PRICE TWENTY-FIVE CENTS

FM AND TELEVISION

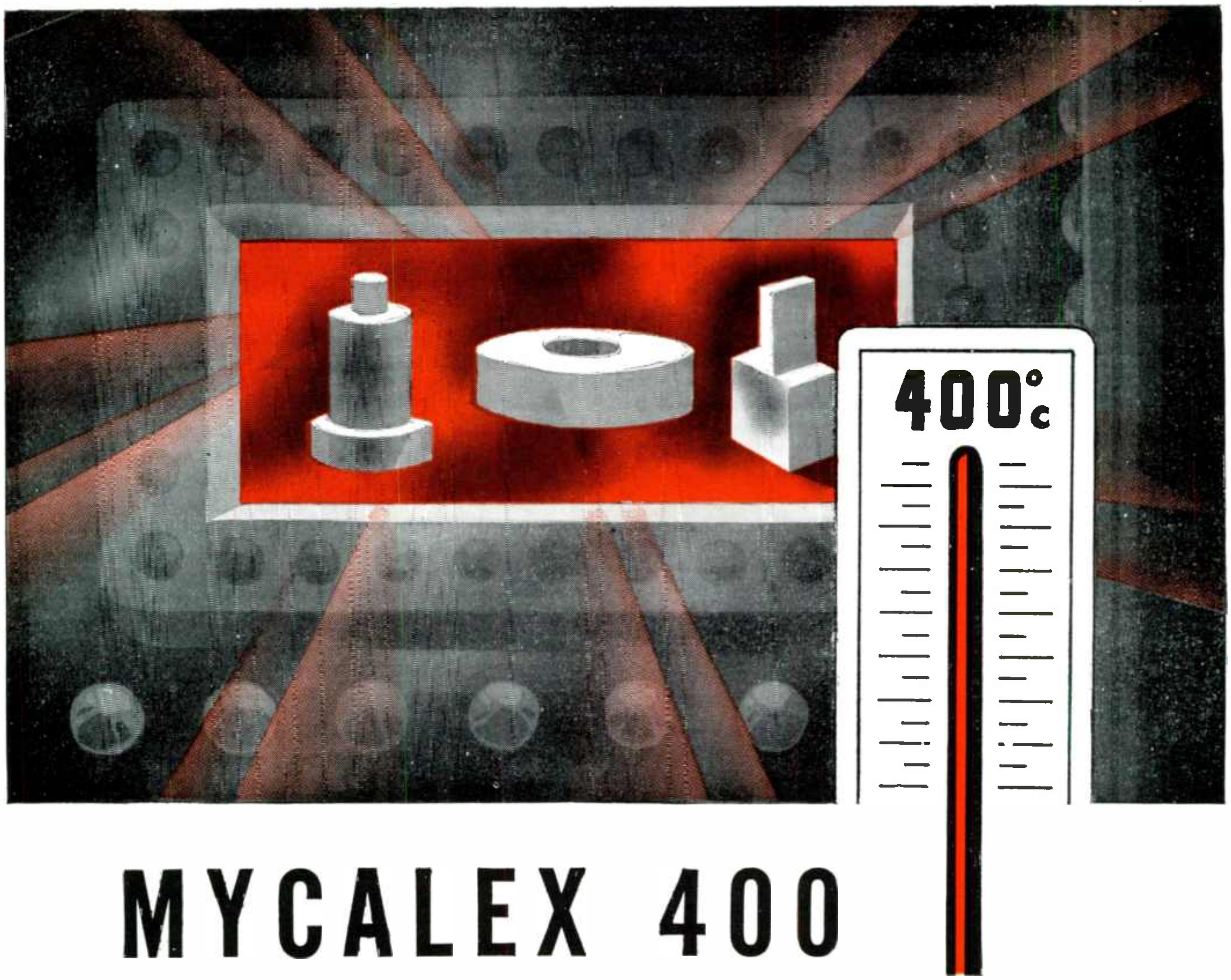
APRIL 1946

CONSTRUCTION OF AN EXPERIMENTAL FM ANTENNA

SEE PAGES 3 AND 23

PRODUCTS DIRECTORY

★ ★ Edited by Milton B. Sleeper ★ ★



MYCALEX 400

WITHSTANDS HIGH TEMPERATURES

An outstanding characteristic of MYCALEX 400 is that it can withstand temperatures above 400° C. without softening or any permanent change in dimensions or properties.

Thus MYCALEX 400 has proved of great value as a low loss insulator in communications and other high frequency apparatus intended for use at elevated operating temperatures.

MYCALEX 400 is inorganic, free of carbonization . . . impervious to oil and water . . . not subject to cold flow. It meets all Army and Navy specifications as Grade L-4 material (JAN-I-10). It combines low loss factor with machinability to close tolerances. In sheets and rods. Fabricated to specifications.

SINCE 1919
MYCALEX
THE INSULATOR
TRADE MARK REG. U. S. PAT. OFF.

OTHER MYCALEX CORPORATION PRODUCTS

●

MYCALEX K

A series of ceramic capacitor dielectrics, with dielectric constant selectable from 8 to 19. Low power factor, high dielectric strength. Meets Army and Navy requirements as Class H material (JAN-I-12). To specifications.

MOLDED MYCALEX

Low loss, high temperature injection molded insulation. Molded in union with metals in irregular shapes. High production rates result in economical prices.

MYCALEX K and MOLDED MYCALEX will also withstand 400° C.

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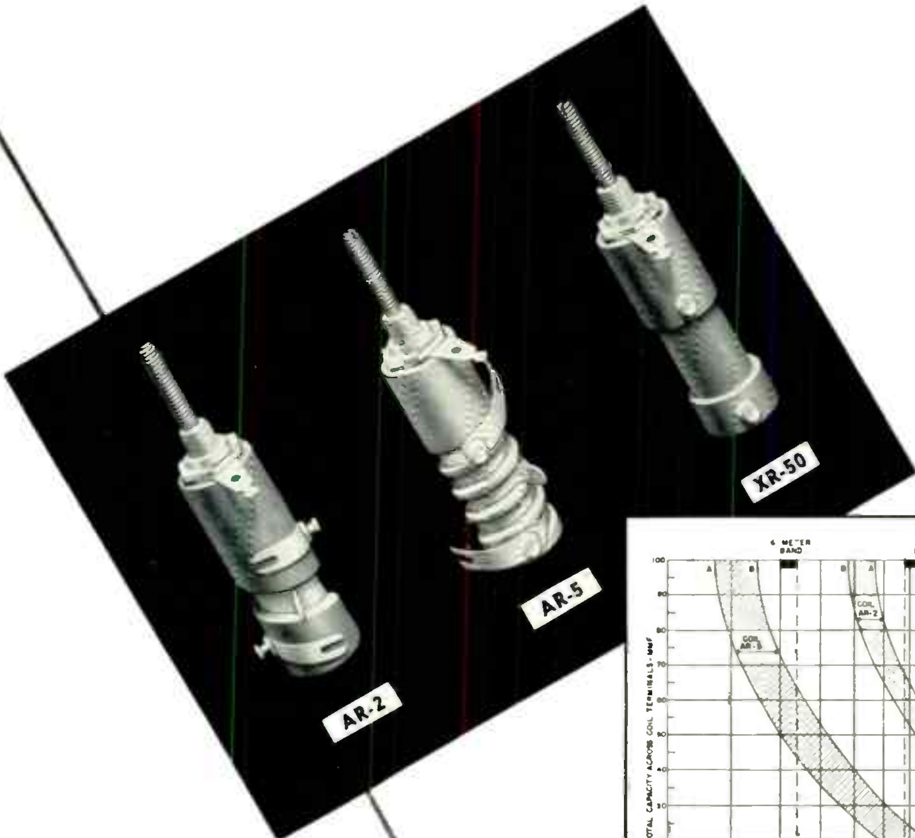
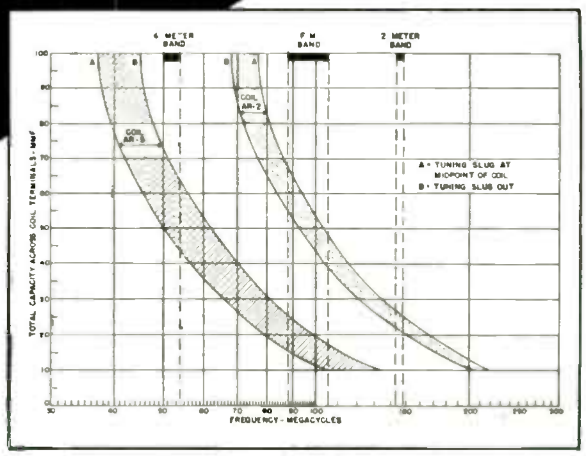
"Owners of 'MYCALEX' Patents"

Plant and General Offices, CLIFTON, N. J. *Executive Offices,* 30 ROCKEFELLER PLAZA, NEW YORK 20, N.Y.





Here are the postwar high frequency coils amateurs will need for work with the micro-waves. Originally designed to meet Navy requirements, these new high-Q units have adjustable inductance and give fine performance as high frequency oscillators, RF stages or frequency multipliers. Two coils are available covering the range from 37 to 220 Mc. A blank form, Type XR-50, may be wound as desired. All three are small and compact, and all are designed for convenient single-hole mounting.

NATIONAL COMPANY, INC., MALDEN, MASS. U.S.A.

FM AND TELEVISION

FORMERLY: FM MAGAZINE and FM RADIO-ELECTRONICS

VOL. 6 APRIL, 1946 NO. 4

CONTENTS

★ ★ ★ ★ ★ ★

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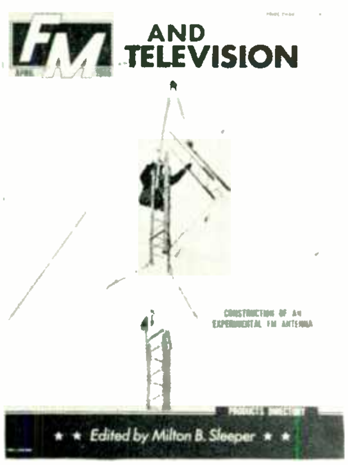


THIS MONTH'S COVER

The best way to determine the results that can be obtained from a really good receiving antenna is to build one. Moreover, the availability of a suitable tower opens the way to many useful, practical determinations. And the erection of a tower, even of relatively modest dimensions, is in itself an interesting project. That's why *FM* AND TELEVISION is putting up an experimental installation at Monterey, Mass., 7 miles east of the publication office at Great Barrington. This month's cover shows one of the tower sections being swung into place — a tricky job, and very interesting to sidewalk superintendents.

Entered as second-class matter, August 22, 1945, at the Post Office, Great Barrington, Mass., under the Act of March 3, 1879. Additional entry at the Post Office, Concord, N. H. Printed in the U. S. A.

WHAT'S NEW THIS MONTH

1. FCC Censorship
2. AFM vs. FCC
3. Added Taxes

1. The FCC Blue Book entitled *Public Service Responsibility of Broadcast Licensees*, issued on March 7th, contains statistical criticism of radio program service so well deserved that it should send a chill down the collective spine of broadcast station management. When, for example, a station is laid open to the complaint that it emitted an average of more than 16 spot announcements per hour throughout a week's operation, something should be done to protect radio listeners from such inhuman treatment.

However, a careful reading of this bold step into program censorship on the part of the FCC shows that its concern over the public service rendered by broadcasters may be just another angle of approach to the rapidly-developing political-party control of broadcasting. The purpose behind this FCC action, illuminated by the light of the record, indicates that the chairmanship of the FCC is being developed into a mechanism for implementing the distribution of political patronage, to outrank the office of Postmaster General.

If the FCC is permitted to carry out the implications of its Blue Book, we may well see broadcast stations change ownership and management with the same certainty that postmasterships come and go with changing administrations.

Is that an extreme view? If it seems so, read the Blue Book again. You will find that the ground work is laid for refusal by the FCC to renew station licenses *at the discretion of the Commissioners*. No rule is proposed for the guidance of all station operators. The FCC does not propose to put the individual operator in a position to say: "I complied with the Commission's requirements as to the composition of my programs. I transmitted even more than the specified percentage of programs in the public service categories, and somewhat less of income-producing programs. Therefore, I have qualified for the renewal of my station license."

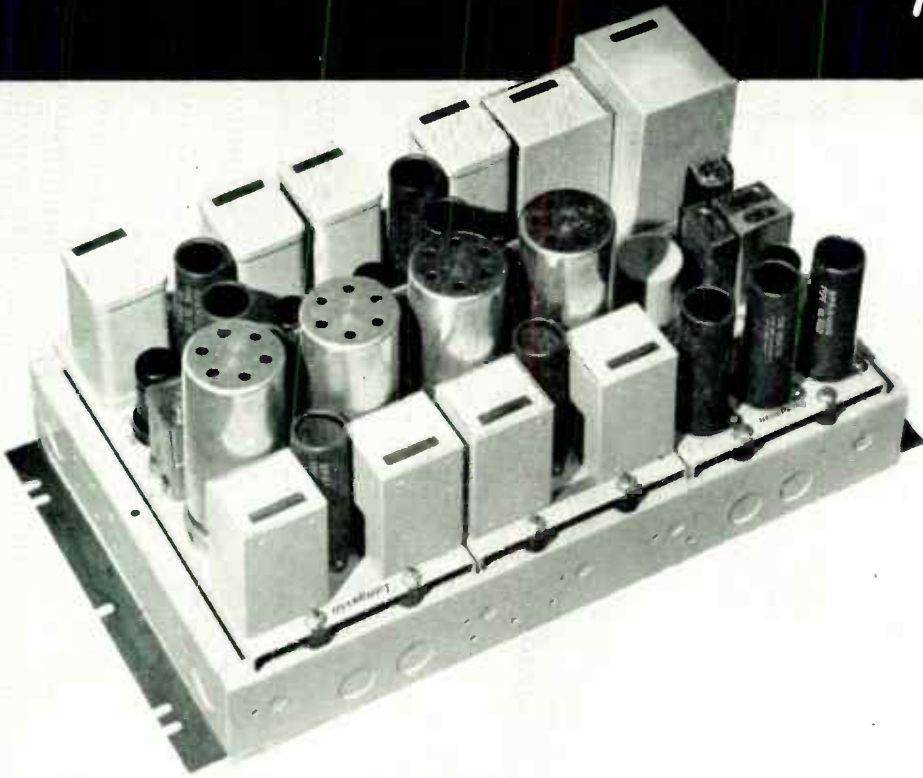
Instead, the FCC has merely defined the different types of programs so that they can be related with other modifying factors as justification for whatever action the Commissioners choose to take, or are instructed to take, on any application for

(CONCLUDED ON PAGE 82)

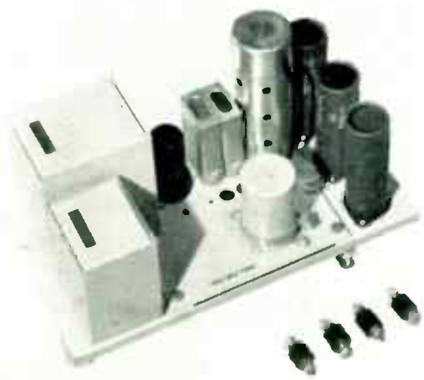
ADVERTISERS INDEX

STUDIO AMPLIFIERS

Engineered for High Quality Performance and Dependable Service



AT LEFT: Two Langevin Type 111-A Dual Pre-Amplifiers and one Langevin Type 102-A Amplifier on a Type 3-A Mounting Frame. This unit provides four pre-amplifiers and one line amplifier, or three pre-amplifiers, one booster amplifier and one line amplifier, all occupying 10½ in. of rack mounting space. An external power supply, the Langevin 201-B Rectifier, as shown below, is required. The Type 3-A Mounting Frame can be housed in a Type 201-A Cabinet, for wall mounting, if desired.



The Type 106-A Amplifier is a two-stage, fixed medium gain, low noise pre-amplifier, or booster amplifier, for use in high-quality speech input systems. The Type 106-A can be mounted on one-third of the space available on a Type 3-A Mounting Frame in combination with two Type 111-A Pre-Amplifiers, or in any similar combination.

The Type 201-B Rectifier supplies plate and filament power for the Langevin Types 102, 106, 111 and similar amplifiers from a 105-125 volt, 50-60 cycle AC source. The ripple voltage of the 201-B Rectifier is 0.04% at full power output 75MA and 0.02% at a drain of 30 milliamperes.

Langevin Audio Transmission Facilities are designed and built to have the extended frequency response, noise and distortion levels required in the F.C.C. Regulations for FM transmission.

In complying with these regulations too much emphasis cannot be placed on the quality of the transformers that are a part of the audio system. Noise, for instance, is largely associated with the input transformers—distortion, with the output transformers—and frequency response with both. Therefore, the transformers in Langevin equipment are manufactured by us—and are held to a specified tolerance—so that frequency response, noise and distortion levels of the entire system are well within requirements.

"Worthy of an Engineer's Careful Consideration"

The Langevin Company

INCORPORATED

SOUND REINFORCEMENT AND REPRODUCTION ENGINEERING

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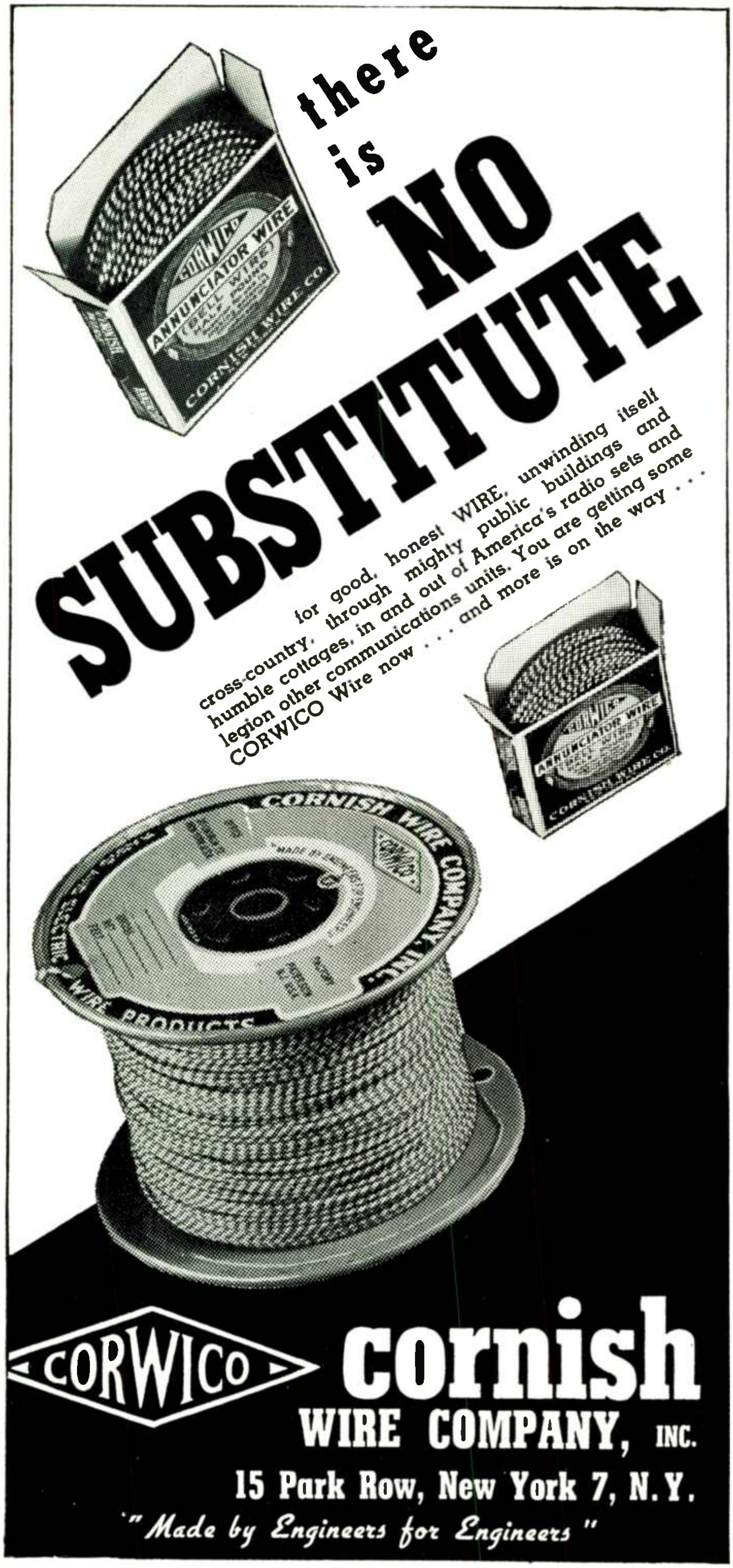
1000 N. Seward St., 38



ENGINEERING SALES

Minerva: Prince Isher Singh Bakshi has been appointed representative for India by Minerva Corporation of America. Prince Bakshi recently left the United States after a brief visit here to study American radio production methods.

C.M.L.: Communication Measurement Laboratory of New York City has opened a Chicago office at 612 North Michigan Avenue, with A. A. Devine in charge. In addition to CML products, this office will display surplus merchandise which the Company is handling for the War Assets Corporation.

Motorola: Ray Baumgart, formerly chief engineer in charge of radio maintenance and construction for the Indiana State Police, has joined Motorola's staff of communications engineers. He has been a very active member of APCO, and will continue to work with police radio supervisors in Indiana.

Insuline: New sales representative covering New York, eastern Pennsylvania, and Virginia is Lester R. Belmuth, recently released as a captain in the Army Air Force.

Sylvania: Raymond W. Andrews, former U. S. Navy commander, has been appointed merchandising manager of Sylvania's radio division. Making his headquarters at Williamsport, Pa., he will specialize in the development and sale of products to be marketed through radio parts jobbers.

Hollywood: Fry & Roberts, west coast factory representatives, have moved to new quarters at 6516 Selma Avenue, Hollywood 28, Calif.

RCA: Fourteen new representatives have been appointed by RCA's renewal tube sales department. They will make their headquarters at the following offices: Ted Martin, 820 Metropolitan Bldg., Boston; Wendell H. Allen and George E. Dittman, 411 Fifth Avenue, New York City; Joseph J. Kearney, Syracuse; Victor W. Williams, Baltimore; Stanley H. Byquist, 221 W. 18th Street, Kansas City; W. L. Garrett, 445 N. Lake Shore Drive, Chicago; Frank Gallagher, 718 Keith Bldg., Cleveland; Kenneth B. Shaffer, Cincinnati; Lysle O. Shanafelt, 530 C & S Bank Bldg., Atlanta; William J. Wright, 2010 Jackson Street, Dallas; Joseph R. Flemming,

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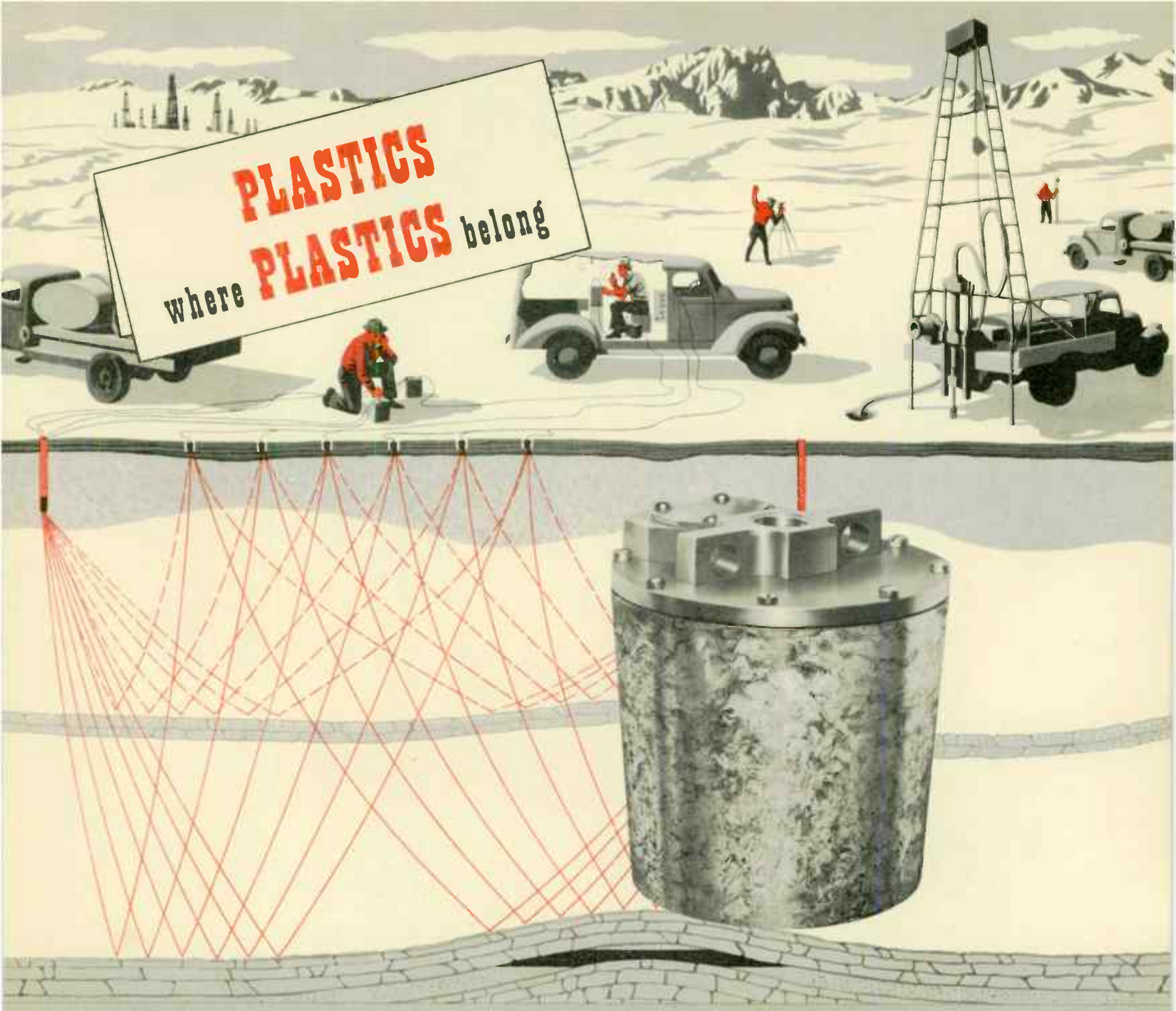
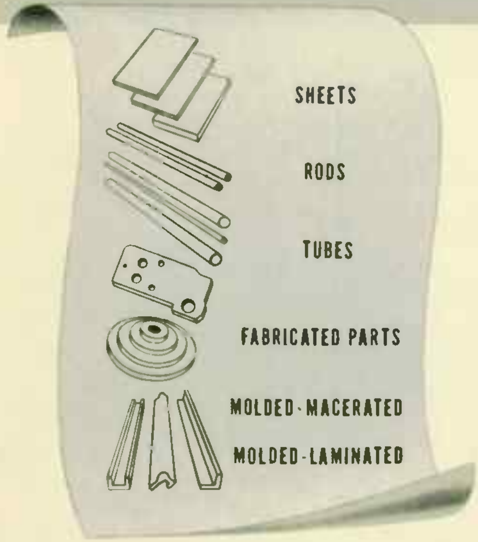


Using Corrosion Resistance, Ease of Machining



A NEW WAY to locate oil makes use of waves originating from a detonation of dynamite. Wave reflections are picked up by flower-pot-like "ears" strategically buried over the suspect area and seismographically recorded.

The pot or case, containing a sensitive electro-magnetic element, can be made of various materials. With Synthane, however, no special surface finish is required to resist corrosion. Synthane is also easily and quickly machined, and non-magnetic. In short, Synthane is *economically* better.

Is Synthane better for your job, too? Could be! Why not find out, preferably *before* you design? We're ready to help you with design, materials or completely fabricated parts.

SYNTHANE CORPORATION • 10 RIVER ROAD • OAKS • PENNSYLVANIA

SYNTHANE

SYNTHANE TECHNICAL PLASTICS • DESIGN • MATERIALS • FABRICATION

MAYBE IT'S TIME TO RECONVERT THINKING, TOO . . . .

By the time you read this, it's likely reconversion will be complete or nearly complete. *Plant* reconversion.

But before many a new product is born or an old product reborn, there will have to be a reconversion of thinking.

Some prewar notions about plastics and their limitations will have to be shelved, if they have not already been. Why? Because, even in the unspectacular technical plastics which we make, there have been important changes in resins and fillers. Low-loss and impact materials have been improved. Postforming of so-called thermosetting laminates is no longer a laboratory curiosity.

The old and erroneous habit of regarding plastics as ersatz materials has almost died out. Now it's the rule to use plastics where they rightfully belong, or not use them at all. As if to prove the point, there were so many legitimate uses for plastics during the war, plastics couldn't be spared for service as substitutes.

Reconvert your thinking about plastics? Yes! By all means go over every single part of your product or equipment to see where the advantages of plastics can be properly used to *your* advantage.

If plastics offer all the properties you want, or more than you want, at a more *economical* cost—considering labor, material, ease of manufacture, length of life, sales appeal, replacement expense, customer satisfaction—then use plastics.

Should our own type of plastics—Synthane—seem to answer your purpose, let us help you investigate the use, find the right grade of Synthane for the job, and—if you desire—fabricate the material for you.

The complete Synthane catalog is packed with helpful information. Before you forget, tear out the coupon and send for your copy now.

WRITE FOR IT TODAY

SYNTHANE

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PLAN YOUR PRESENT AND FUTURE WITH SYNTHANE TECHNICAL PLASTICS • SHEETS • RODS • TUBES • FABRICATED PARTS • MOLDED-LAMINATED • MOLDED-MACERATED

SYNTHANE CORPORATION, 10 RIVER ROAD, OAKS, PA.

Gentlemen:
Please send me without obligation the complete catalog of Synthane technical plastics.

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SYLVANIA NEWS

CIRCUIT ENGINEERING EDITION

APRIL — *Prepared by* SYLVANIA ELECTRIC PRODUCTS INC., Emporium, Pa. — 1946

ANNOUNCING!

EFFICIENT, NEW SYLVANIA R.F. AMPLIFIER TUBE

TYPE 7AG7

TYPICAL OPERATING CONDITIONS

Heater voltage	6.3 volts
Heater current	0.150 ampere
Maximum plate voltage	250.0 volts
Maximum plate dissipation	2.0 watts
Maximum screen grid voltage	250.0 volts
Minimum external negative grid voltage	1.0 volt
Maximum screen grid dissipotion	0.75 watts
Maximum heater-cathode voltage	90.0 volts

Here's a new sharp cut-off r-f pentode amplifier designed especially for 6.3 volt and a-c/d-c series service in Television and Frequency Modulation receivers.

The tube may be operated with full plate voltage on the screen grid to produce high input resistance as a result of reduced electron transit time. Identical voltage requirements for plate and screen grid also eliminate the need of screen grid filter resistors and by-pass capacitors in some circuit applications.

TYPICAL OPERATING CHARACTERISTICS OF TYPE 7AG7 AS A CLASS A1 AMPLIFIER

Plate current	6.0 Ma.
Plate resistance	0.75 megohm
Screen grid current	2.0 Ma.
Mutual conductance	4200 micromhos

Direct Interelectrode Capacitances

Grid to plate	.005 micromicrofarad Max.
Input	7.0 micromicrofarads
Output	6.0 micromicrofarads

Inquiries concerning the new Sylvania Type 7AG7 r-f pentode amplifier tube are invited. Write Sylvania Electric Products Inc., Emporium, Pa.

