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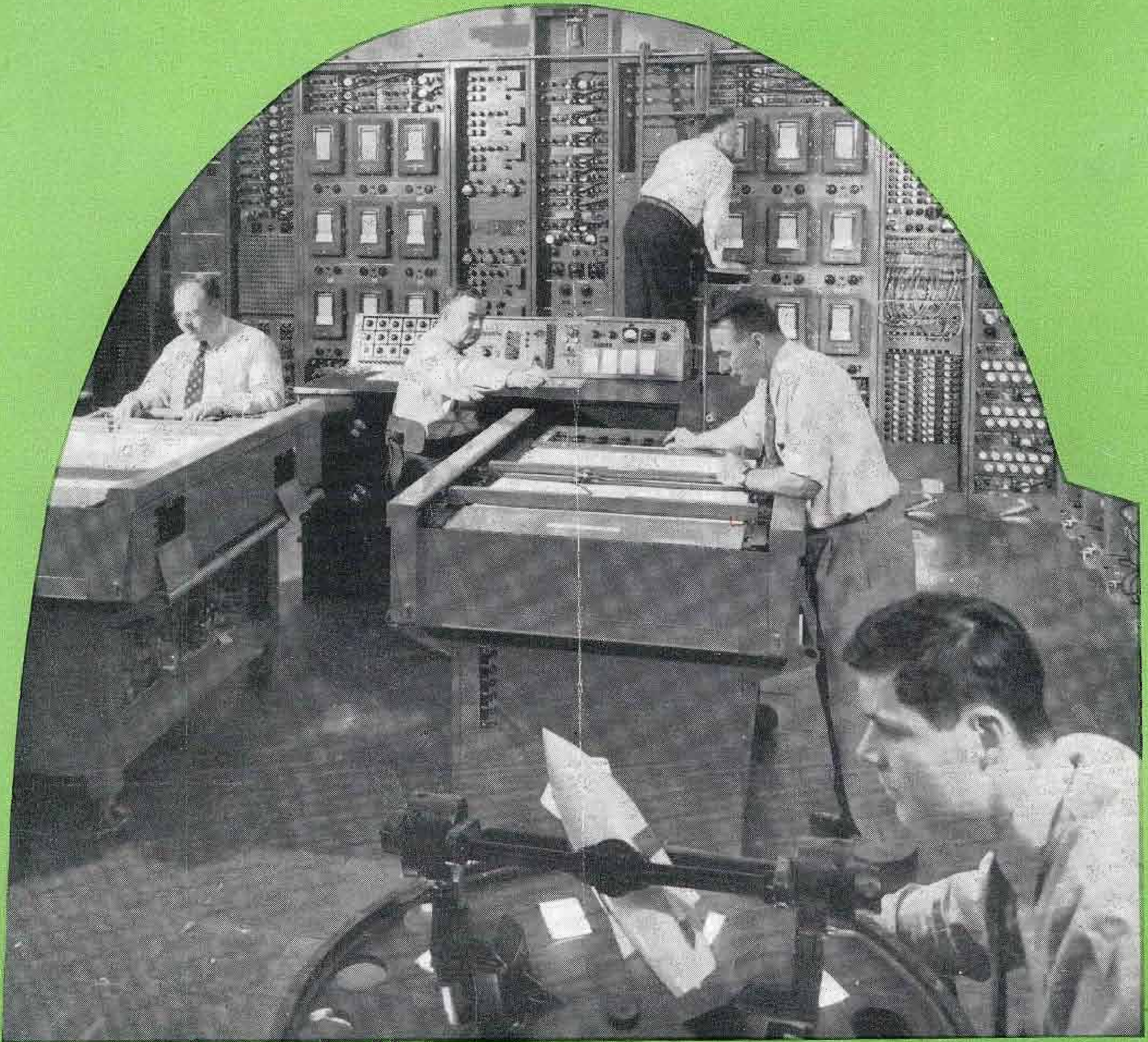
RADIO-TELEVISION-ELECTRONIC INDUSTRIES



Simulating guided missile test flights with Navy's "Typhoon" Computer now installed at Johnsville, Pa.

Crystal Diodes in the Millivolt Region

Magnetic Properties of Ferrite Materials

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Please Route to

May • 1952

TELE-TECH

RADIO-TELEVISION-ELECTRONIC INDUSTRIES

Edited for the 18,000 top influential engineers in the Tele-communications and Electronic Industries, TELE-TECH each month brings clearly written, compact, and authoritative articles and summaries of the latest technological developments to the busy executive. Aside from its engineering articles dealing with manufacture and operation of new communications equipment, TELE-TECH is widely recognized for comprehensive analyses and statistical surveys of trends in the industry. Its timely reports and interpretations of governmental activity with regard to regulation, purchasing, research, and development are sought by the leaders in the many engineering fields listed below.

•

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TELEVISION • FM • ELECTRONIC
LONG & SHORT WAVE RADIO
AUDIO AMPLIFYING EQUIPMENT
SOUND RECORDERS & REPRODUCERS
AUDIO ACCESSORIES
MOBILE • MARINE • COMMERCIAL
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CARRIER • RADAR • PULSE
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RECTIFIERS, TIMERS, COUNTERS
ETC. FOR
LABORATORY • INDUSTRIAL USE
ATOMIC CONTROL

Operation

Installation, operation and maintenance of telecommunications equipment in the fields of

BROADCASTING • RECORDING
AUDIO & SOUND • MUNICIPAL
MOBILE • AVIATION
COMMERCIAL • GOVERNMENT

MAY, 1952

FRONT COVER: THE ANALOG COMPUTER TYPHOON—affectionately dubbed The Monster—has recently been installed at the Naval Air Development Center, Johnsville, Pa. Developed to simulate guided missile performance, the 4000 tube machine gives three dimensional mathematical representation in the analysis of missile design. Total cost of the project is between $1,500,000 and $2,000,000. The computer is mounted on a "floating deck" to reduce vibration, and is cooled by a 70 ton refrigeration system. Power consumption is 65 kw, filament current is 1600 amps. Five principal operating voltages are super-regulated to within 0.001%. See page 102.

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Zero-drag omnidirectional range antenna for 108-122 MC designed especially to receive horizontally-polarized signals

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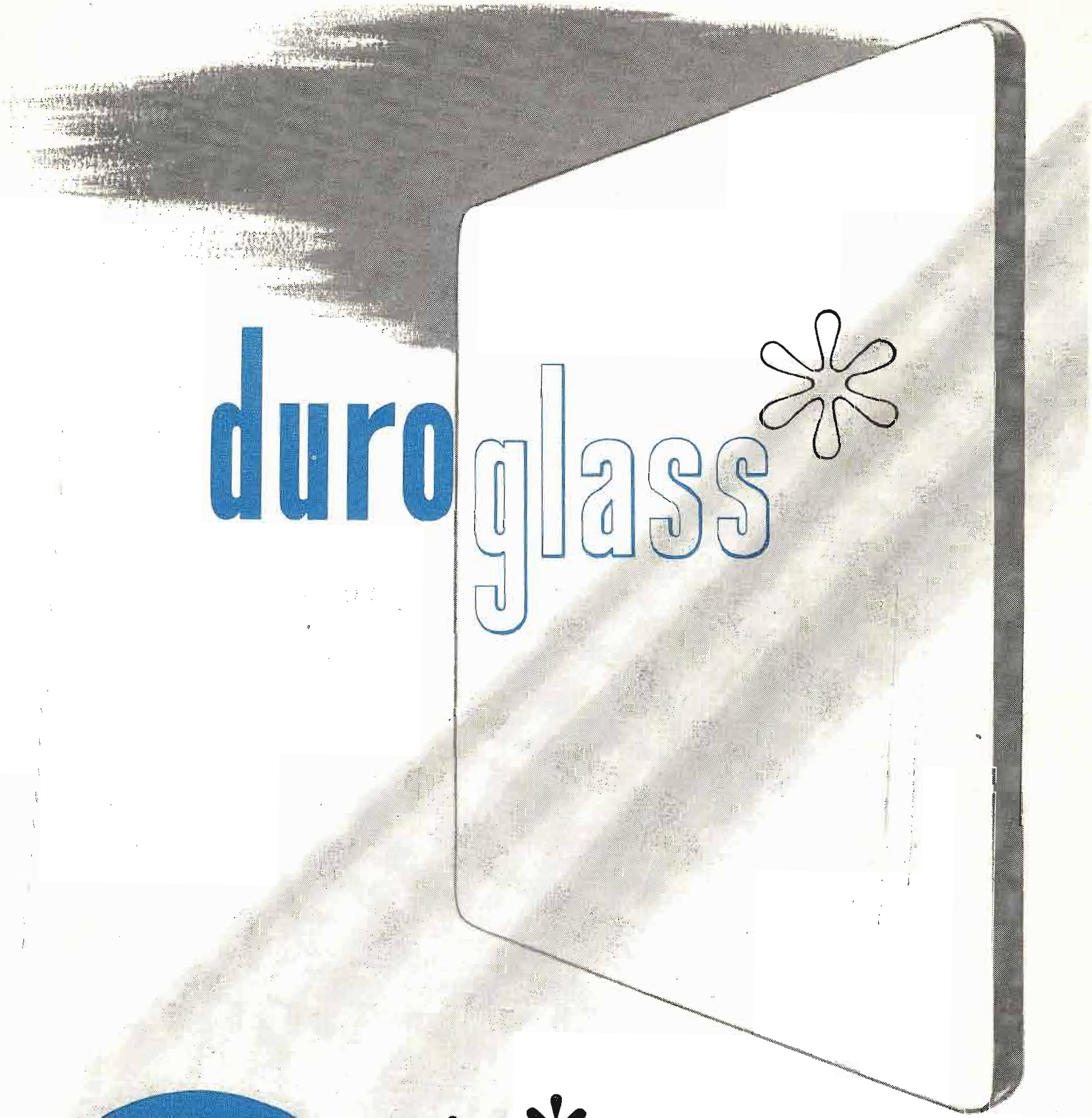

* duroglass is fully tempered to meet underwriters requirements for television implosion plates . . . available in $^7/_{32}$" or $^1/_4$" thickness, formed or flat.

There is no finer <u>tempered glass</u> for implosion plate use.

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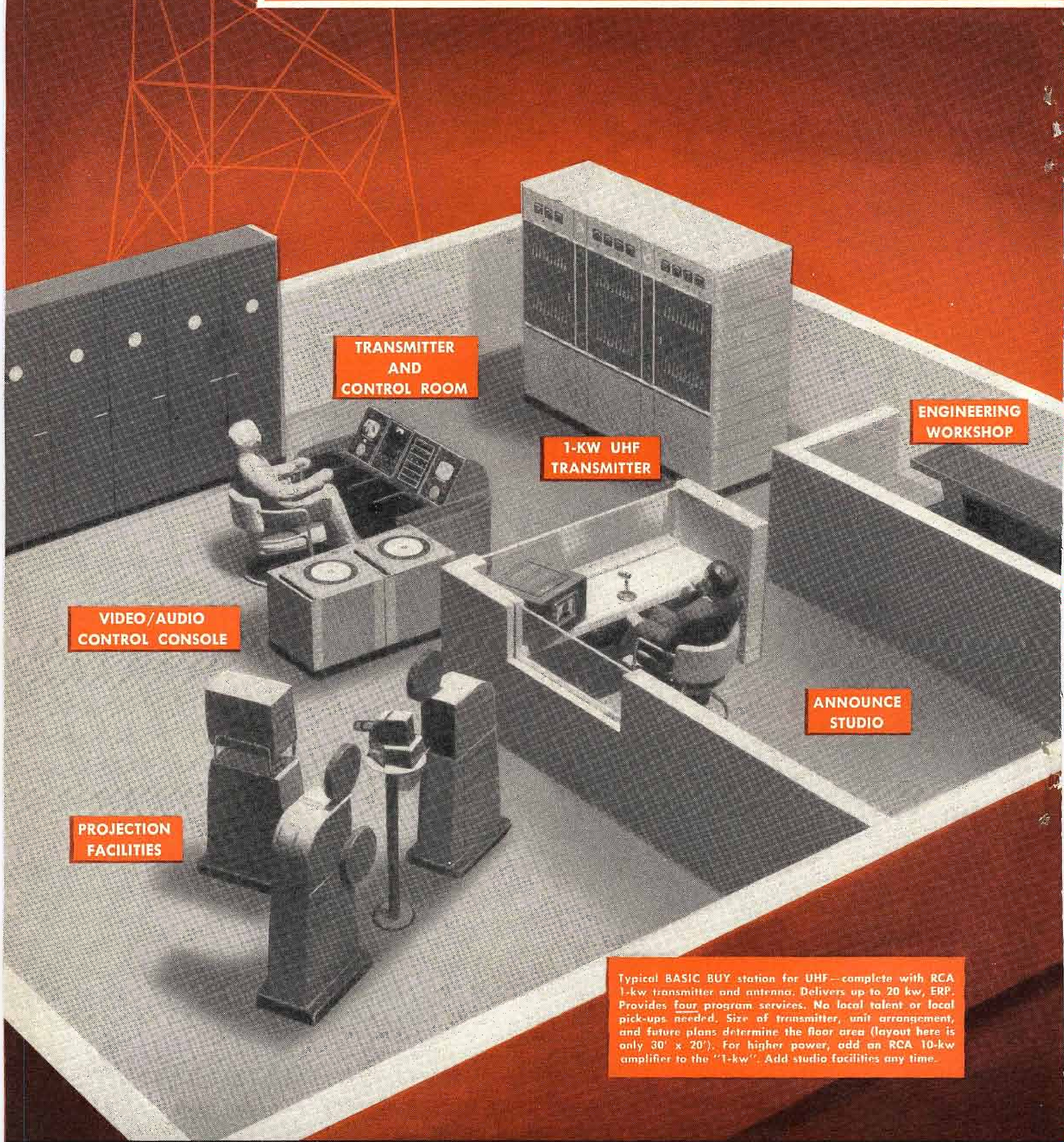
Fabricators of precision glass parts for industry

RCA's TV "Basic



Typical BASIC BUY station for UHF—complete with RCA 1-kw transmitter and antenna. Delivers up to 20 kw, ERP. Provides four program services. No local talent or local pick-ups needed. Size of transmitter, unit arrangement, and future plans determine the floor area (layout here is only 30' x 20'). For higher power, add an RCA 10-kw amplifier to the "1-kw". Add studio facilities any time.

"Buy" does the most

-with the least TV equipment -VHF or UHF!

4 PROGRAM SERVICES
— no local studios needed!

- Network programs
- Local films (16mm)
- "Stills" from local slide projector
- Test pattern from monoscope (including individualized station pattern in custom-built tube)

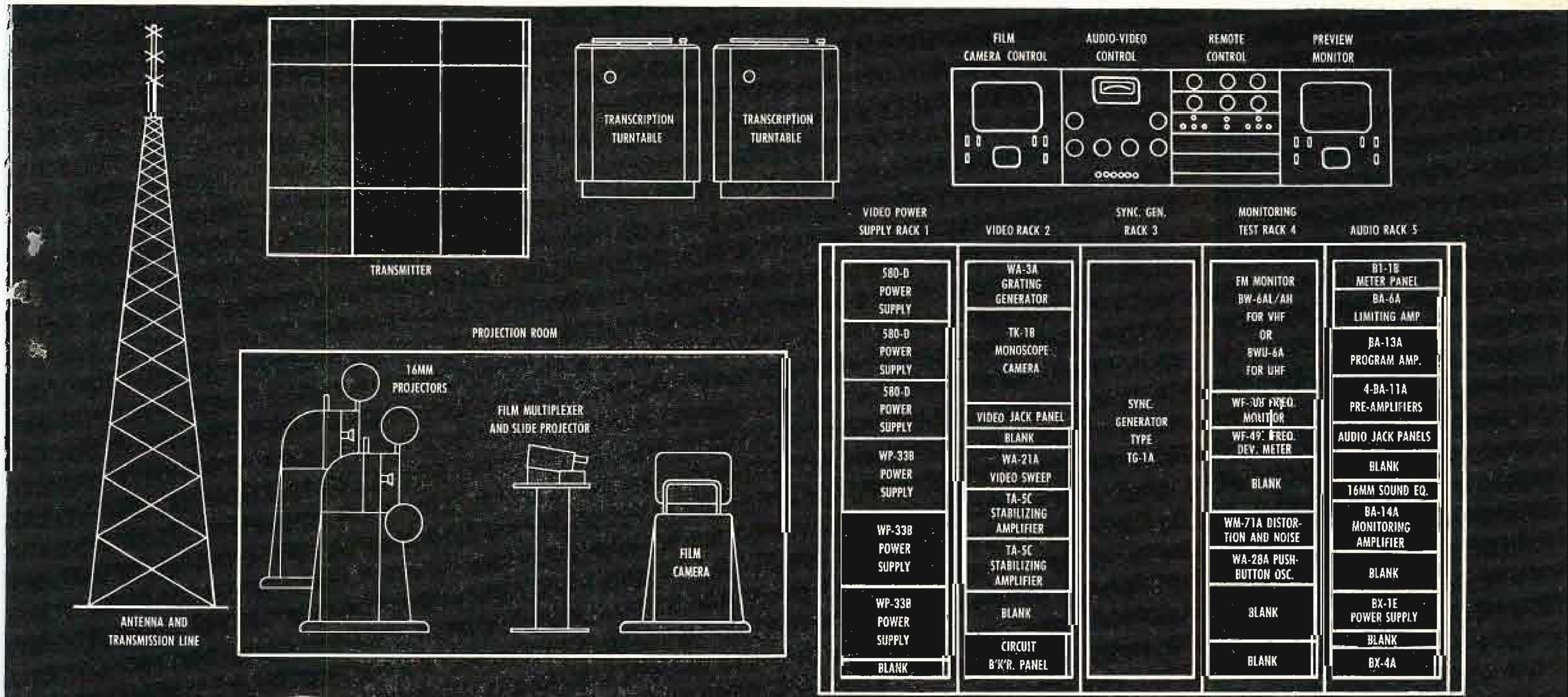
THIS PICTURE ILLUSTRATES what we think is the minimum equipment a TV station should have to start with—*and earn an income.* The arrangement can handle any TV show received from the network and provides station identification and locally inserted commercials as required. In addition, it offers an independent source of revenue—by including film and slide facilities for handling local film shows and spots, or network shows on kine recordings.

The BASIC BUY includes: A transmitter and an antenna (necessary for any TV station); monitoring equipment (required by FCC); film and slide equipment (for local programs—and extra income); monoscope camera for reproducing a test pattern of known quality (important for good station operation and as an aid to receiver adjustment); and a control console that saves operator time and effort (it enables one technical man to run the station during nearly all "on-air" periods).

RCA's BASIC BUY can be used in combination with any RCA TV transmitter and antenna, of any power—VHF or UHF. Matched design and appearance make it easy to add facilities any time (you need never discard one unit of a basic package). And note this: *RCA BASIC UNITS ARE IDENTICAL TO THE RCA UNITS USED IN THE BIGGEST TV STATIONS!*

RCA's BASIC BUY is already being adopted by many TV station planners. Let your RCA Sales Representative work out a flexible package like this for you—show you how to do the most with the least equipment!

This is what the BASIC BUY includes!



RADIO CORPORATION of AMERICA
ENGINEERING PRODUCTS DEPARTMENT CAMDEN, N.J.

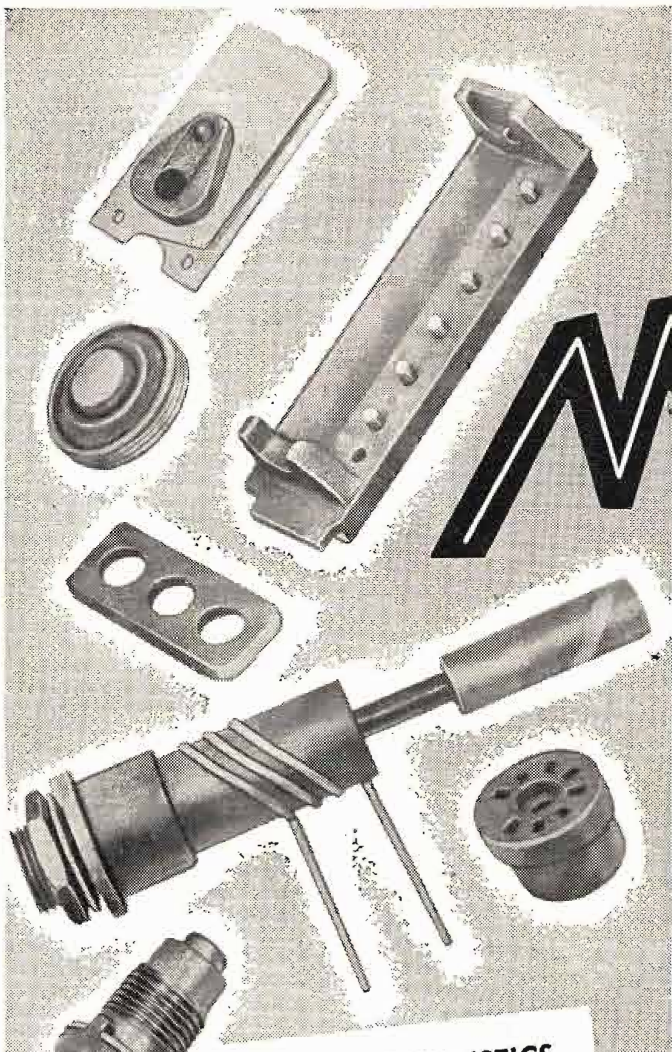
The Ideal Dielectric

FOR NEW UHF-TV APPLICATIONS

MYCALEX

Glass-Bonded Mica INSULATION

—for low loss at low cost!



- LOW-LOSS FROM 60 CYCLES/SECOND TO 24,000 MEGACYCLES/SECOND
- MAXIMUM EFFICIENCY, UTMOST ADAPTABILITY, LOWEST COST
- AVAILABLE MOLDED TO PRACTICALLY ANY SHAPE OR SIZE WITH OR WITHOUT METAL ELECTRODES OR INSERTS

FCC Approval of UHF TV has introduced an era of engineering and manufacture to standards seldom before attained in mass production. Many materials, dielectrics in particular, fail to meet these more critical requirements. MYCALEX 410 is one exception. This dielectric can be molded to close tolerances with or without metal inserts—high efficiency to well over 24,000 megacycles. MYCALEX 410 can be molded in volume at low cost. It can be produced to closer tolerances than higher priced ceramics. Electrically and mechanically, MYCALEX 410 is the ideal dielectric for tube sockets, tuners, condensers, switches, coil structures and many other UHF components.

CHARACTERISTICS OF MYCALEX GRADE 410

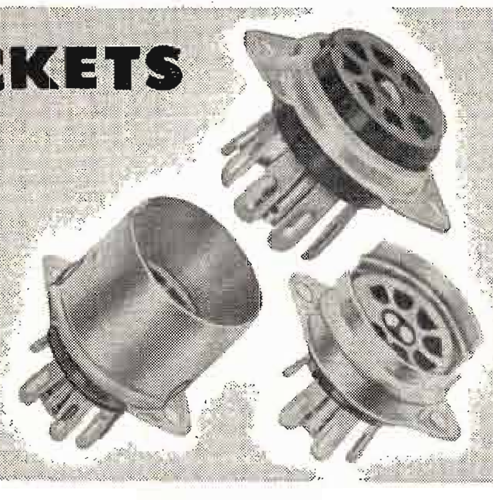
Power factor, 1 megacycle	0.0015
Dielectric constant, 1 megacycle	9.2
Loss factor, 1 megacycle	0.014
Dielectric strength, volts/mil	400
Volume resistivity, ohm-cm	1×10^{15}
Arc resistance, seconds	250
Impact strength, Izod, ft.—lb/in. of notch	0.7
Maximum safe operating temperature, °C	350
Maximum safe operating temperature, °F	650
Water absorption % in 24 hours	nil
Coefficient of linear expansion, °C	11×10^{-6}
Tensile strength, psi	6000

WRITE FOR 20-PAGE CATALOG
This comprehensive compilation of technical and manufacturing data includes complete dielectric information.

TUBE SOCKETS

MYCALEX glass-bonded mica sockets are injection molded to extremely close tolerance. This exclusive process affords superior low-loss properties, exceptional uniformity and results in a socket of comparable quality but greater dimensional accuracy than ceramics—all at no greater cost than inferior phenolic types. These sockets are available in two grades, featuring high dielectric strength, low dielectric loss, high arc resistance and fully meet RTMA standards.

Write for Tube Socket Data Sheets



MYCALEX 410 is priced comparable to mica-filled phenolics. Loss factor is only .015 1 mc., insulation resistance 10,000 megohms. Fully approved as Grade L-4B under N.M.E.S. JAN-1-10 "Insulating Materials Ceramic, Radio, Class L."

MYCALEX 410X is low in cost but insulating properties greatly exceed those of general purpose phenolics. Loss factor is only one-fourth that of phenolics (.083 at 1 mc.) but cost is comparable. Insulation resistance 10,000 megohms.

SINCE 1919 MYCALEX THE INSULATOR TRADE MARK REG US PAT OFF

MYCALEX CORPORATION OF AMERICA

Owners of 'MYCALEX' Patents and Trade-Marks

Executive Offices: **30 ROCKEFELLER PLAZA, NEW YORK 20** — Plant & General Offices: **CLIFTON, N.J.**

THE TRUTH ABOUT

GENERAL ELECTRIC has recently been deluged with letters, telegrams, phone calls and personal visits from electronic engineers, designers and equipment manufacturers seeking information about the availability and applicability of TRANSISTORS.

We believe these inquiries are directed to General Electric for several reasons:

- G.E. is the largest supplier of germanium products in the country.*
- More than 4½ million point contact germanium diodes were used by industry in 1951. General Electric made, sold, and delivered the largest portion of these.
- Point contact or whisker-type germanium transistors have been commercially available from G.E. for over three years (Types G11 and G11A).

**Of all manufacturers reporting through RTMA in 1951, G. E. delivered more germanium diodes than all others combined.*

- G-E Research and Electronics Laboratories have been developing junction germanium devices for several years.
- G.E. announced the first commercial junction (P-N) rectifier (G10 types) in October 1951 and these are now in production.

General Electric has developed several types of junction transistors (P-N-P) and these are now in product engineering. They have not been announced commercially because we want to establish the most desirable characteristics for your use. We want to improve their design without interrupting your program, and test them for stability and life. This is standard General Electric practice on new products and for this reason we cannot give you a specific calendar date for availability. It is fair to state that G.E. intends to lead in the production of transistors

You can put your confidence in—

TRANSISTORS

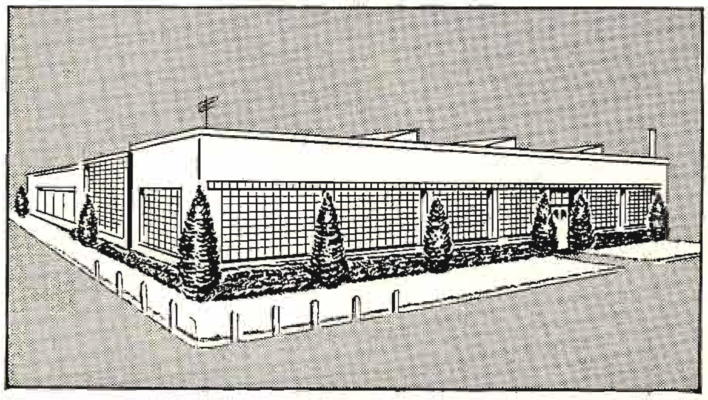
for commercial and government use as it has with diodes.

Many new and revolutionary devices are also under development in our laboratories: high power transistors: high power rectifiers: phototransistors: semiconductor pentodes: high frequency transistors. And many more—all to help you design better equipment.

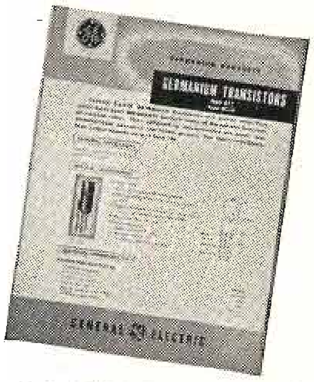
TRANSISTORS TODAY

Transistors have several advantages over other components. These include small size, no cathode power or warm-up time required, very high efficiencies, long life, ruggedness, stability.

Uses are limited today, however, by factors like frequency response (usually below 1 megacycle) and temperature effects (usable at temperatures only slightly above normal ambients at present). Both of these problems are being actively studied.



PLANT CAPACITY! A complete factory, employing upwards of 500 people, is devoted to the manufacture of G-E germanium products. Located at Clyde, New York, this modern installation is turning out diodes, rectifiers, and point contact transistors for your use now, and eventually will be producing junction transistors.



NEW TRANSISTOR BULLETIN! Just printed, this new illustrated bulletin gives you complete specifications on G-E point contact transistors (Types G11 and G11A). Write us and we'll mail your copy immediately. No charge. *General Electric Company, Section 4852, Electronics Park, Syracuse, New York.*

GENERAL ELECTRIC

TELE-TIPS

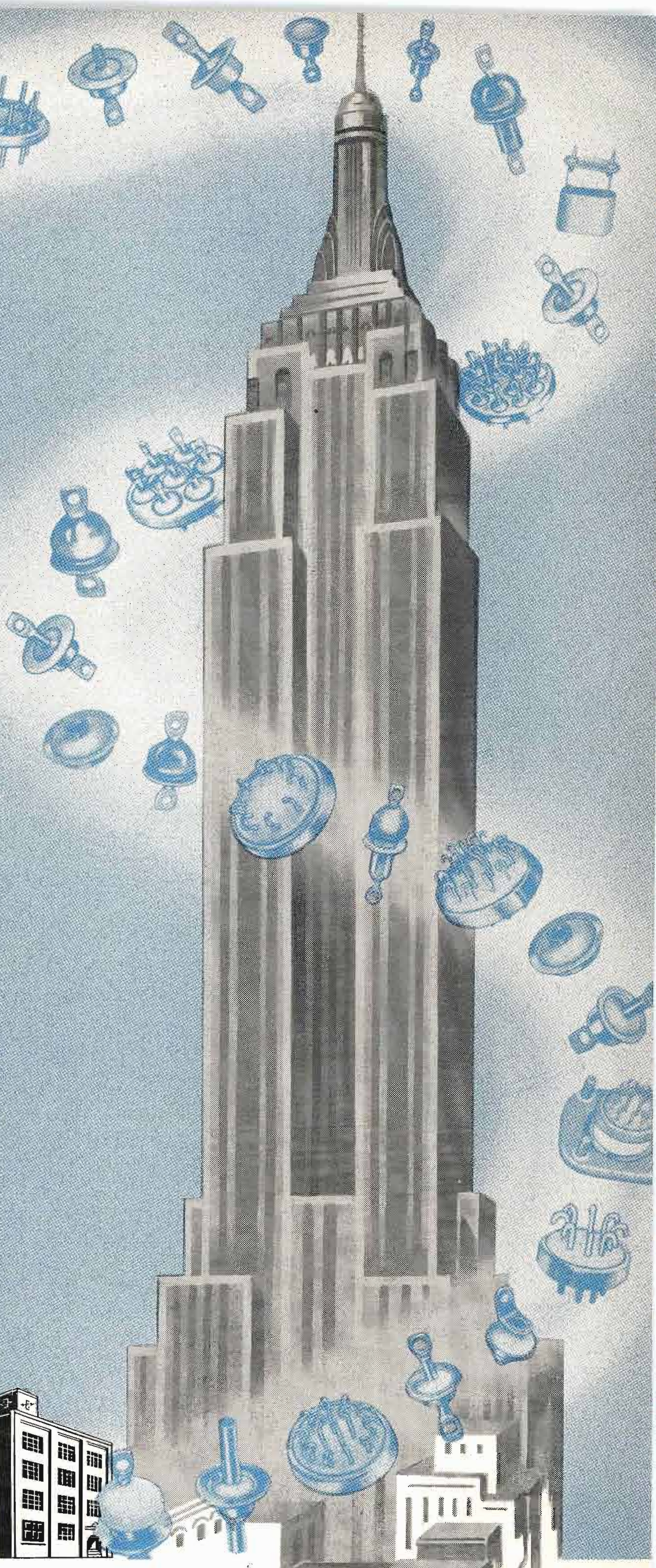
99% COPPER SAVING—Microwave radio systems for pipeline and power utilities use only 1% of the critical copper necessary to provide similar service by conventional telephone lines. At a meeting of the Southwest Interconnected Power Systems group committee, Walter E. Sutter, a G-E microwave specialist from Syracuse, N.Y., said that a 1000-mile six-channel communications system would require 30,000 to 40,000 pounds of copper if done by microwave, and more than 3,000,000 pounds if done by open-wire pole lines. He added that the microwave system would cost about half as much as the telephone system.

REPAIR BOOKS would have to accompany all TV and radio sets, if Congress ever passes the bill (H.R. 6219) recently introduced by Representative Walt Horan, Republican, of Washington State (5th District) who is a member of the House Appropriations Committee. Each failure to attach such instruction-and-repair book would subject the radio-TV manufacturer to a $5,000 fine and a year in jail. But don't worry—experts on "the Hill" predict no Congressional consideration will ever be given this bill, the author of which, it is reported, had some recent disagreeable experiences in getting his home radio devices repaired, and so decided that with simple instructions he could have easily made the repairs himself.

COMPUTER-TRANSLATER—Recently on the UCLA campus the National Bureau of Standards' SWAC—an electronic computer covering 90 sq. ft. of floor space—was put to work on a new task. Scientists were trying to teach it to speak German. Each of the thousands of electronic cells in the machine can store a signal and call it back when needed. A simple numbers-for-letters code turns each word into a digit signal that can be "remembered" in one of the cells. The machine then becomes a mechanical dictionary. Almost instantly the introduction of numbers standing for the letters of a German word triggers another set of numbers, which indicates letters of the English word. But teaching SWAC a language isn't

(*Continued on page* 12)

E-I production now reaching to 5½ TIMES the height of the Empire State Bldg. DAILY!



—the result of engineering ability devoted exclusively to producing

SEALED LEADS AND MULTIPLE HEADERS

Stacked singly, the hermetically sealed terminals produced every day by E-I would make a pile almost six times the height of the world's tallest building. This colossal volume illustrates the acceptance enjoyed by the E-I trademark wherever specifications call for hermetic sealing. If you have a sealed terminal problem, why not ask E-I engineers for a quick solution. Chances are you'll save time and trouble, not to mention the important advantage of custom quality at mass production prices.

WRITE FOR LATEST CATALOGS describing the many standard sealed terminals available for the economical solution of all but the most unusual circuit requirements. Also complete facilities for design and production of special types to specifications.

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44 SUMMER AVENUE, NEWARK 4, NEW JERSEY

TELE-TIPS

(*Continued from page 10*)

simple. A word in German may have several English equivalents. How select the one with the right shade of meaning? And verbs or adjectives in German have a different order in a sentence than in English. How teach the machine to rearrange them so the translation makes sense? It is problems like these the computer experts are now working to lick.

RADIO STARS—Radio astronomy has progressed significantly in the last 12 months. More "radio stars" were discovered, so that the total number is now well over a hundred. Some of the brighter spiral nebulae were found to be emitting radio waves in the micro region. With the radio "telescope," the prediction that between Milky Way stars there is invisible hydrogen that sends forth radio waves is now confirmed.

OLD TUBES WANTED—Leslie C. Rucker, Rucker Radio Wholesalers, 1312 Fourteenth Street Northwest, Washington 5, D. C., has been making a collection of vacuum tubes for many years and now owns some 300 tubes, many of them quite rare. A few types have disappeared from his collections, and he is now seeking replacements, including the following: Majestic Spray Shield (any types), RCA 523 Birdcage (Big rectifier metal), WD12 Brass base, N.U. crinkled plate 80, 81-82-83-83V (straight side (old)). Mr. Rucker asks "any one who has a few old tubes around which are just a nuisance," to send them to him and he will give full credit to the donors. Already Mr. Rucker believes he has a better selection than the National Museum. When he completes the mounting of these tubes, he invites radio old-timers when in Washington to drop into his office, adding: "I know they will get a big kick out of seeing many old friends among my collection."

THESE TIMES?—In a letter to John Adams in April, 1816, Thomas Jefferson wrote: "I think, with you, that it is a good world. . . . There are, indeed, gloomy and hypochondriac minds, disgusted with the present, and despairing of the future; always counting that the worst *will* happen, because it *may* happen. To these I say: What *grief* has been caused by the evils that never happen! I steer *my* bark with Hope in the head, leaving Fear astern. . ."

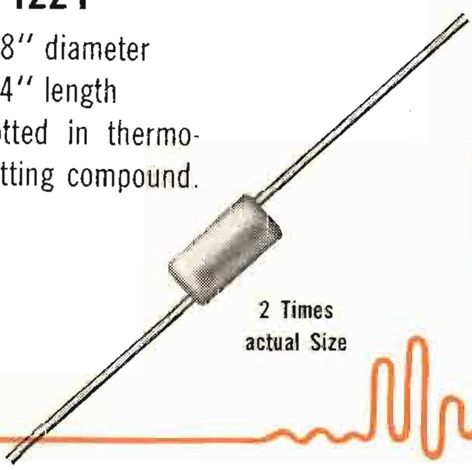
International RECTIFIER CORPORATION

EL SEGUNDO CALIFORNIA

Selenium Diodes

D-1224

1/8" diameter
1/4" length
Potted in thermo-setting compound.



2 Times actual Size

D-1290

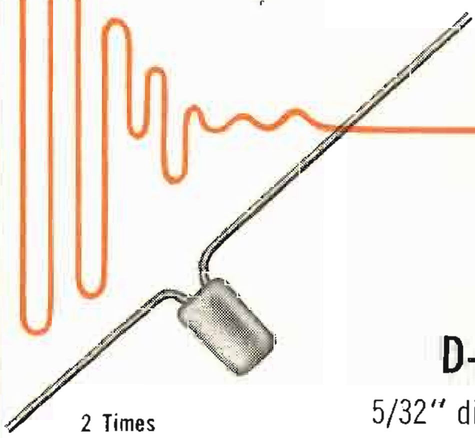
RMS applied voltage, max.	26 volts per cell
Peak inverse voltage	60 volts per cell
RMS input current, max.	3.75 milliamperes
DC output voltage	20 volts per cell
Voltage drop at full load	1 volt per cell
DC output current, avg.	1.5 milliamperes
DC output current, peak	20 milliamperes
Max. surge current	80 milliamperes
Reverse leakage at 10V RMS	2.4 microamperes
Reverse leakage at 26V RMS	12 microamperes
Frequency max. CPS	100 KC

Also available in 2, 3 and 4-cell Diodes.

D-1224

RMS applied voltage, max.	26 volts per cell
Peak inverse voltage	60 volts per cell
RMS input current, max.	500 microamperes
DC output voltage	20 volts per cell
Voltage drop at full load	1 volt per cell
DC output current, avg.	200 microamperes
DC output current, peak	2.6 milliamperes
Max. surge current	10 milliamperes
Reverse Leakage at 10V RMS	0.6 microampere
Reverse Leakage at 26V RMS	3 microamperes
Frequency max. CPS	200 KC

Also available in 2-cell Diodes.



2 Times actual Size

D-1290

5/32" diameter
9/32" length
Potted in thermo-setting compound.

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ROBINSON ENGINEERED MET·L·FLEX MOUNTING SYSTEMS FOR VIBRATION CONTROL

Savings *start* with the *design.* A Robinson engineered mounting system is designed for a specific piece of equipment *and* the conditions under which it must operate. It is not just a combination of a standard tray suspended on stock unit mounts, with potential misalignment and attachment problems.

Savings add up through model, prototype test and production stages. Since you are assured of permanent protection, your engineers can use less rugged components—often saving up to 20% of equipment weight and cost—yet gain better equipment performance.

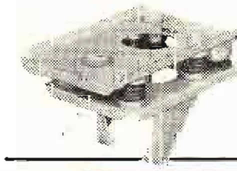
You save even more directly. The cost of a Robinson engineered system is often less than the total cost of unit mounts plus attachment tray—even when the extra assembly costs they entail are ignored.

During the last ten years every major electronic company, airframe manufacturer, airline and branch of the military service has called on Robinson to help solve some complex problem of vibration control. From these cooperative efforts have come many design "firsts" and basic shock mount improvements. Engineers everywhere have found that when *ounces* and *dollars* count—it pays to call on Robinson; to use the experience that comes only from years of specialized engineering.

Robinson engineered mounting systems, with their exclusive MET-L-FLEX elements, provide maximum vibration and shock protection at any altitude, in any part of the world—and do it *permanently.*

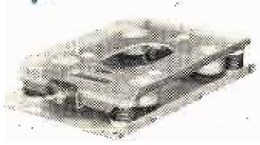
Start saving time and money today. Call on your nearest Robinson engineering representative.

Save on Design



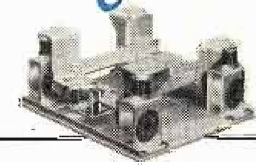
Give your mounting problems to experts in vibration control. Since 1942, Robinson has pioneered many new and effective air-borne mounts, including the first all metal design. Their efficient, production wise designs cut your development costs.

Save on Installation



Use complete MET-L-FLEX mounting bases to prevent misalignment and possible malfunctioning. Instead of the 16 mounting holes and drilling template required by unit mounting bases, Robinson engineered bases have 4 holes, all accurately prespaced.

Save Replacement Costs



Eliminate the usual servicing and replacement expenses. Robinson mounting systems never wear out; never rust; never weaken. They always deliver the same unvarying performance, regardless of environmental or operating conditions; aging or extremes of temperature.

Write for Technical Bulletin A-700

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ROBINSON AVIATION INC.

TETERBORO, NEW JERSEY

Vibration Control Engineers

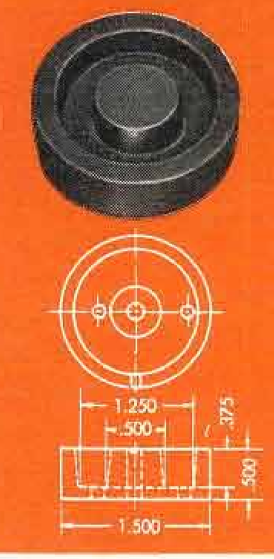
"SEA LEVEL PERFORMANCE AT ANY ALTITUDE"

FERRAMIC
TRADE MARK REG.
CORES

General Ceramics' **FERRAMICS** are soft magnetic materials featuring:

- **HIGH PERMEABILITY**
- **HIGH VOLUME RESISTIVITY**
- **HIGH EFFICIENCY**
- **LIGHT WEIGHT**
- **ELIMINATION OF LAMINATIONS**

• TYPE F-269

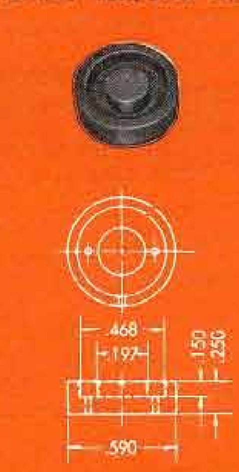


• TYPE F-210

For .145" hole, order F260

• TYPE F-211

For .096" hole, order F261



• TYPE F-188-187

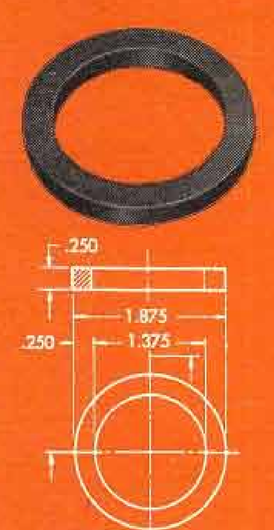
• TYPE F-167

Ferramics offer many important advantages as an electro-magnetic core material. The result has been wide adoption of this material in commercial and military electronic applications. We would welcome an opportunity to tell you how Ferramics can improve your components. For complete information call or write today.

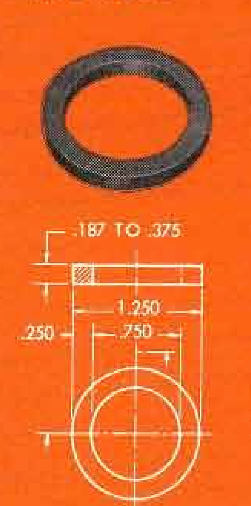
PROPERTY	UNIT	TYPE OF FERRAMIC MATERIAL B-90	C-159	E-212	H-419	I-141	J-472
Initial permeability at 1 mc/sec	—	95	250	750	850	900	330
Maximum permeability	—	183	1100	1710	4300	3000	750
Saturation flux density	Gauss	1900	4200	3800	3400	2000	2900
Residual magnetism	Gauss	830	2700	1950	1470	700	1600
Coercive force	Oersted	3.0	2.1	0.65	0.18	0.30	.80
Temperature coefficient of initial permeability	%/°C.	0.04	0.4	0.25	0.66	0.3	0.22
Curie point	°C.+	260	330	160	150	70	180
Volume resistivity	Ohm-cm	$2x10^5$	$2x10^3$	$4x10^5$	$1x10^4$	$2x10^5$	—
Loss Factor: at 1 mc/sec	—	.00016	.00007	.00008	.00030	.0003	.000055
at 5 mc/sec	—	.0011	.0008	.002	.00155	.005	—
at 10 mc/sec	—	—	—	—	.00275	—	—

High frequency materials are available up to approximately 150 megacycles; write for details.

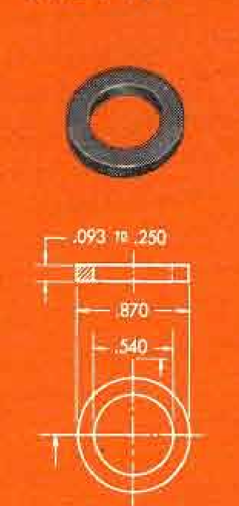
• TYPE F-108



• TYPE F-268



• TYPE F-109



• TYPE F-235

- TYPE F-219 8 — 32 x .500
- TYPE F-234 10 — 32 x .625
- TYPE F-244 1/4 — 28 x .750
- TYPE F-245 5/16 — 20 x .750
- TYPE F-246 3/8 — 16 x .750

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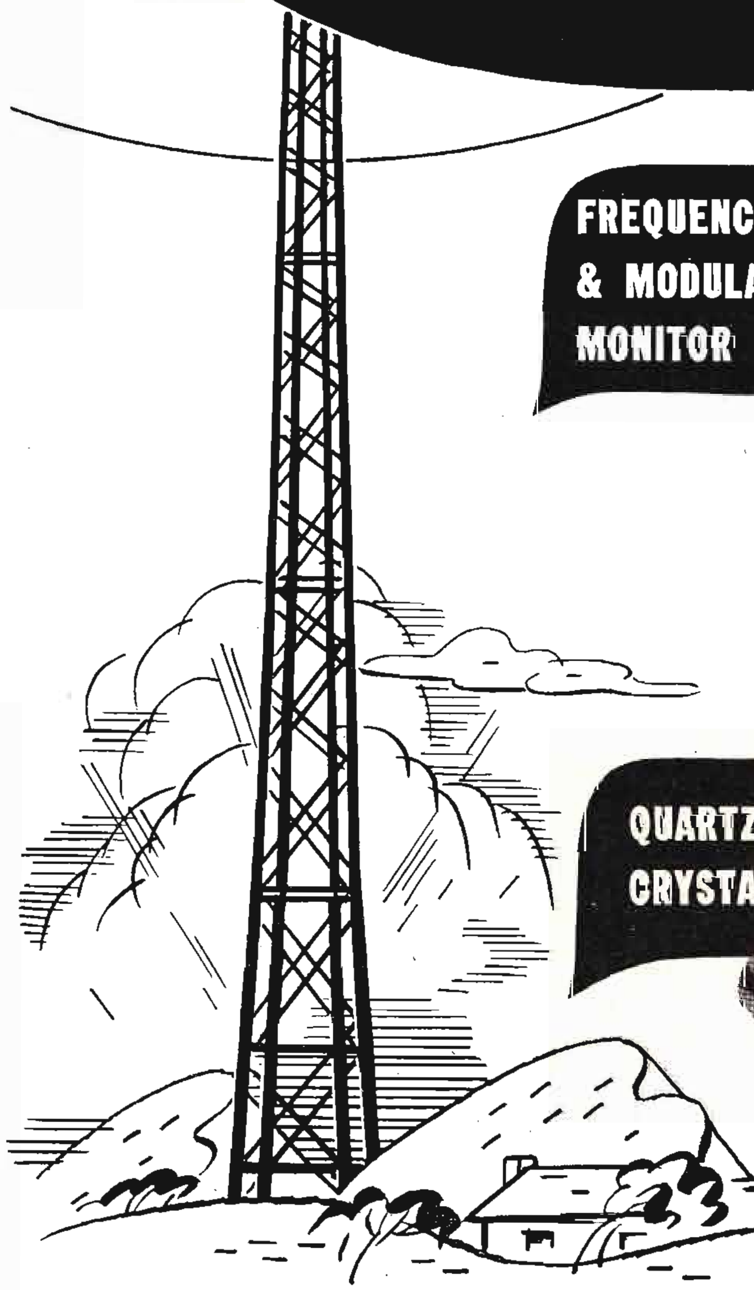
JAMES KNIGHTS



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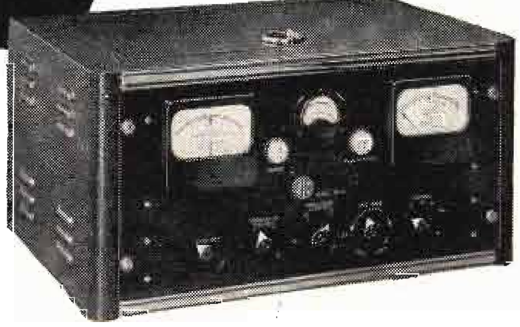
FREQUENCY & MODULATION MONITOR

The JK FD-12 monitors any four frequencies anywhere between 25 mc and 175 mc, checking both frequency deviation and amount of modulation. A truly precise instrument for communication systems!



When used for different bands, plug-in type antenna coils provided. Crystal accuracy guaranteed to be ± .0015% over range of 15° to 50° C. Meets or exceeds FCC requirements.

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QUARTZ CRYSTALS

Regardless of model, type, or design, James Knights can provide you with the very finest in stabilized crystals. Today JK crystals are used everywhere communications require the VERY BEST.

Well known to every communications man is the famous JK Stabilized H-17, with a frequency range of 200 kc to 100 mc. But this is just one crystal in the JK line. Write for complete crystal catalog!

ALSO manufacturer of the James Knights Frequency Standard.

THE JAMES KNIGHTS COMPANY
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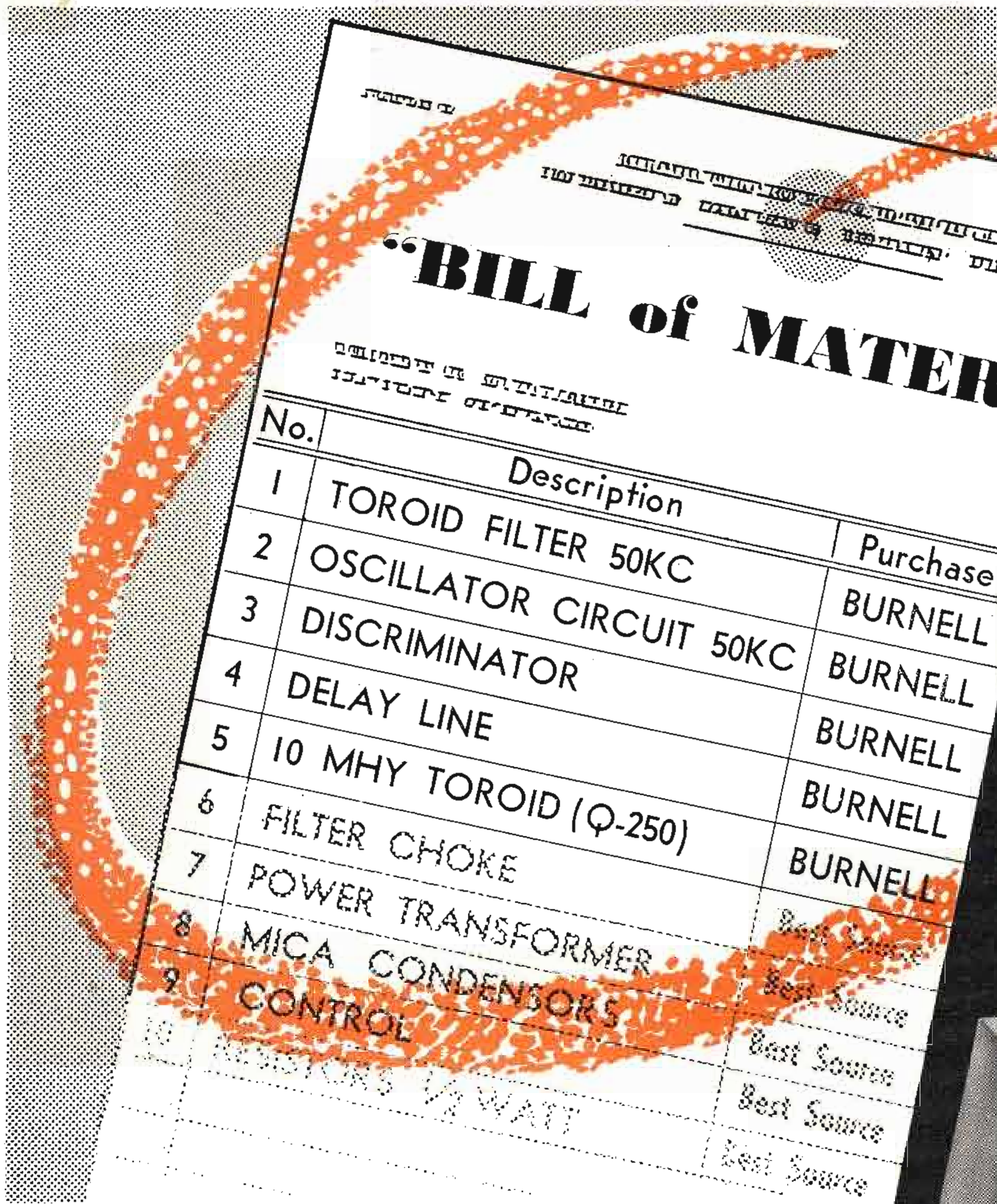
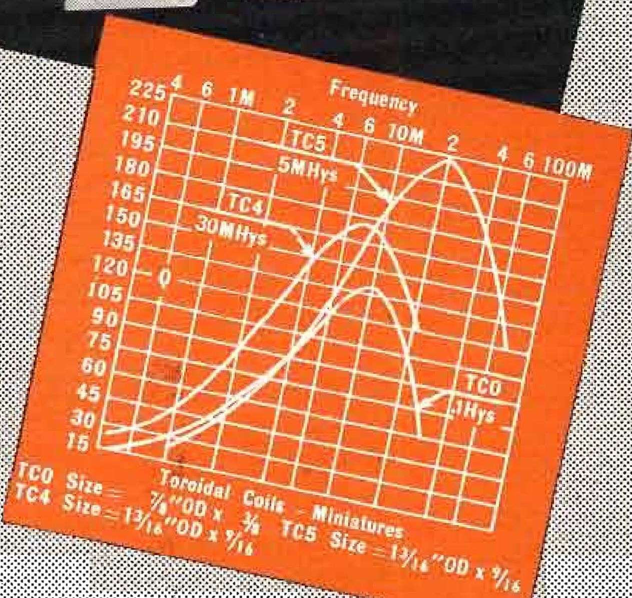
JK PRODUCTS



PREFERRED SOURCE FOR QUALITY TOROIDS & FILTERS



For every "Burnell" toroid or filter specified in the bill of materials for Electronic equipment, we chalk up another credit for our "Burnell Customer Service."

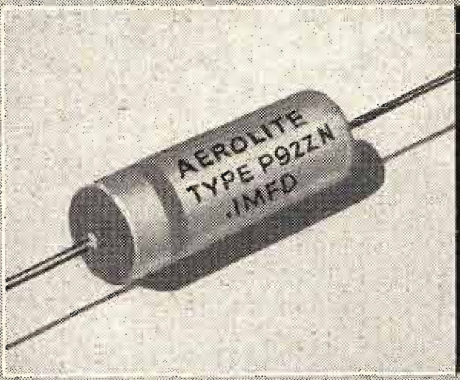
In this highly specialized and technical field, individual attention to the customer's problem assures him of obtaining the best filter for his application. It is the job of our engineering sales department to thrash out every detail of the customer's problem until it is sure that the specifications will guarantee correct performance.

The next step would be to choose from our file of thousands of designs, one which meets the requirements. In many instances, of course, it is necessary to create an original design but *at no extra cost to the customer*. In either case, we can state unequivocally, that the result is invariably one of customer satisfaction. This is why Burnell has been the "preferred source" with so many engineers.

EXCLUSIVE MANUFACTURERS OF COMMUNICATIONS NETWORK COMPONENTS

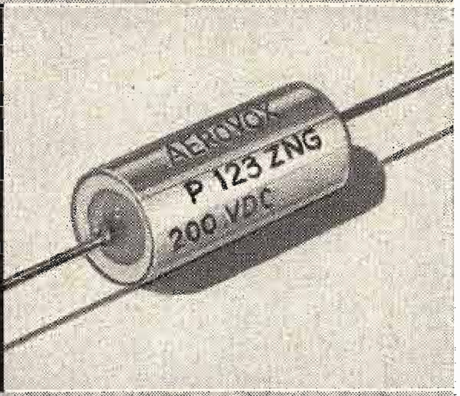
Burnell & Company
YONKERS 2, NEW YORK
CABLE ADDRESS "BURNELL"

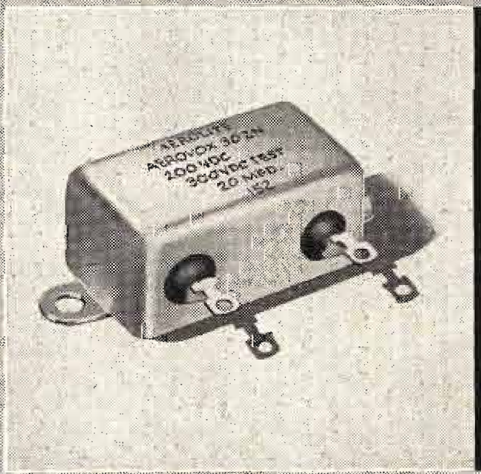
high-temperature metallized-paper capacitors



Series P92ZN Aerolene-impregnated metallized-paper capacitors are modified plastic-tubular duranite-end-sealed units in paper cases. Operating temperatures of −30°C. to +100°C. 200, 400 and 600 V. D.C. 0.01 to 2.0 mfd.

Series P123ZNG Aerolene-impregnated metallized-paper capacitors housed in tubular metal cases with vitrified ceramic terminal seal. Operating temperature range of −55°C. to +100°C. at full rating: to +125°C. at 75% of voltage rating. 200, 400 and 600 V.D.C. .0005 to 2.0 mfd.

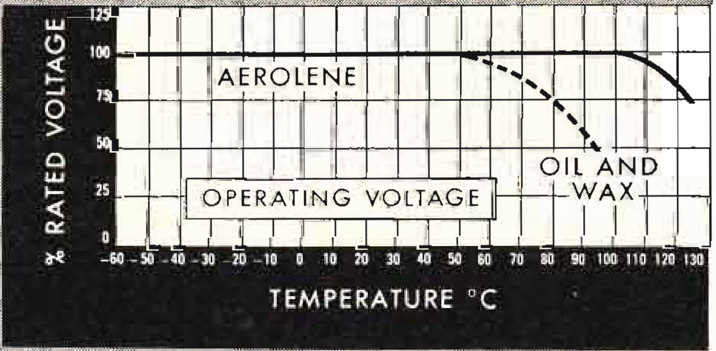




Series P30ZN Aerolene-impregnated metallized-paper capacitors housed in "bathtub" metal cases with vitrified or glass terminal seals. Operating temperature range of −55°C. to +100°C. at full rating; to +125°C. at 75% of voltage rating. Capacitances available from 0.1 mfd. up to 15.0 mfd. at 150 V. D.C., and up to 3.0 mfd. at 600 V. D.C.

Once again, Aerovox is privileged to blaze the capacitor-development trail. For these high-temperature metallized-paper capacitors are definitely Aerovox "firsts" in *conception, production* and *application*.

Their truly phenomenal acceptance is due to (1) The *Space Factor*, especially when *miniaturization* is a prime consideration; (2) *Reliability*, particularly in meeting voltage peaks or surges, by taking advantage of their self-healing characteristics; and (3) *Wide Operating Range*, from sub-zero to elevated temperatures.



Let us quote on your metallized-paper capacitor needs. Or if you are not already familiar with metallized-paper advantages, our engineers will gladly show you how they can fit your functions and circuits.

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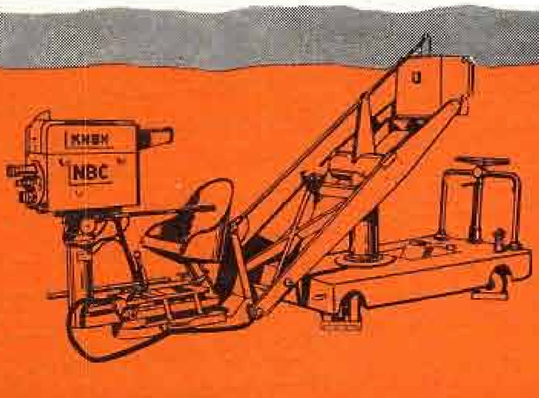
NEW TV CRANE by *Houston-Fearless*

Extreme versatility, maneuverability and ease of operation are combined in the new Houston-Fearless TV Crane, model TC-1. It provides new convenience and comfort for the cameraman. It allows continuous shooting while raising or lowering camera boom from 9'-6" (lens height) high to 3'-6" low, two types of smooth panning, steady rolling-dolly shots or any combination of these actions. High Houston-Fearless quality for complete dependability. This is the perfect answer for top-flight television showmanship.



Write for complete information on the new Houston-Fearless TV Crane, model TC-1 and other television studio equipment.

The* HOUSTON FEARLESS *Corporation

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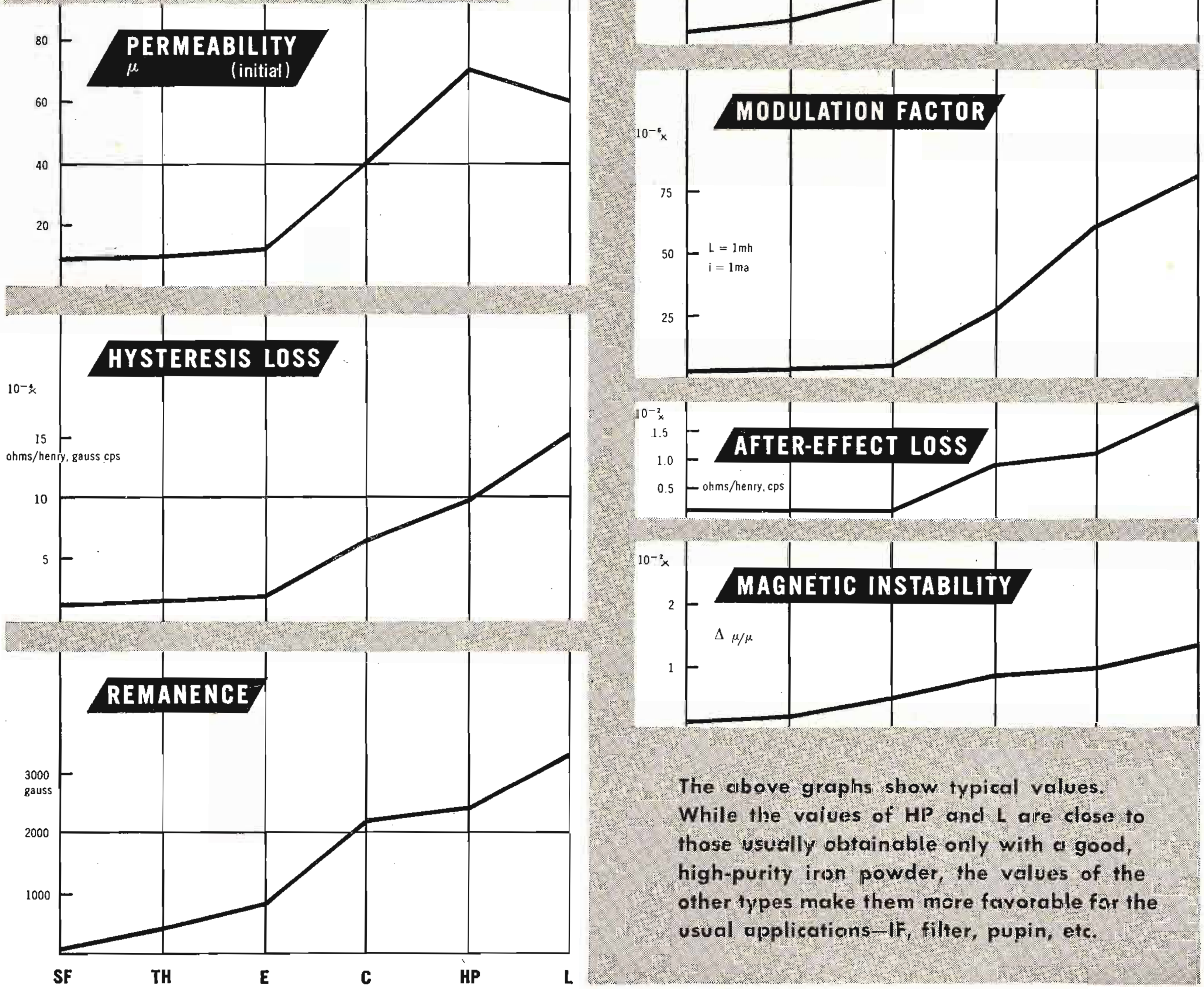
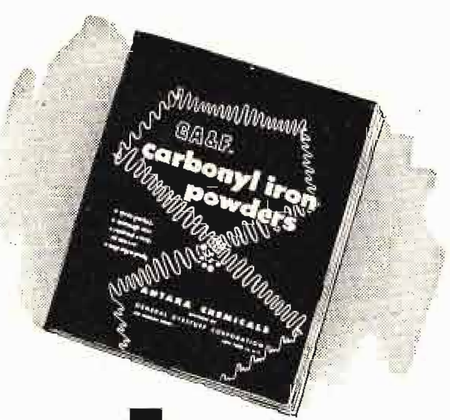
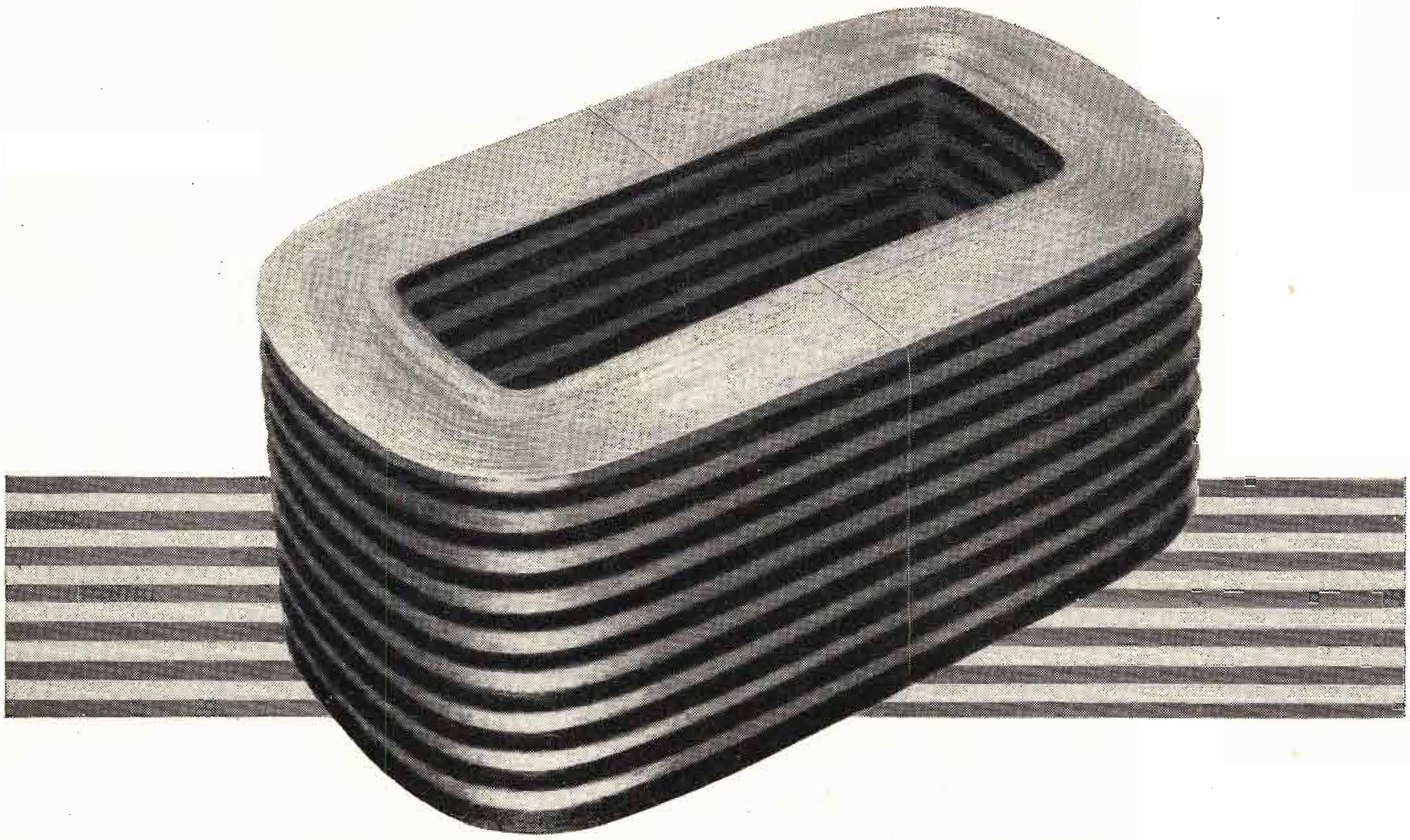


The above graphs show typical values. While the values of HP and L are close to those usually obtainable only with a good, high-purity iron powder, the values of the other types make them more favorable for the usual applications—IF, filter, pupin, etc.

