president.

Graham comes to ITT after 14 years with RCA, where his most recent assignment was division vice president, operations for electronic data processing.

Otarion Listener Changes Name

OTARION ELECTRONICS, INC., is the new name of Otarion Listener Corp., Ossining, N.Y. The new name describes more accurately the hearing aid manufacturer's expanding activities in miniaturized electronics, according to Leland E. Rosemond, president.

Otarion recently organized a microminiature controls division, which is concentrating on radio receivers, transformers and actuators, initially for model craft and later for virtually all electronic devices. Research, design, engineering and production of Otarion's hearing aids, audiometers and related equipment was assigned to a new, augmented hearing aid division.



Budd-Stanley Co. Names Anderson

BUDD-STANLEY CO., INC., Syosset, N. Y., has appointed Tore N. Anderson as vice president for engineering. Company produces precision microwave components and instruments.

Prior to this appointment, Anderson was president of FXR, Inc. and a director of Micromega Corp., an FXR subsidiary.

Joseph Boyd Joins Radiation Inc.

JOSEPH A. BOYD resigns his post as director of the Institute of Science and Technology at the U. of Michigan, to join Radiation Inc. at Melbourne, Fla., as vice president and

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CIRCLE 161 ON READER SERVICE CARD

assistant to the president.

Boyd has been consultant for the Institute for Defense Analysis since 1956, consultant for the National Security Agency since 1957, special consultant to the Army Combat Surveillance Agency since 1958, and member, then chairman of the Advisory Group on Electronic Warfare, Office of the Director of Defense Research and Engineering, since 1959.

Electro-Optical Systems Hires Prince

MORTON B. PRINCE, former corporate vice president of Hoffman Electronics, has joined the staff of Electro-Optical Systems, Inc., Pasadena, Calif., as manager of microelectronics.

In addition to his primary functions in the microelectronics area, Prince will also be active in the company's programs in advanced space power systems using photovoltaic solar cells.

Sprague Electric Names Moynihan

APPOINTMENT of John D. Moynihan as product specialist for high reliability capacitors at the Sprague Electric Co., North Adams, Mass., is announced.

Moynihan rejoins Sprague after a five-year period as chief engineer

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Columbium-Zirconium
Columbium-Titanium
Vanadium-X

These alloys are produced from our electron-beam refined, ultra-high purity materials. Experimental quantities of various compositions in rod, wire, and sheet form are immediately available.

MRC has just moved to a new plant, built to our specifications, on route 303 in Orangeburg, New York. The Advanced Materials Division has an atmosphere-controlled section, equipped with the newest quality control instruments and production tools. This care in production is reflected in the purity of our materials and the true homogeneity of our alloys.

MRC ADVANCED MATERIALS DIVISION
MATERIALS RESEARCH CORPORATION
Orangeburg, New York

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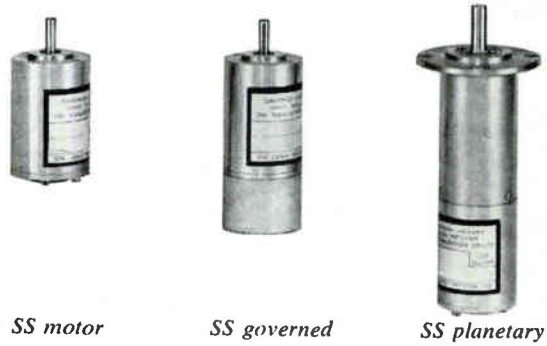

SS motor *SS governed* *SS planetary*

FAMILY OF 7/8" D.C. MOTORS

Basic Type SS p.m. motor produces up to 0.3 oz. in. @ 10,000 rpm continuous; 19 standard windings plus specials can meet your speed, torque, and power requirements. Size: 7/8" dia. x 1 3/8"; weight is 2 oz. Voltages 4 through 50 v.d.c. or more. MIL specs. Mechanically governed SS motors can regulate speed within 2%; electronic governors, within a few parts per million. Gear reducers further extend usefulness to 300 oz. in. torque; 21 standard planetary ratios, 28 standard spur gear ratios. If you need a still smaller motor, ask about Type SD (3/4" dia.) or VT (5/8" dia.). Request Bulletin SS from Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio.

GLOBE INDUSTRIES, INC.

CIRCLE 163 ON READER SERVICE CARD

and later sales representative for the Ferroxcube Corp. of America at Saugerties, N.Y. He had previously been carrier current development engineer with the former Sprague Moduline Department.