SYLVANIA ELECTRIC

Emporium, Pa.

MAKERS OF RADIO TUBES; CATHODE RAY TUBES, ELECTRONIC DEVICES; FLUORESCENT LAMPS, FIXTURES, WIRING DEVICES, ELECTRIC LIGHT BULBS

A SHOT IN THE ARM!

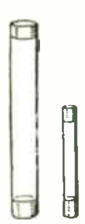
IT ISN'T every product you can say that about. But Corning Coil Forms are something special. Functionally they can add flexibility to your designs and improve performance. One type, for ordinary frequencies, carries the conductor in a groove with metallized tabs for connections. Another type, for high frequencies, employs the metallizing itself as the conductor. They have a low loss factor. The glass surface resists contamination, is chemically stable and is unaffected by weathering. And they are available with many different terminals and mounting fixtures.

One of the most interesting things about these Coil Forms is their dimensional stability and their electrical properties over a wide range of temperatures and frequencies. Best of all, you can have them made out of Corning's 96% silica glass No. 792, which has extremely low loss characteristics from 60 cycles to 3000 megacycles. Yet this glass stands extreme thermal shock; in many cases it can be used at 900° C.

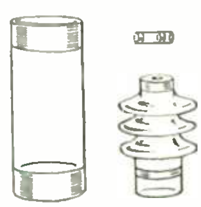
Coil Forms are only one of the ingenious and highly perfected electronic products made from glass by Corning. Some others are shown below. One of them or an adaptation may be just what you need to speed assembly or improve designs or secure hermetic seals. If so, write, wire or phone Electronic Sales Department, F-4, Technical Products Division, Corning Glass Works, Corning, New York. One of our engineers will call on you promptly.

NEW BULLETINS on Corning's Glass Components, Metallized Glassware and Vycor Brand 96% Silica Glass for The Electronic Industry are now available. A note on your business letterhead will bring your free copy of one or all of them by return mail.

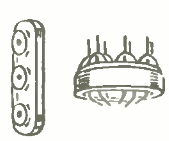
NOTE—*The metallized Tubes and Bushings, Headers and Coil Forms below are all made by the famous Corning Metallizing Process. Can be soldered into place to form true and permanent hermetic seals. Impervious to dust, moisture and corrosion.*



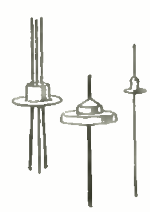
Metallized Tubes *for resistors, capacitors, etc. 20 standard sizes ½" x 2" to 1¼" x 10". Mass-produced for immediate shipment.*



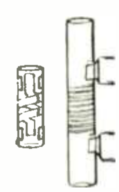
Metallized Bushings. *Tubes in 10 standard sizes, 5/16" x 25/32" to 1" x 4 7/32" in mass production for immediate shipment.*



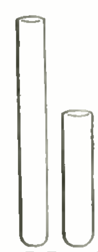
Headers — *The best way to get a large number of leads in a small space for assembly in one operation.*



Eyelet Terminals — *Single or multiple eyelets permit design flexibility. Standard items readily available in quantity.*



Coil Forms—*Grooved for ordinary frequencies—metallized for high frequencies. In various designs and mountings.*



VYCOR Brand cylinders—*very low loss characteristics. Stands thermal shock up to 900°C Can be metallized.*

"VYCOR", "CORNING" *and* "PYREX" *are registered trade-marks and indicate manufacture by Corning Glass Works, Corning, N. Y.*

Electronic Glassware

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BIG VOICES *for*

G-E 1 KW
FM BROADCAST TRANSMITTER

G-E 3 KW
FM BROADCAST TRANSMITTER

The new G-E 1-kw and 3-kw transmitters, like all G-E FM broadcast transmitters, are designed with the *simple* all-electronic modulation system that uses only 10 receiving-type tubes to reach output frequency. The heart of this system is the G-E Phasitron. This tube, with its wide phase shift, allows a frequency multiplication of only 432 to produce a ± 75-kc swing at the output frequency. Frequency conversions are unnecessary, thereby eliminating spurious responses. Important, too, is direct single-crystal control—*independent of modulation.*

STUDIO AND STATION EQUIPMENT • TRANSMITTERS

GENERAL ELECTRIC

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FIRST AND GREATEST NAME IN ELECTRONICS

FM with two remarkable new G.E. transmitters

Built to give you important new advantages and features—including the revolutionary G-E PHASITRON MODULATOR—General Electric's new 1-kilowatt and 3-kilowatt transmitters are part of a complete line of FM broadcast transmitters from 250 watts to 50 kilowatts.

CHECK THESE FEATURES!

• Phasitron Modulator

Most important broadcasting development since the introduction of crystal control.

More than meets all FCC requirements.

Used in all G-E FM broadcast transmitters.

• Simple Design

Only 9 r-f circuits and 10 r-f tubes from crystal to output frequency.

Direct crystal control with *one* crystal.

Minimum number of components and controls.

• Easy-To-Get-At

Vertical chassis construction.

Full-length front and rear doors.

Plenty of room to work in.

• Lower Price

. . . .

For full information on these new transmitters and the complete line of G-E FM broadcast equipment, call your G-E broadcast sales engineer now, or write today to *Electronics Department, General Electric Company, Schenectady 5, N. Y.*

Have you placed your order yet?

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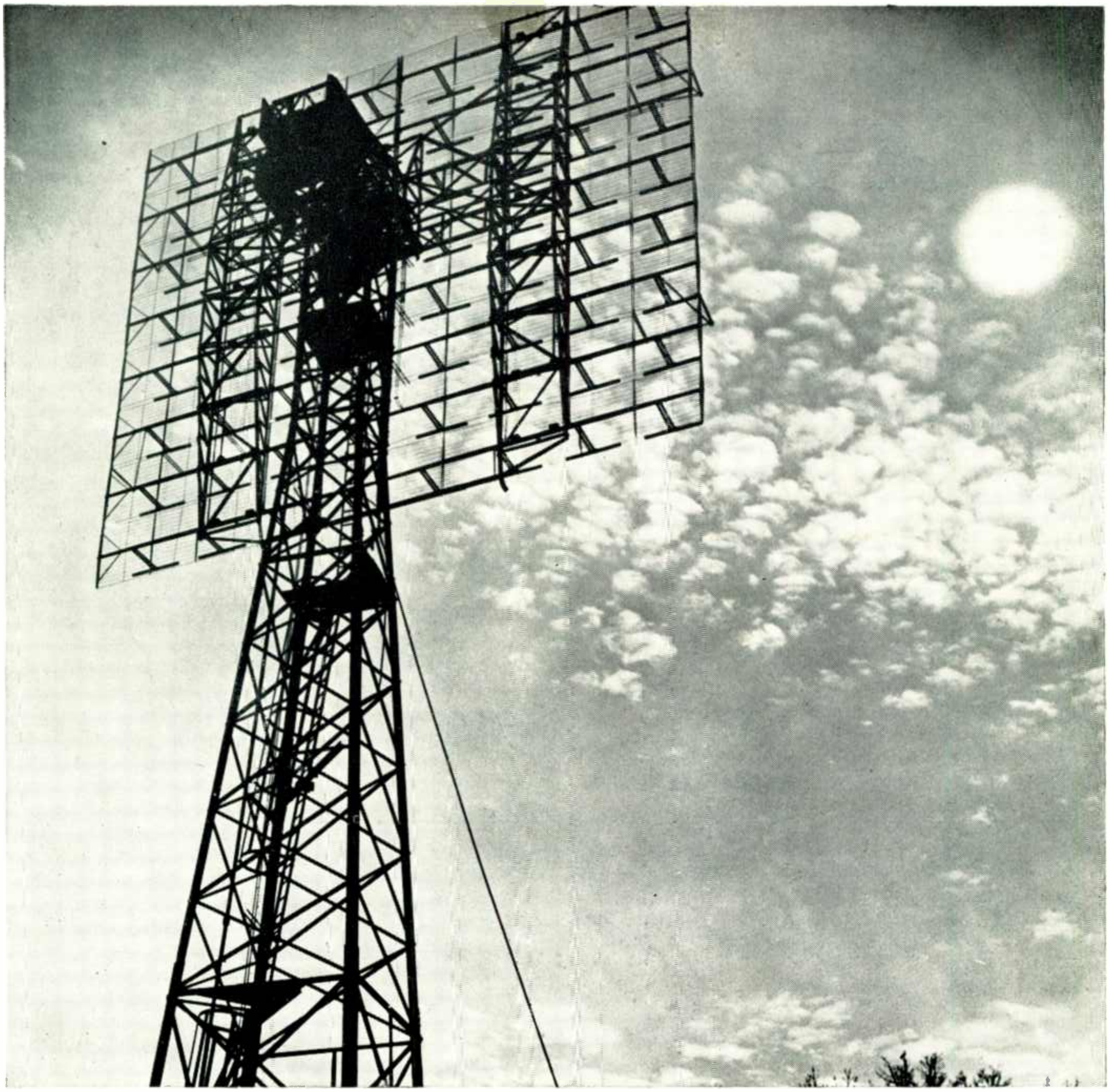
FM • TELEVISION • AM *See G.E. for all three!*



Again... **FEDERAL** *makes* **NEWS**...*with the*

FIRST TRIODE

EVER DEVELOPED THAT GIVES YOU

600 watts at 600 MC!

Now being used successfully in the powerful CBS color television transmitter operating at 490 MC carrier frequency with 10 MC bandwidth at 1 KW peak power output.

Federal's 6C22 is the *only* tube of this type ever to operate at this power output at such high frequency. It's *the* triode to use...as oscillator, amplifier, or frequency multiplier.

Four years of Federal engineering effort were spent in its development for radar equipment. Now it's ready for commercial broadcast use . . . with features making it especially suitable in the UHF spectrum.

For example, Federal's 6C22 has ring-seal electrode construction which reduces lead inductance . . . and extremely close interelectrode spacings to lower transit time losses.

And with 37 years of tube-building experience behind all Federal tubes, you'll find "extras" of rugged mechanical design in the 6C22, in addition to trustworthy electrical performance. It has no internal spacers to break down. Built with solid copper anode block, and water cooled, it works at the high power levels with complete safety. Write for complete information.

ACTUAL SIZE

TENTATIVE MAXIMUM RATINGS AND TYPICAL OPERATION

Key-down conditions without amplitude modulation. Maximum ratings for frequency of 600 MC.

DC Plate Voltage	2500 Volts
DC Plate Current	0.75 Amperes
DC Grid Current	.075 Amperes
Plate Input	1875 Watts
Plate Dissipation	1000 Watts

Typical operation—Self-excited oscillator

Frequency MC	Plate Voltage Volts	Plate Current Amperes	Power Output Watts
300	2500	0.70	900
400	2500	0.65	800
500	2200	0.70	680
600	2000	0.65	500

Federal Telephone and Radio Corporation

Newark 1, New Jersey

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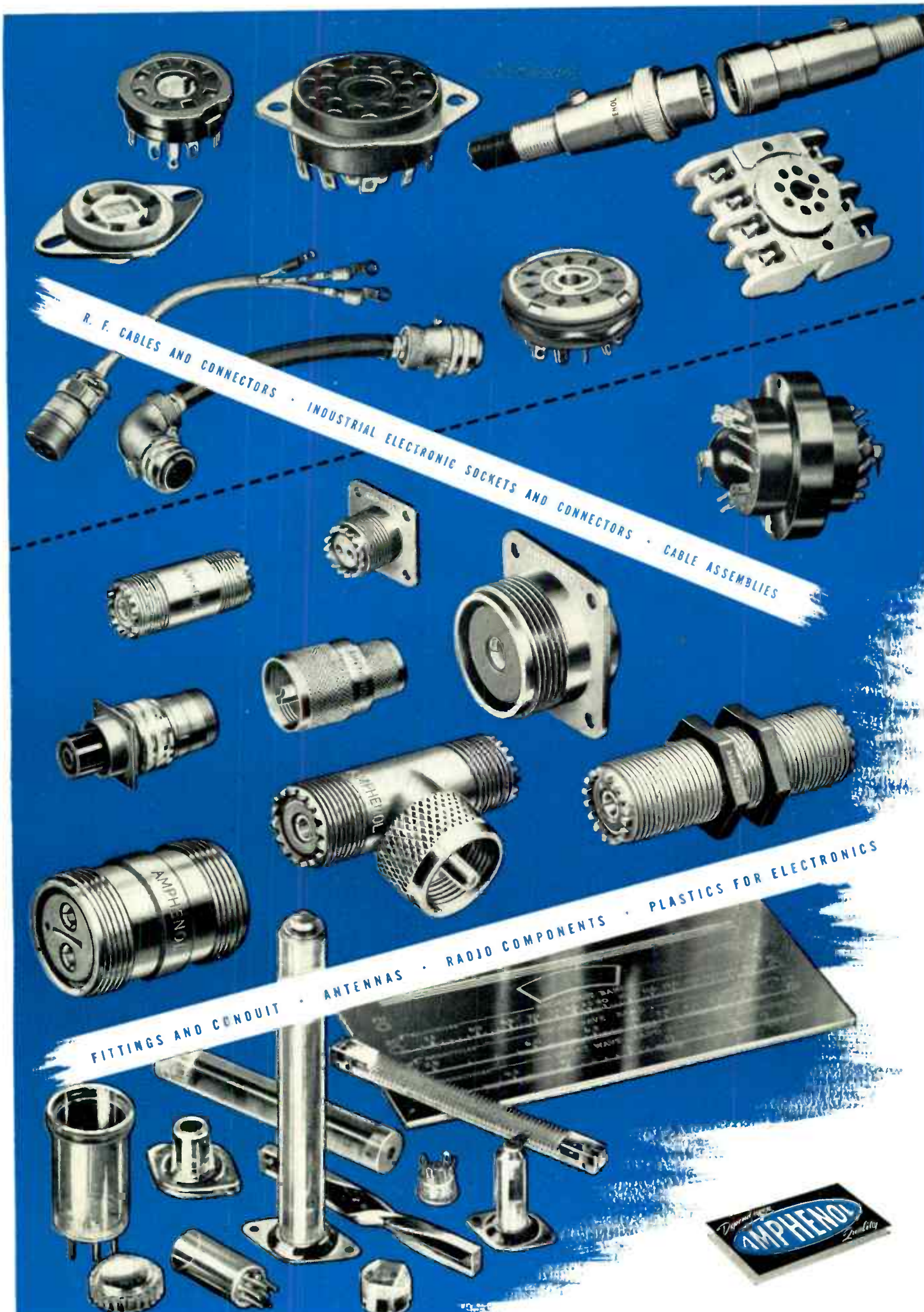
An IT&T Associate


AMPHENOL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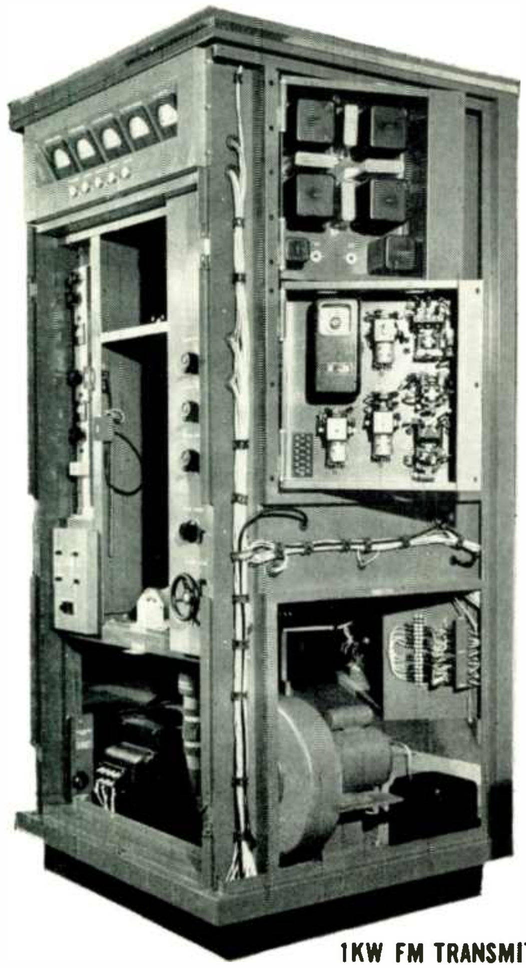

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FIG. 1. HOISTING ROPE IS ATTACHED JUST ABOVE MIDDLE OF MAST SECTION. SMALL LINE STEADIES SECTION ON WAY UP

CONSTRUCTION OF AN EXPERIMENTAL FM ANTENNA

Part 1—Preliminary Layout—Guy Anchors and Tower Base—Erecting the Tower Sections

BY MILTON B. SLEEPER

AT *FM* AND TELEVISION Magazine, we have been reluctant, and properly so, to take any position in the controversy over the comparative merits of upper-band vs. lower-band FM broadcasting over relatively long distances. Service to listeners, after all, is determined by performance, and not by opinions based on counting or discounting sun-spots.

So we decided to put up an experimental station at Great Barrington,[1] Mass., where our publication headquarters are located, in order to learn about FM propagation by listening. Actually, this installation is 7 miles east of Great Barrington, in a little town called Monterey. The spot is 1,250 ft. above sea level. The terrain rises to considerably greater height to the north, but drops off to the east, south and west, rising again to form a ring of hills on those three sides. Due south, in line with New York City, the valley thus formed is about 13 miles long, closed off by Canaan Mountain, 1,680 ft. high. The highest point on this 3-sided rim is Mt. Everett, 11 miles to the southwest, at 2,620 ft. The Empire State Building in New York City is straight south, 105 miles away air-line, and Major Armstrong's station at Alpine, N. J., is 95 miles distant.

Thus, while the location is not within line-of-sight of any present or proposed FM station, it is far enough from the surrounding hills and ridges to be outside the immediate wave-shadow area.

Our original plan was to put up receiving dipoles at the top of a 75-ft. tower. The final decision, however, was to erect a standard 105-ft. Wincharger tower, surmounted by a 10-ft. mast to carry the dipoles, so as to provide the maximum practical advantage for receiving distant FM broadcast stations and, we hope, the Finch facsimile transmission from WGHF, New York City. The initial test has been highly encouraging.

The First Problems ★ It was our intention to have the tower erected by one of the concerns whose business it is to do this type of work. Then, because it was too interesting a project to turn over to someone else, we decided to tackle the job with what assistance we could get locally. We know now that the first plan would have been much simpler and quicker, and somewhat more expensive, but we would have missed the fun of doing it ourselves.

Now, with the undertaking completed, we shall pass on to others the details of our experiences, for it is probable that a great number of similar antennas will be erected for research and experimentation in FM broadcasting and communications.

The Wincharger tower arrived just after our first heavy snowfall, in November. Laid out on the platform at the freight office, it didn't look like a formidable project. The whole shipment consisted of some bundles of 10-ft. steel legs, a coil of guy wire, some turnbuckles, rods, and plates neatly tied together, and a small

[1] Great Barrington is in the extreme southwestern corner of Massachusetts, just north of Connecticut and east of New York State.

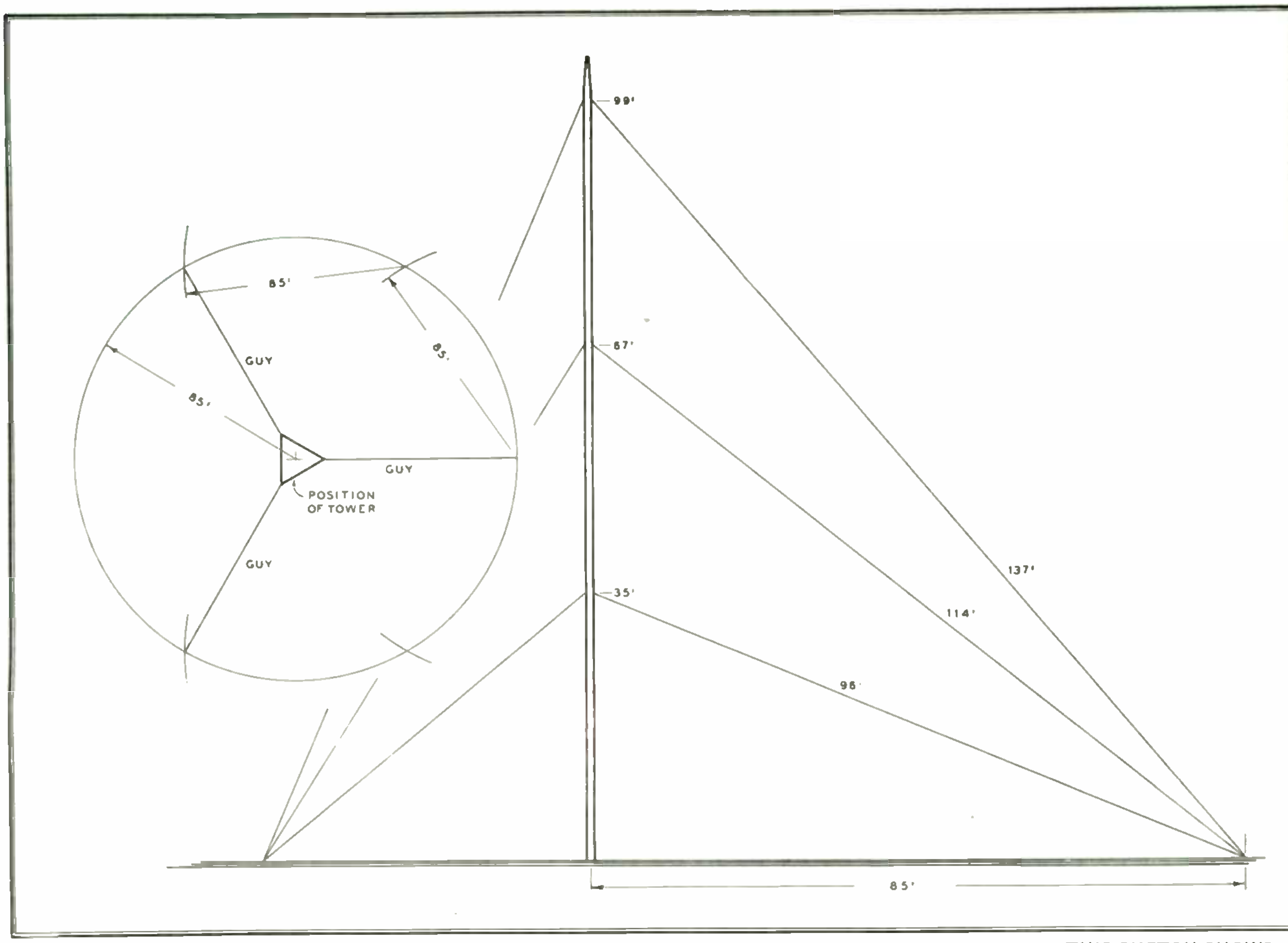
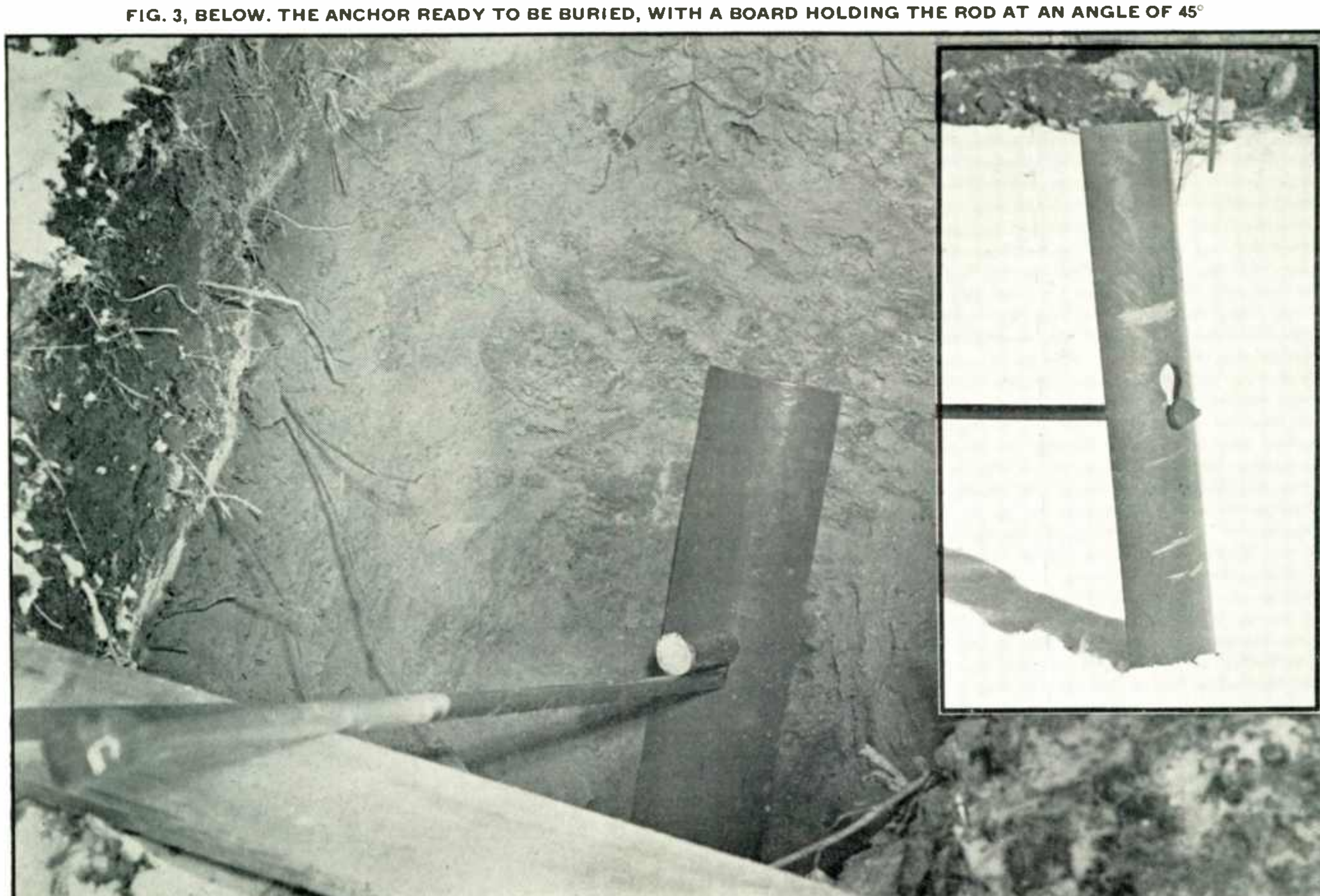


FIG. 2, ABOVE. THREE SETS OF GUY WIRES ARE REQUIRED, SPACED 120° APART ON A RADIUS OF 85 FT., AS THIS SKETCH SHOWS

FIG. 3, BELOW. THE ANCHOR READY TO BE BURIED, WITH A BOARD HOLDING THE ROD AT AN ANGLE OF 45°



but heavy wooden case. The latter proved, on inspection, to be full of carefully stacked cross-braces, and cloth bags of nuts, bolts, and similar hardware. Altogether these parts had the appearance of an overgrown Erector set.

This encouraging introduction, however, was followed quickly by our first set-back. We had tentatively enlisted the services of a local contractor, but when we called to say that the tower had arrived, he told us that he guessed we'd better try someone else, such as the concern that handled tree work, because they had men used to climbing.

Following this suggestion, we were met with an agreeable response, and forthwith arranged for the boss tree man to view the tower as it was laid out on the freight platform. He promptly transported the steel work and hardware to our hill, and stowed it all away in a barn owned by an obliging neighbor. Having learned that people in this section of the country do not consider impatience a virtue, we waited a week before venturing to ask when the work of erection would start.

This inquiry brought the answer: "You'd better get someone else to do it. We never did a job like that," and then: "There's a fellow Bill Winn just got out of the Signal Corps. He knows all about such things."

Meanwhile, the snow had been getting deeper in our Berkshire Hills, and the weather had hit a steady below-zero tempo which was very discouraging. Frost, in these parts, goes 5 ft. deep, and the prevailing northwest wind freezes ears, toes, and hands without regard for the urgency of any out-door work.

But Bill Winn, with his red hair and broad grin, turned out to be one of those GI's that made our allies say thanks for the Yanks. He not only knew about erecting towers because he'd put them up all over Europe, but he would be ready to start as soon as he could call two of his buddies to help him!

Laying out the Base & Anchors ★ Fig. 2 gives the plan of the base and guy anchors. There are 3 of the latter, on an 85-ft. radius. A circle of that size covers considerable ground but, equipped with two sticks separated by 85 ft. of wire (string stretches enough to introduce considerable error) we arrived at a location for the base that brought the anchors within the space available. The position of the first anchor was set in the direction of the prevailing wind.

From that point, we spaced off an 85-ft. segment, and from that point another segment, as indicated in Fig. 2. There we drove a stake into the ground to mark the second anchor.

Starting from the first anchor in the opposite direction, we located the third point by the same method. Then, to be sure we were right, we checked the distance between stakes for the second and

FIG. 4. TWO ASSEMBLED SECTIONS OF THE TOWER, READY FOR THE FIRST COAT OF PAINT

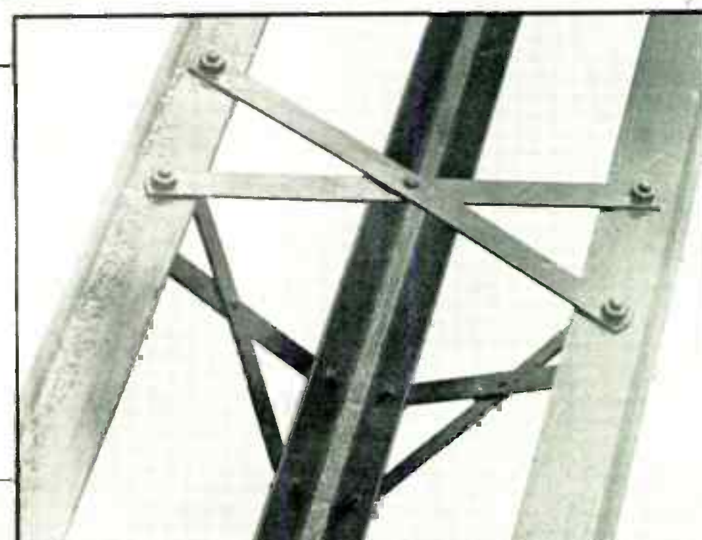


FIG. 5. CLOSE-UP OF A TOWER SECTION, SHOWING THE CROSS BRACES BOLTED TO THE LEGS

FIG. 6, BELOW. THIS SECTION CARRIES THREE SADDLES TO WHICH THE GUY WIRES WILL BE FASTENED third anchors by measuring off two segments again. Since that measurement checked within a few inches, we knew we were right.

The Anchors ★ The guy anchors, Fig. 3, each consisted of a rod and anchor plate. As the insert shows, there is a shoulder on the end of the rod which holds against a slot in the plate. To make sure that the rod could not slip out of the slot, we drove a stick into the hole. This can be seen in Fig. 3.

Holes for the anchors were dug about 5-ft. deep, with the side toward the tower slanting down at about 45°.

The anchors must set at a 45° angle. Therefore, as Fig. 3 shows, we checked the angle by means of the level and 45° head on a machinist's square, and then propped the rod with a board to keep it in place. It is not necessary to do so but, when concrete was poured for the base, we poured a generous amount on each anchor before the dirt was thrown back.

FIG. 7. POURING CONCRETE INTO THE FORM FOR THE BASE OF THE TOWER

The Base ★ The form for the base, Fig. 11, was made from second-hand lumber. After the hole had been dug for the base, and the form fitted squarely in place, we threw in dirt around the form. Otherwise, when the concrete was poured in, the form would have floated up, and the concrete would have run out around the bottom!