THIS WHOLLY NEW 32-PAGE BOOK *offers you the most comprehensive treatment yet given to the characteristics and applications of G A & F Carbonyl Iron Powders. 80% of the story is told with photomicrographs, diagrams, performance charts and tables. For your copy —without obligation—kindly address Department 25.*



G A & F® Carbonyl



NEW RIBBED DESIGN stabilizes core performance!

Latest in a long line of transformer core advancements, ribbed design gives additional stability to the inherent high level of Hipersil® Core performance.

Because this improvement adds to the mechanical strength of the core, it minimizes the possibility of springing the sections, thus keeps the matching etched core surfaces in intimate contact. This assures the best in a low-reluctance, low-loss butt joint. Ribbed cores have the same sizes and tolerances as superseded non-ribbed cores.

You can cut size, weight and assembly costs in all types of electrical and electronic transformers with Hipersil Cores. They combine highest permeability with lowest losses in a wide range of sizes, for all frequencies (1 through 12 mil cores). Greater flux-carrying capacity, increased mechanical strength help make them the best core on the market. For specific information on how to apply them to your product, write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-70629

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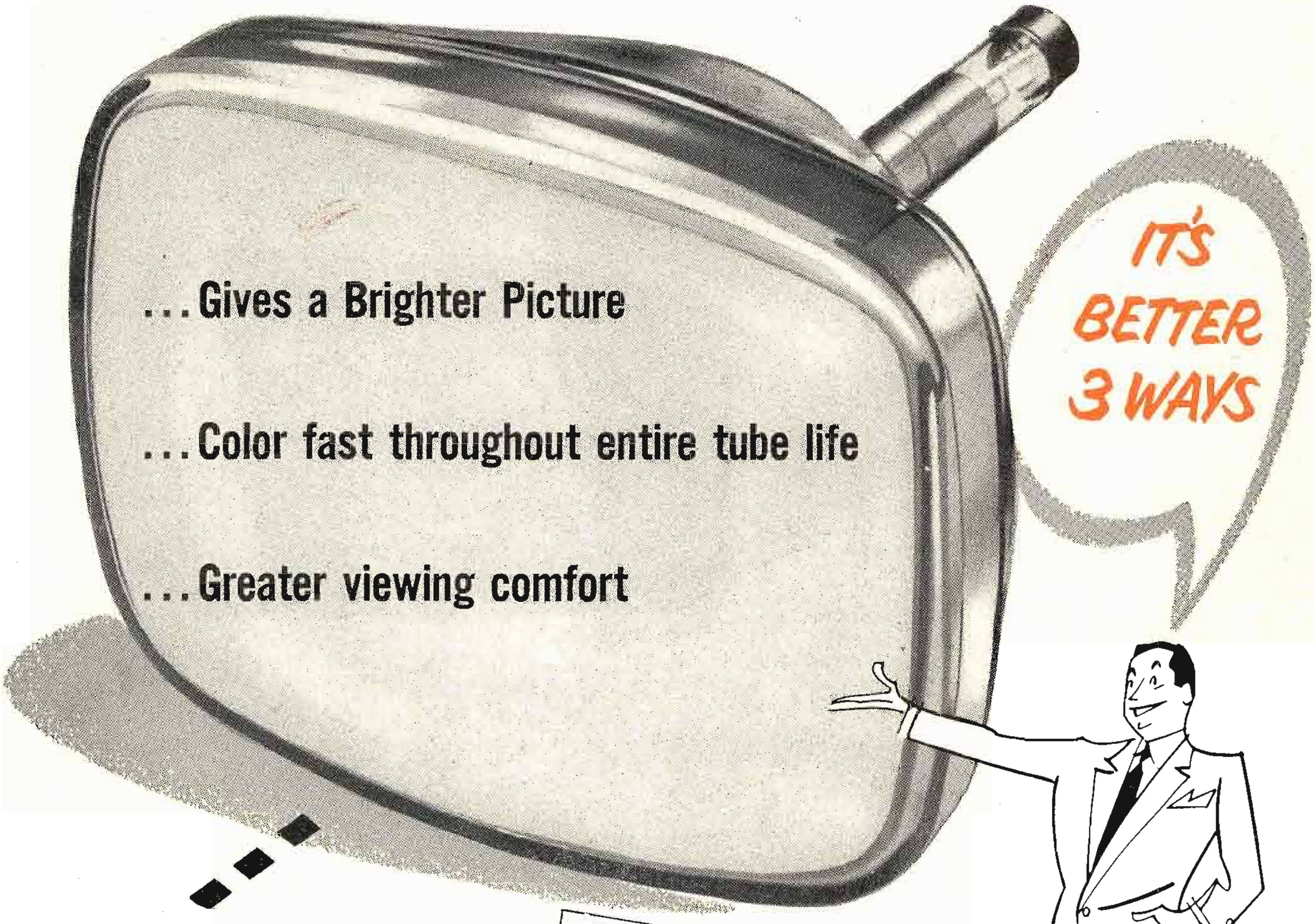
HIPERSIL CORES

Another Sylvania Achievement

...an improved Picture Tube Screen



Once again Sylvania's research in fluorescent phosphors plus vastly increased plant and laboratory facilities pay off in a new improved *picture tube screen.*

This improved screen gives more light output at anode voltages below 14kv. It is absolutely color fast and will remain free from screen discoloration for the life of the tube itself.

This new Sylvania screen is now standard on all Sylvania Picture Tubes . . . from 7-inch to 21-inch . . . round or rectangular.

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Television set manufacturers now receive a full year's guarantee on every Sylvania Picture Tube. If any Sylvania Picture Tube fails within one year from date of shipment from our factory or warehouse, full replacement will be made to the set manufacturer. This guarantee reflects Sylvania's confidence in the superior quality and longer life of Sylvania Picture Tubes. It's your assurance of the best in picture tube performance.

For full details call your Sylvania Representative or write: Sylvania Electric Products Inc., Dept. R-3505, Seneca Falls, N. Y.

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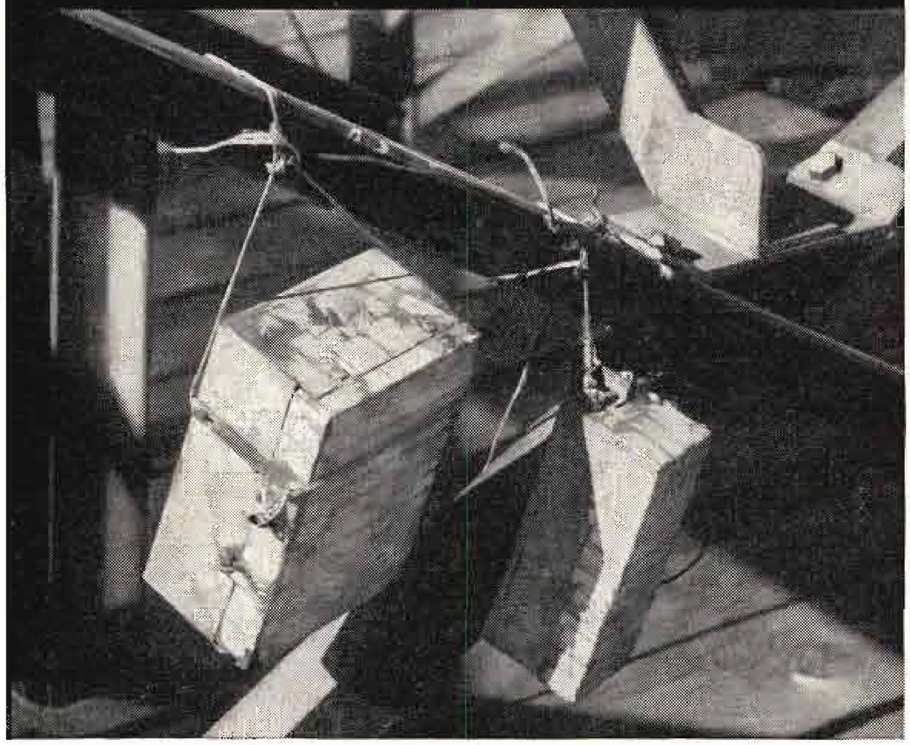
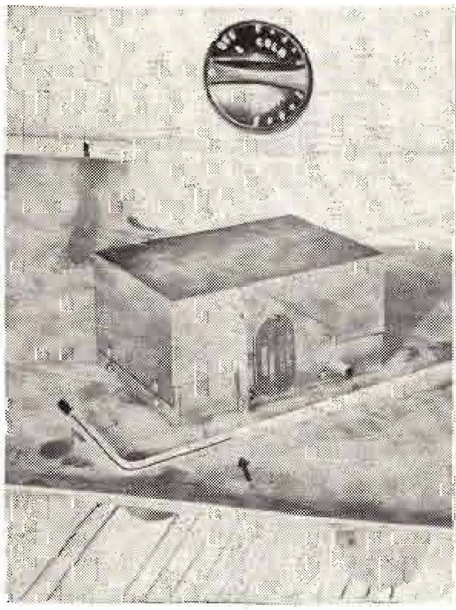
motorola 2-way radio

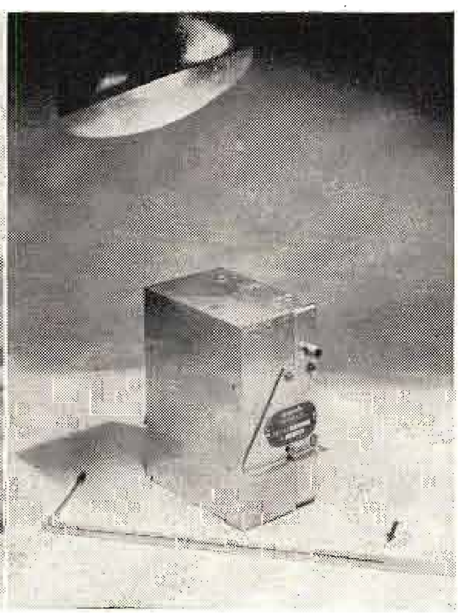


Weather Exposure

After eleven months of exposure, through one of the toughest winters on record, the two Permakay units (photographed on the roof of Motorola plant) showed no significant change in selectivity characteristic.



Thermometer reads —30° centigrade as the Permakay selectivity reading remains same as before this extreme cold test was started



In laboratory torture tests Permakay goes through blistering +90° centigrade test without effect on selectivity readings.

Motorola first with Sealed-Unit Selectivity

In the exclusive *Sensicon* design of the Motorola *Permakay* wave filter, 15 nuisance tuning adustments are removed and permanent selectivity is guaranteed for the life of the set!

More tuned circuits and superior performance with *fewer* tuning adjustments in the SENSICON Receiver are achieved by using the PERMAKAY IF Wave Filter. The modified constant-K, m-derived band pass filter contains 15 tuned circuits . . . BUT . . . you are not burdened with field alignment and complex tuning adjustments. The filter, tuned and sealed during manufacture, requires no further adjustments . . . *ever*. This combination provides over 100 db signal rejection at the *edge* of the adjacent channel while providing a broad band-pass at 6 db for full modulation deviation acceptance.

Motorola's unique Permakay system of linear phase shift adjustment solves the problem of reflection and pulse noise control to provide maximum signal-to-noise ratio for the phenomenally high interference-rejection.

The PERMAKAY Filter characteristics are made permanent by casting the entire unit in a solid block of polyester-styrene plastic. Never can the precisely tuned circuitry be affected by water, dirt, heat, cold or mechanical shock. Temperature compensation insures constant performance even at extreme temperatures as demonstrated in all rigid laboratory torture tests. Motorola's *unconditional* guarantee of the PERMAKAY Filter for the life of the set again demonstrates that Motorola is still your best investment.

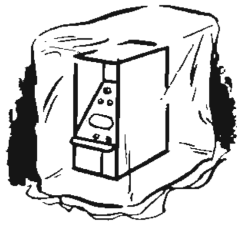
Over 22 Years of Leadership in Mobile Radio . . .

Year in and year out, Motorola installations number more than *twice* those of all other manufacturers *combined* and more than *five times* those of the nearest competitor.

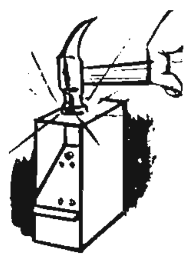
motorola

Communication and Electronics Division
4545 Augusta Blvd., Chicago 51, Illinois

DUST AND HEAT-PROOF



WATER AND COLD-PROOF



TAMPER AND SHOCK-PROOF

motorola 2-way radio

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Instruments of war must be unerringly dependable, and every part used in their construction must contribute to this standard. That is why El-Menco Capacitors have won such wide recognition in their particular field . . . Because of their margin of extra wide safety factor they are absolutely reliable.

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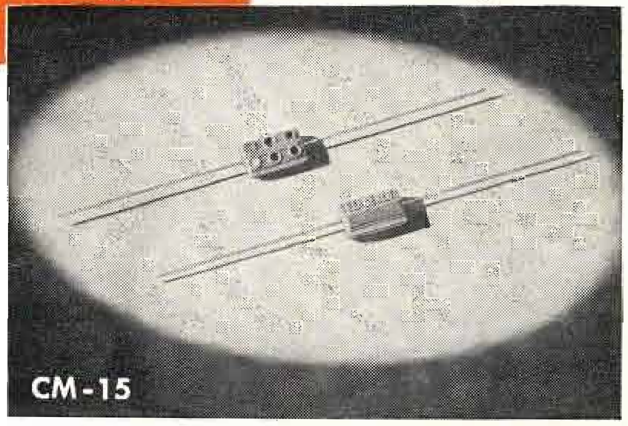
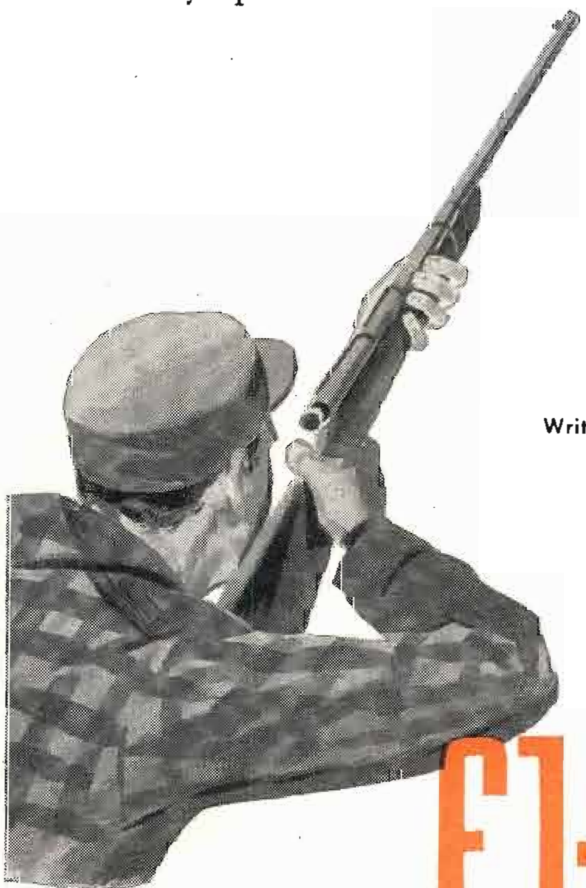
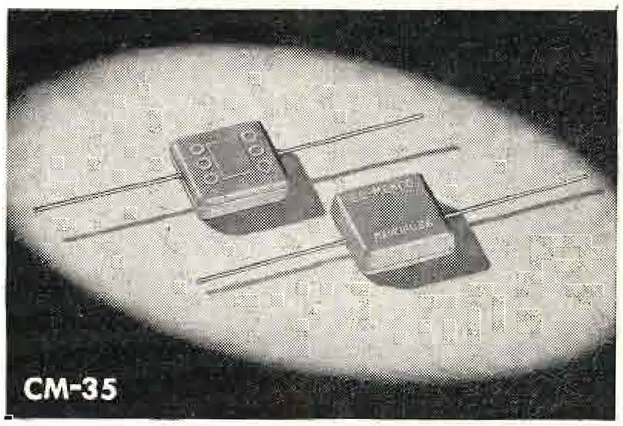


From the smallest to the largest each is paramount in the performance field.



Write on your business letterhead for catalog and samples.



Jobbers and distributors are requested to write for information to Arco Electronics, Inc., 103 Lafayette St., New York, N. Y. — Sole Agent for Jobbers and Distributors in U. S. and Canada.

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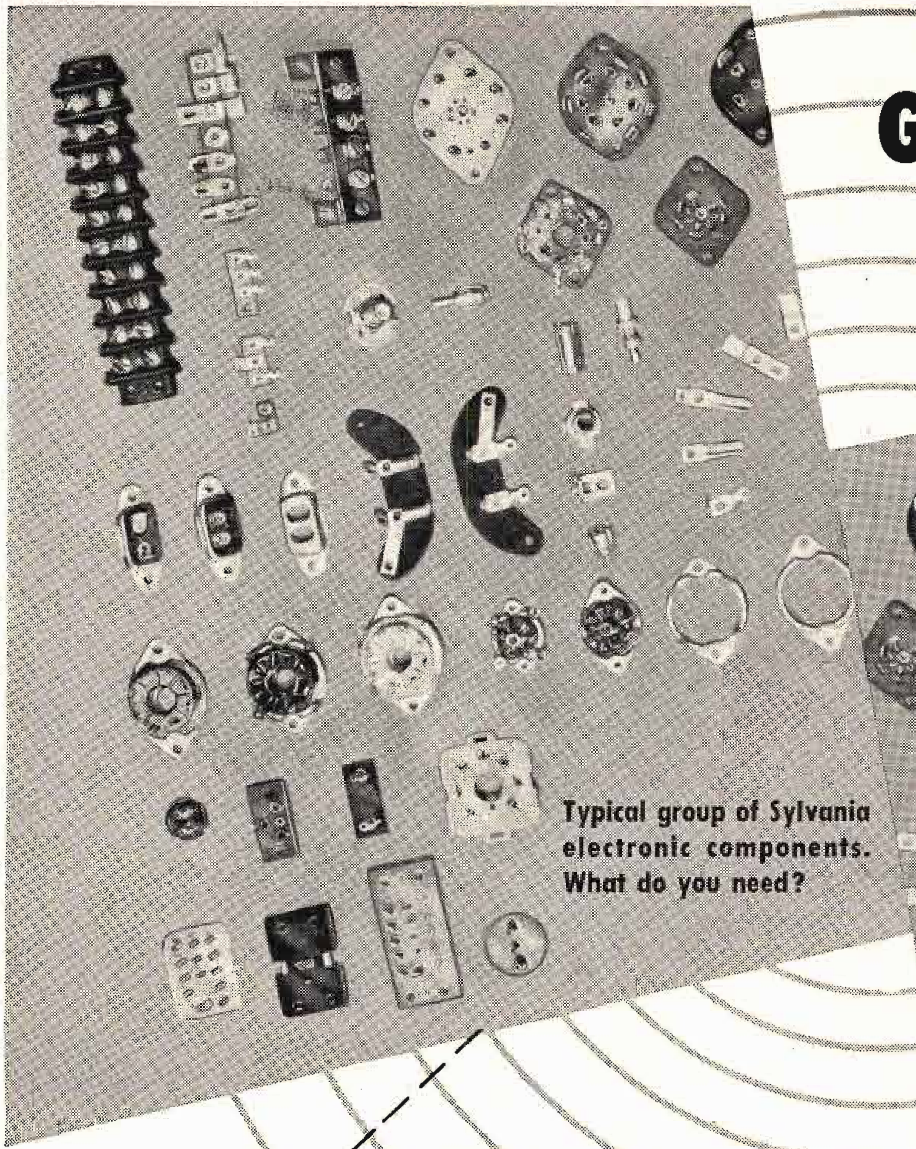
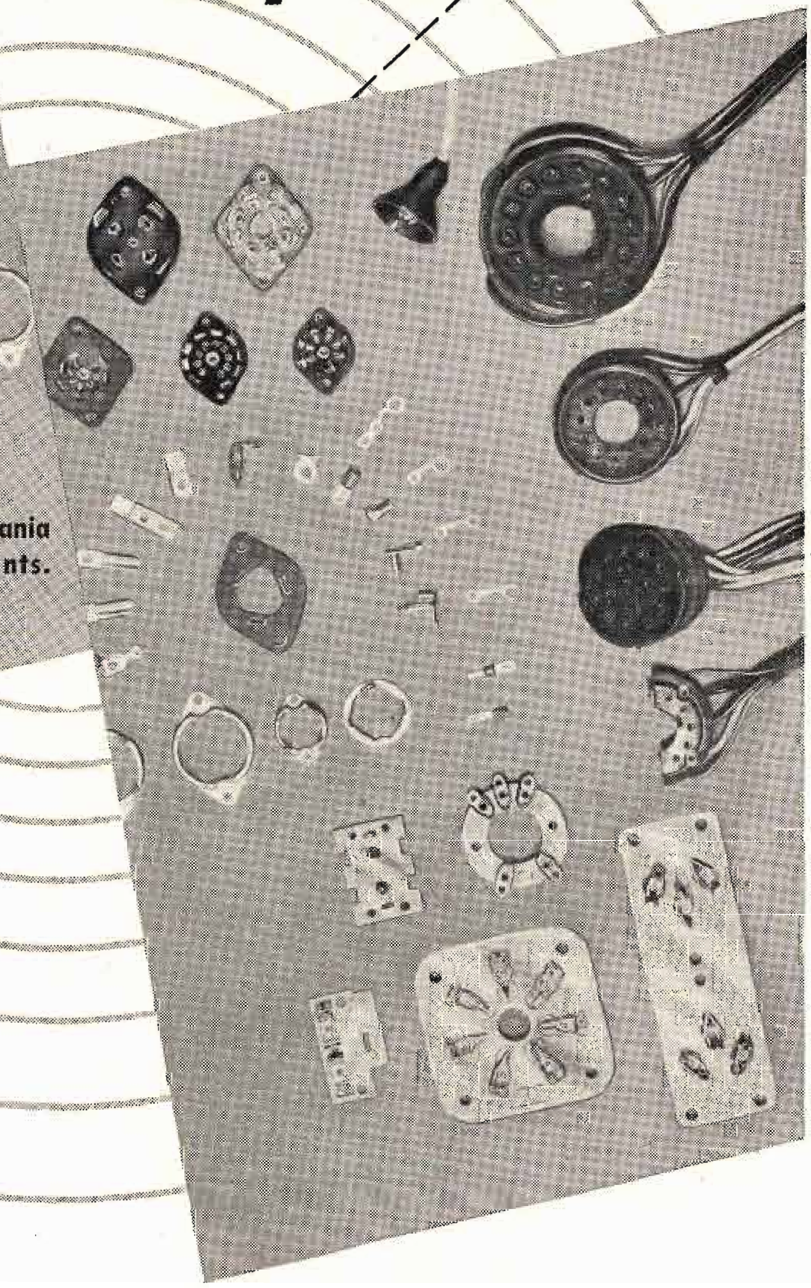


Typical group of Sylvania electronic components. What do you need?



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Sylvania provides highest quality electronic components for radio, television and other electronic equipment . . . at lowest prices.

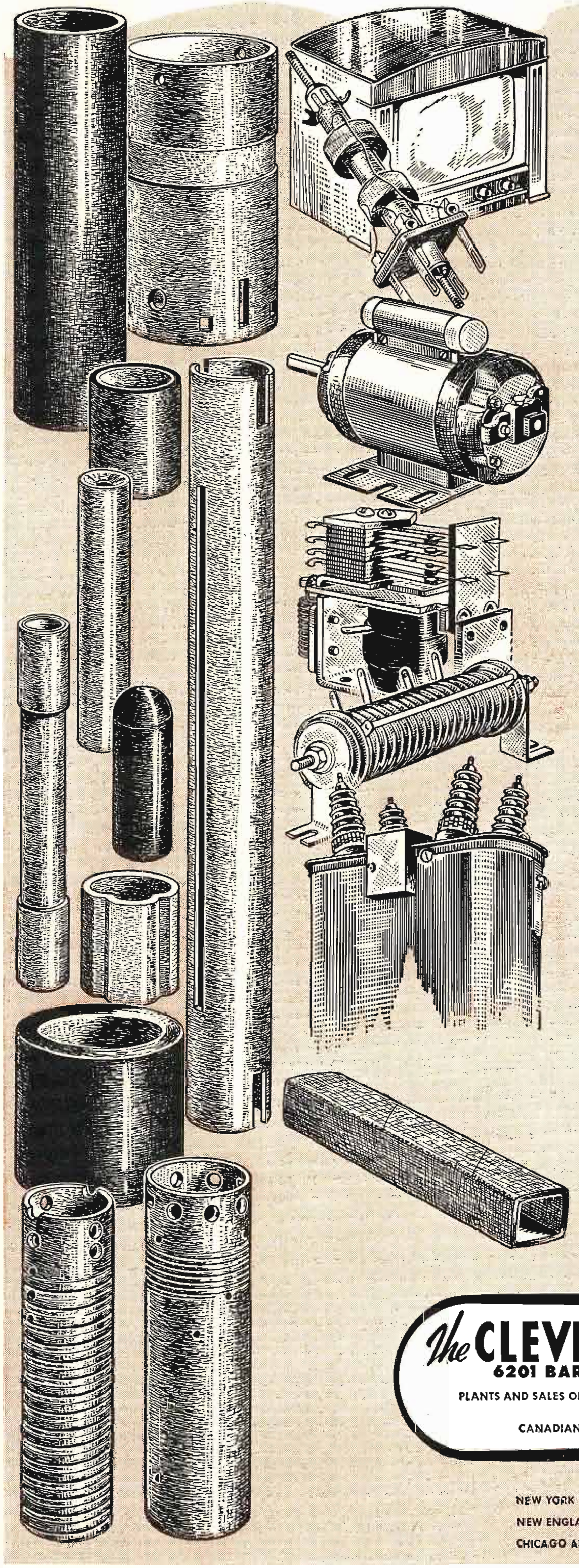
New plant facilities and improved methods now enable Sylvania to provide you with highest quality electronic components for every need . . . *when you need them.*

Typical examples of Sylvania components include hundreds of diversified items such as: *Terminal Strips and Boards; JAN Sockets; Radio Tube, Cathode Ray Tube and Power Tube Sockets; Fuse Holders; Plugs and Connectors.*

To be sure of the finest possible quality . . . put your component problems up to Sylvania. We welcome your inquiries addressed to: Sylvania Electric Products Inc., Dept A-1105, Warren, Pa.

SYLVANIA

RADIO TUBES; TELEVISION PICTURE TUBES; ELECTRONIC PRODUCTS; ELECTRONIC TEST EQUIPMENT; FLUORESCENT TUBES, FIXTURES, SIGN TUBING, WIRING DEVICES; LIGHT BULBS; PHOTOLAMPS; TELEVISION SETS



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PHENOLIC TUBING

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EVERY APPLICATION

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In Radio and Television their use is almost universal. They have high insulation resistance and low moisture absorption. Their low dielectric loss is suitable for ultra high frequency applications.

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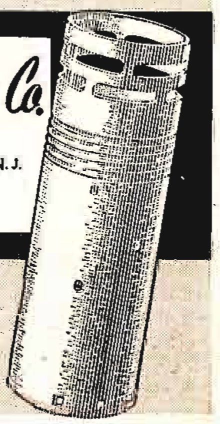

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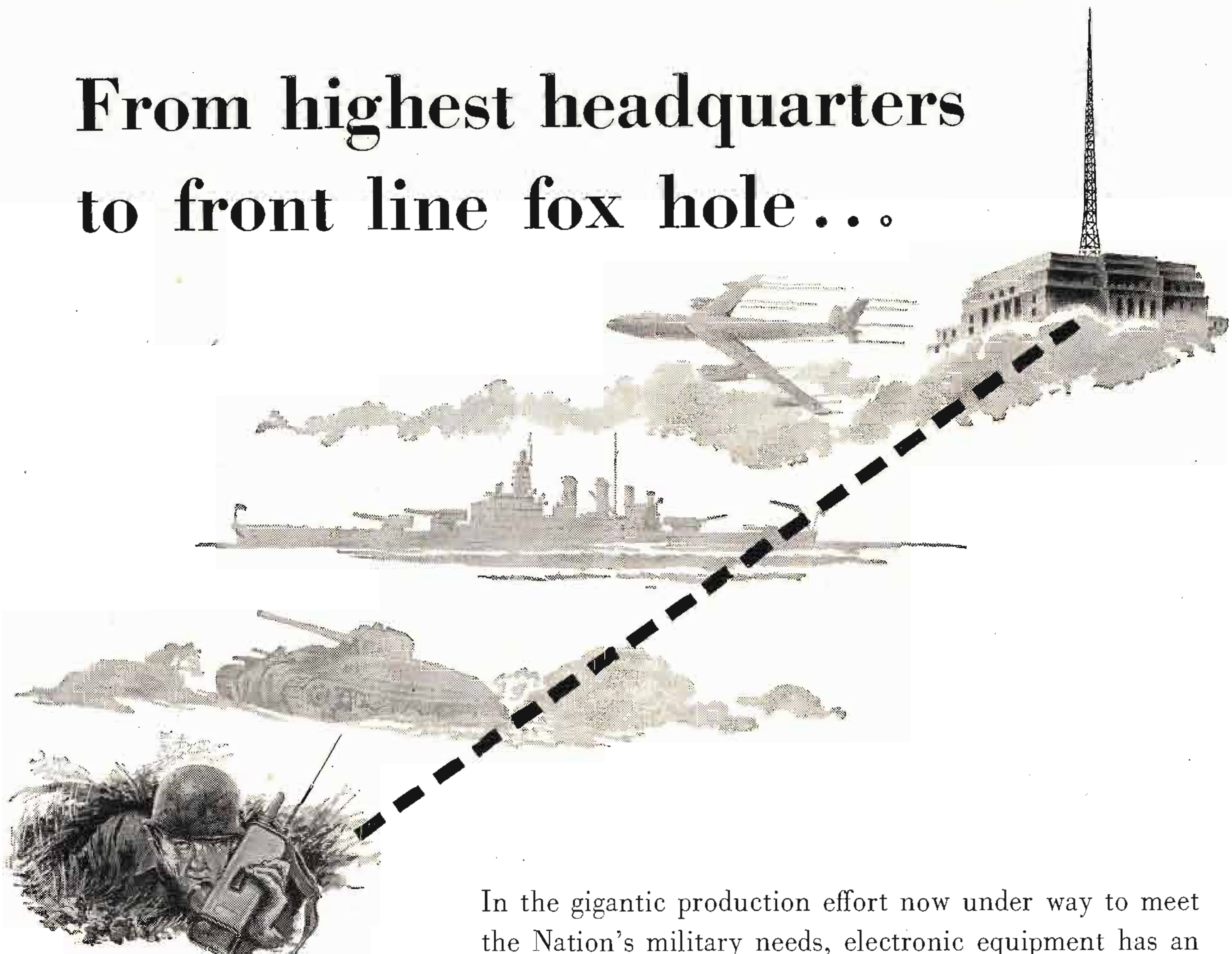
From highest headquarters to front line fox hole . . .



In the gigantic production effort now under way to meet the Nation's military needs, electronic equipment has an increasingly responsible role.

At every level, from highest headquarters to front line fox hole, military personnel and equipment depend on electronic devices. And no electronic equipment can operate without capacitors.

To assure dependable performance of their equipment, many manufacturers rely on Mallory capacitors.

They know Mallory produced the first high voltage dry electrolytic capacitor . . . pioneered electrolytic capacitor miniaturization . . . developed designs providing long shelf life and wide temperature range characteristics. They know Mallory offers unique facilities, personnel and products.

It will pay you to use Mallory capacitors in your electronic equipment . . . to consult Mallory on any problem involving the application of standard capacitors, the development of special types, or the simplification of related circuits.

Key to Subminiaturization

Timely example of Mallory capacitor know-how is the new Tantalum capacitor, developed by Mallory for the Armed Forces subminiaturization program. It is remarkably efficient from —60°C. to +200°C.

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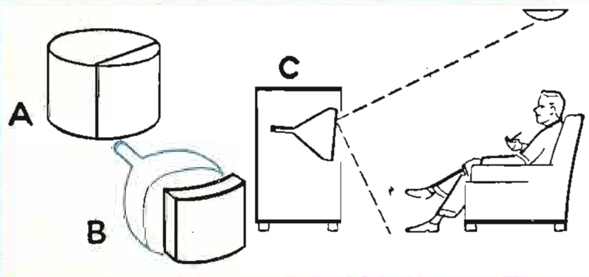
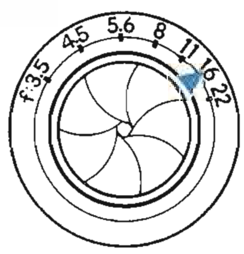
New CBS-Hytron cylindricals
17LP4 and 21FP4A low-voltage electrostatics
17QP4 and 21EP4A electromagnetics

Facts YOU'LL WANT TO KNOW ABOUT NEW CBS-HYTRON Cylindricals



WHY CBS-HYTRON CYLINDRICAL?

To eliminate reflected glare? How? Simple as ABC: A. Imagine a cylinder; slice it vertically. B. You now have the shape of the face plate of a cylindrical tube: curved horizontally; straight, vertically. C. Light falling on this surface at an angle from above is reflected at the same angle...downward. Tilting the tube directs glare downward even more, away from the viewer's eyes.



WHY CBS-HYTRON SHIELDED LENS?

With this shielded lens in the electron gun, greater depth of field and better definition are achieved. Just as when you stop down the diaphragm of a large, fast camera lens (f/3.5) to a small aperture (f/16). Distortion caused by interaction of external electrostatic fields used to focus and accelerate the electron beam is avoided. Focusing is easier, less critical. Slight changes in voltages and currents do not cause drift.

WHY CBS-HYTRON BLUE-WHITE SCREEN?

Ever notice how a shirt laundered with bluing appears whiter? With the CBS-Hytron blue-white screen, whites appear whiter; blacks, blacker. Picture definition is crisper. In fringe areas, the expanded gray scale of the blue-white screen gives noticeably clearer pictures. No wonder CBS-Hytron's original blue-white screen is fast becoming the standard preferred by consumers for best definition.

CBS HYTRON RADIO TUBES

MANUFACTURERS OF RECEIVING TUBES SINCE 1921
HYTRON RADIO AND ELECTRONICS CO.
A DIVISION OF COLUMBIA BROADCASTING SYSTEM, INC.

MAIN OFFICE: SALEM, MASSACHUSETTS

These are just a few reasons why it's smart to demand CBS-Hytron... original studio-matched rectangulars. Try the new CBS-Hytron cylindricals yourself. Discover for yourself why 9 out of 10 leading set manufacturers pick CBS-Hytron.

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- **HAS HIGH SPACE FACTOR**
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CEROC® ST

If smaller, lighter electrical components are needed in the military electronic gear or aircraft controls you are concerned with, investigate the use of CEROC ST, the newest Sprague magnet wire.

Application of a single Teflon overlay to the base ceramic insulation results in a magnet wire which has many of the best properties of both Sprague's CEROC 200 silicone-coated ceramic-insulated wire and CEROC T double-Teflon ceramic-insulated wire.

Complete details of this important new development are given in Engineering Bulletin 404, available on letterhead request.

For latest information on CEROC 200 and CEROC T, write for Bulletins 401-B, 402-H, and 403-C.

QUICK DELIVERY

Immediate deliveries from stock on small sample quantities of all CEROC wires as well as short delivery cycles on production runs are now in effect.

There is plenty of room for your orders on the production schedules of our North Adams, Mass. and Bennington, Vt. plants with their newly-expanded facilities.

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RADIO-TELEVISION-ELECTRONIC INDUSTRIES
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Engineers Must Be Versatile!

How Harvard is Shaping a New Training Curriculum to Make "Men of Affairs" with Sound Technical Backgrounds

Formulated by a group of eminent engineers and scientists, headed by Dr. Vannevar Bush, a new training plan to shape a new type of engineer is now being put into effect, initially at Harvard University. Emphasis in the plan is on versatility and on effective means of applying science to the needs of mankind. The following objectives were set up by the Bush report:

(1) The University should offer graduate education of the highest caliber in engineering and applied science, with keynotes of rigor, flexibility and versatility.

(2) There should be extensive and high-caliber research devoted primarily to bridging the gap between science and practical affairs.

(3) To this end there should be an eminent faculty of engineers and applied scientists in a combined organization. They should operate in concert; not as collaborators at a distance, but as members of a unitary group with common aims.

(4) In furthering these objectives the great resources of the university should be called upon, and collaboration with neighboring institutions extended, to render the educational experience of students both broad and deep.

(5) The object should be to train men who will become leaders in the university, industry or government.

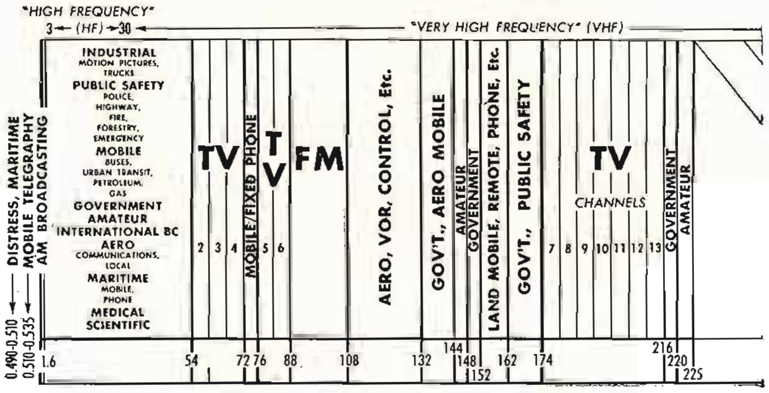
These leaders should be able to operate successfully in a society—rendered complex by science—by reason of their sound grasp of scientific subjects, their ability to apply these well, their understanding of the framework of society within which the applications will be made, "and their worth as educated men."

Further indication of the way in which engineering may be focused in the new dispensation brought about by the steady advance of scientific knowledge is the appointment at Harvard of an eminent mathematical physicist to the new position of Dean of Applied Science and of a leading civil engineer as Assistant Dean.

Their work is to develop this new kind of engineering program, with the emphasis on versatility and more comprehensive cooperation not only in research but in training engineers to go out and do the larger works the world wants done.

RADARSCOPE

Revealing Important Advances Throughout the Spectrum of Radio, TV and Tele Communications



MATERIALS

MAGNETIC SUBSTITUTES—The need for adequate substitute permanent-magnet materials has been accentuated because of the restriction of strategic raw materials. Cobalt and nickel are required in the most widely used and most efficient permanent magnets, and both of these metals are now on the Government's "critical" list. A new approach is required to develop new permanent magnet materials having superior properties or which can be made from raw materials not in short supply, points out A. D. Plamondon, Jr., president Indiana Steel Products Co. Fundamental research should be the first step in our approach. In our field of permanent magnets, practically all of the developments have been achieved by experimental methods. The known combinations of elements and processes that produce permanent magnets are manifold. Magnetic theories have advanced and fit many of the known facts. There is a wealth of experimental data and related information available which can be properly evaluated only by fundamental research. The development of new materials which would have superior magnetic or physical characteristics or which would utilize non-critical material would be the ultimate goal. Even though this objective were not achieved in the near future, theoretical factors would probably be developed which would be of value in the improvement in the production of present permanent magnet materials. Producers and users of permanent magnets should be interested in formulating their own individual research programs to solve this major problem. Research programs should be developed on a long-term basis without regard to any changes which may occur in economic or world conditions. This provision is necessary to assure continuous effort and incentive to those working with such a program.

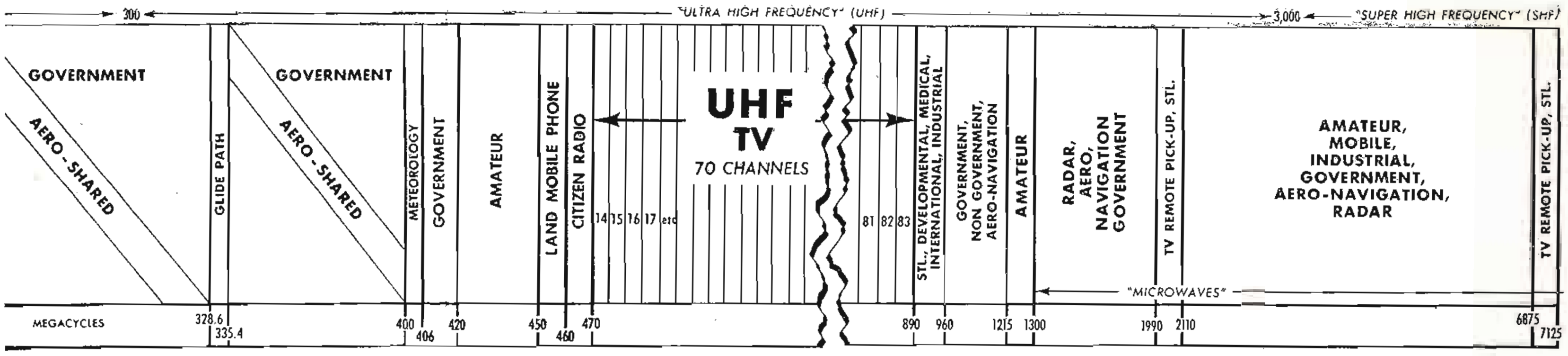
Charles E. Wilson (then Defense Mobilizer) looks on as IRE President Dr. Donald B. Sinclair presents the IRE Medal of Honor to Dr. W. R. G. Baker, for his "early technical contributions to the transmitter art, and his long, sustained and effective leadership of Institute and engineering groups." Earlier recipients of the Medal include G. Marconi, Dr. Lee deForest, Dr. E. W. F. Alexanderson, Dr. E. H. Armstrong, Dr. J. H. Dellinger, and Dr. Haraden Pratt.

AVIATION

AT LAST THE VOR-DME UNITS are going into use! Rather belatedly, the CAA is putting the second part of its VHF/UHF navigation program into operation. An experimental DME (distance measuring equipment) route has been set up between New York and Washington, and about 24 airplanes fitted with the proper receivers will soon prove out the CAA's latest baby. Although this program may help navigation it does not appear that much assistance will be given to planes in the last lap of their flights, i.e., approach and landing. Here, further refinements in blind guidance are urgently needed as shown by the recent crashes in Elizabeth, N. J., and Queens, N. Y. Many drawbacks to the lower frequency radar sets are still being found, and the CAA and the aviation industry now are pinning hopes on the new 2600 MC approach aids.

RELIABILITY

THIRTY LONG-LIFE TUBES for military use have been produced under a Navy Bureau of Ships project in cooperation with the Army and Air Force. The new tubes are of a standard type and can be used commercially as well as in military equipment. Guided by the Department of Defense Research and Development Board, the program has produced electron tubes which have proved from two to ten times more resistant to shock and vibration and have 20 times the life expectancy of former types. At present, fifty electron tubes are in various stages of research and development. Most are designed for use in gunfire directors, ship and aviation navigation instruments and communications equipment. The 30 newly developed tubes announced by the Navy have been subjected to tests that would cause immediate failure in most present day tubes. They are given a 48-hour mortality test to insure against early failure. The tubes must pass a high-voltage heater cycle test during which they are turned on and off 2000 times. This test also subjects the tubes to a thermal shock comparable



to the reaction obtained by dropping a cold glass into boiling water. Use of the new tubes in radio, radar, sonar, navigation and fire control instruments will enable operation despite shock of gunfire. A single large carrier has approximately 12,000 tubes in operation. Failure of one tube may mean an entire instrument system would cease to function. While the new tubes will cost individually five to ten times as much as present commercial types, total costs will be reduced because of low replacement rate.

EDUCATION

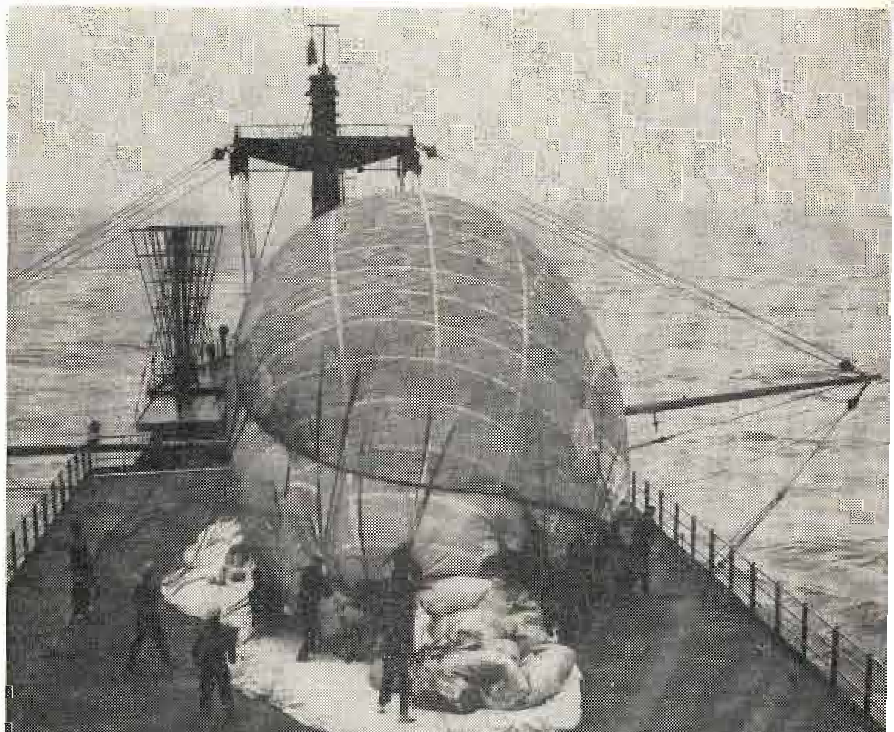
OVER 420 COLLEGES now offer courses in radio and television. Degrees in engineering are granted by eleven institutions of radio broadcasting and 54 others give degrees in science, commerce, and education in radio. And the degree of Bachelor of Television (BT) is now conferred by the University of Southern California. It appears that at last the radio broadcaster is being recognized as a worthy recipient of scholastic honors and the role of education in preparing suitable candidates for the profession is being accepted by the schools. Training of, by, and for, television is now becoming an accomplished fact!

AIRPORT TRAFFIC CONTROL

ROHO-THETA TRANSPONDER is the name of a new device by which an air-traffic officer at a busy airport can positively identify the airplanes he sees as small dots on his radar screen. The basic principle of radar, of course, is that an object is seen on a radarscope because it reflects a small bit of the transmitted radar pulse. It is located as to direction and distance by its "echo." The new Transponder improves on this in two ways. It is a device mounted in the plane. When a radar pulse strikes its antenna, the energy received is amplified, the frequency changed, and a generated pulse sent back in the direction of the received radar signal. The signal sent back by the plane to the control tower is much stronger than a reflected signal. The plane, as a consequence, shows up at greater ranges and lower altitudes, regardless of weather conditions or the size of the aircraft. But the Transponder introduces another extremely advantageous feature. The tower operator can by radio ask the pilot of a certain plane to identify himself. The pilot by pressing a button causes the Transponder to send out a double set of pulses so that his "dot" becomes two closely spaced dots on the radar screen. The tower operator thus knows exactly which of perhaps many dots on his scope is the plane he is talking to. This information can be used to provide further instructions to a pilot, enabling the ground controller to expedite bad-weather landings made with the ground-controlled approach system.

PROPAGATION

IONIZATION IN THE E-LAYER? In considering the effect of the E-layer on radio propagation, the generally accepted theory has taught that *ultraviolet* causes ionization. Now, E. F. George, Geophysical Institute, University of Alaska, finds, from averaging 25,000 individual ionosphere records, that the results "seem to indicate the ionization of the E-region is not due primarily to ultraviolet light." (Journal Franklin Institute, Dec., 1951). He does not suggest what the source is, but, instead, to explain the periodicity of his curve of virtual height of the E-layer plotted vs. geographic latitude, he points out that the prevailing winds within the troposphere—large-scale movements of air—may be carried into the ionosphere. The ions may take part in these movements and hence be the cause of the up-and-down swings of the curve. Something new to ponder.



Coast Guardsmen remove restraining net from 69 x 33 ft. barrage balloon aboard Voice of America's sea-going radio station, "Courier." The helium-filled balloon will rise 1000 ft., carrying aloft the half-wave antenna for 150 kw broadcast transmitter. By retransmitting programs at point-blank range from off-shore locations, Voice will make itself heard in dominated lands throughout the world. (See also p. 41 April TELE-TECH)

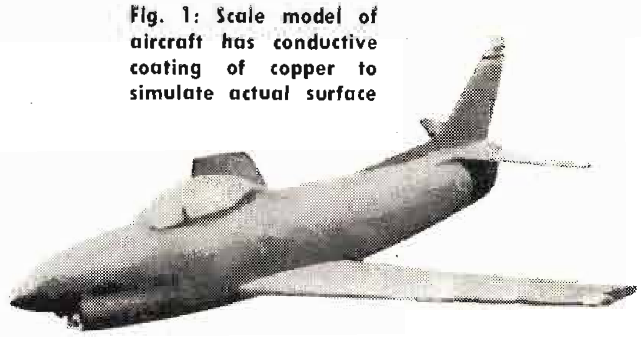


Fig. 1: Scale model of aircraft has conductive coating of copper to simulate actual surface

Wing-Tip Antenna

Zero-drag omnidirectional range an-receive horizontally-polarized signals.

By JAMES O. MARTIN
Electronics Research, Inc.
Evansville, Ind.

THE need for zero-drag navigational antennas has become increasingly apparent with the advent of jet type aircraft. These antennas are particularly objectionable from an aerodynamic point of view since the frequency of both the localizer and omnidirectional ranges is relatively low, with the result that the antenna is usually over 1 ft. in length. In addition, the bandwidth requirements for these antennas is such that even further increases in the physical size of the antenna are necessary, and for this reason external antennas of this size are far too bulky for installation on aircraft with near sonic speeds.

When it was required to develop a zero-drag omnidirectional range antenna for installation on a jet fighter it was decided to investigate the radiation characteristics of an antenna located in the left wing tip of the aircraft. Previous flight tests of a similar installation on a light aircraft had shown that for normal flght conditions such an antenna provided adequate reception, and in propeller driven aircraft was less susceptible to ignition noise.

The specific electrical requirements for this antenna are:

1. The antenna shall adequately cover the frequency range of 108 to 122 MC.
2. The antenna shall receive horizontally polarized and horizontally propagated radio signals with minimum practicable reception of vertically polarized radio signals.
3. The input shall be designed to match a 52-ohm coaxial line with a voltage standing wave ratio (vswr) of less than 5:1 over the frequency range 108 to 122 MC.
4. The radiation pattern of the installed antenna shall be such that it will provide the ranges specified herein at any heading with respect to the signal source, and at any attitude from horizontal to 20°, climb or glide.

The structural design requirements for the antenna are that it be light in weight and the method of fabrication and assembly adaptable to aircraft production techniques. It was also considered that the antenna should be so designed that it could be assembled on a production line basis without the need for post-assembly tuning adjustments.

Radiation Pattern Study

The first step in the development of this type antenna was a radiation pattern study making use of scale model techniques to determine whether or not any type of antenna located in the wing tip of this particular aircraft would meet the pattern requirements previously specified. For this purpose a one-tenth precision scale model of the aircraft was constructed and is shown in Fig. 1. This scale model is made of wood and metal sprayed with an under coat of zinc and a finish coat of copper to provide a highly conducting metal surface similar to that of the actual aircraft.

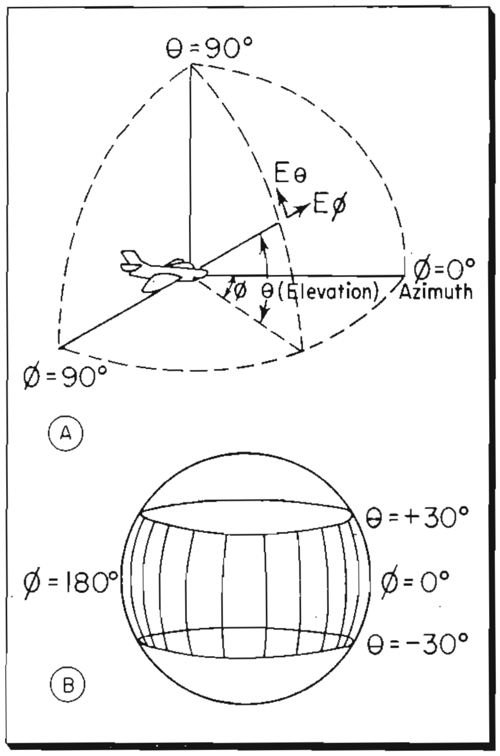
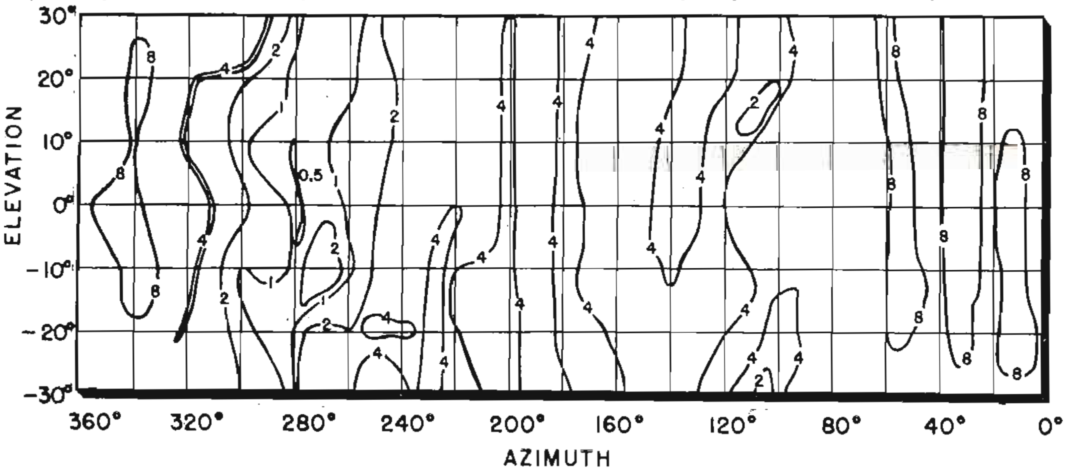


Fig. 2: (a) Radiation pattern coordinate system. (b) Equatorial belt for $\theta = +30°$ to $-30°$

Fig. 3: Spherical radiation patterns at 115 MC converted to equi-signal contours in equatorial belt



A one-tenth scale model of a shunt fed element was mounted on the left wing tip of the model and the metal parts of the anti-icing element, cruising lights, and aileron tip were added to complete the actual scaling of the aircraft. This model antenna was matched to a vswr of 2.5:1 or less throughout the simulated frequency range in order to assure more accurate pattern measurements. The patterns were measured on a model range using a linear superheterodyne system and polar plots on a voltage basis were obtained.

The coordinate system for the important region in space about the model aircraft showing both the horizontal, (EΦ), and vertical, (EΘ), polarization is shown in Fig. 2a. The equatorial belt for the most important region is shown in Fig. 2b. In order to simplify the results of a large number of patterns obtained, the final set of relative patterns were integrated and converted into patterns of equi-signal contours in the equatorial belt of the aircraft. Preliminary measurements of spherical radiation patterns for both horizontal and vertical polarization at 115 MC are shown in Fig. 3.

Examination of Fig. 4 shows that

for Jet Fighter Aircraft

tenna for 108-122 MC designed especially to Coaxial input is 52 ohms with vswr under 5:1

the patterns for horizontal polarization is relatively omnidirectional and that the one null which is present is outside the forward 180° and therefore would not be deleterious to normal localizer operation. The patterns for vertical polarization show that in the fore and aft direction the component of vertical polarization is never more than 1/16th as much as the component of horizontal polarization. And, as may be seen from the patterns, the maximum reception of vertical polarized signals is in such a direction that the bearing errors or course pushing produced by these signals would be relatively unimportant.

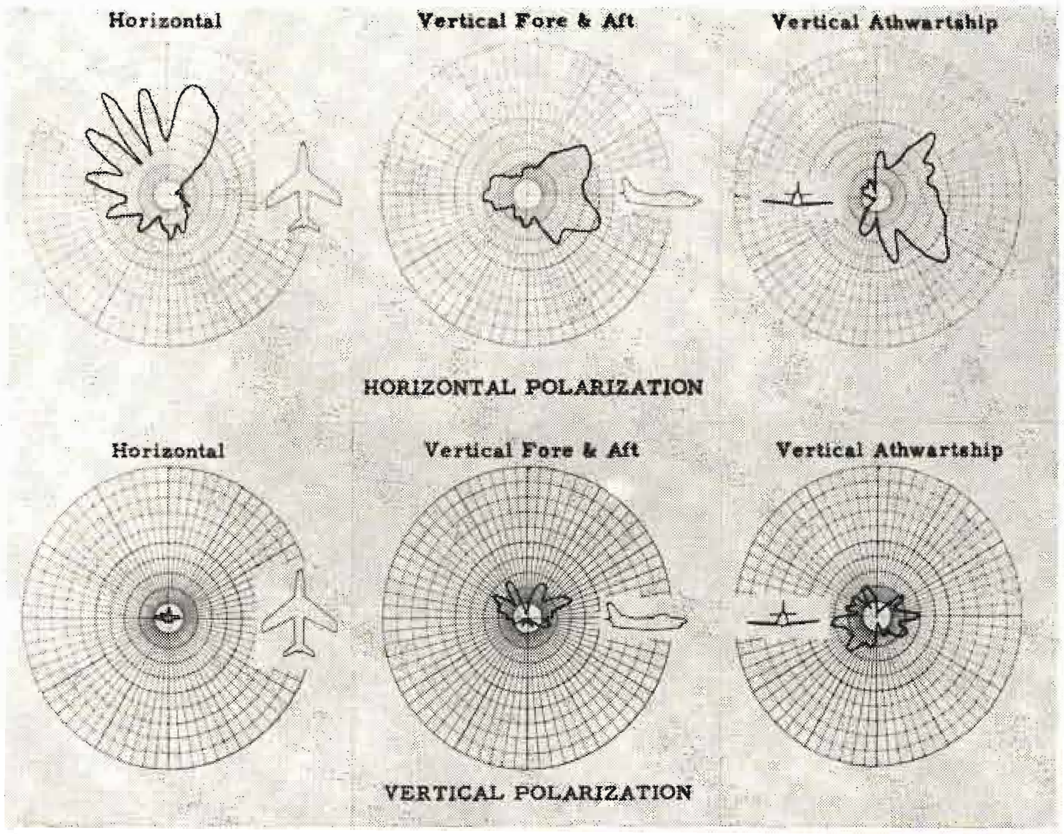


Fig. 4: Antenna radiation patterns at 115 MC for both horizontal and vertical polarization

Operational Performance

In order to determine the operational performance of the antenna system at a required maximum distance from either an AN/CRN-10 or CAA localizer ground transmitter, or a CAA type VOR ground transmitter, the complete set of relative patterns for both horizontal and vertical polarization at 115 MC was integrated by means of a polar planimeter and computations were made to obtain the average value of the relative pattern. This average value was then used for converting the relative pattern into units of absolute field strength. The conventional way of presenting the absolute field strength of a receiving antenna is to assume by the theory of reciprocity

TABLE I: CALCULATIONS OF SIGNAL STRENGTH AT AIRCRAFT RECEIVER INPUT

As a matter of general interest and a means of showing the type of calculation required, these tables show the method used to determine the signal strength which the wing tip ODR antenna on the aircraft delivers to the receiver.

Air Force Specification X-7197 requires minimum signal of 4μv at receiver terminals when aircraft is at altitude of 10,000 ft., and range of 100 miles from ground station.

Assume ODR ground equipment is CAA type VOR transmitter with a power output of 200 watts. Assume 30 ft. of RG-8/U transmitting cable, and assume transmitting antenna has no gain over a half-wave dipole, a vswr of 2 to 1 and located 30 ft. above ground.

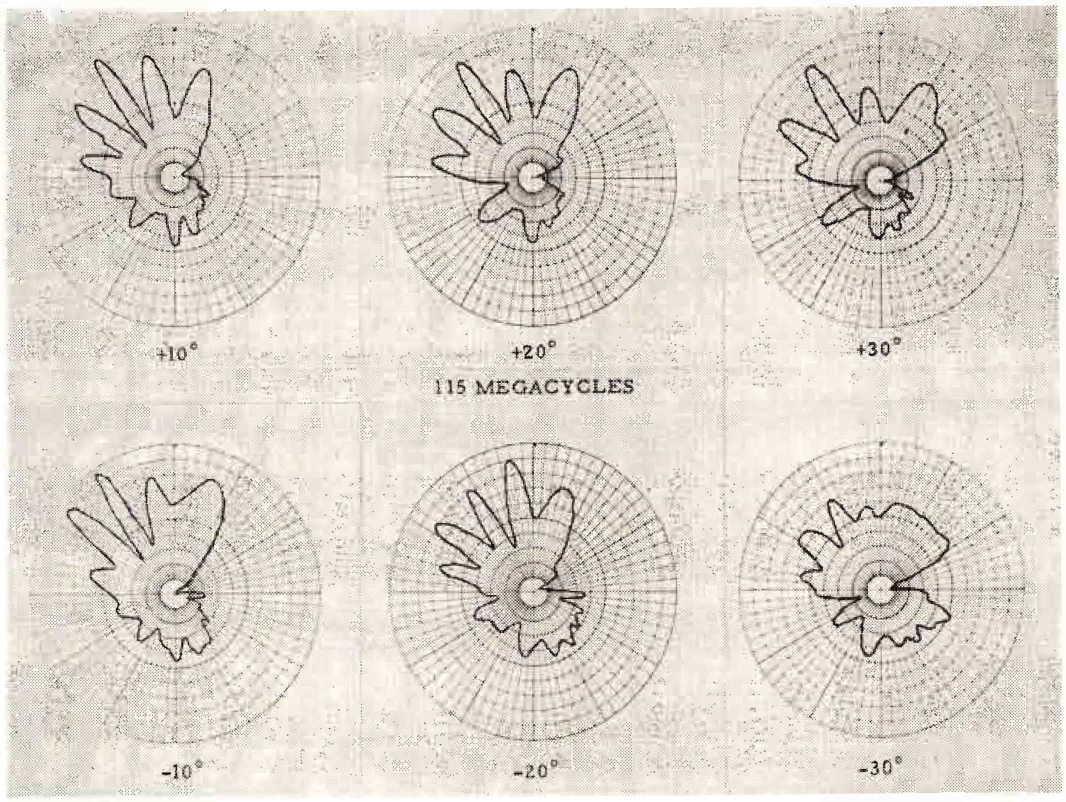
1. Transmitter output correction factor compared to 1 kw = —7.0 db
2. Cable attenuation factor for 30 ft. of cable = —0.8 db
3. Reflection loss factor for vswr of 2:1 = 10 log $(2 + 1)^2/(2 \times 4)$ = —0.5 db
4. Antenna height correction factor for 30 ft. = +9.5 db
5. Field intensity factor above 1 μv/m = +52.0 db (P. 65 of "Propagation Curves" NDRC #966-6C for horizontal polarization, good soil, 10,000 ft. altitude, 100 mile range)
6. Therefore, field strength factor above 1 μv/m at aircraft is (— 7.0 — 0.8 — 0.5 + 9.5 + 52.0) = 53.0 db
7. This is a field strength = 445 μv/m

For comparison assume receiving antenna at the aircraft is a half-wave dipole (HWD) in free space.

8. Effective height of HWD = λ/π which at 122 MC = 0.783 m
9. Open-circuit received signal of HWD = 445 × 0.783 = 348 μv
10. HWD signal into matched load is reduced to half by reradiation and = 348 × 0.5 = 174 μv

Assume 50 ft. of RG-8/U cable in aircraft, and antenna vswr of 5:1.

11. Cable attenuation factor for 50 ft. of cable = —1.3 db
12. Reflection loss factor for vswr of 5:1 = 10 log $(5 + 1)^2/(5 \times 4)$ = —2.6 db
13. Signal at receiver terminals with HWD is (1.3 + 2.6) db below 174 μv = 111 μv
14. Required signal at receiver terminals is 4μv, so ratio of HWD signal to required signal = 111/4 = 27.75
15. When HWD is driven by a one watt transmitter, it radiates an absolute field strength at one mile = 4.35 μv/m
16. Equi-signal contours of Fig. 3 is also plotted for 1 watt radiation at 1 mile range. Contours on these figures which would represent the specified receiver signal of 4 μv are 4.35/27.75 = 0.157 μv/m



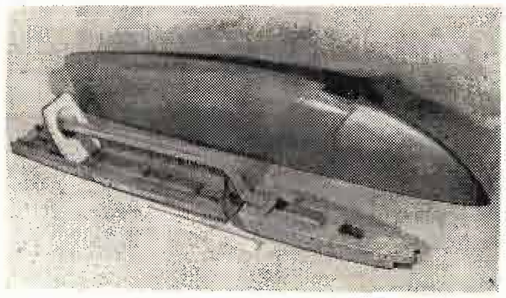


Fig. 6: Prototype of full scale wing antenna

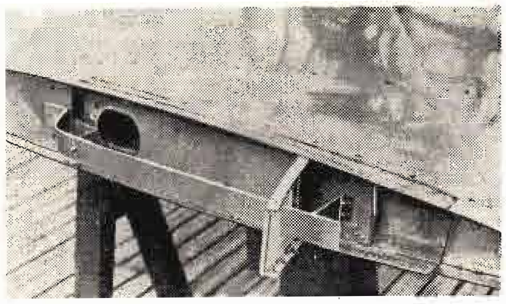


Fig. 7: Final prototype mounted on mock-up

Fig. 5: Antenna radiation patterns at 115 MC in the horizontal plane for important cone angles

that the antenna is used to radiate an input power of 1 watt, assuming also that the antenna is a perfect radiator, and comparing the value of absolute field strength obtained with that of an isotropic source or dipole.

The equi-signal contour diagram of Fig. 3 is a plot of the wing tip antenna for such a transmitting case and shows the cone angles from plus 30° to —30° vs. azimuth. These equi-signal contours are formed on the diagram by connecting the points of equal field strength and enable the reader to evaluate the antenna pattern quickly.

Fig. 5 shows the horizontal radiation pattern at 115 MC for important cone angles.

The computation to determine the received signal when the aircraft is at a range of 100 miles and an altitude of 10,000 ft. from a CAA type VOR transmitter, or at a range of 40 miles and an altitude of 4,000 ft. from an AN/CRN-10 transmitter are shown in Tables I and II. These computations are based on propagation data presented in the book "Propagation Curves," NDRC Report No. 966-6C published by Bell Telephone Laboratories. The necessary factors to allow for transmitter power, transmitting antenna directivity, reflection and cable loss, and transmitting antenna gain are also included in these tables. The calculations shown are made for conditions over good soil, but they also apply for conditions over poor soil since at this frequency and polarization the propagation data is approximately the same for either type soil.

The calculations and values mentioned above for the ODR transmitter do not include a factor to allow for a ground transmitting antenna with a gain greater than a half-wave dipole. Since the ODR ground antenna has a gain greater than a half-

(*Continued on page* 133)

TABLE II: CALCULATIONS OF SIGNAL STRENGTH AT INPUT OF THE AN/ARN-14 LOCALIZER RECEIVER

Air Force Specification X-7197 requires a minimum signal of 5 μv at the receiver terminals when the aircraft is on the localizer course at an altitude of 4,000 ft. and range of 40 miles.

Assume the localizer ground equipment is an AN/CRN-10 transmitter with a radiated power output of 25 watts. Assume that the transmitting antenna has a gain over a half-wave dipole of 1.5 db and is located 5 ft. above ground.

1. Transmitter output correction factor compared to 1 kw = —16.0
2. Antenna gain correction factor = 1.5 db
3. Antenna height correction factor for 5 ft. = —5.0
4. Field intensity factor above 1 μv/m (P. 65 of "Propagation Curves" NDRC #966-6C for horizontal polarization, good soil, 4,000 ft. altitude, 40 mile range) = 59.0 db
5. Therefore, field strength factor above 1 μv/m at aircraft is (—16.5 + 1.5 — 5.0 +59.0) = 39.5 db
6. This is a field strength = 94 μv/m

For comparison assume receiving antenna at the aircraft is a half-wave dipole (HWD) in free space.

7. Effective height of HWD = λ/π which at 108 MC = 0.885 m
8. Open-circuit received signal of HWD = 94 × 0.885 = 83.5 μv
9. HWD signal into matched load is reduced to half by reradiation and = 83.5 × 0.5 = 41.8 μv

Assume 50 ft. of RG-8/U cable in aircraft, and an antenna vswr of 5:1.