Tru-Connector Corp. Erecting New Plant

TRU-CONNECTOR CORP., Lynn, Mass., announces the construction of its new plant is underway. The 20,000 sq ft structure located in the Peabody Industrial Center is due for completion February 1st.

Company manufactures a varied line of r-f connectors and related components.

PEOPLE IN BRIEF

Philco Corp. promotes **Oscar Boyajian** and **James L. Maddox** to supervisor of applications programming and chief engineer, respectively, at its Computer div. **Carl L. Whittier** advances at General Communication Co. to the new post of manager of technical development. **Arthur C. Omberg,** a group executive, elected a v-p of The Bendix Corp. **John J. Iffland,** formerly with Raytheon Co., elected president of Acton Laboratories, Inc. **Claus Haake** moves up to mgr. of the Giannini Controls Corp. Research Laboratories. **Robert L. Edens** leaves Lenkurt Electric to join Moore Associates, Inc., as systems engineer. IBM Corp. elevates **H. Tyler Marcy** to v-p of the General Products div. **Robert D. Schmidt,** previously with Ampex Computer Products Co., appointed v-p/marketing of Electronic Memories, Inc. **James P. Ambrose,** ex-Clevite Transistor Products Co., named production mgr. for National Transistor Mfg., Inc. **Boris Beizer** leaves Philco Computer div. and joins the technical staff of Navigation Computer Corp. **Bruce M. Brown,** formerly with GE, now mgr.-product planning at Midwestern Instruments, Inc.

EMPLOYMENT OPPORTUNITIES

electronics

WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

ATTENTION: ENGINEERS, SCIENTISTS, PHYSICISTS

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

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

STRICTLY CONFIDENTIAL

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

WHAT TO DO

1. Review the positions in the advertisements.
2. Select those for which you qualify.
3. Notice the key numbers.
4. Circle the corresponding key number below the Qualification Form.
5. Fill out the form completely. *Please print clearly.*
6. Mail to: D. Hawksby, Classified Advertising Div., ELECTRONICS, Box 12, New York 36, N. Y. (No charge, of course).

COMPANY	SEE PAGE	KEY #
AMERICAN INSTRUMENT CO., INC. Silver Spring, Maryland	168	1
COLLINS RADIO COMPANY Dallas, Texas	122	2
DALMO VICTOR CO. Div. of Textron, Inc.	169	3
ERIE ELECTRONICS DIVISION Erie Resistor Corp. Erie, Pa.	168	4
GPL DIVISION General Precision Inc. Pleasantville, New York	75*	5
INSTROM ENGINEERING CORP. Canton, Mass.	73*	6
LITTON SYSTEMS INC. Data Systems Div. Canoga Park, Calif.	161	7
LOCKHEED-GEORGIA CO. Div. of Lockheed Aircraft Corp. Atlanta, Georgia	94	8
McDONNELL AIRCRAFT St. Louis, Missouri	167	9
MICROWAVE SERVICES INTERNATIONAL INC. Denville, New Jersey	75*	10
NATIONAL CASH REGISTER CO. Dayton, Ohio	168	11
SIKORSKY AIRCRAFT Div. of United Aircraft Corp. Stratford, Conn.	166	12
SPACE TECHNOLOGY LABS., INC. Sub. of Thompson-Ramo-Wooldridge Los Angeles, Calif.	169	13
P-7950	168	14

* These advertisements appeared in the 12/29/61 issue.

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electronics WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

Personal Background

NAME .....

HOME ADDRESS .....

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

HOME TELEPHONE .....

Education

PROFESSIONAL DEGREE(S) .....

MAJOR(S) .....

UNIVERSITY .....

DATE(S) .....

FIELDS OF EXPERIENCE (Please Check)