Three and one-half cubic yards of concrete were used for the base and to cover the guy anchors. The day the concrete was poured, the temperature was below zero. It would have been impossible, and more expensive, to mix the concrete by hand. However, the mixer tank had been filled with hot water, and we covered the base with burlap sacks to hold in the heat as soon as the base plate was in position.

Figs. 8 and 12 show the base plate assembly. This includes one large and two small angles to hold each tower leg, plus the three 12-in. anchor bolts. The latter are held in place with nuts below and above the base plate. As soon as the concrete had been poured, we pushed the anchor bolts into the concrete, first making certain that the leg angles were accurately lined up with the guy rods. This is important! The base plate tended to sink into the concrete. Accordingly, we placed a pipe over the base, and wired the angles to the pipe as soon as the base plate had been trued carefully with a level. This rig can be seen in Fig. 10. Thus, the base plate was kept true while the concrete hardened.

Most of the form for the base stayed in the ground. After the concrete hardened, we just knocked off the upper part before we finished leveling the dirt around the base.

Tower Section Assembly ★ While that work was going on, the tower sections were assembled and painted. The legs and braces were already galvanized, but it is necessary to put a preliminary coat on any galvanized surface so that the paint will stick. We used a 50% vinegar solution,

FIG. 8. THE ASSEMBLED BASE PLATE AND ANCHOR BOLTS, READY TO PUT IN PLACE

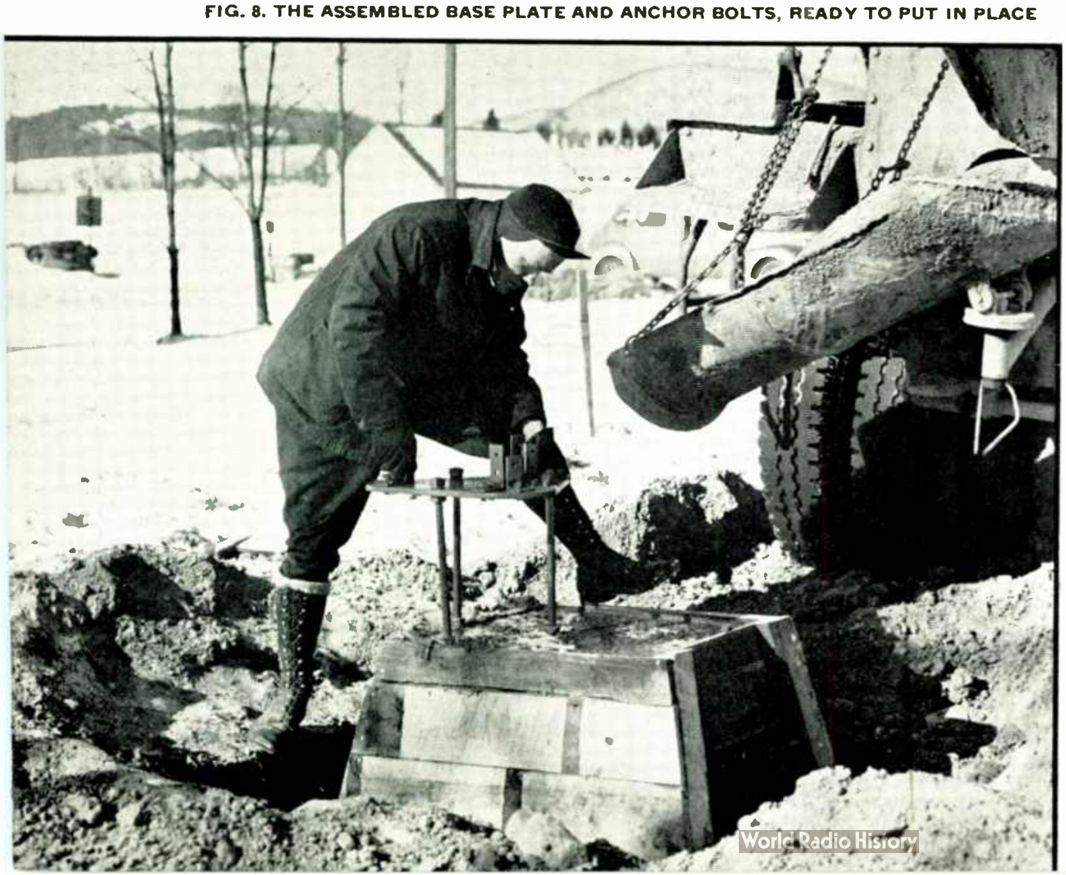


FIG. 9. CAA TOWER PAINT SECTIONS

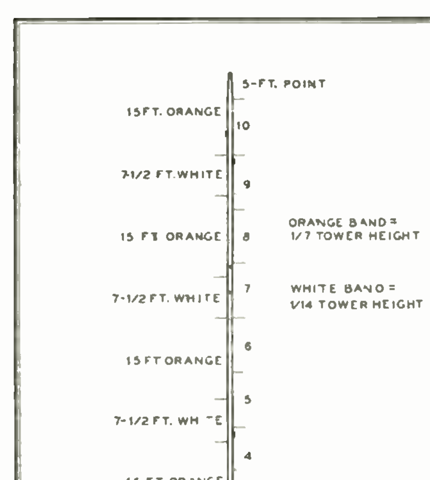


FIG. 10. THE BASE PLATE LEVELLED AND TRUSSED UP IN THE FRESH CONCRETE

brushing it on the legs and dipping the braces into it. It was so cold that the solution froze on the legs. That may have been the reason why the paint did not stick as well as we expected, or perhaps the trouble was with the wartime quality of the paint.

Another time, we would substitute for vinegar the following solution, also recommended by Wincharger: 2 oz. copper chloride, 2 oz. copper nitrate, 2 oz. sal ammoniac, 2 oz. muriatic acid, and 1 gal. of water. This solution must be allowed to dry for 10 hours. After application, it turns the galvanizing black, then dull gray.

Figs. 4, 5, and 6 give detailed views of the 10-ft. tower sections. The assembly was easy, for the cross-braces come with a rivet at the center which sets the exact angle. Bolts 5/16-in. by 3/4-in. are used for this purpose, with nuts and lock washers. The nuts must be on the outside. Each section was tagged with a number as it was put together, for reasons which will appear later.

The 4th, 7th, and 10th sections were fitted with guy attachment saddles, held in place by 5/16 by 1-in. bolts which also pass through the cross braces. Fig. 2 shows where the saddles must come. When they are fastened in place, the eyes which take the guys must, of course, point down, or toward the expanded ends of the legs.

Painting ★ The paint job was started as soon as the sections were assembled.

All parts, including the angle strips that are attached at the joints between sections, were given a coat of red priming paint. Then came the outside coat of international orange or white. Fig. 9 shows the length of these alternate bands, in accordance with CAA requirements.

We had to watch the number tags on the sections carefully, as some sections were partly white and partly orange.

We had some difficulty getting actual international orange, since all paint companies do not make it, but our persistence was rewarded in the end.

Erecting the Sections ★ When the paint was dry, the real fun of putting up the tower began. First, we put sections 1 and 2 together on the ground. This was just a matter of slipping the expanded ends of the legs of one section over the straight ends of the legs on the second section. Then we secured the joints with two 3/8 by 1-in. bolts on the outside, and two 5/16 by 3/4-in. bolts on each side. In addition, one of each of the latter also holds one end of the angle strip braces. These can be seen in Fig. 13.

The expanded ends of the legs are always the bottom of a section. Fig. 12 shows this. The sections are so light that we had no difficulty in raising the first two sections in the same way that one would raise a ladder. When they were bolted to the base plate, as in Fig. 12, we ran ropes to the three guy anchors so as to brace them while we put up the 3rd section and the 4th, which is the first to take guy wires.

Fig. 13 shows how the sections were raised, and Fig. 1 shows a section ready

FIG. 11. DETAILS AND DIMENSIONS OF THE CONCRETE BASE FOR THE TOWER

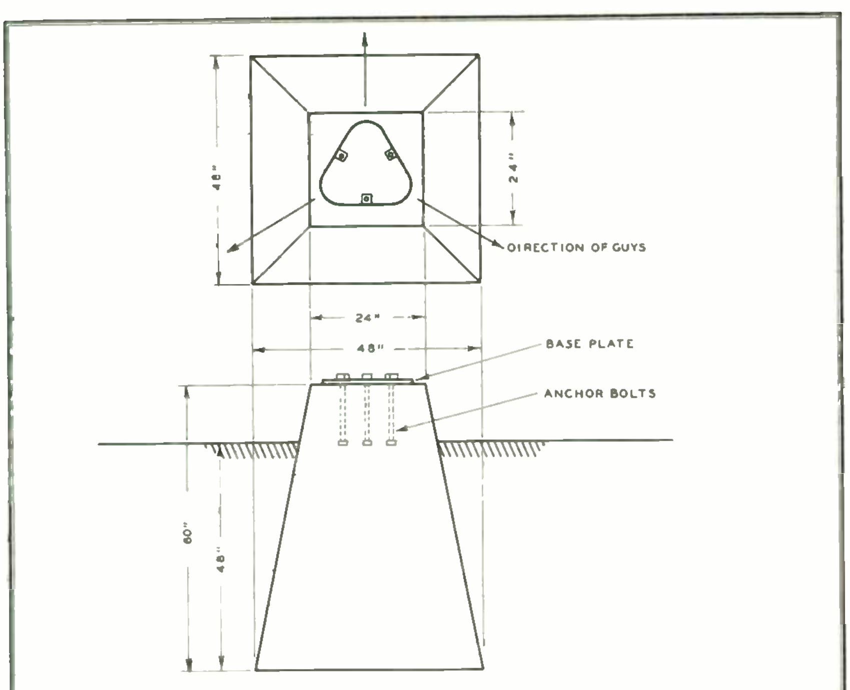
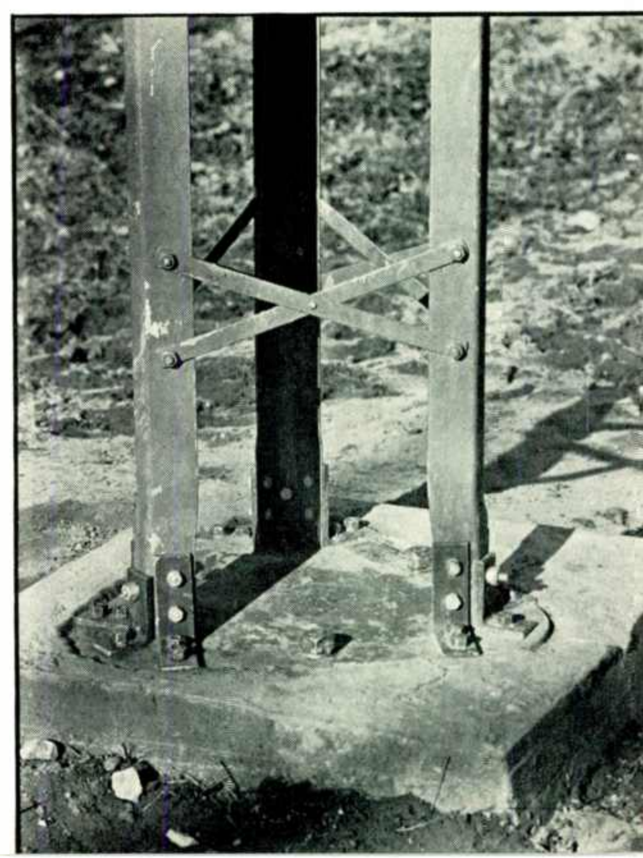
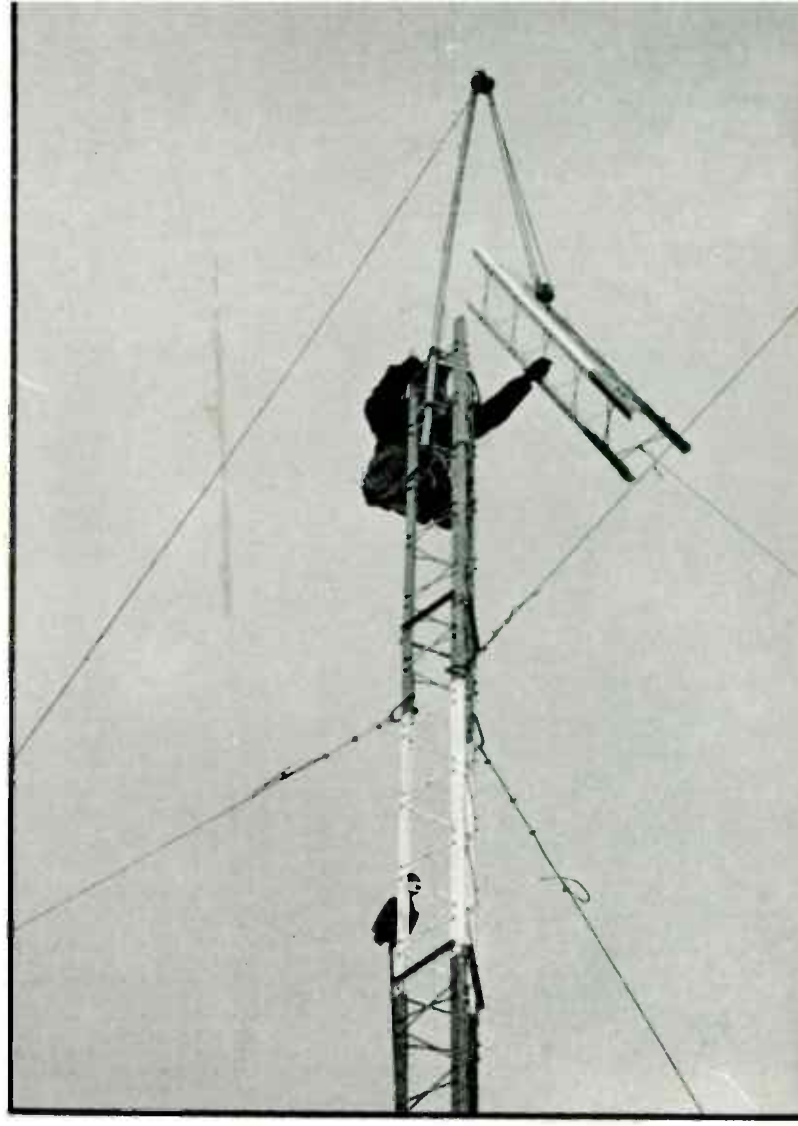


FIG. 12. THE BASE AND TOWER FOOTING





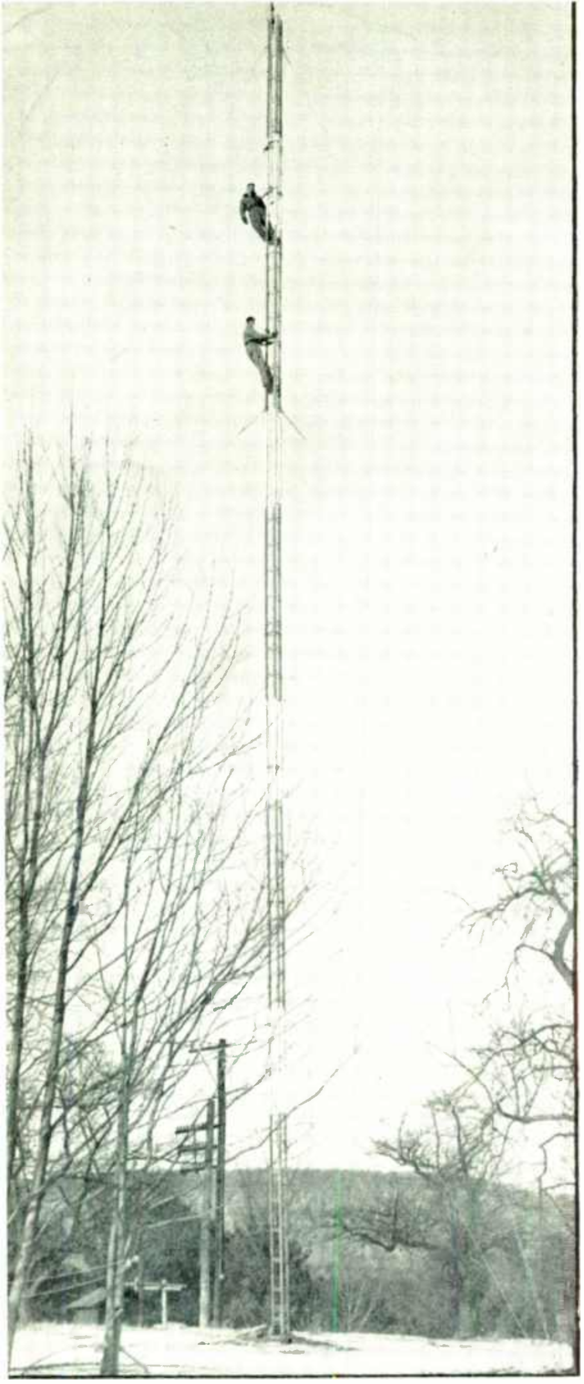


FIG. 14. THE TOWER AT 100 FT. ALL READY FOR THE POINTED SECTION

to leave the ground. For a gin pole, we used the 16-ft. length of 1¼-in. galvanized iron pipe which, later, became the mast carrying the dipoles. A local blacksmith fashioned an iron hook for us in the shape of a long S. This was used to hold the gin pole at the bottom. The upper hook of the S was put over the middle cross brace of the top section, and the lower hook was inserted in the pipe. Then, with ropes, we tied the gin pole to the braces, as Fig. 13 shows. A second, similar hook held the pulley block at the top of the gin pole. This arrangement proved entirely satisfactory, for the pipe carried the load of successive sections without difficulty.

Because the top of the gin pole was hardly more than 10 ft. above the top of the tower, we tied the rope just above the

FIG. 13, LEFT. FOUR VIEWS SHOWING HOW THE TOWER SECTIONS WERE HOISTED AND THEN SET IN PLACE

center of the section to be raised, as in Figs. 1 and 13. In addition, we put a light line on the bottom of the section to guide it on the way up.

Bringing a section into line at the top of the tower was a one-man job, but it required the assistance of the men on the ground who held the main rope and the light line. Since the gin pole could be bent slightly by the pull on the rope, the man who held it moved around, under directions from the man on the tower, until the new section could be brought in exact alignment and settled down into place.

A long, tapered pin proved most useful in lining up the holes for the first bolts to be inserted. Once the first bolt was in place, the next two could be fitted easily. Then the rest slid right in, because the holes had been punched in the legs with great accuracy.

As each section was bolted in place, the gin pole was raised and fastened again, ready for the next section. The use of the pipe instead of a wooden pole proved advantageous because the pipe was much lighter and, therefore, easier to handle.

Fastening the Cables ★ We found that the amount of cable supplied gave us plenty of extra length, although we were careful not to be extravagant. We cut the cable only as it was needed, so that it wouldn't become tangled on the ground. Fig. 2 shows the actual length of each of the guys. Cables were attached to the tower first, held by the clamps visible in Fig. 13. Later, the ends were cut off and taped to give them a neat appearance.

The eyes of the anchor rods are designed to take three clevises which hold the turnbuckles, and the turnbuckles are equipped with thimbles to relieve the guy wires running up to the tower.

Four clips, tightened by nuts, were supplied to clamp each wire after it was run through the thimble.

At the tower, we put a thimble on each guy saddle to take the wire, and four more clips secured the loop.

Before we pulled the wires tight, we opened the turnbuckles all the way. That left us the maximum amount to tighten the wires, and to take up any subsequent stretch. Since we didn't have a cable stretcher to tighten the wires, we used a block and tackle arrangement which, though rather crude, did the job satisfactorily.

As each set of guys was put on, we checked the tower with a plumb bob dropped down the center. That was easier than if we had left this step until the tower was completed. Wincharger specifications call for a tension of 200 to 250 lbs. on each guy wire. They make a tensioning device that determines and maintains the proper tension. These devices are inserted in one set of guys. Thus, when all the guys have been adjusted to make the tower perpendicular, the load on each is correct and distributed evenly.

Special Notes ★ Here is an important word of warning to others who may erect similar towers: Don't go up the tower without a safety belt, and be sure the belt you use is in good condition. Fig. 15 shows Bill Winn with his safety belt. The use of such a belt makes it possible to rest from time to time, and also to work with both hands free.

Some of the people who watched the progress of the tower were amazed at the strength of unguyed sections. Even with three men up, the tower was firm and steady despite strong winds. After the 4th section was put in place and guyed, we went right on with the erection of the 5th, 6th, and 7th sections without any temporary guys. Then, with the 7th section in place, the second set of guys were put on. The same procedure was carried out above the 7th section. No further guys were needed until the 10th section was up.

Part 2 will cover the erection of the last tower section, the mast and dipoles.

FIG. 15. BILL WINN PUT UP SIGNAL CORPS TOWERS ALL OVER EUROPE

FLUCTUATION VOLTAGES IN RECEIVER INPUT CIRCUITS

An Examination of the Source and Effect of Fluctuation Voltages in Radio Receivers

BY JOHN R. RAGAZZINI *

Fluctuation Voltages Due to Thermal Agitation ★ The basic source of fluctuation voltages in circuit elements is a pulsation of the electron gas in the conductors. Such pulses are set up by collisions between the molecules making up the mass of the conductor and the electrons of the free electron gas. The mechanism of this process will be described but first the properties of extremely short pulses will be examined.

A Fourier analysis of a pulse shown in Fig. 1 whose time duration is 2T yields substantial frequency components to an upper frequency of 1/T. If the pulses are of infinitely short duration (T → 0), the harmonic content is uniform at all frequencies up to infinity. Physically, this implies that if an infinitely short pulse of current were applied to a sharply tuned circuit of constant impedance, the voltage developed across this impedance would be constant regardless of the frequency to which the circuit is tuned. The uniformly constant frequency spectrum is a characteristic of extremely short pulses.

Such pulses are spontaneously set up in a circuit due to the thermal agitation of the molecules making up the wire. This process has been studied by various investigators [1,2] and accurate formulas have been derived. However, if some thought is given to the basic phenomena involved, certain simplifications can be presented which make fluctuation noise computations simpler. Such an approach was proposed more recently by Moullin and Ellis [3] but has not been used widely.

Briefly, the analogy between fluctuation voltage effects and the kinetic theory of gases is used. For instance, Brownian movements are an outward manifestation of the gas laws. If a microscopic globule of fat is immersed in water and is observed through a microscope, it is found to have random pulsations or movements in all directions. Closer examination would reveal that the average energy of this globule would rise proportionately to absolute temperature. The source of these pulsations is vibration of the water molecules due to their temperature. As they vibrate, they collide with the globule of fat, which represents a cohesive group of molecules, and impart energy to it. Since the globule is struck at random and from all sides, its movement is a series of aimless pulses in all directions.

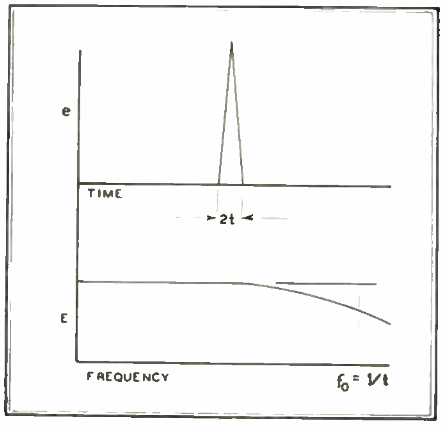


FIG. 1. CURVES SHOWING THE RELATION BETWEEN THE DURATION OF A PULSE, 2T, AND ITS FREQUENCY SPECTRUM

At this point, a basic rule called the principle of equipartition of energy is brought into play. Within a gas whose molecules are in a state of agitation, the molecules will, in time, have the same average energy. For instance, if gases at different temperatures were mixed, the mixture will finally reach a uniform temperature. Since temperature is proportional to the average energy of a molecule, it follows that the average energy of all molecules in a gas is the same. The law defining this phenomenon is the principle of equipartition and more careful analysis will show that the average energy per molecule in a gas is:

$$E = \tfrac{1}{2}\ \text{KT joules per degree of freedom} \qquad (1)$$

K = 1.372 × 10^{-23} joules/degree Kelvin
T = 273 + °C degrees Kelvin

Equation (1) gives the average energy stored by a molecule in each of its independent modes of energy storage. Thus, if the kinetic energy storage is taken in the three coördinate axes, the resultant value will be three times that given in (1).

Surprisingly enough, this principle holds in relation to cohesive masses of molecules such as the fat globules previously described. Since the suspended globules of fat which exhibit Brownian movements have three degrees of freedom, one for each of the three coördinate axes, the average energy of the globules is 3/2 KT joules. This relation can be proved experimentally.

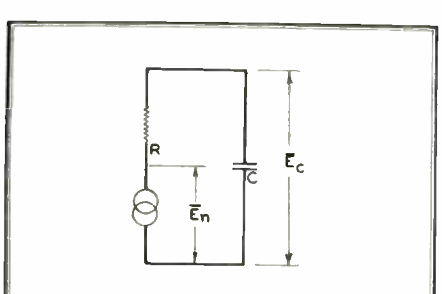


FIG. 2. CIRCUIT USED TO DETERMINE VOLTAGES OF THE EQUIVALENT FLUCTUATION VOLTAGE GENERATOR, E_n

The electron gas in conductors may now be regarded in the same light as the fat globules randomly pulsing in a fluid. That the electron gas is a cohesive entity may be understood by realizing that as soon as one electron is struck by a molecule and suddenly acquires a velocity, its motion sets up a magnetic field which links all the other electrons in the electron gas. This suddenly generated field causes all the electrons in the circuit to be set in motion also. Thus, in a sense, a tight cohesion exists in the electron gas because one electron cannot be moved without similarly disturbing all the other electrons by induction. This cohesion corresponds to the analogy of the fat globule, since collision by a molecule of the fluid with a molecule of the globule sets the *whole* globule in motion.

In addition, just as the fat globule acquires instantaneous changes of velocity due to collision with molecules, so does the electron gas set up infinitely short pulsations of current in a circuit. The electrons set in motion by a molecular collision set up infinitely short pulses of magnetic field with the resultant infinitely short pulses of voltage by induction. Thus, if the effects of electron gas pulses due to molecular collision were considered as an equivalent generator, this generator would produce voltage pulses whose frequency spectrum is uniform from zero to infinite frequency. This reasoning justifies the replacement of fluctuation voltage effects by an equivalent generator of uniform frequency spectrum.

If this analogy can be carried further, it follows that the electron gas in a circuit can absorb a share of energy equal to that of a single molecule providing a means can be found to store that energy. In other words, a component of energy, ½KT joules, will be stored in the electron gas per degree of energy storage. For instance, in the circuit shown in Fig. 2, a single degree of freedom in energy storage exists in the form of a capacitance C. This will give the following energy relation:

$$\tfrac{1}{2}C\overline{E_c^2} = \tfrac{1}{2}KT \qquad (2)$$

where

* Electrical Engineering Department, Engineering Building, Columbia University, New York City 27, N. Y. A paper delivered before the Radio Club of America.

1 Johnson, Phys. Rev., 32, 97 (1928).
2 Nyquist, Phys. Rev., 32, 110 (1928).
3 Moullin and Ellis, Jour. I. E. E., 74, 323 (1934).

$\overline{E_c^2}$ = mean-square voltage across the condenser

Solving equation (2) for the mean-square voltage across the condenser, the value which results is:

$$\overline{E_c^2} = KT/C \text{ volts square} \quad (3)$$

As an example, consider the input circuit of an audio amplifier in which the input capacitance is 25 $\mu\mu f$ and the temperature of the circuit is 27 degrees C. Substituting the values yields the result:

$$\overline{E_c^2} = (1.372)(10^{-23})(273 + 27)/(25)(10^{-12})$$
$$= 165 \times 10^{-12} \text{ volts square}$$
$$E_c = 12.8 \text{ microvolts}$$

This voltage would appear across the input of the amplifier provided the entire frequency spectrum from zero to infinity frequency were considered. A practical amplifier will actually amplify only a fraction of this value because the frequency range is finite but this value of 12.8 microvolts is the maximum value the fluctuation voltage can reach.

It is interesting to note the frequency spectrum of the fluctuation voltages across the condenser. The source of these voltages is a random series of pulse voltages represented by an equivalent generator having a uniform frequency spectrum. It can be shown by consideration of equation (3) that this equivalent generator produces a voltage whose mean-square value over a frequency bandwidth df is:

$$d\overline{E_n^2} = 4KTR \text{ df volts square} \quad (4)$$

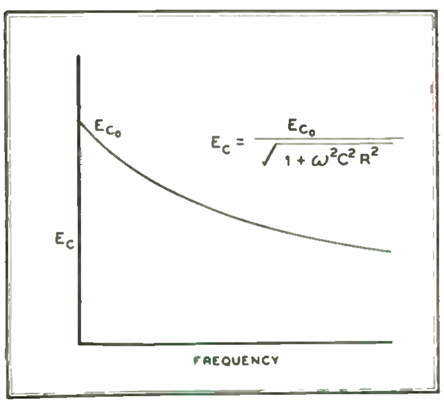


FIG. 3. FREQUENCY SPECTRUM OF THE FLUCTUATION VOLTAGES ACROSS THE CONDENSER OF THE CIRCUIT SHOWN IN FIGURE 2

This is the classical equation for fluctuation voltages generated by a resistance. When these voltages are considered in the circuit of Fig. 3 and are integrated from zero frequency to infinity frequency, the mean-square voltage across the condenser always comes to the value given by equation 3. At the same time, the relative value of the fluctuation voltage content across the condenser as a function of frequency is the same as the frequency characteristic of the circuit. A plot of the frequency spectrum is given in Fig. 3.

It is recognized that equation 4 is the classical fluctuation voltage formula and in most cases is used for computation. Yet in many cases, it is simpler to return to the basic energy concept. At any rate, the simplicity of equation 3 as an outside value of fluctuation voltage makes it very useful.

Fluctuation Voltages in the Tuned Circuit ★ Since the input circuit of a receiver usually has a tuned circuit as shown in Fig. 4 across the grid of the first tube, a study of the fluctuation voltages of this circuit should be

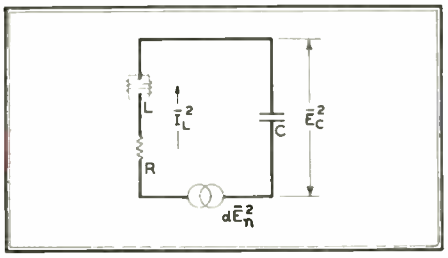


FIG. 4. TUNED CIRCUIT FOR WHICH THE FLUCTUATION VOLTAGES ACROSS THE CONDENSER ARE DETERMINED

examined. Using the basic energy theory, there are *two* independent energy storage modes: the inductance which stores energy by virtue of current flow, and the condenser which stores energy by virtue of the voltages across it. Thus, the relation which holds in this case is:

$$\tfrac{1}{2}L\overline{I^2} + \tfrac{1}{2}C\overline{E_c^2} = 2(\tfrac{1}{2}KT) \quad (4)$$

where: $\overline{E_c^2}$ = mean-square voltage across the condenser

$\overline{I^2}$ = mean-square current in the inductance

These voltages and currents are made up of pulses whose frequency spectra have been altered by the circuit. The pulses of the electron gas are virtually of infinitely short duration and contain all the frequencies of the spectrum. On the other hand the spectra of the voltages and currents included in equation 4 will have the frequency characteristics of the tuned circuit. These spectra are shown in Fig. 5.