10. Cable attenuation factor for 50 ft. cable = —1.3 db
11. Reflection loss factor for vswr of 5:1 = 10 log $(5 + 1)^2/(5 \times 4)$ = —2.6 db
12. Signal at receiver terminals with HWD is (1.3 + 2.6)db below 41.8 μv = 27 μv
13. Required signal at receiver terminal is 5 μv, so ratio of HWD signal to required signal = 27/5 = 5.4
14. When HWD is driven by a 1 watt transmitter, it radiates an absolute field strength at 1 mile = 4.35 μv/m
15. The equi-signal contours of Fig. 3 is also plotted for one watt radiation at one mile range. Contours of these figures which would represent the specified receiver signal of 5 μv are 4.35/5.4 = 0.805 μv/m

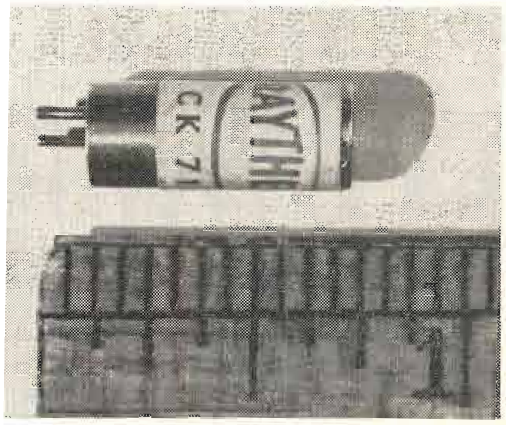
This specified minimum field strength is also shown in the horizontal plane patterns of Figs. 4 through 6 by the dotted circles.

Latest Transistor Units

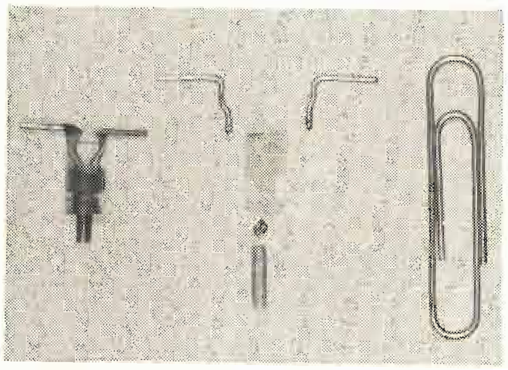
Preview of point-contact germanium types now in developmental and pilot production stages by five manufacturers

WHILE poring through the daily newspaper one may be highly impressed with the imminence of wrist watch radios and pocket-size TV receivers, devices made possible by the advent of the transistor. As one non-engineering enthusiast put it, "The vacuum tube is a cooked goose!" However, the transistor is presently in a developmental phase, and the state of the art does *not* warrant the zealous acclamations of an immediately forthcoming technological revolution. No one is more impressed with the imposing potentialities of the transistor than the scientists actively engaged in its study, but their sober evaluations tell us that although the future holds a key role in store for the crystal triode, much more must be learned before its marvelous abilities become commonplace in our daily lives.

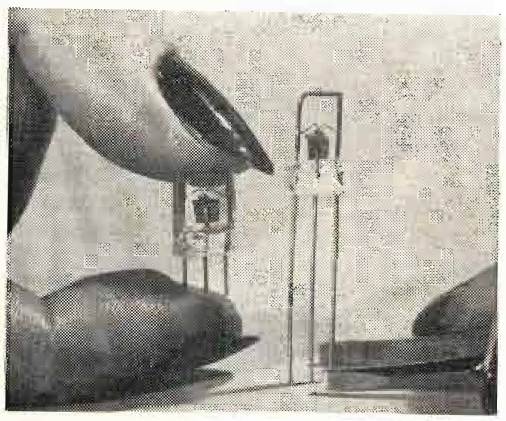
So without sensational fanfare, here are several point-contact germanium transistors fabricated by different manufacturers. Generally speaking, these units are in a developmental or pilot production stage and not commercially available in the mass production meaning of the word. Junction-type transistors have undergone less development to date, and may be considered as being in an even earlier prenatal state so far as well controlled mass production for civilian use is concerned. For a detailed explanation of transistor operation, the reader is referred to the article "Recent Developments in Transistors and Related Devices" in the Dec. 1951 issue of TELE-TECH.



RAYTHEON'S Type CK716 transistor is housed in a brass case, 0.65 in. long and 0.255 in. diameter, which acts as the base. The nickel pins are 0.078 in. apart. The maximum electrical ratings are: collector current — 4 ma; emitter current 10 ma; collector voltage — 40 v.; collector dissipation 100 mw. Operating characteristics with grounded base are: collector current 2.5 ma; emitter current 1.0 ma; collector voltage — 15 v.; emitter voltage 0.5 v.; minimum current amplification 1.2; minimum frequency response 100 KC; maximum noise figure at 1 KC, 65 db. Considered as a three-terminal network, the maximum to minimum range of direct input resistance is 150-450 ohms; transfer input resistance 25-140 ohms; direct output resistance 10,000-40,000 ohms; transfer output resistance 15,000-70,000 ohms.

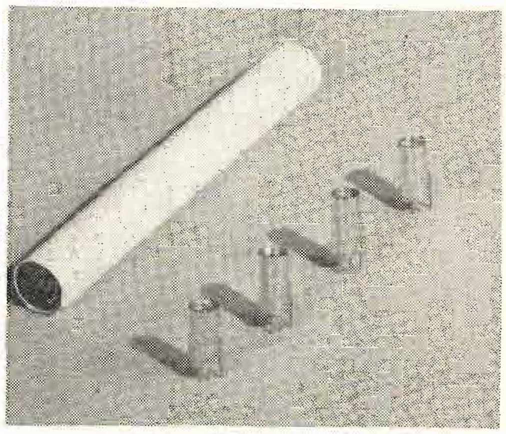


PHILCO'S potted transistor for video and r-f carrier amplification is enclosed in an impregnating plastic. The above picture shows the emitter and collector leads, base pin, germanium block from which the crystal wafer is cut, and the plastic case. Whisker crimp provides predetermined contact pressure on the crystal. Electrical characteristics are comparable to preliminary specifications for similar types.



RCA transistors are imbedded in a thermo-setting resin to maintain power gains within a 2 db variation over extreme conditions of moisture, shock and temperature. Unit measures 0.6 x 0.3 x 0.2 in. and is shown at the right in an advanced stage of construction before being encased in plastic. Operating characteristics of two representative transistors at 25°C are as follows: emitter volts 0.42 and 0.5; emitter current 1.1 and 0.55 ma; collector volts 20 and 17.5; collector current 4.6 and 3.6 ma; power gain 17.9 and 26.5 db.

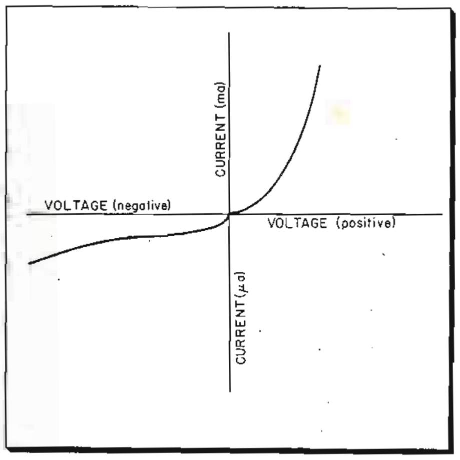
WESTERN ELECTRIC'S Type 2A transistor functions as an amplifier in the "card translator" used with the new 4A toll crossbar system for automatic selection of routes in long distance telephone dialing. These units are used in conjunction with Type 3A phototransistors which are activated by light passing through a series of punched cards. The cartridge Type 2A has its base contact connected to the metal shell.

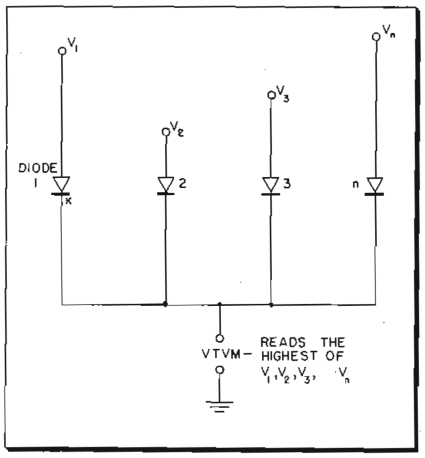


GENERAL ELECTRIC'S Types G11 (amplifier and oscillator) and G11A (counter) transistors have the following physical specifications: brass case maximum size, 0.35 in. high, 0.16 in. diameter; impregnated with moisture resistant wax; silver plated phosphor bronze pins; connections, base soldered to case, emitter center pin, collector opposite base pin. Electrical characteristics are collector dissipation 100 mw, collector voltage (V_c) 30 v., collector current 7 ma, emitter current (I_e) 3 ma, emitter peak-inverse voltage 50 v., ambient temperature 40°C. Operating characteristics for the G11 with grounded base and V_c=25, I_e=0.5 at 25°C, are as follows: base resistance 200 ohms; collector resistance 22,000 ohms; input resistance 475 ohms; current gain 2.2; power gain 17 db; cut-off frequency 2 MC; noise figure 57 db; minimum dc resistance in emitter circuit 500 ohms. For the G11A the characteristics are: base resistance 450 ohms; collector resistance 30,000 ohms; input resistance 900 ohms; current gain 2.2; turn-off time less than 2 μ sec.

An Analysis of Crystal

Since no diodes yet measured will rectify at research emphasis may be placed on new mate-





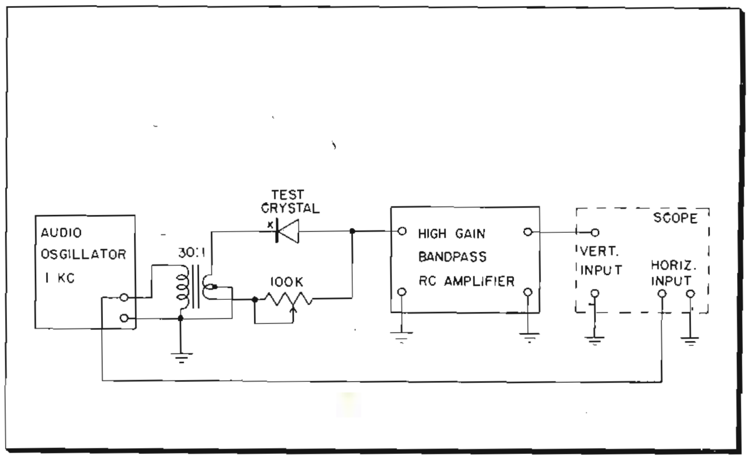


Fig. 1: (Left) Representative I-E crystal diode characteristic curve (linear scales). Fig. 2: (Center) Schematic of peak voltage selection circuit. Fig. 3: (Right) Unit for measuring resistance of crystal diode at signal level where rectification ceases.

By W. B. WHALLEY
& C. MASUCCI
Sylvania Electric Products, Inc.
Bayside, L. I., N. Y.

OVER past years, the emphasis in measurements of the current voltage characteristics of germanium and silicon diodes has been in two regions, one the forward region extending from approximately one tenth volt upwards, and the inverse region extending from about one tenth to 250 volts negative. (See Fig. 1).

To many engineers, crystal diodes appear as very simple devices, partly due to the fact that they have only two terminals and can be looked upon as electronic switches of varying degrees of quality. (The lower the forward resistance and the higher the back resistance, the more closely does the diode approach a perfect switch).

What about the characteristics at and close to zero voltage?

We became keenly interested in this region, which we shall call the "mid-region," for both germanium and silicon diodes. One of the reasons for this interest is the importance of the threshold condition for voltages of about 10 to 500 microvolts in comparator circuits; such circuits as select the largest single voltage from a group of different voltages.

Fig. 2 shows a group of dc voltages numbered V_1 to V_N, each connected through a diode to a suitable common indicator. When, say, two of these voltages differ from each other by only a few millivolts, yet both are large compared to the remainder, it is easy to see the importance of the characteristics of the separate crystals in the region close to zero, so as to determine the best units for the most accurate meter readings. Another reason for examining the "mid-region" was due to some uncertainty as to possible discontinuities as the voltage across a crystal diode passed through zero.

Measurements Below 1 mv

Preliminary measurements showed that the resistance of diodes can be quite high at the very low voltages and that dc methods of measurement were inaccurate and also time-consuming.

A method of measuring the small crystal currents for very small ac voltages was developed (Fig. 3).

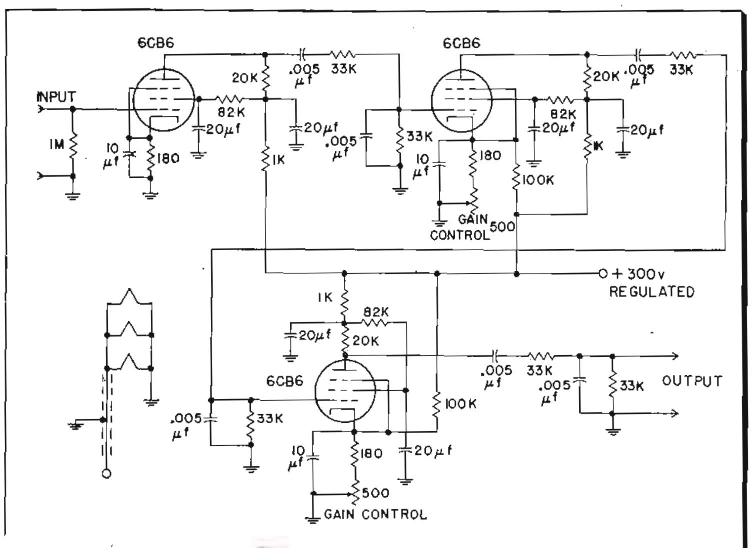


Fig. 4: High gain bandpass RC amplifier

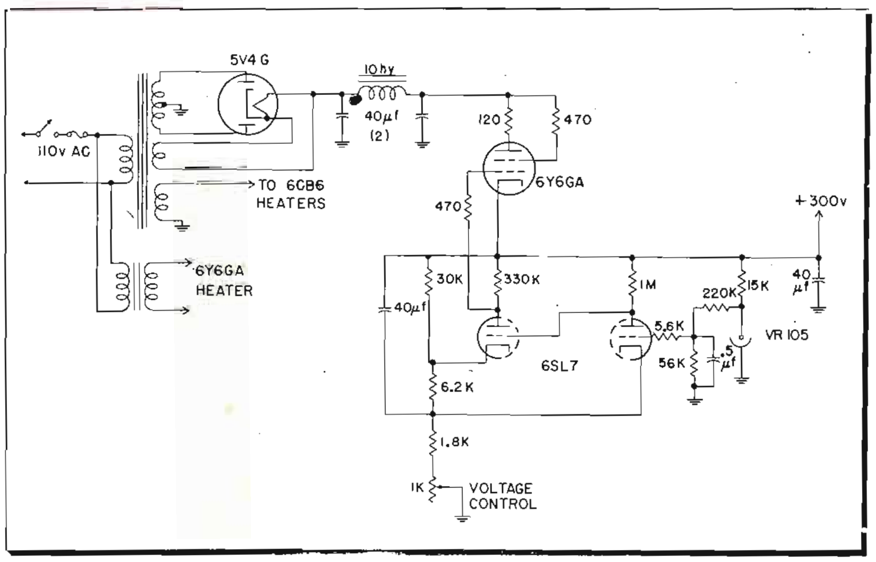


Fig. 5: Regulated power supply for high gain amplifier

Diodes in the Millivolt Region

voltage below approximately one millivolt,
rials suitable for lower voltage rectification

This makes use of a balanced ac voltage source, a high-gain amplifier and an oscilloscope. In order to measure the very small ac currents without interference from 60 to 120 cycle stray fields, the frequency source was set at 1 KC and the amplifier was especially designed. It uses band-pass filters (Fig. 4) for coupling elements covering the audio frequency range from 300 to 3000 cycles, and has a useful maximum voltage gain of 100,000 controlled by two rheostats in the cathodes of the second and third stages.

It may be noted that the band-pass filters specifically avoid the use of inductances as a further precaution in avoiding stray electro-magnetic field pickup.

Fig. 5 shows the circuit of the high stability 300 volt dc supply which has a very low ripple voltage. For interest, the voltage gain-frequency curve of the amplifier is shown in Fig. 6.

Returning to the block diagram (Fig. 3), the potentiometer is adjusted, for each signal voltage input, to give minimum amplifier output, this resistance value being that of the crystal at the particular voltage. It may be seen that the oscilloscope tube has its horizontal voltage obtained from the same source as that applied to the crystal measuring circuit. Hence, a crystal which has a constant resistance value over a range of voltage will show as a straight line on the oscilloscope (since the input signal follows the same waveform in both dimensions).

Change in Trace Shape

It is found that as the voltage across any crystal is reduced progressively from 10 mv down toward 100 μv, the shape of the curve on the oscilloscope changes from a curved profile to a straight line. Hence, the important fact that all germanium and silicon crystals become, in effect, resistors having constant value from plus to minus voltage around the zero region. Of course, the magnitude of this resistance varies widely from one particular crystal to another, even of the same type.

Below the voltage at which the crystal characteristics becomes a straight line, the device can no longer be a rectifier—that is, with very small ac voltages, the positive and negative currents in this mid-region are alike.

It is of interest to plot the curves of resistance of different crystals for

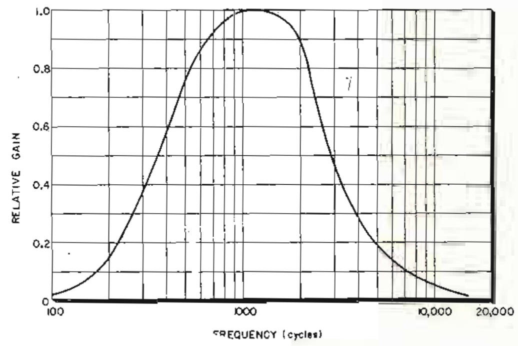


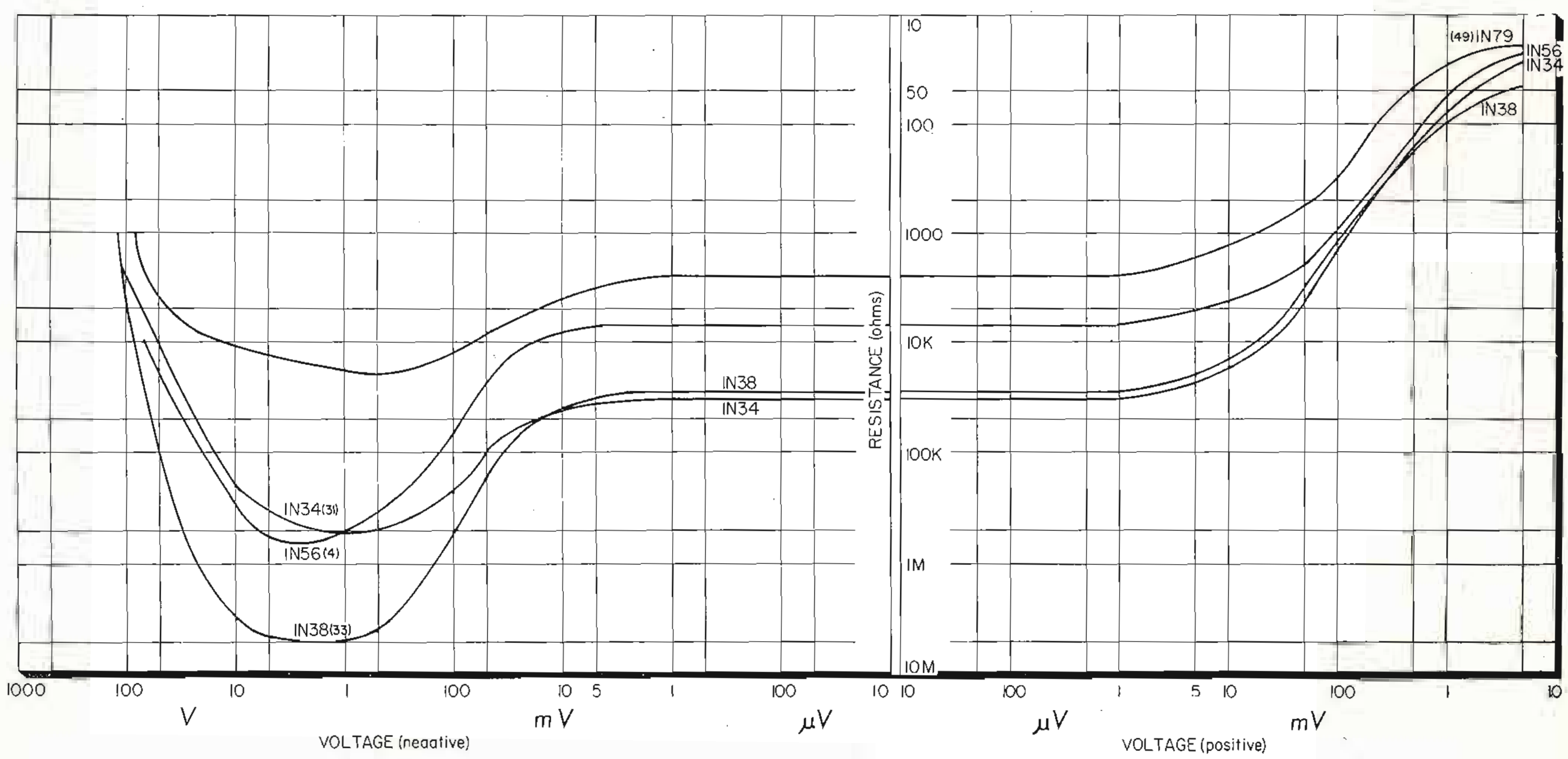
Fig. 6: Response curve for RC amplifier

the whole range from forward voltage through this mid-region to the inverse or negative voltage region. Measurements were taken through the forward and inverse regions with a conventional ac sweep circuit, a keying diode being employed for the back resistance data.

Since it is not practicable to use a linear scale for showing all three regions simultaneously (1 mv represents 0.1% of the usual one volt forward scale), as an experiment, an unconventional double logarithmic scale is presented in Fig. 7. Of course, it is fundamental that no logarithmic scale can ever go to zero, but let us forget this point, and compress the scale below 10 μv.

The curve is drawn with increas-

Fig. 7: Resistance characteristics of four individual crystal diodes (not average crystals)



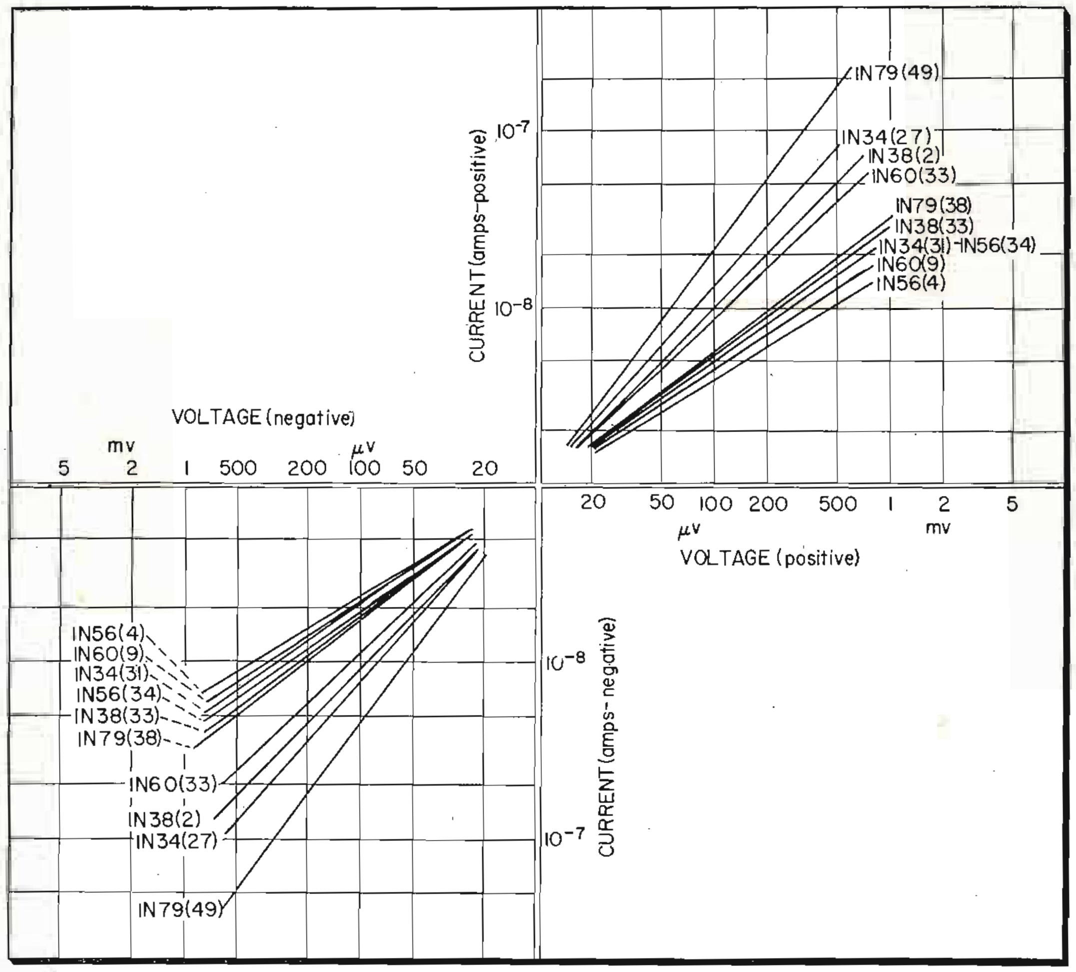


Fig. 8: Expanded mid-region curves indicate the constant resistance of crystals over small voltages

ing values of resistance downward so that a rough approximation to the conventionally appearing curves of forward and back characteristics can be indicated.

For points to the right of zero, we have a curve of values of resistance extending to plus five volts, whereas to the left of zero the resistance curve extends past –100 volts. These curves show quite clearly the mid-region where the value of resistance is constant and also the voltages at which curvature commences and therefore rectification starts.

The next group of curves (Fig. 8) shows this mid-region expanded and indicates the constant resistance of the various crystals over these small voltages.

As one examines this data the interesting question arises—how does this constant resistance region correlate with rectification at low signal voltages? The wider the straight portion, the higher should be the voltage at which rectification ceases. Hence, measurements were made of the voltage input for threshold output signals using a constant carrier frequency and percentage modulation, as shown in Fig. 9. The time constant of the crystal load, 5000 ohms, and 1000 μμf is so large compared to the two MC frequency that circuit conditions are close to optimum for detection.

A reasonably large number of crystals of each of several types were measured for the threshold r-f input signal and then classified into groups of the same sensitivity.

Fig. 11 shows, as an example, a plotting of type 1N56 crystals for the threshold two MC r-f voltage and the voltage indicated as the threshold for the commencement of curvature of the resistance characteristics in the mid-region (that is, the point at which the crystal begins to change resistance with increasing voltage). This correlation is more complete than one might have expected and shows definitely that the crystals which have a long mid-region require a correspondingly larger threshold of r-f voltage.

Threshold R-F Detection Voltage & Mid-Region Resistance Value

Next, the relationships between the signal voltage at which detection occurs and the magnitude of the resistance of a diode in the mid-region were studied. Fig. 12 shows some interesting correlation between this threshold r-f voltage and the resistance value of a group of 1N56 diodes. This plot is of the magnitude of the mid-region resistance and the threshold r-f voltage, independently of the deviation voltage.

Having compared these characteristics for individual crystals of one type there is shown in Fig. 10 a summary of the threshold r-f voltage versus the magnitude of the mid-region resistance, for five different types of crystal diodes.

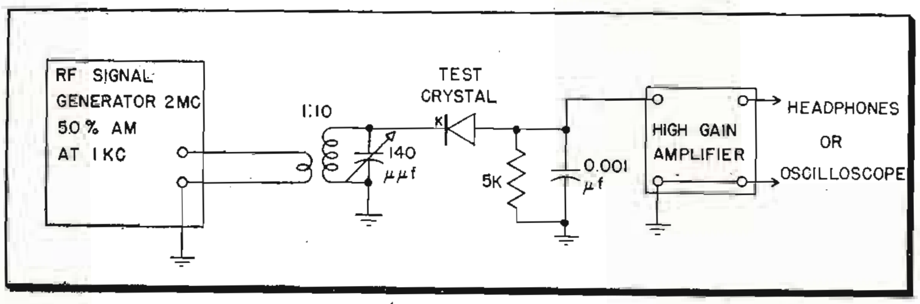
Voltage Selection Operation

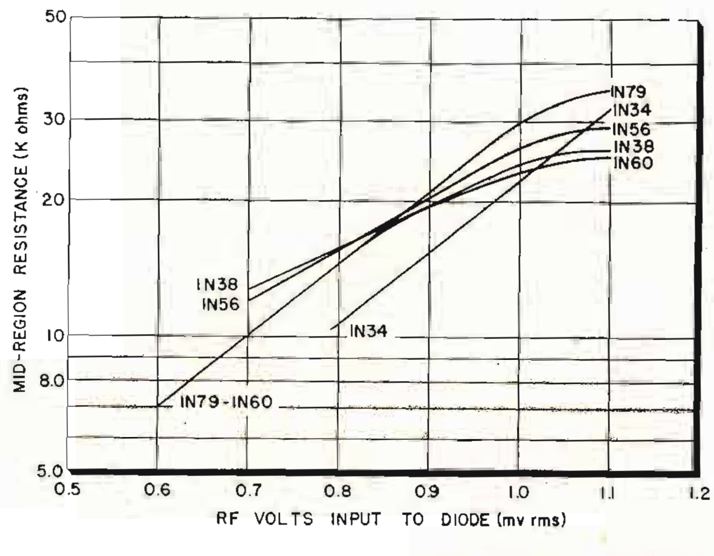
Let us now return to the problem of the selection of the largest voltage by means of N diodes (Fig. 2). To simplify the analysis, consider only two of these circuits with the corresponding two diodes, as shown in Fig. 13. Here the voltage at point B indicated as V_H is slightly greater than the voltage V_L at point A, hence, diode #2 has a potential applied in the direction of forward conductance, whereas diode #1 has a small inverse voltage applied.

Fig. 16 indicates the back region for one crystal with the forward of

(*Continued on page* 130)

Fig. 9: (Left) Low level (millivolt range) demodulation unit. Fig. 10: Curves showing mid-region resistance vs. threshold r-f input





IRE Air Conference

Annual national meeting in Dayton, Ohio, May 12 to 14 will feature 84 technical papers and 44 exhibitors

On May 12-14, 1952, the Biltmore Hotel will again play host to the National Conference on Airborne Electronics in Dayton, Ohio. Some 44 exhibitors of radio equipment and components have arranged to present their displays during the three-day meeting. The annual banquet, plus two luncheons and a dance, will serve as the focal point for entertainment and sociability. The outstanding feature of the Conference will be the comprehensive coverage of 84 technical papers presented at technical sessions including communications systems, components, antennas, measurements, computers, transistors and vacuum tubes. The program for the presentation of these papers is given below.

MONDAY, MAY 12

9:00-11:00 A.M.—Technical Sessions

Computers

"An Integrated Data Recording and Statistical Analysis Computing System"—S. Charp, Franklin Inst.
"Aircraft Flight Path Control for Bombing"—H. Levenstein, W. L. Maxson Corp.
"The Varigear, A New Mechanical Integration"—J. H. Brick, W. L. Maxson Corp.

Systems Analysis & Reliability I

"Special Cooling Problems and Their Solution Within Subminiature Assemblies"—J. P. Welsh, Cornell Aer. Lab., Inc.
"Reliability of Electronic Equipment"—I. Mirman, Rome Air Dev. Center
"Electronics in Naval Aviation"—Cdr. M. A. Mason, Bu. of Aeronautics
"Methods for Calculating the Reliability of Pilotless Aircraft"—C. R. Gates, Cal. Inst. of Technology

USAF's project engineer J. S. Horrigan demonstrates Air Materiel Command's midget transmitter-receiver, URC-4. Unit designed for air-sea rescue is made by Hoffman Radio, Los Angeles

Techniques for Communication Interference Reduction

"Techniques for Radio Interference Reduction in Aircraft"—Dr. W. E. Voisinet, Jr., Frederick Research Corp.
"A System for Maintaining Zero Electrical Charge on An Aircraft"—R. W. Hendricks, Jr., Cornell Aer. Lab., Inc.
"Reduction of Precipitation Static on Aircraft Canopies"—J. A. Bartelt, Wright Air Dev. Center
"Radio Interference from Charged Rain Drops"—M. M. Newman, Lightning and Transients Inst.

Antennas

"Some New Antennas Producing Wide Beam, Circularly Polarized Radiation"—R. Krausz, D. L. Margerum, North Am. Aviation, Inc.
"Aircraft Antennas for Automatic Directing Finding Systems"—J. T. Bolljahn, Stanford Research Inst.
"Some Practical Aspects of Aircraft Liaison Antenna Design"—F. W. Bushman, Boeing Air. Co.
"Side Lobe Suppression by Pattern Multiplication"—R. Justice, Ohio State U., Research Found.
"VHF and UHF Stub Antennas for Light Aircraft"—E. A. Jones, Antenna Research Lab., Inc.
"The Theory of Multiple Layered Radomes"—E. O. Hartig, M. C. Horton, Goodyear Air. Corp.

Communication & Navigation

"Electronic Aids to Search and Rescue"—Saul Weisman, Wright Air Dev. Center
"Pictorial Computers for Air Navigation"—L. E. Setzer, CAA
"The Selectivity and Intermodulation Problem in UHF Communication Equipment"—J. F. Byrne, Motorola, Inc.
"High Frequency Airborne Direction Finding"—P. S. Carter, Jr., Stanford Research Inst.
"Distant Radio Communication from the Standpoint of Modern Communication Theory"—M. J. DiToro, Fed. Telecom. Lab., Inc.

Electronic Instrumentation

"Strain Gauge Telemetering with FM/FM Systems"—R. S. Butts, G. F. Stastny, Melpar, Inc.
"An Airborne Infrared Spectograph with Multi-channel Electronic Display"—C. W. Hargens, Franklin Inst.
"FM/FM Telemeter Receiving Stations at the Air Force Missile Test Center, Cocoa Fla.—R. W. Murray, Raymond Rosen Eng'g Prod., Inc.
"A Precision Range Rate Calibrator for Radar Test"—A. H. Eicher, Mo. Research Lab., Inc.
"Pulse Type Parachute Radiosonde System"—E. J. Diehl, Melpar, Inc.

8:30-9:30 P.M.—SYMPOSIUM.
"Electronics and the Air Lanes"
PARTICIPANTS:
Military and Civil Aviation Interests

TUESDAY, MAY 13

9:00-11:00 A.M.—Technical Sessions

Measurements

"Microwave Pulse Power Measurement Techniques"—W. H. Dobbertin, Convair

B-47 on JATO assisted take-off

"An Airborne Microwave Refractometer"—C. M. Crain, A. P. Deam, U. of Texas
"Radar Video Signal Simulation"—R. C. Shaffer, K. A. Ringo, Goodyear Air. Corp.
"Radar Display Photography"—P. W. Ryburn, L. A. Shaffer, Goodyear Air. Corp.

Systems Analysis & Reliability II

"Large Scale Missile Simulator Maintenance Problems and Techniques"—J. W. Rabb, B. H. Shuman, U. S. Naval Air Dev. Center
"Electronic Equipment Reliability as Influenced by Packaging"—H. Z. Hardaway, J. G. Mathews, Bell Tel. Labs., Inc.
"Heat Transfer Design Problems in Aircraft Electronic Equipment"—L. Katz, Raytheon Mfg. Co.
"Performance of Airborne Electric Components under Environmental Conditions"—J. J. Beck, Raymond Rosen Eng'g Prod., Inc.

(Continued on page 88)

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Fig. 1: Air Force telemetry facilities in the Bahamas record data from missiles in flight

Tape Recording

Multi-track tapes find shock and vibration

By KENNETH B. BOOTHE,
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730 Fifth Ave., New York, N. Y.

PRIOR to 1950, magnetic tape recording played a very small role in scientific research and development. Data and other information requiring study and analysis were usually stored by such means as recording oscillographs, pen recorders, discs, wire and optical film. However, these methods either proved to be too complicated or they contained too many technical disadvantages to meet an ever expanding scope of requirements. With the development of extended range magnetic tape recorders, new tools for scientific research came into being and a new industry was created. . . . Magnetic Tape Recording for Instrumentation and Data Analysis.

Some requirements of this new field have been readily met through simple modifications of standard audio frequency tape recorders. In other cases, special engineering projects have been undertaken to develop entirely new types of recorders with precision drive systems. Today, as a result of these projects, practically any type of information which can be converted into electrical terms can also be faithfully recorded and reproduced on magnetic tape equipment. Such *special purpose recorders* may be divided into three main categories under the general headings of telemetering, shock and vibration, and computers.

The first large scale trend toward magnetic tape for special applications was brought about by a system primarily designed for testing aircraft and other forms of airborne devices under pilotless flight conditions. Here a number of sensory elements are used to convert various types of information, such as acceleration, vibration, temperature, etc., into electrical energies. These quantities to be measured cause changes in the frequencies of various subcarrier oscillators. Mixed together, these subcarriers FM a radio link as one composite signal and are transmitted to a ground station receiver. This technique is referred to as FM-FM telemetering.

Figs. 1 and 2 are Air Force photographs of telemetry facilities operating under tropical conditions in the Bahamas. Data is received from missiles in flight via an r-f link, recorded on tape at these down-range sites, and decoded and analyzed elsewhere.

The three racks at the left are primarily receiving and recording units. The remaining racks are used to play back the information through banks of discriminators and computers. Fig. 3 is a close-up of the receiver, recorder and tape playback.

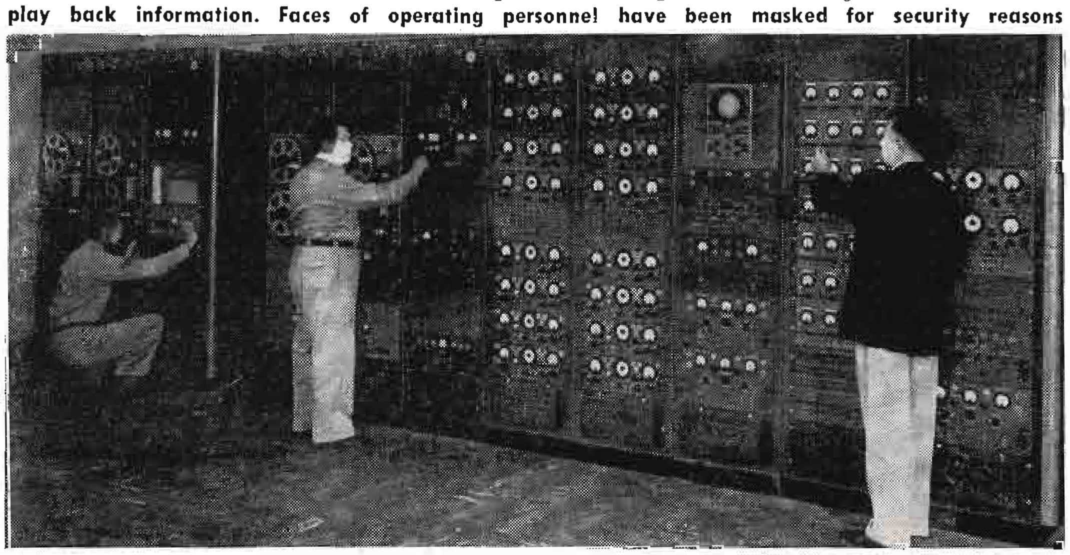
In an FM-FM system, the FM carrier is demodulated at the receiver and the composite subcarrier signal containing all information channels is recorded directly on the tape. During tape playback, individual information channels are separated by means of bandpass filters. Each filter has an associated limiter and discriminator that converts frequency changes into voltages proportional to the original quantities being measured. Thus as many as 16 channels of information may be recorded simultaneously on a single-track, wideband recorder.

This means that a considerable number of FM subcarriers must be crowded within the limited frequency spectrum of a single radio link. It follows, therefore, that the percent frequency deviation of each subcarrier must be considerably restricted if cross modulation or interference is to be avoided. Since subcarriers are usually deviated by only ±7.5% of center frequency, stringent requirements are imposed upon the recording equipment. In other words, the signal-to-noise ratio of any FM recording system is limited by the ratio of maximum percent peak frequency deviation to maximum percent peak flutter. Obviously, the recorder and reproducer must be as free from wow and flutter as the art permits.

Advantages of Tape

Actually, no other recording device has been able to compare with magnetic tape in this respect. Nor has tape been equalled in wideband frequency response. Telemetering sub-

Fig. 2: Three racks at left are for receiving and recording while remaining units are used to play back information. Faces of operating personnel have been masked for security reasons



for Telemetry & Data Analysis

PART ONE OF TWO PARTS

applications in studies of guided missiles, aircraft and vehicular operation, tests, and computers. Recent innovations sharply reduce wow and flutter

carriers now cover approximately 350 to 80,000 cycles. This fact presents no problem to magnetic tape but it does preclude the use of other systems where this entire frequency band must be accurately recorded and reproduced. Tape offers additional advantages because of its characteristically low harmonic distortion. Cross modulation resulting from this source is reduced to a minimum since cancellation takes place on all even order harmonics and only a negligible amount remains in the third.

Of course, tape recording is not the only method for obtaining flight information per se. This may be done with direct reading meters calibrated in terms related to original data, but with certain basic restrictions. For example, when trouble develops or some unusual phenomenon occurs, detailed study and analysis of from one to sixteen separate channels of information may be required. Therefore. permanent records must be made. One method which has had considerable use is the recording oscillograph which makes continuous multichannel records and permits detailed study and analysis at some later time. But in actual practice, this approach has proven to be both complicated and time consuming. Only an estimated 4% of usual flight tests are of particular interest. Therefore, reams of photographically developed oscillographic records must be taken for a small portion of data requiring attention.

Magnetic tape offers two simple solutions: First, all multichannel data may be stored on tape during time of flight. By monitoring the tape later, the small amount of pertinent information may be quickly located and transferred electrically from tape to the recording oscillograph at a great saving in time and materials. Second, and what is even more important, is the elimination of the recording oscillograph altogether. With the development of new types of computers, all flight data may be first recorded on tape and then played back directly into automatic data reduction equipment. Thus, a continuous flow of multi-channel data may be reduced automatically without having to resort to the tedious analysis of numerous oscillographic traces.

The first standard tape recorder developed specifically for FM-FM telemetering use was the popular Ampex Model 302. At 30 inches per second (ips) tape speed, response is flat within 2 db from 200 to 30,000 cycles and is down no more than 10 db at 50,000 cycles.

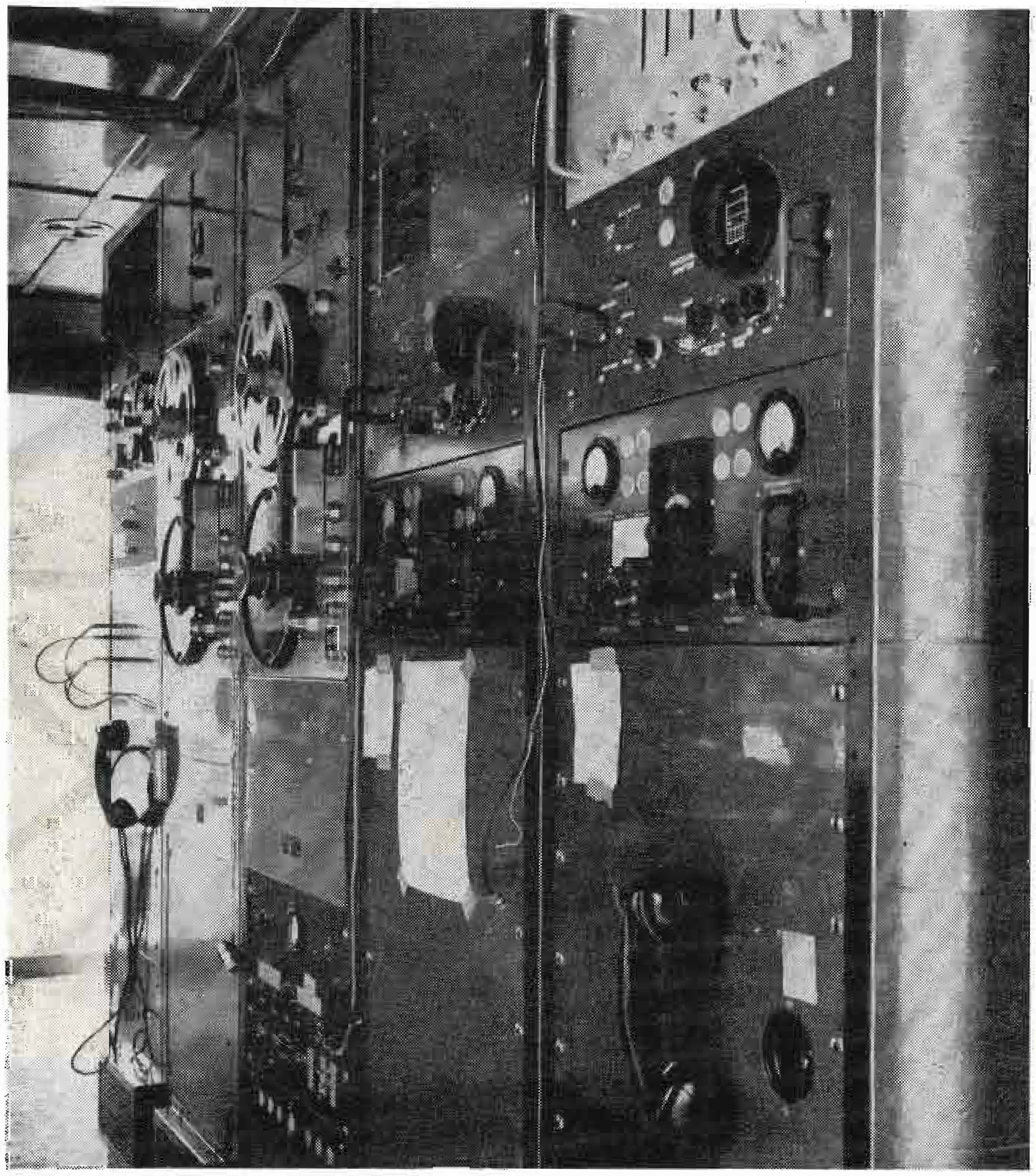
In order to meet the growing need for recording much higher frequencies, Ampex developed the Model 307. This unit is a three speed recorder: 60, 30 and 15 ips, and replaces the earlier Model 302. Frequency response at 60 ips is ±3 db from 200 to 80,000 cycles and is down no more than 10 db at 100 and 100,000 cycles. All existing telemetering subcarrier frequencies may, therefore, be recorded and reproduced with this machine.

Since some data frequencies may approach 100 KC, the bias has been been moved up to 350 KC in order to avoid objectional beats between bias and recorded data. Special record and playback heads were also developed which have very low loss out to 100 KC.

Planned as Basic Unit

Because of the great diversity of requirements, the Model 307 was planned to serve as the basic unit for a number of different applications. For example, the Model 307 may be quickly converted into a dc

Fig. 3: Close-up view of receiver, magnetic tape recorder and playback units



to 2,500 cycle recorder by simply plugging in a standard Model 306 FM electronics unit in place of the 307. With a Model 303 unit and a different plug-in head assembly, the 307 becomes a recorder for pulse-width modulation data. Information may be recorded and played back at the same frequency or, by changing tape speeds, at one-half, one-fourth, twice or four times the original frequency. With a few minor modifications, the equipment may be used as a continuous-loop playback system for detailed study and analysis of recorded data.

Fig. 4. shows the airborne recorder model S-3079 which contains its own tuning for and power amplifier for self-generation of a stable tape driving voltage. It is a record only unit, since it is not required that information be played back during flight.

Fig. 5 illustrates the model S-3039 tank mounting recorder. It is shock and vibration proof, and operates with a 40 db signal-to-noise ratio.

Returning again to telemetering applications, all conventional types of magnetic tape recorders require some form of electronic flutter compensation when recording FM subcarrier deviations of only ±7.5%, if an overall system error of less than 1% is to be maintained. Narrow-band FM recording is extremely critical due to mechanical speed variations and, in this case, peak-to-peak modulations are multiplied by a factor of 13.3 on the reproduced data.

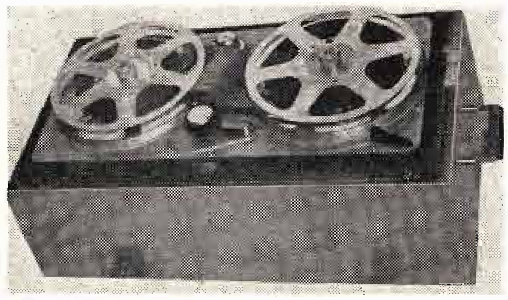


Fig. 5: Model S-3039 tank mounting recorder

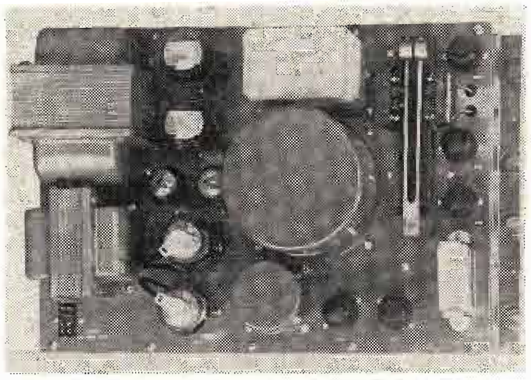


Fig. 6: Model 375 power amplifier provides stable 60 CPS voltage to operate motor drive

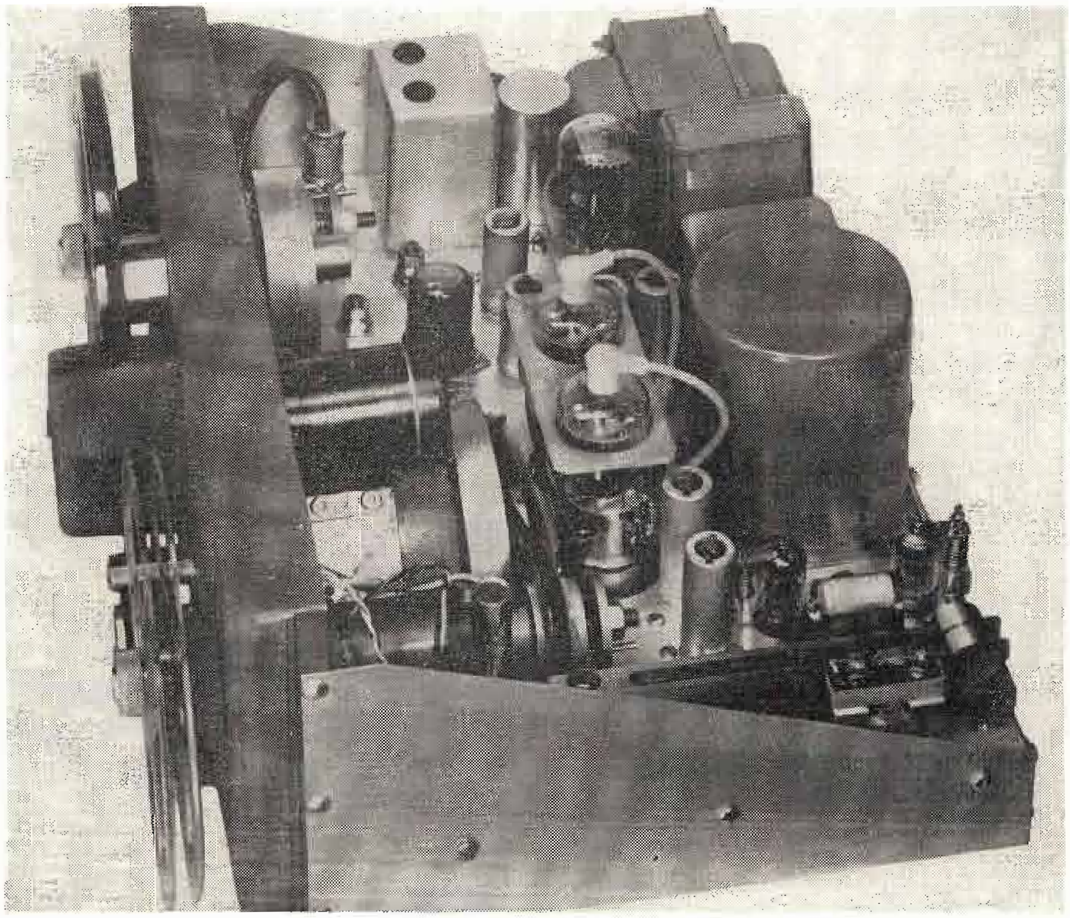
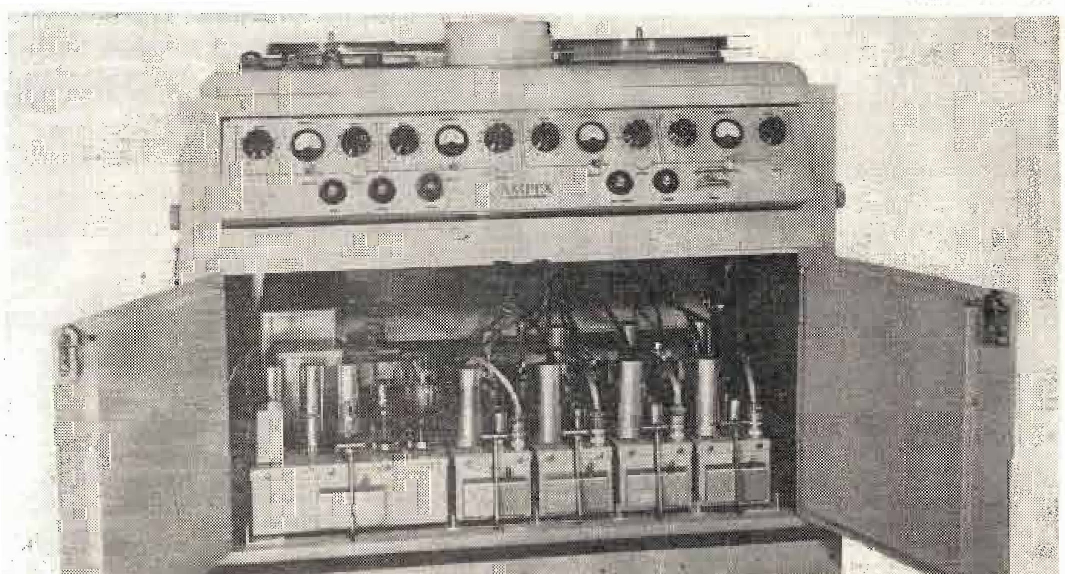


Fig. 4: Model S-3079 airborne recorder contains tuning fork and power amplifier

Fig. 7: Recently announced Model 500 has novel tape drive mechanism which reduces flutter. Particularly suitable for ballistic applications, unit records four channels on half-inch tape



Flutter Compensation

Electronic flutter compensation, such as the Raymond Rosen system, is accomplished by mixing one unmodulated signal from a stable crystal oscillator source with the composite carrier received at the ground station. These complex signals are recorded on the tape. During the record and playback process, the frequency stable or compensation carrier becomes frequency modulated by the small amount of mechanical flutter and wow present in the tape drive system. Identical modulations also occur on each subcarrier of the complex signal. When tapes are played back, the compensation frequency is fed in the usual way through a bandpass filter, limiter and discriminator. Output voltages of the compensation discriminator are then fed at opposite phase across the outputs of each subcarrier discriminator in order to cancel out wow and flutter products. In this manner, flutter reductions of as much as 5 to 1 may be expected.

For field as well as fixed recording installations, a thoroughly reliable

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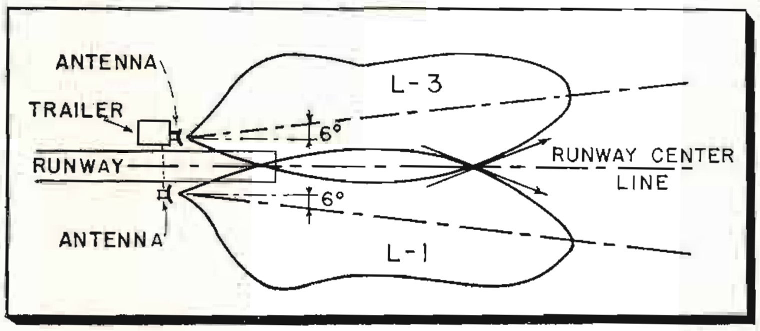


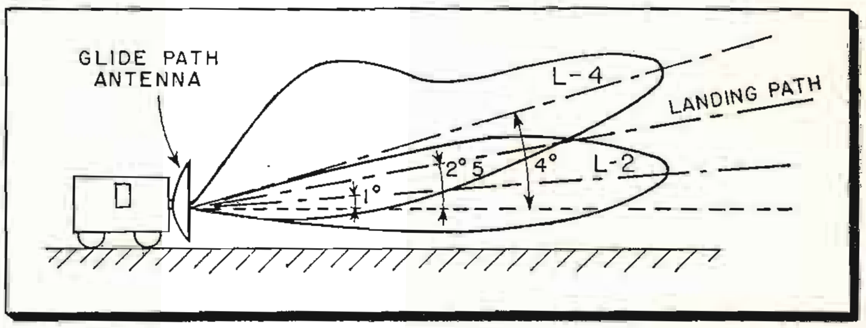


Fig. 1: (L) Antennas on both sides of runway radiate localizer patterns which provide horizontal guidance to aircraft making landing approach. Fig. 2 (R) Lobes of glide path patterns emitted from single antenna combine with localizer lobes to map out landing path which is presented visually

An Improved ILS for Aircraft

Compact UHF localizer and glide path system developed in France provides continuously dependable landing information

MAJOR improvements in the field of non-visual aids to aircraft final approach and landing should be forthcoming as microwave techniques are applied to the design and operation of radio landing systems. The advances contained in an instrument landing system (ILS) developed in France by the Compagnie Générale de Télégraphie sans Fil (CSF) are sufficiently important to have moved the International Civil Aviation Organization to focus considerable attention on the system's potentialities.

The purpose of this improved ILS, called the ASV 23, is to provide guidance to aircraft under any weather conditions by giving the pilot visual indications without radio contact with the ground. The basic operation consists of one 1300 MC common carrier which provides localizer and glide path guidance information to an indicator in the cockpit, showing the aircraft's position with reference to a landing path.

The landing path is determined by pulses which are radiated successively along four lobes. The intersections of these lobes, in pairs, define the localizer plane and the glide path plane. Pulse duration is approximately $1/60$ sec. and the four lobes shown in Figs. 1 and 2 radiate in the following order: left localizer (L-1), lower glide path (L-2), right localizer (L-3), upper glide path (L-4). The time interval between pulses is $1/360$ sec. A greater interval, about $1/40$ sec., is provided at the end of the cycle of four pulses.

The two lobes for determining the vertical localizer plane are obtained from two parabolic antennas located on both sides of the runway. The other two lobes for the glide path plane radiate from a single parabolic "cheese" antenna comprising two exciters close to the focal point. It should be noted in Figs. 1 and 2 that lobes L-1, L-3, and L-4 have bulges which are produced by an additional exciter near the antenna focal points to increase coverage.

Successive pulses are formed by a 600 rpm distributor comprising a rotating cavity tuned to the carrier frequency and radiating through a slot passing in front of four waveguides. Each waveguide in the trailer-installed transmitter system (see Fig. 3) is connected to the proper antenna to maintain the pulse sequence indicated above. The duration of the passage of the slot in front of each guide prescribes the emitted pulse time.

Each rectangular pulse is modulated at a different sinusoidal frequency. For particular lobes the frequencies are: L-1, 20 KC; L-2, 34 KC; L-3, 24 KC; L-4, 30 KC. Voltages are applied to a capacitive switch mounted on the same shaft driving the rotating distributor, thereby providing the specific modulation for each antenna.

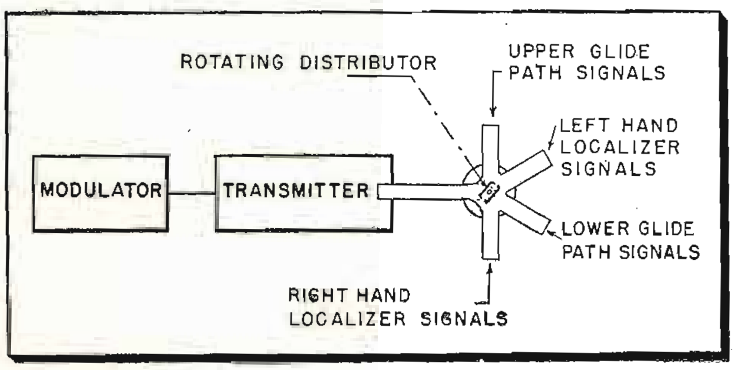
It should be noted that additional provisions are incorporated in the 200-watt transmitter for associated distance measuring functions.

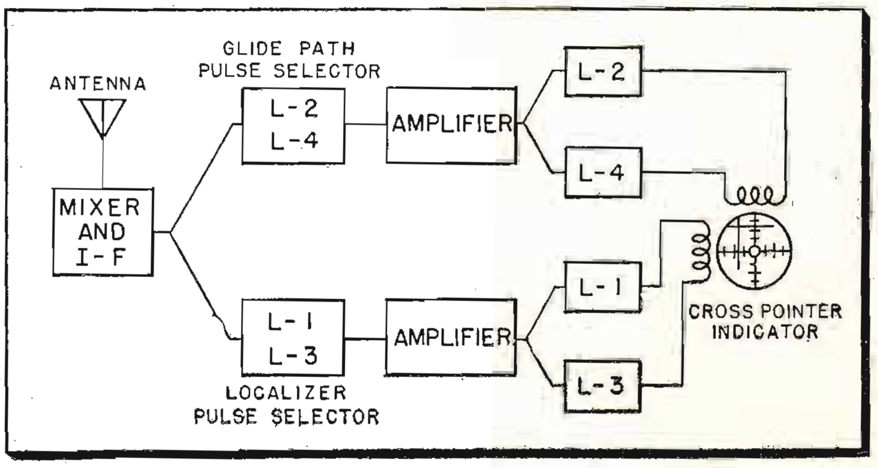
Airborne Equipment

Mounted above the pilot's cockpit, a receiving antenna, made up of three half-wave elements, and molded into a streamlined plexiglass housing, feeds received signals to an agc-afc receiver, as shown in Fig. 4. The receiver operates a cathode-ray tube or cross-pointer indicator to provide two fixed rectangular reference axes whose point of inter-

(*Continued on page* 118)

Fig. 3: (L) ASV 23 system successively transmits four digerently modulated signals on one carrier frequency. Fig. 4: (R) Airborne receiver combines glide path and localizer signals on pointer indicator





CUES for BROADCASTERS

Practical ways of improving station operation and efficiency

$$$ FOR YOUR IDEAS

Readers are invited to contribute their own suggestions which should be short and include photographs or rough sketches. Typewritten, double-spaced text is preferred. Our usual rates will be paid for material used.

Talk-Back Console

ORVILLE D. JACKSON, Assistant Engineer, WGGH, Marion, Ill.

AT WGGH there is a complete Gates setup, which includes the SA50 console. This console includes two "talk-back" keys, which are set for use with an external amplifier. However, in view of the plentiful power available, the terminals which are supposed to feed the auxiliary amplifier were tied across the input of the monitor. This put the output of the microphone pre-amplifiers across the input of the monitor amplifier, skipping all gain controls, and providing plenty of volume for talk-back, and guaranteeing that the mike used for this purpose will never get on the air. Associated relay circuits, of course, had to be altered. There are sufficient terminals on the talk-back keys to take care of these changes.

Tape Recorder Modifications for Editing to Disc

VINCENT SALMON, Stanford Research Institute, Stanford, Calif.

THESE notes refer to a Webster-Racine model 101-8 Ekotape used for recording and editing to disc. The signal-to-noise ratio was improved about 15 db by adding a filter and shielding to the first stage. The choke must have less than 0.3 ohms resistance. The one actually in use is the 16-ohm secondary of a 15-watt output transformer.

This model machine has a two-winding record-playback head, but only one winding is in use. The other one was employed in an earlier model for the record current. By bringing the unused winding out to a jack, it is possible to monitor the bias voltage quite easily. The voltage ratio to the record-playback winding is 1:20; the inductances are about 0.185 and 74 mh respectively. A second use for this other winding is for introducing dc into the recording head to reduce the noise and distortion arising from a magnetized head or asymmetrical waveform of bias. Still another use is for monitoring during recording; however, careful attention to circuit details is necessary to avoid introducing hum into the tape.

For editing it is desirable to be able to pull tape by hand. This requires holding back the pinch roller from contact with the capstan. The figure shows a simple holdback clamp made from 1/8-in. brass rod. One end is flattened and bent to engage the pinch roller arm. The rod is held in the desired position by friction where the solder lug is screwed down, but more positive locking arrangements are easy to construct.

In editing, program material can be lost by accidental contact between the tape and the erase magnet. The latter should be removed for editing, or may be shielded by a piece of rubber tubing. The tubing is placed over the magnet in the orientation shown.

A simple editing aid can be made by breaking the serrated ends off a pair of plastic probing tweezers. Dress the raw surfaces, drill a hole, and cement in a piece of a phono needle. With this gadget the tape can be indented at the edit spot rapidly and positively making later identification of the spot easy.

For locating material on the tape when programs have to be rapidly edited, a revolution counter engaged to the take-up shaft is invaluable. Because of the high reverse speeds on rewind, it is essential to lubricate the counter with graphite powder before using. The repeatability of the arrangement is so good that the editor need note only a few key words and the counter reading.

On playback a good indication of recorded level is obtained by advancing the "Record" control until the eye flickers. By recording at a series of levels, the settings corresponding to the distortion point are easily located.

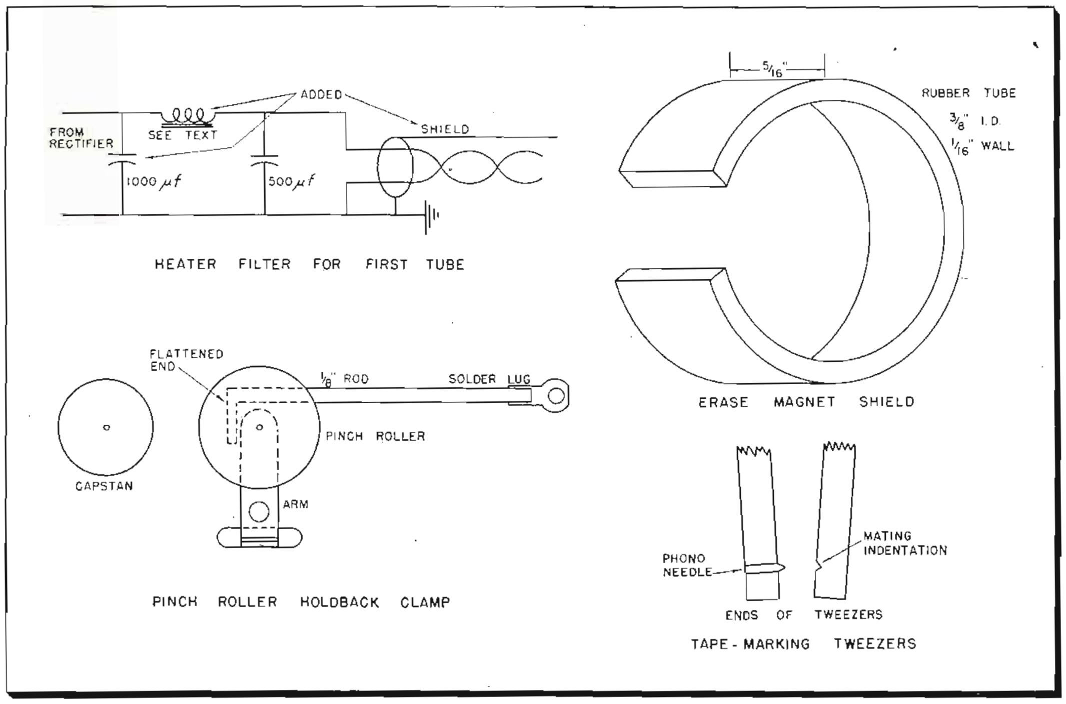
When the program signal is fed to the "High Level" input, local voice comments can be interpolated by inserting the mic plug just far enough into the "Low Level" input to make gentle contact. Complete insertion will open the high level input. These features have been used in the preparation of standard tapes and other test material.

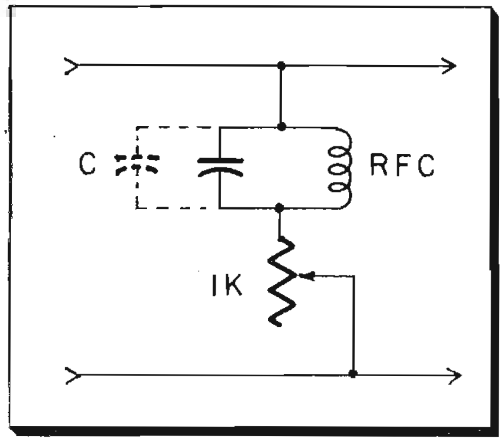
Simple Line Equalizer

GEORGE H. MARTIN, Brownsville, Tex.

REMOTE and network lines can be easily equalized without resort to use of complicated or expen-

Gadgets for use with Webster-Racine Tape Recorder make operation simpler.





Circuit for "junk-box" equalizer for remotes

sive equipment. All that is needed is an r-f choke, one or more capacitors, and a potentiometer. The values of the r-f choke and capacitor should be chosen to resonate near the maximum frequency on the flat portion of the desired equalized response curve. The slope of the non equalized line's response curve at this frequency determines the value of the series resistance. The exact value is best determined by adjustment until a satisfactorily flat response is obtained in operation.