1562

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

CATEGORY OF SPECIALIZATION

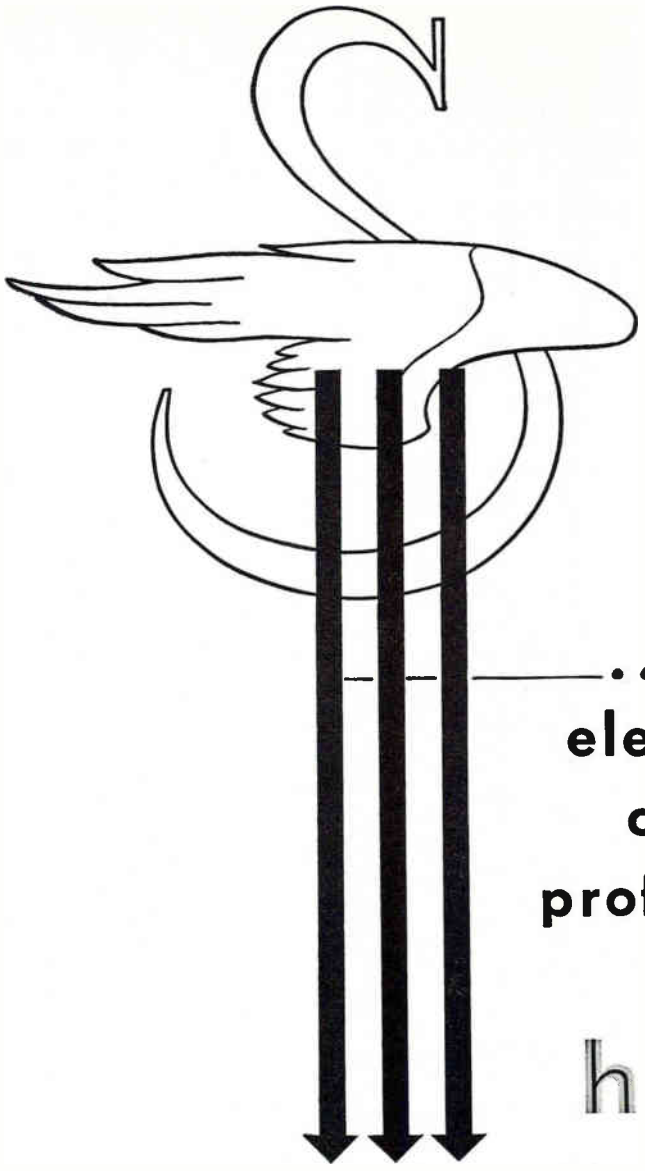
Please indicate number of months experience on proper lines.

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

CIRCLE KEY NUMBERS OF ABOVE COMPANIES' POSITIONS THAT INTEREST YOU

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

pioneer and leading manufacturer of rotary wing aircraft



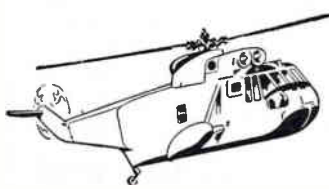
...at SIKORSKY electronic engineers can broaden their professional horizons in the field of helitronics

Today, as Sikorsky Aircraft's activities expand in significance and scope, particular emphasis is being directed to a sphere of activity which we term "*helitronics*". This area embraces a blending of two major technologies: *heli*copters and elec*tronics*. Specifically, helitronics means the integration of guidance and navigation systems, specialized electronic search and detection equipment to enhance the mission capability of the helicopter; specialized sensors and automatic controls to increase its versatility as an optimum military weapon system and a commercial carrier.

The need for more sophisticated electronic systems offers exceptional opportunities to competent electronic engineers with particular skills in: design • instrumentation • test • development • air-borne systems • production and service support equipment • trainers and simulators.

Unusually interesting openings as Avionics Instructors also exist for men with aircraft electronics experience and a desire to teach.

If you are interested in these career opportunities, please submit your resume, including minimum salary requirements, to L. J. Shalvoy, Personnel Department.



SIKORSKY AIRCRAFT STRATFORD, CONNECTICUT

DIVISION OF UNITED AIRCRAFT CORPORATION

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

ENGINEERS SCIENTISTS PHYSICISTS

LET'S SWAP RESUMES

MCDONNELL AIRCRAFT CORPORATION
LAMBERT • ST. LOUIS MUNICIPAL AIRPORT • ST. LOUIS 66, MISSOURI

PERSONAL:
Name: Mc Donnell
Address: St. Louis, Missouri
Age: 22 yrs.
Health: Free of Debt - Growing Aerospace Backlog
Physical Appearance: Complete, modern Aerospace Engineering, Research Laboratories and Production Facilities.
Size: Over 21,000
MILITARY SERVICE: Contracts with U.S. Navy, U.S. Air Force, U.S. Army and the NASA.

ACHIEVEMENTS:
FH-1 Phantom: First Navy jet fighter to land and take off a carrier.
F2H Banshee: Saw extensive combat in Korea.
F-101 Voodoo: Holder of 10 world records
F3H Demon: In service with the Navy
Quail GAM-72: Decoy Missile
F4H Phantom: World's record holder 2 mission fighter
Asset: Re Entry Research Spacecraft.
Mercury Spacecraft: Carried first American into Space.

FUTURE OBJECTIVE: To design and build, through innovation, those aerospace products which leap across the state of the art to become unique engineering achievements ahead of their time.