In such a circuit, it may be shown that the energy stored in the inductance is equal to that stored in the condenser if the entire frequency spectrum is considered. Thus:

$$\tfrac{1}{2}L\overline{I^2} = \tfrac{1}{2}C\overline{E_c^2} \quad (5)$$

Then, from equation 4,

$$C\overline{E_c^2} = KT \quad (6)$$

and the mean-square voltage across the condenser is,

$$\overline{E_c^2} = \frac{KT}{C} \text{ volts square} \quad (7)$$

where K = $1.372(10^{-23})$ joules/degree
T = (273 + deg C) degrees Kelvin
C = farads

This extremely simple relation is independent of resistance in the circuit and represents the mean-square value of *all* the frequency components from zero to infinity. More practically, it covers all the frequency components from virtually d-c to frequencies many times the resonant value.

As an example, consider the following constants:

C = 50 $\mu\mu f$
L = 10 μh
R = 60 ohms
T = 27 deg C.

$$\overline{E_c^2} = \frac{(1.372)(10^{-23})(273 + 27)}{(50)(10^{-12})} \text{ volts square}$$

$\overline{E_c^2}$ = 82.3 microvolts square

E_c = 9.08 microvolts

This value of 9.08 microvolts is the root-mean-square value of the fluctuation voltage across the condenser and contains components at frequencies in relative values as shown in Fig. 6.

In a receiver, the circuits following the input circuit (such as the IF amplifier) are usually sharper than the input circuit. Certainly, they are not so broad as to extend from zero to infinity as is implied in equation (7). Hence a "band-width factor" must be added to the expression. Referring to the nominal input circuit band-width as the radian frequency span ($2\,\Delta\omega_o$) over which the resonant voltage drops 3 db and the band-width of the subsequent circuits as $2\Delta\omega$ the effect on the total noise can be computed. The relation between these defined values are shown graphically in Fig. 7. To obtain the equation of the spectrum curve of Fig. 7, the fluctuation voltages will be considered as being produced by a pulse generator

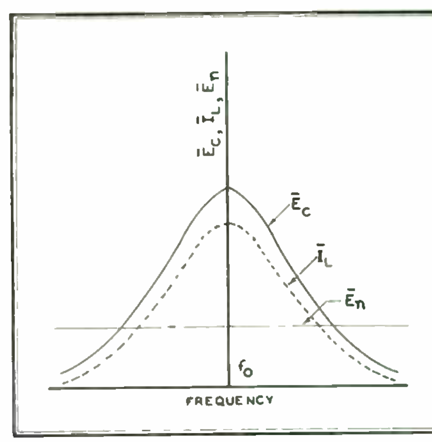


FIG. 5. SPECTRUM OF THE FLUCTUATION VOLTAGES ACROSS THE CONDENSER AND EQUIVALENT GENERATOR AND FLUCTUATION CURRENTS IN THE INDUCTANCE

($\overline{E_n^2}$) whose frequency spectrum is uniform. Thus:

$$d\overline{E_c^2} = \frac{d\overline{E_n^2}\,\frac{1}{\omega^2C^2}}{R^2 + (\omega L - \frac{1}{\omega C})^2} \quad (8)$$

Defining: $$\omega_o = \frac{1}{\sqrt{LC}} \quad (9)$$

$$Q = \frac{1}{\omega_o CR} = \frac{\omega_o L}{R} \quad (10)$$

and noting that:

$$dE_n^2 = 4KTR\,df \qquad (4)$$

and assuming that $\Delta\omega$ is reasonably small compared to ω_o (about 10%), a close approximation to this integral is:

$$\overline{E}_c^2 = \frac{KT}{C}\frac{1}{\pi}\int_{\omega_o-\Delta\omega}^{\omega_o+\Delta\omega}\frac{2\,Q/\omega_o\;d\omega}{1+4Q^2(\omega-\omega_o)^2/\omega_o^2} \qquad (11)$$

whence:

$$\overline{E}_c^2 = \frac{KT}{\pi C}\left[\arctan\frac{2Q}{\omega_o}(\omega-\omega_o)\right]_{\omega_o-\Delta\omega}^{\omega_o+\Delta\omega}$$

$$= \frac{2KT}{\pi C}\arctan\frac{2\Delta\omega}{2\Delta\omega_o} \qquad (12a)$$

$$= \frac{KT}{C}(F) \qquad (12b)$$

where $2\Delta\omega_o$ = Input circuit bandwidth for 3 db loss in gain
$2\Delta\omega$ = Bandwidth of circuits following input stage

Thus, the correction factor which must be applied to the complete spectrum formula

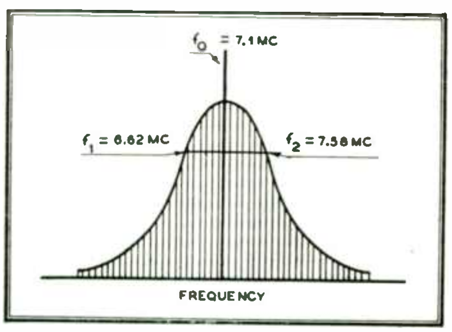


FIG. 6. FREQUENCY SPECTRUM OF THE FLUCTUATION VOLTAGES ACROSS THE CONDENSER IN THE ILLUSTRATIVE PROBLEM. THE BANDWIDTH OF THIS CIRCUIT IS 480 KC. ON EITHER SIDE OF RESONANCE

(equation 7) is the "bandwidth factor," F:

$$F = \frac{2}{\pi}\arctan\frac{2\Delta\omega}{2\Delta\omega_o} \qquad (13)$$

This factor is plotted in Fig. 8. It is observed that in a "consistent" design in which the input circuit bandwidth is the same as that of the subsequent circuits, this factor is 0.5. Thus taking the illustrative example previously given, the values for a "consistent" condition become:

$\overline{E}_c^2 = 82.3 \times \frac{1}{2} = 41.15$ microvolts square

and $\qquad \overline{E}_c = 6.42$ microvolts

Equation 12b is directly applicable to the design of the input circuit of a receiver. Essentially it assumes that the gain of the I.F. amplifier is constant over the pass band although if it is not exactly so, only small error results.

Signal-to-Noise Ratio in Input Circuit ★ In the ultimate analysis, it is the ratio of the useful signal to the fluctuation noise that is important. To make such an analysis, the input circuit will be assumed a simple inductively coupled circuit as shown in Fig. 9. The antenna is assumed matched to a transmission line (or tuned) so that the equivalent antenna impedance is a pure resistance R_a. It is further assumed that the primary reactance (ωL_1) is negligible compared to R_a. If this is true, then it is accurate enough to say that:

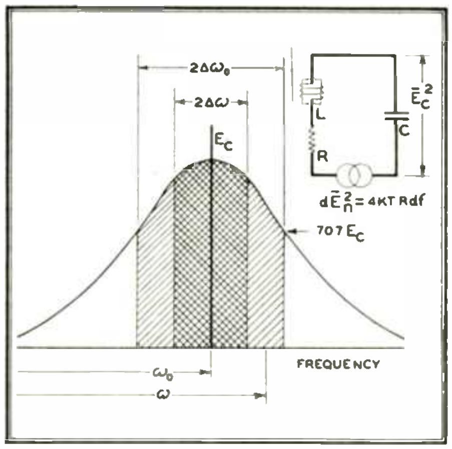


FIG. 7. FREQUENCY SPECTRUM OF FLUCTUATION VOLTAGES SHOWING THE RELATION OF THE R.F. BANDWIDTH ($2\Delta\omega_o$) AND THE BANDWIDTH ($2\Delta\omega$) OF THE INTERMEDIATE FREQUENCY AMPLIFIER FOLLOWING THE RF STAGE

$$I_1 = \frac{E_a}{R_a} \qquad (14)$$

Also, referring to Figs. 9b and 9c,

$$E_{12} = j\omega M I_1 = j\omega M\frac{E_a}{R_a} \qquad (15)$$

and the reflected primary impedance in the secondary circuit R'_a is:

$$R'_a = \frac{X_{12}}{R_a} = \frac{\omega^2M^2}{R_a} \qquad (16)$$

The useful relations which can be derived from the equivalent circuit given in Fig. 9c are the resonant gain of the circuit as well as the effective Q or bandwidth.

$$Q_e = \frac{\omega L_2}{R_2+R'_a} = \frac{\omega L_2/R_2}{1+R'_a/R_2} = \frac{Q_2}{1+\dfrac{\omega^2M^2}{R_aR_2}}$$

$$Q_e = \frac{Q_2}{1+x^2} = \frac{\omega_o}{2\Delta\omega_o} \qquad (17)$$

where $\quad Q_2 = \omega L_2/R_2 = 1/\omega C_2R_2$ = Q of secondary circuit

$x^2 = \dfrac{\omega^2M^2}{R_aR_2}$ = coupling factor

ω_o = resonant frequency

$2\Delta\omega_o$ = total bandwidth to half-energy points

also,

$$E_2 = \frac{\dfrac{1}{j\omega C_2}\,j\omega M\,\dfrac{E_a}{R_a}}{R'_a + R_2 + j\left(\omega L_2 - \dfrac{1}{\omega C_2}\right)}$$

(at resonance) (18)

which can be simplified to

$$E_2 = \frac{Q_2}{1+x^2}\,x\sqrt{\frac{R_2}{R_a}}\,E_a = Q_e\,x\sqrt{\frac{R_2}{R_a}}\,E_a \qquad (19)$$

Equation 17 gives the effective Q of the system and the resultant RF bandwidth while equation 19 gives the gain of the circuit at the resonant frequency.

The signal-to-noise ratio may now be computed using equation 12b and equations 17 and 19:

$$\frac{\overline{E}_2^2}{\overline{E}_c^2} = \frac{Q_e^2x^2R_2/R_a}{(KT/C_2)(F)}\,\overline{E}_a^2 \qquad (20)$$

Simplifying,

$$\frac{\overline{E}_2^2}{\overline{E}_c^2} = \frac{1}{2FKTR_a(2\Delta\omega_o)}\left[\frac{2x^2}{1+x^2}\right]\overline{E}_a^2 \qquad (21)$$

Now if the following values are assigned:

$K = 1.372 \times 10^{-23}$ joules/degree Kelvin

$T = (273 + 27)$ degrees Kelvin (absolute)

Then by substitution and simplification,

$$\frac{E_2}{E_c} = \frac{\text{Signal Volts}}{\text{Noise Volts}} = \frac{4400}{\sqrt{(2\Delta f_o)FR_a}}\sqrt{\frac{2x^2}{1+x^2}}\,E_{a\mu v} \qquad (22)$$

where

$(2\Delta f_o)$ = Nominal RF bandwidth for 3 db loss of gain

F = Bandwidth factor (See Figure 8)

R_a = Antenna resistance

$x = \dfrac{\omega_oM}{\sqrt{R_aR_2}}$ = Coupling factor

$E_{a\mu v}$ = R.M.S. signal voltage in microvolts

A plot of equation 22 is shown in Fig. 10 in which it is observed that the signal-to-noise ratio improves as the coupling is increased. High degrees of coupling are not always attainable nor desirable. For instance, in the case of receivers which are tuned over a wide range, the antenna impedance varies over considerable limits. In order to prevent these variations from affecting the input circuit of the receiver excessively, the antenna is loosely coupled to the input with a resultant reduction in signal-to-noise ratio. In the case of fixed frequency receivers, however, heavy coupling is desirable from the point of view of noise reduction.

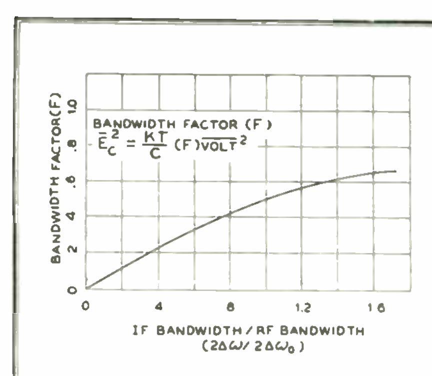


FIG. 8. PLOT OF BANDWIDTH FACTOR, F, VERSUS BANDWIDTH RATIO

As an illustrative example of the previous conclusions, consider the following requirements:

f_o = Mid-frequency = 50 Megacycles/sec.

$2\Delta f_o$ = RF Bandwidth = 2 Megacycles/sec.

R_a = Antenna Resistance = 100 ohms

F = Bandwidth Factor = 0.5

The bandwidth factor indicates that the I.F. amplifier bandwidth is 2 megacycle/sec. Using equation 22, the signal-to-noise ratio is:

$$\frac{\text{Signal volts}}{\text{Noise volts}} = \frac{4400}{\sqrt{(2)(10^6)(0.5)(100)}} \sqrt{\frac{2x^2}{1+x^2}}\, E_{a\mu v}$$

$$= 0.44 \sqrt{\frac{2x^2}{1+x^2}}\, E_{a\mu v}$$

For instance, if critical coupling (x = 1) is used, the signal-to-noise ratio becomes:

$$\frac{\text{Signal Volts}}{\text{Noise Volts}} = 0.44\, E_{a\mu v}$$

Thus, if an antenna signal of 2.28 microvolts is applied to the input of the receiver, the input circuit yields a signal-to-noise ratio of unity.

The choice of the circuit constants making up the input circuit is made as follows (Figure 9a):

$$Q_\epsilon = \frac{f_o}{2\Delta f_o} = \frac{50}{2} = 25$$

(From equation 17)

and for critical coupling,

$$Q_2 = 2Q_\epsilon = 50$$

(From equation 17)

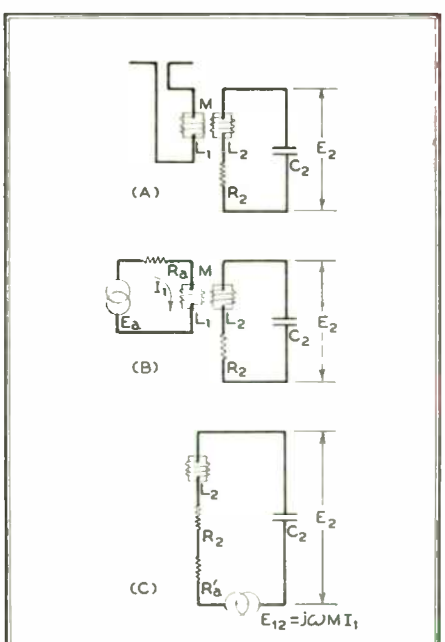


FIG. 9. TYPICAL INPUT CIRCUIT OF A RECEIVER SHOWING THE EQUIVALENT CIRCUITS USED FOR THE COMPUTATION OF THE SIGNAL VOLTAGE, E_2

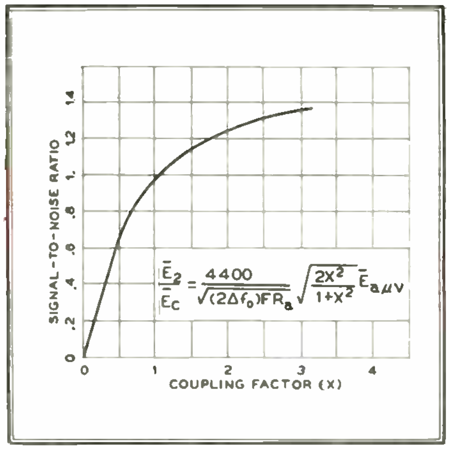


FIG. 10. CURVE OF SIGNAL-TO-NOISE RATIO FOR THE INPUT CIRCUIT OF A RECEIVER PLOTTED VERSUS COUPLING FACTOR, x

$(x = \omega M / \sqrt{R_a R_2})$

If the tuning condenser C_2 is 20 $\mu\mu$f, then the inductance should be:

$$L_2 = \frac{1}{\omega_o^2 C_2} = 0.506\ \mu\text{hys}$$

and its effective resistance should be: (to make $Q_2 = 50$)

$$R_2 = \frac{\omega_o L_2}{Q_2} = 3.18 \text{ ohms}$$

The mutual inductance should be: (to make x = 1)

$$M = \frac{1}{\omega_o} \sqrt{R_a R_2} = 0.057\ \mu\text{hys}$$

If the coefficient of coupling is made 0.25, the primary or antenna coupling coil inductance is:

$$L_1 = \frac{M^2}{kL_2} = 0.0256\ \mu\text{hys.}$$

Effect of Tube Noise ★ The signal-to-noise ratio as given by equation 22 yields the effect of the input circuit only. If the first tube following this circuit is effective in producing gain, the fluctuation noise contributed by the tube may be neglected. On the other hand, if the tube is noisy, its effect must be included in the total signal-to-noise ratio. The subject of the origin and computation of fluctuation voltages in diodes, triodes and pentodes has been covered in a series of papers [1] by Thompson, North, Harris and others. The fluctuation voltages produced by the tube may be simulated by an equivalent generator as shown in Fig. 11 and values of the voltage $\overline{E_t^2}$ may be found in one of the series of papers previously given.[2] It may be pointed out here that the tube fluctuation voltage is dependent on the bandwidth of the circuits following the tube which means that in the analyses previously presented, it would be proportional to the IF bandwidths chosen.

[1] B. J. Thompson, D. O. North, W. A. Harris, "Fluctuations in Space-Charge-Limited Currents at Moderately High Frequencies," RCA Review. In five parts, 1940 and 1941.

[2] Part V of papers quoted in (1).

Thus, referring to Fig. 11,

$$\overline{E_n^2} = \overline{E_t^2} + \overline{E_c^2} \tag{23}$$

where

$\overline{E_t^2}$ = Tube noise voltage squared

$\overline{E_c^2}$ = Input circuit noise voltage squared

$\overline{E_n^2}$ = Total noise input voltage squared

Thus, the total signal-to-noise ratio may be written:

$$\frac{\overline{E_2^2}}{\overline{E_n^2}} = \frac{\overline{E_2^2}}{\overline{E_t^2} + \overline{E_c^2}} = \frac{(\overline{E_2^2}/\overline{E_c^2})}{1 + (\overline{E_t^2}/\overline{E_c^2})} \tag{24}$$

or (Total signal-to-noise ratio)^2 =

$$\left[\frac{(\text{Circuit signal-to-noise ratio})^2}{1 - (\text{Tube noise/Circuit noise})^2}\right] \tag{25}$$

There are several implications in equations 24 and 25 concerning the relative effects of the circuit and tube noise. For instance:

1. If the tube noise is negligible, equation 24 shows that the total signal-to-noise ratio is the same as the circuit signal-to-noise ratio. For this condition, overcoupling is desirable.

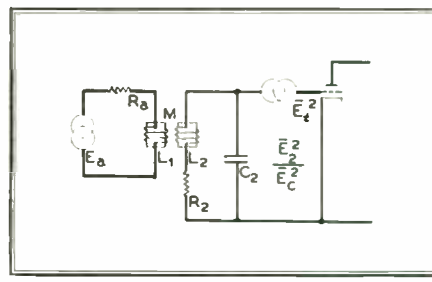


FIG. 11. CIRCUIT SHOWING EQUIVALENT TUBE NOISE GENERATOR, $\overline{E_t^2}$

2. If the tube noise is very large as compared to the circuit noise, then equation 24 becomes:

$$\frac{\overline{E_2^2}}{\overline{E_n^2}} = \frac{\overline{E_2^2}}{\overline{E_t^2}} \tag{26}$$

This equation indicates that the circuit noise need not be considered as a factor in design in those cases where tube noise is large as compared to circuit noise. On the other hand, to increase the signal-to-noise ratio, it is desirable to make the useful signal, E_2, as large as possible. If bandwidth is not a consideration, this may be accomplished by using a value of coupling as close to critical (x = 1) as possible. However, if the bandwidth is to be kept at a fixed value (Q_ϵ = constant), equation 19 indicates that overcoupling will yield the maximum signal voltage, E_2.

3. If the tube and circuit fluctuation voltage values are of comparable value, equation 24 must be considered in its entirety. If it is necessary that the bandwidths of the RF and IF sections be maintained at a given value, then overcoupling is desirable to raise the signal-to-noise

(CONCLUDED ON PAGE 49)

SPOT NEWS NOTES

Items and comments, personal and otherwise, about manufacturing, broadcasting, communications, and television activities

FM Communications: Yellow Cab Company of Philadelphia has been authorized to install an experimental transmitter and receiver for tests on radio cab dispatching. In Cleveland, authority has been issued to the Automobile Club Company for the erection of one fixed and four mobile transmitters for emergency service trucks.

Publication Resumed: The *RCA Review*, suspended during the war, has resumed publication. Under the editorship of Dr. C. B. Jolliffe, it will appear quarterly. Subscription orders should be addressed to RCA Laboratories, Princeton, N. J.

TBA Conference: Television Broadcasters Association will hold its second annual conference on October 10th and 11th at the Waldorf-Astoria, New York City. Plans include exhibits of equipment. General chairman of the conference is Ralph B. Austrian, 500 Fifth Avenue, New York 18.

FM Contracts: Latest companies to sign Armstrong license agreements are Western Electric and Westinghouse Electric Corporation. Western Electric will produce the FM equipment for the Bell System's new mobile radio telephone installations, for rural telephone service where radio will be used instead of wire lines, and for relay purposes. The Westinghouse license covers all receivers, and railroad and other special-services communications equipment.

Both companies manufacture FM broadcast transmitters, but these are not covered in the contracts because such licenses are issued directly to station operators. The six Westinghouse FM stations are included in the latter type of license contract.

Rosel H. Hyde: Named by President Truman to fill the unexpired term of the late FCC Commissioner William H. Wills, running to June 30th, 1951. Mr. Hyde is the senior member of the FCC in point of service, for he joined the Federal Radio Commission as docket clerk in 1928. At the time of his nomination to commissionership, he was general counsel for the FCC.

FM in Washington: FCC has granted 8 FM applications out of the 11 on which a hearing was held March 20th. Grants were issued to:

Cowles Broadcasting Co. — 100.5 mc.; Commercial Radio Equipment Company — 101.3 mc.; National Broadcasting Company — 94.5 mc.; Metropolitan Broadcasting Corporation — 101.7 mc.; Potomac Broadcasting Cooperative, Inc. — 93.3 mc.; Evening Star Broadcasting Company — 94.1 mc.; WINX Broadcasting Company — 102.1 mc.; and Theodore Granik — 93.7 mc. All were assigned 20 kw. effective power with an antenna height of 500 ft.

Norton-Allen Paper: Comment from one engineering consultant on the latest offering from FCC braintrusters Kenneth Norton and Edward Allen is that their paper, published in this issue of *FM* and Television, should have been entitled "Fun with Figures". Inquiries directed to engineers qualified to express well-informed opinions have elicited mild comments to the effect that the paper has no practical significance, and should not be taken seriously.

Time Sales: The 53 AM stations operating on 50 kw. have reported time sales of \$60,981,000 for 1945, an increase of 4.3% over 1944. Of this total, 35.7% were to the major networks, representing 37% of payments by the nets to all their affiliates. These figures can be taken as a measure of the opposition to high-power FM stations which could deliver static-free service to a considerably larger number of listeners than are now getting even fair reception from those 50-kw. AM stations.

WBKY: Elmer G. Sulzer, public relations manager of the University of Kentucky's FM Station, has advised us that their transmitter is located at Lexington, and not at Beattyville, as it has been listed in our FM Station Directory and in FCC reports. WBKY is still operating on 42.9 mc., although it will have 1 kw. on the upper band in the near future.

Theatre Television: On April 3rd, General Electric staged a demonstration of television reception with images projected on a screen 11 by 16 ft. The projector is a development of the Rauland Corporation, Chicago. Transmission was accomplished with microwave equipment developed by G.E. for a projected 2-way system between New York City and Schenectady.

Albert Preisman: Has been elected vice president in charge of engineering at Capital Radio Engineering Institute. During the past three years, following his resignation from Federal Telephone & Radio Corporation, he has headed the Institute's engineering activities.

For Safer Transit: In response to complaints from subscribers that copies of *FM* and Television have been damaged in the mails, we have started to use heavy mailing envelopes instead of wrappers. This should insure the arrival of copies in perfect condition. We shall appreciate comments from our readers on the results of this change.

Violet Kmety: After six months in charge of programming for Muzak at New York City, Miss Kmety is back at Zenith's FM station WWZR, Chicago, where she had been program director for five years.

Kesten-Porter Plan: Someone who did not identify himself mailed us an April 1st copy of the *Boston Traveler*, and marked in red pencil an advertisement of station WLAW, an AM station at Lawrence, Mass. Said the advertisement: "Soon Boston and New England will be hearing the popular ABC (American Broadcasting Co.) programs over the *ten-times-more-powerful* WLAW. A 5,000-watt station now, WLAW soon jumps to 50,000 watts. — Station WLAW will have Boston studios. Present studios are in Lawrence and Lowell."

Note penned on the margin said: "This is no April 1 joke for FM, with the single-market plan."

Actually, the joke will be on the AM broadcasters, for the K-P single-market plan is already a dead mackerel. It will be buried and forgotten long before postwar investments in new AM equipment can be amortized.

New Appointments: Robert L. Wolff has been named chief radio and electronics engineer for Centralab. Before joining this company in 1937, he was engaged in development and design work at Western Electric's Hawthorne plant for four years.

Rolland R. Roup has replaced G. Milton Ehlers as chief ceramics engineer. He has been with Centralab since 1933, except for a 15-month period of service at the Stupakoff laboratories in Pittsburgh.

Television Plans Changed: At least 25 companies have withdrawn their applications for television construction permits within the last few weeks. Some of these applications, no doubt, did not represent genuine intentions to put television stations on the air in the immediate future, but were filed merely as speculative hedges against possible developments in technical progress, or actions by competitors. Others have decided to wait until the question of low-band, black-and-white vs. high-band, color transmission is settled definitely.

J. Ernest Smith: Former division head of RCA Laboratories has joined Raytheon to head its microwave communication engineering department. Raytheon is now operating an experimental microwave circuit between New York and Boston, the first link in a projected communications and broadcast program network.

Educational FM Stations: Construction per-

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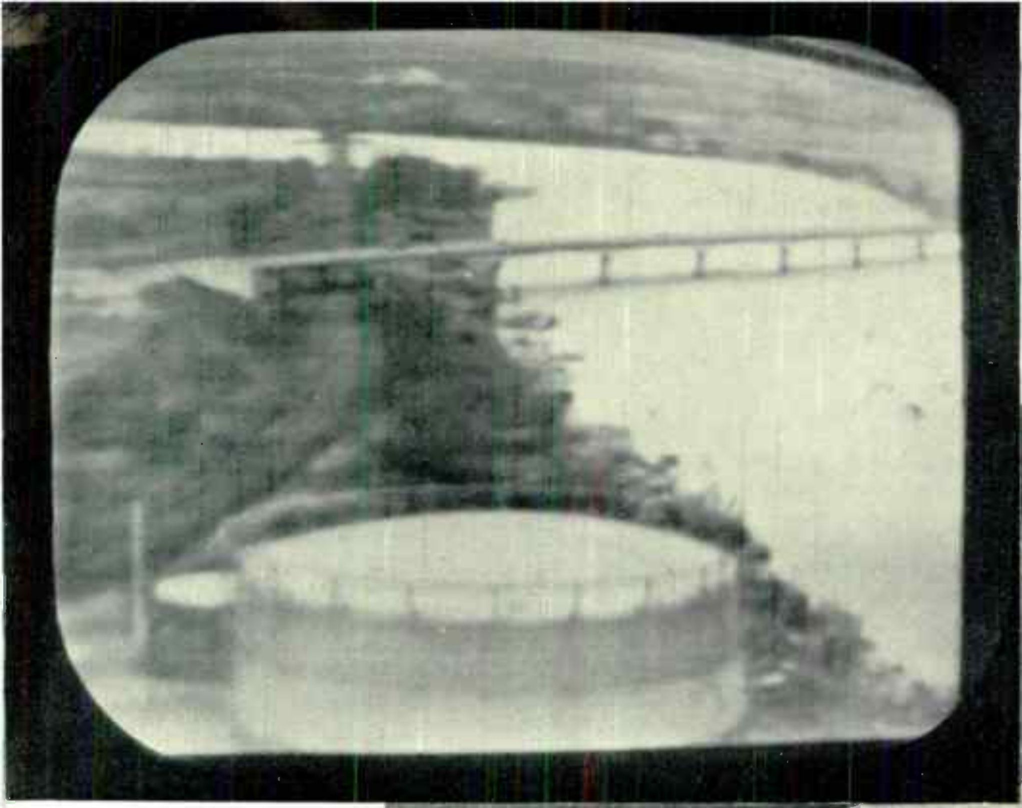
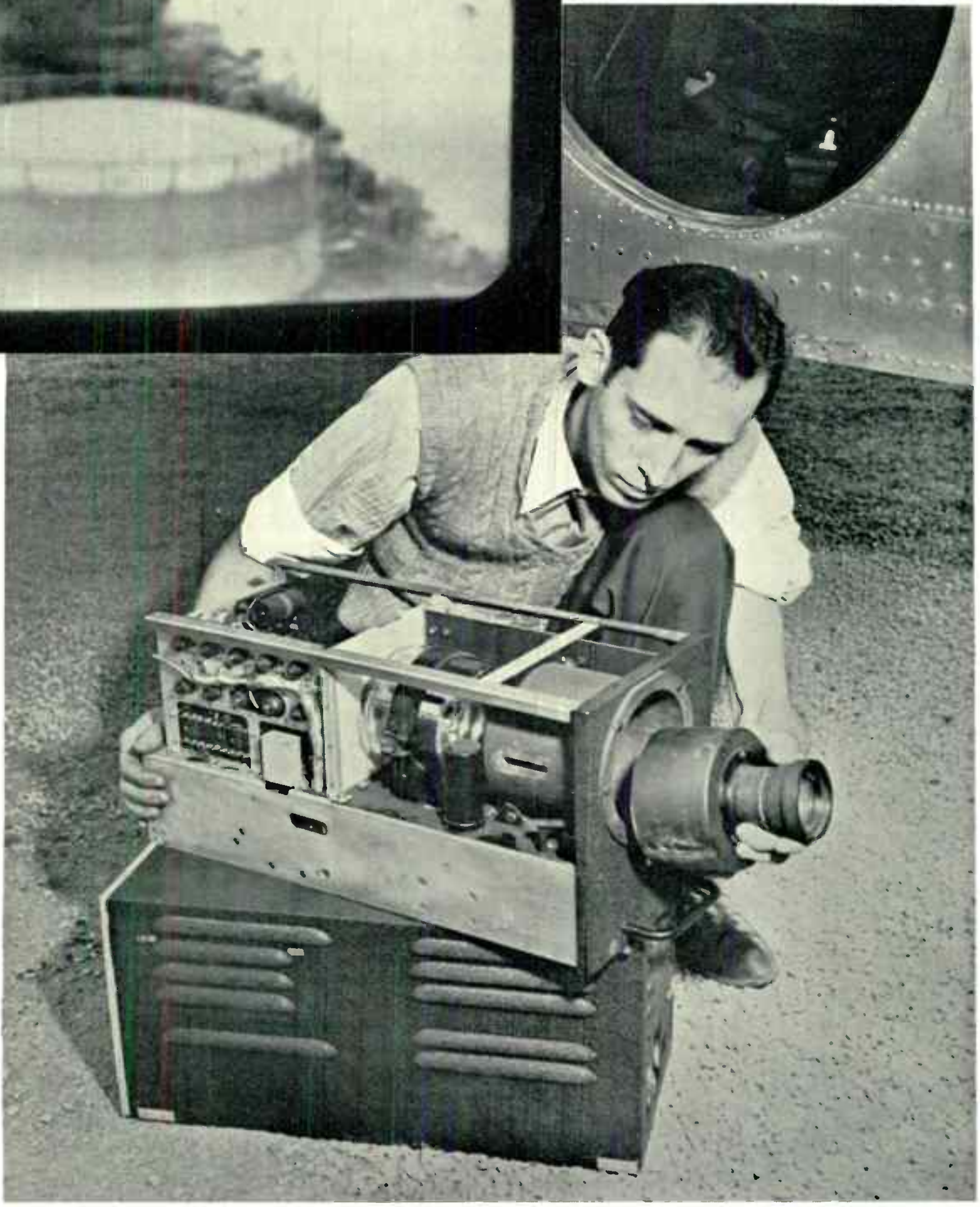


LEFT, ACTUAL PHOTOGRAPH OF AN IMAGE RECEIVED ON THE GROUND OF TERRAIN SCANNED BY THE AIRBORNE TELEVISION TRANSMITTER

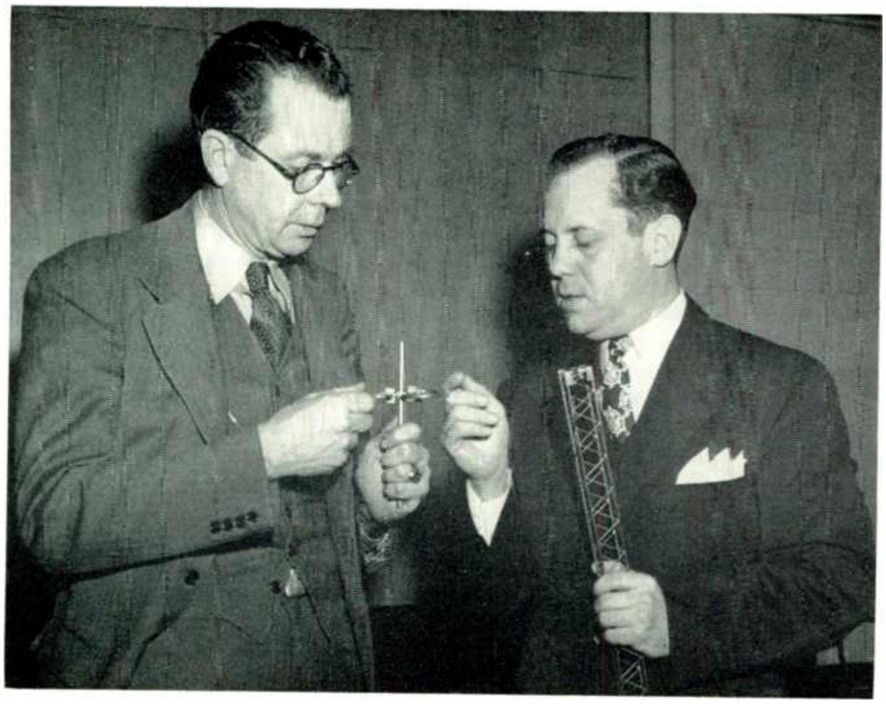


AIRBORNE TELEVISION EQUIPMENT USED FOR OBSERVING ENEMY TERRITORY FROM THE GROUND. IT IS CARRIED IN SCOUTING PLANES OR RADIO-CONTROLLED SHIPS

NEWS PICTURE

THE use of television equipment for observing enemy positions is not new to the men who operated it during the war, but a demonstration of its performance at Anacostia certainly amazed engineers and editors who were invited by RCA to see the system in action. The upper photograph on this page shows what information could be sent down by an airborne television transmitter, and the lower photograph explains why such a premium was set on the size of tubes and components for military equipment.