F 1,000 cps (approx.)	RFC millihenries	C microfarads
10	10.0	.03
9	1.0	.3
8	10.0	.04
7	1.0	.5
6	2.5	.3
5	2.5	.4

Studio Stethoscope for Detecting Sound Leaks

KENNETH MAXWELL, Chief Engineer, KLTI, KLTI-FM, Longview, Texas

TO detect sounds leaking from studio to studio, an Altec "saltshaker" microphone was connected to a remote amplifier. This was set up in one studio while an audio oscillator and loudspeaker were placed in an adjoining studio. The oscillator was adjusted to various frequencies from 200 to 5000 cps and each time the microphone was moved back and fourth across the walls, doors, and windows.

This revealed that low frequency tones were vibrating the door panels, and high frequency tones passed through the cracks around the door, and through the air conditioning ducts. Sound passage through the air conditioning ducts was reduced by lining the inside of the ducts with more sound deadening material. It was noted that moving the microphone around the edge of the door caused the VU meter to rise and fall every few inches. These points were marked by pressing small pieces of white splicing tape on the door. When the door was opened, it was found that these marks were in line with the tacks used to fasten the gasket material to the door frame. The gasket material, a round sponge rubber with a cloth covering fastened to the door frame, was removed as a result of this examination. In its place, a strip of flat sponge rubber was glued to the door frame covered with a small strip of felt. The felt was added to keep the sponge rubber from sticking to the door. This gave a lower, more uniform transmission of sound. Standing sound waves may be present in the room being checked. To prevent this from affecting the work, a piece of sound deadening material should be wrapped around the microphone.

The single channel remote amplifier proved no great problem for our carpenter to master and he was soon using the oscillator and amplifier to check the work as he went along.

Remote Controlled Selection of Remote Telephone Lines

ANTONIO VACCARO, Chief Engineer, WHEB, Portsmouth, N. H.

WITH the coming of television, AM broadcasting stations were faced with the problem of curtailing operations to meet expenses and at the same time make for flexible operations with a minimum of operations personnel. In most small stations this meant that since the studios and control room were located away from the transmitter, the announcer had to run the control room and announce. Locating the remote lines at the studio to either jack strips or control switches on console did not produce flexibility or smooth operation, especially when a recording had to be made while one line was being used for a program broadcast. Termination of remote lines at the studio gave the engineer no means of checking lines should trouble occur.

In order to give the announcer full control over a selection of lines, a system of remote control for all incoming remote lines was developed. All relays and impulsers are manufactured by the Automatic Electric Co., and the following parts are needed:

1 stepping relay, catalog #RA-77; 1 stepping relay, catalog #RA-67; 1 Dial phone impulse sender, type 24A36 Catalog #AK-14; 2 Quick acting pulsing relays, series AQA, Cat. #RA-15; 1 D.P.S.T. push button switch or lever switch; 25,000 ohm wire wound rheostats; 11 pilot lights and sockets.

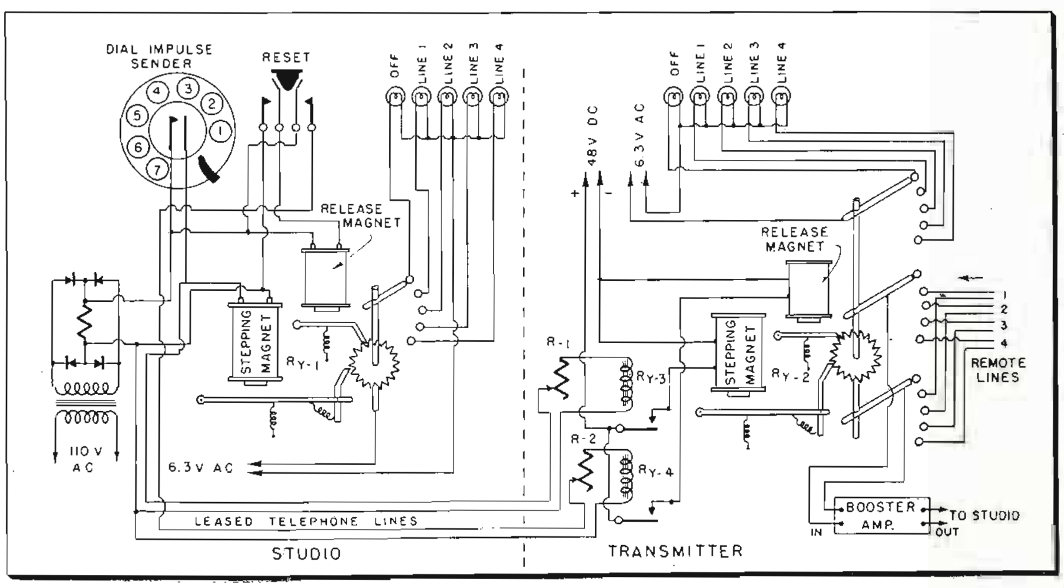
The RA-77 (RY-2 in schematic) and RA-67 (RY-1) are identical except that the RA-77 has three wiper arms and the RA-67 has only one, since it is used only to control the indicating lights on control panel at the studio.

As first conceived, the remote control system consisted of one dial impulse sender and two stepping relays in parallel, both controlled by the dial impulse sender. Data on desired relays shows that these relays require heavy current at low voltage or low current at high dc voltages, both being undesirable.

With the following variables in mind the problem was discussed with engineers at the local telephone company and the system finally adopted as shown in the schematic: a) what is the maximum dc voltage allowable on a leased Tel. & Tel. line?; b) what is maximum current allowable on a leased line?; c) what would be the dc resistance of these leased lines where we were approx. 2½ miles from studio? The relays operate from 48 v. dc at 300 ma.,

(Continued on page 94)

Circuit makes flexible operation and selection of remote lines foolproof



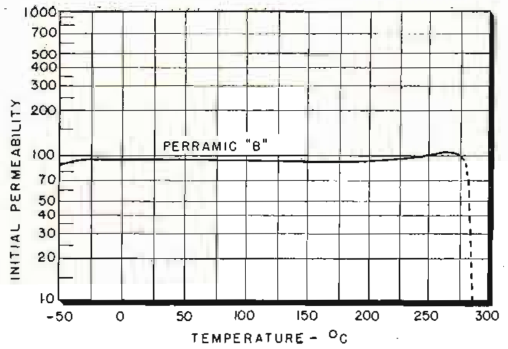


Fig. 1: Permeability vs. temperature at 10 KC

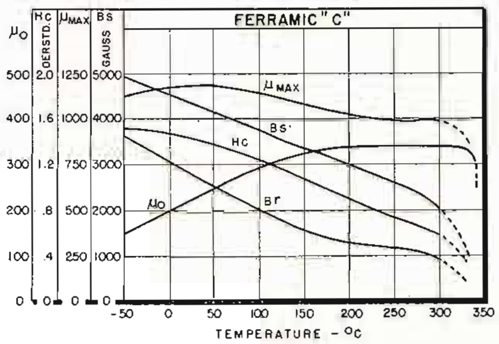


Fig. 2: Temperature characteristics of Ferr. C

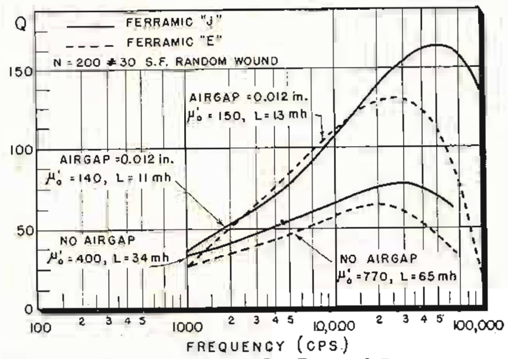


Fig. 3: Frequency vs. Q, Ferr. J-E cup cores

Magnetic Properties of

Wide range of permeability, saturation flux density and merous magnetic core applications. Developmental types

By EPHRAIM GELBARD
Project Engineer
General Ceramics & Steatite Corp.
Keasbey, N. J.

FERRITES, used as magnetic core materials, consist of oxides of metals, and are formed at high temperatures by means of solid state reactions. In general, a ferrite magnetic core is a polycrystalline substance of bivalent oxides and iron oxide.

The desired shapes are formed before the firing process by pressing or extruding. After firing, the material is hard and brittle, but cutting or grinding can be performed with adequate tooling. Such ferrites are black in color and have a specific gravity of about 5.

It is fairly well known that the ferrites can be used at higher frequencies than metallic magnetic materials since their high resistivities sharply reduce eddy current effects. This also eliminates the necessity for laminating ferrite cores.

The properties of seven grades of ferrite are shown in Table 1.

Ferramic B

Ferramic B has a relatively low permeability with an extremely stable temperature characteristic of initial permeability. The curve of initial permeability versus temperature is shown in Fig. 1. The calculated temperature coefficient of initial permeability from test data gives + 0.04/° C. This measurement was performed on toroidal cores and so it is to be expected that the temperature coefficient will be smaller for magnetic circuits containing air gaps. This temperature stability has proven useful in applications such as tuned or resonant circuits where the inductance should not vary with temperature.

Ferramic C is a higher saturation and relatively temperature stable material. Fig. 2 shows the variation of the magnetic properties over the temperature range −50° C to the Curie temperature of about 350° C. These measurements typify the variation of the properties of any ferrite with temperature except for the shape of the permeability curves in Fig. 2. It is noteworthy that saturation, B_s, for Ferramic "C" still is about 2000 gauss at 300° C, a temperature at which most other ferrites commercially available are no longer useful. Between 300° C and the Curie temperature, the saturation flux density decreases very rapidly. In addition, the maximum permeability subscript of this material is almost as temperature stable as the initial permeability μ_o, of Ferramic B. Although the temperature curve of μ_{max} is not actually a linear function, the temperature coefficient of maximum permeability is −0.054/° C from 25° C to 300° C, using these two points for the calculation. These properties of Ferramic "C" lend themselves admirably to high temperature, power handling applications.

Ferramic E

Ferramic E has proven generally useful in low power applications where operation is at or about μ_o level. The μ_o of this ferrite is about 750. In tuned circuits or filters, circuit Q is of paramount importance. This circuit Q is a measure of the efficiency, or conversely, the losses that the circuit presents to the ac signal. Since capacitive components used in these applications usually have low losses, then the greater part of the circuit Q is due to the loss characteristic of the inductive component. Yet in addition to its Q, the size of the inductance both electrically and physically is often a

TABLE 1—TYPES OF FERRAMIC MATERIAL

PROPERTY	UNIT	B 90	C 159	E 212	H 419	H-1 1102	I 141	J 472
Initial permeability at 1 MC/sec	—	95	250	750	850	550	900	330
*Maximum permeability	—	183	1100	1710	4300	3800	3000	750
*Saturation flux density	Gauss	1900	4200	3800	3400	2800	2000	2900
*Residual magnetism	Gauss	830	2700	1950	1470	1500	700	1600
*Coercive force	Oersted	3.0	2.1	0.65	0.18	.35	0.30	0.80
Temperature Coeff. of Initial Permeability	%/°C	0.04	0.4	0.25	0.66	0.80	0.30	0.22
**Curie Point	°C	260	330	160	150	125	70	180
Loss Factor:								
At 1 MC/sec	—	.00016	.00007	.00008	.0003	.0004	.0003	.000055
at 5 MC/sec	—	.0011	.0008	.002	.0020	—	.005	.0004
at 10 MC/sec	—	.004	.004	—	—	—	—	.002
Volume Resistivity	ohm-cm	$2x10^5$	$2x10^6$	$4x10^5$	$1x10^4$	$2x10^4$	$2x10^5$	$5x10^7$

*Measurements made on dc Ballistic Galvanometer with Hmax = 25 oersteds.
**From measurements of initial permeability vs. temperature.

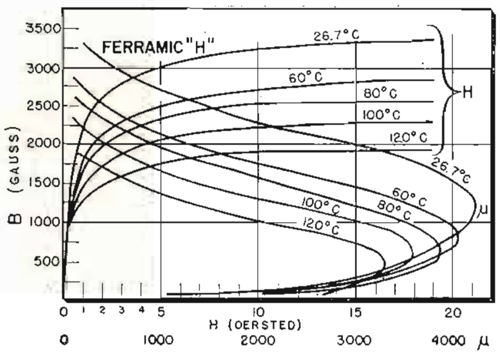


Fig. 4: Normal curves for various temperatures

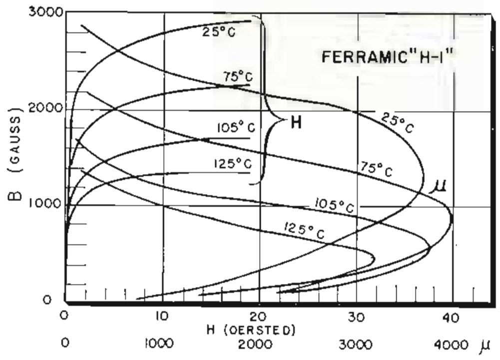


Fig. 5: Normal curves for various temperatures

Ferrite Materials

volume resistivity make Ferramics useful in nu-

show promise for computer and memory systems

practical problem. The Q of powdered iron inductance is high, but the low permeability obviates any large inductances which are physically small. Ferramic E material is a compromise between Q and permeability. From Table I, the initial permeability, μ_0, is found to be 750 and the loss factor, $1/\mu_0 Q$, at 1 MC is 0.00008. Upon comparing these values with those of the other Ferramics, it is seen that Ferramic E offers a relatively high μ_0 with a low loss factor.

Capitalizing upon these properties of Ferramic E still more can be gained when inductances are in cup coreshape. At the present time, about six sizes and variations in construction are available. The main advantages of cup core inductances are that a bobbin-wound coil can be used, the circuit is self-shielding, and the air gap is readily adjustable for tuning. One method used to accomplish the latter is to use a shim to set the air gap. Another method unique to cup cores is to rotate one-half of the cup core assembly with respect to the other half. When two rectangles notched in the outer rims are directly opposed, maximum inductance is attained. This method gives a very smooth vernier adjustment and is useful especially for sharply tuned circuits.

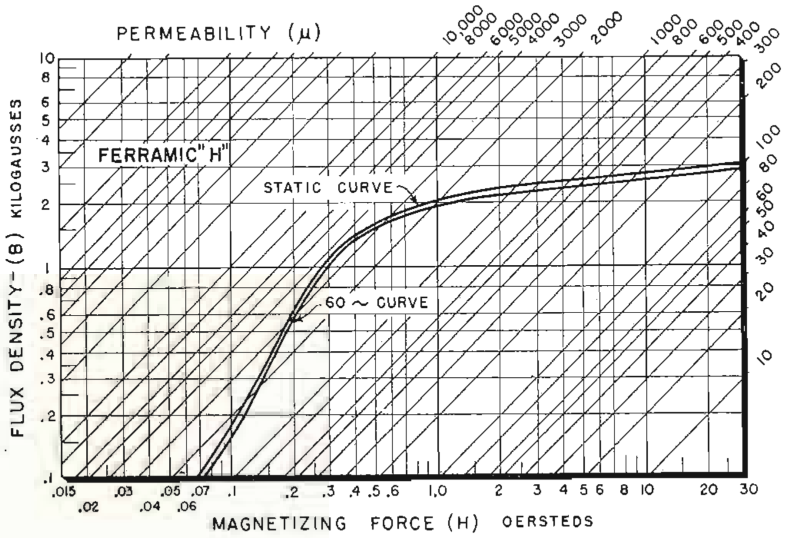
Introducing Air Gap

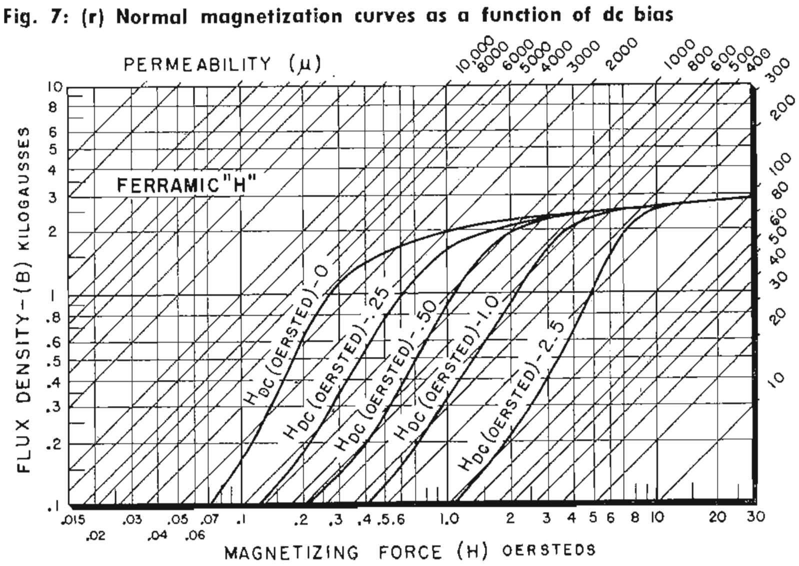
When an air gap is introduced into a magnetic circuit, the usable or effective permeability decreases and sometimes the losses are reduced or Q increases. For a metallic magnetic material with a specific air gap and coil, it has been found that a curve of Q vs. frequency (within the upper frequency limit of the material) reaches a peak at some point. If the air gap is changed, the peak will shift to another frequency, but the maximum Q will remain essentially constant. For powdered irons, however, the frequency of maximum Q theoretically remains the same, but the maximum Q will vary as a function of various air gaps. Thus it is reasonable to expect that for the ferrites with eddy current loss characteristics and permeabilities in between the metals and powdered irons, the maximum Q and also the frequency at which it occurs will vary as a function of air gap. This has been found to be true by experiment. For any given ferrite core material, a set of Q vs. frequency curves can be found by using either air gap or coil inductance as a parameter for each curve. In general the peak of any one curve or optimum Q occurs when the magnetic losses are balanced out by copper losses.

Ferramic J is used for similar applications as is Ferramic E except that its losses are lower. The μ_0 of Ferramic J is about half of that for Ferramic F. It is useful for high Q circuits where large inductances are not necessary, such as antenna rods, tuning slugs, and cup cores. **Fig. 3** shows curves of cup cores for Ferramic J and Ferramic E over a limited frequency range and illustrates a series of Q vs. frequency curves with and without air gaps. The curves do not necessarily represent maximum values possible.

Ferramic I is a material which combines high permeabilities and a low saturation flux density. Also, the retentivity (B_r) is low with respect to B_s. The ratio of retentivity to saturation, B_r/B_s, for this ferrite is lower than any of the other materials and is about 0.35. Certain useful applications have been found for these properties. It can be used as a gating or switching device, since at low power levels, the impedance is high due to the high initial permeability; but when driven with a relatively low pulse of exciting current, the impedance drops to a low value as it saturates quickly. The low B_r/B_s ratio of this material makes

Fig. 6: (l) Normal magnetization curves for Ferramic H toroids. Fig. 7: (r) Normal magnetization curves as a function of dc bias





possible its use as a highly variable inductance remotely controlled by a dc winding. If a toroid is once magnetically saturated and then excitation removed, the core maintains retentivity or remanance. If a small ac signal is then applied, the permeability will not be the same as true initial permeability but will be roughly one-half. If a dc bias is then added, this permeability will become smaller as the bias is increased. The change in permeability to a low power signal under these conditions can be as high as several hundred to one.

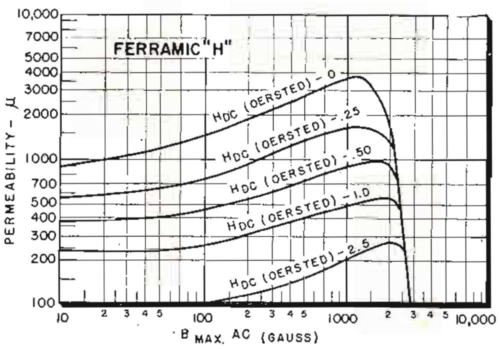


Fig. 8: Incremental permeability vs. ac flux

Ferramic H

Ferramic H is a ferrite of optimum magnetic properties for low frequency and communication work. It combines a high initial and maximum permeability with a fairly high saturation flux density for a ferrite. For these reasons, it has perhaps been used more than any of the other ferrites. In all cases where large inductances are the prime requisite, Ferramic H is the best choice due to its high permeability. In addition, this material has low power losses; the coercive force, H_c, being of the order of 0.20 oersted. The normal magnetization curves and permeability curves, as a function of temperature, are as shown in Fig. 4. It has proved excellent for TV horizontal deflection cores and yokes.

In recent months, Ferramic H has been replaced by Ferramic H-1 for non-military and TV applications. This latter ferrite represents a large saving of scarce nickel oxide with a relatively small reduction of magnetic properties and efficiency. The magnetic properties of this ferrite are shown in Fig. 5. Comparison of these magnetic properties with those of Ferramic H (Fig. 4) shows that H-1 material is almost equivalent in all respects. In actual use in TV circuitry, the ferrite cores are almost always used with an air gap in the magnetic path. Since true magnetic properties are thus reduced by some factor, the very good properties of Ferramic H were not being utilized to the best advantage.

In certain applications, however, where the highest efficiency is necessary, Ferramic H is still the best choice for the designer. These applications include the following examples:

(1) Highest inductance per unit volume at either low level or power applications.
(2) Saturable reactors or magnetic amplifiers where the greatest degree of non-linearity of magnetic properties is desired, plus low power losses.
(3) Large inductance requirements with dc superimposed on the ac signal.

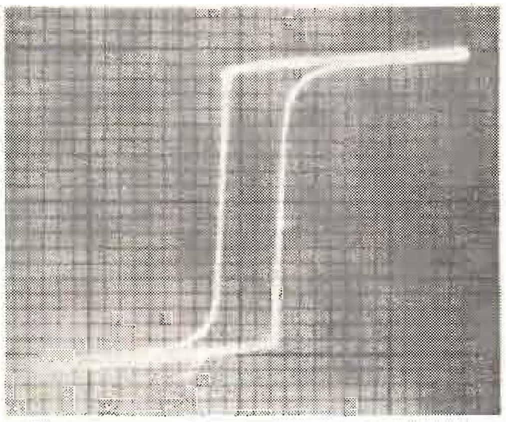


Fig. 9: Developmental ferrite (MF-1118) 60 cps rectangular hysteresis loop. Static properties: $B_s = 2350$ gauss; $B_r = 2140$ gauss; $H_c = 1.5$ oersted; $\mu_0 = 43$; $\mu_{max} = 700$; $B_r/B_s = 0.91$

One illustration of the first example can be shown as follows: an inductance of 10 hy. at the μ_0 level was constructed using a Ferramic H cup core, about 1 in. in diameter. The same cup core would give about 40 hy. if operated at maximum permeability. The second and third examples are related and measurements of basic properties to aid the designer have been completed; that is, the variation of magnetic properties as a dc excitation component is added.

This measurement was made at a frequency of 60 CPS by using a calibrated oscilloscope as a peak-reading voltmeter. The first approach toward accuracy was the correlation between this ac measurement with no dc excitation and the static measurements using a ballistic galvanometer connected as a fluxmeter. Fig. 6 shows these measurements taken on the same Ferramic H ring. Similar measurements made on magnetic metals have shown larger variations in the same direction; that is, the ac permeabilities being less than the static dc permeabilities. The maximum difference between these two measurements for the ferrite core is about 5%, which includes any measurement errors as well as a frequency effect. This result was anticipated since eddy currents are negligible at this low frequency for Ferramic H. In addition, it is logical to assume that similar measurements of the other Ferramics would agree even closer since H material has the lowest resistivity or highest eddy current effect. Similar measurements at higher frequencies are planned.

Next the measurement of magnetic properties of Ferramic H as a function of dc bias was made. Fig. 7 shows a family of normal magnetization curves as a function of dc excitation. The bias was applied on a separate winding in series with a high impedance at 60 CPS. Fig. 8 shows the familiar incremental permeability curves with ac permeability vs. ac flux density at various dc excitations. The largest value of dc used was equivalent to 2.5 oersteds, which is more than 10 times as large as the coercive force. It is noteworthy that even with this large value of bias, the maximum permeability is still about 8% of that with no dc excitation.

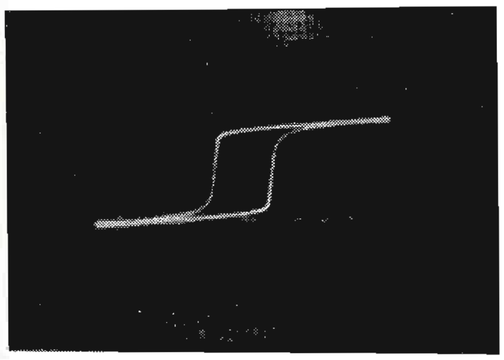


Fig. 10: Developmental ferrite (MF-805) 60 cps square hysteresis loop. Static properties: $B_s = 1500$ gauss; $B_r/B_s = 0.83$; $H_c = 2.34$ oersted; $\mu_{max} = 300$; $\mu_0 = 40$; Curie Temperature over 150°C; Volume resistivity = 4×10^7 ohm-cm

During the last few years, research and development at General Ceramics and Steatite Corp. has been done on ferrite materials exhibiting rectangular hysteresis loops. A material exhibiting rectangularity (Fig. 9) can be defined in terms of its magnetic properties:

(1) The B_r/B_s ratio should be as close to unity as possible.

(2) The hysteresis loop should be steep, or the differential permeability, dB/dH, large.

(*Continued on page* 82)

WABD's New TV Transmitter

Installation atop Empire State Building in N.Y.C. employs centrally located console and U-shaped rack arrangement of equipment. VHF antennas permit flexible operation

By ROBERT I. BROWN,
General Engineering Dept.,
Network Div.
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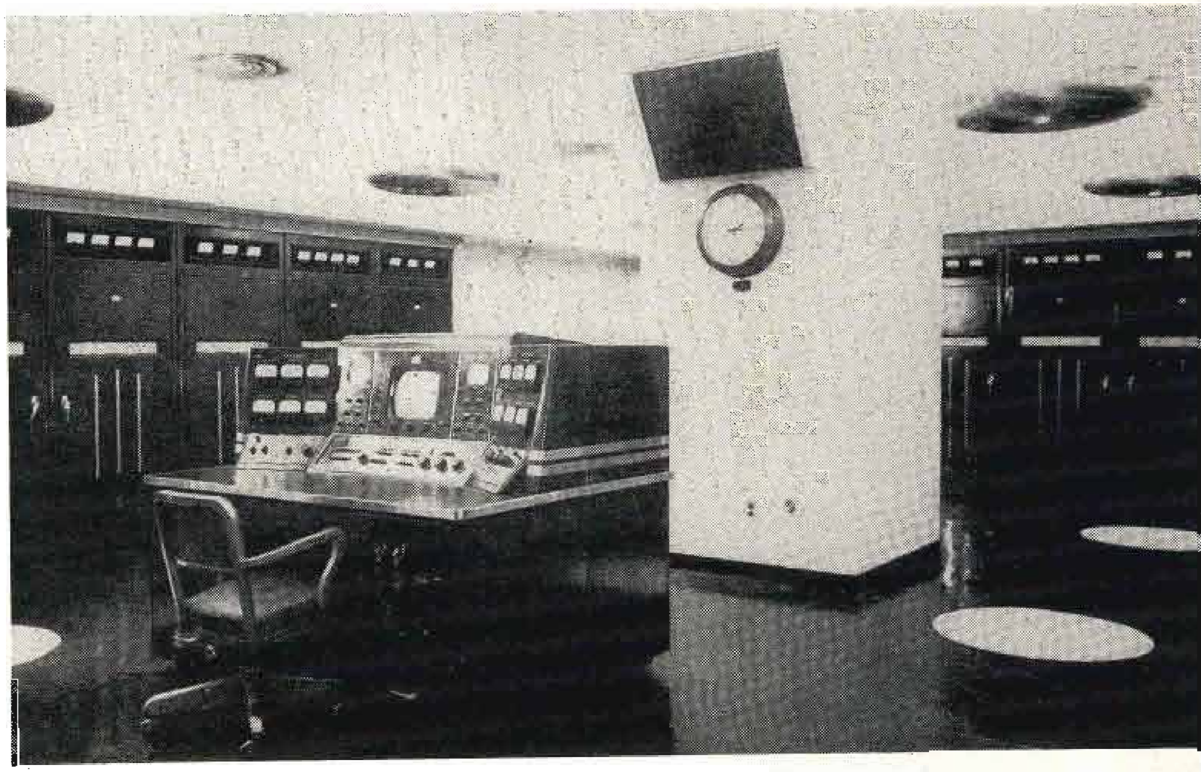


Fig. 1: WABD's operating console affords convenient view of the transmitter racks seen at the left

AFTER more than two years' planning and several months' construction, the DuMont Television Network, division of Allen B. Du Mont Labs., Inc., completed the WABD transmitter installation atop the Empire State building in New York City. The project has been engineered for the years ahead and designed to operate with little or no modification in the event of color, high power transmission, and UHF, as these are presently anticipated.

The entire transmitter installation occupies approximately 2500 sq. ft. in the NE corner of the 82nd floor of the Empire State Building. This area includes a 240 sq. ft. fully equipped workshop, supervisors' office, and crew living quarters. In case of emergency, cots and supplies are available so that the transmitter may be operated for several days even though the area were to be isolated. Figs. 1 and 2 show the "U" arrangement of the transmitter, transmitter console, auxiliary rack-mounted equipment, and emergency transmitter. All normal operating is done from the console, but the transmitter and all 13 auxiliary racks containing the speech amplifiers, video amplifiers, test equipment, and terminal equipment have been arranged for easy viewing from the console.

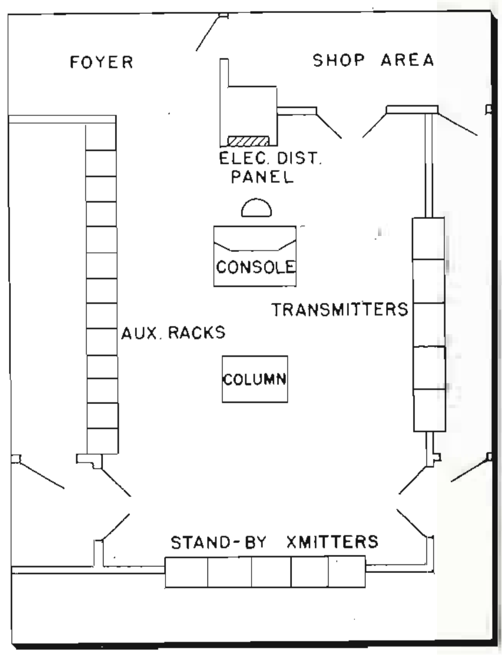
Video System

In the flexible video system, all amplifiers, signal sources, and switching units have both inputs and outputs appearing on a 120 jack jack-field made up of DuMont type 5246B panels. Since small "normaling plugs" make the necessary connections, the use of long patch cords is eliminated. R-F signals appear on a small patch-field in an isolated rack where they are interpatched and sent to other locations as desired.

Fig. 3 shows, in block form, the video equipment layout. A normal program signal may be routed in the following manner. The signal out of the telephone company terminating equipment goes to a picture distribution amplifier. Three isolated standard 1.4v. peak-to-peak composite video and sync signal outputs are obtained from the distribution amplifier which feeds the Du-Mitter, Telco cue transmitter, and, of course, one section of the transmitter input selector switch on the transmitter console. From the diagram it is seen that two sections of the picture distribution amplifier are utilized in parallel to feed the Telco send line. Since longer lines must be terminated in their characteristic impedance at both the send and receive positions to reduce reflections, the amplifier works into a load of 37.5 ohms instead of the usual 75 ohms; consequently, it is necessary to utilize the second amplifier to maintain the signal at the standard level. The output of the console feeds a phase corrector designed to operate similarly to an FM pre-emphasis circuit, i.e., to slightly predistort the signal to compensate for transmitter distortion introduced primarily by vestigial side-band attenuation.

The video signal next appears at a special switch, located on the console, which instantaneously inserts either of two stabilizing amplifiers in the line feeding the transmitter. The special switching arrangement was developed for use here because the stabilizing amplifier is a critical component of the video system, and, to follow the pattern of providing a switch-in emergency unit for all electronic components of the system. It is in this stabilizing amplifier that the pulses are given a final check and reshaped, the amount of sync

Fig. 2: Operator sits in center of "U" layout formed by auxiliary racks, transmitters and standby transmitters. Area occupies 2500 sq. ft.



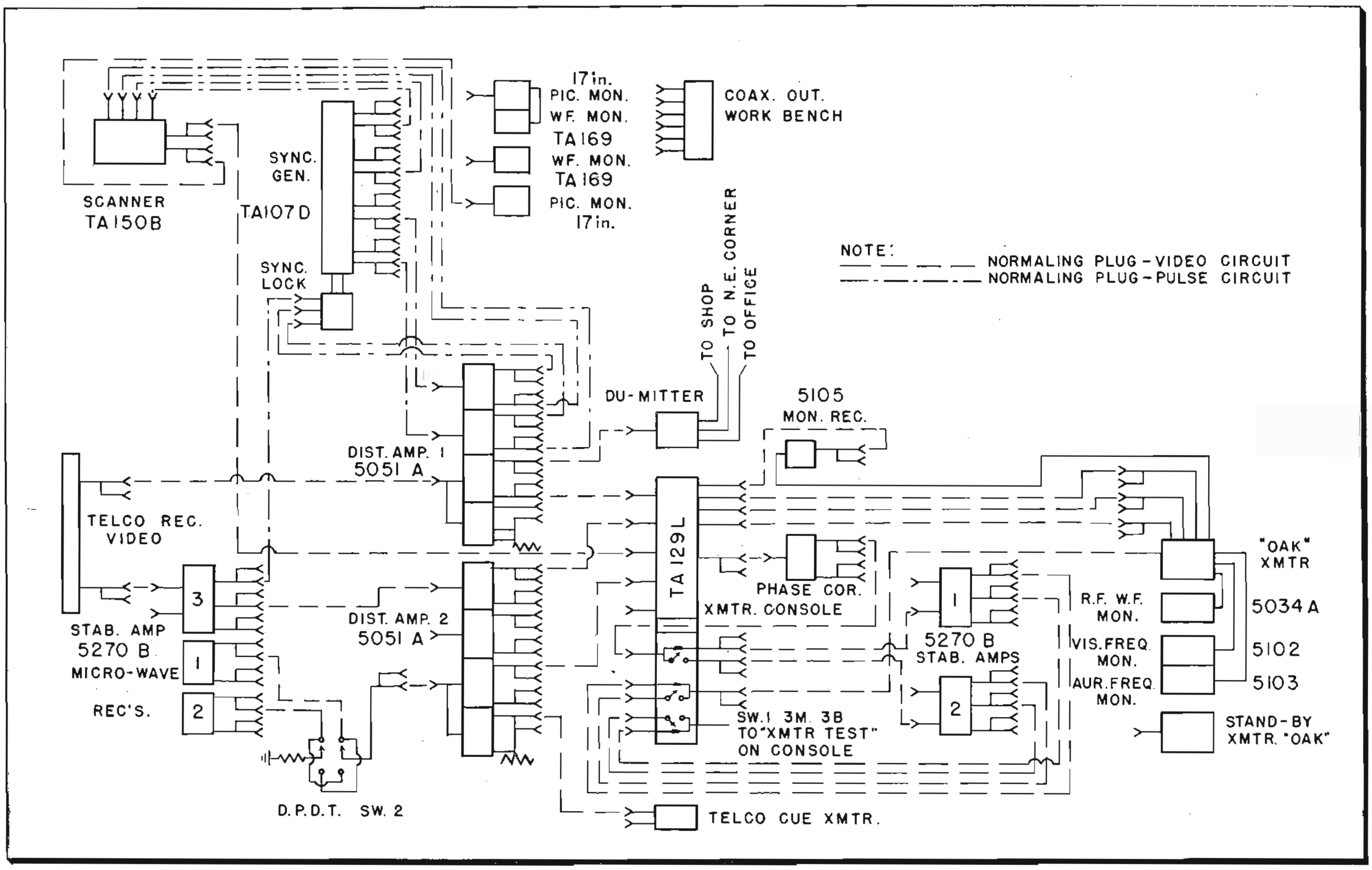


Fig. 3: Video equipment layout indicates how signal is routed from telephone lines through distribution amplifiers to the console and transmitter

signal adjusted, and the correct ratio of video-to-sync established. The monitor output of the stabilizing amplifier selected appears at the test selector switch on the console as "XMTR INPUT," since this is the last stage before the modulator. Through the patching system any of these units may be bypassed or others inserted. Provision is made also for patching a stabilizing amplifier on the incoming line to separate the sync from video before feeding the signal to the transmitter console. The separated sync is utilized to key a line phasing device which synchronizes the local sync generator, which in turn generates new sync to be reinserted in the final stabilizing amplifier. Station reports have indicated that many long distance signals which are transmitted on many miles of common carrier cables or microwave relay units, arrive with the sync portion too distorted for broadcast transmission.

Test pattern and other test signals to be used either on the air or in the maintenance shop are generated at the transmitter location by a Du-Mont flying spot scanner and a type TA107B sync generator.

The audio system consists of a five line input selector switch and gain control, a patch bay, two complete sets of line and monitoring amplifiers, a limiting amplifier, tone generators, test equipment and associated transformers and wiring. The selector switches and gain controls for selecting and controlling the transmitter and monitor inputs are located on the operator's console for convenience. The patch bay and two independent amplifier layouts, one

Fig. 4: Simplified diagram of audio system which contains input selector switch, gain control, patch bay, two sets of line and monitoring amplifiers, tone generators and associated test equipment

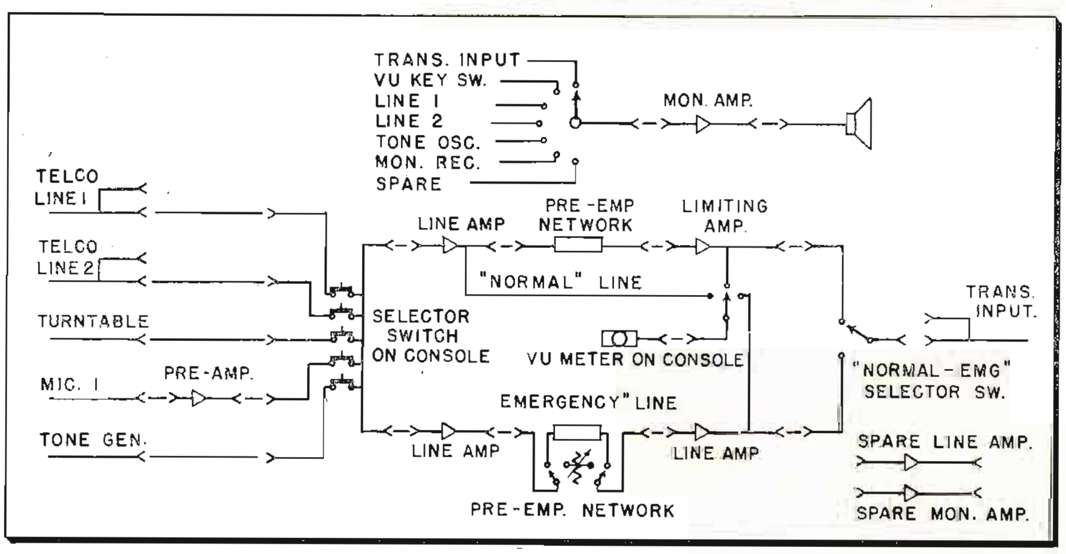
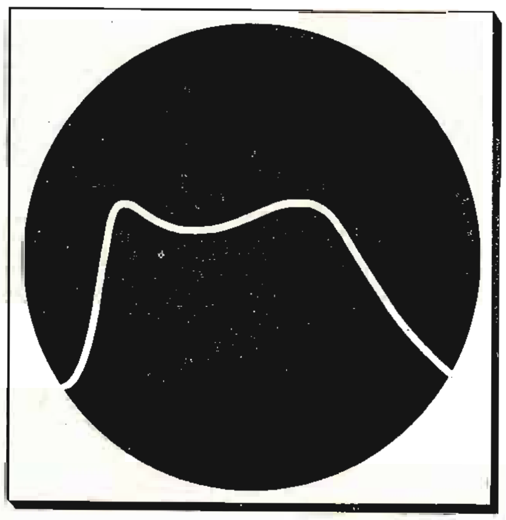


Fig. 5: Bandpass indicator wobbulator signal. Center frequency is 1/4 between peaks on left



for normal and one for emergency use, are located in two of the auxiliary racks; VU meters are in each rack and on the console. Test and measurement equipment includes signal generators, VU, multi, and VTVM meters, noise and distortion analyzer, and oscillographs. See Fig. 4.

The incoming telephone lines as well as local turntable, microphone, and tone generator sources appear first at the patch bay where pre-amplifiers are patched into low level lines. Five lines run from the patch bay to the transmitter input selector switch and gain control on the console. The selected line is matched to the first line amplifier in the "normal" amplifier line and bridged to the line amplifier in the "emergency" amplifier line. The second unit in both layouts is a standard 75 μsec pre-emphasis network which boosts the signal approximately 3 db at 2 KC and 17 db at 15 KC; a shorting switch in the "emergency line" will allow this network to be bypassed when desired. The final amplifier in the "normal" line is the limiting amplifier; in the "emergency" line the final amplifier is simply a booster.

Maximum Protection

This layout gives the operator maximum protection against lost air time and the option of utilizing or bypassing the pre-emphasis network and limiting amplifier as the situation demands. The output of each line feeds a switch on the console which selects either one to feed the transmitter. The monitor amplifier selector switch, also located on the operator's console, is bridged across all incoming lines and local sources as well as the transmitter input. A VU meter on the console may be bridged across the output of either amplifier line or the first amplifier in the "normal" line by operation of a selector switch. VU meters located in both auxiliary racks may be bridged across the same three points plus several spare lines which may be patched across any amplifier or source.

A spare line and monitoring amplifier also appear on the patch panel for insertion in the system as needed. As in the video system, the inputs and outputs of all components of the audio system appear on a patch panel to facilitate rapid system maintenance. Should the line amplifier in the "normal" line fail, the operator at the console would switch to the "emergency" line and step over to the patch bay in the racks where he would repatch the input and output of the non-operating amplifier to the spare amplifier. He could then switch back to the "normal" line whenever convenient. The disabled amplifier may be repaired in the racks or removed to the shop bench as proves necessary. In an extreme situation the operator could bypass both amplifier lines and patch the Telephone Co. signal directly into the transmitter from the gain control on the console; this

(*Continued on page* 96)

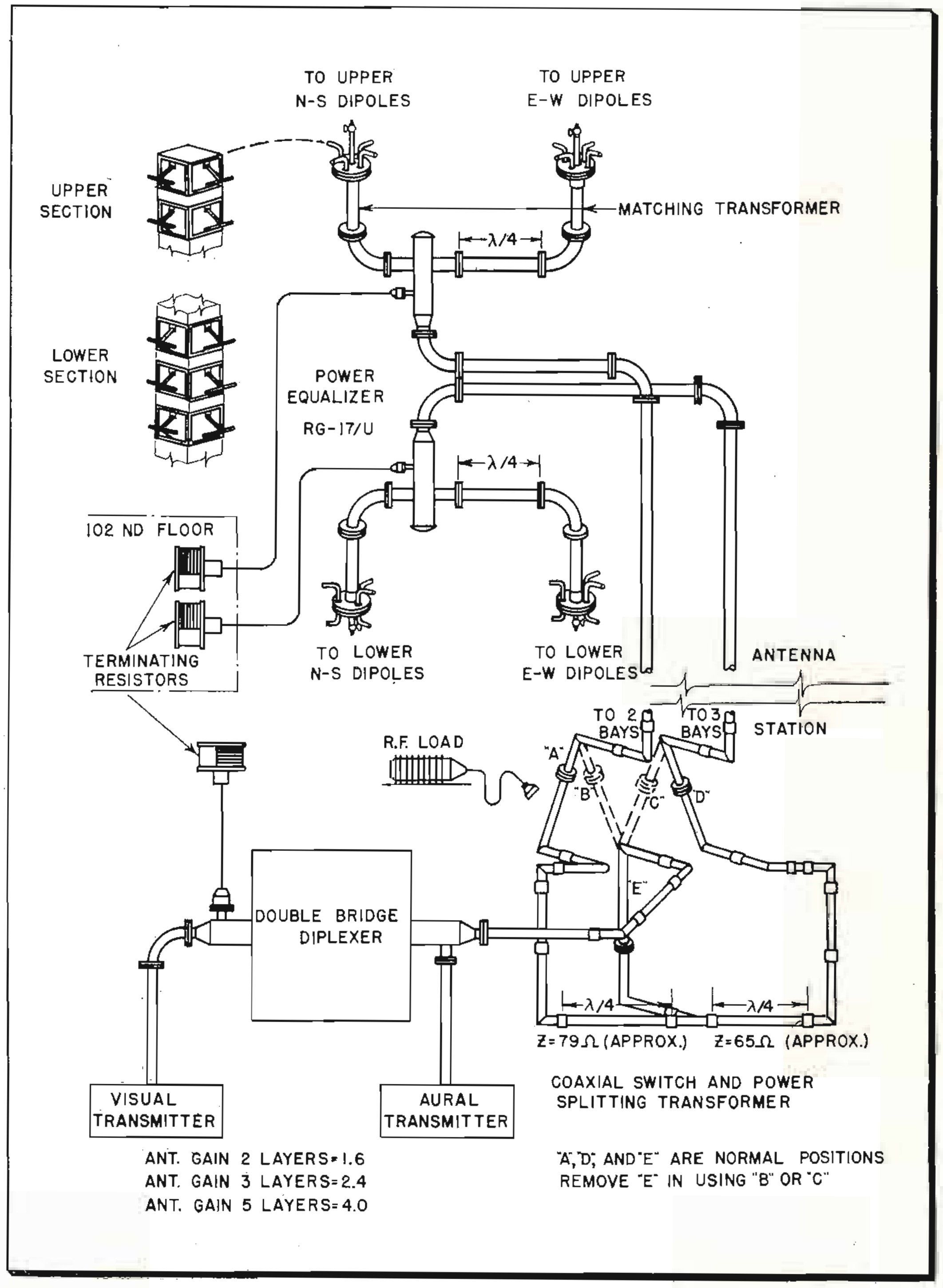
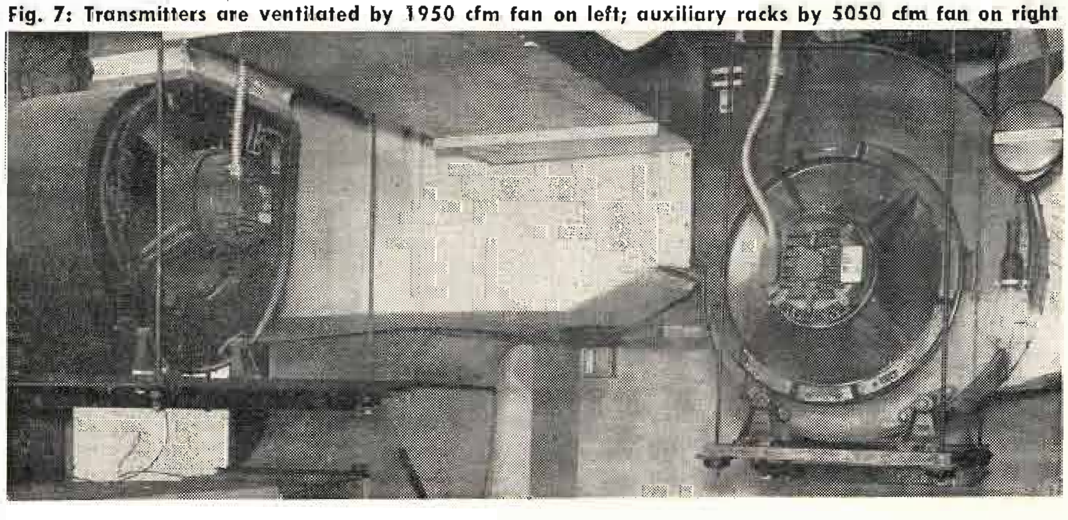


Fig. 6: R-F transmission system has switch which permits use of either antenna bay or both together

Fig. 7: Transmitters are ventilated by 1950 cfm fan on left; auxiliary racks by 5050 cfm fan on right



Nonlinear Elements and

Saturable reactors, ferroelectric capacitors
Details of new nonlinear resistor, termed
resistive detectors, overload protectors,

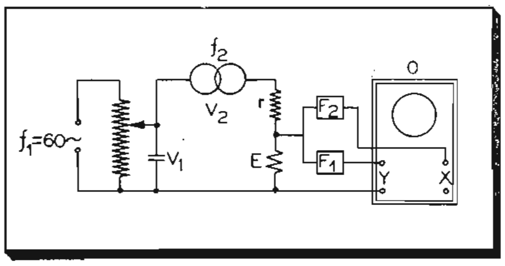


Fig. 5: Diagram showing arrangement of equipment for production of modulation figures

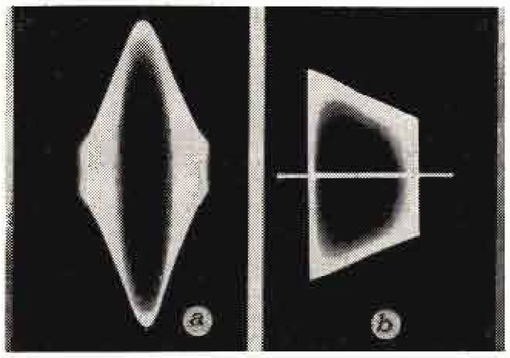


Fig. 6: Resistive AM oscillograms. Hexagon (a), under influence of a bias, assumes trapazoidal form (b). Center line is voltage calibration

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SINCE there is little known about polaresistivity, I would like to explain it in detail. The starting point is the so-called magnetic fluid[9] and electric fluid.[10] These are fine magnetic or dielectric particles suspended in oil. When acted upon by magnetic or electric fields, the particles attract each other and form metallic or dielectric fibers. The resulting fibration manifests itself in various ways. First, there is a mechanical manifestation in that the originally-fluid suspension solidifies. In other words, the viscosity increases. Second, there exist additional electrical effects which, according to dielectric constant and conductivity of the particles, are more or less pronounced. Besides a slight increase of the permittivity owing to the sluggish alignment of the particles, the fibers produce a semiconductive connection between two bounding electrodes, that means the resistivity drops from infinity to a relatively low value as soon as the fibers, under a certain threshold field, are formed. The resulting picture, however, is incomplete because the resistivity is nonlinear; that means the conductivity increases above its threshold value when the polarizing field increases. Whether this nonlinearity is caused by increasing forces of electrostatic attraction along the particle chains or whether electrostriction plays an additional role is debatable. Be that as it may, the frequency response of the polaresistive nonlinearity goes up into the microwave range.[8]

Now let us go a step further ahead. On the basis of the described phenomena in liquid suspensions, it is possible to transfer the polaresistivity into the solid state. This significant step may best be understood by remembering the prepolarization of the ferroelectric dielectrics which is nothing but a prepolarization of the dipole molecules above Curie temperature and then a freezing of this molecular array down to room temperature. If we apply this teaching to polaresistive suspensions, it is only necessary to freeze the semiconductive fibers once they are formed; in other words, to allow the liquid carrier to solidify. Suitable carriers are the cold-setting plastics known under the trade names Castolite, Plasticast, etc. Graphite particles and titanium dioxide powder have been found to be very sensitive.

Parameters

It is clear at once that stability, sensitivity, and other properties of the new polaristors depend on a multiplicity of parameters such as mix ratio, conductivity, size and surface properties of the particles; also on the amount of prepolarization, and finally on the arrangement of the electrodes which determines the strength of the polarizing field. For practical purposes it is interesting to note that a large range of zero conductivity can be covered merely by means of small or large electrodes while a high nonlinearity requires minute electrode gaps. The most sensitive polaristors result with the aid of minute slots which, similar to a diffraction grating, are cut into the silver layer of a mirror. Mirror-polaristors containing ten slots per millimeter have been developed.

The sensitivity of any arbitrary substance may be characterized to an accurate degree by the "Nonlinearity Index" or simply the "Nonlinearity," denoting the maximum slope of the nonlinear characteristic at the optimum point of operation. Another determination is the ratio by which the bias value of the element or substance in question changes when the controlling force, in all our cases the impressed voltage, deviates from its bias value by unity.

In order to explain in full detail what the nonlinearity means, let us consider a polaristor. Its ac or differential resistance depends on the impressed voltage according to the curve shown in Fig. 4. The differential resistance decreases from its zero value R_0, at low voltages in the form of a parabola, but after passing a point of inflection, asymptotically approaching a saturation value R_s. The nonlinearity then is the maximum slope at this point of inflection, i.e.

$$NL = \frac{2\,R' - R''}{\Delta V\, R' \rightarrow R''}$$

The formula, obviously, has the same form as that for evaluating the degree of amplitude modulation with the aid of a modulation trapezoid. Although the nonlinearity also may be evaluated from the aforementioned FM oscillograms, the analytical similarity suggests an amplitude modulation method.

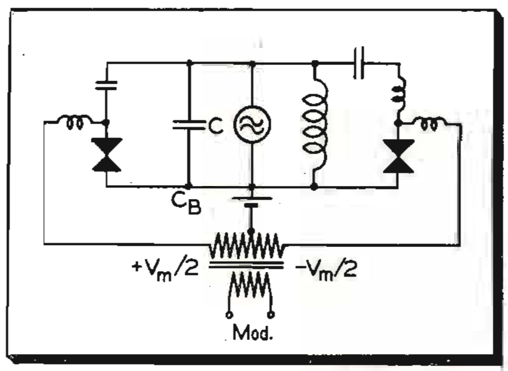

Fig. 7: Schematic of a resistive-reactive frequency modulator for push-pull action

The circuit depicted in Fig. 5 was found to satisfy all practical requirements. In particular, it allows not only the control of polaristors during fabrication but at the same time,

Applications in AF and RF Circuits

and varistors comprise the three component groups. "polaristor" explained. Applications of these devices, as modulators, harmonic generators, mixers, etc. is discussed

PART TWO OF TWO PARTS

provides the required polarization. The nonlinear element E under test, combined with a fixed preresistor r, forms a nonlinear attenuator driven by two different frequencies, for example, by 60 cycles and 100,000 cycles. Both inputs of the cathode ray oscilloscope O are fed by the output voltages across the element E, but a high-pass filter F_1 and a low-pass filter F_2 allow only either one of the two frequencies to deflect the beam in the X- and Y-axis. An alternate explanation is that the nonlinear element modulates the intermediate-frequency in the rhythm of 60 cycles. In such a manner, both

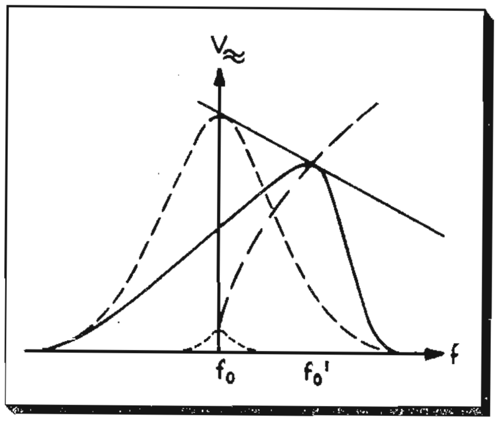

Fig. 8: Diagram illustrating asymmetrical deformation of a resonance curve.

frequencies produce a hexagonal figure, an example of which is depicted in Fig. 6a. With the aid of an additional bias half of the hexagon may be cancelled so that a trapezoid as shown in Fig. 6b remains. When the X-axis is calibrated in voltages, the nonlinearity may be easily evaluated according to our previous considerations.

Some data may explain the nonlinearity values of various elements. Crystal diodes exhibit nonlinearities up to 25, that means their differential resistance under the influence of a single volt would change at a rate of 2500 per cent or better, it decreases or increases by 2.5 per cent when the bias is changed by one millivolt. At the present state of development, the most sensitive polaristors reach similar values, but it is to be expected that further improvements will yield much higher values. Thyrites, the non-ohmic silicon carbide resistors,[7] give nonlinearities less than one.

In comparison to polaristors, ferroelectric capacitors show much lower nonlinearities. For example, a barium strontium titanate piezoid, 0.1 mm thick, exhibits only 0.5. On the other hand, saturable reactors reach nonlinearities up to some hundreds which may well be understood if we remember the very sharp knees of their hysteresis loops.

Only for the sake of completeness I would like to point out that the developed method is sensitive enough for disclosing small nonlinearities of modern high-Q capacitors and also of some types of carbon potentiometers, particularly if somewhat worn out.

Practical Applications

The three types of nonlinear elements offer a great variety of practical applications throughout the entire field of radio and audio-frequency engineering. Only for completeness, some well known examples may be mentioned very briefly.

1. Varistors may be used as overload protectors for sensitive instruments, for example, for galvanometers in bridge circuits. Moreover, vacuum-tube amplifiers may be protected from overshooting, either by nonlinear grid resistors or by nonlinear coupling condensers, or even by combinations of both in the form of coupling networks. This action may be easily derived from Thyrites which originally were designed to be lightning arresters.

2. Varistors provide very simple stabilizers for dc and ac voltages. In cascade operation, they may even be utilized as limiters.

3. Nonlinear reactances are excellent frequency modulators, as we remember from the described FM method.[11,12] Automatic frequency stabilization may be achieved, in particular, if the carrier frequency is generated by means of two heterodyning master oscillators, one serving for the purpose of FM and the other for the carrier stabilization.

4. A nonlinear reactance and a varistor, when driven by a certain

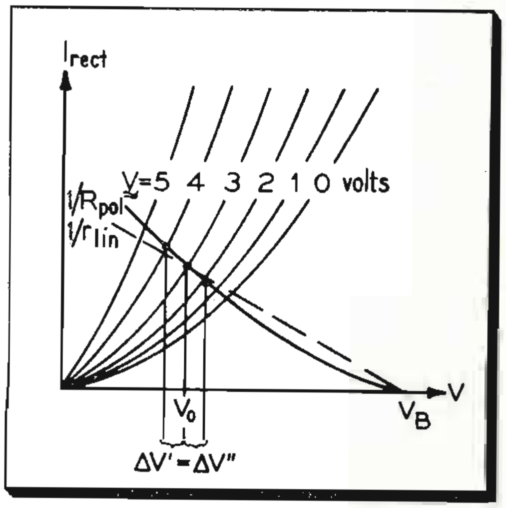

Fig. 9: Linearization of a square-law detector by means of a nonlinear load

frequency, modulates this frequency by itself. The result is a frequency tripling when the nonlinear element operates symmetrically around its zero value, that is, without bias, while a frequency doubling occurs as soon as the element operates at optimum bias on the linear portion of its characteristic. Consequently, only by means of the bias voltage, may either even or odd harmonics be generated, the one decreasing or increasing at the expense of the other. This phenomenon may be interesting for electrical music in order to change the timbre of the tones.

5. Any nonlinear element provides a detector or mixer.[13] In contrast to asymmetrical detectors such as crystal diodes, symmetrical varistors require a bias and then operate as square-law detectors. The same is true for nonlinear reactance. A saturable reactor as well as a ferroelectric condenser, under the influence of an impressed r-f voltage, changes its average reactance. In both cases, the output voltage or more accurately, the output power dissipated in a load resistor stems from the bias. If we consider a nonlinear condenser as detector and mixer, the circuit and the energy conversion is exactly the same as in the case of a condenser microphone. As soon as further developments allow the production of r-f iron alloys combining low r-f losses with sharp

(*Continued on page* 122)

A Microwave Polarization Switch

System design provides for independently determined
cularly polarized. Switching is accomplished by changing

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THE desirability of obtaining a radiating structure in which the polarization of the radiating energy could be varied in a controlled manner, while providing a radiation pattern with invariant shape, led to the investigation which is the subject of this paper.

The primary requirements were to provide a stationary radiating device which would radiate either horizontal, vertical or circularly polarized energy, and which had a radiation pattern independent of the particular polarization chosen. A generalization of these requirements were analyzed, and it is shown that under certain conditions restricted elliptic polarization was obtainable, while under different conditions unrestricted elliptic polarization was possible.

Switching Section

Let us consider the effects of the various components which comprise this universal polarization device.

Fig. 1 shows a block diagram consisting of a feed section, a polarization switching section and a radiating section. The polarization switching section enables a linearly polarized wave which enters the section to emerge as either a linearly polarized wave with the same orientation (inclination of the major diameter of the polarization ellipse) as the entering wave, or a linearly polarized wave oriented perpendicular to the entering wave, or an elliptically polarized wave of restricted ellipticity and orientation. The theory of this polarization switching section is based upon the dependence of the phase velocity of a metallically bounded wave on the dimensions of the waveguide.

If we have a square waveguide as shown in Fig. 2, a and b, which is energized along a diagonal, the electric vector E can be separated into two components: one, E_a, perpendicular to the parallel walls "a," and one, E_b, perpendicular to the parallel walls "b." The phase velocity of E_a is dependent upon the waveguide dimension "a," while the phase velocity of E_b is dependent upon the waveguide dimension "b."

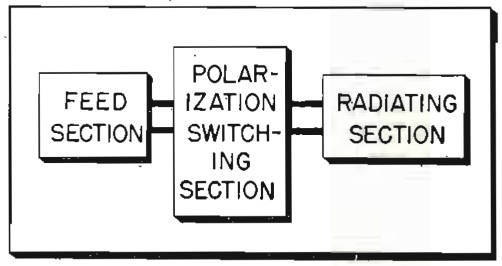


Fig. 1: Universal polarization device consists of feed, switching and radiating sections

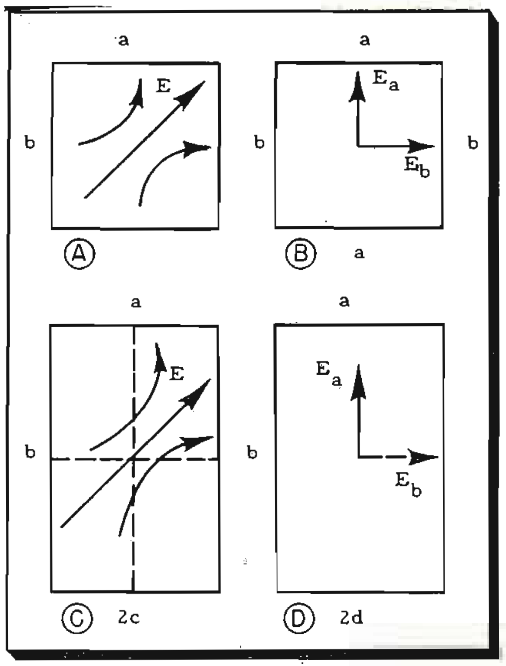
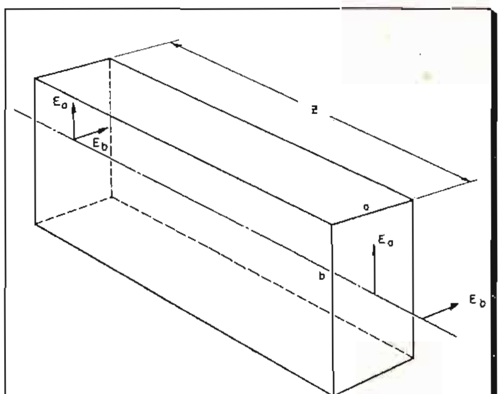


Fig. 2: Resolution of electric field into components for square and rectangular guides

Fig. 3: Effect of guide on phase velocities



For a TE_{mn} wave, the phase constant

$$\beta_{mn} = \sqrt{\frac{\omega^2}{c^2} - \pi^2\left(\frac{m^2}{a^2} + \frac{n^2}{b^2}\right)}$$

For TE_{01}, $\beta_{01} = \beta_b = \pi\sqrt{\frac{4}{\lambda_o^2} - \frac{1}{b^2}}$

For TE_{10}, $\beta_{10} = \beta_a = \pi\sqrt{\frac{4}{\lambda_o^2} - \frac{1}{a^2}}$

Relative phase between E_b and E_a is

$$(\beta_b - \beta_a)z = \left(\sqrt{\frac{4}{\lambda_o^2} - \frac{1}{b^2}} - \sqrt{\frac{4}{\lambda_o^2} - \frac{1}{a^2}}\right)\pi z$$

For a relative phase of 90°

$$\left(\sqrt{\frac{4}{\lambda_o^2} - \frac{1}{b^2}} - \sqrt{\frac{4}{\lambda_o^2} - \frac{1}{a^2}}\right)\pi z = \frac{\pi}{2}$$

If "a" = "b," as is the case for a square waveguide, the phase velocity of E_a equals that of E_b. Now, suppose the waveguide is rectangular as shown in Fig. 2, c and d, instead of square, and is energized by an electric field oriented 45° with respect to its walls. Again, the electric vector E can be separated into two components of equal amplitudes, E_a and E_b, as before. Again, the phase velocity of E_a is dependent upon the dimension "a" and that of E_b dependent upon the dimension "b." However, since in this case "a" ± "b," these two phase velocities differ. In traveling along a fixed length of guide (Fig. 3) the relative phase of component E_b with respect to E_a will change. The amount of relative phase change is $(\beta_b - \beta_a)z$, where "z" is the length of guide.

Referring to Fig. 4, if one of the guide walls, say "a," is movable so that the dimension "b" can be changed, the phase velocity of E_b can be varied and hence the relative phase between E_b and E_a can be controlled. The movable wall can contain an r-f choke as shown in Fig. 4b.

Referring to Fig. 5, let us energize the polarization switch with an electric field polarized vertically and oriented 45° with respect to the walls, and investigate the nature of the electric field emerging from the polarization switch for different positions of the movable wall.

Positioning Movable Wall

If this movable wall is positioned so the polarization switching section is approximately square, both the $TE_{0,1}$ and $TE_{1,0}$ modes are propagated with equal phase velocity and combine in time-phase to produce a linearly polarized electric field which emerges oriented parallel with the exciting electric field and hence is also polarized vertically. If instead, however, this movable wall is positioned so that one of the components, say E_b, is 180° out of time-phase with

and Universal Horn

radiation pattern horizontally, vertically or cir-
phase velocity in waveguide with movable wall

the other component, E_a, as they emerge from the polarization switching section, the resulting electric field will be linearly polarized and oriented perpendicular to the exciting electric field and hence polarized horizontally. At some intermediate position of the movable wall, one component will be in time-phase quadrature with the other component E_a as they emerge from the polarization switching section. This will result in a circularly polarized field.

For an arbitrary position of the movable wall, the component E_b will be related to the component E_a by an arbitrary time-phase as they both emerge from the polarization switch. This will result in an elliptically polarized wave of restricted freedom; that is, the ellipticity ratio (major to minor diameter of the polarization ellipse) is dependent upon the inclination of the major axis. Included in this restricted elliptical polarization are the two linear polarizations (horizontal and vertical) and circular polarization (of both senses) already discussed.

Radiating Section

Let us now investigate the properties of the radiating section. It was stated earlier that the primary requirement was to obtain a radiation pattern which was independent of the three prime polarizations; namely, horizontal, vertical and circular. Since the radiation pattern is dependent upon both the aperture of the radiating section and the mode of the exciting energy, a compromise design is required.

For an aperture of dimensions "a" and "b" excited by an electric field perpendicular to "a," the half-power beamwidths are: $BW_{az} = 70\,\lambda/a$ and $BW_{el} = 51\,\lambda/b$. If the aperture is excited perpendicular to "b," the half-power beamwidths are: $BW_{az} = 51\,\lambda/a$ and $BW_{el} = 70\,\lambda/b$.

Therefore the beamwidth in azimuth can be expected to vary between $70\,\lambda/a$ and $51\,\lambda/a$, while the elevation beamwidth could vary between $51\,\lambda/b$ and $70\,\lambda/b$. It would appear that for a compromise design $BW_{az} = 60\,\lambda/a$ and $BW_{el} = 60\,\lambda/b$ would be suitable.