Please complete this form and forward to: Mr. D. F. Waters, Professional Placement, Dept. 62, McDonnell Aircraft, St. Louis 66, Missouri. *This is not an application for employment.* Your qualifications will be reviewed by our placement staff and you will be advised of positions at McDonnell for which you qualify. You may then make application if you wish.

Name _____ Address _____
City & State _____ Phone _____ Age _____
Primary Experience Area _____ Number of Years _____
Secondary Experience _____ Number of Years _____
Additional Comments _____

Education: AE ___ ME ___ Math ___ Physics ___ Chemistry ___ EE ___ Astronomy ___ Other ___
Degree: BS ___ Date ___ MS ___ Date ___ PHD ___ Date ___ I would like to receive application form ___

I would like to receive literature about professional opportunities at McDonnell ☐

My primary interest is:

☐ Airborne Communications
☐ Antenna & Microwave Techniques
☐ Automatic Test Equipment
☐ Computer Development
☐ Digital Technique & Logic Design
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The National Cash Register Company's Research and Development Division located in Dayton, Ohio has opportunity for experienced Senior Engineers and Scientists for the following positions:

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- DEVELOPMENT PLANNING STAFF — to conduct studies of electronic equipment requirements for AERO/SPACE projects with background in Microwave Equipment, Digital Computers Electro-Optical Devices, Human Engineering of Controls and Displays, or Navigation and Guidance Systems. Prefer M.S. in E.E. or Physics and 5-7 years experience in Military Development.
- ENGINEER ANALYST — to investigate multipath phenomenon relative high frequency communications. BS, EE and some graduate work in mathematics. Prefer experience in information theory and communications.
- ELECTRONIC ENGINEERS — BS, EE, 2-5 years in military electronics and familiarity with ground based or airborne equipment development.
- CIRCUIT ENGINEERS — BS, EE, 3-5 years in design of electronic equipment using solid state or vacuum tube circuits.
- LOGIC ENGINEERS—BS, EE, 2-4 years in design of digital logic circuits.
- COMPONENT ENGINEERS — BS, EE, 1-3 years in testing and evaluation of electronic components.
- COMMUNICATION SYSTEM ENGINEERS—BS, EE, 5-7 years in the high frequency communication area. Experience in propagation techniques.

To be considered for one of these challenging positions, send resume to:

Mr. T. F. Wade, Technical Placement, The National Cash Register Company, Main and K Streets, Dayton 9, Ohio.

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Ankara - Teheran - Karachi
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Contact them through this

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He makes it his business to read **electronics**. It keeps him well informed of up-to-the-minute events and developments in the electronics industry and the technology to which he contributes his experience.

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electronics
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CLASSIFIED ADVERTISING DIVISION
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(Classified Advertising)

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Experienced Engineers and Physicists will find stimulating assignments, career growth opportunities based on performance, and the opportunity to make significant individual contributions toward major state of the art advances in the areas indicated above.

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Symposium Interviews Washington, D. C. January 9-11, 1962

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Requirements:

Reliability Engineers—BS in Engineering or Physical Sciences with 5 or more years experience in aerospace or related industries in reliability programs, preferably including hardware design experience.

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Symposium interviews arranged at headquarters hotel by calling Mr. H. R. Stevens, EXecutive 3-5030, Tues., Jan. 9 thru Thurs. Jan. 11, or send resumes to Mr. H. R. Stevens at STL, an equal opportunity employer.

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P.O. Box 95005E, Los Angeles 45, Calif.

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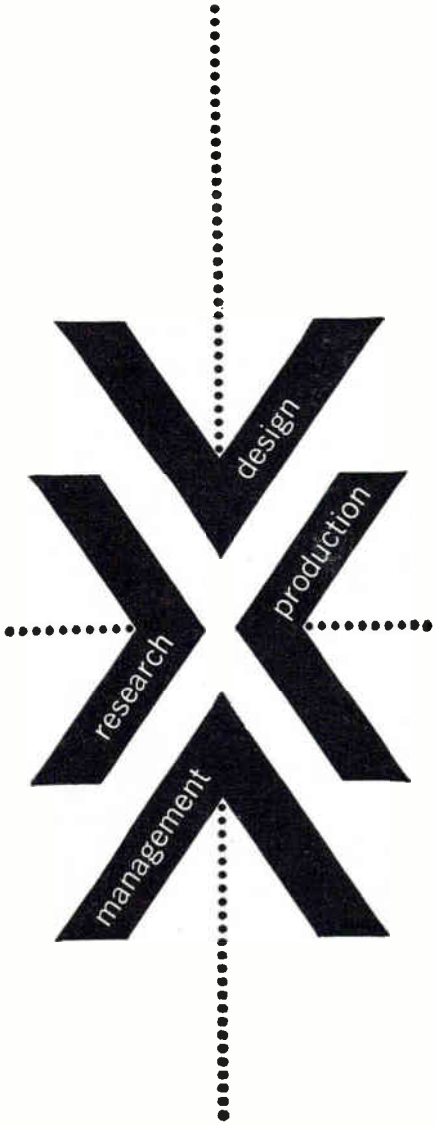