The success of the demonstration was a very forceful reminder that however far the development and perfection of radio and television equipment was carried during the last war, the work was by no means completed. Rather it should be considered an excellent start on which to go forward. Right now, the radio industry, whose peacetime progress contributed so much to our military success, is taking a serious licking from the government it served so well. But soon the tremendous gains in engineering progress made during the war will be paying dividends through new applications to a great number of civilian communications services.



FCC CHIEF ENGINEER GEORGE R. ADAIR AND JOHN F. MORRISON WITH A MODEL OF THE CLOVERLEAF RADIATORS AND THE SPECIAL TYPE OF SUPPORTING TOWER

CLOVERLEAF FM ANTENNA

Western Electric Cloverleaf Design Uses a Central Conductor and the Tower Legs to Feed Antenna Elements

A NEW angle of approach to FM antenna design is represented in Western Electric's 54A Cloverleaf design, intended for operation in the broadcast band from 88 to 108 mc., with transmitter output power up to 50 kw.

Antenna Design ★ The antenna comprises an array of two or more vertically stacked radiating units, each composed of a cluster of four curved elements which, in plan view, form a symmetrical shape similar to a four-leaf clover, as shown in Fig. 1. A radio frequency voltage applied between the junction of the four elements and their ends causes, in effect, a ring of uniform current which produces a circular radiation pattern. The radiating elements, separated by half-wave intervals, are connected at their inner ends by means of simple clamps to a 3-in. feed conductor, centrally located within the tower structure. The outer ends of the elements are connected to the respective tower legs. Details of this arrangement can be seen in Fig. 1. Thus, the tower serves as the return or outer conductor of the feed line.

The usual phase reversal occurring along such a feed line at half-wave intervals is compensated for by merely reversing the mounting position of the radiating elements in adjacent units. This simple installation procedure, illustrated in Fig. 1, assures the correct phasing for maximum gain at the station's operating frequency.

This new design, therefore, eliminates the need for multiple transmission lines, phase correcting lines or networks, and balancing lines which are troublesome because their length must be adjusted for the operating frequency to avoid error in antenna current relations with a corresponding loss of antenna gain.

Maximum gain from the antenna is further assured by the use of four small-diameter, vertical cables, indicated in Fig. 1, to nullify vertically polarized radiation which might otherwise be radiated at high angles. This type of radiation is usually caused by spurious currents flowing in vertical structural members as the result of coupling between the structure and radiating elements.

The impedance of the antenna array is matched to the impedance of a coaxial transmission line by means of a low-loss transformer which utilizes the base section of the tower and antenna feed conductor. This transformer can be adjusted easily over a wide impedance range, and it is set to the proper adjustment at the time of installation.

Energy Distribution ★ The distribution of the radiated energy about a typical antenna of the 5-unit size is shown in Fig. 2. It will be observed from this radiation pattern that the signal intensity is greatest in the direction of the horizon (0°) and is substantially less at higher elevations. With

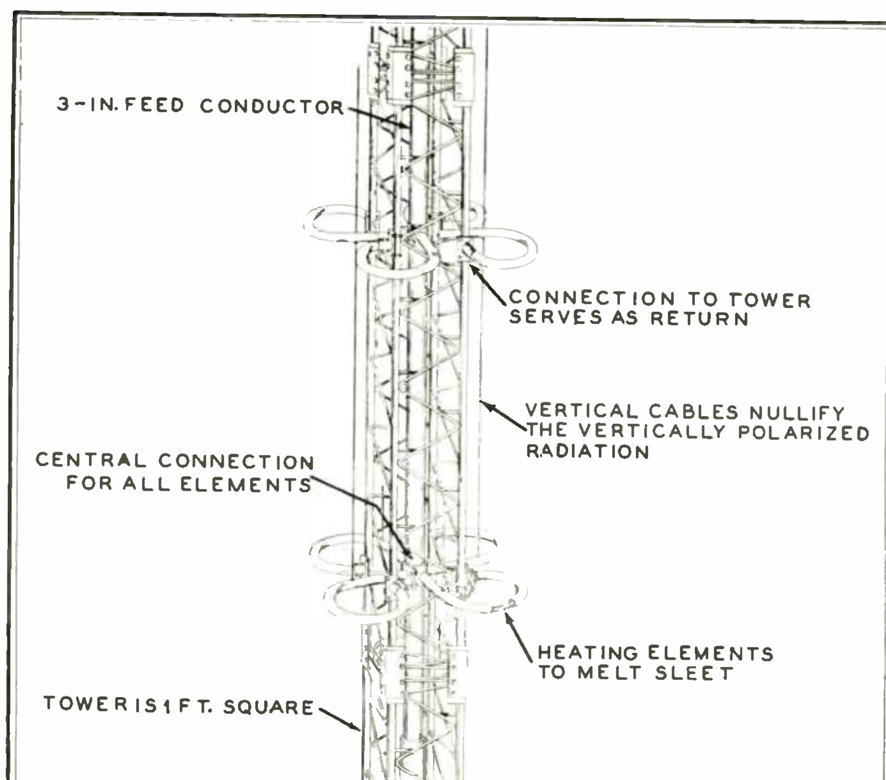


FIG. 1. DETAILS OF THE ANTENNA, SHOWING HOW RADIATORS ARE CONNECTED BETWEEN THE CENTRAL CONDUCTOR AND THE LEGS OF THE SUPPORTING TOWER

this type, as with all types of directive antennas, the vertical radiation pattern becomes progressively broader and the gain less as the number of radiating units and length of the array is reduced. Conversely, the pattern becomes narrower and the gain higher as the number of units and length of the antenna are increased — all providing that the instantaneous currents in the individual radiating units are established and maintained in their proper relationships.

Antenna Gain ★ Maximum gain, the condition when the instantaneous currents of all the elements are in time phase and are of equal amplitude, can be obtained readily in the Cloverleaf antenna. At the time of installation, the correct current relationships can be established easily and accurately.

Fig. 3 shows the antenna gain vs. the number of antenna units. This data, related to the height of the antenna and the cost of the elements and supporting tower, will give information necessary to determine the economy of design for any specific installation.

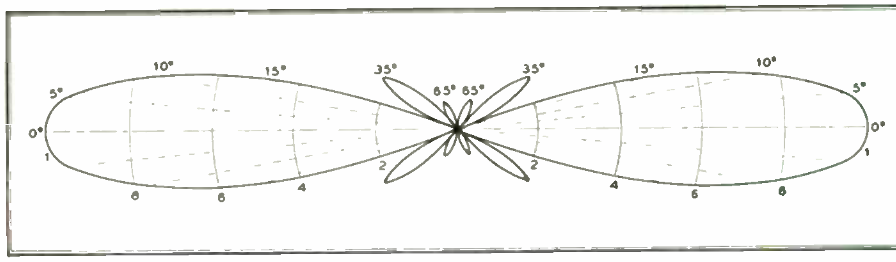


FIG. 2. COMPUTED RADIATION PATTERN FOR A 5-UNIT CLOVERLEAF ARRAY

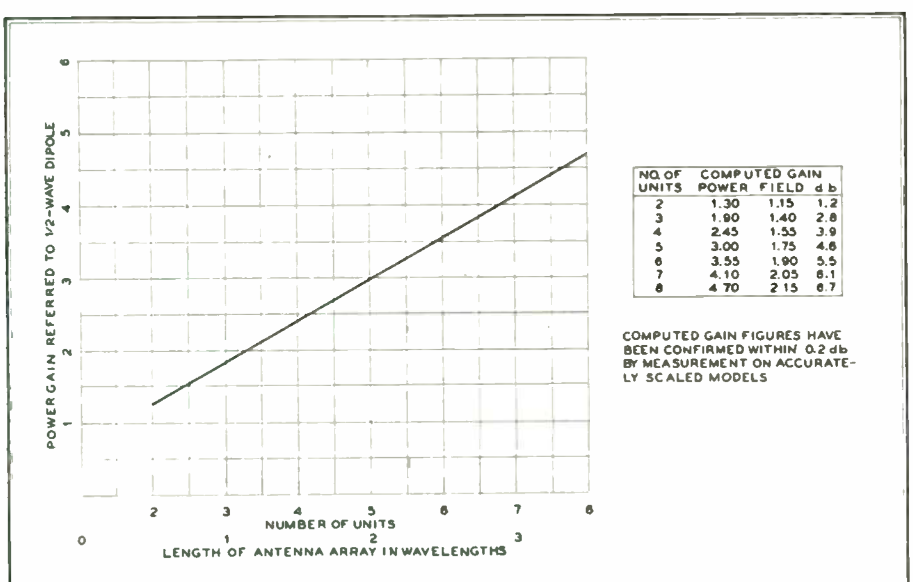
Supporting Tower ★ The tower furnished as a part of the antenna is composed of an assembly of standardized, welded structural steel sections, 1 ft. square. This structure has been conservatively designed and constructed by Blaw-Knox to withstand high wind velocities and heavy icing loads. All steel parts of the antenna are hot-dip galvanized to assure the maximum protection against corrosion.

Provisions are made for installing electric heating cables inside the tubular radiating elements for sleet melting. Since one end of each radiating element is connected directly to the tower structure, the need for RF filters in the heater power circuit is avoided.

TABLE 1

Frequency, Megacycles	2-Unit	3-Unit	4-Unit	5-Unit	6-Unit	7-Unit	8-Unit
88–89	1	2	3*	3	4*	4	
89–90	1	2	3*	3	4*	4	
90–91	1	2	3*	3	4*	4	
91–92	1	2	3*	3	4*	4	
92–93	1	2*	2	3	4*	4	
93–94	1	2*	2	3*	3	4	
94–95	1	2*	2	3*	3	4*	4
95–96	1	2*	2	3*	3	4*	4
96–97	1	2*	2	3*	3	4*	4
97–98	1	2*	2	3*	3	4*	4
98–99	1	2*	2	3*	3	4*	4
99–100	1	2*	2	3*	3	4*	4
100–101	1	2*	2	3*	3	4*	4
101–102	1	2*	2	3*	3	4*	4
102–103	1	2*	2	3*	3	4*	4
103–104	1	2*	2	3*	3	4*	4
104–105	1	2*	2	3*	3	4*	4
105–106	1	2*	2	3*	3	4*	4
106–107	1	2*	2	3*	3	4*	4
107–108	1	2*	2	3*	3	4*	4

* Asterisk indicates that the required minimum number of "A" tower sections will permit the installation of an additional radiating unit.



NO. OF UNITS	COMPUTED GAIN POWER	FIELD	db
2	1.30	1.15	1.2
3	1.90	1.40	2.8
4	2.45	1.55	3.9
5	3.00	1.75	4.8
6	3.55	1.90	5.5
7	4.10	2.05	6.1
8	4 70	2 15	6.7

FIG. 3. POWER GAIN VS. NUMBER OF ANTENNA UNITS AND LENGTH OF ARRAY

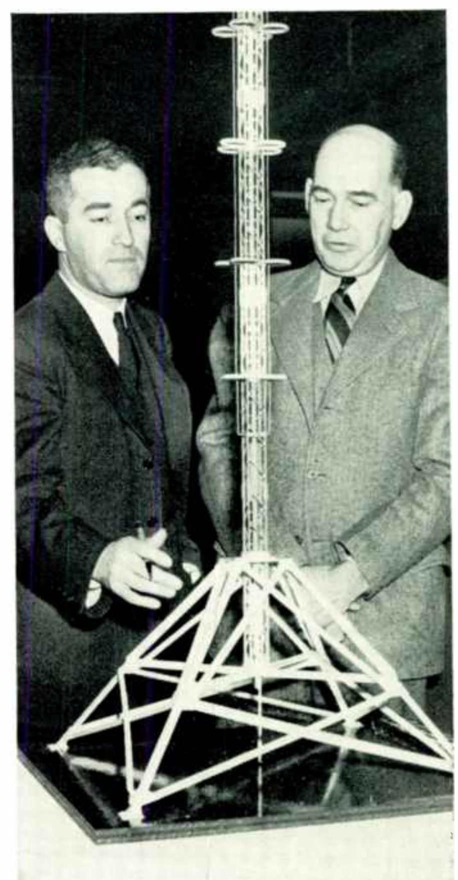


FIG. 4. WM. H. DOHERTY AND DIXIE B. McKEY WITH THE COMPLETE MODEL

Standard designs provide for mounting of a 300-mm. aircraft warning beacon light on top of the tower structure. The heating units and beacon light are not required in all installations. Therefore, they are not furnished as a part of the antenna but can be procured separately.

A detailed model of the tower and antenna is shown in Fig. 4. In the base section, below the first antenna units, are two enlarged sections of the center con-

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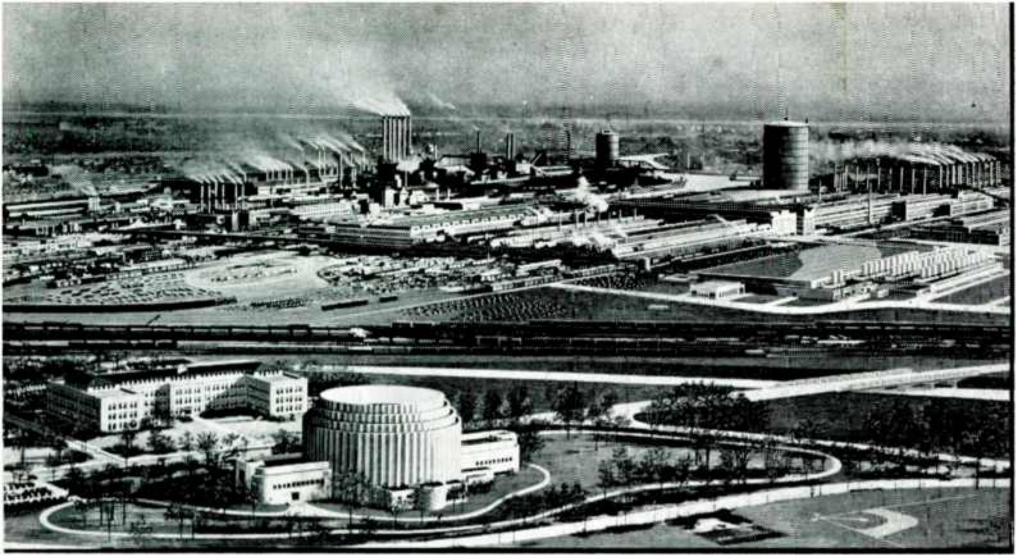

FIG. 1. ONE END OF THE RADIO CIRCUIT IS LOCATED AT THE FORD RIVER ROUGE PLANT. CONDITIONS HERE REPRESENT THE EXTREME CONDITIONS OF INTERFERENCE WHICH MIGHT BE ENCOUNTERED IN THE OPERATION OF A RADIO COMMUNICATIONS SYSTEM FOR HANDLING RAIL YARD TRAFFIC

161-MC. SATELLITE SYSTEM FOR RAIL YARDS

Report of Detroit Tests on System Using 189-kc. FM Induction and 161-Mc. Space Radio

BY ARNOLD C. NYGREN AND WILLIAM G. CLINTON*

AN ARTICLE on railroad radio communications, published in the December, 1944 issue of *FM* AND TELEVISION [1] aroused a great deal of interest among railroad officials. At Detroit, several officials of the Detroit, Toledo & Ironton Railroad Company were convinced that radio communications would assist in speeding up operations and would permit greater efficiency and safety in handling the heavy freight load within the interrelated D.T. & I. yards at Flat Rock, Michigan, and the yards of the Ford Motor Company's Rouge plant, Fig. 1.

Plans were made to investigate the subject, and preparations were finally completed for actual tests held on March 19 to 21, 1946. The tests were conducted by the D.T. & I. Railroad and the Ford Motor Company, in association with Farnsworth Television and Radio Corporation, which supplied the necessary experimental space radio and induction equipment.

The area to be covered for normal operations is shown by the map of Fig. 2. The D.T. & I. Flat Rock yards are situated approximately 14 miles southwest of the Ford Motor Company. These probably are two of the busiest and most highly industrialized inter-related yards in the country. Thus, they were selected to determine radio's ability to deliver satisfactory coverage under adverse conditions. The tests included point-to-train, train-to-train, intra-train, and point-to-point radio communications in yard and main line operations.

Executives and communications engineers of the major U.S. railroads and the Ford Motor Company were present to observe the results and to examine the equipment which had been particularly designed for railroad use.

Need for FM ★ Preliminary surveys by Farnsworth engineers indicated the need for two low-power, fixed transmitters to obtain positive coverage of such a large area. As control of all operations would normally be from the yardmaster's office in the Flat Rock yards, it was decided to make one fixed installation at that point for coverage of the area south of the Ford yards. For coverage of the Ford Motor Company area, it was decided to utilize a similar transmitter as a satellite station, located within the Ford yards.

To permit satellite operation, particularly non-synchronized operation, it was necessary to employ Frequency Modulation to eliminate heterodyne beats between the two fixed stations, and between any mobile units on the same frequency. Frequency Modulation would also make it possible to virtually eliminate flutter in areas of low signal intensity, due to the very rapid action of the limiter circuit in FM receivers, as contrasted with the relatively slow action of automatic volume control circuits in AM receivers. Further, it would be possible to operate with a minimum of primary power, due to the absence of high-level modulators common to AM transmitters. This feature is particularly important when equipment is installed on mobile units where the primary power is limited, and transmitter power output in excess of 10 watts is employed.

Another factor in favor of FM is that it produces a minimum change in audio output when a mobile unit moves from the immediate vicinity of a fixed station to a remote part of a service area. This is due to the relatively flat AVC characteristic of

RAILROAD OFFICIALS INSPECTING THE DIESEL INSTALLATION USED ON THE D.T. & I.

* Respectively Associate Editor, *FM* AND TELEVISION Magazine, and Signal and Communications Engineer, Detroit, Toledo and Ironton Railroad Company.

[1] "What's Going On In Railway Radio," by John A. Curtis, *FM* AND TELEVISION, December, 1944.

an FM receiver as compared to an AM receiver. An additional FM advantage is improved signal-to-noise ratio at the outer fringe areas.

FM Induction Radio ★ The demonstrations were also to test the practicability of remote control of the satellite transmitter from the central station by means of 189-kc. carrier signals impressed on the existing wayside wires extending between the central station at Flat Rock and the satellite station at the Ford yards. Telephone lines were not available for this purpose. Second, it was known that communications could be maintained over this distance with the induction equipment alone, even though some of the lines were down or severed. Third, this system would permit great flexibility in operations because additional transmitters and receivers could be coupled to the wayside wires at

In this new satellite technique, which some railroad communications engineers believe will find a number of applications in the railroad field, a VHF fixed station, located at a central point in a yard or terminal, can be linked by low-frequency FM induction radio circuits to one or more VHF satellite stations, operating on the same carrier frequency, and disposed in different yards or other local service zones thus covering a large rail-service area.

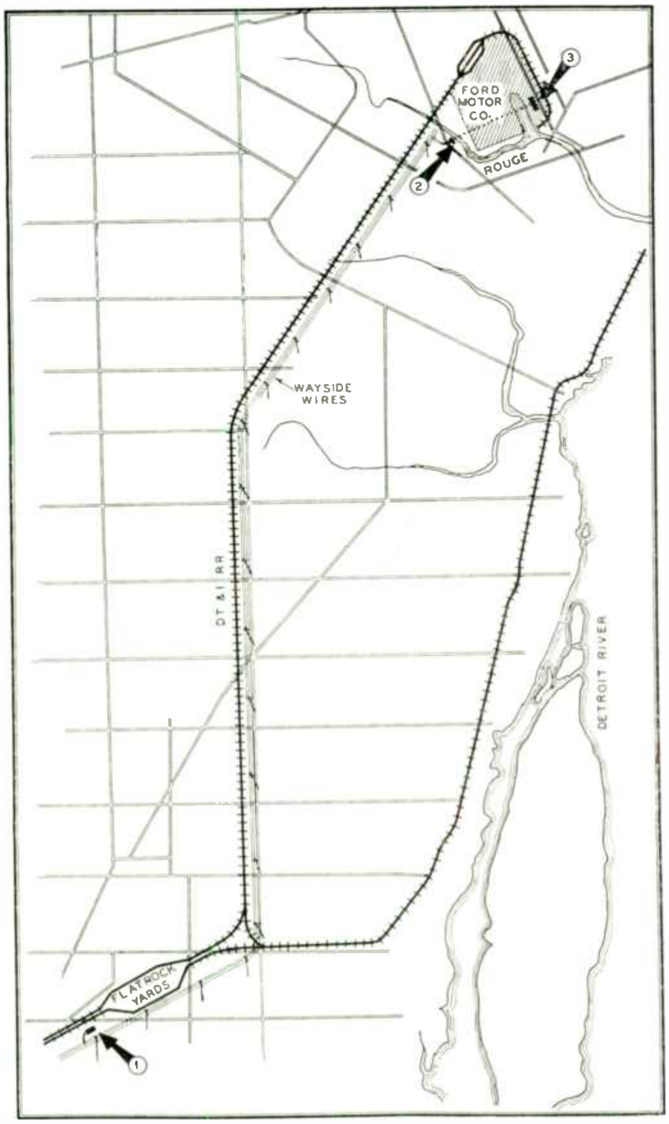

FIG. 2. AREA COVERED BY THE FARNSWORTH TEST INSTALLATION

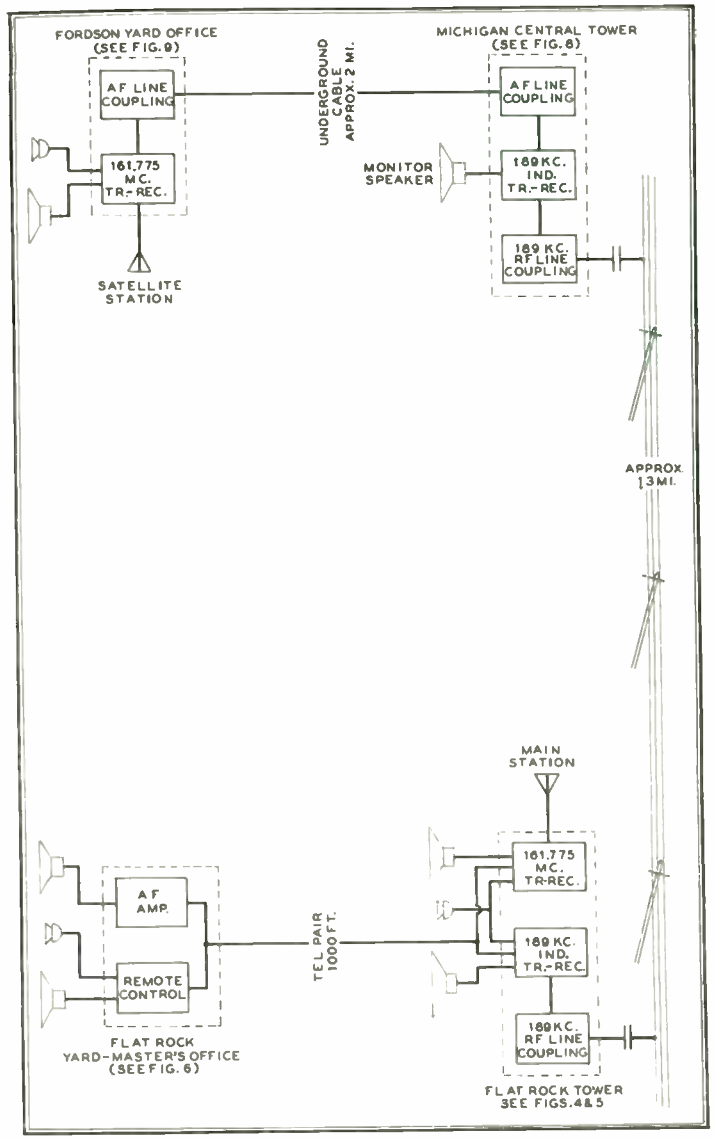

FIG. 3. DIAGRAM OF THE FM INDUCTION AND SPACE RADIO SYSTEM

two yards. It was felt that the use of induction type transmitters and receivers in conjunction with space radio equipment would permit greater overall flexibility of operation than with either method alone. With a dual system, a radio signal of relatively high intensity could be delivered to all parts of both yards and the adjoining areas with the use of low-power fixed-station equipment.

The decision to utilize FM induction type equipment for control of the satellite link was based on past experience and a working knowledge of its advantages and limitations. First, the induction equipment would provide direct communication any point and the same or different carrier frequencies used. This factor would be increasingly important with the addition of portable transceivers for the use of working crews. Fourth, FM carrier equipment in the spectrum between 150 and 200 kc. would deliver a high-level signal practically free of line noise and cross-talk.

On the basis of laboratory and field tests, past experience with both space radio and induction equipment, and the known advantages of Frequency Modulation, particularly with respect to satellite operation, experimental apparatus was designed and installed by Farnsworth engineers for these railroad tests.

The induction radio signals can be impressed, by inductive or capacitive coupling means, as RF carrier-wave energy on existing wayside wires which normally extend between the various yards of railroad terminal service areas.

The induction radio signals, when properly applied, cause no interference with existing wire and carrier circuits. Since the radio wave energy follows all wayside conductors, serving as wave-guiding paths along the railroad right of way, the system should still function even when the continuity of wire telephone circuits is broken by storms or other causes. A high degree of discrimination against electrical noise,

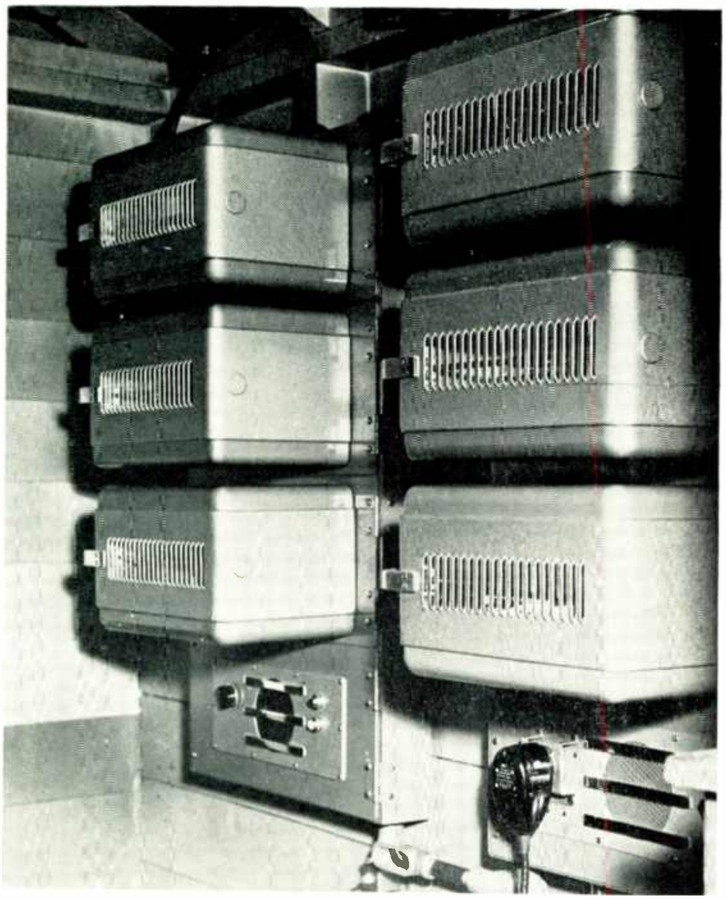

FIG. 4. POWER SUPPLY, TRANSMITTERS, AND RECEIVERS FOR FM INDUCTION AND SPACE RADIO AT THE FLAT ROCK MAIN STATION

FIG. 5. MAIN STATION ANTENNA ON THE WATER TOWER AT THE FLAT ROCK END OF THE SYSTEM

such as static discharges, line transients, and crosstalk is provided by the use of Frequency-Modulation in the induction radio equipment.

Equipment Used At Detroit ★ Fig. 3 presents a block diagram of the satellite system used at Detroit. In the tests, a 10-watt, 161.775 mc. central station FM transmitter and associated FM receivers, shown in Fig. 4, were installed in a small shanty at the foot of a 165-ft. water tower, Fig. 5, in the Flat Rock Yard of the Detroit, Toledo and Ironton Railroad.

A remote control unit, Fig. 6, including handset, loudspeaker, amplifier, and associated equipment, was employed at the Flat Rock yardmaster's office, and was joined to the VHF space radio equipment by means of a telephone pair, approximately 1,000 ft. in length.