A horn of dimensions 0.90 x 1.55

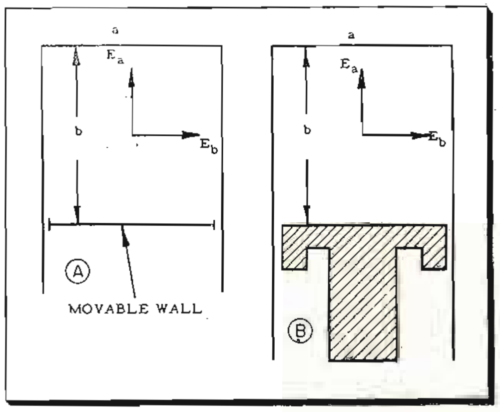


Fig. 4. Guide with movable wall controls relative phase of E_a and E_b by changing wall "b"

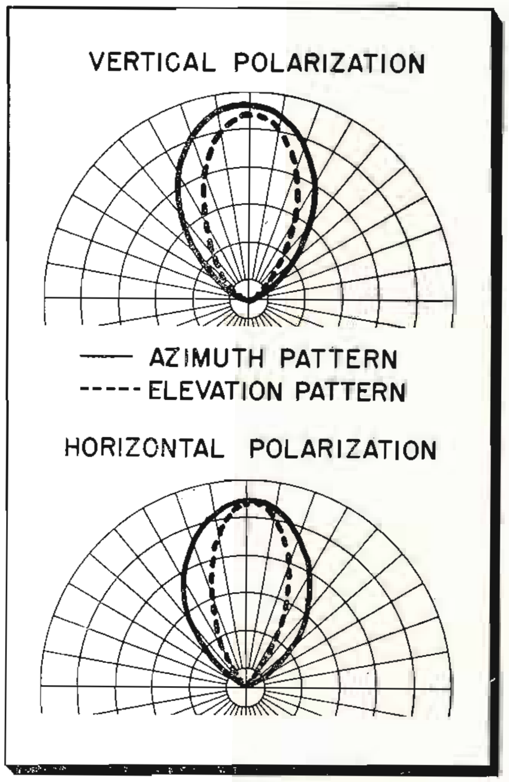


Fig. 7: Radiation patterns of linearly polarized horn illustrated in Fig. 6a shows both the horizontal and vertical components

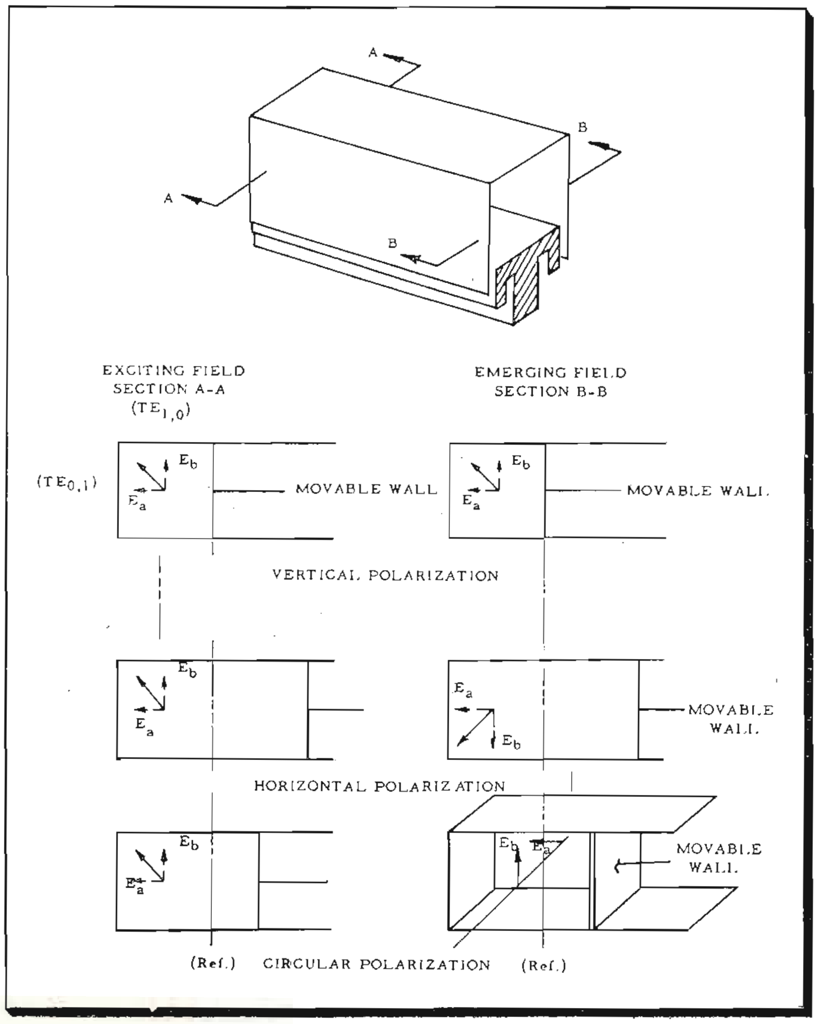


Fig. 5: Explanatory diagram of polarization switching section using movable wall

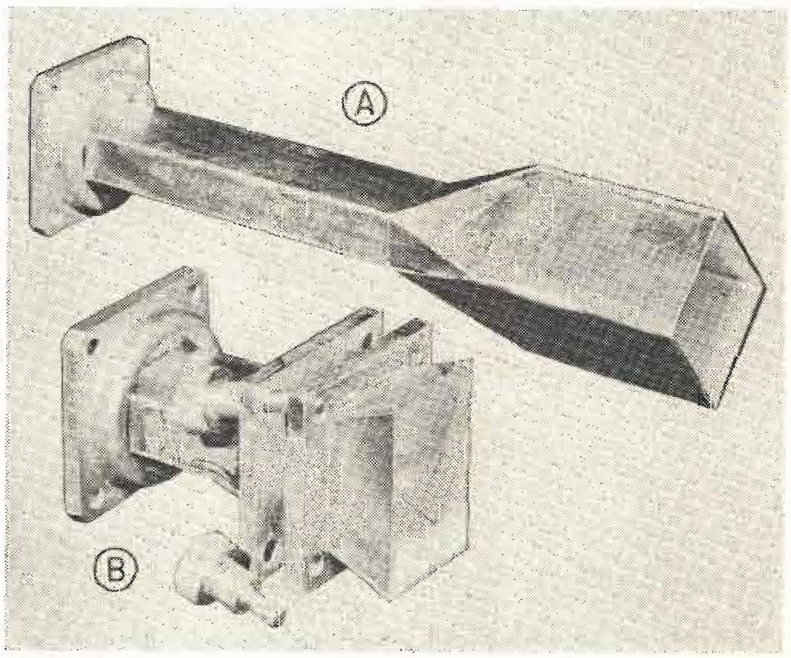


Fig. 6: (a) Linearly polarized horn, and (b) circularly polarized horn of same aperture

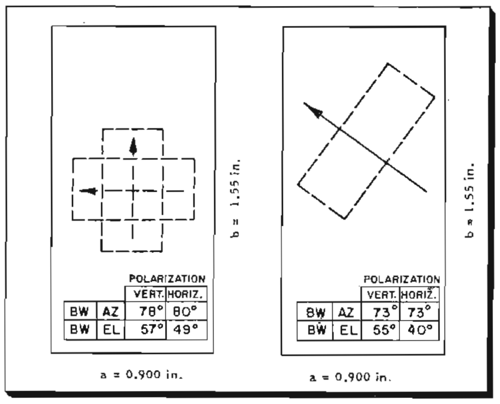


Fig. 8: (l) Beamwidth and electric field for linearly polarized horn. Fig. 9: (r) Beamwidth and field for circularly polarized horn

in., shown in Fig. 6a, was designed to give a radiation pattern approximately 84 x 51°. The radiation patterns shown in Fig. 7 and tabulated in Fig. 8, show reasonable agreement with the design computations.

In the circularly polarized horn (Fig. 6b), a radiating section whose aperture is the same as that of the previously discussed horn was designed. This section is energized by an electric field oriented 45° with respect to its walls. Its length was computed by the method shown in Fig. 3 and adjusted so that the radiating energy is circularly polarized. The azimuth and elevation patterns (Fig. 10) were measured for both a horizontally polarized and vertically polarized detecting system. The half-power beamwidths are indicated in Fig. 9.

Let us now investigate the general case.

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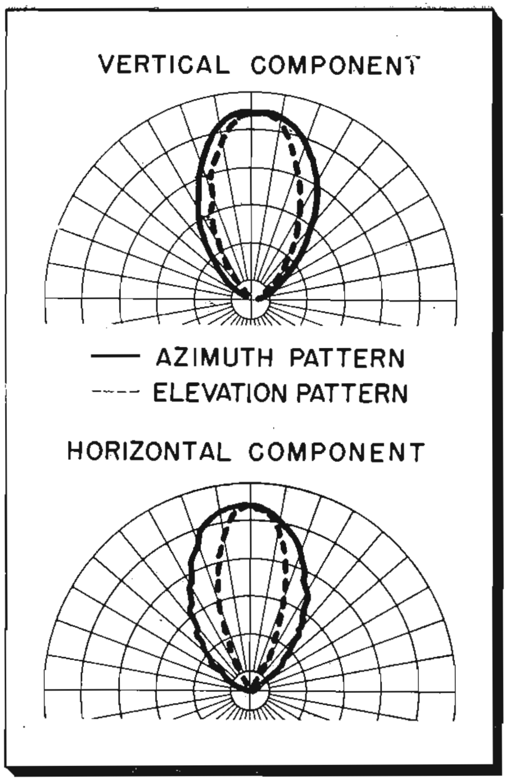
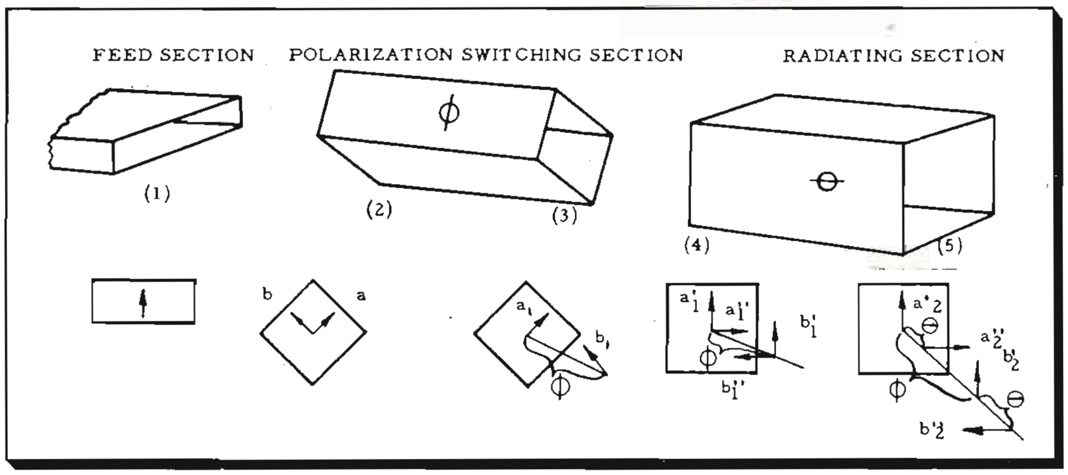


Fig. 10: Circularly polarized horn patterns

Fig. 11: Vector analysis of overall system comprising feed, switching and radiating sections



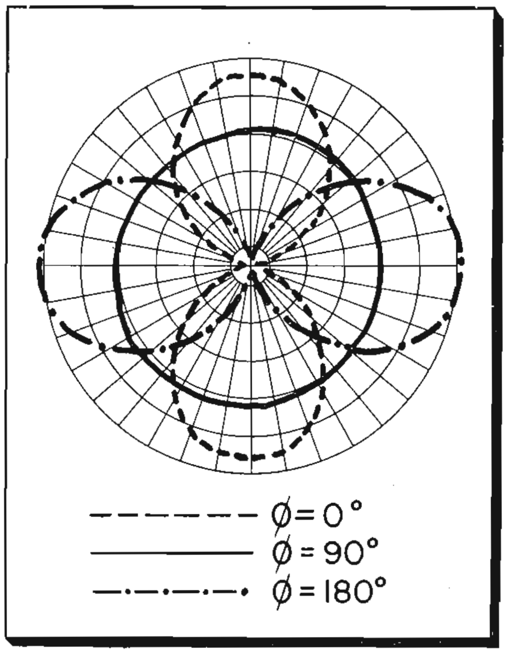


Fig. 12: Experimental polarization patterns for 3 values of ϕ; phase difference between radiating section vector components equals π

Fig. 13: Experimental polarization patterns for 4 values of ϕ; phase digerence between radiating section vector components equals $\pi/2$

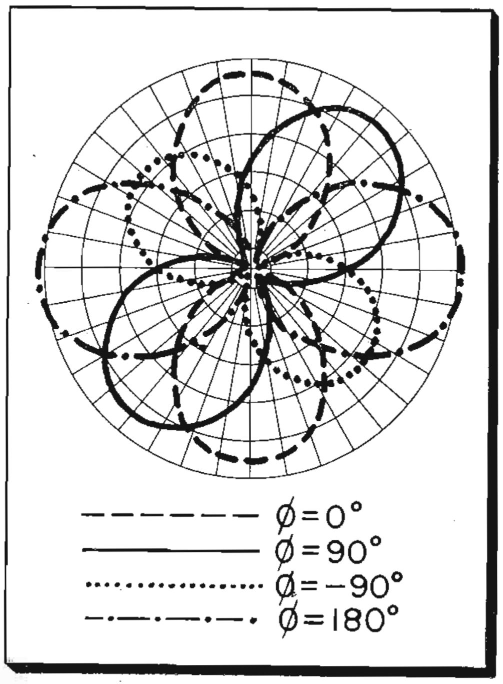


Table of equations describing vector components shown in Fig. 11

$$1 \cos \omega t \quad (1)$$

$$\underbrace{(.5 + .5j) \cos \omega t}_{a} + \underbrace{(.5 - .5j) \cos \omega t}_{b} \quad (2)$$

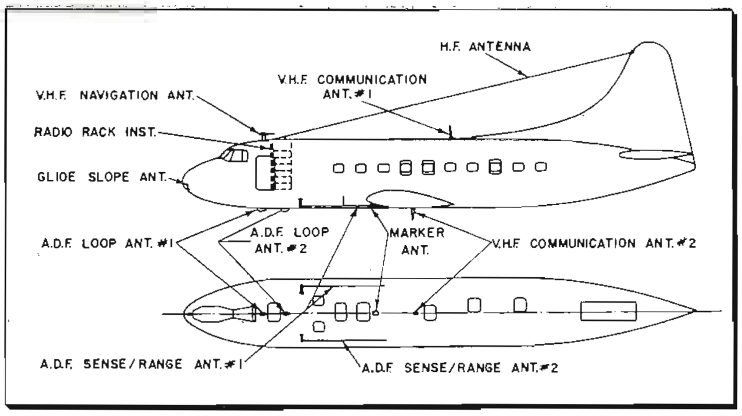
$$\underbrace{(.5 + .5j) \cos \omega t}_{a_1} + \underbrace{(.5 - .5j) \cos (\omega t - \phi)}_{b_1} \quad (3)$$

$$\underbrace{(.5 + .5j)(.5 - .5j) \cos \omega t}_{a_1'} + \underbrace{(.5 + .5j)(.5 + .5j) \cos \omega t}_{a_1''} + \underbrace{(.5 - .5j)(.5 + .5j) \cos (\omega t - \phi)}_{b_1'} + \underbrace{(.5 - .5j)(.5 - .5j) \cos (\omega t - \phi)}_{b_1''} \quad (4)$$

$$\underbrace{5 \cos \omega t}_{a_1'} + \underbrace{.5j \cos \omega t}_{a_1''} + \underbrace{.5 \cos (\omega t - \phi)}_{b_1'} - \underbrace{.5j \cos (\omega t - \phi)}_{b_1''} \quad (4')$$

$$\underbrace{.5 \cos \omega t}_{a_2'} + \underbrace{.5j \cos (\omega t - \theta)}_{a_2''} + \underbrace{.5 \cos (\omega t - \phi)}_{b_2'} - \underbrace{.5j \cos (\omega t - \phi - \theta)}_{b_2''} \quad (5)$$

$$c = \cos \phi/2 \cos (\omega t - \phi/2) - j \sin \phi/2 \sin (\omega t - \theta - \phi/2) \quad (5')$$



Glenn L. Martin's Model 4-0-4 commercial airliner carries 10 antennas for communications, navigation and instrument landing systems

Antennas for Commercial Aircraft

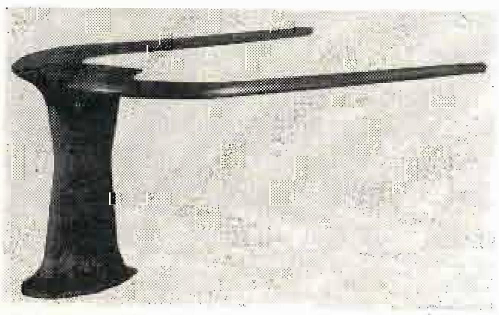
Modern airliners use 10 or more antennas operating between 100 KC to 423 MC for radio navigation and communication systems

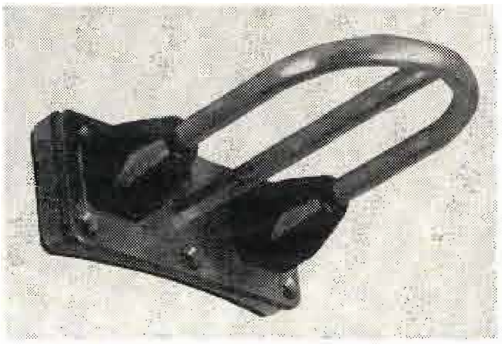
AIRLINE passengers are often unaware of the numerous antennas, mounted at diverse locations about the aircraft. These units which function in the radio navigation and communication systems operate to insure safe and efficient travel. Glen L. Martin's Model 4-0-4, pictured in the Eastern Airlines version illustrates a plane with 10 antennas for voice communication, visual omni-directional range (VOR), vertical and lateral guidance (localizer) while landing, automatic visual bearing low frequency radio range, aural and visual marker identification and terrain clearance. The following describes in detail the antennas carried on the Model 4-0-4.

The *HF wire antenna,* extending from the forward crown to the vertical fin, provides for long range, two-way, voice communication between aircraft and ground stations in the 2.5-13.0 MC range. The 3/32 in. diameter stranded wire is made of phosphor bronze.

A modified Aeronautical Radio, Inc., mast type AN-104 antenna, installed on the top centerline in the

Collins 37J-1 VHF navigation antenna for 108-122 MC weighs 5.75 lbs. and is made of cast aluminum, tubular alloy and natural rubber. Dimensions are 12 x 17 x 27 in. SWR is 5:1





Collins 37P-1 glide slope antenna for 328-336 MC weighs 1.4 lb., mounts on plane nose, is 5 in. high, and matches 52 ohm line. SWR is 2:1

aft section, provides 118-135 MC voice communication. This *VHF mast antenna* is mounted by means of a clamp type base casting through the airplane skin for easy installation and servicing. A similar antenna at the midpoint of the underside fills the requirement for dual equipment. Location is dictated by minimum susceptibility to nulls and propeller modulation.

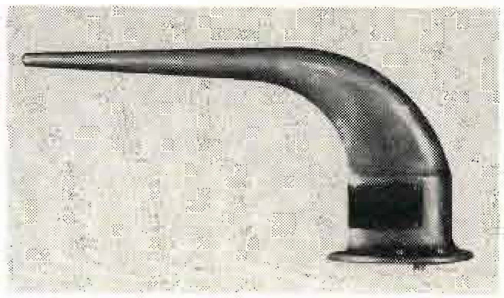
A Collins Radio folded dipole type 37J-2, for 108-122 MC *VOR and localizer* operation, is used to receive horizontally polarized waves on some Martin craft. However, the EAL plane employs a similar Aircraft Radio Corp. type A-13, which has a straight dipole in addition to the folded dipole to act as a spare 328-336 MC antenna for vertical guidance.

Primary vertical guidance is received by a *glide slope antenna* which picks up horizontally polarized waves during instrument landing. On planes made for TWA a Collins "bull-ring" type 37P-2 is used, while EAL craft carry two Bendix flush type MN-92A antennas recessed in the nose. The latter unit comprises four parallel elements, all grounded except for the fed conductor. The conductors are resonated by an adjustable capacitor at the common end.

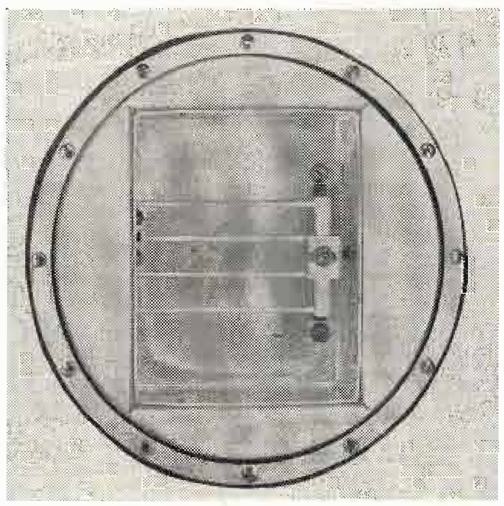
The *automatic direction finding (ADF) antennas,* installed on the bottom centerline in the forward section, consist of two Bendix loop type MN-60A antennas. Aural reception of radio range signals and automatic visual bearing indication lies in the

(Continued on page 80)

Collins 37R-1 VHF antenna for 118-136 MC communication is omnidirectional, has swr under 1.5 and mounts externally on aircraft skin



Bendix MN-92A glide path antenna mounts flush in the plane nose. Unit comprises four parallel 1/8 in. brass conductors and operates at 328.6-335.4 MC with 52 ohm impedance



For MANUFACTURERS

New Methods, New Materials and New Machines

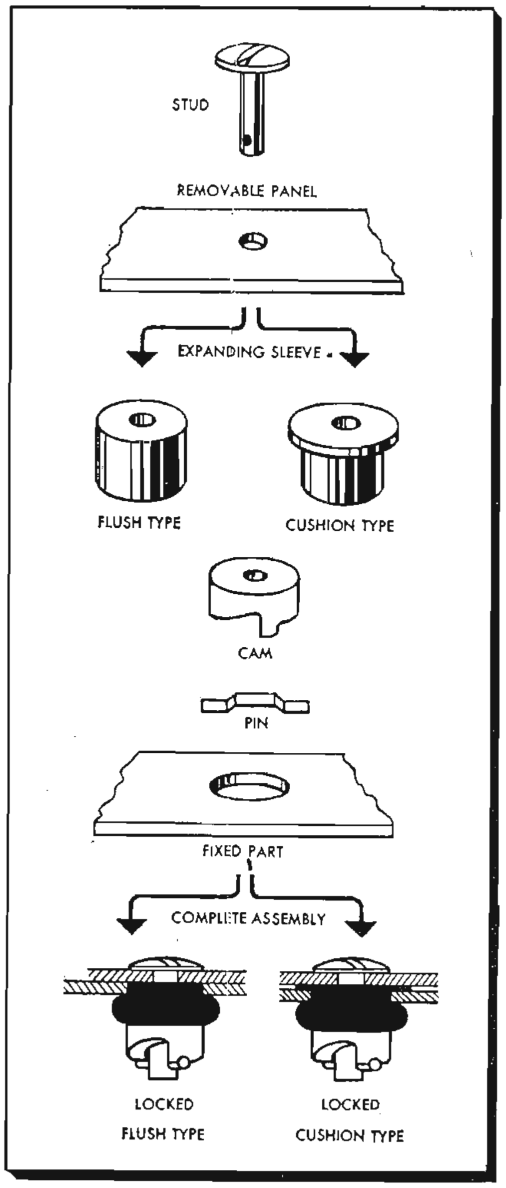
Edited By Bernard F. Osbahr

New Aircraft Fastener

Named Vibrex Expanding Fastener by Air Associates, Inc., Teterboro, N.J., this new device was designed primarily for installations requiring permanent positive locking and easy disassembly for rapid access to instrument panels, inspection panels, access doors, or similar applications.

Present designs have established two basic types, namely "flush" and "cushion." The flush type locks parts firmly metal to metal. The cushion type utilizes a neoprene or rubber cushion between the parts to further absorb vibration or provide electrical insulation. Both types lock securely in place yet snap open rapidly and easily with a screwdriver.

Diagram showing complete assembly details of flush and cushion type Vibrex fasteners



$$$ FOR YOUR IDEAS

Readers are invited to contribute their own suggestions which should be short and include photographs or rough sketches. Typewritten, double-spaced text is preferred. Our usual rates will be paid for material used.

Tests are presently being conducted for aircraft applications. Present uses are being confined to quick-fastening methods for vibration proof mountings for instruments, radio, and other electronic equipment; also for aircraft interior trim, galleys, access doors, and similar applications where quick, easy removal of panels is desirable.

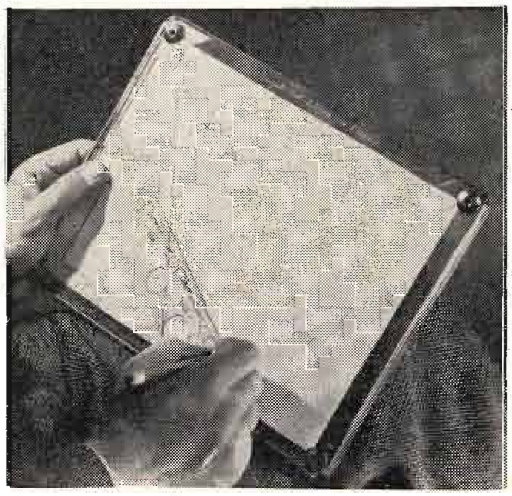
Two simple drilled or punched holes are used for each fastener—a small hole for the stud and a larger hole for the bottom portion. No additional rivets or grommets are needed and countersinking is not necessary. No special tools are needed for mounting. When installed, the Vibrex fastener can be opened or closed with a twist of a coin or screwdriver.

Improving Germanium Diode Noise Figures

Extremely poor noise figures are usually the dividends of processing germanium crystals in rooms with high humidity. Seldom does a very good noise figure result when the humidity is much over 50%. In order to eliminate this often deleterious effect, several laboratories are making their units in a vacuum or in the atmosphere of an inert gas. Some of the mechanical obstacles of this technique are hurdled by mounting the crystals in steel racks so that they can be moved about in the vacuum housing by external magnets. Probes and syringes extend into the housing interior through vacuum seals. Although extensive correlation between humidity and noise figure have not been made public yet, the vacuum technique is considered sufficiently worthwhile since it eliminates one more parameter (and a disruptive problem) in a process which is badgered by its share of variables.

Portable Drawing Board

New portable drawing board molded from lightweight Bakelite styrene plastic is 9¾ x 12¼ in. Four corner clamps for attaching 8½ by 11 paper are recessed into the plastic so that the triangle or roller can ride freely over them without interference. The two metal straight edges, one vertical and one horizontal, are retractable so that the triangles can be moved over all four edges of the paper. A. Patrick Co., 9 Grave St., Westwood, N.J., manufacturers, report that the use of lightweight Bakelite styrene plastic has reduced the weight of the drawing board by as much as 75% over conventional boards. Retail price is $3.95; with two 8 in. triangles to fit, $4.95.



New portable plastic drawing board weighs as much as 75% less than conventional boards

Shielded Production Test Stations

A completely redesigned type of shielded test bench to replace standard screened-in test booths has been engineered for use in Motorola's new Communications and Electronics Division plant in Chicago.

An individual radio unit, transmitter or receiver, is placed into a small screened box mounted in the surface of each of the benches. The unit to be tested is dropped into the box and the tip-back screened lid is pulled up from the back and over the unit. Adjustments are made through the screening.

New type of shielded test bench on assembly lines at Motorola's new Chicago plant. Adjustments to equipment are made through screening which tips back to allow insertion or removal.

Power supplies and test instrumentation circuits are contained within a screened-in section of the bench also. This section is double screened, first by the metal bench itself, and inside by a hardware clothe screen. Each test unit is operated from an AC power supply using selenium rectifiers to furnish 6VDC, 12 VDC and 117 VAC. These units are protected by means of an isolation transformer and special Motorola-designed filtering units.

Built into the shielded area of each bench, also, is a complete set of controls which are separated by isolated shafts. This permits selection and operation of all functions and circuits of the various types of radio units being tested.

The screened box-sections for holding the radio units being manufactured by Motorola for use with 2-way communications systems, permit 110 db attenuation for each unit or a total of 220 db attenuation between two units being checked in two adjacent benches.

Manufacture of Mica Paper Insulation

R. L. Griffeth and E. R. Younglove of the Mica Insulator Co., Schenectady, N. Y., report that mica in the form of mica paper will soon make its appearance as a component of electrical insulation. The raw material for mica paper is Muscovite mica in the form of mine waste, scrap, or recovered mica. This is first heated to a temperature sufficient to induce partial dehydration of the mica, but not sufficient to produce total dehydration, and extreme care is necessary to assure a very uniform temperature throughout the mass. For each mica there is a well defined optimum temperature and time of treatment.

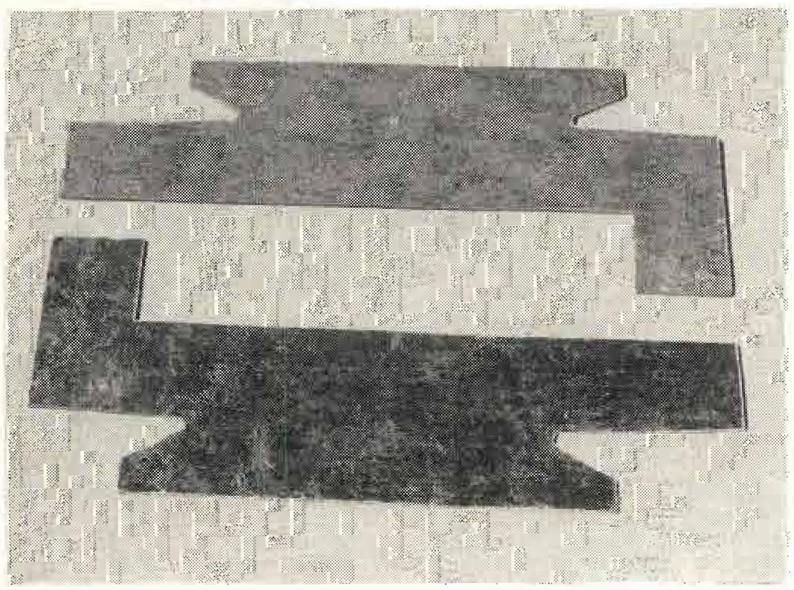
As the hot mica emerges from the treating furnace it is quickly immersed in a saturated boiling solution of sodium carbonate or bicarbonate, to expel the air from the interlamillar structure. Upon cooling, the mica appears as thin layers scarcely adhering to each other and retaining a large amount of the alkaline solution. It is then immersed in a strong solution of hydrochloric acid or sulphuric acid. The resultant gaseous reaction puffs the mica to a very great extent. Puffing in the order of a hundred times the original thickness of the mica film is common. The coherence of the strata of mica in this state is very weak and only washing and agitation are required to produce a pulp suitable for the formation of a coherent sheet of mica paper.

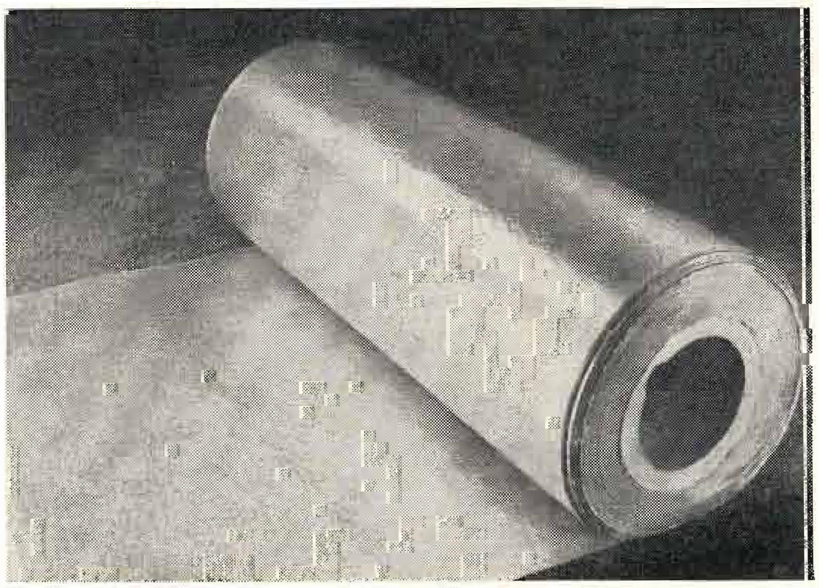
Mica paper is composed of a large number of mica layers of extreme thinness, of the order of a few hundred thousandths of an inch. Some of the mica flakes attain a surface area as large as one tenth of a square inch.

The mica paper as it comes from the paper machine has about one half the density of natural mica because of the interposition of air between the elementary layers. The tensile strength of the paper is variable and depends on the source of the mica and its treatment. Mica paper does not compare with mica splittings in mechanical or electrical properties as it comes from the machine, but in combination with suitable bonding agents, products can be made which are superior to conven-

(*Continued on page* 108)

(Left) Comparison of mica and mica paper insulation. Upper is fabricated from mica paper, lower is from mica splittings. (Right) Roll of mica paper is silvery, extremely uniform in weight and thickness. Mica paper tapes wrap neatly and compactly on coils and bars.





Servomechanism Techniques Applied

Test results in physical system show how servo methods more efficient use of process facilities, products having

By S. P. HIGGENS, Jr. & G. W. McKNIGHT
Minneapolis-Honeywell Regulator Co. Philadelphia 44, Pa.

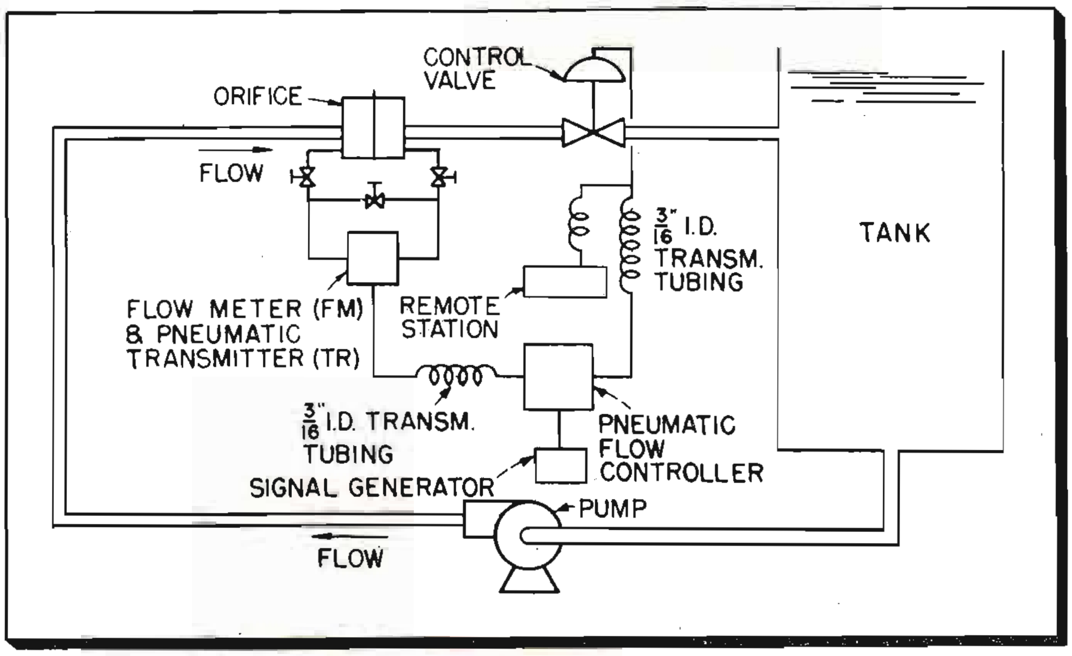


Fig. 1: Schematic of flow control loop constructed in laboratory for testing

As manufacturing processes and their associated control problems become more complex, the need becomes apparent for systematic analysis, with the problem expressed in terms of numbers, to supplement practical experience. The so-called servo techniques seem to offer a powerful tool for expressing control problems in terms of numbers.

Origin of Servo Techniques

The search for a mathematical approach to process design and control application is not a new one. In the early stages, attempts were made to write differential equations for process and instruments to effectively define their operation. The complexity of equations and difficulties experienced in assigning numbers to the coefficients were sufficient to make the methods impractical. Methods based on empirical formulas, such as the transient or step change method[1] were more practical and did receive some acceptance, although the size of the disturbances to the process required and the degree of accuracy attained led many to use intuition, good judgment and experience rather than any formalized approach to solve the problems.

During the last war, great progress was made in predicting the operation of combinations of devices for anti-aircraft artillery use. The methods were taken from many fields including design of feed-back amplifiers and electrical filter circuits. Collectively these have become known as the servomechanism techniques. Since the factors involved in effectively laying a gun are very similar to those of process control, it is only logical that the servo theory should be applied to process analysis.

As occurs in the positional servo devices for anti-aircraft artillery, limitations of many physical components used in the process industries—such as pumps, heat exchangers, controllers, valves, measuring and transmitting devices—have combined effects on the quality and quantity of the end product. Naturally, for most efficient operation of a plant, each of the above components should be correctly specified for the job. Thus, the process and its instrumentation must be considered jointly during the plant design stages rather than separately as in the old practice of designing the process and later adding the instruments. Naturally, compromises may have to be made since important factors other than the ultimate in performance must also be considered.

The experience of G. S. Brown and D. P. Campbell with the application of servo techniques to system design prompted them to propose the need for men trained in these many phases of process control and instrumentation to be called System Engineers.[2] Before system engineering is feasible, however, methods of analyzing the various components of the system and for predicting their combined behavior must be made available on a practical basis.

As a vehicle for crossing the

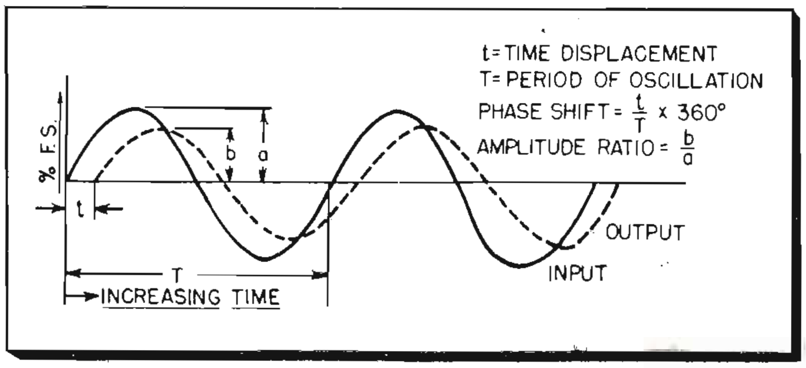
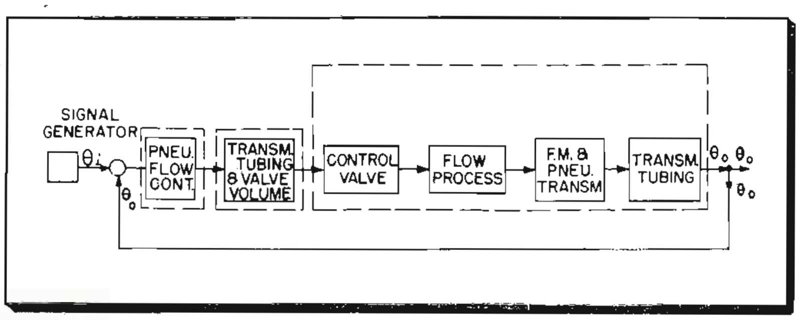


Fig. 2: Transfer function is determined from ratio of output to input amplitude and by measuring phase shift between curves

Fig. 3: Block diagram of the elements shown in Fig. 2



to Manufacturing Problems

can be employed for predicting system behavior. Through greater uniformity and higher quality may be obtained.

PART ONE OF TWO PARTS

boundary between the process and instrumentation phases, servo techniques seem to offer many advantages. Most people, however, when confronted with the term servo techniques, think, immediately, of involved terminology and mathematicians equipped with computers. Such is not necessarily the case. This can best be proved by examining the techniques themselves.

What Servo Techniques Are

Each component or process to be tested is essentially an energy transferring or modulating device; that is, if a change is made to the input of the device, at some later time there will be a change in its output. Obviously, the nature of the input signal, the device construction, and especially the relative ability of the device to transfer energy will determine the amount by which the output lags or leads the input as well as the degree of amplification obtained from the device. This energy transferring characteristic is known, in the servo field, as the transfer function of the device. (In the case of an energy modulating device, such as a controller, the transfer function is a measure of the regulating ability of the device.)

One of the most practical ways of determining the transfer function of a device or process is to observe its response to a sinusoidally varying disturbance. This is commonly known as the "frequency response method." If the system under test is linear, the output response must also be sinusoidal with time; that is, the frequency of the response sinusoid must be identical with the frequency of the disturbing sinusoid.

It is realized that most systems are not linear. Non-linearities, due to valve characteristics, hysteresis, friction and other losses, exist in all processes. However, if the band of operation is kept within a relatively narrow range, the system will be sufficiently linear to permit the successful application of servo methods for predicting system behavior within this range.

If the sinusoidal disturbance is introduced, as above, the dynamic

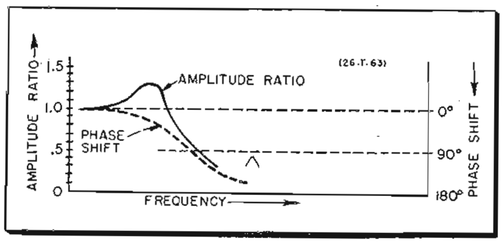


Fig. 4: Quarter amplitude recovery curve in system where set point changes are made to vary in a sinusoidal manner.

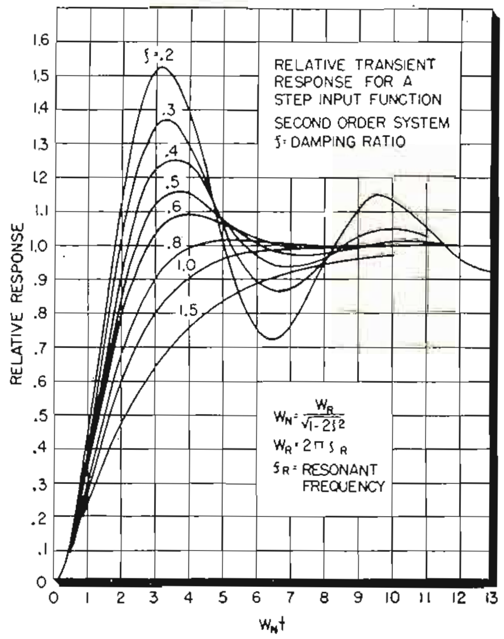


Fig. 6: Curves showing transient response in terms of damping ratio and natural frequency

characteristics of the component under test will determine the ratio of the magnitudes of the output to the input signal and will cause them to be displaced timewise. If the frequency of the disturbing signal is changed, a new magnitude ratio and a different amount of phase shift will occur after the transient has died out. The transfer function and hence the dynamic performance of the unit is determined by measuring the ratio of output amplitude to input amplitude and by measuring the phase shift between the curves over a range of input frequencies.

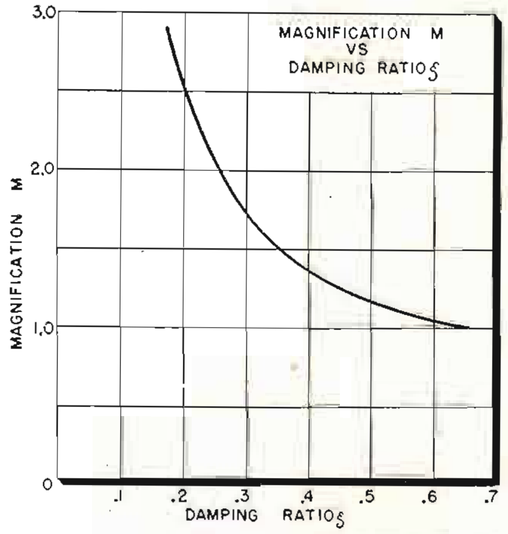


Fig. 5: Curve showing damping factor as a function of amplitude ratio magnification

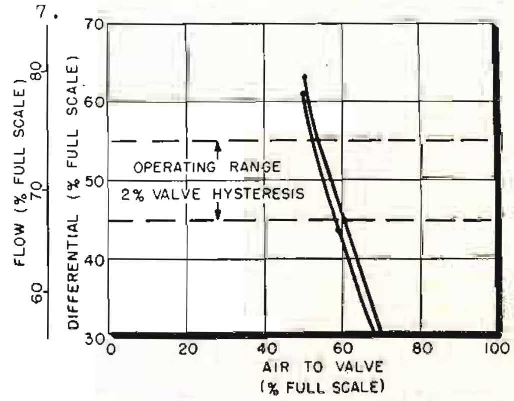


Fig. 7: Hysteresis curve for standard valve

This is shown diagrammatically, in Figure 2, for one value of input frequency.

Sinusoidal Disturbances

If sinusoidal disturbances are introduced into a process or component at different frequencies (such as by loading a valve in a process) a series of amplitude ratios and phase shift angles will be established. If plots are made of Amplitude Ratio and Phase Lag against frequency of disturbance, the resultant curves established the

Table I—Flow Control Systems

System	Type of Flow meter	Transmitter to Controller*	Transmitter to Remoteset*	Controller to Valve*	Controller to Remoteset*
A	Mercury Meter	150 ft.	150 ft.	150 ft.	5 ft.
B	Mercury Meter	30 ft.	150 ft.	5 ft.	150 ft.
C	Dry Transmitter	150 ft.	150 ft.	150 ft.	5 ft.
D	Dry Transmitter	30 ft.	150 ft.	5 ft.	150 ft.

* All connecting tubing was 3/16 inch I.D. tubing

SERVOMECHANISM TECHNIQUES (Continued)

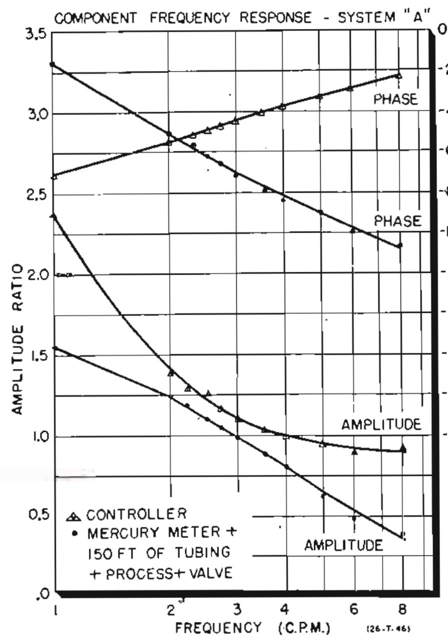


Fig. 8: Component frequency response—(A)

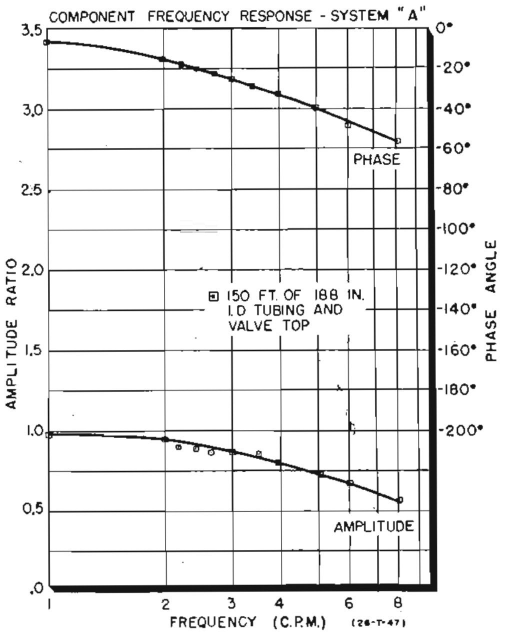


Fig. 9: Component frequency response—(A)

dynamic characteristics for the component or system under test. These plots are known as "frequency response plots."

Although the frequency response plots, themselves, give valuable information, as is shown later, some correlation to system performance, such as the response of a system to a change in controller set point, must exist so that the data has practical utility. Various methods are available for making this correlation, one of which is used in the analysis to be described. It is of interest to note that the transfer function plots themselves indicate the method to be chosen as well as the probable accuracy associated with the correlation.

Obviously the above is an over-simplified outline of the techniques, and does not indicate some of the physical difficulties involved. One difficult problem is the design of a signal generator and recorder capable of producing an undistorted sinusoid over a wide range of frequencies, with pneumatic, electrical and motion outputs. This has been accomplished and information concerning it will be published at a future date. Similarly, necessity for evaluating the frequency data in terms of the previous process and control experience cannot be discounted, and this problem will be discussed later in the paper.

To facilitate testing, it was desired to have available a simple process control system having sufficient physical significance to be associated with actual processes. Experience indicated that a flow control system could be constructed in the laboratory to meet the above requirements. This flow control loop is shown schematically in Fig. 1.

A centrifugal pump is used to pump water around the loop and back into the sump tank. The flow is measured by conventional orifice methods. The length of connecting tubing between the meter, controller and control valve can be varied along with the appropriate side tubing lengths so as to show the response for a process mounted controller as well as for a controller mounted in the control house. In addition, flow meters of the mercury and dry type are tested with the controller in the locations mentioned above. The signal generator is the device which loads the system or system components with a sinusoidally varying disturbance.

Analyzing Elements

The various elements of the system of Fig. 2 may be represented as a series of blocks as shown in the block diagram of Fig. 3. The signal generator is an analytical tool only and forms no part of the automatic flow system. The breaking up of the system into the parts indicated by the blocks is done so that the parts may be isolated as needed for analysis and design. The ultimate objective is to identify or tag each of these blocks in such a way that we can determine what the design of each of the blocks should be for optimum performance of the system as a whole. This, in the language of the servomechanism engineer, is a method offering means for analysis of the elements or blocks that exist or synthesis of those yet to be designed.

It may be more convenient, in certain cases, to have the block represent two or more components in the system, such as the valve and process. The individual transfer function for the process could then be obtained if the valve transfer function (i.e., the response in valve position to valve pressure) was known. The dotted blocks, of Fig. 3, show one instance where transfer function across a group of compo-

TABLE II—SYSTEM "A" TRANSIENT RESPONSE

	Actual	Derived From Measured Closed-Loop Frequency Response	Derived From Predicted Closed-Loop Frequency Response
First Overshoot	29% at 9.6 sec.	25% at 10.2 sec.	35% at 9 sec.
First Undershoot	12% at 16.8 sec.	7% at 20.4 sec.	13% at 18 sec.
Second Overshoot	very slight	1.5%	2%

TABLE III—SYSTEM "B" TRANSIENT RESPONSE

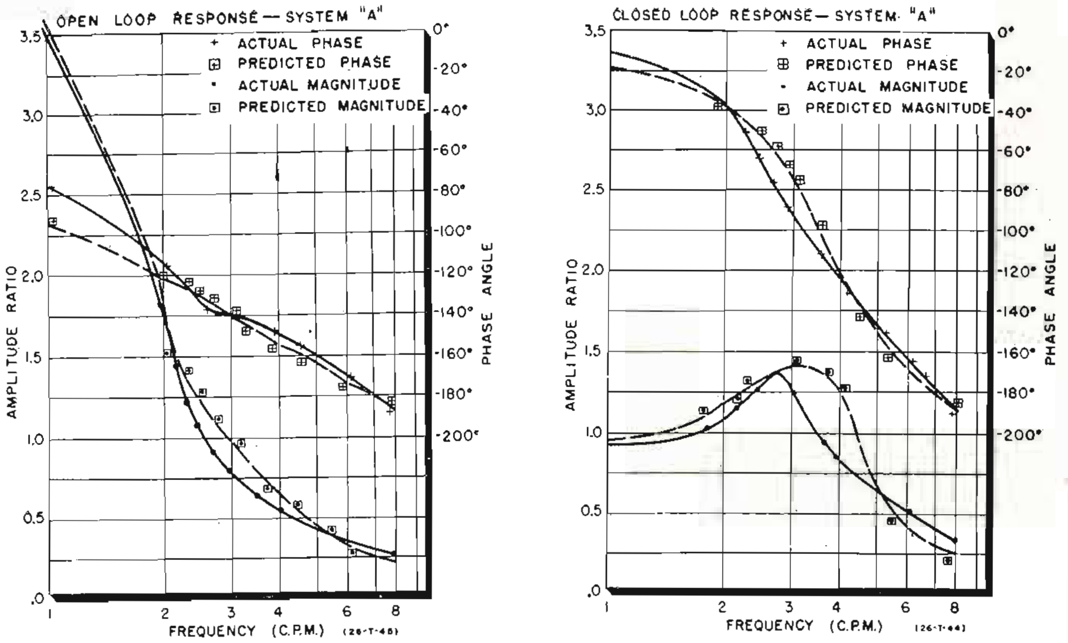
First Overshoot	30% at 7.8 sec.	30% at 8.4 sec.	35% at 8 sec.
First Undershoot	12% at 13.2 sec.	10% at 16.8 sec.	12% at 16 sec.
Second Overshoot	Very slight	3%	5%

TABLE IV—SYSTEM "C" TRANSIENT RESPONSE

First Overshoot	45% at 3.0 sec.	51% at 2.7 sec.	
First Undershoot	26% at 5.5 sec.	20% at 5.6 sec.	
Second Overshoot	14% at 8.2 sec.	12% at 7.8 sec.	

nents might be studied, rather than the individual transfer functions of the components themselves.

Before the use of the frequency response method on the flow control loop is described, its application to a hypothetical example will be considered to see what results might be expected. If the system under test acts, in certain respects, like a simple system, such as the common two capacity system, many useful approximations can be made. For example, such a system, if subjected to a sudden set point change, might have a damped oscillatory response, as evidenced by over and underpeaking, with each successive peak smaller in magnitude than the last. An example of this type of recovery is the well known quarter amplitude recovery curve. Such a system, if subjected to sinusoidally varying set point changes would have a closed loop frequency response as shown in Fig. 4.



Figs. 10-11: (Left) Open loop response and (right) closed loop response for system A

Note the amplitude peak and the rapid change of phase at the resonant frequency. If the frequency response of the system under test resembles the response of the simple system in the region of resonance, some simple methods can be applied to approximate system transient response from the system frequency response. From the relative height of the amplitude peak and the frequency at which it occurs (the resonant frequency), the transient response can be approximated by the use of Figs. 5 and 6.

Fig. 5 shows the damping factor ζ as a function of the amplitude ratio.

(*Continued on page* 114)

Radio-Controlled Airborne Lifeboats

A 30-ft life raft developed by Westinghouse, can be dropped by airplane to sea survivors and piloted to safety via radio controls located in the plane. The 3500-pound craft can hold 15 men, and has a 10-day food supply, fuel for an 800-mile cruise, a machine for distilling fresh drinking water from sea water, and a communications system for boat-to-plane contact.

If the survivors are not physically capable of navigating the lifeboat, they can turn control over to the aircraft by throwing a master switch. A transmitter-receiver system developed by the Wright Air Development Center takes over all steering and engine control.

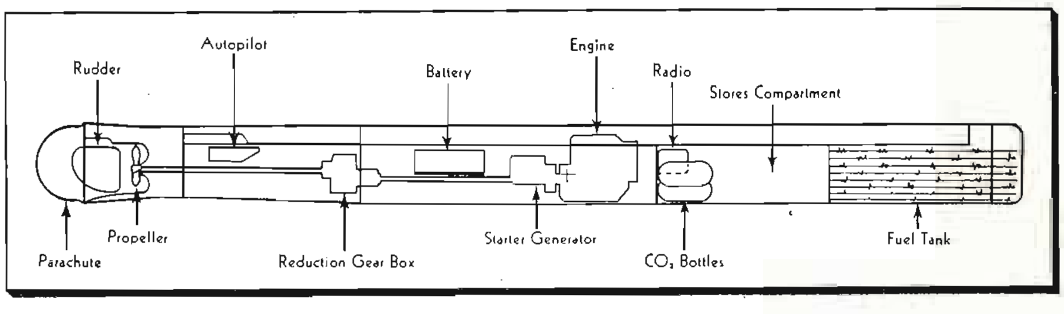
The system consists of an airborne transmitter operating at 73 MC with five different modulating frequencies. The boat receiver picks up these signals and uses them to control various functions. A 955 CPS tone cranks the engine and jettisons the propeller and rudder guard; the 3000 CPS modulation shifts the gear into forward; 650 and 300 CPS tones steer the boat left and right respectively; and an emergency 1390 CPS tone bypasses the magnetic compass steering system if it is not operating properly.

A similar CO_2 inflated lifeboat, the

(*Continued on page* 90)

Lifeboat equipped with Westinghouse control system is parachuted to "survivors" in test run. Using one carrier with five different modulation frequencies, transmitter in airplane will direct boat

Douglas' A-4 radio controlled lifeboat forms 21 ft. cylinder of 21 in. diameter. When waterborne, rubberized nylon flotation cells within the hull automatically expand to 5.75 ft. width



The New FCC Television

ALABAMA

	Channel No.
Andalusia	29
Anniston	37
Auburn	*56
Bessemer	54
Birmingham	6,*10,13,42,48
Brewton	23
Clanton	14
Cullman	60
Decatur	23
Demopolis	18
Dothan	9,19
Enterprise	40
Eufaula	44
Florence	41
Fort Payne	19
Gadsden	15,21
Greenville	49
Guntersville	40
Huntsville	31
Jasper	17
Mobile	5,8,*42,48
Montgomery	12,20,*26,32
Opelika	22
Selma	58
Sheffield	47
Sylacauga	24
Talladega	64
Thomasville	27
Troy	38
Tuscaloosa	45,51
Tuskegee	16
University	*7

ARIZONA

Ajo	14
Bisbee	15
Casa Grande	18
Clifton	25
Coolidge	30
Douglas	3
Eloy	24
Flagstaff	9,13
Globe	34
Holbrook	14
Kingman	6
Mesa	12
Miami	28
Morenci	31
Nogales	17
Phoenix	3,5,*8,10
Prescott	15
Safford	21
Tucson	4,*6,9,13
Williams	25
Winslow	18
Yuma	11,13

ARKANSAS

Arkadelphia	34
Batesville	30
Benton	40
Blytheville	64,74
Camden	50
Conway	49
El Dorado	10,26
Fayetteville	*13,41
Forrest City	22
Fort Smith	5,*18,22
Harrison	24
Helena	54
Hope	15
Hot Springs	9,52
Jonesboro	8,39
Little Rock	*2,4,11,17,23
Magnolia	28
Malvern	46
Morrilton	43
Newport	28
Paragould	44
Pine Bluff	7,38
Russellville	19
Searcy	33
Springdale	35
Stuttgart	14

CALIFORNIA

Alturas	9
Bakersfield	10,29
Brawley	25
Chico	12
Corona	52
Delano	33
El Centro	16
Eureka	3,13
Fresno	12,*18,24,47,53
Hanford	21
Los Angeles	2,4,5,7,9,11,13,22,*28,34
Madera	30
Merced	34
Modesto	14
Monterey (see Salinas)	
Napa	62
Oakland (see San Francisco)	
Oxnard	32
Petaluma	56
Port Chicago	15
Red Bluff	16
Redding	7
Riverside	40,46
Sacramento	3,*6,10,40,46
Salinas-Monterey	8,28
San Bernardino	18,*24,30
San Buenaventura	38
San Diego	8,10,*15,21,27,33,39
San Francisco-Oakland	2,4,5,7,*9,20,26,32,38,44
San Jose	11,48,*54,60
San Luis Obispo	6
Santa Barbara	3,20,26
Santa Cruz	16
Santa Maria	44
Santa Paula	18
Santa Rosa	50
Stockton	13,36,*42
Tulare	27
Ukiah	18
Visalia	43,49
Watsonville	22
Yreka City	11
Yuba City	52

COLORADO

	Channel No.
Alamosa	19
Boulder	*12,22
Canon City	36
Colorado Springs	11,13,*17,23
Craig	19
Delta	24
Denver	2,4,*6,7,9,20,26
Durango	6,15
Fort Collins	44
Fort Morgan	15
Grand Junction	5,21
Greeley	50
La Junta	24
Lamar	18
Leadville	14
Longmont	32
Loveland	38
Montrose	10,18
Pueblo	3,5,*8,28,34
Salida	25
Sterling	25
Trinidad	21
Walsenburg	30

CONNECTICUT

	Channel No.
Bridgeport	43,49,*71
Hartford	3,18,*24
Meriden	65
New Britain	30
New Haven	8,59
New London	26,81
Norwalk (see Stamford)	
Norwich	57,*63
Stamford-Norwalk	27
Waterbury	53

DELAWARE

Dover	40
Wilmington	12,53,*59

DISTRICT OF COLUMBIA

Washington	4,5,7,9,20,*26

FLORIDA

Belle Glade	25
Bradenton	28
Clearwater	32
Daytona Beach	2
De Land	44
Fort Lauderdale	17,23
Fort Myers	11
Fort Pierce	19
Gainesville	*5,20
Jacksonville	4,*7,12,30,36
Key West	14,20
Lake City	33
Lakeland	16,22
Lake Wales	14
Leesburg	26
Marianna	17
Miami	*2,4,7,10,27,33
Ocala	15
Orlando	6,9,18,*24
Palatka	17
Panama City	7,*30,36
Pensacola	3,15,*21,46
Quincy	64
St. Augustine	25
St. Petersburg (see Tampa)	
Sanford	35
Sarasota	34
Tallahassee	*11,24,51
Tampa-St. Petersburg	*3,8,13,38
West Palm Beach	5,12,*15,21

GEORGIA

Albany	10,25
Americus	31
Athens	*8,60
Atlanta	2,5,11,*30,36
Augusta	6,12
Bainbridge	35
Brunswick	28,34
Cairo	45
Carrollton	33
Cartersville	63
Cedartown	53
Columbus	4,28,*34
Cordele	43
Dalton	25
Douglas	32
Dublin	15
Elberton	16
Fitzgerald	23
Fort Valley	18
Gainesville	52
Griffin	39
La Grange	50
Macon	13,*41,47
Marietta	57
Milledgeville	51
Moultrie	48
Newnan	61
Rome	9,59
Savannah	3,*9,11
Statesboro	22
Swainsboro	20
Thomasville	6,27
Tifton	14
Toccoa	35
Valdosta	37
Vidalia	26
Waycross	16

IDAHO

Blackfoot	33
Boise	*4,7,9
Burley	15
Caldwell	2
Couer d'Alene	12
Emmett	26
Gooding	23
Idaho Falls	3,8
Jerome	17
Kellogg	33
Lewiston	3
Moscow	*15
Nampa	6,12
Payette	14
Pocatello	6,10
Preston	41
Rexburg	27
Rupert	21
Sandpoint	9
Twin Falls	11,13
Wallace	27
Weiser	20

ILLINOIS

	Channel No.
Alton	48
Aurora	16
Belleville	54
Bloomington	15
Cairo	24
Carbondale	34,*61
Centralia	32,59
Champaign-Urbana	3,*12,21,27,33
Chicago	2,5,7,9,*11,20,26,32,38,44
Danville	24
Decatur	17,23
De Kalb	*67
Dixon	47
Elgin	28
Freeport	23
Galesburg	40
Harrisburg	22
Jacksonville	29
Joliet	48
Kankakee	14
Kewanee	80
La Salle	35
Lincoln	53
Macomb	61
Marion	40
Mattoon	48
Moline (see Davenport, Iowa)	
Mt. Vernon	38
Olney	16
Pekin	49
Peoria	8,19,*37,43
Quincy	10,21
Rockford	13,39,*45
Rock Island (see Davenport, Iowa)	
Springfield	2,20,*26
Streator	65
Urbana (see Champaign)	
Vandalia	26
Waukegan	22

INDIANA

Anderson	61
Angola	15
Bedford	39
Bloomington	4,*30,36
Columbus	42
Connersville	38
Elkhart	52
Evansville	7,50,*56,62
Fort Wayne	21,*27,33
Gary	50,*66
Hammond	56
Indianapolis	6,6,13,*20,26,67
Jasper	19
Kokomo	31
Lafayette	*47,59
Lebanon	18
Logansport	51
Madison	25
Marion	29
Michigan City	62
Muncie	49,55,*71
Richmond	32
Shelbyville	56
South Bend	34,*40,46
Tell City	31
Terre Haute	10,*57,63
Vincennes	44
Washington	60

IOWA

Algona	37
Ames	5,25
Atlantic	45
Boone	19
Burlington	32,38
Carroll	39
Cedar Rapids	2,9,20,*26
Centerville	31
Charles City	18
Cherokee	14
Clinton	64
Creston	43
Davenport-Rock Island & Moline, Illinois	4,6,*30,36,42
Decorah	44
Des Moines	8,*11,13,17,23
Dubuque	56,62
Estherville	24
Fairfield	54
Fort Dodge	21
Fort Madison	50
Grinnell	46
Iowa City	*12,24
Keokuk	44
Knoxville	33
Marshalltown	49
Mason City	3,35
Muscatine	58
Newton	29
Oelwein	28
Oskaloosa	52
Ottumwa	15
Red Oak	32
Shenandoah	20
Sioux City	4,9,*30,36
Spencer	42
Storm Lake	34
Waterloo	7,16,*22
Webster City	27

KANSAS

Abilene	31
Arkansas City	49
Atchison	60
Chanute	50
Coffeyville	33
Colby	22
Concordia	47
Dodge City	6,23
El Dorado	55
Emporia	39
Fort Scott	27
Garden City	9,11
Goodland	31
Great Bend	2,28
Hays	7,20
Hutchinson	12,18
Independence	20
Iola	44
Junction City	29
Larned	15
Lawrence	*11,17
Leavenworth	54
Liberal	14
McPherson	26
Manhattan	*8,23
Newton	14
Olathe	52
Ottawa	21
Parsons	46
Pittsburg	7,38
Pratt	36
Salina	34
Topeka	13,42,*48
Wellington	24
Wichita	3,10,16,*22
Winfield	43

KENTUCKY

	Channel No.
Ashland	59
Bowling Green	13,17
Campbellsville	40
Corbin	16
Danville	35
Elizabethtown	23
Frankfort	43
Glasgow	28
Harlan	36
Hazard	19
Hopkinsville	20
Lexington	27,33
Louisville	3,11,*15,21,41,51
Madisonville	26
Mayfield	49
Maysville	24
Middlesborough	57,63
Murray	33
Owensboro	14
Paducah	6,43
Pikeville	14
Princeton	45
Richmond	60
Somerset	22
Winchester	37

LOUISIANA

Abbeville	42
Alexandria	5,62
Bastrop	53
Baton Rouge	10,28,*34,40
Bogalusa	39
Crowley	21
De Ridder	14
Eunice	64
Franklin	46
Hammond	51
Houma	30
Jackson	18
Jennings	48
Lafayette	38,67
Lake Charles	7,*19,25
Minden	30
Monroe	8,43
Morgan City	36
Natchitoches	17
New Iberia	15
New Orleans	*2,4,6,20,28,32,61
Oakdale	54
Opelousas	58
Ruston	20
Shreveport	3,12
Thibodaux	24
Winnfield	22

MAINE

	Channel No.
Auburn	23
Augusta	10,29
Bangor	2,5,*16
Bar Harbor	22
Bath	65
Belfast	41
Biddeford	59
Calais	7,20
Dover-Foxcroft	18
Fort Kent	17
Houlton	24
Lewiston	8,17
Millinocket	14
Orono	*12
Portland	6,13,*47,53
Presque Isle	8,19
Rockland	25
Rumford	55
Van Buren	15
Waterville	35

MARYLAND

Annapolis	14
Baltimore	2,11,13,18,*24.30
Cambridge	22
Cumberland	17
Frederick	62
Hagerstown	52
Salisbury	16

MASSACHUSETTS

Barnstable	52
Boston	*2,4,5,7,44,50,56
Brockton	62
Fall River	40,48
Greenfield	42
Holyoke (see Springfield)	
Lawrence	38
Lowell	32
New Bedford	28.34
North Adams	15
Northampton	36
Pittsfield	64
Springfield-Holyoke	55,61
Worcester	14,20

MICHIGAN

	Channel No.
Alma	41
Alpena	9,30
Ann Arbor	20,*26
Bad Axe	46
Battle Creek	58,64
Bay City	5,63,*73
Benton Harbor	42
Big Rapids	39
Cadillac	13,45
Calumet	13
Cheboygan	4,36
Coldwater	24
Detroit	2,4,7,50,*56,62
East Lansing	60
East Tawas	25
Escanaba	3
Flint	12,16,*22,28
Gladstone	40
Grand Rapids	8,*17,23
Hancock	10
Houghton	19
Iron Mountain	9,27
Iron River	12
Ironwood	31
Jackson	48
Kalamazoo	3,36
Lansing	6,54
Ludington	18
Manistee	15
Manistique	14
Marquette	5,17
Midland	19
Mount Pleasant	47
Muskegon	29,35
Petoskey	31
Pontiac	44
Port Huron	34
Rogers City	24
Saginaw	51,57
Sault Ste. Marie	8,10,28,*34
Traverse City	7,20,*26
West Branch	21

MINNESOTA

Albert Lea	57
Alexandria	36
Austin	6,51
Bemidji	24
Brainerd	12
Cloquet	44
Crookston	21
Detroit Lakes	18
Duluth-Superior, Wisc.	3,6,*8,32,38
Ely	18
Fairmont	40
Faribault	20
Fergus Falls	16
Grand Rapids	20
Hastings	29
Hibbing	10
International Falls	11
Little Falls	14
Mankato	15
Marshall	22
Minneapolis-St. Paul	*2,4,5,9,11,17,23
Montevideo	19
New Ulm	43
Northfield	26
Owatonna	45
Red Wing	63
Rochester	10,55
St. Cloud	7,33
St. Paul (see Minneapolis)	
Stillwater	39
Thief River Falls	15
Virginia	26
Wadena	27
Willmar	31
Winona	61
Worthington	32

MISSISSIPPI

Biloxi	13,*44,50
Brookhaven	37
Canton	16
Clarksdale	6,32
Columbia	35
Columbus	28
Corinth	29
Greenville	21,27
Greenwood	24
Grenada	15
Gulfport	56
Hattiesburg	9,17
Jackson	12,*19,25,47
Kosciusko	52
Laurel	33
Louisville	46
McComb	31
Meridian	11,30,*36
Natchez	29
Pascagoula	22
Picayune	14
Starkville	34
State College	*2
Tupelo	38
University	*20
Vicksburg	41
West Point	8,56
Yazoo City	49

MISSOURI

Cape Girardeau	12,18
Carthage	56
Caruthersville	27
Chillicothe	14
Clinton	49
Columbia	8,16,22
Farmington	52
Festus	14
Fulton	24
Hannibal	7,27
Jefferson City	13,33
Joplin	12,30
Kansas City	4,5,9,*19,25,65
Kennett	21
Kirksville	3,18
Lebanon	23
Marshall	40
Maryville	36
Mexico	45
Moberly	35
Monett	14
Nevada	18
Poplar Bluff	15
Rolla	31
St. Joseph	2,30,*36
St. Louis	4,5,*9,11,30,36,42
Sedalia	6,28
Sikeston	37
Springfield	3,10,*26,32
West Plains	20

MONTANA

Anaconda	2
Billings	2,8,*11
Bozeman	*9,22
Butte	4,6,*7,15
Cut Bank	20
Deer Lodge	25
Dillon	20
Glasgow	16
Glendive	18
Great Falls	3,5,*23
Hamilton	17
Hardin	4
Havre	9,11
Helena	10,12
Kalispell	8
Laurel	14
Lewistown	13
Livingston	18
Miles City	3,*6,10
Missoula	*11,13,21
Polson	18
Red Lodge	18
Shelby	14
Sidney	14
Whitefish	16
Wolf Point	20

NEBRASKA

Alliance	13,21
Beatrice	40
Broken Bow	14
Columbus	49
Fairbury	35
Falls City	38
Fremont	52

Allocations — VHF and UHF

	Channel No.
Grand Island	11,21
Hastings	5,27
Kearney	13,19
Lexington	23
Lincoln	10,12,*18,24
McCook	8,17
Nebraska City	50
Norfolk	33
North Platte	2,4
Omaha	3,6,7,*16,22,28
Scottsbluff	10,16
York	15

NEVADA

Boulder City	4
Carlin	14
Carson City	37
Elko	10
Ely	3,6
Fallon	29
Goldfield	5
Hawthorne	31
Henderson	2
Las Vegas	8,*10,13
Lovelock	18
McGill	8
Reno	4,8,*21,27
Tonopah	9
Winnemucca	7
Yerington	33

NEW HAMPSHIRE

Berlin	26
Claremont	37
Concord	27
Durham	*11
Hanover	*21
Keene	45
Laconia	43
Littleton	24
Manchester	9,48
Nashua	54
Portsmouth	19
Rochester	51

NEW JERSEY

Andover	*69
Asbury Park	58
Atlantic City	46,52
Bridgeton	64
Camden	*80
Freehold	*74
Hammonton	*70
Montclair	*77
Newark	13
New Brunswick	*19,47
Paterson	37
Trenton	41
Wildwood	48

NEW MEXICO

Alamogordo	17
Albuquerque	4,*5,7,13
Artesia	21
Atrisco-Five Points	18
Belen	24
Carlsbad	6,23
Clayton	27
Clovis	12,35
Deming	14
Farmington	17
Gallup	3,*8,10
Hobbs	46
Hot Springs	19
Las Cruces	22
Las Vegas	14
Lordsburg	23
Los Alamos	20
Lovington	27
Portales	22
Raton	46,*52
Roswell	*3,8,10
Santa Fe	2,*9,11
Silver City	*10,12
Socorro	15
Tucumcari	25

NEW YORK

Albany-Schenectady-Troy	6,*17,23,41
Amsterdam	52
Auburn	37
Batavia	33
Binghamton	12,40,*46
Buffalo (also see Buffalo-Niagara Falls)	17,*23
Buffalo-Niagara Falls	2,4,7,59
Cortland	56
Dunkirk	46
Elmira	18,24
Glens Falls	39
Gloversville	29
Hornell	50
Ithaca	*14,20
Jamestown	58
Kingston	66
Malone	20,*66
Massena	14
Middletown	60
New York	2,4,5,7,9,11,*25,31
Niagara Falls (see Buffalo-Niagara Falls)	
Ogdensburg	24
Olean	54
Oneonta	62
Oswego	31
Plattsburg	28
Poughkeepsie	21,*83
Rochester	5,10,15,*21,27
Rome (see Utica)	
Saranac Lake	18
Schenectady (also see Albany)	35
Syracuse	3,8,*43
Troy (see Albany)	
Utica-Rome	13,19,*25
Watertown	48

NORTH CAROLINA

	Channel No.
Ahoskie	53
Albemarle	26
Asheville	13,*56,62
Burlington	63
Chapel Hill	*4
Charlotte	3,9,36,*42
Durham	11,*40,46
Elizabeth City	31
Fayetteville	18
Gastonia	48
Goldsboro	34
Greensboro	2,*51,57
Greenville	9
Henderson	52
Hendersonville	27
Hickory	30
High Point	15
Jacksonville	16
Kannapolis	59
Kinston	45
Laurinburg	41
Lumberton	21
Mount Airy	55
New Bern	13
Raleigh	5,*22,28
Roanoke Rapids	30
Rocky Mount	50
Salisbury	53
Sanford	38
Shelby	39
Southern Pines	49
Statesville	64
Washington	7
Wilmington	6,29,*35
Wilson	56
Winston-Salem	12,26,*32

NORTH DAKOTA

Bismarck	5,12,18,*24
Bottineau	16
Carrington	26
Devils Lake	8,14
Dickinson	2,4,*17
Fargo	6,13,*34,40
Grafton	17
Grand Forks	*2,10
Harvey	22
Jamestown	7,42
Lisbon	23
Minot	*6,10,13
New Rockford	20
Rugby	38
Valley City	4,32
Wahpeton	45
Williston	8,11,*34

OHIO

Akron	49,*55,61
Ashtabula	15
Athens	62
Bellefontaine	63
Cambridge	26
Canton	29
Chillicothe	56
Cincinnati	5,9,12,*48,54,74
Cleveland	3,5,8,19,*25,65
Columbus	4,6,10,*34,40
Coshocton	20
Dayton	2,7,*16,22
Defiance	43
Findlay	53
Gallipolis	18
Hamilton-Middletown	65
Lancaster	28
Lima	35,41
Lorain	31
Mansfield	36
Marion	17
Massillon	23
Middletown (see Hamilton)	
Mount Vernon	58
Newark	60
Oxford	*14
Piqua	44
Portsmouth	30
Sandusky	42
Springfield	46,52
Steubenville (see Wheeling, W. Va.)	
Tiffin	47
Toledo	11,13,*30
Warren	21
Youngstown	27,33,73
Zanesville	50

OKLAHOMA

Ada	50
Altus	36
Alva	30
Anadarko	58
Ardmore	55
Bartlesville	62
Blackwell	51
Chickasha	64
Claremore	15
Clinton	32
Duncan	39
Durant	27
Elk City	12,15
El Reno	56
Enid	5,21,*27
Frederick	44
Guthrie	48
Guymon	20
Hobart	23
Holdenville	14
Hugo	21
Lawton	7,*28,34
McAlester	47
Miami	58
Muskogee	8,*45,66
Norman	31,*37
Oklahoma City	4,9,*13,19,25
Okmulgee	26
Pauls Valley	61
Ponca City	40
Pryor Creek	54
Sapulpa	42
Seminole	59
Shawnee	53
Stillwater	29,*69
Tulsa	2,6,*11,17,23
Vinita	28
Woodward	8

OREGON

	Channel No.
Albany	55
Ashland	14
Astoria	30
Baker	37
Bend	15
Burns	16
Corvallis	*7,49
Eugene	*9,13,20,26
Grants Pass	30
Klamath Falls	2
La Grande	13
Lebanon	43
McMinnville	46
Medford	4,5
North Bend	16
Pendleton	28
Portland	6,8,*10,12,21,27
Roseburg	28
Salem	3,*18,24
Springfield	37
The Dalles	32

PENNSYLVANIA

	Channel No.
Allentown	39,45
Altoona	10,19,25
Bethlehem	51
Bradford	48
Butler	43
Chambersburg	46
Du Bois	31
Easton	57
Emporium	42
Erie	12,35,*41,66
Harrisburg	27,33,71
Hazleton	63
Johnstown	6,56
Lancaster	8,21
Lebanon	15
Lewistown	38
Lock Haven	32
Meadville	37
New Castle	45
Oil City	64
Philadelphia	3,6,10,17,23,29,*35
Pittsburgh	2,11,*13,16,47,53
Reading	55,61
Scranton	16,22,73
Sharon	39
State College	*44
Sunbury	65
Uniontown	14
Washington	63
Wilkes-Barre	28,34
Williamsport	36
York	43,49

RHODE ISLAND

Providence	10,12,16,*22

SOUTH CAROLINA

Aiken	54
Anderson	58
Camden	14
Charleston	2,5,*13
Clemson	*68
Columbia	10,*19,25,67
Conway	23
Florence	8
Georgetown	27
Greenville	4,23,*29
Greenwood	21
Lake City	55
Lancaster	31
Laurens	45
Marion	43
Newberry	37
Orangeburg	44
Rock Hill	61
Spartanburg	7,17
Sumter	47
Union	65

SOUTH DAKOTA

Aberdeen	9,17
Belle Fourche	23
Brookings	*8,25
Hot Springs	17
Huron	12,15
Lead	5,26
Madison	46
Mitchell	5,20
Mobridge	27
Pierre	6,10,*22
Rapid City	7,15
Sioux Falls	11,13,38,*44
Sturgis	20
Vermillion	*2,41
Watertown	3,35
Winner	18
Yankton	17

TENNESSEE

Athens	14
Bristol, Tenn.-Bristol, Va.	5,46
Chattanooga	3,12,43,49,*55
Clarksville	53
Cleveland	36
Columbia	39
Cookeville	24
Covington	19
Dyersburg	46
Elizabethton	40
Fayetteville	27
Gallatin	46
Harriman	67
Humboldt	25
Jackson	9,16
Johnson City	11,34
Kingsport	28
Knoxville	6,10,*20,26
Lawrenceburg	50
Lebanon	56
McMinnville	46
Maryville	51
Memphis	3,5,*10,13,42,48
Morristown	54
Murfreesboro	18
Nashville	*2,4,5,8,30,36
Oak Ridge	32
Paris	51
Pulaski	44
Shelbyville	62
Springfield	42
Tullahoma	65
Union City	55

TEXAS

Abilene	9,33
Alice	34
Alpine	12
Amarillo	*2,4,7,10
Athens	25
Austin	7,18,24,*30
Ballinger	25
Bay City	33
Beaumont-Port Arthur	4,6,31,*37
Beeville	38
Big Spring	4
Bonham	43
Borger	33
Brady	15
Breckenridge	14
Brenham	52
Brownfield	15
Brownsville (also see Brownsville-Harlingen-Weslaco)	36
Brownsville-Harlingen-Weslaco (1)	4,5

(1) These assignments may be utilized in any community lying within the area of the triangle formed by Brownsville, Harlingen and Weslaco.