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electronics

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A SUBSIDIARY OF GENERAL MILLS

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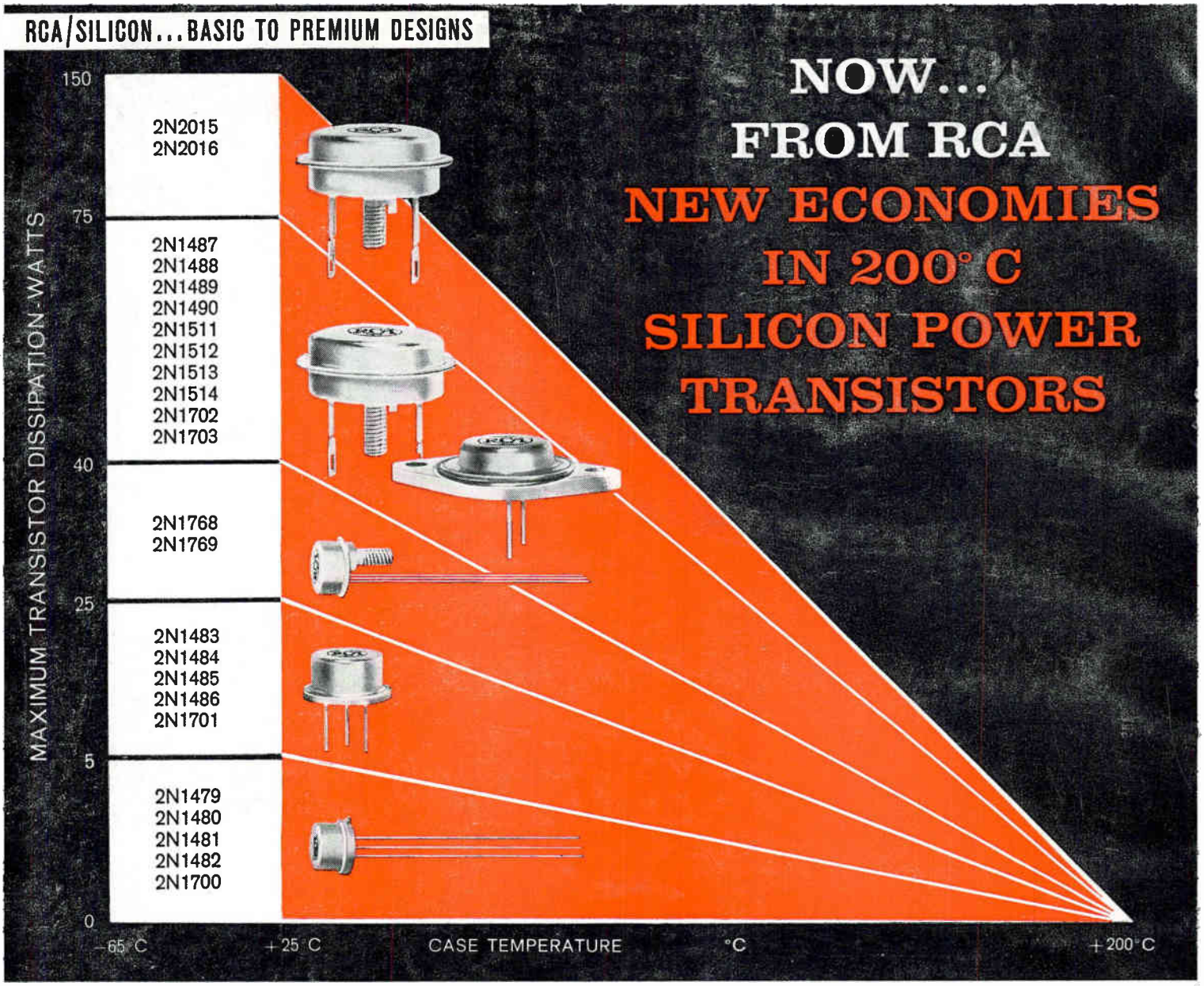

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