An FM induction radio transmitter of experimental mobile type, with a maximum power output rating of 35 watts, and an associated FM induction radio receiver, operating on a frequency of 189 kilocycles, were installed in proximity to the space radio equipment, Fig. 4, at the tower shanty.

The induction transmitter was connected with the remote control unit at the yardmaster's office by means of a selector switch located at that point. The induction receiver was connected to an audio-frequency amplifier and loudspeaker located in a small desk cabinet adjacent to the remote control unit at the Yard Office. A handset with noise-discriminating microphone, earphone, and conventional press-to-talk switch were utilized at the yardmaster's control position. The loudspeakers and amplifiers associated with the VHF and induction radio channels were selectively activated by the received space-radio or induction-radio signals, thereby facilitating rapid identification of the channel by which reception of voice signals was accomplished at the Yard Office, and indicating to the operator whether the mobile transmitter was in a remote outlying zone served by the satellite system, or within the local service area served by the Flat Rock VHF equipment.

The space-radio equipment was connected with a new type of vertical an-

FIG. 6. MESSRS. CLINTON, LEFT, AND NYGREN AT THE FLAT ROCK CONTROL POINT

tenna, developed by Farnsworth, which was mounted on the top of the water tower at a height of approximately 175 ft. above ground. A solid-dielectric coaxial transmission line, 1 in. in diameter, was used to connect the VHF receiving and transmitting equipment with the antenna.

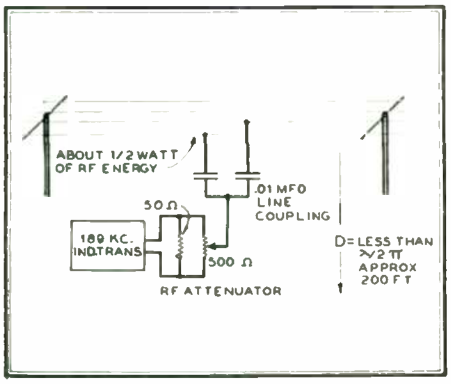

FIG. 7. INDUCTION RADIO CONNECTIONS

The induction radio equipment was coupled through capacitors, Fig. 7, to the wayside wire-telephone circuit extending between Flat Rock and Dearborn. Approximately ½ watt of RF signal energy was found adequate for the wire-circuit link. This reduction in power was obtained by means of a resistive attenuator, connected between the output circuit of the induction radio transmitter and the wire line.

Coöperating induction-radio equipment, comprising a low-frequency FM transmitter and receiver, similar to that used at Flat Rock, was located in a signal tower of the Michigan Central railroad, about 13 miles from Flat Rock. This equipment, shown in Fig. 8, was coupled to the overhead wayside wire circuits by an arrangement similar to that employed at Flat Rock. The output of the induction radio receiver at the Michigan Central tower was connected to a telephone pair, which ran underground in a lead-sheathed cable from the Michigan Central tower to the Yard Office at the Ford Motor Company's plant.

The same telephone pair was employed for transmission from the Ford Yard Office to Flat Rock, with relays being used to effect automatic transfer of the single pair between transmitting and receiving equipment. A carrier-operated relay in the induction radio receiver at the Michigan Central tower was employed to apply a DC control voltage on the underground telephone circuit. This served to turn on the space-radio satellite transmitter at the Ford Yard Office during periods when signals were received by induction radio from Flat Rock.

The space-radio satellite equipment at the Yard Office in the Ford Motor Company's plant, similar to that used at the Flat Rock control point, was mounted on the wall of the office. A microphone and loudspeaker were provided to permit local two-way communications by VHF space radio between the Ford Yard Office and mobile units within the plant area and its vicinity, or between the Ford Yard Office and the Flat Rock station.

In normal operation, the satellite sta-

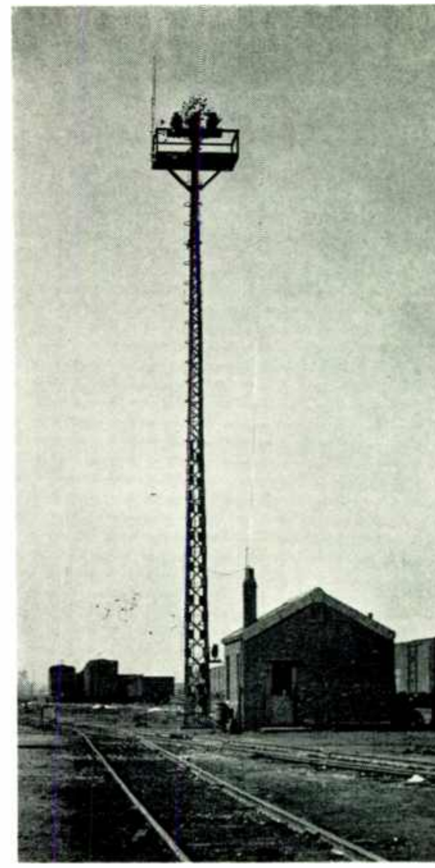

FIG. 9. SATELLITE ANTENNA AT THE FORD PLANT END OF THE SYSTEM

tion was controlled, via the induction link, from the Yardmaster's Office at Flat Rock. The antenna was of the same type used at Flat Rock, and was mounted at the top of a 75-foot flood-light tower, in the Fordson yard, as shown in Fig. 9.

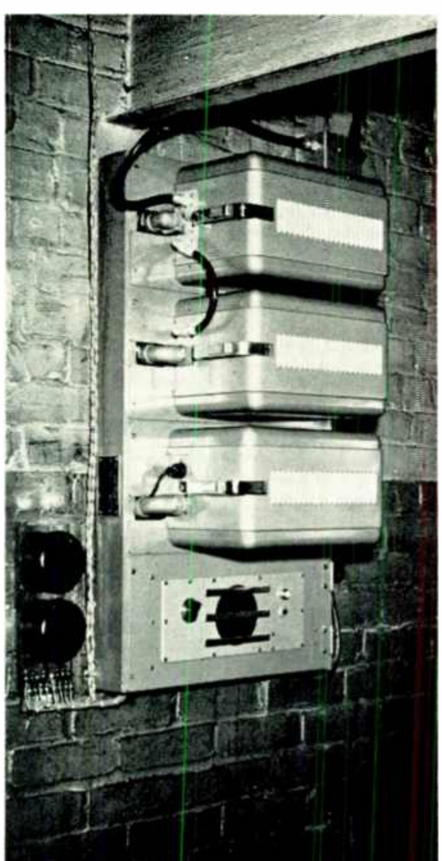

FIG. 8. INDUCTION RECEIVER AND TRANSMITTER AT MICHIGAN CENTRAL TOWER

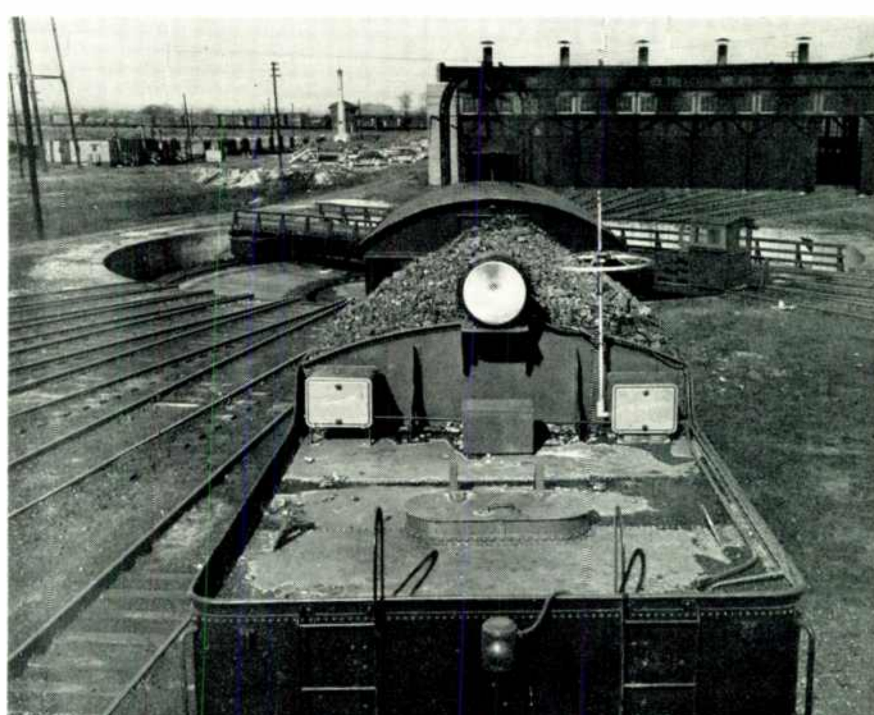

FIG. 10. THE CARTWHEEL GROUND-PLANE ANTENNA, AND THE WATERTIGHT ENCLOSURES FOR THE TRANSMITTER AND RECEIVER, MOUNTED ON A LOCOMOTIVE

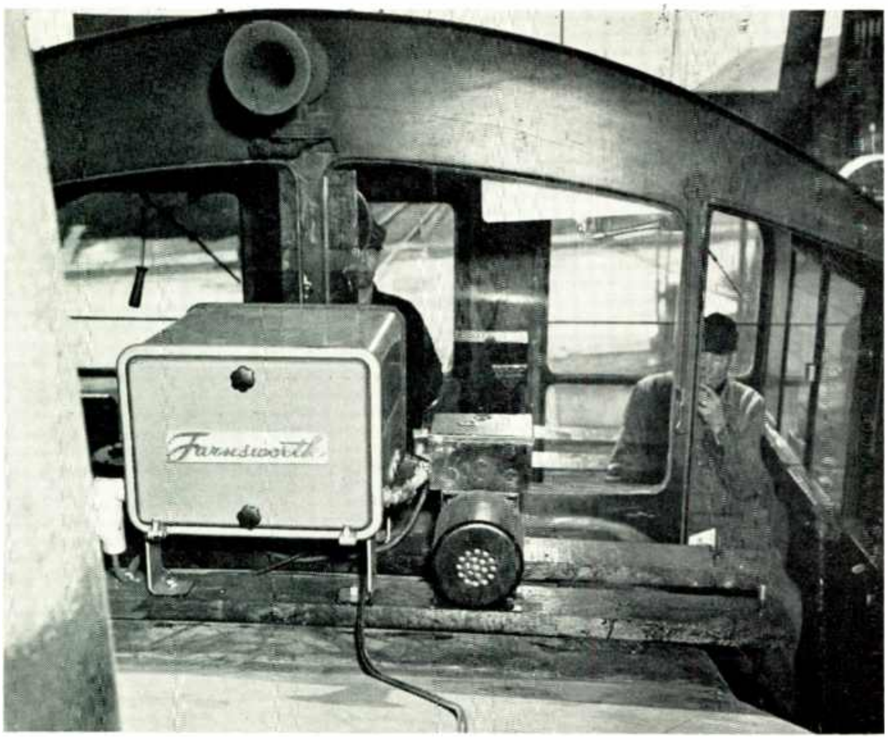

FIG. 11. THIS SHOWS THE METHOD OF MOUNTING THE RADIO EQUIPMENT ON A DIESEL ENGINE. THIS VIEW IS LOOKING INTO THE CAB FROM THE FRONT

This was joined to the transmitter and receiver by a coaxial line of the same type used at Flat Rock. The power output of the satellite transmitter was approximately 10 watts.

Two locomotives, one steam and the other a Diesel-electric, were equipped with two-way VHF units. The installation on the steam locomotive was mounted on the tender, at a convenient point above the water tank, Fig. 10. The transmitter and receiver were housed in an air tight metal case to provide adequate protection from the corrosive sulphur fumes which are present in the smoke from steam locomotives. A second air-tight case was used to house the 115-volt AC power supply unit. A rotary converter provided 115 volts AC from the 32-volt DC primary power circuit of the locomotive.

The antenna, of an experimental cart-wheel ground-plane type, was mounted on the side of the radio equipment case, as shown in Fig. 10. A threaded pipe fitting on the base of the antenna support permitted the antenna to be swung down out of the way, if desired, during coaling operations. The top of the antenna was approximately 5 ft. above the deck of the tender, and complied with the overhead clearance restrictions of the D.T. & I. railroad.

The remote control unit, loudspeaker, and microphone were located in the locomotive cab, near the engineman's position. The remote control unit included a loudspeaker volume control, power OFF-ON switch, pilot lights, receiver TEST button (a squelch-opening switch of momentary contact type), INTERCOM switch to permit use of the equipment in audio-frequency intercommunications, and a channel selector switch for selecting either of the two transmitting frequencies provided.

The cab loudspeaker was of the re-entrant type, of weatherproof construction. Audio level was more than adequate to override the high ambient noise levels experienced in steam-locomotive operation.

A second remote control unit, loudspeaker, and a microphone similar to those used in the locomotive cab were installed in a Pullman coach which carried visiting engineering and operating personnel invited to attend the tests. This made it possible to control the radio transmitter and receiver on the locomotive from the Pullman, as well as from the cab, and allowed the visitors to listen to talk between the train and fixed points, or between trains. Through use of the INTERCOM switch, the microphone and loudspeaker in the coach could be employed for two-way speech communications between the coach and locomotive cab. In normal railroad service, this intercommunications circuit could be used by railroad personnel on the ground or on the foot-boards [2] at the rear or front of yard engines in talking between these points and the cab, or in two-way radio communications with fixed points or other engines.[3]

The radio transmitter and receiver on the Diesel-electric locomotive were installed in an air-tight case at the top of the engine hood, in front of the locomotive cab, as shown in Fig. 11. A dynamotor, operable on 64-volts DC, was mounted next to the transmitter-receiver case. This provided plate and filament voltages.

A remote control unit, speaker, and microphone, similar to those used in the steam locomotive, were installed in the Diesel cab, as shown in Fig. 13.

A new low-clearance VHF antenna, developed by Farnsworth, was located on the top of the engine hood, near the bell of the locomotive, as seen in Fig. 12. This antenna, of extremely rugged construc-

[2] See "Progress Report on Railroad FM" by Arnold C. Nygren, *FM* AND TELEVISION, December, 1945, page 25.

[3] See "FM Aids the Battle of Transportation" by W. S. Halstead, *FM* RADIO-ELECTRONICS, page 23, July, 1943.

FIG. 12. THE 11-IN. FIRECRACKER ANTENNA CAN BE SEEN AT THE LEFT OF THE BELL

tion, projected less than 11 ins. above the hood, and resembled a locomotive whistle in appearance. The performance approximated a half-wave dipole, and proved superior to a ground-plane antenna of greater overall height. No insulator was required between the antenna and motor hood, thereby adding to the ruggedness of the antenna structure.

Details of VHF Equipment ★ The VHF transmitter, of an experimental FM type, had a maximum power output rating of 15 watts and was designed for operation in the 152–162 megacycle band. Phase modulation was employed in the transmitter, with a frequency swing of 15 kc. during normal voice modulation. An audio-frequency peak limiting circuit was employed to prevent frequency deviations substantially in excess of 15 kc. Provision was made for the use of two crystals, to permit operation of the transmitter on either of two frequencies. However, only one frequency, 161.775 mc., was used in the tests. A frequency stability of ±.005% or better was obtained under normal operating conditions.

The experimental VHF receiver had a power output rating of approximately 5 watts. Sensitivity of the receiver was such that an RF signal voltage of 0.5 microvolts at the input terminals would produce full saturation of the limiter circuit. The selectivity was sufficient for alternate channel operation, with response at least 60 db down at 120 kc. from the operating frequency. Provision for use of two crystals was incorporated in the receiver to permit optional operation on either of two designated carrier frequencies, as determined by the position of a channel selector switch on the remote control unit.

FIG. 14. ARNOLD NYGREN, LEFT, AND JOHN CURTIS, MANAGER OF THE FARNSWORTH MOBILE COMMUNICATIONS DIVISION, IN THE CAB OF THE DIESEL LOCOMOTIVE

FM Induction Radio Equipment ★ The induction-radio transmitter, designed primarily for mobile use, has a power output rating of 35 watts. It employed a reactance-tube modulator to effect a frequency swing of ± 4 kilocycles with normal modulation. Since the audio frequency range of the equipment extended to 4,000 cycles, the deviation ratio was 1. An audio peak-limiter was used to restrict the frequency swing substantially within ± 4 kilocycles. The equipment was designed to provide a frequency stability of 0.1% or better under normal operating conditions. The transmitter was designed for operation on any selected frequency in the band between 150 and 250 kc.

The induction receiver was of the tuned RF type, covering 150 to 250 kc. with a sensitivity of approximately 10 microvolts for full saturation of the limiters. The power output rating was approximately 5 watts. Response of the receiver was within ± 3 db between 200 and 4,000 cycles. Selectivity was 70 db down at 13 kc. removed from the operating frequency, and 50 db down at 10 kc.

A carrier-operated relay was built into the receiver to permit automatic control of an associated space radio transmitter for repeater or satellite operation during reception of carrier wave energy from a coöperating induction-radio station.

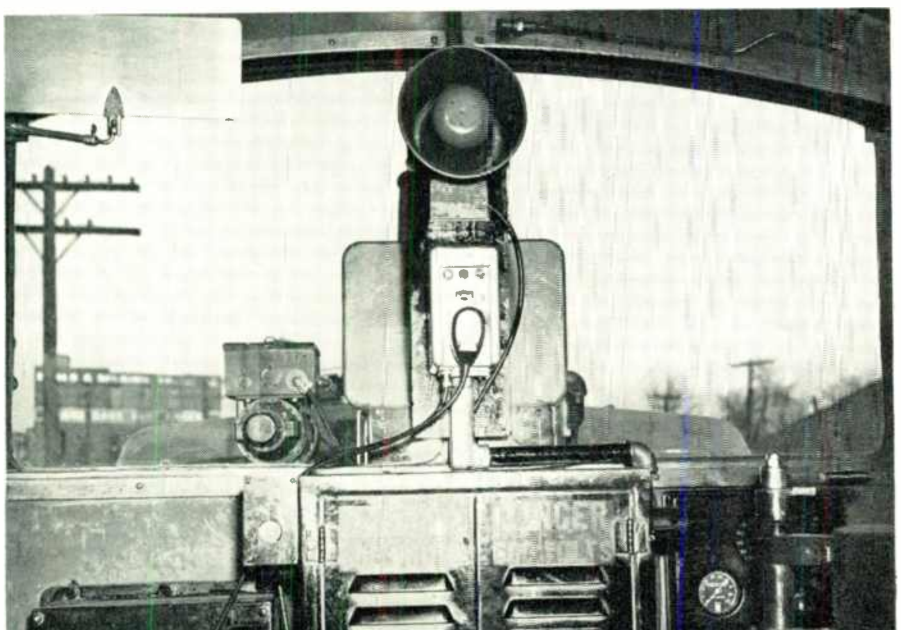

FIG. 13. LOOKING OUT OF THE DIESEL LOCOMOTIVE CAB. SPEAKER AND MICROPHONE MOUNTING CAN BE SEEN, AS WELL AS THE RADIO EQUIPMENT MOUNTED OUTSIDE

Test Results ★ Tests of the system over the 3-day period demonstrated that solid 2-way communication could be maintained at all points in the Flat Rock and Dearborn yards, almost 13 miles apart, in adjoining industrial districts, and on the main line between Flat Rock and Dearborn. In preliminary tests, solid 2-way communications were maintained in open country between Flat Rock and the steam locomotive over an air-line distance of 29 miles.

The test run in which the authors participated began from the Ford yards. Communications were immediately established with the Flat Rock station, both

(CONCLUDED ON PAGE 68)

FM AND TELEVISION SIGNAL PROPAGATION

The Variation With Frequency of the Signal Range of FM and Television Broadcasting Stations

BY KENNETH A. NORTON AND EDWARD W. ALLEN, JR.*

Copies of this paper were made available to those attending the final session of the Sixth Annual Broadcast Engineering Conference held at Columbus, Ohio, March 18–23. Because of the intense interest of the radio industry in propagation above 30 megacycles, it is reprinted here as a matter of information and record.

Internal receiver noise, cosmic noise, sporadic E, and F-layer transmissions are discussed with their relation to television coverage, and to FM broadcast coverage in both the old and new bands.

IT IS the purpose of this report to determine the effect of the carrier frequency on the expected maximum signal ranges of FM and television broadcasting stations as affected by the transmitting and receiving antenna gains and as limited by internal receiver noise and the ever present effects of cosmic noise received on VHF frequencies from inter-stellar space. The signal ranges shown on the attached charts are thus applicable only in the absence of local thunderstorms or man-made noise. The conclusions reached are those of the authors and do not necessarily indicate the views of the Federal Communications Commission.

During World War II, considerable progress[1, 2, 3, 4] was made in understanding the nature of the limitations on VHF and UHF receiver sensitivity arising from the presence of various fluctuation noise sources within the receiver such as the thermal noise from the resistance components of impedance elements and the random noise due to the fluctuation of electrons in vacuum tubes. Also, due to the work of several observers scattered throughout the world,[4, 5, 6, 7] we have a fairly precise knowledge of the intensity of cosmic noise throughout the portions of the HF and VHF frequency bands in which it is known to be important.

We will first discuss the concept of the *noise figure* used as a measure of the absolute sensitivity of a radio receiver. To understand the meaning of the term *noise figure*, the concept of *available power* must first be appreciated. Consider a voltage generator V with an internal resistance R. The available power from such a generator is the power which it would deliver to a matched load, and is thus $V^2/(4R)$. If a load of different impedance were substituted, the actual power delivered would change, of course, but since the generator has not been touched, its available power is unaltered. This simple concept allows us to separate the effects of the load impedance from the properties of the rest of a circuit. In terms of available powers, the noise figure of a receiver is defined as follows:

$$\overline{NF} \equiv \frac{\left(\begin{matrix}\text{Available signal}\\ \text{power at input}\end{matrix}\right)}{(kTB)} \cdot \frac{\left(\begin{matrix}\text{Available noise}\\ \text{power at output}\end{matrix}\right)}{\left(\begin{matrix}\text{Available signal}\\ \text{power at output}\end{matrix}\right)} \qquad (1)$$

Where:

$k = 1.37 \times 10^{-23}$ = Boltzmann's constant

T = absolute temperature in degrees Kelvin (taken as 300°)

B = effective noise band width of the receiver in cycles per second

$kTB = 4.11 \times 10^{-21}$ watts for a dummy antenna at room temperature ($T = 300°$) and with a receiver noise band $B = 1$ cycle/second and represents the available noise power from the passive resistance of the dummy antenna.[8]

We see by (1) that $\overline{NF}$ is simply the ratio of the signal to noise power ratio at the input to the receiver divided by the signal to noise power ratio at the receiver output. If we write (S/N) for the signal to noise power ratio at the receiver output[9] and P_a for the available signal power at the receiver input (1) may be written:

$$(S/N) = P_a/\overline{NF}\,kTB \qquad (2)$$

The above equations define the noise figure of a receiver when $T = 300°$.

In the report "The Maximum Range of a Radar Set"[4] it is shown how the effects of the external cosmic noise (often corresponding to antenna resistance noise temperatures of many thousands of degrees) may be combined with the internal receiver noise and expressed in terms of an *effective noise figure* $\overline{NF}'$ to be used instead of $\overline{NF}$ in (2) for determining the signal to noise ratio when the receiver is coupled to an antenna:

$$\overline{NF}' \equiv \frac{\overline{NF}}{L_r} + (\overline{EN} - 1) \qquad (3)$$

In the above $\overline{NF}$ is the actual noise figure of the receiver as measured with a signal generator having the same ouput impedance as that of the receiving antenna and with the same coupling between the receiver and the signal generator as that used in coupling the receiver to the antenna. L_r is a transmission line loss factor defined as the ratio of the available signal power at the receiver terminals divided by the available signal power at the antenna terminals. $\overline{EN}$ is an external noise factor and provides a measure of the effects of noise picked up by the antenna. Thus, when a receiver is coupled to an antenna, the receiver input resistance is largely determined by the antenna radiation resistance and the absolute temperature of the latter is determined entirely by the noise which the antenna absorbs from its surroundings. If we write T_a for the effective absolute temperature of the antenna radiation resistance, then, by definition:

$$\overline{EN} \equiv T_a/300° \qquad (4)$$

A directional receiving antenna will absorb different amounts of noise energy as it is pointed in different directions. This directional dependence of $\overline{EN}$ may be expressed in terms of the directional dependence of T_a as follows:

* Respectively, Civilian Engineer, Radio Propagation Section, Office of the Chief Signal Officer, The Pentagon, Washington 25, D. C., and Engineer, Technical Information Division, Federal Communications Commission, Washington 25, D. C. A paper released but not presented at the Sixth Annual Broadcast Engineering Conference, March 18–23, 1946, at the Ohio State University, Columbus, Ohio.

[1] R. E. Burgess, "Noise in Receiving Aerial Systems," *Proc. Phys. Soc.*, Vol. 53, pp. 292–304, May 1941.

[2] D. O. North, "The Absolute Sensitivity of Radio Receivers," *RCA Review*, Vol 6, pp. 332–343, January 1942.

[3] H. T. Friis, "Noise Figures of Radio Receivers," *Proc. I.R.E.*, Vol. 32, pp. 419–422, July 1944. Also discussion on this paper by D. O. North, *Proc. I.R.E.*, Vol. 33, February 1945, pp. 125–127.

[4] K. A. Norton and A. C. Omberg, "The Maximum Range of a Radar Set," *Technical Report* ORG-P-9-1, February 1943, Operational Research Staff, Office of the Chief Signal Officer, The Pentagon, Washington 25, D. C.

[5] Karl G. Jansky, "Directional Studies of Atmospherics at High Frequencies," *Proc. I.R.E.*, Vol. 20, pp. 1920–1932, Dec. 1932; "Electrical Disturbances Apparently of Extraterrestrial Origin," *Proc. I.R.E.*, Vol. 21, pp. 1387–1398, Oct. 1933; "Minimum Noise Levels Obtained on Short Wave Radio Receiving Systems," *Proc. I.R.E.*, Vol. 25, pp. 1517–1530, Dec. 1937.

[6] Grote Reber, *Proc. I.R.E.*, Vol. 28, p. 68, 1940 and Vol. 30, p. 367, 1942; *Astrophys. J.*, Vol. 91, p. 621, 1940 and Vol. 100, p. 279, 1944.

[7] K. Franz, *Hochfrequen en Tech. U. Electroakustik*, Vol. 59, 1942.

[8] H. Nyquist, "Thermal Agitation of Electric Charge in Conductors," *Physical Review*, Vol. 32, p. 110, July 1928.

[9] In the case of an FM receiver employing a limiter, (S/N) is usually taken as the carrier to noise power ratio just ahead of the limiter so that the FM characteristic of reducing the effects of the noise in the output are not included in the *noise figure*.

$$300^\circ \overline{EN} \equiv T_a \equiv \frac{1}{4\pi}\iint T(\theta,\phi)\cdot G(\theta,\phi)\, d\omega \qquad (5)$$

In the above $T(\theta,\phi)$ is an effective absolute temperature of the material in space as properly averaged with respect to distance along the beam in an elementary solid angle, $d\omega$, centered about the direction θ, ϕ. $G(\theta, \phi)$ is the gain of the antenna in the direction θ, ϕ relative to that of an isotropic radiator. The proper method of determining the effective value of $T(\theta, \phi)$ may be seen most readily from the reciprocal problem in which energy radiated from the antenna is absorbed as it is propagated from the antenna out to a distance such tl at it is completely absorbed. The follo ving artificial example will serve to clarify the problem. If 1/3 of the total energy radiated in the elementary solid angle $d\omega$ centered on the direction θ ϕ, were absorbed in a gas of uniform absolute temperature 300° extending from 0 to 1000 miles from the antenna, another 1/3 absorbed in a gas of uniform absolute temperature 30° extending from 1000 to 1250 miles and the final 1/3 of the energy absorbed in a black body at the distance 1250 miles with a surface temperature of 600°, then $T(\theta, \phi)$ for that direction would be equal to 1/3 (300 + 30 + 600) = 310° absolute temperature. It should be noted that, when $T(\theta,\phi)$ equals a constant value T_c, in all directions, then T_a will simply be equal to T_c since the constant T_c may then be taken from under the integral signs and the integral is, by definition of $G(\theta, \phi)$, simply equal to 4π. On the other hand, for a high gain antenna, if $T(\theta, \phi)$ has a very large value T_o over the effective beam of the antenna and a very small value in other directions, then T_a will again be nearly equal to T_o since the contributions to the integral for directions ϕ and θ far removed from the maximum of the antenna will be negligible. Measurements of the effective noise temperatures of antennas in the UHF band beamed on the open sky are of the order of 10° absolute corresponding to the very low value of $\overline{EN}$ = 0.033. When these antenna beams are directed horizontally along the ground, a small part, say 1/10, of the energy which could be transmitted from such an antenna would be absorbed in the ground and, since the earth is at a temperature approximating 300°, the effective noise temperature of such an antenna used for reception and directed horizontally along the ground would be equal to $T_a = \left(\frac{1}{10} 300^\circ + \frac{9}{10} 10^\circ\right) = 39^\circ$ corresponding to a value of $\overline{EN}$ = 0.13. In the future, when receivers with very low noise figures become available in the UHF band, it may turn out to be desirable to discriminate against the ground reflected waves in order to reduce the received noise; discrimination against the ground-reflected wave by means of highly directional receiving antennas has already proven to be a valuable method for reducing, and in some cases practically eliminating, the adverse effects of within-line-of-sight fading due to the interference between the direct and ground-reflected components.[10]

At microwave frequencies the large antenna gains which are available have made possible the direct observation of radio noise from the sun by Southworth.[11] In the region 1–10 cm, Southworth has been able to show that the radiation received from the sun is quantitatively only slightly greater than that to be expected from a black body the size of the sun with a surface absolute temperature of 6000°. Since Southworth used an aperture angle on his receiving antenna at his highest frequency comparable to that of the sun, it follows from (5) that $\overline{EN}$ should be approximately equal to 6000°/300° = 20 when the antenna is pointed directly at the sun. At the two lower frequencies, the receiving antenna apertures were larger and this resulted in smaller values of $\overline{EN}$; in other words the antenna "sees" some of the space adjacent to the sun which has a very much lower effective temperature.