	Channel No.
Brownwood	19
Bryan	54
Childress	40
Cleburne	57
Coleman	21
College Station	*3,48
Conroe	30
Corpus Christi	6,10,*16,22
Corsicana	47
Crockett	56
Crystal City	28
Cuero	25
Dalhart	16
Dallas	4,8,*13,23,29,73
Del Rio	16
Denison	52
Denton	*2,17
Eagle Pass	26
Edinburg	28
El Campo	27
El Paso	4,*7,9,13,20,26
Falfurrias	52
Floydada	45
Fort Stockton	22
Fort Worth	5,10,20,*26
Gainesville	49
Galveston	11,35,41,*47
Gonzales	64
Greenville	62
Harlingen (also see Brownsville-Harlingen-Weslaco)	23
Rebbronville	58
Henderson	42
Hereford	19
Hillsboro	63
Houston	2,*8,13,23,29,39
Huntsville	15
Jacksonville	36
Jasper	49
Kermit	14
Kilgore	59
Kingsville	40
Lamesa	28
Lampasas	40
Laredo	8,13,*15
Levelland	38
Littlefield	32
Longview	32,38
Lubbock	5,11,13,*20,26
Lufkin	9,46
McAllen	20
McKinney	65
Marfa	19
Marshall	16
Mercedes	32
Mexia	50
Midland	2,18
Mineral Wells	38
Mission	14
Monahans	9
Mount Pleasant	35
Nacogdoches	40
New Braunfels	62
Odessa	7,24
Orange	43
Pampa	17
Paris	33
Pearsall	31
Pecos	16
Perryton	22
Plainview	29
Port Arthur (see Beaumont)	
Quanah	42
Raymondville	42
Rosenberg	17
San Angelo	6,8,17,*23
San Antonio	4,5,*9,12,35,41
San Benito	48
San Marcos	53
Seguin	14
Seymour	24
Sherman	46
Snyder	30
Stephenville	32
Sulphur Springs	41
Sweetwater	12
Taylor	58
Temple	16,22
Terrell	53
Texarkana	6,*18,24
Tyler	7,19
Uvalde	20
Vernon	18
Victoria	19
Waco	11,*28,34
Waxahachie	45
Weatherford	51
Weslaco (see Brownsville-Harlingen-Weslaco)	
Wichita Falls	3,6,*16,22

UTAH

Brigham	36
Cedar City	5
Logan	12,30,*46
Ogden	9,*16,24
Price	6
Provo	11,22,*26
Richfield	13
St. George	18
Salt Lake City	2,4,5,*7,20,26
Tooele	44
Vernal	3

VERMONT

Bennington	33
Brattleboro	58
Burlington	*16,22
Montpelier	3,40
Newport	46
Rutland	49
St. Albans	34
St. Johnsbury	30

VIRGINIA

	Channel No.
Blacksburg	*60
Bristol (see Bristol, Tenn.)	
Charlottesville	*45,64
Covington	44
Danville	24
Emporia	25
Farmville	19
Fredericksburg	47
Front Royal	39
Harrisonburg	3,34
Lexington	64
Lynchburg	13,16
Marion	50
Martinsville	35
Newport News (see Norfolk-Portsmouth-Newport News)	
Norfolk-Portsmouth (also see Norfolk-Portsmouth-Newport News)	27
Norfolk-Portsmouth-Newport News (also see Norfolk-Portsmouth)	3,10,16,*21,33
Norton	52
Petersburg	8,41
Portsmouth (see Norfolk-Portsmouth and also see Norfolk-Portsmouth-Newport News)	
Pulaski	37
Richmond	8,12,*23,29
Roanoke	7,10,27,*33
South Boston	14
Staunton	36
Waynesboro	42
Williamsburg	17
Winchester	28

WASHINGTON

Aberdeen	58
Anacortes	34
Bellingham	12,18,24
Bremerton	44,50
Centralia	17
Ellensburg	49,*65
Ephrata	43
Everett	22,28
Grand Coulee	37
Hoquiam	53
Kelso	39
Kennewick (also see Kennewick-Richland-Pasco)	25
Kennewick-Richland-Pasco	*41
Longview	23
Olympia	60
Omak-Okanogan	*35
Okanogan (see Omak)	
Pasco (also see Kennewick-Richland-Pasco)	19
Port Angeles	16
Pullman	*10,24
Richland (also see Kennewick-Richland-Pasco)	31
Seattle	4,5,7,*9,20,26
Spokane	2,4,6,*7
Tacoma	11,13,*56,62
Walla Walla	5,8,*22
Wenatchee	*45,55
Yakima	23,29,*47

WEST VIRGINIA

Beckley	6,21
Bluefield	41
Charleston	8,*43,49
Clarksburg	12,22
Elkins	40
Fairmont	35
Hinton	31
Huntington	3,12,*53
Logan	23
Martinsburg	58
Morgantown	*24
Parkersburg	15
Welch	25
Weston	32
Wheeling (also see Wheeling-Steubenville, Ohio)	*57
Wheeling-Steubenville, Ohio	7,9,51
Williamson	17

WISCONSIN

Adams	*58
Appleton	42
Ashland	15
Beaver Dam	37
Beloit	57
Chilton	*24
Eau Claire	13,*19,25
Fond du Lac	54
Green Bay	2,6
Janesville	63
Kenosha	61
La Crosse	8,*32,38
Madison	3,*21,27,33
Manitowoc	66
Marinette	11,32,*38
Milwaukee	4,*10,12,19,25,31
Oshkosh	48
Park Falls	*18
Portage	17
Prairie du Chien	24
Racine	49,55
Rhinelander	22
Rice Lake	21
Richland Center	15,*68
Sheboygan	59
Shell Lake	*30
Sparta	50
Stevens Point	20,26
Sturgeon Bay	44
Superior (see Duluth, Minn.)	
Wausau	7,16,*46
Wisconsin Rapids	14

WYOMING

Buffalo	29
Casper	2,6
Cheyenne	3,5
Cody	24
Douglas	14
Evanston	14
Gillette	31
Green River	16
Greybull	40
Lander	17
Laramie	*8,18
Lovell	36
Lusk	19
Newcastle	28
Powell	30
Rawlins	11
Riverton	10
Rock Springs	13
Sheridan	9,12
Thermopolis	15
Torrington	27
Wheatland	24
Worland	34

U. S. TERRITORIES AND POSSESSIONS

ALASKA

Anchorage	2,*7,11,13
Fairbanks	2,4,7,*9,11,13
Juneau	*3,8,10
Ketchikan	2,4,*9
Seward	4,9
Sitka	13

HAWAIIAN ISLANDS

Lihue, Kauai	3,*8,10,12
Honolulu, Oahu	2,4,*7,9,11,13
Wailuku, Maui	3,8,*10,12
Hilo, Hawaii	2,*4,7,9,11,13

PUERTO RICO

Arecibo	13
Caguas	11
Mayaguez	3,5
Ponce	7,9
San Juan	2,4,*6

VIRGIN ISLANDS

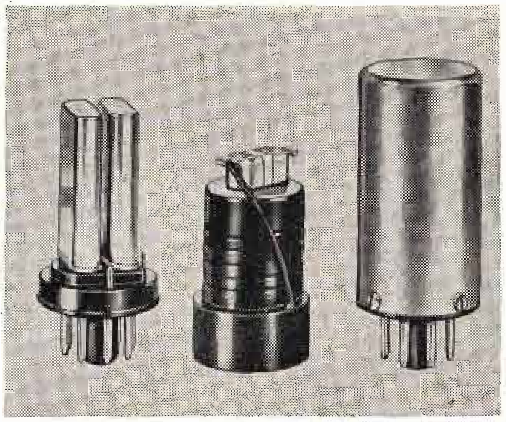
Christiansted	8
Charlotte Amalie	10,12

Channels identified with an asterisk (*) are reserved for non-commercial educational stations

New Equipment and Components

Crystal Oven

A new miniature crystal temperature control oven (JKO-2T) provides temperature stabilization for crystal units normally in



the frequency range of 16 to 200 KC. It provides a stable temperature of 75°C.±2° for one or two James Knights type H-17T (military type HC-13/U) crystal units in ambients from −55° to +70° C. Standard octal base is used. Overall width is 1.28 in. Height, less pins, is 2.41 in. Heater is rated at 6.3c. av or dc at approximately 1.40 amps. Power consumed at ±25°C. is 3.3 watts; at −55°C., it is 6.8 watts. The JKOT-2 oven is electrically interchangeable with the JKO-2 oven, the two types providing temperature stabilization over the entire range of frequencies available in miniature, hermetically-sealed, military type crystal holders.—**The James Knights Co., Sandwich, Ill.**—TELE-TECH.

Soldering Unit

Suitable for soldering connections of radio parts, the Soldering Unit Model K-72 has an adjustable heat control which allows the carbon electrode to heat up to 1500°F instantly. The power unit is enclosed in a 4 x 5 x 6 in. case and weighs 10 lbs. with 7 in. handle. Cost is $36.45.—**Sunrise Products Co., P.O. Box 173, Hawthorne, N. J.**—TELE-TECH.

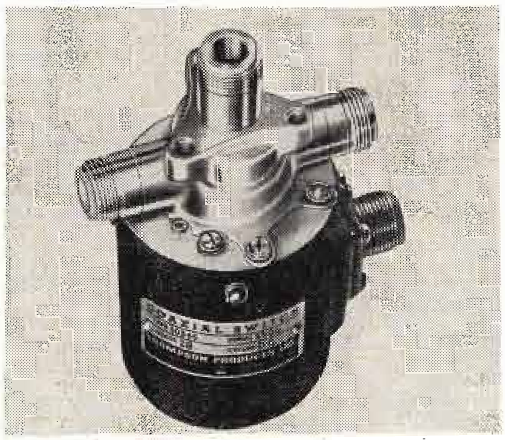
Voltmeter-Amplifier

Model R voltmeter is primarily intended for measuring dc potentials from 1 v. to 1000 v. full scale in seven ranges with an accuracy better than 1%. Wirewound resistor input is 10 meg. Instrument also measures 1 to 1000 mv in seven ranges with input grid current less than 5 x 10^{-10} amps; ac voltage range covered is same as dc, with 3% accuracy and 10 to 100,000 CPS frequency response. Seven ohmeter ranges cover from zero to infinity within 2% accuracy. Distended ohms and dc voltage scales permits reading small values on standard scale with greater accuracy with-

out further adjustment. Built-in dc amplifier can drive 1 ma recorder, has gain of 200, frequency range 0-100 KC, and 50 v. peak output. Self-contained standard cell and regulated power supply are included in the 34 lb. unit. Dimensions are 13.75 x 10.25 x 9 in., and power requirements are 105-120 v. at 60 CPS, 80 watts. Price is $620.00 FOB Houston.—**Southwestern Industrial Electronics Co., 2831 Post Oak Rd., P.O. Box 13058, Houston 19, Texas.**—TELE-TECH.

R-F Coaxial Switch

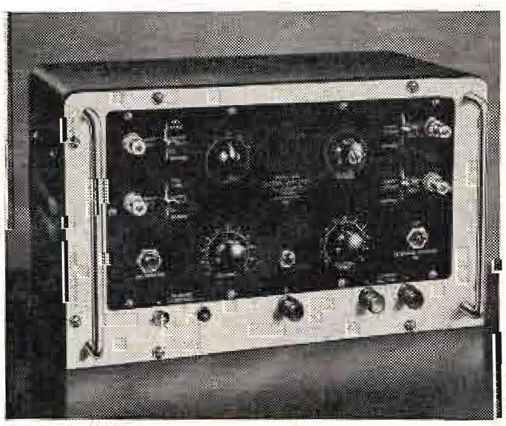
Model 10565 coaxial switch is actuated by a 24-28 v. dc rotary solenoid and meets rigid military performance specifications. At fre-



quencies to 11,000 MC it has a maximum vswr of 1.5 db and less than 0.2 db insertion loss. At 3,000 MC, cross-talk is in excess of 55 db. Power handling capabilities are 100 watts continuous cw at 3,000 MC. Actuation time is less than 0.5 sec. with a minimum life of 10,000 cps. Weight is 1.6 lbs. Catalog available upon request.—**Thompson Products, Inc., 2196 Clarkwood Road, Cleveland 3, Ohio**—TELE-TECH.

DC Preamplifier

The Cossor model 1430 is a directly coupled pre-amplifier of high stability which has been designed for use with a further amplifier or with a recording device. It covers a frequency range from dc to 30 KC; response being 15% down at 30 KC. The instrument may be used to amplify either balanced or unbalanced input signals, and will provide a balanced or unbalanced output as required from either kind of input



signal. Amplifier balance and the setting up of the recording device can be checked without disconnecting the signal input or output leads. A 1 mv calibration signal can be switched to the preamplifier input terminals for the ac or dc calibration of the combination of preamplifier and recorder. The circuit consists of two stages of balanced amplification with a high impedance cathode-follower input and low impedance cathode-follower output. Direct coupling is used throughout. Maximum gain is 50, but two intermediate gains of 5 and 15 may be selected by means of a gain switch which is mounted on the front panel. Power is supplied by a standard 120 v H.T. battery and three 2-volt cells.—**Beam Instruments Corp., 350 Fifth Ave., New York 1, N. Y.**—TELE-TECH.

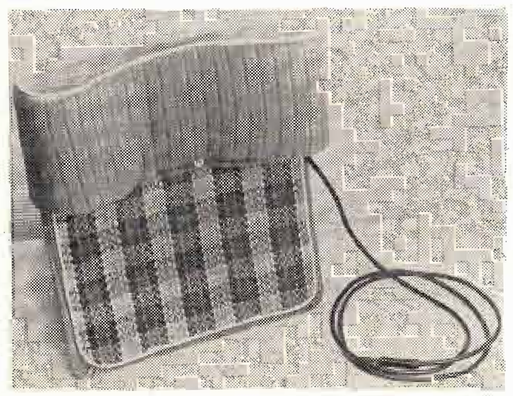
Tape Recorder for Telemetering Applications

Reproduction of 100 to 100,000 CPS with very low flutter and wow and less than 0.1% peak-to-peak limit is accomplished by

the Ampex model 500. Fabricated to conform to JAN specifications, provisions are made to record four individual data tracks. A signal-to-noise ratio is attained that is well over 40 db below 1% harmonic distortion when measured in 15% band widths. A new drive system eliminates any effect of tape backing and other usual causes of speed variation. No complicated auxiliary equipment for compensation is required as the model 500 introduces negligible error in the final data in the most stringent systems. The Ampex Speed-Lock unit included in this equipment eliminates any dc error by automatically adjusting the speed of the recorder during playback. Thus recorded frequencies are played back as originally recorded, regardless of tape dimensional changes, power line frequency variations or slippage of the tape. The tape is rigidly held to a capstan by vacuum, providing extremely reliable tape motion without introducing any flutter or wow by pressure rollers or slippage. Since both the record and playback heads contact the tape at the capstan, tape scrape and vibration are reduced to a minimum. The capstan is coupled directly to a damped flywheel which is belt driven by a high speed hysteresis synchronous motor. The tape is fed to the capstan under constant tension to eliminate any effect of differences in diameter of the tape reel. Tape capacity is up to 5000 ft. on 14 in. reels providing a playing time of 16 minutes at 60 ips. or 32 minutes at 30 ips.—**Ampex Electric Corp., Redwood City, Calif.**—TELE-TECH.

Seat Speaker

Model 1X156 speaker system for aircraft and vehicular communications mounts on the

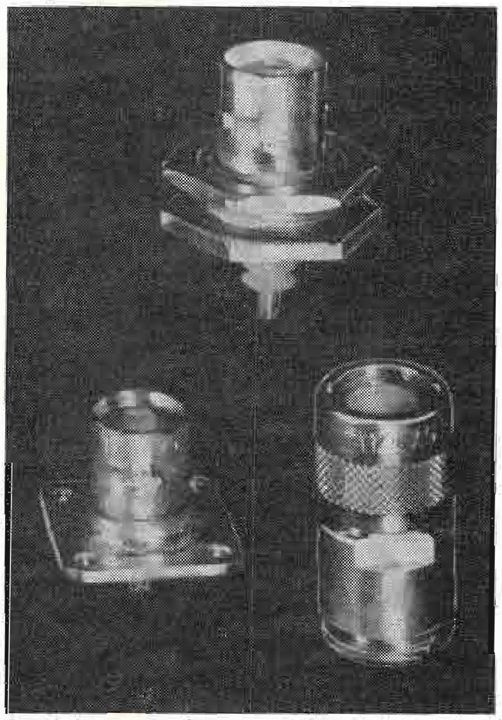


seat close to rear of head. Unit consists of universal matching transformer and two loudspeakers which provide constant volume with head movement. Price is $29.50.—**Mitchell Industries, Inc., P.O. Box 17, Mineral Wells, Texas.**—TELE-TECH.

for Designers and Manufacturers

Coaxial Connectors

A new line of type C connectors features a quick connect-disconnect bayonet locking coupling. New electrical designs, with Teflon



insulators, produce a minimum vswr at frequencies up to 10,000 MC. Improved cable clamping and sealing furnish weatherproofing at temperature extremes. Plugs and jacks are available for all types of RG cables. Adapters to other types of connectors can be supplied.—**Mendelsohn Speedgun Co., Inc., 457 Bloomfield Ave., Bloomfield, N. J.** —TELE-TECH.

Sampling Switch

A motor-driven sampling switch for zero drift correction of dc amplifier in analog computers makes possible the use of an ac

amplifier alone for zero correction and gain improvement of as many as 30 dc computing amplifiers. The unit has two poles, with 60 contacts per pole and the sampling rate is 3½ RPS. It has inter-contact resistance over 1,000 megohms. In tests, the switch has proved to have an extremely low noise level and a service life of several thousand hours. The same design and circuitry may be used for special sampling rates and contact configurations, as ordered.—**Applied Science Corporation of Princeton, P.O. Box 44, Princeton, N. J.**—TELE-TECH.

Miniature Circuit Breaker

A new miniature circuit breaker provides overload and short circuit protection in communications equipment. Manufactured by El-

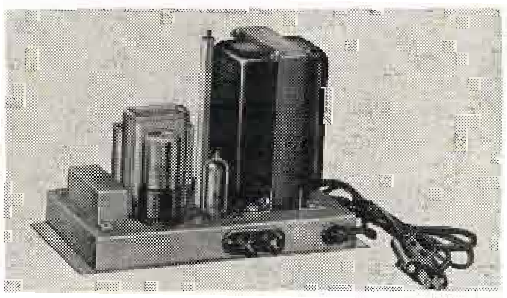
lenberger & Poensgen, Altdorf, Nurenberg (U.S. zone of Germany), it can prevent damage caused by failures in plate circuits when connected in the transformer primary. Separate auxiliary fuses in different circuits (plate and filament) are not required. Starting currents are handled without tripping. If the rated current of the device is properly selected, the risk of damage to the transformer due to short circuit or overload is eliminated. Rated voltages are up to 24 v. dc and 250 v. ac. Rated current is 0.15 to 2.0 amps. Opening time in case of short circuit in the plate circuit is 0.25 sec.—**Radio Quality Supply Service, 3547 N. Wilton Ave., Chicago 13, Ill.**—TELE-TECH

Terminal Boards

A new line of terminal boards, designed by the Bureau of Ships of the USN, are made with 4, 12, 16, and 20 studs. The studs are made of special copper alloy having a high tensile strength and are securely molded into the plastic body. Slotted brass nuts made to navy specifications are supplied with the boards and come packed separately, unless otherwise ordered. Also supplied, when desired, are stud connectors for joining two opposite studs electrically. With the stud removed, the terminal board has twice the number of connection points indicated and is suitable for varied applications provided specified wire terminal is used.—**Kulka Electric Mfg. Co., Inc., 633 South Fulton Ave., Mount Vernon, N. Y.**—TELE-TECH.

Power Supply

A new constant current supply provides a 10 ma output at 1.4 v. dc with a high degree of stability to well within the limitation of



± 1/10 of 1%. Units for other voltages and currents can be supplied on special order. Operating from a 115 v., 60 cps supply, this unit (model 50220) consists of a regulated input transformer, a 6x4 rectifier, a 5651 voltage reference, and a 6SN7 control tube. The special compensated feedback circuit allows a flat current characteristic over a wide input voltage range (80-140 v.).— **Weston Electrical Instrument Corp., 617 Frelinghuysen Ave., Newark 5, N. J.**—TELE-TECH.

Microphone

Ideal response for maximum clarity of speech, 100 to 4500 cps range, is claimed for the model 11M5 single button carbon microphone. Designed for convenient hand use, the 11M5 has a double-pole, single-throw switch, with relay and microphone circuits normally open (press-to-talk). It is adaptable easily to a wide variety of circuits and is recommended for a similarly broad variety of mobile transmitter applications and other hand mike uses. It will work into power output tubes without preamplifier stages, with use of step-up transformer. The carbon element is moisture- and fungus-proofed, to meet exacting military specifications. The switch control button is positioned for ease of thumb operation. A hang-up bracket, for holding the mike on wall, panel or dash, is standard equipment and has anti-rattle prongs which slip on or off a button on the back of the mike. Also standard is the four-conductor, self-coiling cable with oil-resistant Neoprene rubber cover. It has a retracted length of 12 in., extended length of 5 ft. The conductors are color-coded, free ends stripped and tinned. A coiled spring cable protector is mounted at the microphone. The housing is die-cast, finished in grey Hammerlin.—**Astatic Corp., Conneaut, Ohio.**—TELE-TECH.

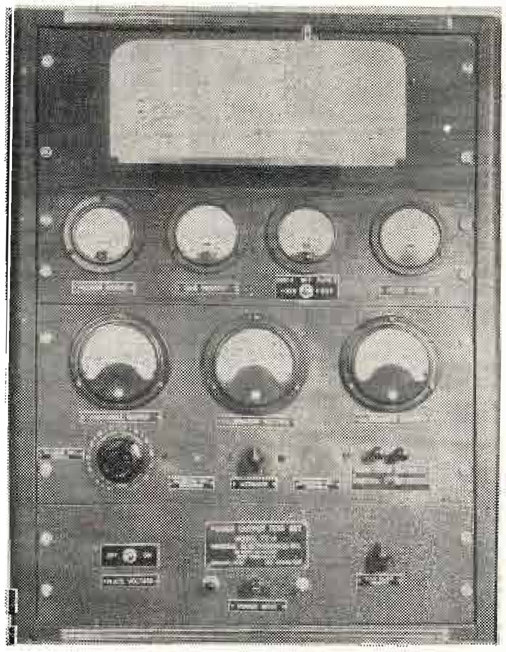
Servo Stabilizer

The Kay-Lab Twin-T Servo Stabilizer is a plug-in amplifier incorporating a stable and accurately balanced twin-T filter. It is not

critical to source impedance, load impedance or supply voltage. With the damping control set at zero, the only effect on a servo system is the introduction of a fixed insertion loss of 43 db. The model 104A Kay-Lab preamplifier (plug-in) may be used to offset this loss. Any desired amount of derivative voltage may be introduced by means of the potentiometer to give the proper amount of damping to suppress hunting. Center frequency tolerance is 0.3%, minimum is 50 db. —**Kalbfell Laboratories, Inc., P.O. Box 1578, San Diego 10, Calif.**—TELE-TECH.

Power Output Test Set

Designed to measure the useful r-f power output of any vacuum tube oscillator, model TS-4 test set has a self-contained calibration



circuit and an interchangeable oscillator panel. There is provision for use of an external r-f bridge and the oscillator may be mounted in front of the panel or completely enclosed in the cabinet. Variable filament and regulated plate supplies are included.—**General Electrosonics, Inc., 32 W. 22nd St., New York 10, N. Y.**—TELE-TECH.

Ex-President Hoover addressing the Waldorf dinner to Dr. Lee deForest, April 8

Industry Honors Dr. deForest

Unparalleled Turnout of Radio-TV Leaders and Notables Marks 45th Anniversary of Audion

Filling the Waldorf's great Starlight ballroom to overflowing, a huge audience of radio executives and engineers on April 8 heard ex-President Herbert Hoover and ex-Governor Charles Edison of New Jersey (son of Thomas A. Edison) pay eloquent tribute to Dr. Lee deForest, on the 50th anniversary of his entry into wireless and the 45th anniversary of his invention of the three-element electron tube, the audion, which underlies all present radio, TV, sound pictures, long-distance communications, and electronics.

Admiral Ellery W. Stone, president of American Cable & Radio, served as toastmaster, and Charles A. Rice, vice-president of United Electronics Co., headed the committee on arrangements. Seated at the long speakers' table, here shown with ex-President Hoover at the center rostrum, were the following, from left to right:

Earl I. Sponable, Past President, Society of Motion Picture and Television Engineers; John R. Binns, President, Hazeltine Corporation; Harold E. Fellows, President, National Association of Radio and Television Broadcasters; Dr. Alfred N. Goldsmith, Editor, Institute of Radio Engineers; Dr. Allen B. DuMont, President, Allen B. DuMont Laboratories, Inc.; Dr. Haraden Pratt, Telecommunications Advisor to the President of the United States; Walter P. Marshall, President, The Western Union Telegraph Company; Thomas Watson, Sr.; Chairman, International Business Machines Corporation; Dr. Mervin J. Kelly, President, Bell Telephone Laboratories, Inc.; Brigadier General David Sarnoff, Chairman, Radio Corporation of America; Hon. Charles Edison, Former Governor of New Jersey; Dr. Lee de Forest.

Rear Admiral Ellery W. Stone, Toastmaster, President, American Cable & Radio Corporation; Hon. Herbert Hoover, Former President of the United States; Irving S. Olds, Chairman of the Board, United States Steel Corporation; Admiral W. F. Halsey, Vice-President, International Telephone and Telegraph Corporation; Rear Admiral John R. Redman, USN, Director, Communications-Electronics, Joint Chiefs of Staff; Dr. W. R. G. Baker, Vice President, General Electric Company; George H. Bucher, Director, Westinghouse Electric Corporation; Max F. Balcom, Chairman, Sylvania Electric Products Inc.; Robert C. Sprague, Chairman, Radio-Television Manufacturers Association; Elmo N. Pickerill, President, The De Forest Pioneers; C. S. Purnell, Vice President, American Institute of Electrical Engineers; William Dubilier, Vice President, Cornell-Dubilier Electric Corporation; George Bailey, President, The American Radio Relay League.

Unveiling the bronze bust of Dr. deForest, which was presented to Yale, from which the inventor was graduated in 1896. From left to right, Toastmaster Ellery W. Stone; Catherine Allaben, granddaughter of Dr. deForest; Dr. deForest; and Ex-Governor Charles Edison of New Jersey, son of Thomas A. Edison

Coming Events

May 4-8—Electrochemical Society, 50th Anniversary Meeting, Benjamin Franklin Hotel, Philadelphia, Pa.

May 5-16—British Industries Fair, Earls Court and Olympia, London, England.

May 5-7—IRE-AIEE-RTMA Symposium on Progress in Quality Electronic Components, Dept. of Interior Auditorium, Washington, D. C.

May 8-10—ASA, Semi-Annual Meeting, Hotel Statler, New York City.

May 10—New England Radio Engineering Meeting, Sponsored by the North Atlantic Region of the IRE, Copley (Sheraton) Plaza, Boston, Mass.

May 12-14—IRE National Conference on Airborne Electronics, Dayton-Biltmore Hotel, Dayton, Ohio.

May 16-17 Southwestern IRE Conference and Radio Engineering Show, Rice Hotel, Houston, Tex.

May 19-22—1952 Radio Parts and Electronic Equipment Show, Conrad Hilton Hotel, Chicago, Ill.

May 22-23—Symposium on Electronics and Machines, Sponsored by the Professional Group on Industrial Electronics of the IRE, Palmer House, Chicago, Ill.

May 23-24—Audio Fair in Chicago, Conrad Hilton Hotel, Chicago, Ill.

June 23-27—AIEE Summer Meeting, Hotel Nicolet, Minneapolis, Minn.

August 19-22—1952 APCO Conference, Hotel Whitcomb, San Francisco, Calif.

August 27-29—Western Electronic Show & Convention, WCEMA and IRE, Long Beach, Calif.

September 8-12—ISA, 7th National Instrument Conference and Exhibition, Cleveland Auditorium, Cleveland, Ohio.

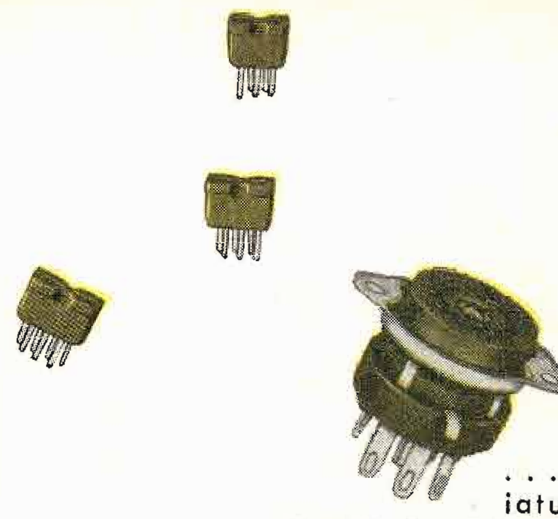
September 22-25—NEDA, 3rd National Convention, Ambassador Hotel, Atlantic City, N. J.

September 29-October 1—Eighth National Electronics Conference and Exhibition, Sherman Hotel, Chicago, Ill.

October 21-23—1952 RTMA-IRE Fall Meeting, Syracuse, N. Y.

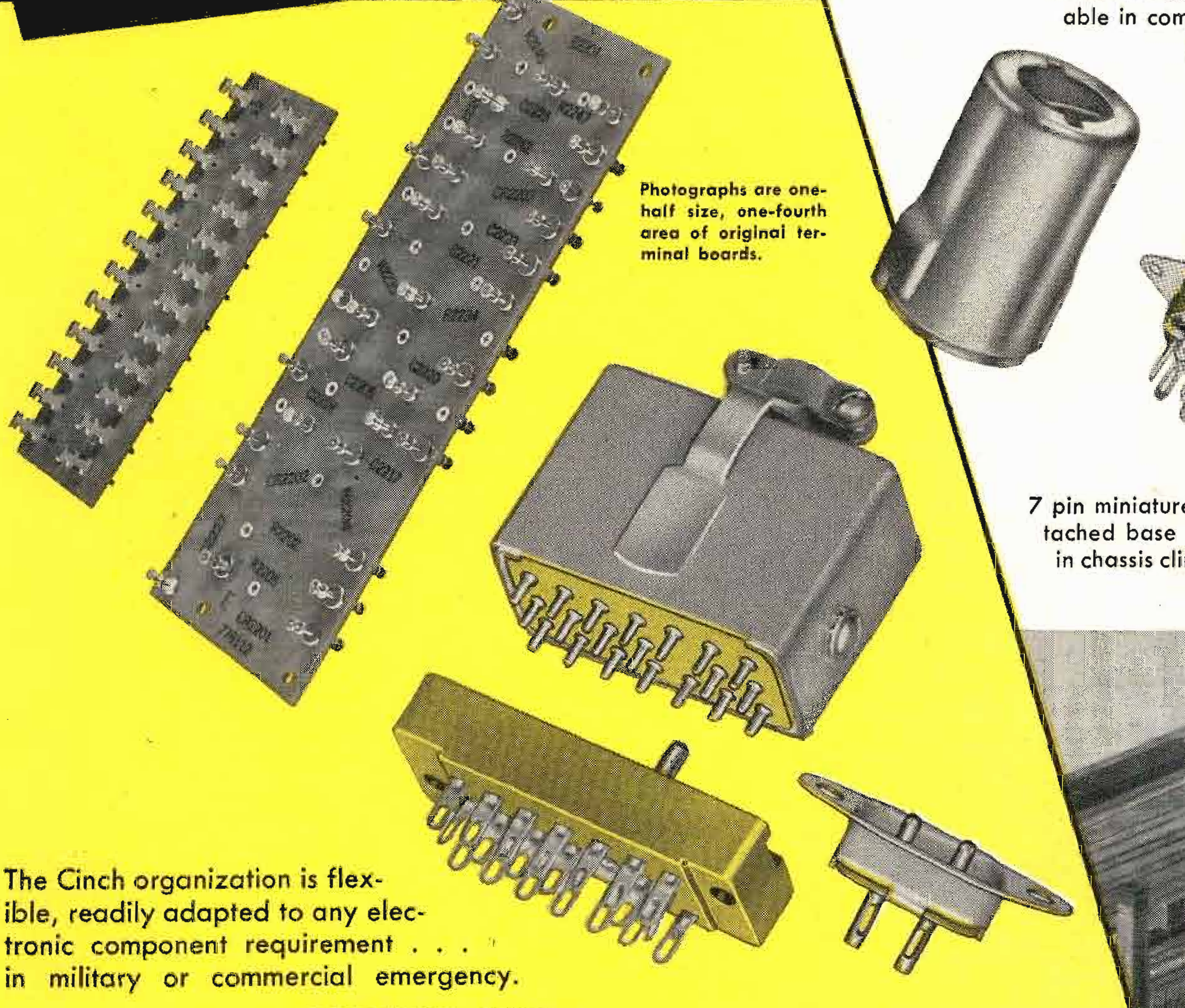
AIEE: Amer. Institute of Elec. Engineers.
APCO: Associated Police Communication Officers.
ASA: Acoustical Society of America
IRE: Institute of Radio Engineers
ISA: Instrument Society of America
NARTB: Nat'l. Assoc. of Radio & Television Broadcasters.
NEDA: Nat'l. Electronic Distr. Assoc.
NEMA: Nat'l. Electrical Mfrs. Assoc.
RTMA: Radio-Television Mfrs. Assn.
WCEMA: West Coast Electronic Mfrs. Assn.

Cinch
ELECTRONIC COMPONENTS



. . . 7 pin miniature Cinch-Erie *Plexicon* tube socket, available in commercial and military types; also in Octal, Loktal and Noval.

Noval, and 7 pin miniature, molded socket attached base type, also available in chassis clinch and saddle type.



Photographs are one-half size, one-fourth area of original terminal boards.

The Cinch organization is flexible, readily adapted to any electronic component requirement . . . in military or commercial emergency.

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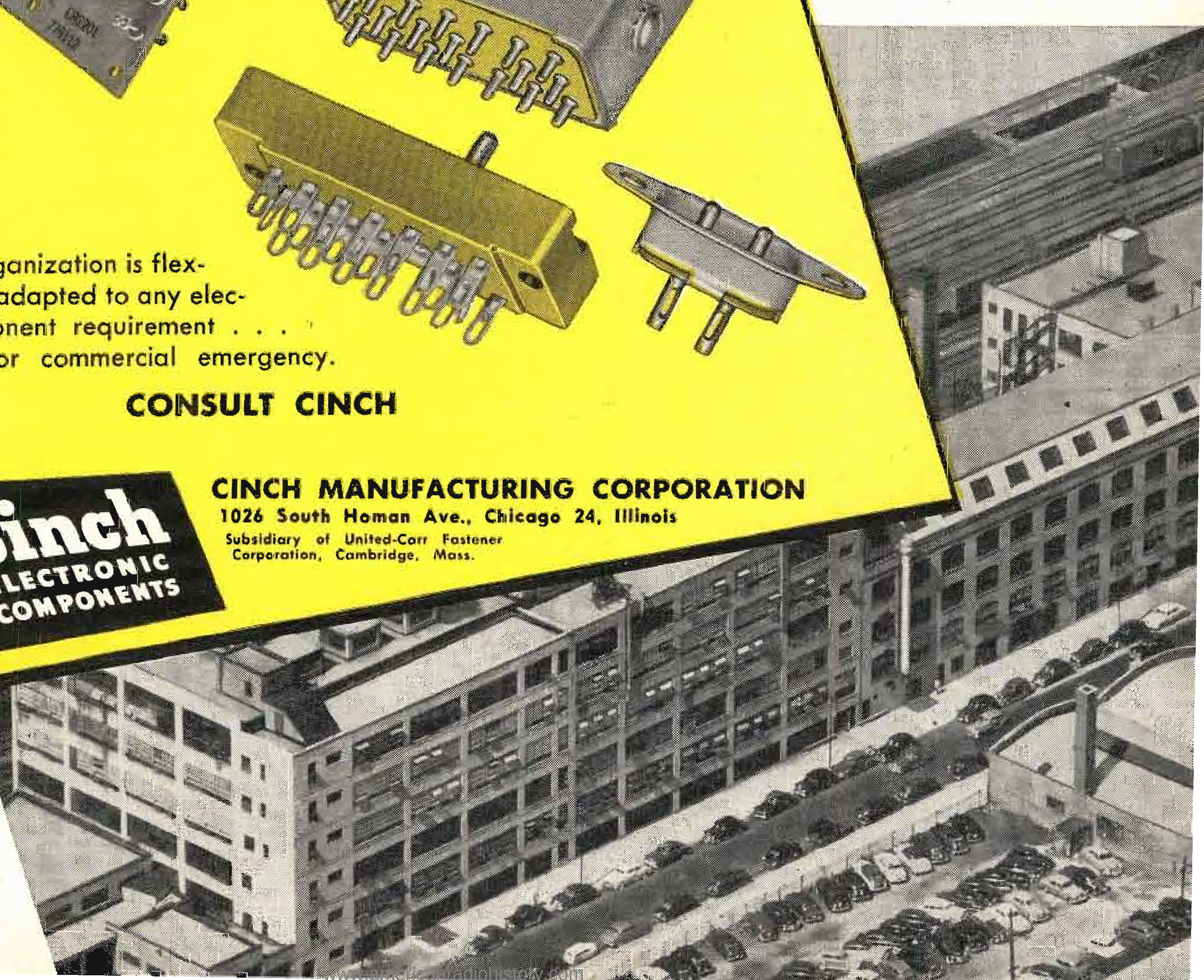


Cinch components available at leading electronic jobbers — everywhere.

WASHINGTON
News Letter

Latest Radio and Communications News Developments Summarized by TELE-TECH's Washington Bureau

TOO LONG DELAY—The television freeze has at long last been lifted. But the FCC can not claim much credit for this action, because the more than three and a half years' delay in its thaw has set back the progress of television—universally admitted to be the most important medium of communication to the public in the world—most substantially in the United States. Spearheaded by its former Chairman Wayne Coy, the FCC had continued the freeze for these long years, because of its protracted controversial inquiry into color television. That was the major cause for the delay in the freeze thawing.

COMPLAINT FLOOD—The public in the areas without TV service, or with only one or two video stations, particularly through their Senators and Congressmen, have virtually inundated the FCC with complaints and censure about the long-delayed freeze lifting. There will be more to come, as the television-hungry populations of cities and larger towns without any or adequate TV service realize there will be only a handful—a score or so—of new television stations authorized during the remainder of this year. In dollars and cents, the delay has been, and is, most costly to the manufacturing industry. With production of TV and broadcasting sets and equipment now at about 50% of last year, the industry has been able to maintain itself on an even keel only through its procurement contracts from the military services.

SLOW ACTION NECESSARY—FCC Chairman Paul A. Walker who has made the TV task practically a daily assignment for consideration by the Commission since he took the FCC helm warned that television "will not gallop into its new frontier" but will proceed "at a snail's pace" with the lifting of the freeze. Hearings will be necessary for a great many of the thousand or more new station applications, Chairman Walker has cited, and with the inadequate funds and staff of the FCC confronted with the biggest workload in its history the proceedings will be lengthy and the authorizations will necessarily have to come slowly. But the FCC Chairman promised that the Commission and its staff would do everything possible to establish a firm and stable foundation for television.

BRIGHTER OUTLOOK—With the authoritative forecast by National Production Authority Administrator Henry H. Fowler before the National Association of Radio and Television Broadcasters at their Chicago convention that the nation is well on the road toward overcoming the scarcities of metals like steel, copper, aluminum and other materials needed by the radio-television manufacturing industry, the raw materials problem after the FCC "green light" on new television stations with the increased demand for receivers is certain to be materially alleviated in 1953. In fact, barring a drastic change in the present materials situation, the Defense Production Administration and the NPA in their recent actions and in their third quarter allocations to the radio-television industry have indicated that all radio-TV station construction will be authorized some time after July 1 with assurance of materials by fall to complete any projects sought by broadcasters. By next year, if the present materials outlook at our press deadline continues, the Controlled Materials Plan will be largely eliminated except for some controls on materials such as copper and nickel.

AIR SAFETY PROGRESS—Much work lies ahead before a completely finished air navigation and radar control system is actually in existence, Civil Aeronautics Administrator Charles F. Horne stressed recently before the Radio Technical Commission for Aeronautics. Today's "very limited radar setup," the CAA chieftain pointed out, is "the forerunner of a more systematic network of tomorrow." Much has been done to improve the air navigation facilities in the airports, it was stressed to the RTCA. The development of air traffic control in the United States has already gone far enough to insure that, from almost any position in the air in the U. S., a plane reasonably equipped with communications and electronics apparatus should have little difficulty in maintaining continuous communications and navigation control with ground stations which should aid materially in the safety of flight.

ANTENNA TOWERS— Aviation industry and government agencies in that field have been critical of the heights of TV antenna towers even though the CAA rules require that airplanes fly not less than 1000 feet above the towers. All broadcast antenna towers above 500 feet have to be approved by the regional airspace committee of the city or town in which the broadcast or TV station is located. Broadcasters and telecasters in general feel that the fears about antenna towers as hazardous to flying are largely groundless.

National Press Building
Washington, D. C.

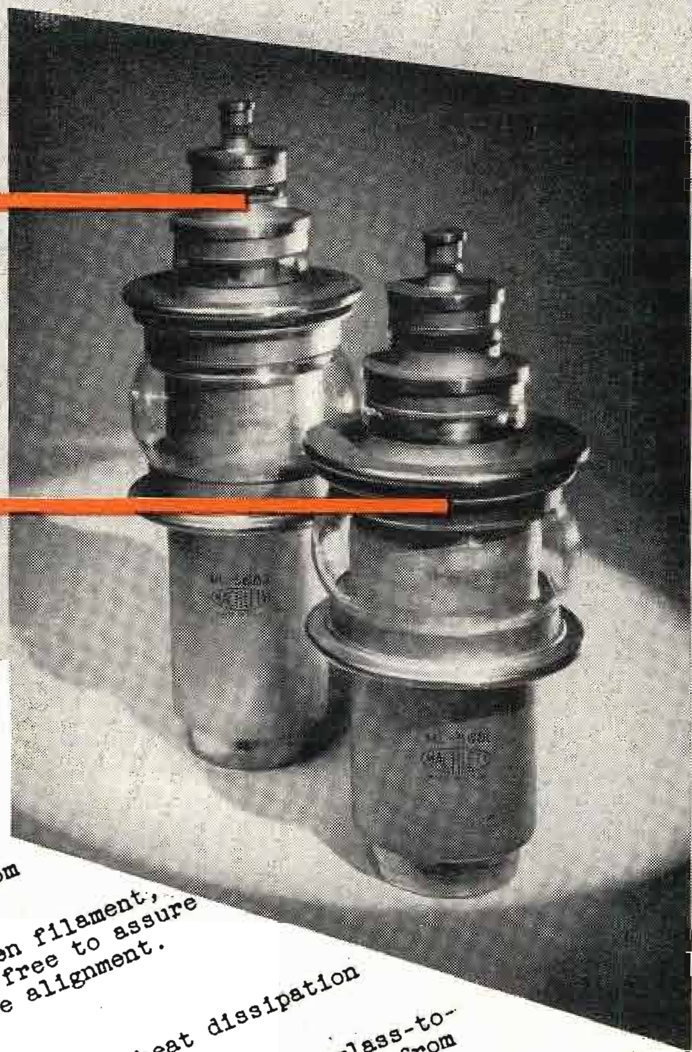
ROLAND C. DAVIES
Washington Editor

ML-5682

16 kV, 300 kW INPUT TO 30 Mc
9 kV, 170 kW INPUT TO 88 Mc

ML-5681

15 kV, 150 kW INPUT TO 30 Mc
9 kV, 100 kW INPUT TO 110 Mc



All ring-seal water and forced-air cooled triodes.

Sturdy electrodes mounted directly from heavy copper cylinders.

Uniquely supported thoriated-tungsten filament, completely balanced and stress-free to assure maintenance of original precise alignment.

Heavy-wall copper anode.

Emission-suppressed grid capable of high heat dissipation and maximum stability.

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May be installed by a single attendant; tube replacement possible in less than five minutes.

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4th Southwestern IRE Conference

Reflecting the rapid rise of the Gulf Coast area of Texas as an important trade and manufacturing center, the 4th Southwestern IRE Conference and Radio Engineering Show will be held at the Rice Hotel in Houston on May 16-17, 1952. Some 50 exhibitors will display their wares, including an appreciable number of manufacturers who have never before directly exhibited in this regional Conference. In addition to a keynote address by Dr. Donald B. Sinclair, President of the Institute of Radio Engineers, the meeting will feature technical sessions covering instruments and geo-physics, communication and navigation, components, broadcast and TV, and microwaves. Following is a list of the technical papers program.

FRIDAY, MAY 16, 1952

Keynote address—Dr. Donald B. Sinclair
Student Papers

Session A—Instruments & Geophysics

"A Continuously Recording Dielectric Meter"—**J. Feagin,** Humble Oil & Refining Corp.

"An Instrument for measuring Specific Gravity by Radioactive Methods"—(Speaker to be announced) Instruments, Inc.

"D C Amplifier Developments"—(Speaker to be announced) Leeds & Northrup Corp.

"Nuclear Instruments in the Petroleum Industry" **M. C. Burns,** Berkeley Scientific Corp.

"An Electric Fourier Analyzer"—**F. J. McDonal,** Magnolia Petroleum Corp.

(Title to be announced), **G. Herzog,** The Texas Co.

Session B—Communication & Navigation

"An Integrated Flight System"—**E. Hamilton,** Collins Radio

"Mobile Radio Problems Brought About by New Techniques"—**E. White,** FCC

"Mobile Communications"—**G. O. Griffith,** RCA

"Monitoring as a Public Service"—**W. R. Foley,** FCC

"An Audio Circuit with Splatter Suppression"—**J. Reinartz,** Eitel-McCullough, Inc.

SATURDAY, MAY 17, 1952

Session A—Components

"Transistors"—**J. Campbell, Jr.,** Bell Telephone Labs.

"Transistors"—**J. S. Saby,** GE

"Magnets"—**J. Ireland,** Thomas & Skinner Steel Co.

"High Temperature and Metallized Paper Condensers"—**O'Donnell,** Tobe-Deutschmann, Inc.

(Audio Papers to be Announced)

Session B—Broadcast & TV

(Speaker and title to be announced)—General Precision Lab.

"Tall Towers for TV"—**A. E. Cullem,** Consulting Engineer

"Mechanical and Electrical Design Considerations in Speech Input Systems of the Highest Fidelity"—**N. L. Jochem,** Gates Radio Co.

A symposium in Microwave Communication—Col. S. Wolff, Federal Telephone & Radio Corp.

"The Microwave Relay Communications System General Technical Philosophy and Specific Engineering Solution"—**H. Magnuski, Motorola, Inc.**

"The Philosophy of Design and Operational Experience"—**R. S. Dahlberg,** Philco Corp.

"A Combined Microwave Communications and Control System for a Large Public Utility"—**D. B. McKey and B. F. Wheeler,** RCA Victor **E. W. Kenesafe,** GE 8:00 P.M.—**Banquet** "TV Spectrum Allocations"—**Comm. T. A. M. Craven.**


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Don Fink to Philco as Co-Director of Research

In furtherance of Philco's expanding activities in electronic research and development, Donald G. Fink will resign as editor of "Electronics" to join Philco Corporation on June 1st as Co-Director of Research—Operations, it was announced by William Balderston, president.

"The scope of Philco activities in radar, television and industrial electronics is constantly increasing," Mr. Balderston said, "and the appointment of Mr. Fink will further strengthen our research organization headed by Leslie J. Woods, Vice President—Research and Engineering, David B. Smith, Vice President—Research, and William E. Bradley, Co-Director of Research. Philco today has one of the largest research and engineering organizations in our industry, and with the assignments we have accepted from the Armed Forces as well as the plans we have for expansion in civilian fields, the addition of Mr. Fink will add greatly to our research department."

DuMont Program for UHF Broadcasters

DuMont has announced a three-point program to get UHF broadcasters on the air as rapidly as possible when FCC authorizations are issued. Combining the action of the Transmitter Div., Receiver Div., and TV Network, the program calls for prompt filing of applications for uncontested UHF channels, ordering studio and transmitting equipment, and negotiating early for a network affiliation or program service. Concurrently, potential audience interest will be built up by making UHF converters and UHF-VHF receivers available, and by instituting an aggressive promotional campaign through public displays and advertising.

ABC Opens New AM Centers

The American Broadcasting Co. has recently expanded its AM studio facilities by opening three radio centers in New York, Chicago and Los Angeles at a total cost of $3,000,000. The new plants will centralize operations in three of ABC's five outlets, WJZ, WENR and KECA. New York's $1,250,000 installation at 39 W. 66 St. includes 11 studios with spacious control rooms. Four of these studios are two stories high and have been designed to accommodate TV equipment with a minimum of renovation should it be desired to utilize these studios for telecasting.

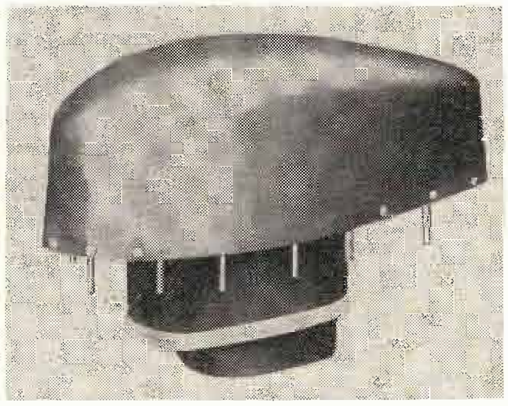
In Los Angeles, the center at 1539 N. Vine St. has 12 studio and announcers' booths, including three audience studios which can seat an average of 321 persons. The six modern studios at 400 W. Madison St., Chicago, cost approximately $500,000, and will be used in addition to the large ABC Civic Theatre.

Aircraft Antennas

(*Continued from page* 61)

100-1750 KC range. The hermetically sealed loop antenna comprises an iron core loop, center tapped and electrostatically shielded, a drive motor, and an autosyn transmitter.

ADF sense antennas, used in conjunction with the automatic loop antennas, consist of two non-directional



Bendix type MN-60A loop antenna for ADF aural and visual range and bearing operates in 100 to 1750 KC range. Dimensions are 5.5 x 10.64 x 16.84 in. Conductive paint dissipates static

"L" type wire antennas installed on the underside of the aircraft, in the vicinity of the wing center section.

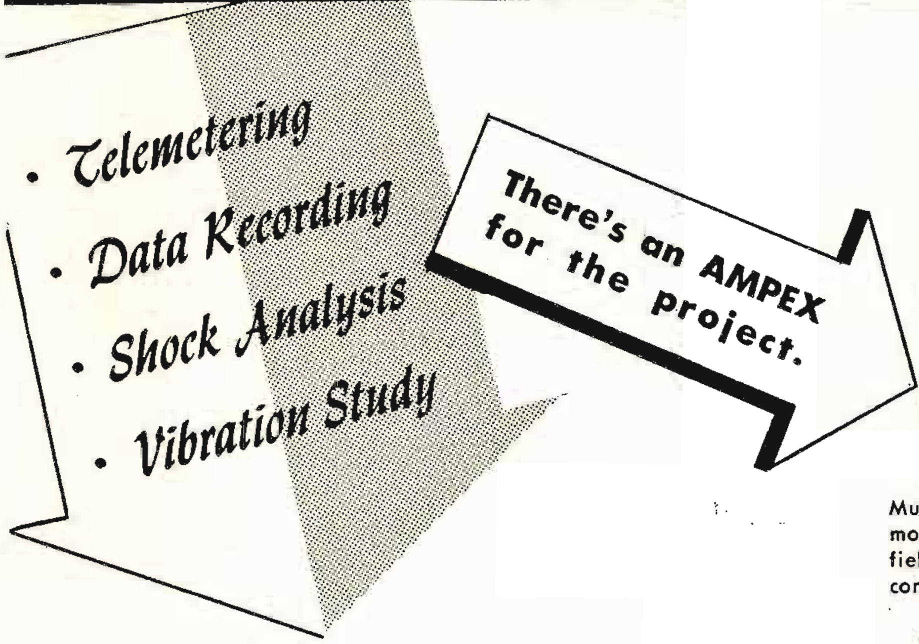
To identify passage over airways, 75 MC marker signals are received aurally and visually by a Glenn L. Martin cavity type MBA-1 *marker beacon antenna.* Unit comprises a

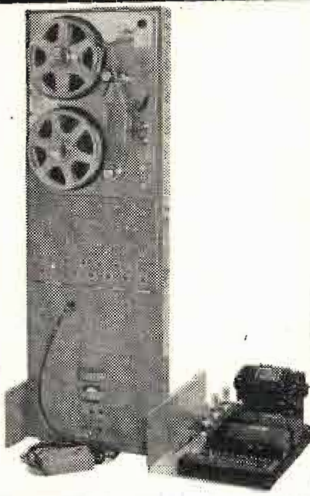
Bendix MN-76A iron core loop antenna for ADF with housing removed. Total weight is 47 lbs.

shunt fed bent channel receiving element, top loaded by a variable capacitor. One end of the element is grounded to the case of the cavity.

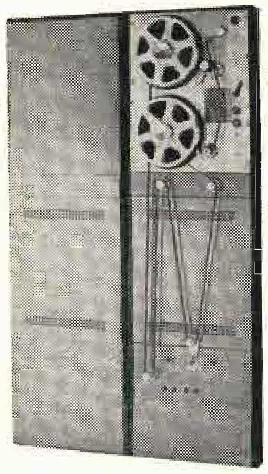
A *terrain warning indicator antenna,* a Hughes modified off-center fed dipole type HA-3C, is installed on the bottom centerline of TWA aircraft for transmitting and receiving 423 MC signals. Aural and visual indication of proximity to terrain enables the pilot to maintain a safe preset altitude.

Telemetering • Data Recording with AMPEX and Magnetic Tape!

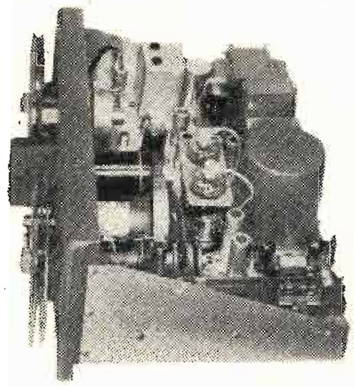




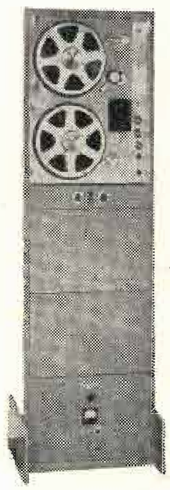
Multi-channel recorder for seismograph data recording in the field with remote control. Custom construction by AMPEX.



Multi-channel continuous loop reproducer. Custom construction by AMPEX.

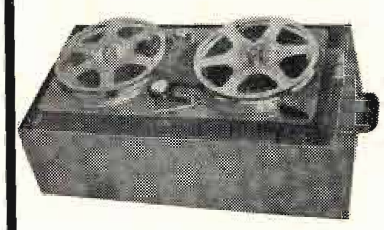


Model S3079 Air-borne recorder; a miniaturized Model 307.



Low frequency data recorder. Custom construction by AMPEX.

Model 500 high stability multi-track recorder and playback.



Mobile multi-channel shock and vibration data recorder. Custom construction by AMPEX.

MODEL S3084—Standardized By AFMTC—is a special dual-track recording system. One track records pulse width modulation data and preserves an accuracy of ± 2 microseconds on pulses that vary from 100 to 1000 microseconds in width. The second track records all RDB-approved telemetering sub-carrier channels and duplicates the specifications for the Model 307.

MODEL 306 is designed to record low frequency data within the spectrum of 0 to 5,000 cycles.

MODEL 307 is specially designed to record and reproduce all frequencies from 100 cycles to 100,000 cycles.

MODEL 375 is a 60 watt Capstan Motor-Power Amplifier driven by a precision, 60 cycle compensated tuning fork.

MODEL S3079 Air-borne recorder operates from 24 volt dc or 400 cycle aircraft supply; self-contained tuning fork frequency stabilizer; 2 speeds: 60″ and 30″; same specs as for Model 307, except record only; can be modified for multi-track recording.

MODEL 500 Low Flutter and Wow of less than .1% peak to peak over the spectrum of 0 to 10,000 cycles is achieved by an exclusive-with-Ampex drive system. Complete specs and data describing this and all other special AMPEX equipment are available on request.

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My name is: ....

My business affiliation: ....

My position there: ....

Mail address: ....

City & State: ....

Ferrite Materials

(Continued from page 52)

(3) The corners of the hysteresis curve should be sharp.

(4) The coercive force should be low.

(5) Saturation flux density should be high.

Magnetic materials having these properties have found particular applications in computer and magnetic memory systems.

In general, the function of square loop cores in such a system operates as follows: The core material is magnetized and then excitation removed so that the magnetic state of the core is at retentivity (B_r) or at remanance. If a current pulse of short duration and suitable polarity is then applied which is large enough to drive the material in the opposite direction, a voltage output

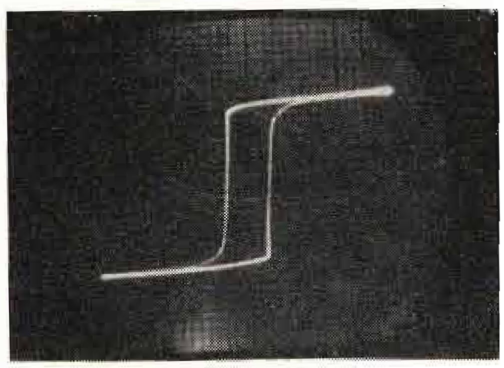

Fig. 11: Developmental ferrite (MF-1147) 60 CPS square hysteresis loop. Static properties: $B_s = 1500$; $B_r/B_s = 0.87$; $H_c = 1.51$; $\mu_{max} = 700$; $\mu_o = 1200$

on a separate winding can be taken off due to the change of flux in the core. By arranging a set of these magnetic cores in some kind of array, basic mathematical operations can be performed. Certain magnetic metals can be used if very thinly laminated, but the eddy current losses and shielding effects make the response time of these materials relatively slow. On the other hand, the square loop ferrites with their high resistivities have shortened the response time of magnetic memory systems by a ratio of about 40 to 1, thus allowing the systems to be operated at much higher speeds.

The square loop ferrite which has been evaluated with respect to response time is called MF-666. It has a switching time of about 0.5 μ sec, and is similar in magnetic properties to MF-805 which is shown in Fig. 10, The three ferrites on this figure and the one on the preceding figure (MF-1118) have not been evaluated for response time. They represent four of the most promising compositions made in the laboratory and are

not to be considered as the end of this developmental effort. Further work is being done to improve these types of ferrites in all respects.

Although it has been shown that each Ferramic material lends itself more efficiently to certain types of applications, it is not logical categorically to place these applications alone as limits for each grade of ferrite. From the vantage point of the investigation of hundreds of possible and new applications, it has been proven in many cases that hitherto

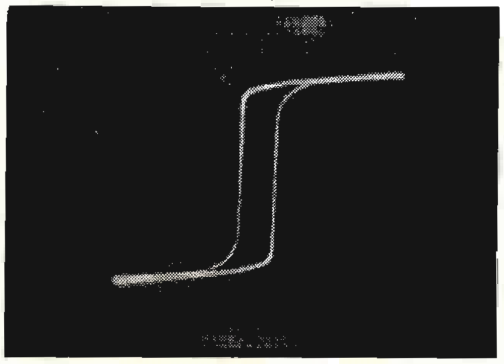

Fig. 12: Developmental ferrite (MF-1128) 60 CPS square hysteresis loop. Static properties: $B_s = 3000$; $B_r/B_s = 0.82$; $H_c = 1.21$; μ_{max} 1200; $\mu_o = 185$

unknown or uninvestigated properties of these ferrites open unexplored fields for the various Ferramics or new ferrite materials as they are developed.

Polarization Switch

(*Continued from page* 60)

Referring to Fig. 11, we have the feed section, phasing section and radiating section. The phasing section is oriented 45° with respect to the feed section and the radiating section is oriented 45° with respect to the phasing section.

The output of the feed section shown in (1) is given in Eq. (1).

At the input (2) of the phasing section, this reference vector is resolved into two orthogonal components, "a" and "b," normal to the waveguide walls, and are represented by Eq. (2).

At the output (3) of the phasing section, a relative phase, ϕ, exists between component "b" and component "a." These components are now designated as a_1 and b_1, and are expressed by Eq. (3).

At the input (4) of the radiating section, the components a_1 and b_1 are further resolved into orthogonal components a_1', a_1'', b_1', b_1'', normal to the walls of the radiating section. These components are expressed by Eq. (4). This can be simplified to Eq. (4').

At the output (5) of the radiating

(*Continued on page* 86)

THE LAST WORD IN
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Don't miss this book! It contains the very latest tested circuits using crystal diodes.

Here are short cuts and tested circuits of value to radio amateurs, engineers, as well as radio and TV service men.

You'll find detailed directions for building crystal meters and meter accessories.

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Partial List of Contents includes How to Make:

- A Linear Voltmeter for Built-in Instrumentation.
- An Amplifier Protective Relay.
- A Voice (Modulation) Controlled Relay.
- A High-Resistance Crystal Voltmeter.
- A TV Antenna Orientation Meter.
- A Tuned Crystal-Type Signal Tracer.
- A Square-law D.C. Voltmeter
- An FM Dynamic Limiter.
- An Amplitude Modulator.
- An Audio-Frequency Microvolter.
- A Spike Generator.
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section, a relative phase, θ, exists between the components a_1'' and a_1' and also between the components b_1'' and b_1'. These components are now designated as a_2'', a_2', b_2'', and b_2' and are expressed by Eq. (5).

The vectors a_2' and b_2' can be combined into one vector c′, while the vectors a_2'' and b_2'' can be combined into another vector c″. Then the resultant vector, $c = c' - jc''$, gives the simplified expression of Eq. (5′).

In studying Eq. (5′) we observe the following:

A. For $\phi = 0$, $c = \cos \omega t$ for all values of θ. Hence, we have vertical polarization for all lengths of the radiating section.

B. For $\phi = 180°$ $c = j \cos \omega t$ for all values of θ. Hence, we have horizontal polarization for all lengths of the radiating section.

C. For $\phi = 90°$ and $\theta = 0°$, 180°, 360°, etc., we have circular polarization.

Therefore in order to obtain all three polarizations by having a fixed radiating section, its length must be such that the relative phase between emerging TE_{01} and TE_{10} components must be nπ, where n is any integer including zero. Fig. 12 shows experimental data which modifies the theory and substantiates the conclusions.

D. An extremely interesting case occurs when the length of the radiating section is such that the relative phase between the emerging TE_{01} and TE_{10} components is $\frac{n\pi}{2}$. Linear polarization results for all angles of φ. The inclination or orientation of the linearly polarized field is φ/2. Fig. 13 shows polarization patterns for various angles of φ which also verify the theory and substantiate the conclusions.

E. All other combinations of φ and θ give elliptical polarization.

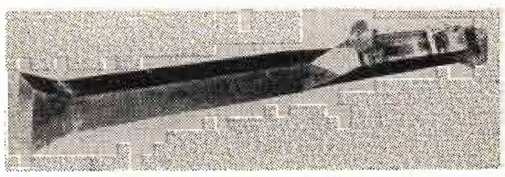
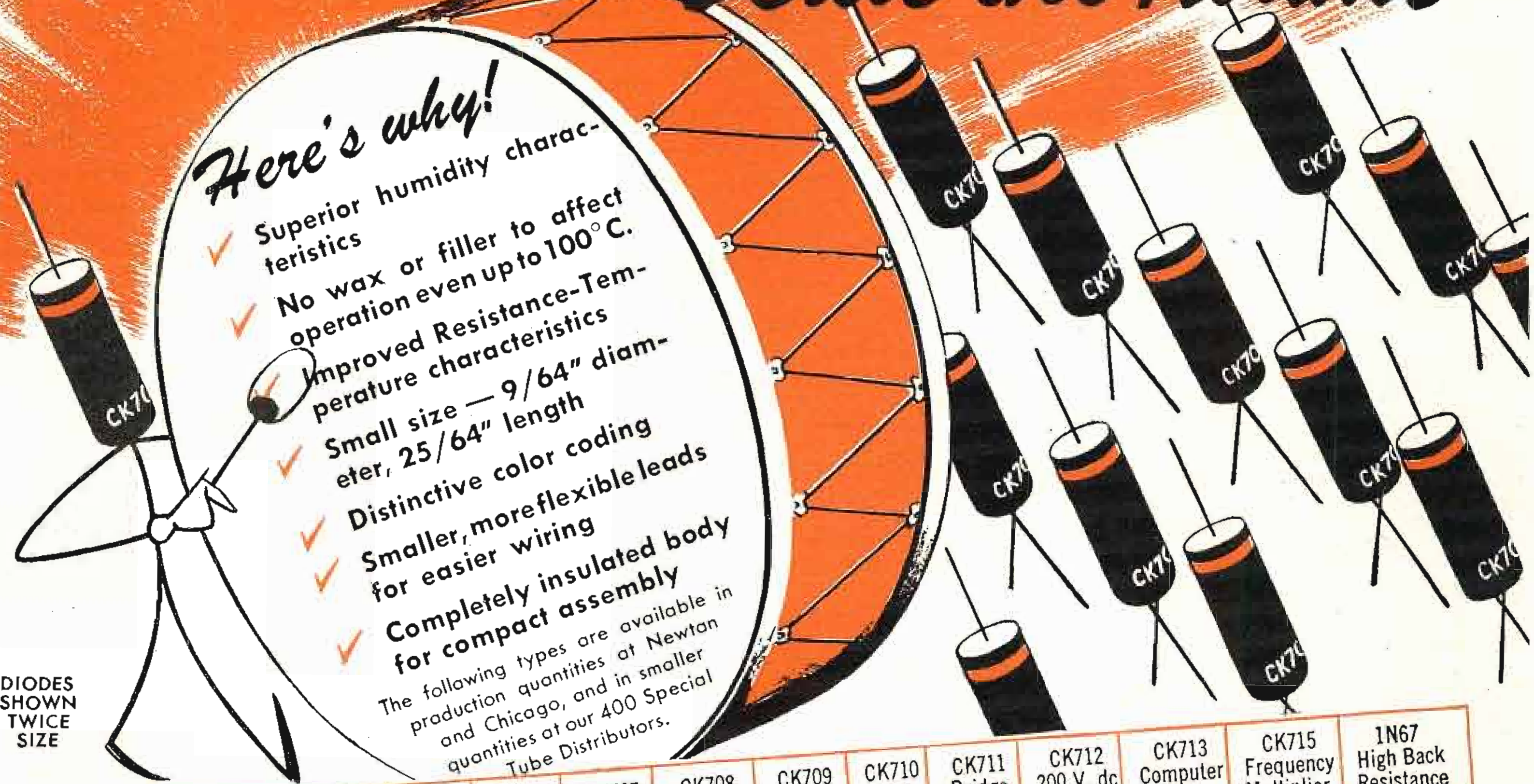


Fig. 14: Polarization switch and universal horn used to obtain data for Figs. 12 and 13

The polarization switch and universal horn used to obtain the data for Figs. 12 and 13 is shown in Fig. 14.

In conclusion, it has been shown that the universal horn described in conjunction with the polarization switch described can radiate energy which runs the gamut of elliptical polarizations.

RAYTHEON "Single Crystal"* GERMANIUM DIODES *Lead the Parade*



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- ✓ Superior humidity characteristics
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- ✓ Improved Resistance-Temperature characteristics
- ✓ Small size — 9/64" diameter, 25/64" length
- ✓ Distinctive color coding
- ✓ Smaller, more flexible leads for easier wiring
- ✓ Completely insulated body for compact assembly

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DIODES SHOWN TWICE SIZE

	CK705 General Purpose	CK706 Video Detector	CK707 50 V. dc Restorer	CK708 100 V. dc Restorer	CK709 Bridge Rectifier	CK710 UHF Mixer	CK711 Bridge Rectifier	CK712 200 V. dc Restorer	CK713 Computer Diode	CK715 Frequency Multiplier	1N67 High Back Resistance
MAXIMUM RATINGS (at 25°C.)					Four matched type CK705 diodes		Four matched type CK707 diodes			Low impedance frequency multiplier for UHF television	
DC Inverse Voltage (volts)	60	40	80	100		5		200	75		80
Average Rectified Current (ma.)	50	35	35	35		50		22.5	50		35
Peak Rectified Current (ma.)	150	125	100	100		150		70	150		100
Surge Current (for 1 sec.) (ma.)	500	300	500	500		500		250	500		500
Ambient Temperature for all types	−50°C to +100°C for all types										
CHARACTERISTICS (at 25°C.)											
Max. Inverse Current at −0.6 volts (ma.)						0.2					
Max. Inverse Current at −5 volts (ma.)			0.008								0.005
Max. Inverse Current at −10 volts (ma.)	0.05										
Max. Inverse Current at −40 volts (ma.)									0.25‡		
Max. Inverse Current at −50 volts (ma.)	0.8		0.10								0.05
Max. Inverse Current at −100 volts (ma.)				0.625							
Max. Inverse Current at −200 volts (ma.)								0.8			
Min. Forward Current at +0.5 volts (ma.)						3.0					
Min. Forward Current at +1 volt (ma.)	5.0		3.5	3.0				2.0			4.0
Min. Forward Current at +2 volts (ma.)									21.0‡		
Min. DC Reverse Voltage for Zero Dynamic Resistance (volts)	70.0	50	100.0	120.0		10.0		225.0	75.0‡		100.0
Shunt Capacitance (uuf), average	1.0		1.0	1.0		1.7		1.0	1.0		1.0
Rectification Efficiency at 54 mc (approx. %)		60									
Oscillator injection current (ma.)						0.75*					

*Conversion loss at 500 mc. and noise factor comparable with 1N21B. ‡at 50° C.

*For several years, Raytheon Germanium Diodes have been made from "Single Crystal" germanium.

Dayton IRE

(*Continued from page 43*)

Transistor

"Some Aspects of Transitor Applications in Airborne Equipment"—O. M. Stuetzer, Wright Air Dev. Center
"Theory of Germanium Diodes and Transistors"—J. P. Jordan, GE
"Transistors in Simple Pulse Circuits"—A. E. Anderson, Bell Tel. Labs., Inc.
"The Transistor as a Computer Component"—J. H. Felker, Bell Tel. Labs., Inc.

2:00-5:00 P. M.—Technical Sessions

Antennas II

"Synthesis of Antenna Patterns"—A. E. Smoll, GE
"The Characteristics of Semi-Conducting Coatings on Antenna Housings"—R. L. Hensell, R. M. Lambert, Naval Air Test Center
"A Method for Measuring Antenna Pattern of Aircraft in Flight"—H. S. Barsky, U. S. Naval Air Dev. Center
"Microwave Gas Discharge in Airborne Radars"—R. L. Mattingly, Bell Tel. Lab., Inc.
"Relations Between the Far Field and the Illumination of Antenna Apertures"—J. S. Kerr, W. L. Murdock, GE

Component & Techniques I

"Mechanical Scanners for Radar Antennas"—G. A. Walters, J. B. Damonte, Dalmo Victor Co.
"Study of the Radar Receiver Gain Characteristics"—N. P. Cedrone, Raytheon Mfg. Co.
"Radome Antenna Systems Dielectric Materials"—H. Pearl, Wright Air Dev. Center
"Coaxial Cables with Liquid Dielectric"—E. J. Luoma, Wright Air Dev. Center
"Basic Building Blocks of Electronic Circuitry"—C. E. Doyle A. C. Speak, G. Tarrants, Wright Air Dev. Center

General Session

"System for the Measurement of Transmission Loss in Radio Propagation at Frequencies between 92 and 1047 MC"—C. R. Chambers, Central Radio Propagation Lab.
"Output Errors in Complex Devices Due to Component Inaccuracies"—R. S. Raven, Westinghouse El. Co.
"A New UHF Television Transmitter Equipment Designed for Airborne Military Service"—W. F. Fell, RCA
"Automatic Calling System"—WOJG, J. M. Mayer, Wright Air Dev. Center
"Application of Statistics to Communication Systems"—H. M. Thaxton, Sylvania El. Prod. Inc.

Magnetic Amplifiers

"A Magnetic Amplifier Frequency and Voltage Regulator for Aircraft Inverters"—C. B. Grady, W. L. Maxson Corp.
"Airborne Applications of Magnetic Amplifiers"—F. S. Malick, Westinghouse El. Corp.
"Application of Magnetic Amplifiers to Airborne Remote Positioning System"—D. B. Kleason, C. Johnson, Minn.-Honeywell Reg. Co.
"Servo Systems with Magnetic Amplifier Motor Control for Airborne Applications"—H. A. Helm, L. W. Stammerjohn, Bell Tel. Labs., Inc.
"Evaluation of Magnetic Core Materials for Electronic Applications"—S. R. Hoh, Wright Air Dev. Center

WEDNESDAY, MAY 14, 1952

9:00-11:00 A.M.—Technical Sessions

SYMPOSIUM OF SIX YEARS OF PROGRESS IN THE COMMON SYSTEM OF AIR NAVIGATION AND TRAFFIC CONTROL

"Operational Practices, Facilities and Philosophy"—S. P. Saint, Air Transport Ass. of America
"Short Distance Navigation, Approach and Landing"—F. Brady, Air Transport Ass. of America
"Voice and Visual Ground to Air Communication, Radar Safety Beacons, Ground Base Aids to Long Distance Navigation"—V. Weihe, Air Transport Ass. of America

Human Engineering

"A Dynamic Aircraft Simulator for Study of Human Frequencies Response Characteristics"—A. M. Pichitino, W. H. Deily, I. Glassman, Franklin Inst.
"The Spectral Destiny Approach to a Perceptual Motor Task"—E. S. Krendel, Franklin Inst.
"Analog Computer Simulation of Aircraft

(*Continued on page 90*)

TUNER-TUBE PROBLEM *Solved* FOR TV DESIGNERS!

- The kit of new General Electric tubes at right is *your* answer, Mr. Designer, to the $64 TV-tuner question on which the success of your set may depend a year from now!
- Usable at all frequencies from 45 mc to 870 mc, these G-E tubes make possible a single, combined tuner circuit that (1) is simple in layout, (2) *saves* components, (3) gives one-dial tuning without the need to switch tubes between low and high bands.
- To a far simpler tuning circuit, add low noise level and freedom from snow. Add the big advantages of less radiation interference, greater selectivity!
- Investigate this up-to-the-minute tube group! Wire or write today for facts on the characteristics and performance of G.E.'s new tuner "4"s! Or if you wish, a G-E tube engineer will be glad to call on you. *Tube Department, Section 15, General Electric Company, Schenectady 5, New York.*

GENERAL ELECTRIC

162-1A3

Pilot Dynamics"—R. Mayne, R. Mead, Goodyear Air. Corp.
"An Analysis of Ground-Air Communication from the Standpoint of Human Engineering"—R. H. Henneman, L. S. Reid, U. of Va.

Vacuum Tubes

"New Ceramic Tubes for the VHF and UHF Frequencies"—R. P. Watson, R. E. Manfred, GE
"Shock and Vibration Considerations in the Design of Industrial Electron Tubes"—H. N. Price, GE
"The Production and Qualification Contractor Aspects of Premium Subminiature Tubes"—R. W. Slinkman, Sylvania El. Prod. Inc.
"A Planar Triode Frequency Multiplier for UHF"—H. R. Holloway, Ol Saulborn, Sylvania Prod. Inc.

2:00-5:00 P.M.—Technical Sessions

Circuits

"I.F. Amplifiers Employing Crystal Lattice Structures"—W. C. Vergara, Bendix Radio Corp.
"A Modulated Error Servo"—R. E. King, RCA
"A 20 CPS Bandwidth, 27-Channel, Airborne Navaglobe Receiver"—M. Dishal, Fed. Telecom. Lab., Inc.
"Subminiaturization of Servo Amplifiers"—A. C. Smith, Minn.-Honeywell Reg. Co.

Components & Techniques

"Unitized Packaging and Miniaturization Through Plastic Embedment"—D. G. Heitert, Emerson El. Mfg. Co.
"Mechanical I. F. Filters"—M. L. Doelz, J. C. Hathaway, Collins Radio Co.
"Coaxial Switches, Their Availability and Performance"—T. C. Noon, Thompson Prod., Inc.
"Microphones for Use in High Ambient Noise"—W. A. Beaverson, Electrovoice, Inc.
"Twin Gyro Rate Tables"—A. E. Hayes, A. Zalon, Minn.-Honeywell Reg. Co.

Microwaves

"Rotary Linear Microwave Phase Shifters"—M. Simpson, A. Sawelson, W. L. Maxson Corp.
"A Modern Airborne Navigational Radar"—F. G. Suffield, RCA
"Practical Notes on the Effect of Radomes on Airborne Microwave Antennas with Emphasis on the Boresight Problem"—M. H. Paiss, U. S. Naval Air Dev. Center
"Radiation from an Open-ended Coaxial Line"—E. O. Hartig, Goodyear Air. Corp.
"A Frequency Stabilized Microwave Signal Source"—R. C. Lee, Boeing Air. Co.

Airborne Lifeboats

(Continued from page 67)

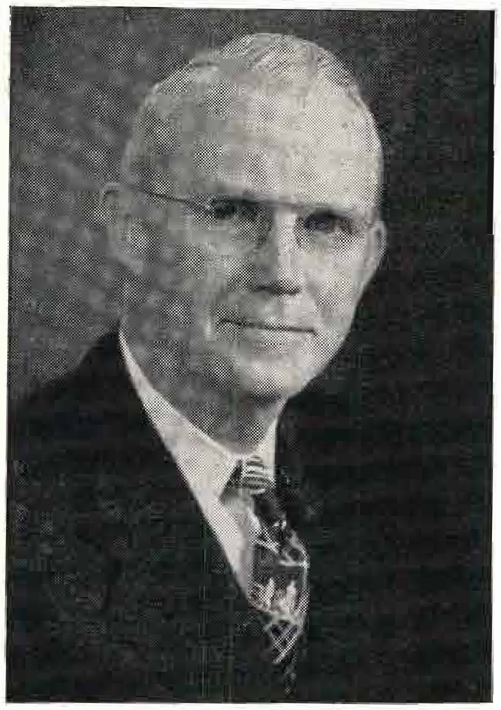
A-4 has been developed by Douglas Aircraft to carry eight survivors for five days. This 19-foot, 1650-pound craft may be remotely radio controlled by a standard AN/ARC-3 transmitter with a five-tone modulator unit manufactured by West Coast Electronics Co. of Los Angeles. The R438/ARW/26AY receiver on the boat, in conjunction with an autopilot steers the boat on a compass-set course.

The modulator circuit consists of a Wein-Bridge oscillator followed by two power amplifier tubes in parallel. A control switch changes RC elements in the oscillator to produce the various audio signals. A thermostatically controlled heater limits the temperature of these frequency determining elements.

The 100-156 MC receiver, manufactured by Setchell-Carlson, Inc., New Brighton, Minn., has been widely

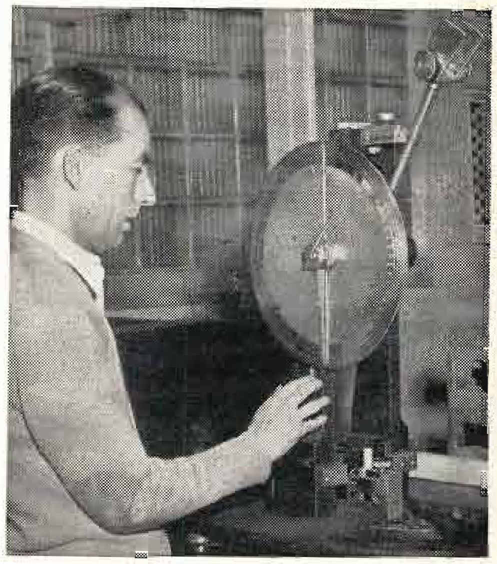
(Continued on page 92)

Men who design, engineer and buy America's products rely on..and use..National Laminated Plastics because..



"One of the most important objectives of National's relationships with its customers is the never-failing, always-continuing program of engineering research and production control. We follow a policy of: The sale only *begins* when a sale is made . . . it only *ends* after the best processing methods have been coupled with rigid testing—to produce the best laminated plastic for the specific application."

F. Irving Crow
Vice President
National Vulcanized Fibre Co.



How much sock?

How much energy does a specimen of laminated plastic absorb in foot pounds per inch of notch? This impact tester is very important in the production control of National laminated plastics—very important in the research for better, stronger materials.

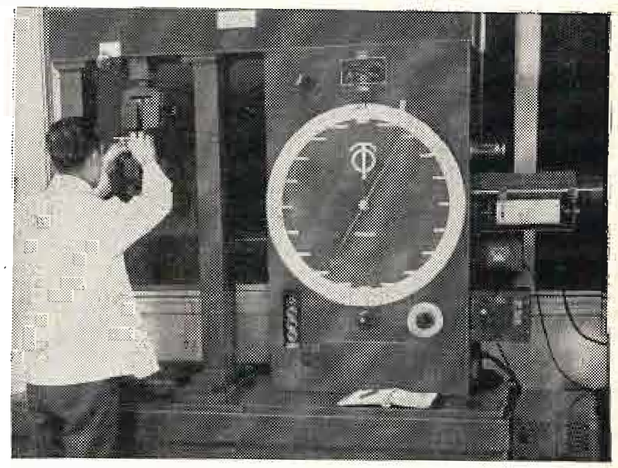
National Laminated Plastics nationally known—nationally accepted

NATIONAL VULCANIZED FIBRE

A tough horn-like material with high dielectric and mechanical strength. Excellent machinability and forming qualities, great resistance to wear and abrasion, long life, lightweight. Sheets, Rods, Tubes, Special Shapes.

PHENOLITE Laminated PLASTIC

Phenolite possesses an unusual combination of properties—a good electrical insulator, great mechanical strength, high resistance to moisture; ready machinability, lightweight. Sheets, Rods, Tubes, Special Shapes.



"Specs" must

There's no equivocation with NEMA, Army, Navy or customer's specifications. "Specs" must be met. That's why National has the finest equipment for testing flexural, bonding, tensile and compressive strengths of all laminated plastics it produces. Such equipment is invaluable in the creation of new, better materials.

National Vulcanized Fibre Company

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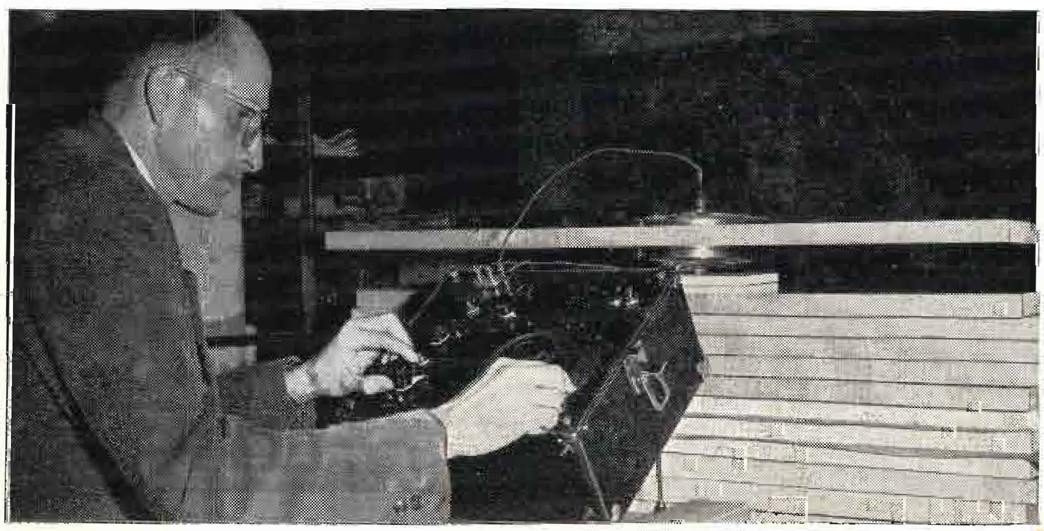
Since 1873



"Lab" in the Plant

Science speeds production—and deliveries—by making tests *right in the plant* of large, heavy Phenolite transformer stock for dissipation factor at 60 cycles. Portable equipment, exactly like the lab's equipment, is used on the spot—typical evidence of National's efficient production control.

used in controlling target drones. Reception of one of the modulated signals causes a relay to close a circuit to ground. Each one of five relays is therefore capable of controlling a particular steering or power operation.

The autopilot used to provide automatic steering is a miniature version of the "Iron Mike" used by fishing boats to relieve helmsmen. The device is produced by Metal

Push button controls enable weakened survivors to operate craft. Single master switch turns control over to aircraft radio operator

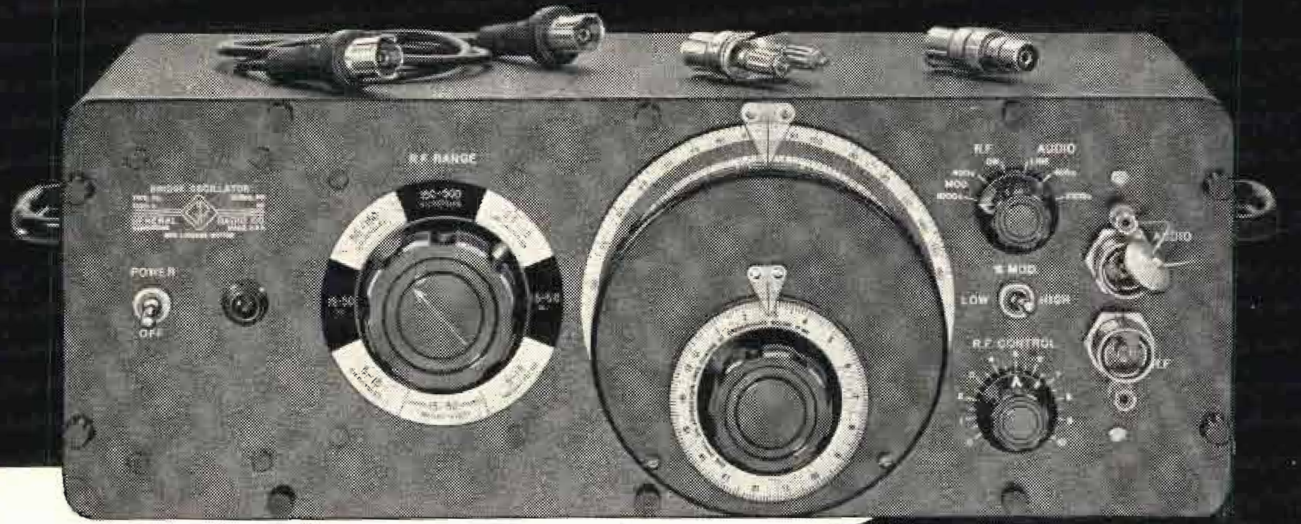
Marine Pilot, Tacoma, Wash. Essentially it consists of a compass sensing element which has its low voltage output amplified to actuate two relays controlling the direction of rotation of a compound wound reversing motor. This electric motor, through a reduction gear train, causes the rudder to move to the left or right. To cause movement of the compass sensing element, the compass bowl is rotated by a chain drive to the steering motor. This causes the steering motor to rotate in an opposite direction each time the compass is moved off course by rudder action.

Kirk o' Shotts TV Transmitter

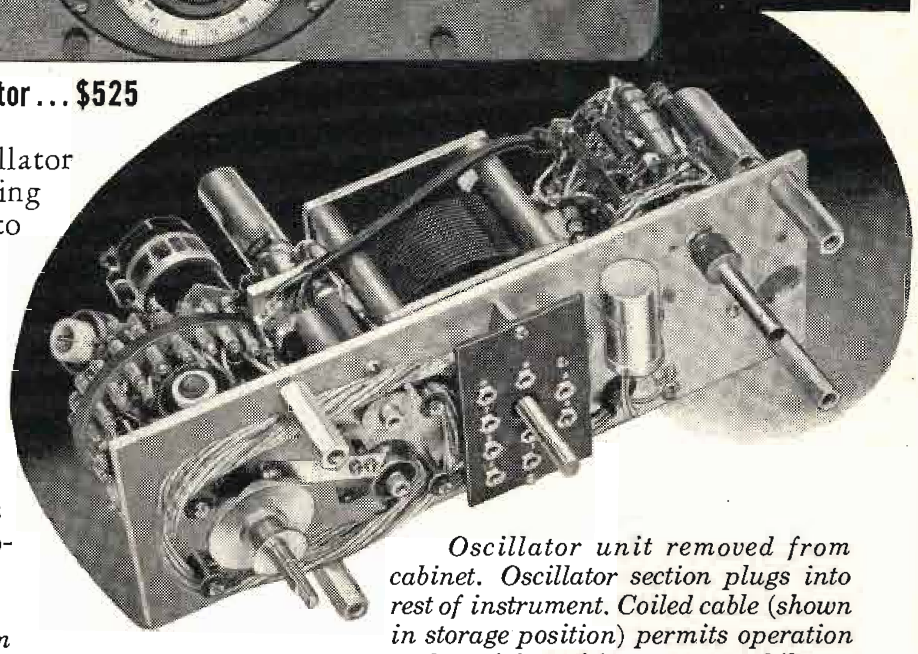
Scotland's first TV transmitter has recently been placed in operation at Kirk o' Shotts, midway between Glasgow and Edinburgh. Programs are received from London 400 miles away by coaxial cable and microwave relay, and fed to a 750 ft. high antenna which is 1600 ft. above sea level. Later in the year when the station will change from medium power to high power transmitters, the potential audience coverage will reach 4,000,000, thereby extending TV service to a total of nearly 80% of Great Britain's population.

BRIDGE OSCILLATOR

Unusually Wide Frequency Range
Low Distortion   Excellent Stability
Internal Modulation



Type 1330-A Bridge Oscillator . . . $525



Oscillator unit removed from cabinet. Oscillator section plugs into rest of instrument. Coiled cable (shown in storage position) permits operation and servicing of instrument while removed from cabinet.

The General Radio Type 1330-A Bridge Oscillator is a compact variable frequency source providing power over a very wide range — from 5 kc to 50 Mc and at 60, 400 and 1000 cycles.

Switching permits internal modulation at 400 and 1000 cycles, at 30% or 60% modulation levels.

The stability and wide range of this oscillator ideally adapt it to bridge and antenna measurements. Low distortion, a maximum power output of one watt and many operating conveniences make this instrument a versatile general laboratory source.

WIDE FREQUENCY RANGE — *continuously adjustable from 5 kc to 50 Mc; 60, 400 and 1000 cycle fixed audio frequencies*

GOOD ACCURACY — *±2% for carrier frequencies above 150 kc; ±3% below 150 kc; ±5% at 400 and 1000 cycles*

RAPID FREQUENCY SETTING — *r-f tuning dial and range switch permit rapid and accurate frequency selection*

INCREMENTAL FREQUENCY DIAL — *vernier on tuning dial indicates 0.1% frequency increments of main dial division*

INTERNAL MODULATION — *400 or 1000 cycles at 30% or 60% levels*

ADEQUATE OUTPUT — *r.f. is 10 volts, open circuit; 1 watt into matching 50-ohm load — audio is 12 volts, open circuit, ¾ watt into matching 50-ohm load*

ADJUSTABLE OUTPUT — *attenuator for 5 kc—50 Mc range*

LOW DISTORTION — *r-f 3% over most of range; a-f approximately 5% at 400 cycles and at 1 kc; envelope distortion less than 6% at 60% modulation, 3% at 30% level*

LOW LEAKAGE — *r-f and audio circuits are in a shielded compartment within the main cabinet. Leads to plate and heater are filtered. At 1 Mc stray fields are about 50 μv per meter at two feet from instrument*

SHIELDED OUTPUT JACKS — *matching coaxial connectors, cables and adapters are provided for complete shielding of oscillator output.*

GENERAL RADIO Company

275 Massachusetts Avenue, Cambridge 39, Massachusetts

90 West St., NEW YORK 6 · *920 S. Michigan Ave.,* CHICAGO 5 · *1000 N. Seward St.,* LOS ANGELES 38

CUES for BROADCASTERS

(*Continued from page 49*)

which was too much current to pass through a telephone line. So, it was suggested by the telephone company engineers that the dial impulsing device be used to operate quick acting Class "A" relay located at the transmitter, since it requires low current, which could be used to trip the heavy duty stepping relay RY-2.

Stepping relay RY-1, located at the studio, is operated directly from the impulsing device, as its current does not flow through the leased lines which are used to control the relays at the transmitter. This impulsing device must, however, simultaneously control RY-1 and RY-2. Relay 2 is therefore controlled by RY-3, which is a low current relay, requiring only 10 v. dc for its operation at 12 ma. Since the pulsing relays RY-3 and RY-4 require only 10 v. dc and the stepping relays RY-1 and RY-2 require 48 v. dc. One dc source is needed at the studio. This can be any suitable selenium rectifier which will give the desired 50 v. and current requirements. The 50-v. source is keyed by the impulser, so that any number of pulses, depending upon number, dialed up to 10, are available. Each pulse will cause the stepping relays to step up accordingly so that if the number three is dialed, three pulses are developed which cause RY-1 to step-up three places and at the same time the quick acting pulsing relay RY-3 will be tripped three times, causing stepping relay RY-2 to step up three places. Relay RY-1 will now cause pilot light number four, which is marked line three "ON" to glow indicating that line three is ready for broadcasting.

Since Relays 3 and 4 operate from 10 v. and the available dc voltage from the rectifiers at the studio is 50 v., (the voltage needed for RY-1,) a 3333 ohm resistance is needed.

Part of this resistance consists of the dc resistance of the leased telephone line between the studio and transmitter, the balance is taken care of by the rheostats R-1 and R-2. These rheostats are adjusted so that RY-3 and RY-4 latch in on pulses.

The dial impulser is capable of sending 10 pps or one pulse every .1 sec. The pulsing relays RY-3 and RY-4 require .002 sec. to operate and .025 sec. to release or a total operating cycle of .027 sec.

Mounted on the studio panel are the dial phone impulse sender, a "Home" or "Reset" push button and eleven panel lights. The first light is green and should be marked "Off." The remaining ten lights are red and should be marked 1, 2, 3, etc., or marked "Network," "Boston," "Dover," etc.

Reset Button

The reset push button is used to reset relays RY-1 and RY-2 to their off-normal positions. This is accomplished by an additional magnet located on each stepping relay, which when energized releases its detent holding ratchet wheel. In this position there is located a set of "off-normal" springs which automatically opens release voltage.

Every time a new line is selected, the reset button must first be depressed so that the stepping relays will reset to their off positions; otherwise, dialing the number (2) with the purpose of setting up line (2) when the relay already is in its third position, would cause both stepping relays to move up two additional positions, bringing them to rest on their fifth positions.

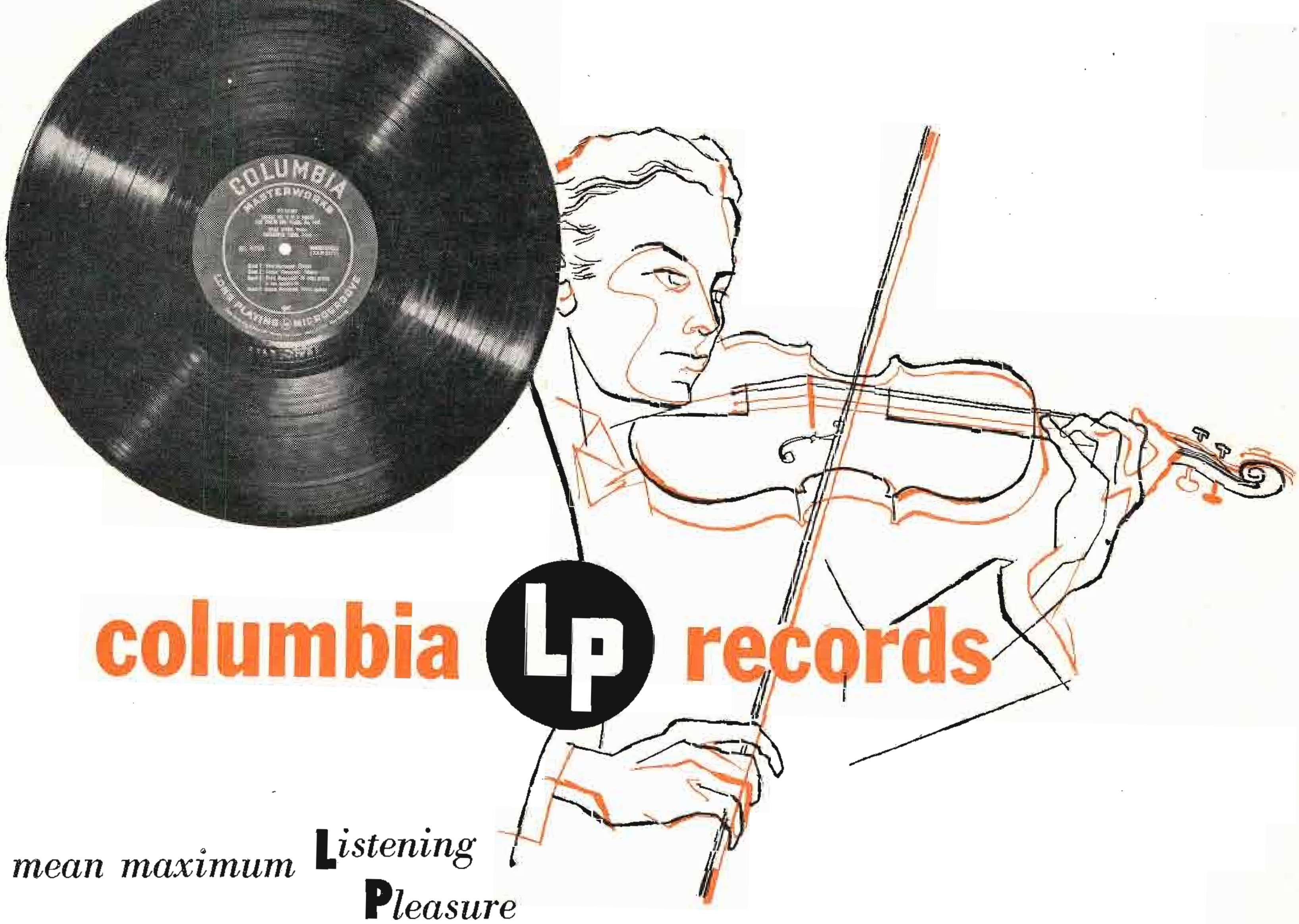
A program to originate from "Line 3" or "Network," and the operating cycle is as follows:

a) Dial the number three on dial impulsing device. This will cause three pulses to be transmitted to relays one and three. Relay one will immediately step up to its number three position and the red light marked "Line 3" will glow. At the same time, Relay 3 will latch in three times, causing Relay 2 to step up to its third position. This will cause red light marked "Line 3" to glow at the transmitter end and at the same time line three is fed to its input of the booster amplifier which feeds the boosted output to the studio.

Tape Storage

GLEN BARNETT, Chief Engineer, KAYS, Hays, Kansas

THE problem of securing a handy tape reel storage rack was solved at KAYS by purchasing standard Lyric record racks made for storage of 45 rpm discs. Cutting out three successive wires in the rack and leaving in every fourth wire makes a perfectly fitting tape rack with a capacity of twelve tapes. The wires may be cut without damage to adjacent wires by grasping each wire with a pair of long-nose pliers and pulling them inside the rack where they can easily be cut with wire-cutters.



columbia LP records

mean maximum Listening Pleasure

—thanks to the finest in modern sound recording methods and equipment

Music lovers everywhere know that Columbia LP records mean more listening pleasure—not in playing time alone, but in superb quality of reproduction. Yet few listeners outside the professional circle realize the degree of perfection which this record quality requires in every step of manufacture and processing. Take the original sound recordings and the processing masters, for example. Frequency response, signal-to-noise ratio, distortion and surface noise must measure up to standards which would have seemed entirely impractical a few years ago. But Columbia has found that Audiotape and Audiodiscs are an ideal combination for meeting all of these exacting requirements — Audiotape for recording the original sound and Audiodiscs for the masters from which stampers are made. In fact this same record-making combination is now being used with outstanding success by America's leading producers of fine phonograph records and broadcast transcriptions.

You can get this same sound perfection in *your* recording work, too — with Audiodiscs and Audiotape. Their superior quality is the result of more than 12 years of specialized experience by the only company in America devoted solely to the manufacture of fine sound recording media, both tape and discs.

Ⓛ The exclusive trade-mark of Columbia Long Playing Records—symbol of highest quality. Trade-Marks "Columbia," "Masterworks," Ⓛ, Ⓛ Reg. U.S. Pat. Off. Marcas Registradas.

...including

audiotape*

for the original sound

...and **audiodiscs***

for the master recording

**Trade Mark*

AUDIO DEVICES, Inc.

444 MADISON AVE., NEW YORK 22, N. Y.
Export Dept.: 13 East 40th St., New York 16, N. Y., Cables "ARLAB"

WABD Transmitter

(*Continued from page* 55)

would eliminate all electronic circuits prior to the transmitter.

The transmitters are the new DuMont 5 kw aircooled Oak series. These units occupy five cabinets on the north side of the room and have all operating controls duplicated at the operator's console. Briefly the transmitters are designed as follows: the crystal controlled visual exciter feeds a pair of 4X150A tetrodes which are grid modulated with video by a pair of 4E27A tetrodes in parallel. This signal is amplified by a pair of 4X500A tetrodes in push-pull to approximately 800 watts maximum and feeds a final pair of 3X2500A3 triodes in push-pull to boost the power output to a full 5 kw. The aural transmitter, being FM, is modulated in the exciter; the driver stages also multiply the crystal frequency to carrier frequency and feed a pair of 4X500A tetrodes which supply 250 watts into the final power amplifier, a pair of 3X2500A3s built similarly to the visual final stage for economy of spares and maintenance. Provisions have been made for adding another power amplifier to boost the visual transmitter erp to 100 kw, and the aural to 50 kw erp (effective radiated power, the figure obtained by multiplying the gain of the antenna system times the transmitter output, less losses sustained between the transmitter and antenna terminals).

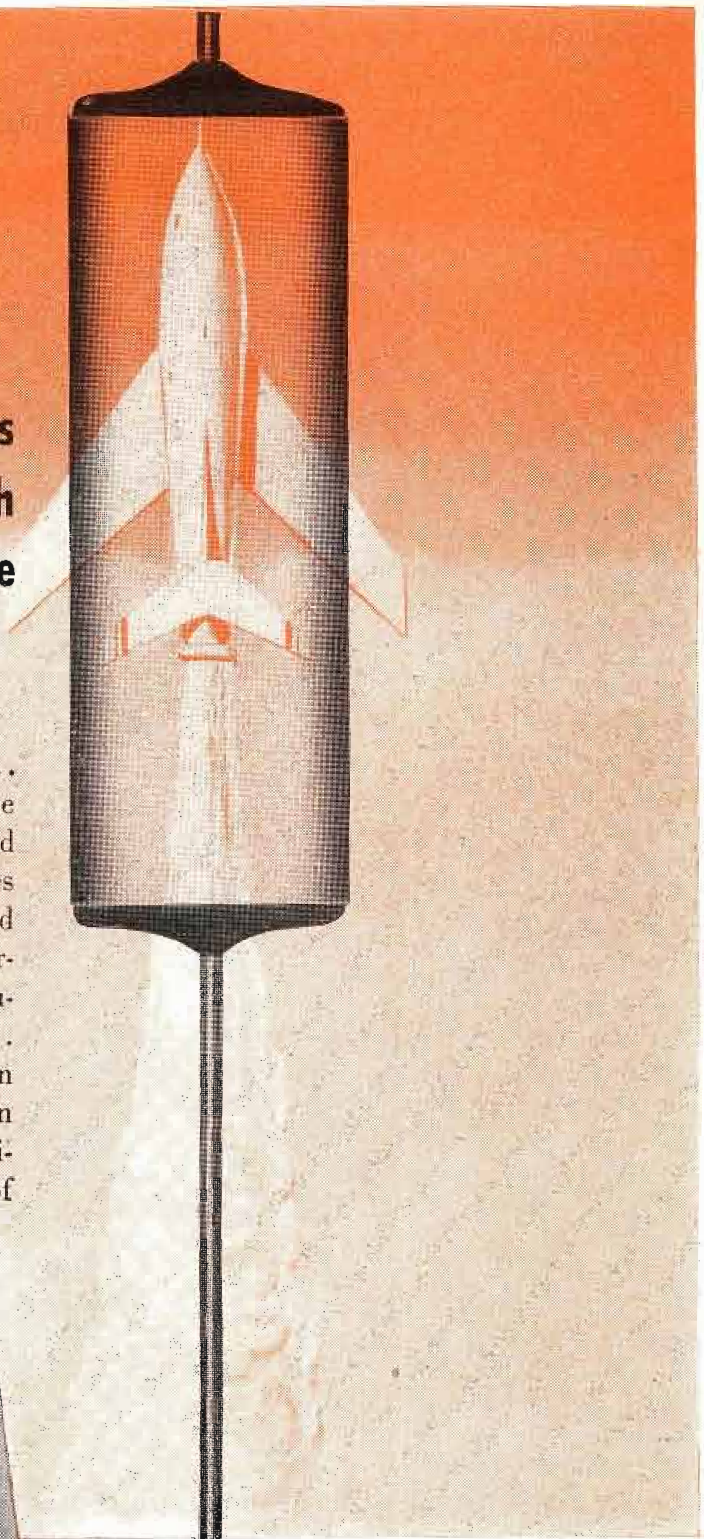
For simplified routine maintenance, a video wobbulator which generates an FM signal and bandpass indicator were made an integral part of the DuMont transmitter. The center frequency is made coincident with the stage of the transmitter to be checked and is frequency modulated to swing 10 MC at a 60 cycle rate. The bandpass indicator is essentially an FM receiver and oscillograph. The horizontal base line of the oscilloscope is developed at the 60 cycle modulation rate so that it may be calibrated in MC to synchronize with the wobbulator. The vertical deflection plates are energized by the FM receiver signal. The width and height of the pulse seen on the oscillograph face will be a direct function of the bandwidth and amplification characteristics of the unit or stage under test. See Fig. 5. The lower sideband attenuation for vestigial sideband transmission, required by the FCC for TV transmitters, is obtained by stagger tuning and a final filter in the Oak transmitter.

On the transmitter operating con-

(*Continued on page* 98)

HI-Q SERVES NATIONAL DEFENSE

Wherever Electronics Play Tag with a Plane



Guided missiles that can chase an enemy plane for miles... and eventually catch and destroy it... are just one of the many "fantastic weapons" which electronics have contributed to the defense of our nation. And here, as in all other phases of this great new science, you'll find **HI-Q** components valued for their dependable performance, long life and rigid adherence to specifications. Whether it be disk capacitors... tubulars, plates or plate assemblies... high voltage slug types... trimmers, wire wound resistors or choke coils... you can count on the **HI-Q** trade mark as a guarantee of quality in ceramic units. And you can likewise count on **HI-Q** engineers for skilled cooperation in the design and production of new components to meet specialized or unusual needs.

HI-Q TUBULAR CAPACITORS

...may be had with axial leads and a specially developed endseal as shown above, or with conventional leads. **HI-Q** tubulars are available in a complete range of by-pass, coupling and temperature compensating types as well as in an HVT line developed specifically for use on the relatively high pulse voltages encountered in the horizontal sweep and deflection sections of television circuits. Whatever your needs for tubular capacitors or other ceramic components, you are invited to consult **HI-Q.**

HI-Q* DIVISION

AEROVOX CORPORATION

OLEAN, NEW YORK, U. S. A.

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Export: 41 E. 42nd St., New York 17, N. Y. • Cable: AEROCAP, N. Y. • In Canada: AEROVOX CANADA LTD., Hamilton, Ont.

JOBBER ADDRESS: 740 Belleville Ave., New Bedford, Mass.

SALES OFFICES IN ALL PRINCIPAL CITIES

sole, DuMont type TA129K, the operator has duplicate filament and plate switches, and five section input selector switches for both aural and visual transmitters. Frame and line frequency waveform monitors and a picture monitor may be switched to monitor any incoming line, one of three points in the transmitter, the transmission line, or a special receiver. Two meter panels of six meters each provide full metering facilities for both transmitter final

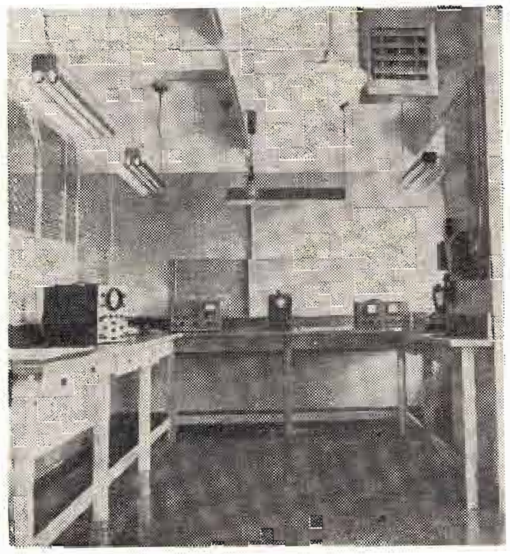


Fig. 8: Maintenance shop contains tube checker, wobbulator, signal generator and small tools

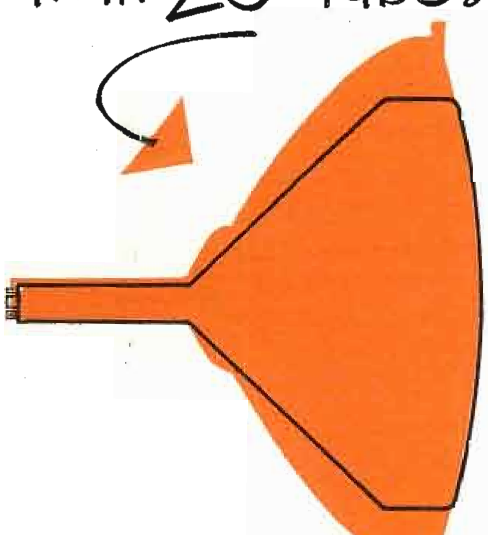
r-f stages, modulation and deviation measurements, and ac line voltage measurements. The design allows space on the console for the addition of switches or pilot lights as may be desirable in individual installations. To provide a more concentrated control center for the operators at the Empire State installation, switches for selecting either of two transmitter input stabilizing amplifiers, and either of two microwave receivers, are mounted on the console.

Antenna & Transmission Line

The antenna is the supergain type, consisting of sections of dipoles and reflectors stacked one above the other with radiators spaced slightly less than ½ wavelength apart. Here, each section is made up of four units, one facing in each direction, north, south, east, and west. One unit is formed by one dipole mounted ¼ wavelength in front of a screen. Five of these sections are stacked to give a gain of 4.1 (compared to a dipole). The circular pattern is obtainable by feeding the east-west and north-south elements in quadature, i.e. 90° current phase difference.

(*Continued on page* 100)

Actually shorter than 20" tube!



On March 3, Rauland unveiled the first "giant-screen" tube that makes attractive cabinetry possible.

This new 27" tube, with 390 square inch picture area, minimizes cabinet problems in two ways. First, it has the compactness of rectangular rather than round cone and face. Second, by means of 90° deflection, depth has actually been held slightly shorter than present 20" tubes!

The tube employs Rauland's usual "reflection-proof" filter glass face plate with maximum reflection of only 2½% of incident light. It uses the Rauland tilted offset gun with indicator ion trap. It is offered with either magnetic or low-focus-voltage electrostatic focus. Weight is held at minimum by use of a metal cone.

If you want a picture of really spectacular size that can be housed in acceptable furniture, here is your answer.

A picture actually more than 70 sq. in. larger than the center spread of a tabloid newspaper. Rectangular for minimum cabinet height and width. And actually permitting a small reduction in depth from today's 20" cabinets!

THE RAULAND CORPORATION

Perfection Through Research

4245 N. Knox Avenue, Chicago 41, Illinois

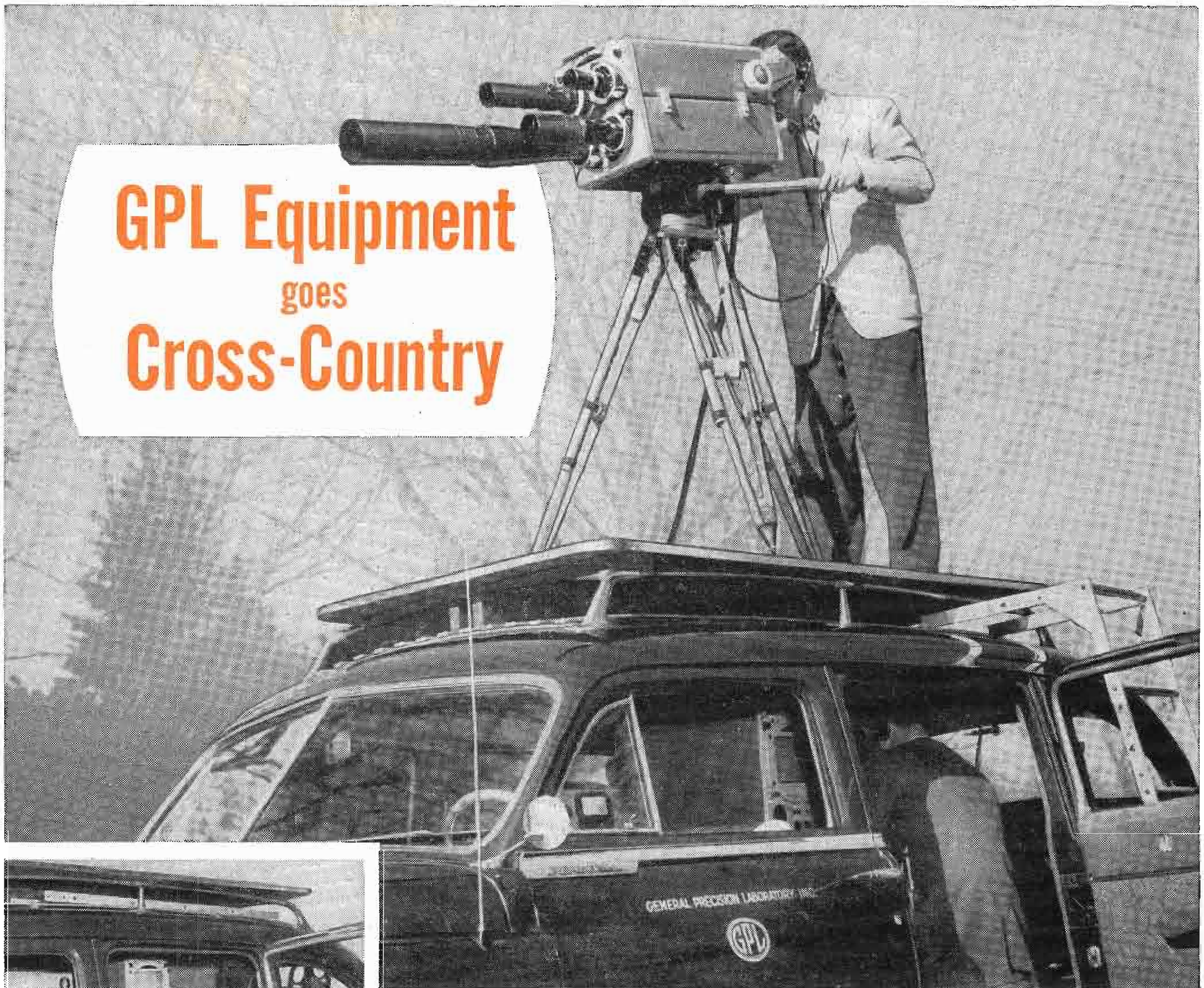
The antenna system is split into two groups, the upper of two sections and the lower of three; each group is fed by an individual transmission line. By the use of a unique manual switching arrangement and power splitting coaxial transformer, all or only part of the antenna system and both or either transmission line may be used. This feature would be utilized in the event breakdown should develop in one transmission line or one antenna group. See Fig. 6. Both transmission lines are exactly the same length to prevent any phase shift (time delay) between the upper and lower groups of the antenna system, and consequent alteration of the vertical pattern. These lines are constructed of 414 ft. of 3⅛ in. coaxial tubing and operate with an efficiency of approximately 88%. Other approximate efficiencies are: feed cable 95.4%; power splitting transformer 99%; and diplexer 98%. These factors reduce the overall gain of the antenna system to 3.4, giving an erp of approximately 16.9 kw for the visual transmitter and 8.3 kw for the aural.

Ventilation

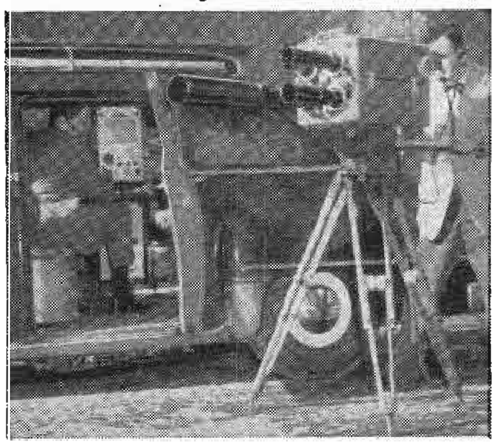
The aircooled transmitters contribute to a simpler operation. Since the Oak transmitters use no water but are entirely aircooled, the four independent ventilating systems are an important feature of this new installation. Two systems are used for the transmitters and standby transmitters respectively. No cooling of the air is required, and only one 1950 cfm centrifugal fan is utilized per transmitter system. This fan exhausts the warm air from the five cabinets. The exhausted air may be exited from the building or emptied into the plenum area at the rear of the transmitter cabinets to be recirculated, depending on the temperature of the outside air. The plenum area is formed by closing the space between the ends of the transmitters and the outside walls with air tight walls. This plenum area provides the facility necessary for mixing the fresh intake air and exhaust air to provide the correct temperature to enter the transmitter itself.

A thermostat is located at the intake grill of one of the cabinets; if the incoming air temperature drops to 50° F., dampers in the intake and outlet vents to the outside are closed, or partially closed, automatically to reduce the entrance of outside air into the plenum until the thermostat rises above 50° F. A similar system utilizing a 5050 cfm fan

(*Continued on page* 102)



Included in cross-country demonstration unit is the GPL Utility Projector, with "3-2" intermittent which permits use with I.O. camera for film telecasting from remotes.



Compact GPL studio camera chain fits easily in station wagon, and may be operated from there, drawing power by cable from studio and returning signal to transmitter.

...to Drive its Story Home!

Stations all over the country will soon be able to see GPL TV equipment in operation right in their own studios. They can compare it with their present equipment, try it for compactness, smooth efficiency, flexibility, operational simplicity, and overall performance quality. Maintenance-minded engineers will examine its swing-up, swing-out panels. Camera and camera control men will note its many new operating features—pushbutton turret control, remoting of focus, turret and iris—all engineered for faster, smoother control.

Be sure *your* station is on the schedule of the GPL Mobile Unit Tour. *See* why network users have said: "Best picture on the air today!" Compare "the industry's leading line—in quality, in design."

Write, wire or phone today, and we'll work your station into our itinerary for earliest possible dates.

General Precision Laboratory GPL

INCORPORATED

PLEASANTVILLE NEW YORK

TV Camera Chains • TV Film Chains • TV Field and Studio Equipment • Theatre TV Equipment serves the auxiliary racks, except that the thermostat is located in the plenum area rather than a cabinet. The fourth system, using another 1950 cfm fan serves the operating area for the comfort of the men on duty. See Fig. 7.

Microwave Relays

On account of the height and three-sided exposure, the transmitter location at the Empire State building is excellent for microwave relay operations. Two receiver and one transmitter control units are permanently mounted in one of the auxiliary racks with cables running to the two building corner locations. Normally "remote" signals will be picked up here and relayed via Telephone Co. lines to master control for program integration. However, the signal will also appear at the transmitter input switch to be put directly on the air instantly in case of telephone line or master control failure. The outputs of both receivers are fed, through the video patch section, to a "flip-flop" switch on the operator's console which alternately terminates one line while feeding the other to a distribution amplifier. Refer to Fig. 3.

Test and Maintenance

Some of the test and maintenance equipment is rack-mounted to be utilized through the patch sections.

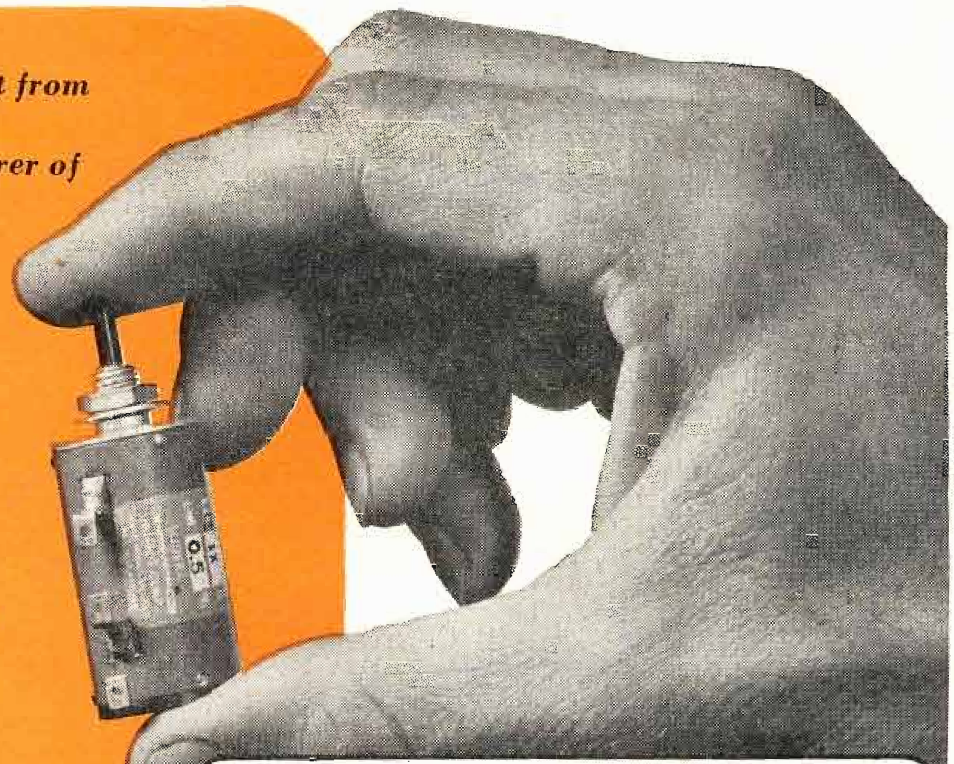
(*Continued on page* 104)

TYPHOON MISSILE MODEL

H. G. Tremblay, Acting Supt. of the Analytical and Computer Div. (L) and Dr. W. A. Boghosian of the U. of Pa., consultant to the ACD, study the missile model used in conjunction with the analog Typhoon (see front cover) recently installed at the Naval Air Development Center, Johnsville, Pa. The model simulates the missile's three dimensional flight attitudes for a particular design being analyzed mathematically by the computer. The model in this official Navy photograph has controls which manipulate flight surfaces in accordance with Typhoon computations.

Another important development from

Helipot *world's largest manufacturer of precision potentiometers . . .*



TINY in size—
the diameter of a penny!

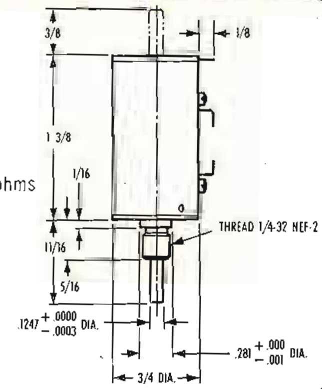
BIG in performance—
12 times the resolution of a conventional "pot."

THE MODEL AJ

Helipot

CONDENSED SPECIFICATIONS

Number of turns	10
Power rating	2 watts
Coil length	18″
Mechanical rotation	3600° + 12° − 0°
Electrical rotation	3600° + 12° − 0°
Resistance ranges	100 ohms to 50,000 ohms
Resistance tolerance	± 5.0%
Linearity tolerances:	
All values	± 0.5% (standard)
5000 ohms and above	± .1%
Below 5000 ohms	± .25%
Starting torque	0.75 oz. in.
Net weight	1.0 oz.



Miniaturization, weight reduction and circuit simplification are key design objectives in all airborne and many other electronics applications for precision potentiometers. Helipot's new Model AJ meets these needs with a compact potentiometer having over 12 times the resolution of conventional potentiometers of the same diameter . . .

- **SIZE AND WEIGHT: The AJ is only ¾″ in diameter (small as a penny)—1⅜″ long—weighs 1.0 oz. It requires only a minimum of valuable panel space!**
- **PRECISION, WITH CIRCUIT SIMPLICITY: On many applications the AJ replaces two conventional potentiometers, providing *both* wide range and fine adjustment in *one* unit. Its 18″ slide wire gives a resolution of 1/3000 in a 100 ohm unit—1/6550 in a 50,000 ohm unit!**
- **RELIABILITY: The AJ is rugged and simple, is built to close tolerances with careful quality control. Its performance and reliability reflect the usual high standards of Helipot quality!**

MANY IMPORTANT CONSTRUCTION FEATURES: If you have a potentiometer application requiring light weight, unusual compactness, high accuracy and resolution, be sure to get the complete information on AJ advantages . . .

Here is a "pot" with bearings at *each* end of the shaft to assure precise alignment and linearity at all times. In addition, each bearing is *dust-sealed* for long life and is mounted in a *one-piece* lid and bearing design for exact concentricity.

Either single or double shaft extensions can be provided to meet individual needs—also, special shaft lengths, flats, screwdriver slots, etc.

Tap connections can be provided at virtually *any* desired point on the resistance element by means of a unique Helipot welding technique which connects the terminal to only ONE turn of the resistance winding. This important Helipot development eliminates "shorted section" problems!

BUILT TO HELIPOT STANDARDS

Helipot—world's largest manufacturer of precision potentiometers—has built an enviable reputation for highest standards in all its products, and the Model AJ is no exception.

The resistance elements themselves are made of precision-drawn alloys, accurately wound by special machines on a copper core that assures rapid dissipation of heat.

Each coil is individually tested to rigid standards, then is permanently anchored in grooves that are precision-machined into the case. Slider contacts are of long-lived Paliney alloy for low contact resistance and low thermal e.m.f. . . . and precious-metal contact rings are used to minimize resistance and electrical noise. All terminals are silver plated and insulated from ground to pass 1,000 volt breakdown test.

LONG LIFE: Although Unusually compact, the AJ is built throughout for rugged service. Potentiometer life varies with each application, of course, depending upon speed of rotation, temperature, atmospheric dust, etc. But laboratory tests show that, under proper conditions, the AJ has a life expectancy in excess of one *million* cycles!

Helipot representatives in all major cities will gladly supply complete details on the AJ—or write direct!