Recently, several observers[12, 13] have reported the reception, at VHF frequencies, of unusually intense noise from the sun which appears to be associated with sun spots since it occurs only when large groups of spots are visible on the sun. As an indication of the possible practical importance of this solar noise a description will be given of some measurements of it made at the Federal Communications Commission monitoring station at Laurel, Maryland, from January 31 to February 12, 1946 during which time several large groups of sun spots were crossing the face of the sun. The solar noise was recorded at 44.9 mc. on a half-wave horizontal

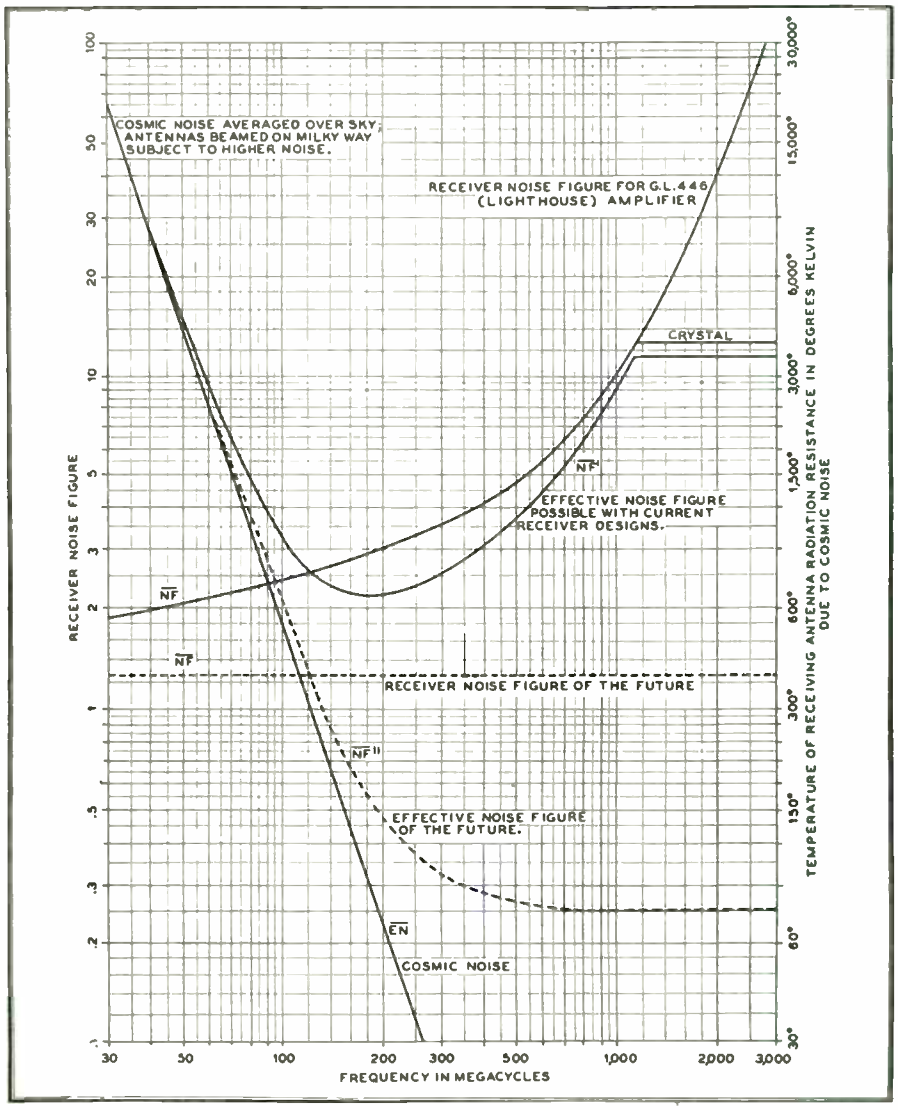

FIG. 1. EFFECTIVE NOISE FIGURES FOR VHF AND UHF RECEIVERS. THIS DATA INCLUDES EFFECTS OF COSMIC NOISE. CURVES ARE FOR PRESENT AND POSSIBLE FUTURE SETS

[10] Thomas J. Carroll, "Complementary Diversity Reception on Microwaves;" *Propagation Report No. 2*, in connection with "Comparative Tests of Radio Relay Equipment," Radio Propagation Section, Office of the Chief Signal Officer, The Pentagon, Washington 25, D. C.

[11] G. C. Southworth, *J. Franklin Institute*, Vol. 239, pp. 285, 1945.

[12] E. V. Appleton, *Nature, 156*, 534, Nov. 1945.

[13] J. S. Hey, *Nature, 157*, 48, January 1946.

dipole 30 ft. above the ground. The sensitivity of the receiver, which had a noise band of approximately 120 kc., corresponded to a noise figure of about 10 and the Esterline Angus recorder used for indicating the amplified levels of the incoming signals at the intermediate frequency of the receiver would respond to signal generator voltages less than 0.8 microvolts. When coupled to the antenna, the usual noise voltage V_n, appearing across the antenna terminals, was approximately equal to 1.5 microvolts but this increased during the daytime on each day of the above period, reaching a maximum equal to 15 microvolts at 1300 E.S.T. on February 6, which lasted a few minutes. The usual level of this solar noise as recorded during this period corresponded to something less than 4 microvolts. To convert these data into effective antenna temperatures we may equate the available noise power from the antenna ($V_n^2/4 \times 73$) to the available noise power kT_aB in the 120-kc. receiver band, B, to be expected from the antenna resistance at the temperature T_a. Thus, with V_n expressed in microvolts:

$$T_a = V_n^2 \cdot 10^{-12}/292\,kB = 2080\,V_n^2 \quad (6)$$

We see by the above that the noise temperature of the half-wave dipole radiation resistance due to this solar noise reached a peak value of more than 450,000°. Furthermore, the equivalent temperature of a black body with the projected surface area of the sun must be much greater than T_a in order to produce this much noise power. This can be seen from (5) which can be written in this case:

$$T_a = \frac{\Delta\omega}{4\pi} T_s(\theta,\phi)\, G(\theta,\phi) \qquad (7)$$

where $G(\theta,\phi)$ is the gain of the dipole antenna in the direction of the sun and T_s is the surface temperature of the sun. Over the small aperture angle, $\Delta\omega$, occupied by the surface of the sun, $G(\theta,\phi)$ will be constant and since T_s is practically equal to zero in other directions, (5) becomes equal to (7). Since the aperture of the sun, $\Delta\omega$, is equal to 6×10^{-5} steradians and $G(\theta,\phi)$ will never be larger than 1.64, we see by (7) that T_s would have to be at least 4×10^{10} degrees in order to account for the observed solar noise. We are thus forced to the conclusion that this solar noise observed at VHF frequencies and associated with sun spots is of an entirely different character than that observed at microwave frequencies. Observations [14] on various frequencies in the VHF band indicate that the intensity of this sun spot noise decreases rapidly with increasing frequency. This suggests that the source of this sun spot noise is similar to that of the cosmic noise from inter-stellar space, the intensity of which is known to be of importance in the lower part of the VHF band but which decreases rapidly in intensity with increasing frequency, becoming of negligible importance at microwave frequencies and, in fact, at present undetectable at such frequencies.

A good summary of the available data on cosmic noise has been prepared by J. M. C. Scott [15] and he finds that the cosmic noise, when averaged over the sky, or alternatively received on an isotropic receiving antenna, corresponds to an effective noise temperature which varies inversely as the cube of the radio frequency and with an absolute average intensity such that we obtain the following expression for EN resulting from cosmic noise alone:

$$\overline{EN} \doteq 1.8(10^6)/f^3_{mc.} \quad (18\text{ mc} < f < 160\text{ mc}) \qquad (8)$$

This relation is shown on Fig. 1, together with a scale on the right giving the effective temperatures of the antenna radiation resistance due to this cosmic noise. Since these temperatures are considerably in excess of room temperature (300°) at frequencies below 120 mc., we may expect that this cosmic noise, since it is always present, will form the lower limit to the sensitivity of radio receivers operating in the lower part of the VHF band. The sources of this cosmic noise are not uniformly distributed over the sky, but tend to be concentrated in several regions on the celestial sphere, the principal source being in the region Scorpio-Sagittarius near the center of the galaxy. Consequently, when received on a directional antenna, the noise varies in a characteristic manner from hour to hour and from day to day.

It is interesting to speculate on the nature of this cosmic noise and the reason for the observed rapid decrease in the intensity of this noise with increasing frequency. It was suggested above that it might be the same as sun spot noise which is occasionally received from the sun, and the continuous nature of the cosmic noise could easily be explained as originating in

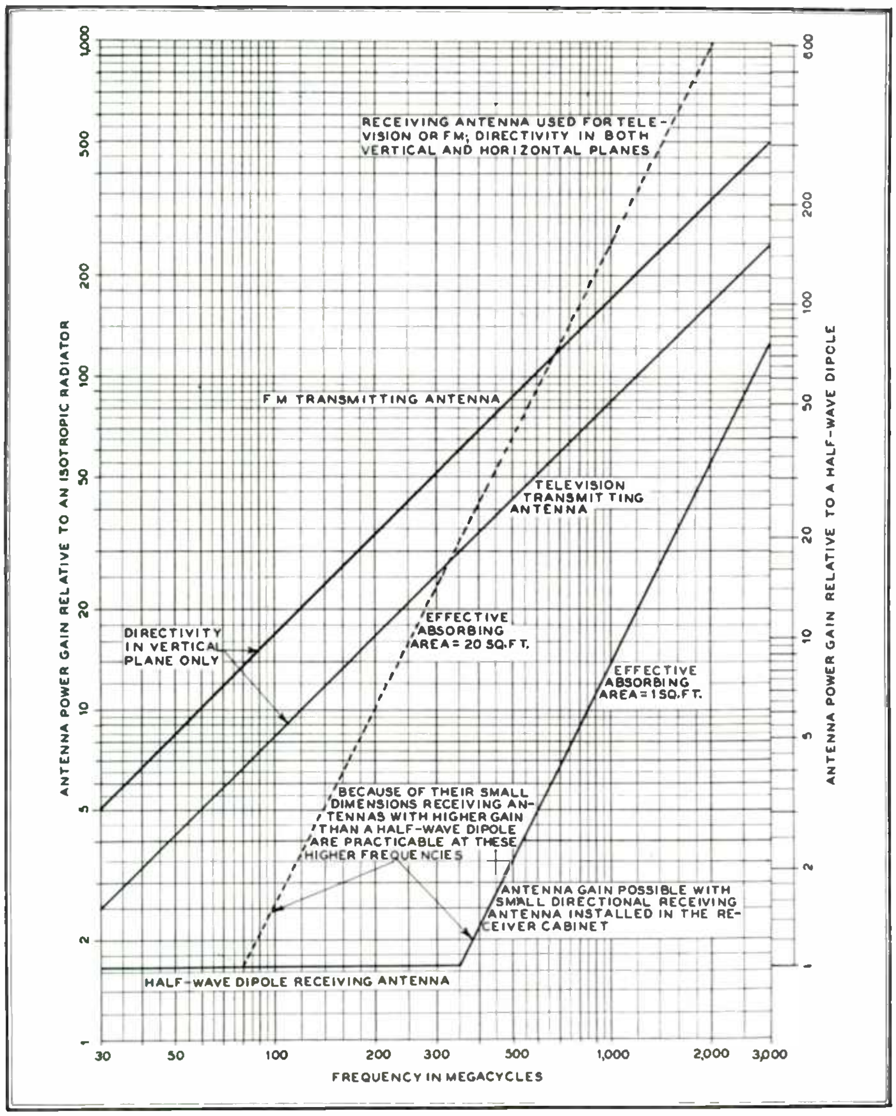

FIG. 2. TRANSMITTING AND RECEIVING ANTENNA GAINS USED IN ESTIMATING EXPECTED SIGNAL RANGE OF FM AND TELEVISION BROADCASTING STATIONS

[14] J. L. Pawsey, R. Payne-Scott, L. L. McCready, "Radio Frequency Energy From The Sun," *Nature*, Vol. 157, pp. 158–159, Feb. 9, 1946.

[15] J. M. C. Scott, "The Intensity of Cosmic Noise: A Survey of the Data Available," *Radar Research Development Establishment Report* No. 286, August 13, 1945, London, England.

the spots on the many thousands of stars in the Milky Way, each of which probably has its own eruption periodicity. The observed frequency-cubed law for cosmic noise is not far from the fourth-power law which applies to the effective antenna temperature due to the noise received from a local thunderstorm, and this suggests that sun spot and cosmic noise may have an electrical origin. Other investigators have suggested that the frequency-cubed law arises from variations in the absorption of the noise radiation occurring in outer space.[16] Whatever the explanation may be, the experimental data all point, without exception, to a very rapid decrease in the intensity of cosmic noise with increasing frequency. We turn now to a consideration of the practical effects of cosmic noise in limiting the reception of weak FM or television signals.

On Fig. 1, the solid curve labelled $\overline{NF}$ corresponds to the measured noise figure of a good receiver employing a GL446 (Lighthouse) amplifier and represents very nearly the present optimum performance of radio receivers of modern design. Above about 1,000 mc., a crystal gives somewhat better performance than a radio frequency amplifier, and this is also shown on Fig. 1. If we assume no transmission line losses, then $L_r = 1$ and this value of $\overline{NF}$ may be combined by means of (3) with the value of $\overline{EN}$ shown for cosmic noise to give the effective value of noise figure labelled $\overline{NF}'$ on Fig. 1. This curve is believed to be a reasonably accurate measure of the maximum possible sensitivity to be expected from currently available receiver designs. It is interesting to note that the effective noise figure $\overline{NF}'$ with the receiver coupled to an antenna is actually less, above 120 mc., than the noise figure $\overline{NF}$ measured in the laboratory; this is due to the very low effective temperatures of the antenna resistance at these higher frequencies. As an estimate of what may conceivably be expected in the future, we have shown the results to be expected from a receiver with a *noise figure* of 1.25, i.e., about one db. The curve labelled $\overline{NF}''$ gives the corresponding value of the effective noise figure for the receiver coupled to an antenna. The large differences between $\overline{NF}'$ and $\overline{NF}''$, which amount to nearly 14 db in the upper part of the UHF band, represent a challenge to the receiver engineers; reductions in these differences can usually be immediately translated into increased communication ranges or into reduced transmitter powers.

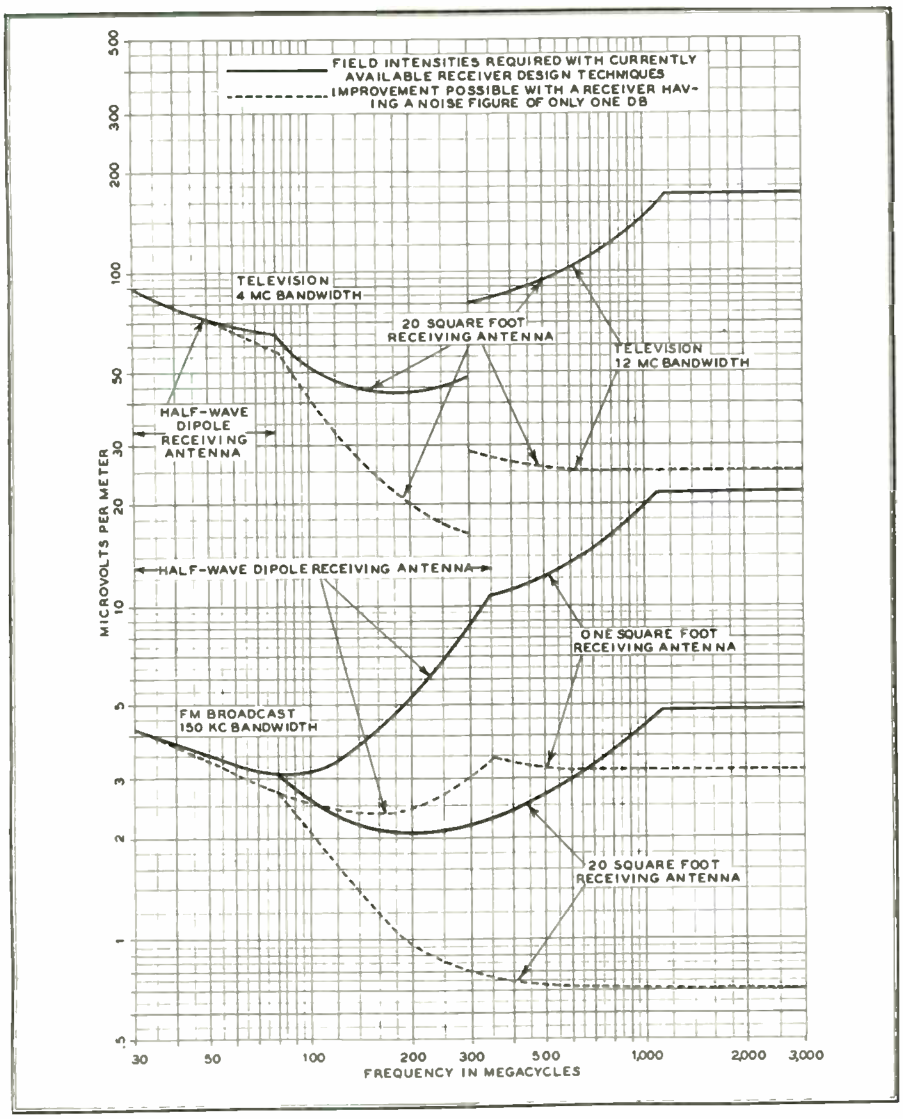

FIG. 3. FIELD INTENSITIES REQUIRED FOR SATISFACTORY TELEVISION OR FM RECEPTION IN THE ABSENCE OF THUNDERSTORMS OR MAN-MADE NOISE

We turn now to a discussion of the transmitting and receiving antenna power gains used in calculating the signal ranges. Fig. 2 shows these antenna gains as a function of frequency. The gains are shown relative to an isotropic radiator as well as relative to a half-wave dipole. For both FM and television, the transmitting antenna gains are assumed to increase linearly with the frequency which would be the case for an antenna of fixed dimensions and with directivity in the vertical plane only. For television, a highly directional receiving antenna is often required for the elimination of ghosts. However, at VHF frequencies, high gain may require very large structures. Consequently, as with FM, an antenna with a fixed size is assumed; an antenna with an effective absorbing area of 20 sq. ft. will have the frequency-gain characteristic shown. A receiving antenna with a high gain is also desirable with FM, and ranges are calculated with the 20-sq. ft. receiving antenna used for television as well as for a half-wave dipole receiving antenna.

We have now laid the groundwork for computing the field intensities required for FM or television in order to over-ride the receiver noise and the ever-present effects of cosmic noise. The available signal power from an antenna with an effective absorbing area, A_r, expressed in square meters and with a power gain, G, relative to an isotropic radiator in the presence of a field intensity E expressed in volts per meter may be written:

$$P_a = \frac{A_r E^2}{Z} = \frac{G\lambda^2 E^2}{4\pi Z} \text{ watts} \qquad (9)$$

where Z = 376.7 ohms is the impedance of free space and λ is the wavelength in meters. When this is substituted in (2) with $\overline{NF}$ replaced by $\overline{NF}'$ and solved for E, we obtain:

$$E = \left[(S/N)\, Z\, \overline{NF}'\, kTB/A_r\right]^{\frac{1}{2}} \text{ volts per meter} \qquad (10)$$

T = 300° in the above equation. With FM a signal-to-noise power ratio (S/N) = 16, i.e., 12 db, at the input to the limiter will provide a satisfactory service with a receiver band B = 150 kilocycles. When these values are substituted in (10) we obtain for FM:

$$E = 6.33\sqrt{\overline{NF}'} \text{ microvolts per meter (1 sq. ft. receiving antenna)} \qquad (11)$$

[16] H. Kramers, *Phil. Mag.*, Vol. 46, p. 836, 1923.

[17] Based on the effective receiver noise figures shown on Fig. 1 which include the ever present effects of cosmic noise; intermediate frequency RMS signal-to-noise ratio = 24 db for television and 12 db for FM broadcasting.

$$E = 1.414\sqrt{NF'} \text{ microlts per meter (20-sq. ft. receiving antenna)} \quad (12)$$

$$E = 0.0178\sqrt{NF'}\ f_{mc} \text{ microvolts per meter (half-wave receiving antenna)} \quad (13)$$

With amplitude modulation television, an output signal to noise ratio (S/N) = 256, i.e., 24 db. is required for satisfactory service. In the VHF band, a bandwidth of 4 mc. is assumed while 12-mc. bandwidth is used in the UHF band. Thus:

$$E = 0.368\sqrt{NF'}\ f_{mc} \text{ microvolts per meter (VHF half-wave receiving antenna)} \quad (14)$$

$$E = 29.2\sqrt{NF'} \text{ microvolts per meter (VHF 20-sq. ft. antenna)} \quad (15)$$

$$E = 50.3\sqrt{NF'} \text{ microvolts per meter (UHF 20-sq. ft. receiving antenna)} \quad (16)$$

Using the values of NF′ and of NF″ shown on Fig. 1, we obtain from the above equations the required field intensities shown on Fig. 3 for FM and television.

We can now determine the maximum range of an FM or television station by determining the distance at which the field intensities shown on Fig. 3 may be expected for given values of transmitting antenna input power and with the transmitting antenna gains shown on Fig. 2. The service ranges shown on Fig. 4 are calculated ground wave ranges [18] and correspond to a ground wave field intensity equal to 5 times the required field intensities shown on Fig. 3. This factor of 5 was introduced in order to allow for fading. Thus, at distances beyond the line of sight, tropospheric waves will be present and they will combine with the ground wave and cause fading. At any given distance, the tropospheric waves will vary in intensity from values much less than the ground wave to values much stronger than the ground wave. The received fields will reach their lowest instantaneous values when the tropospheric wave field intensities are approximately equal to the ground wave field intensities and, in that case, the instantaneous fields will exceed one-fifth of the ground wave field for about 99% of the time. Thus, the ranges shown on Fig. 4 are conservative figures. At night and in the early morning hours, the tropospheric waves will be much stronger than the ground wave and will thus increase these service ranges considerably.

Also shown on this chart are the reductions in service area in the old FM band which occur because of sporadic E transmissions and F layer transmissions from one other station operating with the same radiated power and on the same frequency at a distance of 900 miles and one other similar station at a distance of 2000 miles. We see by this chart that, regardless of the amount of power employed, a station operating on 50 mc. will be limited by two other similar stations for 1% of the time to a range of less than 17 miles due to F layer interference and for an additional 1% of the time to a distance of less than 69 miles due to sporadic E transmission. The interference ranges shown on this chart were obtained from the data shown on the curves [19] associated with Mr. Kenneth A. Norton's original statement made on October 28, 1944 to the Federal Communications Commissions at the Hearing in the Matter of Allocation of Frequencies to the Various Classes of Non-Governmental Services in the Radio Spectrum from 10 kilocycles to 30,000 kilocycles.

On Fig. 5 are shown the expected rural service and interference ranges for television broadcasting stations as determined by the calculated ground wave ranges corresponding to the required field intensities shown on Fig. 3. In this case, no allowance was made for fading since no threshold problem is involved as with FM and it was considered possible that the 24 db signal-to-noise ratio might furnish a margin which would permit some fading without a serious impairment of the entertainment value of the picture. Furthermore, except for the 10-kw. stations, the ranges are not as great as with FM, so that the ratio of tropospheric wave to ground wave field intensity would be smaller on the average. If a fading allowance is considered necessary, and the above described method of allowing for FM fading is adopted for television, then a 5 to 1 allowance for fading can be made simply by re-labelling the 100-watt and 1-kw. range curves with the new values 2.5 kw. and 25 kw., respectively.

The reductions in service area which occur because of sporadic E transmissions

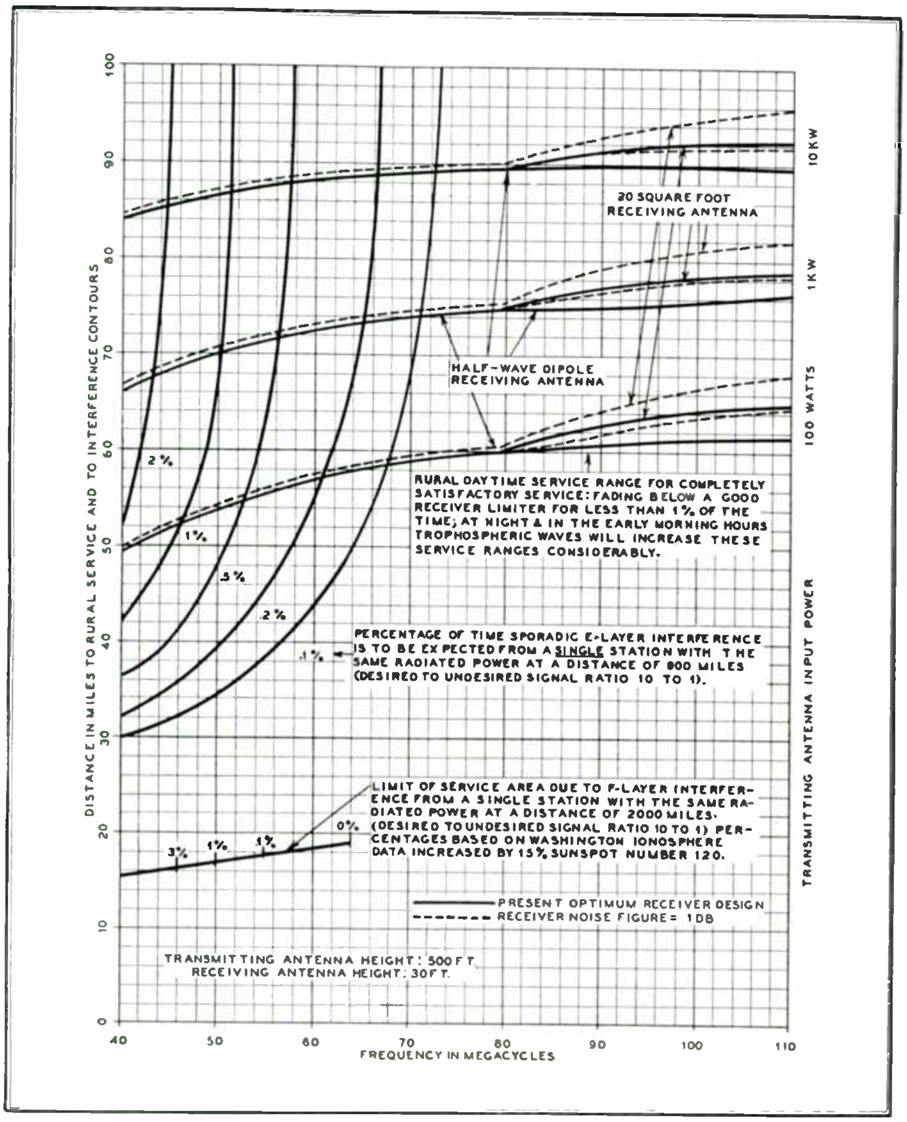

FIG. 4. EXPECTED RURAL SERVICE AND INTERFERENCE RANGES FOR FM BROADCAST STATIONS IN ABSENCE OF THUNDERSTORMS OR MAN-MADE NOISE. TRANSMITTING ANTENNA HEIGHT, 500 FT.; RECEIVING ANTENNA HEIGHT, 30 FT.

[18] Kenneth A. Norton, "The Calculation of Ground Wave Field Intensity over a Finitely Conducting Spherical Earth," *Proc. I.R.E.*, Vol. 29, pp. 623–639, Dec. 1941.

[19] These curves were published in *FM* AND TELEVISION, March, 1945, pp. 27 to 31.

and F-layer transmissions were determined in the same manner used for FM except that the desired-to-undesired signal ratio of 100 was used since this value is appropriate for this amplitude modulation service.

Comments are invited relative to any of the points discussed in this report. The most troublesome problem at the present time in estimating the expected service ranges of VHF and UHF stations is the fading due to tropospheric waves. Any assistance or data which can be made available relative to this or other aspects of this report will be very much appreciated.

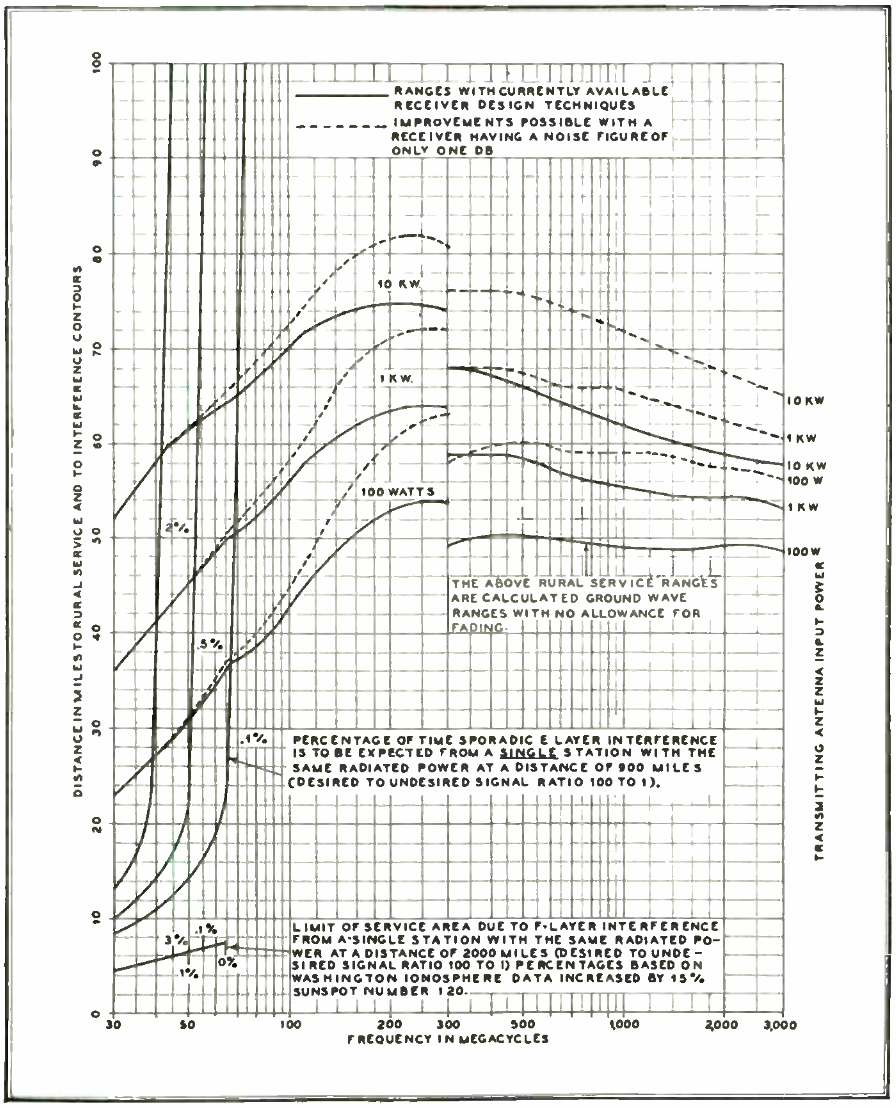

FIG. 5. EXPECTED RURAL SERVICE AND INTERFERENCE RANGES FOR TELEVISION BROADCAST STATIONS IN THE ABSENCE OF THUNDERSTORMS OR MAN-MADE NOISE. TRANSMITTING ANTENNA HEIGHT, 500 FT.; RECEIVING ANTENNA HEIGHT, 30 FT.

CLOVERLEAF FM ANTENNA

(CONTINUED FROM PAGE 37)

ductor, each a quarter-wave long. These provide a low-loss transformer for matching the impedance of the antenna array to the impedance of the transmission line.

The antenna is comprised of one base section and a minimum number of "A" tower sections in accordance with Table I. The "A" sections are 9 ft., 8 in. in length by 1 ft. square, while the base section is 10 ft., 8 in. in length by 1 ft. square.

The weight of the antenna, less beacon lights and conduits, can be determined by the following formula:

$$\text{Weight (lbs.)} = 500 + S(270) + N(70)$$

S = number of "A" tower sections
N = number of antenna units

The supporting structure must be designed to withstand the bending moments given in Fig. 5 and Table II. These moments include the 300-mm. beacon.