THE Helipot CORPORATION

South Pasadena 3, California

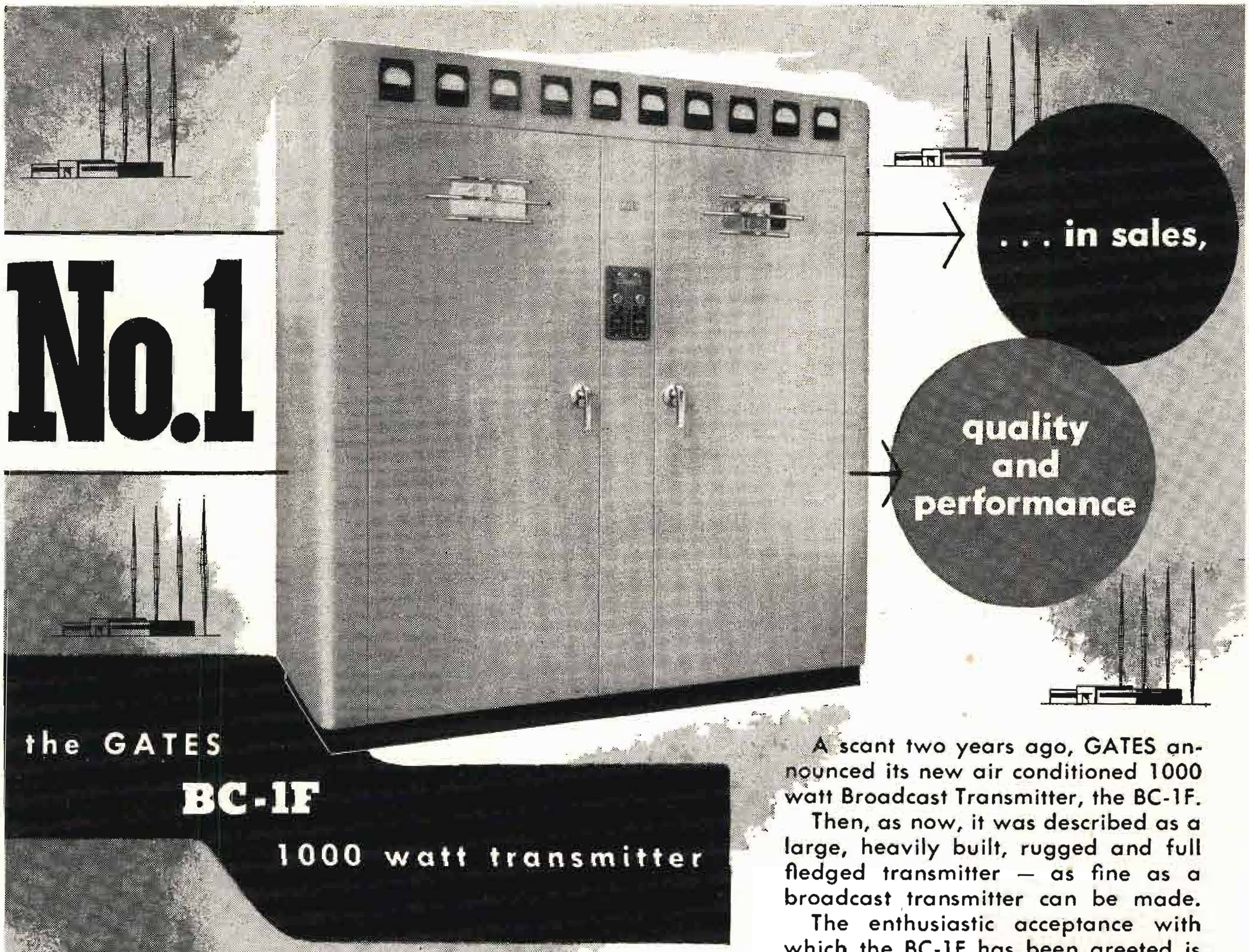
Field Offices: Boston, New York, Philadelphia, Rochester, Cleveland, Detroit, Chicago, St. Louis, Los Angeles, Seattle, Dallas and Fort Myers, Florida. In Canada: Cossor Ltd., Toronto and Halifax. *Export Agents:* Frathom Co., New York 18, New York.

This procedure is especially convenient for the audio, video, and r-f signal generators. Two picture monitors and two high quality waveform monitors are also rack-mounted and connected to the patching system for flexibility of operation. However, two dollies will be equipped with a DuMont type 303 oscillograph and other test equipment for emergency trouble shooting and routine maintenance of the equipment. Bench repairs will be made in the maintenance shop which is fully equipped with small tools, a tube checker, wobbulator, signal generator, drill press, and meters. Six coaxial lines are brought to an outlet box over the work bench from the video patch section; four of these lines will normally carry the four sychronizing signals and two are spares. See Fig. 8.

A 1600-ampere ac service has been made available at the transmitter. However, only one-half of this service is utilized for present operations; the balance is a reserve for operation of the 30 kw amplifiers and associated equipment required to operate the visual and aural transmitters at 100 kw and 50 kw erp respectively. The system contains a main distribution panel and two secondary panels. The main panel feeds the transmitters, antenna de-icing elements, and the secondary panels. One secondary panel is located near the operator's console and feeds the console and auxiliary racks. The second secondary panel is located in back of the standby transmitter and distributes power to the ventilating fans and crews' living quarters appliances. The auxiliary racks and transmitter cabinets are fed ac from the top into utility outlets. Two DuMont type 5208C power distribution panels service all the regular operating equipment in the auxiliary racks, and are so located that the operator may readily view them from his console. If a fuse is blown, a lamp on the 5208C panel identifies the equipment which is out of service.

To prevent ice from forming on the antenna and altering the electrical characteristics, five banks of eight 500-watt heater elements are installed as an integral part of the antenna. These units are operated automatically with provisions for manual operation if necessary. At the base of the tower a thermostat and humidastat are located which send a low voltage signal to the transmitter room when the combination temperature and humidity conditions indicate a danger of ice forming. This signal will light a lamp

(*Continued on page* 106)



A scant two years ago, GATES announced its new air conditioned 1000 watt Broadcast Transmitter, the BC-1F.

Then, as now, it was described as a large, heavily built, rugged and full fledged transmitter — as fine as a broadcast transmitter can be made.

The enthusiastic acceptance with which the BC-1F has been greeted is unquestioned verification of quality, since only quality of the highest order could build such an impressive "owner list" as that below!

Why not ask those who own one?

OWNERS OF GATES BC-1F BROADCAST TRANSMITTERS*:

WGEM	Quincy, Illinois	KCRV	Caruthersville, Missouri	WKAP	Allentown, Pennsylvania	KOSY	Texarkana, Arkansas
WKRS	Waukegan, Illinois	KMAN	Manhattan, Kansas	KGAL	Lebanon, Oregon	KCNO	Alturas, California
WKXY	Sarasota, Florida	CJSO	Sorel, Quebec, Canada	WRIC	Richlands, Virginia	KWCB	Searcy, Arkansas
WTVB	Coldwater, Michigan	KTOE	Mankato, Minnesota	WRAY	Princeton, Indiana	KDLM	Detroit Lakes, Minnesota
WDKD	Kingstree, South Carolina	WFVG	Fuquay Springs, N. C.	KILO	Grand Forks, North Dakota	WTRW	Two Rivers, Wisconsin
WCBA	Corning, New York	KPBM	Carlsbad, New Mexico	WFHG	Bristol, Virginia	WCPA	Clearfield, Pennsylvania
WYVE	Wytheville, Virginia	WMPM	Smithfield, North Carolina	KBOP	Pleasanton, Texas	KDAS	Malvern, Arkansas
KERG	Eugene, Oregon	WATC	Gaylord, Michigan	WCTT	Corbin, Kentucky	WOKE	Oak Ridge, Tennessee
WDZ	Decatur, Illinois	WOPT	Oswego, New York	KSMN	Mason City, Iowa	WBUD	Trenton, New Jersey
WPEP	Taunton, Massachusetts	WLIL	Lenoir City, Tennessee	WGSM	Huntington, L. Island, N. Y.	CFCL	Timmins, Ontario, Canada
WKVA	Lewistown, Pennsylvania	KBKH	Pullman, Washington	WCEN	Mt. Pleasant, Michigan	XEAS	Nuevo Laredo, Mexico
WCOJ	Coatesville, Pennsylvania	KTYL	Mesa, Arizona	WLYC	Williamsport, Pa.	WTIM	Taylorville, Illinois
KTRM	Beaumont, Texas	WKCT	Bowling Green, Kentucky	WORD	Spartanburg, S. C.	KGMC	Englewood, Denver, Colo.
CKVL	Verdun, Quebec, Canada	WTOB	Winston-Salem, N. C.	WJPR	Greenville, Mississippi	KMMO	Marshall, Missouri
KGWA	Enid, Oklahoma	WIAM	Williamston, N. C.	WPAZ	Pottstown, Pennsylvania	WBOK	New Orleans, Louisiana
WNAH	Nashville, Tennessee	KIUP	Durango, Colorado	WFUL	Fulton, Kentucky	WAKN	Aiken, South Carolina
WJAT	Swainsboro, Georgia	KPOC	Pocahontas, Arkansas	WLEA	Hornell, New York	WCMY	Ottawa, Illinois
KNED	McAlester, Oklahoma	WTIL	Mayaguez, Puerto Rico	WRAG	Carrollton, Alabama	WALK	Patchogue, L. I., N. Y.
		WGCB	Red Lion, Pennsylvania	WAIN	Columbia, Kentucky	WEYE	Sanford, North Carolina
		WWSW	Pittsburgh, Pennsylvania	WHJC	Matewan, West Virginia	CFRA	Ottawa, Ontario, Canada
		KOKX	Keokuk, Iowa	CKPB	Victoriaville, Quebec, Can.	KWOC	Poplar Bluff, Mo.

*Above list excludes all export sales other than Canada. Any domestic omissions are unintentional. Substantial military purchases of this model can not be listed for obvious reasons. Purchases after December 30, 1951, not shown.

GATES

GATES RADIO COMPANY • QUINCY, ILLINOIS, U.S.A.

manufacturing engineers

2700 Polk Avenue, Houston, Texas • Warner Building, Washington, D. C. • International Division, 13 E. 40th St., New York City

Canadian Marconi Company, Montreal, Quebec in one of the auxiliary racks, in view of the operator, as well as actuate a small 24-volt relay which in turn actuates the larger 110-volt relays to apply power to the heaters. A lamp on the same panel as the signal lamp informs the operator that power is being applied. A meter in combination with a selector switch is provided to check the current being drawn by each bank of heaters.

The project was completed through the cooperation of several groups. First a "primary" committee was formed to determine the type of tower construction and antenna to be utilized and coordinate the work of the five licensees. The DuMont antenna and transmission line installation was handled by the primary committee, Dr. Goldsmith, and Mr. Sayer of the research division of DuMont Labs. The transmitter center design was handled by Mr. R. D. Chipp, Director of Engineering, and Mr. R. F. Bigwood, Chief, General Engineering Dept., DuMont TV Network, with W. T. Meyer architect.

New FCC TV Allocations

On pages 68 and 69 of this issue, we list the new TV allocations released April 14 by FCC, providing for 2053 new stations in 1291 communities. About one-eighth of the assignments will be educational and non-commercial. Some 25 cities will have certain of their present VHF assignments shifted. This includes Chicago which trades Ch. 4 for Ch. 2, and adds Ch. 11. Pending are 521 applications, expected to be swelled to over 1000 by the time assignments are made in July.

The new FCC TV report contains 600 pages and over 50 charts, but follows closely the third FCC engineering report. Allocations are based on the following engineering principle:

Minimum Co-Channel Spacing:

ZONE	UHF	VHF
1 (Northeastern U.S.)	155 miles	170 miles
2 (Areas outside Zones 1, 3)	175 miles	190 miles
3 (Within 150 miles of Gulf Coast)	205 miles	220 miles

Maximum Effective Radiated Power:
VHF Ch. 2-6, 100 kw. Ch. 7-13 316 kw.
UHF All channels. 1000 kw.

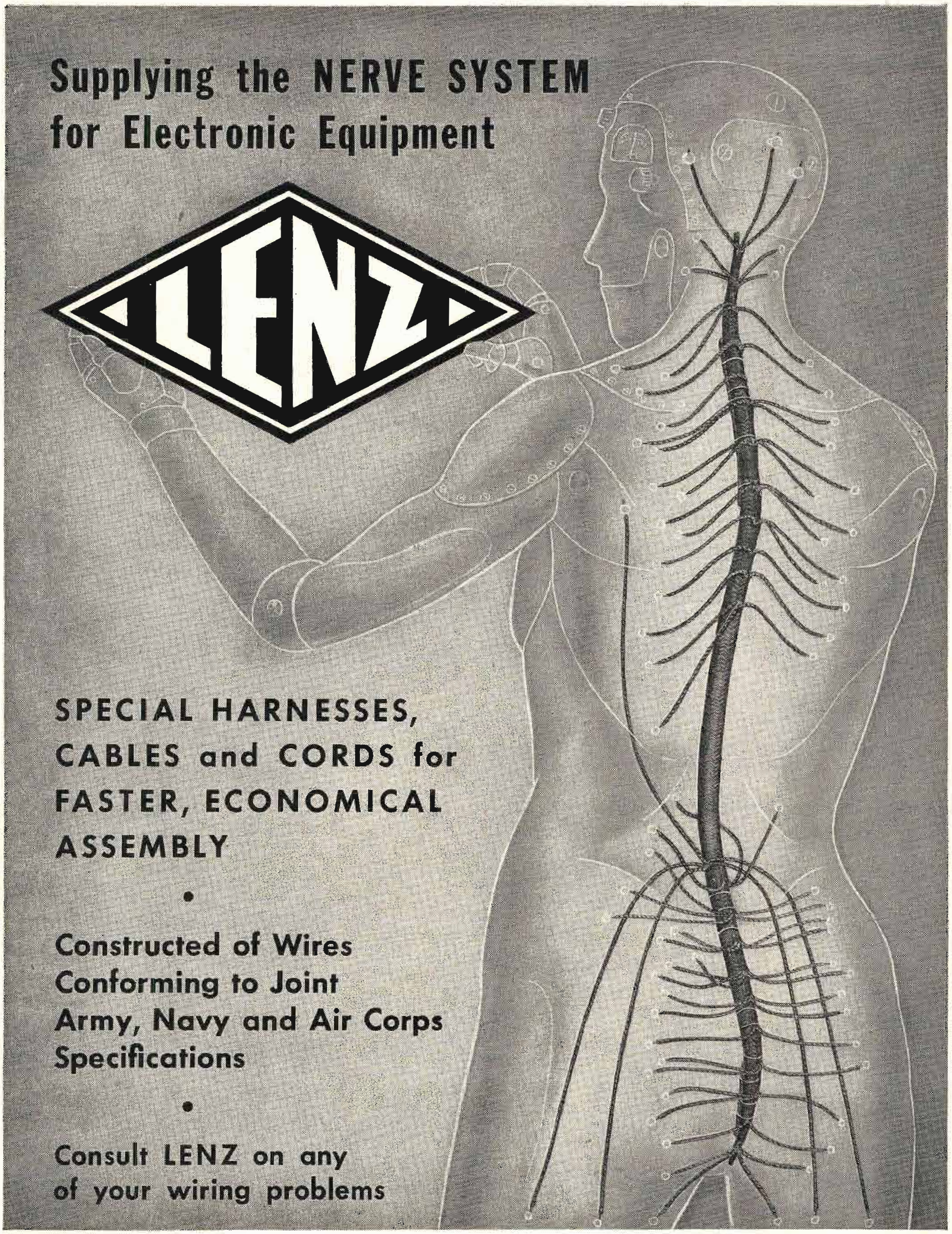
Antenna Heights: Maximum heights for maximum powers
Zone 1 UHF 2000 ft. VHF 1000 ft.
Zones 2 and 3 UHF & VHF 2000 ft.
In cases of antenna heights above the maximums just listed, the antenna power must be decreased as height increases.

Processing: Starting April 14, there will be a two-and-a-half month period for the filing of new applications and amending old applications. Processing of applications will begin July 1. Present applications will not be thrown out, but amendments for each are required and this will demand the use of a new form.

Priorities: A system has been set up to process high-priority applications first. Priorities will be based on need. For instance, the larger cities having no or very limited services will have the highest priorities. At FCC there will be two processing "lines" operating in parallel.

Applications: Applications will be considered on a channel-by-channel basis. That is, there will be no hearings "lumped" by cities.

Construction Permits: Actually it is expected that construction permits on some applications requiring no hearing, can be issued the first week in July.



LENZ ELECTRIC MANUFACTURING CO.

1751 North Western Avenue • Chicago 47, Illinois

IN BUSINESS SINCE 1904

For Manufacturers

(*Continued from page* 63)

tional electrical insulation now being made.

Tapes can be made from mica paper in almost all of the combinations where mica splittings are now used. In discussing the value of mica paper tapes the emphasis is on the thickness uniformity of the mica paper obtained since it allows a very neat and compact wrapping on coils and bars. The dielectric strength of mica paper tapes does not show the wide variations, and does not have the voids that have long proved a source of trouble to both manufacturer and consumer.

Aluminum Conservation

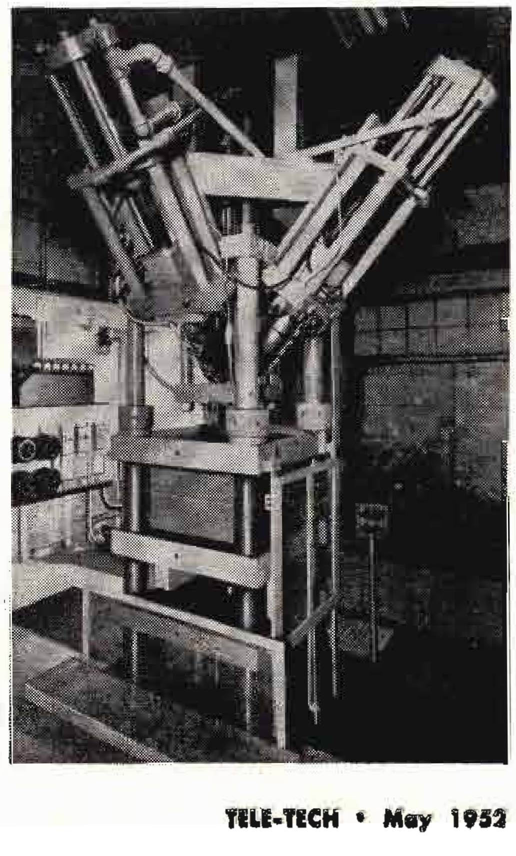
The Aluminum Association, 420 Lexington Ave., N.Y. 17, N.Y., has announced the publication of the booklet "Conservation of Aluminum" which contains material on the efficient use of available supplies of this strategic lightweight metal as well as proper handling of scrap.

Giant Plastic Moulder

A giant vertical moulding machine designed and developed by Worcester Moulded Plastics Co., Worcester, Mass., is said to possess 25% more moulding capacity than any known plastics moulding machine in existence. Four huge pre-plasticizing units preheat the plastic material to give it greater flowing properties, which together with 25% greater locking pressure on the dies, permit the moulding of pieces in large sizes never before possible.

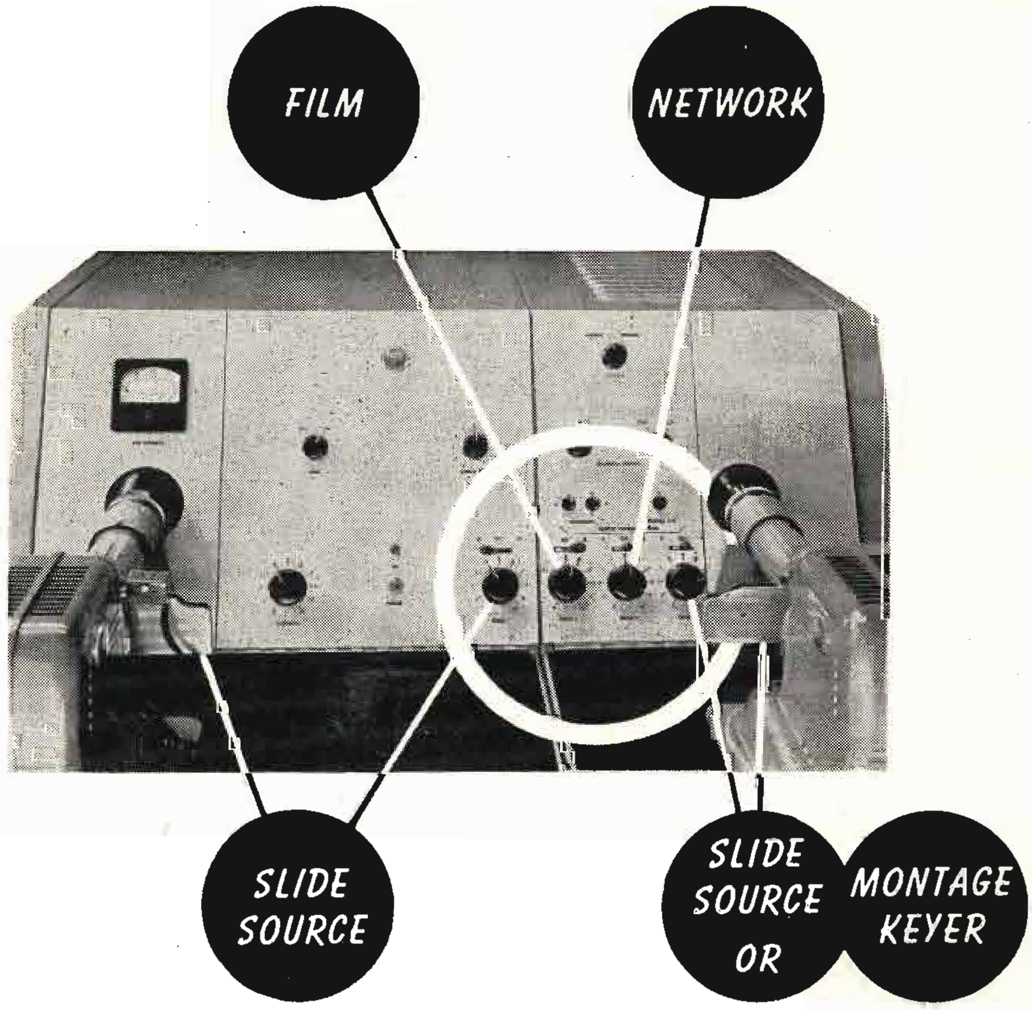
(*Continued on page* 110)

Giant moulding machine developed by Worcester Moulded Plastics Co., Worcester, Mass.



TV PROGRAM CONTROL AT ITS VERY BEST WITH

FEDERAL'S POLY-EFEX SCANNER FTL-93A



The varied transition techniques and special effects required for up-to-date programming can be accomplished with the utmost operating ease by the FTL-93A. The key to its many applications is its four channel video switcher for the two self-contained slide sources plus any two external signal sources—film, network, studio, or remotes. It permits montages, superimpositions, wipes, lap dissolves, 3 speed automatic or manual fades of all four signals to be done skillfully and effectively at one convenient operating position.

Call your Graybar distributor and have him explain how the Poly-Efex Scanner can serve your programming facilities.

FEDERAL TELECOMMUNICATION LABORATORIES

Distributed by Graybar Electric Company

Federal Telecommunication Laboratories, Inc.

An Associate of the International Telephone and Telegraph Corp.

500 Washington Ave., Nutley, N. J.

Canadian Distributor: Federal Electric Manufacturing Co. Ltd., Montreal, P. Q.

Export Distributor: International Standard Electric Corp., 67 Broad St., New York

Printed Circuit Stethoscope

The technical details of the "Lectron-O-Scope," manufactured by the Electronic Stethoscope Corp., 1316 Sherman Ave., Evanston, Ill., are of considerable interest. It is the smallest electronic stethoscope on the market, complete self-contained and pocket sized. Only 5¼ in. long and 1⁵⁄₁₆ in. in diameter, it weighs only 8 oz. including the "A" and "B" batteries. A contact microphone is employed that is sensitive to frequencies ranging between 40-2000 cps. The amplifier is a printed circuit using three sub-miniature pentode tubes. Power is supplied by a 1½ v. mercury "A" battery and a 22½ v. "B" battery. The Lectron-O-Scope has two controls—a combination "ON and OFF" switch and volume control, and a tone control, so the listening frequency can be selected.

Sounds picked up by the contact microphone placed against the patient's skin are amplified up to 72 db and put out through the doctor's binaurals by a small speaker in the main housing. The Lectron-O-Scope is available from any surgical dealer and the price is $99.50, including leather case and extra "A" battery.

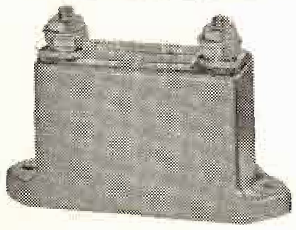
Construction details of medical stethescope that uses three stage printed circuit audio amplifier and has self-contained batteries

THE LITTLE INDIAN SAYS- "Heap good for Signals!"

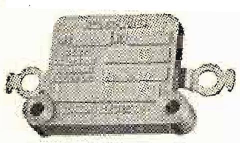
the Little Indian

SANGAMO TRANSMITTING MICAS

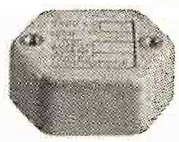
Type G (CM 75-80-85-90-95)



Type F (CM 65-70)



Type H (CM 45-50)



Type A (CM 55-60)

Built to JAN Specifications

Whether you need a certain characteristic or a combination of several performance features, Sangamo Transmitting Mica Capacitors are "heap good" for your specific capacitor applications. You can safely specify them for use in all types of military, radio and electronic equipment—they are built to meet all standards set by joint Army and Navy Specifications JAN-C-5.

Type G Capacitors are designed for use in medium and high power, high voltage and high current circuits. They are ceramic encased and are frequently connected in gangs to handle heavy loads.

Type F Capacitors are used in similar applications to type G's and are potted in bakelite cases.

Type A and Type H Mica Capacitors are molded in a thermo-setting plastic and are designed for use in low voltage, low power and low current circuits.

Sangamo Transmitting Micas and many other types of Sangamo Mica Capacitors, are fully described in Catalog No. 831. Write for your copy.

Those who know ... *choose Sangamo*

The SANGAMO Tribe

PAPER · MICA · SILVER · ELECTROLYTIC CAPACITORS

SANGAMO ELECTRIC COMPANY

MARION, ILLINOIS

IN CANADA: SANGAMO COMPANY LIMITED, LEASIDE, ONTARIO

SC52-3

News of MANUFACTURERS' REPS

Milton E. Gamble has resigned as chief engineer of the rectifier division of P. R. Mallory & Co., after seven years in that position, to become an associate of Robert O. Whitesell, 2208 E. Washington St., Indianapolis, Ind., engineering representative for manufacturers of electrical products. Mr. Gamble is a registered professional engineer in Indiana, and holds degrees from Purdue University.

G. S. Marshall Co., Pasadena, Calif., has become representative in California, Arizona and New Mexico for Eastern Air Devices, Brooklyn, N. Y., makers of small motors and blowers.

Neely Enterprises, Hollywood, Calif., has become representative for Markel Products Co., Buffalo, N. Y., makers of record changers in a 4-state western area.

Kenneth E. Hughes, manufacturers representative of 17 West 60th St., New York City, has announced that Paul W. Leighton is now associated with him. Mr. Leighton, who is a graduate of Cornell University and a licensed Professional Engineer, will assist Ken Hughes in covering industrial accounts in the Metropolitan-New York area.

Roy Magnuson, Chicago, representative for Helipot Corp., So. Pasadena, Calif., in Illinois, Indiana and Wisconsin, has now added Iowa and Minnesota.

George Davis, Los Angeles representative, 5259 E. Beverly Blvd., has changed his business name to George Davis Co.

The Astron Corp., 255 Grant Ave., E. Newark, N. J., manufacturers of electrolytic, metallized paper and other fixed capacitors and r-f noise suppression filters, have appointed the Dick Hyde Co., manufacturer's representatives, 3879 Tennyson St., Denver, Colorado. The Hyde organization will represent Astron to the jobbing and industrial trade in New Mexico, Colorado, Utah, Wyoming and South Dakota.

E. J. Baughman, who has been in electrical engineering and sales in the Far West for over 30 years, has been named as the West Coast representative of General Precision Laboratory for television equipment sales. He will handle sales of GPL image orthicon camera chains, video recorders, switching and control units, projectors and various specialized TV components. Headquarters for this West Coast office will be at 350 South Central Ave., Los Angeles.

Heppner Manufacturing Co., Round Lake, Ill., has appointed Ralph Haffey, 2417 Kenwood, Ft. Wayne, Ind., a company representative for the Indiana, Ohio and Michigan territories. He was formerly a member of Magnavox's purchasing department in Fort Wayne.

in solder *flux* cores, too...

the right size is important!

AND ONLY

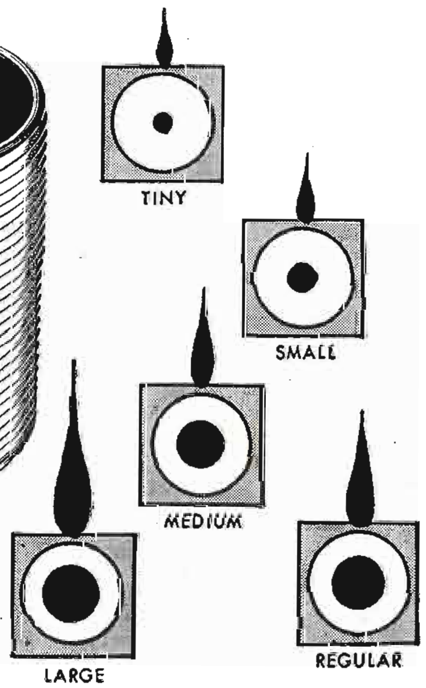
KESTER SOLDER

GIVES YOU

5

ENGINEERED CORE SIZES!

Just as in selecting the right hat size, it's important to select the correct core size in Flux-Core Solder to give you the proper predetermined amount of Flux needed to do the job right. Core size, which controls the ratio of flux to solder regardless of strand size, is always uniform with Kester.



Kester Solder meets all applicable Government and Military specifications

With five different core sizes, available only in Kester Solder, you're sure of the desired solder-spread and absolute control of flux residue. This is a "job-insurance" feature, only to be had with Kester, that will see you through satisfactorily in your production on those exacting government contracts, and all other soldering.

KESTER SOLDER COMPANY

4210 Wrightwood Ave., Chicago 39
Newark 5, New Jersey • Brantford, Canada

Servomechanisms

(*Continued from page* 67)

magnification. With the damping ratio established, Fig. 6 shows the transient response in terms of the damping ratio and the natural frequency. As shown in the diagram, the natural frequency is related to the resonant frequency by the equations below.

$$\omega_n = \frac{\omega_r}{\sqrt{1-2\zeta^2}} \quad (1)$$

where $\omega_n = 2\pi f_r$
ω_n=natural frequency (radians/min)
ω_r=resonant frequency (radians/min)
f_r=resonant frequency (cycles/min)

Thus the height of the resonance peak indicates the degree of damping and the resonant frequency indicates the time for recovery. A high peak, showing a relatively low damping ratio, would indicate that the transient response to a set point change would have large over and undershoots as indicated for the smaller values of, on Fig. 6. A system having high resonant frequency would require a shorter time for recovery than one having a low resonant frequency.

Thus the curve is easily dimensionalized with respect to time by observing the value of ω_n for the point in question. Time is given by the expression:

$$t = \frac{\omega_n t \text{ from Fig. 6}}{\omega_n} \quad (2)$$

The closed-loop frequency response can be measured or it may be derived from the frequency response of the components used to make up the closed loop. If for example, A, B and C are components for which we know the transfer functions, the over-all open-loop transfer functions can be determined by multiplying the amplitude ratios and adding the phase angles. Thus, the open-loop frequency response for one frequency is shown below.

$$Ms = M_A \times M_B \times M_C \quad (3a)$$
$$Ps = P_A + P_B + P_C \quad (3b)$$

where M = Amplitude Ratio
P = Phase Lag

With the amplitude ratio and the phase shift established for a number of these frequencies, the open-loop transfer function of the system comprised of the components is, in effect, predicted. The conversion from the open-loop frequency response of the system to the closed-loop frequency response is easily accomplished graphically or by charts which will not be discussed here.

Thus, it has been shown that the

(*Continued on page* 116)

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closed-loop frequency response which is representative of the system transient response can be measured on an existing system or computed from the component responses.

Part Two will appear in the June issue.

Magnetic Tape

(*Continued from page* 46)

source of 60 cycle supply current such as the Ampex Model 375 amplifier (see Fig. 6) is essential. A stable 60 cycle frequency source is generated by a tuning fork which is accurate to 5 parts/million/°C. The amplifier portion of this unit delivers 60 watts, ample to operate the synchronous drive motor. Any sudden change in frequency or power loads that may normally occur in the supply source will be completely isolated from the critical tape drive mechanism. Therefore, instantaneous power line fluctuations cannot affect the accuracy of the recorded data.

The new Ampex Model 500 (see Fig. 7) incorporates exclusive features which radically depart from previous concepts of tape drive mechanisms. Because of this development, wow and flutter have been reduced without flutter compensation equipment to the point where the playback of recorded tapes will actually duplicate original test data in every practical respect.

Actually, more than 5 to 1 flutter improvement has been achieved over the best available tape recorders and typical measurements indicate only 0.052% peak-to-peak. However, since no well defined standards for measuring wow and flutter have ever been established for magnetic tape equipment, the full significance of this statement may be overlooked. For example, conventional flutter bridges only measure rms conditions over a frequency range that does not exceed 200 or 300 cycles. In tape recording, flutter produces instantaneous as well as bursts of peak deviations which may far exceed average or rms values. Therefore, serious short time errors may be present in a recording system which will go undetected with rms measurements.

Part Two will appear in the June issue.

Transistor Sales

The Department of Defense has announced the award of a contract with Western Electric Co. for the purchase of 32,000 transistors at a cost of $240,000.

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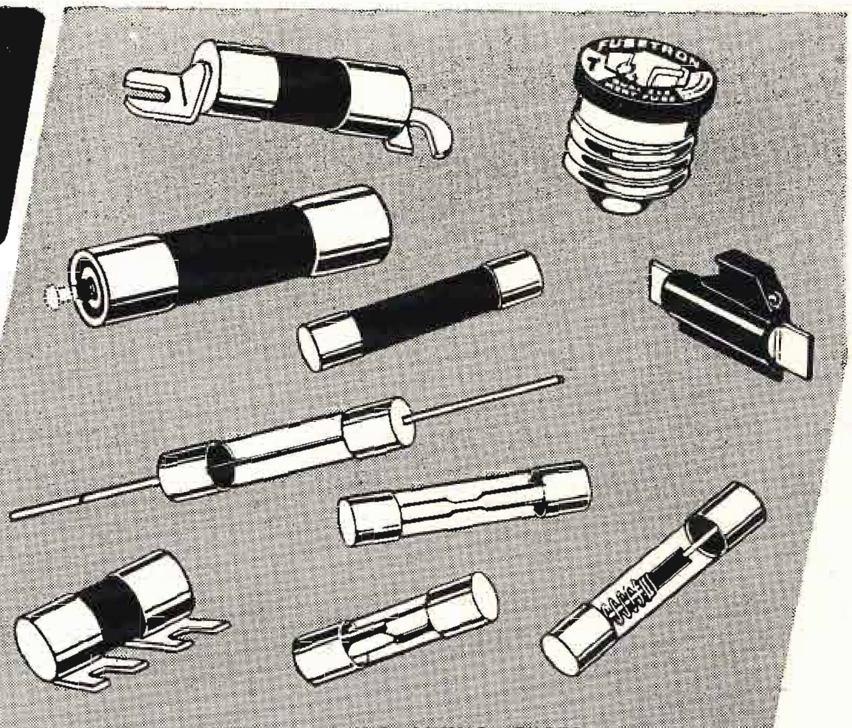

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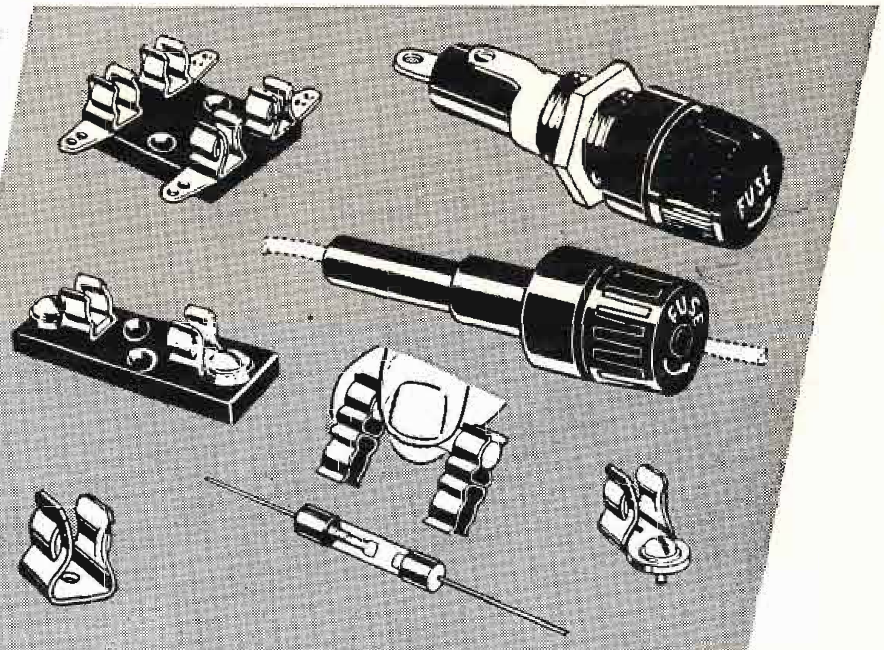

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ILS for Aircraft

(Continued from page 47)

section gives the position of the aircraft in space. The pilot need only keep the intersection within the center circle of the indicator by manipulating the plane's controls, and his glide path will coincide with the one mapped out in space by the UHF lobes.

Performance Tests

Over 200 approaches or transverse passages were observed. Photographs were taken of the landings and recordings of cross-pointer indications were made. Descents were also made using the receiver output signals to control an automatic pilot. Results indicated that the required 40 km range was exceeded over a horizontal sector of 60° centered on the landing path. Satisfactory operation resulted up to 100 km from the runway over sections within 15° on either side of the landing path.

Localizer coverage over the 40 km range was more than ±30° about the landing path for an angle between 0.75° and 7° above the horizontal, which was more than covered by the glide path. Localizer accuracy under manual or automatic piloting was about 0.3°, while glide path accuracy approximated 0.1° and 0.05° for manual and automatic, respectively. Approach-to-runway accuracy was better than ±12 m.

Systems Comparison

Comparison of CSF's ASV 23 with conventional ILS highlights the advantages of the French system. In ILS, the glide path is obtained by utilizing the ground reflection of horizontally polarized waves, with the possible introduction of interfering fringes which cause ridges on the descent path. The CSF system employs highly directional antennas, does not rely on reflected waves, and results in a more uniform path unaffected by terrain conditions.

Equipment-wise, ASV 23 requires one transmitter, one receiver and three antennas, all operating on one frequency. In contrast, ILS employs two transmitters, three beacons, and three receivers operating on three frequencies.

Distance information with ILS is given at three specific points corresponding to the positions of the beacons located along the path at 7 km, 3 km and at the approach end of the runway. With the CSF system, distance is provided continu-

(Continued on page 120)

ously even when the aircraft is not entirely on course, thus facilitating approach and landing at the proper time. Also, maintenance of three beacons used in isolated positions with ILS is more difficult than repairing the ASV 23 next-to-runway antennas.

Finally, a small course deviation in ILS (as little as 0.9° for a 60 m wide runway) is sufficient to place the descending airplane off the field because azimuthal guidance is given by a transmitter located on the extended center line of the runway about 2 km from the stop end. The fact that the pilot brings his plane in between two course antennas located on each side of the runway in the CSF system, allows a course deviation of about 3° without presenting any major difficulty.

As We Go to Press . . . .

FILM SCANNER SYSTEM

DuMont has presented a preview of their 16 mm flying spot scanner-continuous motion film pickup system which will be available in 1954. TV broadcasters may operate the mechanism at variable speeds as a projector, or may use the system as a recorder to photograph pictures from the CRT face in the local station. The unit is gamma corrected for grey scale, requires no phasing to the sync generator or power line, needs no shading or rim and back lights, and may be adapted to any future color system. The continuous motion mechanism eliminates intermittent film movement.

AUDIO CONSOLES

Altec Lansing's new line of plug-in consoles and amplifiers designed for TV, FM and AM use miniature tubes and smaller transformers to reduce overall dimensions. The consoles contain all necessary amplifiers, power supplies, relays and controls, so that external accessories are not required.

TV FILM PROJECTOR

Incorporating an Eastman type 25 projector mechanism, GE's new 16 mm Synchro-lite type PF-5A TV film projector uses a pulsed xenon gas flash lamp instead of a mechanical shutter. The projector has a two hour reel capacity, and film may be stopped at any point without overheating. Type PE-5A film camera channel associated with the projector accommodates positive or negative film prints, and features an ad-

(*Continued on page* 127)

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Nonlinear Elements

(*Continued from page 57*)

knees in their hysteresis loops, the conversion efficiency of such reactive detectors may easily be seen to be much greater than that of conventional detectors and diodes.

The new form of reactive and polaresistive detection opens the field for significant improvements up into the microwave region. More details, however, are far beyond the scope of our considerations.

6. Frequency modulation also may be achieved by the use of varistors, provided they operate in combination with a fixed reactance. Fig. 7 illustrates the basic schematic of a resistive-reactive push-pull modulator. The left varistor R_1 operates in series with the fixed capacitor C_s while the second varistor R_2 shunts the oscillator circuit in series with an inductance L_s. In order to assure both individual frequency modulations to superimpose each other, both varistors must be modulated in push-pull with the additional result that the parasitic amplitude modulations neutralize each other.

Instead of controlling the varistors by means of an external supply voltage, asymmetrical diodes may simply be loaded with fluctuating resistors or resistive transducers such as carbon microphones, carbon pickups, or strain gauges. The external supply source then is replaced by the rectified dc current; in other words, the transducers are actually fed by the plate voltage of the oscillator tube via the r-f energy and the subsequent detector action.

Frequency Control

Another FM or frequency control method results from the replacement of the resistors in a phase-shift network or a Wien-bridge circuit with varistors. Such a phase-shift generator may be used for wobbling purposes or in order to achieve a large frequency range.[14]

7. We remember the fact that the effective reactance as well as the effective resistance of any nonlinear element does not only depend on the external bias but also on the impressed r-f amplitude. A ferroelectric capacitor, when operating without bias, can easily be seen to produce a "capacitive rectification," or more accurately, a rectification of the displacement current, as long as the r-f cycle controls a nonlinear portion of its characteristic. In other words, the average zero capacity decreases when the impressed r-f

(*Continued on page 124*)

amplitudes increase. The same phenomenon occurs with resistive-reactive modulators because the a-f resistance of the varistor increases from its initially differential value to a type of "reversible" value.

This phenomenon manifests itself in two different ways. If the tank circuit of an amplitude modulated oscillator contains one of the described modulators, the amplitude modulation automatically is transformed into frequency modulation. This may be seen more clearly if we consider the resonance curve of the nonlinear tank circuit. At very low r-f amplitudes, the modulator operates linearly, i.e., the dotted reson-

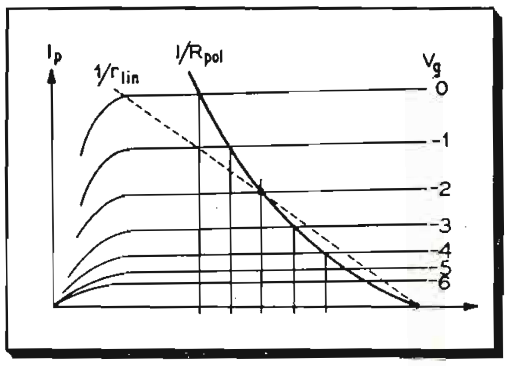


Fig. 10: Linearization of a pentode amplifier by means of a nonlinear plate resistor

ance curve in Fig. 8 is symmetrical around the resonance frequency f_0. At higher r-f amplitudes, however, the average reactance of the modulator changes and the resonance frequency of the tank circuit is shifted accordingly, as illustrated by the dashed characteristic of Fig. 8. The combination of both curves results in a deformation of the original resonance curve which, in our example, assumes the solid form. By means of this diagram, the transformation of AM into FM may easily be seen.

8. Besides the shifting of f_0, we see the resonance curve being asymmetrically deformed in that one flank becomes steeper than the other. Under a sufficiently high nonlinearity, the one flank may assume an infinitely great slope or even a negative slope so that the tank circuit becomes unstable. Without going into greater detail, I only want to point out a new possibility for developing asymmetrical band filters in which several of the described nonlinear resonance circuits are coupled. Such asymmetrical band filters may be useful for single-sideband transmission.

According to the reciprocity theorem, a similar device allows the conversion of FM into AM so that new discriminators result. The simplest frequency demodulation is achieved

(Continued on page 126)

by controlling the steep flank, a method permitting a high sensitivity as soon as the instability condition is approached. Two nonlinear resonance circuits, the one containing a ferroelectric capacitor, the other a saturable r-f reactor, may be combined in the form of a push-pull discriminator.

On the other hand, with the aid of a negative slope, trigger discriminators may be produced.

9. Let us turn back to a polaresistive detector, the function of which may be illustrated by means of the detector characteristics depicted in Fig. 9. When loaded with a fixed resistor, illustrated by the dashed loadline, the output voltages across the load follow a square law. This nonlinearity, however, is reduced when the square-law detector is loaded with a second varistor as can easily be seen by means of the solid load curve. The nonlinearity of the detector itself is canceled by that of the load resistor.

It is easy to apply a similar linearization to any electronic device. As a perfect example let us consider a vacuum tube amplifier. The well known plate characteristics of a pentode, as shown in Fig. 10, when intersected by the dotted loadline, produce harmonic and intermodulation distortions which limit the permissible control range and therefore the permissible output power and efficiency. The distortions decrease, between certain limits, as soon as the fixed plate resistor is replaced with a varistor which may be characterized by the solid load curve. Obviously, the distortions can be considerably reduced or, on the other hand, the efficiency can be increased. Experiments gave the practical result that the output power of a pentode, limited by 4% harmonic distortions, could be increased 25% merely by replacing the conventional plate resistor with a polaristor.

Instead of inserting the linearizer into the plate circuit, it may also be utilized in the form of a nonlinear feedback channel. The modifications are much too numerous to be described even in the smallest details.

On the other hand, the function of the nonlinear element may be reversed in such a way as to increase the nonlinearity. The simplest method, equivalent to a negative feedback, is a nonlinear cathode resistor. If we make the feedback factor large enough, we asymptotically reach a condition wherein the nonlinearity is completely determined by the feedback element and not any more by the amplifier itself.

(*Continued on page* 128)

As We Go To Press

(*Continued from page* 120)

justable deflection yoke, automatic background control, sweep failure protection circuit and sweep reversal switch to correct for picture reversal resulting from mirror changeover.

VHF AMPLIFIERS

Anticipating an FCC authorization for increased power for TV stations, General Electric has announced two VHF amplifiers which may be added to existing and future transmitters. The 35 kw unit is intended for channels 2 through 6, while the 20 kw amplifier will be used for channels 7 through 13.

TV TRANSMITTING EQUIPMENT

General Precision Labs. has revealed an image orthicon camera chain with control and indication of lens aperture at the camera control unit, and remote control of optical focus and lens turret position. A sync pulse generator employs binary counters and delay line control of pulse timing. The video switching and mixing unit provides facilities for handling five synchronous and two non-synchronous signals.

LOW-POWER UHF TRANSMITTER

General Electric has announced a 100-watt UHF transmitter selling for $55,000, including the cost of the antenna. This complements two other transmitters, 1 kw and 12 kw units, placing before the potential UHF TV broadcaster a line of transmitter-antenna systems capable of radiating 1 kw, 100 kw, and 200 kw erp, respectively. The low-power transmitter, which costs one-fourth as much as the most powerful model, covers an audience area of 8 to 10 mi. radius when the antenna is mounted 250 ft. above average terrain.

(*Continued from page* 126)

As far as the new applications are concerned, only the basic phenomena have been checked by experiments. Various additional problems must be solved to realize a high sensitivity of the reactive detector, a high conversion factor of the AM-FM converter, or a negative flank of a resonance curve without additional damping. Such important details as an equivalent circuit analysis for each individual case, a more thorough study of temperature coefficients, frequency response, and noise figure are necessary before the complete picture of all individual examples can be ascertained. Nevertheless, the common aspect opens significant outlooks for the entire field of nonlinearities.

[9] J. Rabinow, "Magnetic Fluid Clutch," Tech. News Bull. Bur. Stand., vol. 32, pp. 54-60, May, 1948

[10] W. M. Winslow, "Induced Fibration of Suspensions," Journ. Appl. Phys., vol. 20, pp. 1137-1140, Dec. 1949

[11] H. L. Donley, "Effect of Field Strength on Dielectric Properties of Barium Strontium Titanante," RCA Review, vol. 8, pp. 539-553, Sept., 1947

[12] A. L. Pressman and J. P. Blewett, "A 300- to 4,000-Kilocycle Electrically Tuned Oscillator," Proc. I.R.E., vol. 39, pp. 74-76, Jan., 1951

[13] A. van der Ziel, "On the Mixing Properties of Nonlinear Condensers," Journ. Appl. Phys., vol. 19, pp. 999-1006, Nov., 1948

[14] L. A. Rosenthal, "Wide-Range Sweeping Oscillator," Electronics, pp. 114-116, Oct., 1951.

This paper was first presented before the National Electronics Conference in Chicago, Ill. Oct. 22-24, 1951.

BULLETINS

Magnet Wire

Newest addition to the Sprague high-temperature magnet wire family is Ceroc ST wire. This 250 wire combines the inorganic ceramic insulation of Ceroc 200 with a single outer coating of Teflon instead of a double coating, as in the older Ceroc T wire. Ceroc ST has excellent electrical properties approaching that of Ceroc T while its diameter is substantially reduced to approach that of Ceroc 200. Complete data on this important new development is given in Engineering Bulletin No. 404. Write Sprague Electric Company, North Adams, Massachusetts.

Thermostat

The Instrument Division of Thomas A. Edison, Inc., West Orange, N. J., announces availability of a new specification sheet on their miniature thermostat for applications in small baking and crystal ovens; electric heating pads; small electrically controlled platens; electric heat control to prevent freezing of bearings in ADF loops, anemometers, etc.; battery charging systems—for protection against excessive electrolyte temperatures.

Towers

Electric Tower Service, Inc., 202 N. Main St., Creve Coeur, Ill., has published a bulletin describing their tower erection service for radio and television installations. A complete list can be furnished of tower and construction jobs that the company has completed, names for reference purposes, and facts or information on any Electric Tower installation. Inquiries are welcome.

Hermetically-Sealed Components

Hermetic Seal Products Co., 33 South 6th St., Newark 7, N. J. has released a bulletin describing the company's line of crystal holders, multi-terminal headers, and crystal holder components. Detailed diagrams and photos are included.

Potassium Silicate Binder

Kasil No. 1 Potassium silicate binder for CR tubes is the subject of a bulletin published by the Philadelphia Quartz Co., Public Ledger Bldg., Philadelphia 6, Pa. Although Kasil No. 1 is a technical material produced and shipped in carload quantities, it meets many specifications to which laboratory reagent chemicals do not conform. It is extremely low in harmful impurities such as copper, nickel, manganese and iron. Spectrographic analysis has repeatedly indicated the absence of copper. The amount of sodium present is also at a minimum.

TV Tube

Hytron Radio & Electronics Co., Salem, Massachusetts, has issued Engineering Bulletin #E-187 describing their type 17QP4, a 17 rectangular, all-glass, picture tube incorporating a cylindrically shaped face plate. This tube is magnetically focused and deflected and incorporates the following features: single ion-trap gun design; neutral density face plate for better contrast; external conductive coating for increased anode supply filtration and radiation shielding.

Tube Sockets

The 1952 12-page Cinch-Erie catalog is designed to provide engineers, designers and draftsmen a source of useful and pertinent information on Cinch-Erie vacuum tube sockets. It includes descriptions of each component, helpful engineering and electrical data, information on materials, capacitor characteristics and specifications, mounting diagrams, illustration, designations and instruction on how to order. It may be had by writing Cinch Manufacturing Corporation, 1026 South Homan Ave., Chicago 24, Ill.

Carrier Equipment

The Lenkurt "Demodulator" is a new house organ which will be mailed regularly to individuals interested in the field of telephone and telegraph carrier equipment by the Lenkurt Electric Co., San Carlos, Calif. Requests for the copies should be addressed to the Publications Department, and should include name, company, position and address.

CRYSTAL DIODES IN THE MILLIVOLT REGION

(Continued from page 42)

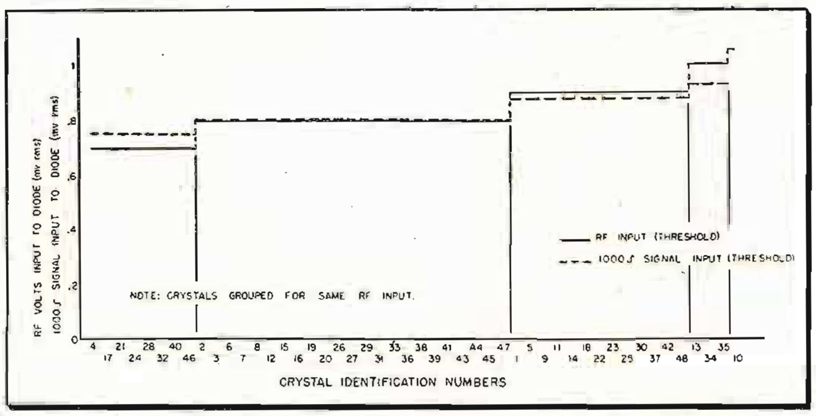


Fig. 11: Threshold r-f and signal input for M-R resistance, type 1N56.

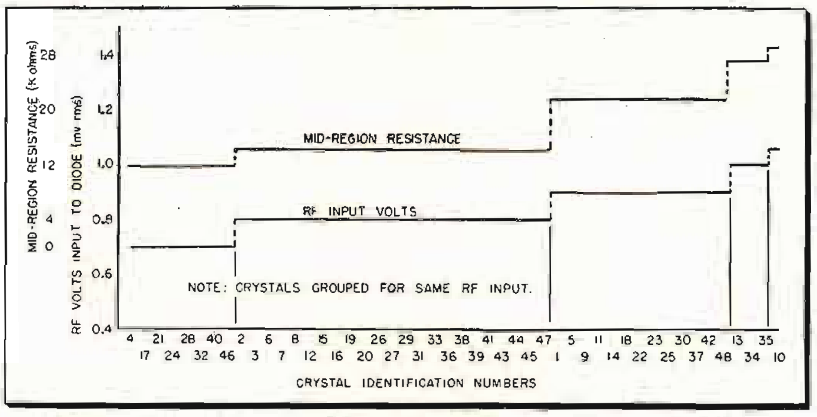


Fig. 12: M-R resistance and threshold r-f input voltage, type 1N56

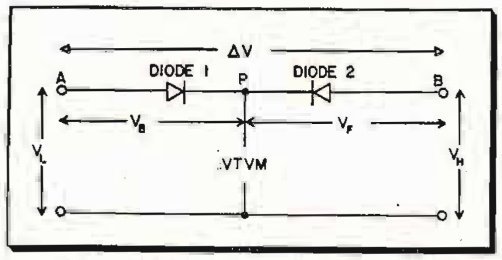


Fig. 13: Diagram showing peak voltage selector for only two of the n circuits

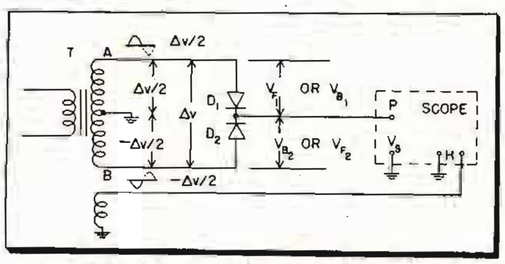
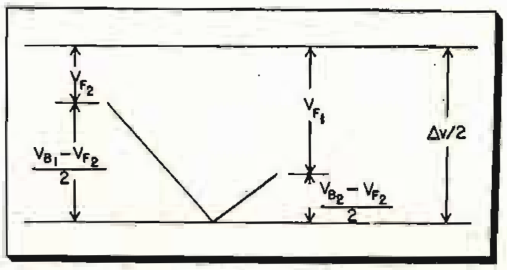


Fig. 14: Selector diode analysis circuit

another (noting, of course, that the shape of these curves indicates voltages somewhat in excess of the mid-region). The low portion, Fig. 17, indicates a combination voltage curve for both diodes simultaneously, where ΔV on the base line is the sum of the V_F of one crystal and the V_B across the other. It is easy to see that the same current is flowing through both diodes and therefore these two curves cross at the same current value.

Another representation of this voltage selection analysis is shown in Figs. 14 and 15 where two crystals are placed in opposing polarity across a balanced ac voltage source. The trace on the oscilloscope shows as a letter V which will have arms of the same length when the two crystals are alike. In the example, diode #1 has a higher forward resistance than diode #2.

Fig. 15: Oscilloscope representation



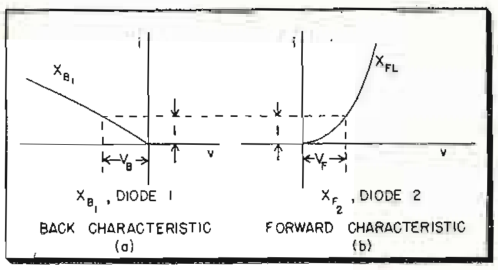


Fig. 16: Curves showing back region for one crystal compared with the forward of another

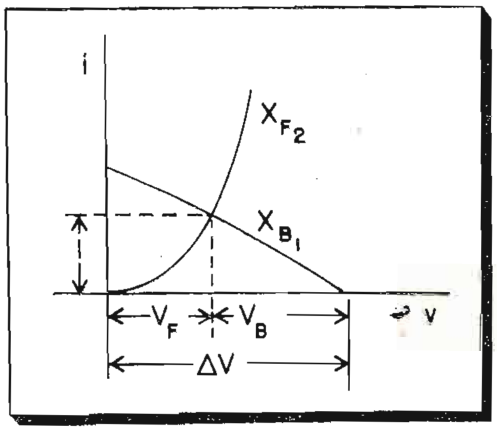


Fig. 17: Combination E-I curve for both diodes

This brief account of some measurements of crystals at low voltages may encourage further detailed analyses. Since no diodes yet measured will rectify at voltages below approximately one millivolt, more emphasis may be placed upon further research in new materials suitable for lower voltage rectification.

The authors express their appreciation to E. H. Ulm of the Electronics Division for his encouragement of this experimental work. They are also glad to acknowledge the assistance of N. P. Salz during the beginning of this project and of E. J. Cuddy and E. F. Prufer of our laboratory in making numerous measurements.

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Antennas for Jets

(*Continued from page* 38)

wave dipole, a factor of safety is available as the antenna gain would result in a greater field strength in free space.

In the case of the localizer ground antenna, since its radiation pattern is directional, an antenna gain of 1.5 db over a half-wave dipole is assumed. These calculations show that the wing tip antenna will give a signal at the input terminals of the receiver greater than the required minimum at all angles where the equi-signal diagram of Fig. 3 indicates a field strength greater than 0.805 mv/m. As mentioned previously, the one deep null just aft of the right wing tip will not provide sufficient reception to satisfy this requirement, but inasmuch as the null is extremely sharp the probability of its effect being noticed during normal flight procedure is remote.

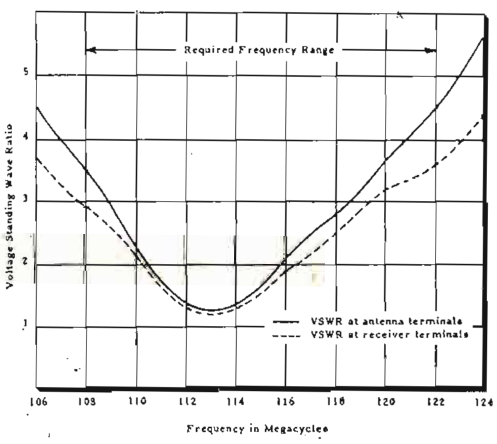


Fig. 8: VSWR characteristic of mounted antenna

After the radiation pattern study showed that a wing tip antenna gave a relatively omnidirectional pattern, a full scale mock-up was constructed including all details of the left wing tip. The mock-up was such that it extended approximately one and one-half wavelengths from the antenna location, and was made of wood spars covered with terne metal and soft soldered as shown in Fig. 6. The measurement of the vswr on the full-scale prototype antenna was carried out with the mock-up approximately the same height above ground as the actual wing tip of the aircraft. Conventional slotted line

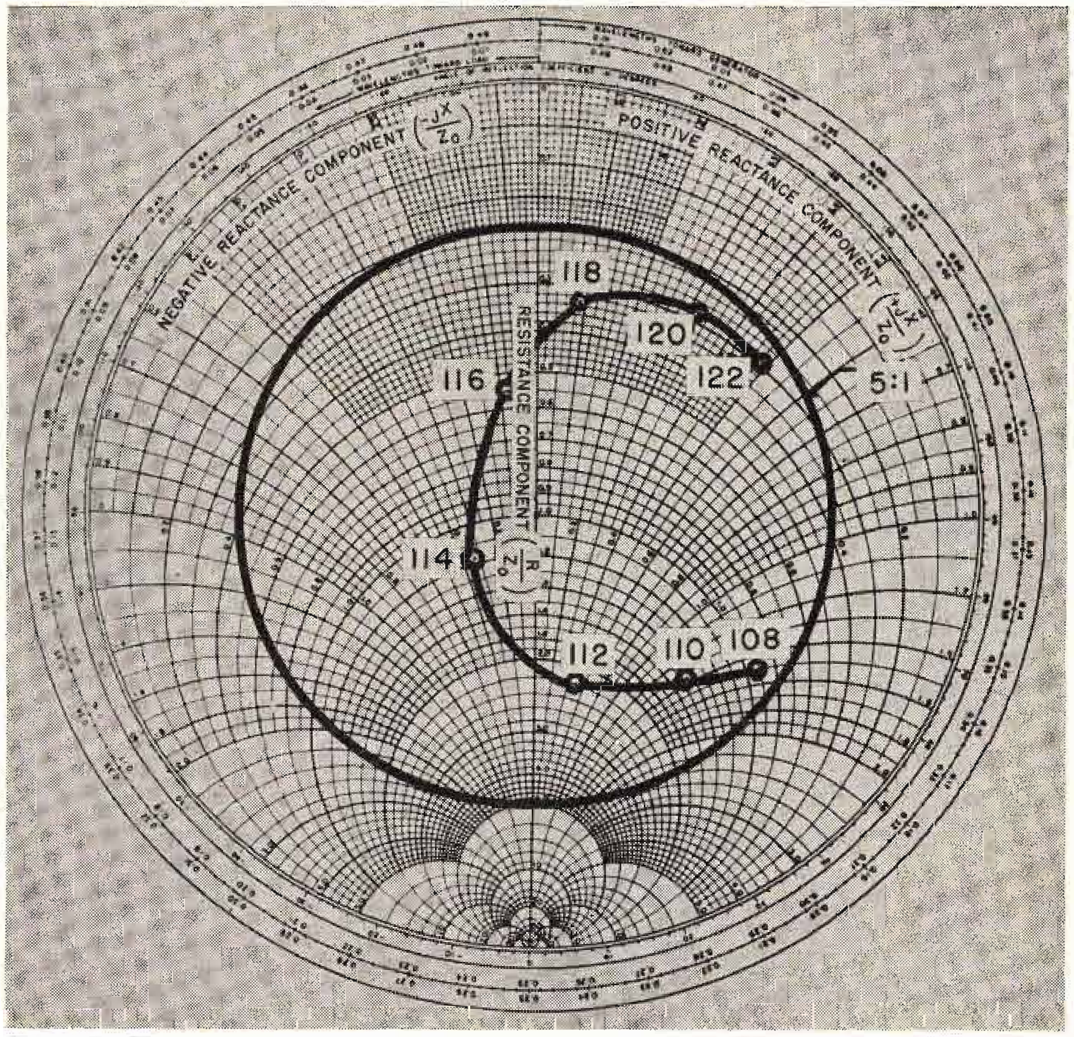
(*Continued on page* 134)

Hermetic Sealing Service

Formation of the Hermetic Sealing Corp., 99 E. Hawthorne Ave., Valley Stream, N. Y., has recently been announced by William Brown, president. The company provides vacuum sealing service for all types of radio equipment.

ANTENNAS FOR JETS

(*Continued from preceding page*)



technique employing a precision slotted line was used to obtain the vswr measurements.

Numerous models of a shunt fed quarter-wave element were investigated using tubing, flat strip and rectangular bar for the radiating element, and the final choice of material was a flat strip of 24SO aluminum. A fiberglas supporting member, also within the fiberglass wing tip, necessitated the use of a plastic support near the aft end of the radiating element and the capacity loading effect of both this support and fiberglas rib made it possible to shorten the antenna several inches. The final prototype antenna was mounted on the mock-up as shown in Fig. 7, and an impedance curve is given in Fig. 9. It may be seen from the vswr characteristic of the mounted antenna, Fig. 8, that the specification requirement of a vswr of 5:1 is satisfied and that the vswr is less than 4:1 over 86% of the frequency band.

The writer would like to take this opportunity to thank Mr. Ben Zieg and Mr. D. A. Grunow, of Electronics Research, Inc., who assisted in obtaining the data presented in this paper.

← **Fig. 9: Impedance curve of wing tip prototype antenna on mock-up plotted on Smith chart**

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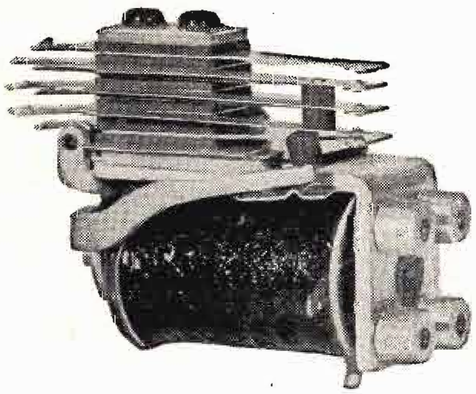

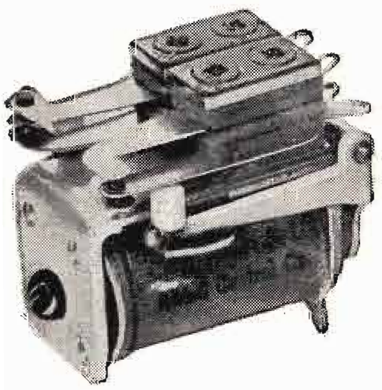

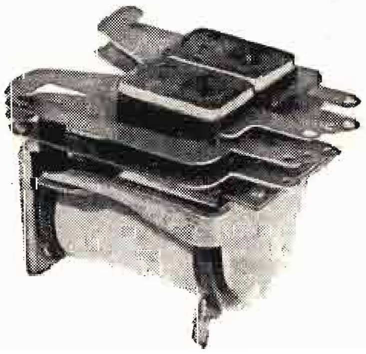

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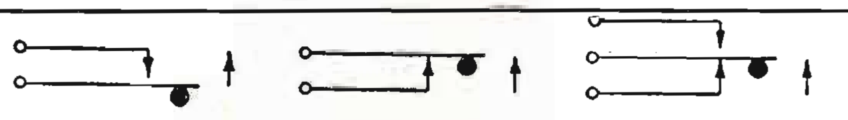

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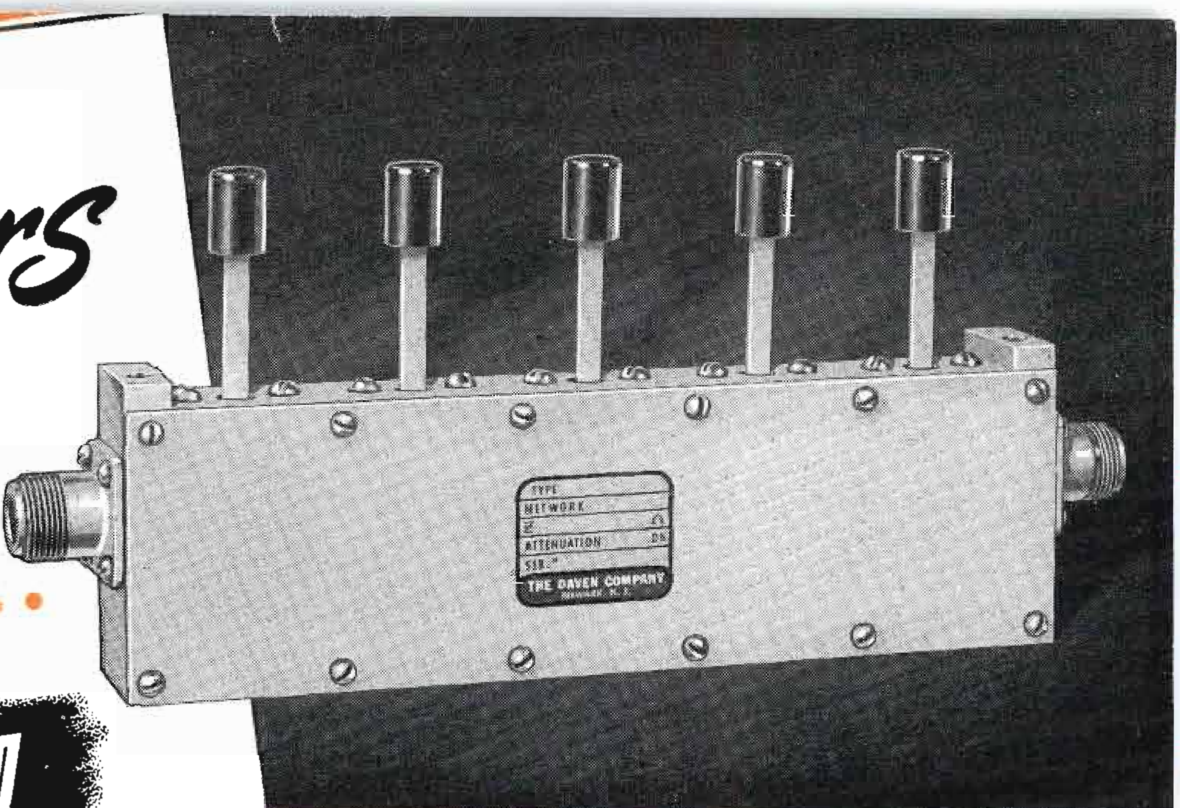

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RFA & RFB 543	20, 20, 20, 20 DB	80	50/50Ω and 73/73Ω
RFA & RFB 550	1, 2, 3, 4, 10 DB	20	50/50Ω and 73/73Ω
RFA & RFB 551	10, 10, 20, 20, 20 DB	80	50/50Ω and 73/73Ω
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