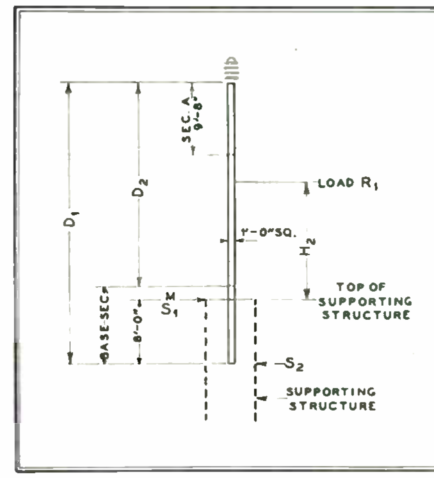

FIG. 5. DIMENSIONS OF THE ANTENNA GIVEN IN ACCOMPANYING TABLE 2

TABLE 2

Number of Sections A	Load R_1	D_1	D_2	H_2	Bending Moment at Top of Supporting Structure—Ft.-Lbs. M*	Reaction at Top of Supporting Structure S_1	Reaction at Bottom of Antenna Tower S_2
1	326 lbs.	20' 4"	12' 4"	7.7'	2,512 ft.-lbs.	640 lbs.	314 lbs.
2	529	30' 0"	22' 0"	12.65'	6,715	1,368	839
3	703	39' 8"	31' 8"	17.65'	12,892	2,341	1,611
4	933	49' 4"	41' 4"	22.8'	21,080	3,568	2,635

* These moments are given for the maximum (2) radiating units per "A" tower section. The reduction in moments for less than 2 radiating units per section is negligible.

FLUCTUATION VOLTAGES

(CONTINUED FROM PAGE 33)

ratio. However, if the RF bandwidth is not considered, it will follow that a degree of coupling somewhere between critical and overcoupling will be optimum. An exact value of the best coupling in this case is not easily determined since it depends on arbitrary choices of circuit constants such as the value of the tuning condenser and best values of Q which are obtainable.

Summary ★ There are a number of points which have been stressed. In the first place, the analogy between Brownian movement and fluctuation voltage phenomena has been reiterated. The simplicity resulting in the use of this concept in calculating the fluctuation voltage across a tuned circuit is of importance. Considering the complete frequency spectrum, the fluctuation voltage squared is given simply as KT/C. If only a portion of this spectrum is amplified by the following intermediate-frequency amplifiers, the bandwidth factor F must also be introduced. Finally, it has been shown that if receiver bandwidth is to be maintained, overcoupling is very desirable in all cases to improve the signal-to-noise ratio. If receiver bandwidth is not of consequence, and input tube noise is high, then it is desirable to use critical coupling.

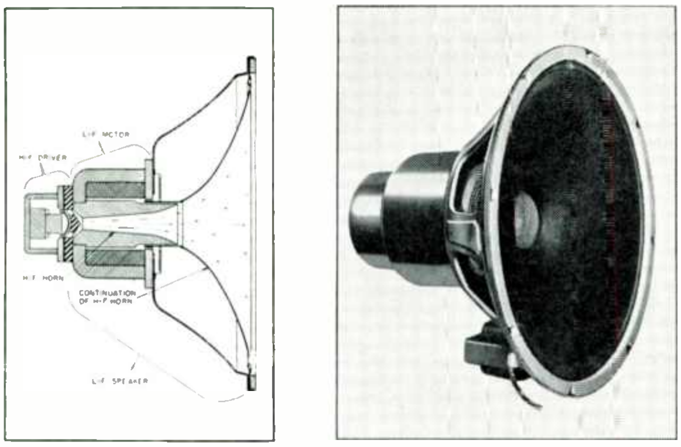

FIG. 1. CROSS-SECTION AND ASSEMBLED VIEW OF JENSEN SPEAKER

RADIO DESIGNERS' ITEMS

Notes on Methods and Products of Importance to Design Engineers

Transmitting Tubes: The complete line of Eimac transmitting tubes, rectifiers, vacuum capacitors, pumps, vacuum switches, and pulse-type tubes are described in a new bulletin from Eitel-McCullough, Inc., San Bruno, Calif. Copies are available on request.

Coaxial Speaker: First of a series of postwar speakers from Jensen Radio Manufacturing Company, 6609 S. Laramie Avenue, Chicago 38, is illustrated in Fig. 1, with a cross-section in Fig. 1. Designed particularly for use with high-quality amplifiers on FM receivers, the power-handling capacity of this 15-in. model is rated at 25 watts. The field is designed for 20 watts dissipation, or 14 watts minimum. A cabinet closure incorporating the bass-reflex principle is recommended.

Flexible Waveguides: An interesting development in flexible metal tubing of rectangular cross-section is the Waveflex tubing manufactured by Titeflex, Inc., Newark, N. J. It can be bent to a very small radius without distorting critical dimensions that affect electrical performance. Assemblies in accordance with A-N standards are made up with connecting flanges and with chokes, if required.

Capacitors: Electrical Reactance Corporation, Franklinville, N. Y., has issued a new bulletin on high-Q silver electrode ceramic capacitors of the CI type, with axial leads. Also shown are illustrations of the steps of manufacture and quality control. Listing of type designations is in accordance with JAN specifications.

Communications Receiver: Fig. 2 shows the post war model of the Super-Pro series of receivers produced by Hammarlund Manufacturing Company, Inc., 460 W. 34th Street, New York City. Five-band tuning is continuous from .54 to 30 mc., on the model X, with continuous band-spread on the 3 top bands. Model SX covers 1.25 to 40 mc., with band-spread on all 5 bands

FIG. 2. LATEST MODEL OF THE HAMMERLUND SUPER-PRO SERIES

Eighteen tubes include a 5U4G high-voltage rectifier and a 5Y3GT/G C-bias rectifier. Two 6F6 pentodes in push-pull class AB are used in the amplifier. Output impedance is 500 ohms. Connections are supplied for earphones. Other features include 3-stage IF amplifier with adjustable coupling, crystal filter, AVC on 2 RF and 2 IF stages, noise limiter, S-meter with external compensation.

Volt-Ohm-Milliammeter: A new multi-purpose instrument has been added to the line of test equipment produced by Hickok Electrical Instrument Company, 10530-A Dupont Avenue, Cleveland 8, Ohio. Operating on 105 to 125 volts, 50 to 70 cycles, this multi-range instrument measures AC and DC volts, DC milliamperes, resistance, capacity, and frequency up to 5 mc. The tube complement of the meter comprises two 6 × 5 GT rectifiers, a 6SJ7 cathode follower, a 6SN7GT for the vacuum-tube voltmeter, and an OD3/VR150 voltage regulator.

Crystal Microphone: A new cardiode unidirectional crystal microphone, Fig. 3, has been introduced by Electro-Voice, Inc., South Bend, Indiana. Designed to give wide-angle front pickup, and to be dead at the rear, this unit is equipped with a 2-position switch for either wide, flat response or wide range with a rising characteristic to emphasize the higher frequencies. It is intended for public address and recording, as well as for handling communications traffic.

FIG. 3. ELECTRO-VOICE CRYSTAL MIKE

Relays: A 640-page, pocket-size Relay Engineering Handbook has been published by Struthers-Dunn, Inc., 1321-A Arch Street, Philadelphia 7. Containing 863 diagrams, 81 tables, and 270 illustrations, the book covers all details of relay types and their applications, as well as relay servicing and inspection. Price of the Handbook is $3.00.

Glass Materials & Components: Three bulletins of special interest to apparatus designers

1. Designed to permit operations beyond the highest frequencies allocated for F M broadcast.

2. Extremely low plate to grid capacitance of these tubes permits operation without neutralization in many cases—simplifies neutralization in others.

3. The unique arrangement of low inductance leads, plus especially treated grids minimizes the possibility of parasitic oscillations.

4. The high power gain of the Eimac tetrodes makes possible the utilization of extremely low power exciter equipment. For example at 100 mc, the 4-125A will deliver its full rated output of 375 watts with less than 3 watts driving power.

5. Extremely low output capacitance reduces charging current to a minimum.

6. No internal insulators—Eimac 4-125A and 4-250A tubes do not load tank circuits with leaky internal hardware.

7. Eimac vacuum technique plus the proper choice and treatment of materials used in each vital element, insures long trouble-free performance.

The 4-125A *and* 4-250A *power tetrodes are but two of the many new tubes, some of radically different design, which Eimac is producing for every industrial use. For further information and complete engineering data, write direct or contact your nearest Eimac representative.*

CALL IN AN EIMAC REPRESENTATIVE FOR INFORMATION

ROYAL J. HIGGINS (W9AIO), 600 S. Michigan Ave., Room 818, Chicago 5, Illinois. Phone: Harrison 5948.

V. O. JENSEN, General Sales Co., 2616 Second Ave., Seattle 1, Washington. Phone: Elliott 6871.

M. B. PATTERSON (W5CI), 1124 Irwin-Keasler Bldg., Dallas 1, Texas. Phone: Central 5764.

ADOLPH SCHWARTZ (W2CN), 220 Broadway, Room 2210, New York 7, N. Y. Phone: Cortland 7-0011.

HERB BECKER (W6QD), 1406 S. Grand Ave., Los Angeles 15, California. Phone: Richmond 6191.

TIM COAKLEY (W1KKP), 11 Beacon Street, Boston 8, Massachusetts. Phone: Capitol 0050.

Follow the leaders to

Eimac REG. U. S. PAT. OFF. **TUBES**

EITEL-McCULLOUGH, INC., 1213L San Mateo Ave., San Bruno, Calif.

Plant Located at San Bruno, California

Export Agents: Frazar and Hansen, 301 Clay St., San Francisco 11, Calif., U. S. A.

are now available from Corning Glass Works, Corning, N. Y. One is devoted to Vycor glass sheets, rods and tubes which can be fabricated for various components, particularly in high-frequency applications. Another bulletin concerns metallized glass for hermetic seals and other purposes, while the third has to do with glass components, ranging from insulators to relay covers, and from bushings to instrument windows.

C-R Tubes and Oscillographs: Two new catalogs are now available on request from Allen B. DuMont Laboratories, Inc., Passaic, N. J. One presents data on eight of the most widely used types of cathode-ray tubes for oscillographs and experimental uses. The other describes six types of oscillographs designed for precision tests and measurements.

Record-Changer: Garrard record-changers are available again, through Garrard Sales Corporation, 401 Broadway, New York.

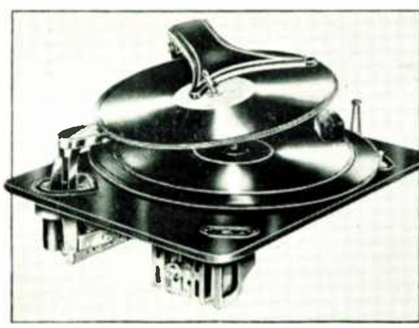

FIG. 4. GARRARD RECORD-CHANGER

One of the first new models, shown in Fig. 4, handles both 10- and 12-in. records, and is equipped with an automatic stop. Either a magnetic pickup for interchangeable needles or a new 1-oz. crystal cartridge can be supplied.

Hermetic Seals: An interesting improvement in cases for oil condensers is shown in Fig. 5. Cans of this design are being supplied with glass-seal terminals by Cincinnati Electric Products Company, Cincinnati 12, Ohio. For sealing without

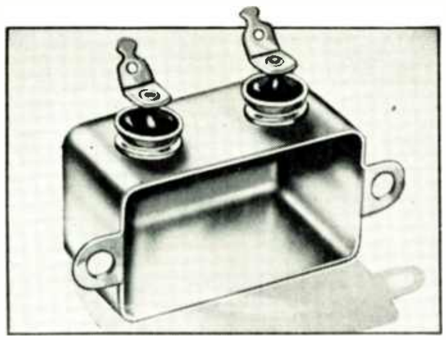

FIG. 5. SEALS FOR CONDENSER CASES

solder, round cans are supplied with separate tops carrying the glass-sealed terminals. The top is then rolled onto the can with a sealing machine.

Pilot Lights and Mountings: A great range of pilot lights and mountings, in many types, sizes, and designs are shown in a catalog just published by Gothard Manufacturing Company, Springfield, Ill. These include variable-intensity lights with shutters or polarized discs. Also listed are various types of bulbs and an ingenious soft rubber lamp remover. Four pages are devoted to technical data on lenses and colors.

Resistors: Data on standard and special resistors and controls is presented in catalog 46, issued by Clarostat Manufacturing Company, 285 N. 6th Street, Brooklyn, N. Y. Included are glass-insulated flexible resistors, composition and wire wound rheostats and potentiometers, constant-impedance input and output attenuators, voltage regulators and ballasts, and power resistance decade boxes.

Noise & Field Meter: A portable or laboratory noisemeter and field strength meter, operating over a single band from 100 to 400 mc., is shown in Fig. 6. It is used to locate and measure the amplitude of noise, and to determine the effectiveness of filtering and shielding. Range is up to 100,000 microvolts. RF amplifier, mixer, and oscillator circuits have butterfly condensers to eliminate sliding contacts.

Field intensity range is 5 to 100,000 microvolts per meter. The complete instrument, operating on 105–125 volts AC, weighs 56 lbs. and measures 15¼ by 21½ by 14½ ins. deep. It is manufactured by

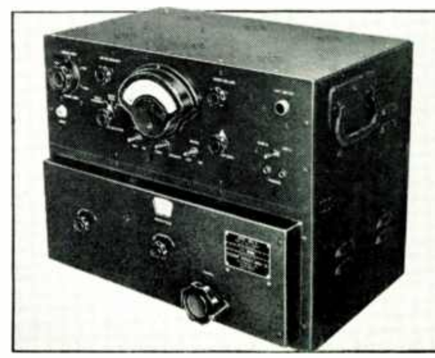

FIG. 6. NOISE AND FIELD STRENGTH METER

Stoddart Aircraft Radio Company, 6644 Santa Monica Boulevard, Hollywood 38.

NOTES ON FM FREQUENCIES

The FCC's decision to keep FM broadcasting in the band from 88 to 108 mc., announced on January 23rd and explained in a report issued March 5th, has been accepted by the radio industry as the final word insofar as the design of new FM receivers is concerned. Even though, as many believe, the Commission declined an opportunity to correct a previous error and reëstablish itself in the confidence of the industry, it is certain that FM will overcome the handicap of upper-band operation if, indeed, the handicap exists. Yet, because of the manner in which this matter was handled by the FCC, we shall hear still more about it.

However, to complete the record, we publish Major Armstrong's comments on the FCC's report which explained the denial of the Zenith-G.E. petition to retain the lower band:

The Commission's report virtually admits that its Engineering Department has made one of the colossal mistakes of radio history. The statement "There is nothing whatever in the present proceeding which casts any doubt upon the ability of the FM stations in the 88- to 108-megacycle band to render a superior interference-free and static-free service over ranges of sixty miles, and perhaps in excess thereof" makes this quite clear.

Of course the 100-megacycle FM band will go sixty miles. That was known eight years ago when I was developing FM on the only band available to me then, namely, the 117-megacycle band. But the question here involved is which is the best band. FM has demonstrated and is demonstrating every day that it will go over a hundred miles on the old band and cover two to three times the area of the new one. Why move it to where it will go sixty miles?

The reason the Commission gave when it first moved FM was the superior rural service of the higher band, based on the theoretical calculations of a Commission engineer, K. A. Norton. Those calculations were disproved by Zenith's and the Commission's own measurements, but the Engineering Department of the Commission has evidently chosen to ignore them to maintain a position previously taken but now untenable.

In addition to the refusal to face the plain implications of the tests, the report is full of mistakes of technical facts which would be amusing were their effects not so serious to the public. It is now in order to challenge the responsible members of the Commission's engineering staff to substantiate the technical findings of this report, which will have a profound effect on radio history for years to come.

Controversies concerning the laws of nature are never closed until the facts come out. The only way the facts in this situation can be suppressed is by shutting down the present 40-megacycle stations before the comparative performance of the two bands can be observed in actual practice by engineers and the public alike.

What DOES Make a BETTER Loud Speaker?

WILL the possession of physical facilities and desire create a better product? No, because for all of their importance, these possessions are certainly not unique. All institutions have them to some degree. Is it fanciful claims and fluent use of superlatives in product description that make a product better? Obviously not. Is it the achievement of theoretically perfect performance in the laboratory? No, not that either, for perfection in such respects does not necessarily create the *practical ideal.*

The simple truth is that no product can be better than *know how* and the honest application of that *know how* as the product is created and its virtues described.

What is the yardstick of these ingredients in a product? The record of achievements and the list of contributions to the advancement of science and art is one good measurement. The First PM Speaker, the Bass Reflex Principle, the Hypex Formula are just a few of the advancements contributed to the industry by JENSEN. There is also the endorsement by those users and connoisseurs of Loud Speaker performance whose first and last emphasis is always on superiority. JENSEN Loud Speakers and Reproducers are the overwhelming choice of such people. Finally, and perhaps most important of all, there is the established custom of the manufacturer to make honest statements as to the *real ability* as well as *limitations* of the product. Here at JENSEN this has always been a fixed policy, an absolutely essential ingredient in *honesty of purpose,* even though by some standards it is called "selling down."

And so, a better Loud Speaker is created because of *know how,* achievement as shown by the record, significant endorsement and integrity of purpose from start to finish. JENSEN Loud Speaker Products, personnel and policy meet these requirements.

For those interested in the proper appraisal, selection, use and operation of Loud Speakers, JENSEN is publishing a series of Technical Monographs—of which five issues are now in print. Note the titles listed below and write for one or all of them.

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5 MONOGRAPHS AVAILABLE

1. Loud Speaker Frequency-Response Measurements
2. Impedance Matching and Power Distribution
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JENSEN RADIO MANUFACTURING CO.
6609 SO. LARAMIE AVENUE, CHICAGO 38, ILLINOIS
In Canada: Copper Wire Products, Ltd., 137 Oxford Street, Guelph, Ont.

Specialists in Design and Manufacture of Fine Acoustical Equipment

FM & TELEVISION PRODUCTS DIRECTORY

The Radio Engineers' & Purchasing Agents' Guide to Essential Materials, Components, and Equipment

SUPPLY HOUSES

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SAN FRANCISCO, Zack Radio Supply Co., 1426 Market St.

CONNECTICUT

BRIDGEPORT, Hatry & Young, 117 Cannon St.
HARTFORD
Hatry & Young, 203 Ann St.
Scell & Co., 227 Asylum St.
NEW HAVEN, Hatry & Young, 1172 Chapel St.

DISTRICT OF COLUMBIA

WASHINGTON, Southern Wholesalers, Inc., 1519 L St. N. W.

GEORGIA

ATLANTA
Concord Radio Corp 265 Peachtree St.
Yancey Co., Inc., W. Peachtree St.
MACON, Specialty Dist. Co.
SAVANNAH, Specialty Dist. Co.

ILLINOIS

CHICAGO
Allied Radio Corp., 833 W. Jackson Blvd.
Chicago Radio App. Co., 4155 S. Dearborn St.
Concord Radio Corp 901 W. Jackson Blvd.
Newark Electric Co., 323 W. Madison St.
Radio Parts Co 612 W Randolph St
Walker-Jimieson, Inc., 311 S. Western Ave.
ELGIN, Fox Elec. Supply Co., 67 N. State St.
PEORIA, Klaus Radio & Elec Co Main St

INDIANA

INDIANAPOLIS, Kiefer-Stewart Co., W. Georgia St.

IOWA

CEDAR RAPIDS, Checker Elec. Supply, Inc., 1st S. E.
DAVENPORT, Midwest-Timmerman Co., Western Ave.

KENTUCKY

LOUISVILLE, Smith Dist. Co., E. B'way

MARYLAND

BALTIMORE, D & H Distributing Co., 202 S. Pulaski St.

MASSACHUSETTS

BOSTON, Radio Wire Television, Inc., 110 Federal St.
CAMBRIDGE, Eastern Co.
SPRINGFIELD, Cushing, T. F.
WORCESTER, Radio Maint. Supply Co.

MICHIGAN

FLINT, Shand Radio Spec., W. Kearsley St.

MISSOURI

KANSAS CITY, Burstein Applebee Co., 1012 McGee St.
ST. LOUIS, Interstate Supply Co., 10th & Walnuts Sts.

NEW JERSEY

NEWARK
Continental Sales Co 195 Central Ave.
Krich-Radisco Inc 422 Elizabeth Ave
Lippman & Co., Aaron, 246 Central Ave.
Radio Wire Television, Inc., 24 Central Ave.

NEW YORK

BINGHAMTON, Morris Distributing Co., Inc., 25 Henry St.
GLOVERSVILLE, Fulton County Dist. Co.
ITHACA, Stallman of Ithaca, N. Tioga St.
NEW YORK
Bruno-New York Inc 460 W 34th St
Com. Radio-Sound Corp., 570 Lexington Ave.
H. L. Dalis Inc., 17 Union Sq.
Harrison Radio Corp., 12 W. B'way
Harvey Radio Co., 103 W. 43 St.
Newark Electric Co., 115-117 W. 45 St.
Radio Wire Television, Inc., 100 Sixth Ave.
Sanford Electronics Corp., 136 Liberty St.
Sun Radio & Electronics Co., 212 Fulton St.
Terminal Radio Corp., 85 Cortlandt St.
SYRACUSE, Morris Distributing Co., Inc., 412 S. Clinton St.

NORTH CAROLINA

RALEIGH, Southeastern Radio Supply Co., E. Hargett St.

OHIO

CLEVELAND, Goldhamer Inc Huron Rd

PENNSYLVANIA

HARRISBURG, D & H Distributing Co., 3115 Cameron St.
PHILADELPHIA, Radio Elec. Service Co., 7th & Arch Sts.
PITTSBURGH
Cameradio Co., 963 Liberty St.
Tydings Co., 623 Grant St.

PREPARATION OF THIS DIRECTORY

From the point of view of the users of any products directory, what counts is not the elaborateness of the indexing or the number of company names, but the ease with which accurate information can be obtained as to the manufacturers of a given product.

First of all, the preparation of a products directory involves much more than indexing questionnaires returned by manufacturers. This highly specialized work requires an intimate knowledge of the manufacturers and their products, and also of the habits of engineers and purchasing agents who use the directories.

Three common sources of complaints from users of other products directories are eliminated here. They are: 1) the need of consulting an index in order to locate the group in which a specific product is located, 2) the use of letter symbols to identify different but related products listed together in groups, and 3) the inclusion of company names under product listings which they do not sell in the open market. This latter error comes from the tendency of many manufacturers to list as "products" items which they buy outside or produce only for their own consumption, or which they only made under war controls.

We believe that this Products Directory is the most accurate and helpful, from the users' point of view, of any directory published for the radio industry. We shall welcome criticisms, suggestions, or corrections which can be incorporated in the next edition.

RHODE ISLAND

PROVIDENCE, Edwards Co., W. H., 94 B'way

SOUTH DAKOTA

SIOUX FALLS, Power City Radio Co., S. Main Ave.

TENNESSEE

KNOXVILLE, McClung Co., C. M.
MEMPHIS, Bluff City Dist. Co., Union Ave.
NASHVILLE, Electra Dist Co W End Ave

TEXAS

HOUSTON, Hall, R.C. & L.F. Caroline St.

UTAH

SALT LAKE CITY, Radio Studios, Inc., E. B'way

VIRGINIA

DANVILLE, Five Forks Battery Station
RICHMOND, Wyatt-Cornick, Inc., Grace St.

WASHINGTON

SEATTLE
Seattle Radio Supply, Inc., 2nd Ave.
Zobrist Co., 2016 Third Ave.

WEST VIRGINIA

CHARLESTON, Chemcity Radio Elec. Co., E. Washington St.
MORGANTOWN, Trenton Radio Co.

WISCONSIN

RACINE, Standard Radio Parts Co., State St.

ACOUSTICAL MATERIALS

Johns-Manville Corp., 22 E. 40 St., N. Y. C. 16

AIRPORT RADIO Installations

Air Associates, Inc., Los Angeles, Calif.
Aireon Mfg. Corp., Kansas City, Kans.
Bendix Radio, Towson, Md.
Collins Radio Co Cedar Rapids Ia
Communications Equip. Corp., 134 Colorado St., Pasadena, Calif.
Erco Radio Labs. Inc., Hempstead, L. I., N. Y.
Radio Receptor Co., Inc., 251 W. 19 St., N. Y. C.
Wilcox-Gay Corp. Charlotte Mich.

AMPLIFIERS, Public Address

Bogen Co Inc David 663 Bway NYC 12
Eastern Amplifier Corp 794 E 140 St N Y C 54
Graybar Electric Co., 420 Lexington Ave., N. Y. C. 17
Holtzer-Cabot, 125 Amory St., Roxbury 19, Mass.
Langevin Co 37 W 65 St N Y C 23
Operadio Mfg. Co St Charles Ill
Radio Corp. of Amer. Camden N J
Rauland Corp., 4245 N. Knox Ave., Chicago 41
Setchel Carlson Inc., 2233 University Ave., St. Paul 4
Simpson Mfg. Co., Mark 188 W. 4 St., N. Y. C. 14
Stromberg Carlson Co Rochester 3 N Y
Webster Electric Co., 1900 Clark St., Racine, Wis.
Western Electric Co 195 Bway N Y C

AMPLIFIERS, Studio

Altec Lansing Corp., 250 W. 57 St., N. Y. C. 19
Amer. Radio Co., 611 E. Garfield Ave., Glendale 5, Calif.
Collins Radio Co., Cedar Rapids, Ia.
Fairchild Camera & Inst Corp Jamaica 1 N Y
Gates Radio Co., Quincy, Ill.
General Electric Co., Syracuse, N. Y.
Langevin Co 37 W 65 St N Y C 23
Radio Corp. of Amer. Camden N J
Raytheon Mfg. Co. 7517 N. Clark St. Chicago 26
Western Electric Co 195 Bway N Y C

ANTENNAS, Loop, Built-in

DX Crystal Co 1200 N Claremont Ave Chicago 22
Franklin Airloop Corp., 175 Varick St., N. Y. C. 14
Sickles Co F W, Chicopee Mass.

ANTENNAS, Mobile Whip & Collapsible

Aireon Mfg. Corp., Funston Rd., Kansas City, Kans.
Bendix Aviation Corp., Pacific Div., 116 Sherman Way, N. Hollywood
Birnbach Radio Co., 145 Hudson St., N. Y. C.
Brach Mfg. Corp., L. S., Newark, N. J.
Camburn Elec. Co., 484 Broome St., N. Y. C.
Galvin Mfg. Corp., Chicago, Ill.
Link, F. M., 125 W. 17th St., N. Y. C.
Premax Products, 4214 Highland Ave., Niagara Falls, N. Y.
Radio Eng. Labs., Inc., L. I. City, N. Y.
Snyder Mfg Co 2218 W Ontario St Phila
Tech. Appl. Co., 516 W. 34 St., N. Y. C.
Ward Products Corp., 1523 E. 45 St., Cleveland, O.

ANTENNAS, Tower Type

Blaw-Knox Co., Pittsburgh, Pa.
Harco Steel Cons. Co., E. Broad St., Elizabeth, N. J.
Lehigh Structural Steel Co., 17 Battery Pl., N. Y. C.
Lingo & Son, John E., Camden, N. J.
Tower Sales & Erecting Co., 6100 N. E. Columbia Blvd., Portland 11, Ore.
Truscon Steel Co., Youngstown, O.
Wincharger Corp., Sioux City, Iowa

ATTENUATORS

Cinema Engineering Co., Burbank, Calif.
Daven Co., Summit Ave., Newark, N. J.
General Radio Co., Cambridge, Mass.
Intl. Resistance Co 429 Broad St Phila
Mallory & Co., P. R., Indianapolis, Ind.
Ohmite Mfg. Co., 4835 W. Flournoy St., Chicago
Remler Co., Ltd., 2101 Bryant St., San Francisco
Shallcross Mfg. Co., Collingdale, Pa.
Tech Labs. Lincoln St Jersey City N J
Utah Radio Prod. Co., 842 Orleans St., Chicago

BEADS, Insulating

Amer. Lava Corp., Chattanooga, Tenn.
Corning Glass Works, Corning, N. Y.
Star Porcelain Co., Trenton, N. J.
Steward Mfg. Co., Chattanooga, Tenn.

BEARINGS, Glass Instrument

Bird, Richard H., Waltham, Mass.

BERYLLIUM

Clifton Products Inc Painesville O
Machlett Labs, Inc., Springdale, Conn.

BINDING POSTS

Amer. Radio Hdware Co., Mt. Vernon, N. Y.
Chase Brass & Copper Co., Waterbury, Conn.
Franklin Mfg. Corp., 175 Varick St., N. Y. C. 14
General Radio Co., Cambridge 39 Mass.
Industrial Screw & Supply Co., 717 W. Lake St., Chicago 6
Radex Corp., 1308 Elston Ave., Chicago

BINDING POSTS, Push Type

Amer Radio Hdware Co., Mt. Vernon, N. Y.
Eby, Inc., H. H., W. Chelten Ave., Phila

BLOWERS, for Radio Equipment

Eastern Air Devices, Inc., 585 Dean St., Bklyn 17
L-R Mfg. Co., Torrington, Conn.
Trade-Wind Motorfans, Inc., 5725 S. Main St., Los Angeles

BOOKS on Radio & Electronics

Macmillan Co., 60 Fifth Ave., N. Y. C.
Maedel Pub. House, 593AE 38 St., Bklyn, N. Y.
McGraw-Hill Book Co., 330 W. 42 St., N. Y. C.
Murray Hill Books Inc., 232 Madison Ave., N. Y. C. 16
Pitman Pub. Corp., 2 W. 45 St., N. Y. C.
Rider, John F., 404 Fourth Ave., N. Y. C.
Ronald Press Co., 15 E. 26 St., N. Y. C.
Van Nostrand Co., D., 250 Fourth Ave., N. Y. C.
Wiley & Sons, John, 440 Fourth Ave., N. Y. C.

BRIDGES, Percent Limit Resistance

Leeds & Northrup Co., 4901 Stenton Ave., Phila.
Radio City Products Co., 127 W. 26 St., N. Y. C.
Shallcross Mfg. Co., Collingdale, Pa.

BRIDGES, Wheatstone

Industrial Instruments, Inc., Culver Ave., Jersey City, N. J.
Leeds & Northrup Co., 4901 Stenton Ave., Phila.
Shallcross Mfg. Co., Collingdale, Pa.

BUSHINGS, Terminal Sealing

Amer. Lava Corp., Chattanooga 5, Tenn.
Corning Glass Works, Corning, N. Y.
Electrical Industries, Inc., 42 Sumner Ave., Newark 4, N. J.
Isolantite Inc., Belleville, N. J.
Lenox Inc Trenton 5 N J
Peerless Electrical Prod. Co., 6920 McKinley Ave., Los Angeles 1
Sperti, Inc., Cincinnati, O.
Sprague Elec Co N Adams Mass
Westinghouse Elect. & Mfg. Co., E. Pittsburgh, Pa.

CABINETS, Metal

Cole Steel Equip. Co 349 Bway N Y C
Corry-Jamestown Mfg Corp Corry Pa
Insuline Corp of Amer L I City N Y
Karp Metal Prod. Co Inc 126 30th St Bklyn 31
Par-Metal Prod. Corp., 32-49th St., L. I. City, N. Y.
Porter Metal Prod Co 490 Johnson Av Bklyn
Sherron Electronics Co., 1201 Flushing Ave., Bklyn 6

CABINETS, Wood, for Home Radios

Churchill Cabinet Co., 2119 Churchill St., Chicago
Tillotson Furniture Co., Jamestown, N. Y.

CABLE, Coaxial

American Phenolic Corp., 1830 S. 54 Av., Chicago
Anaconda Wire & Cable Co., 25 B'way, N. Y. C.
Andrew Co 363 E 75 St Chicago
Belden Mfg. Co., 4673 W. Van Buren, Chicago
Boston Ins Wire & Cable Co Boston
Comm Prods Co 346 Bergen Av Jersey City 5 N J
Cornish Wire Co., 15 Park Row, N. Y. C.
Doolittle Radio, Inc., 7521 S. Loomis Blvd., Chicago
Federal Tel. & Radio Corp., Newark, N. J.
General Cable Corp., 420 Lexington, N. Y. C.
General Insulated Wire Corp., 53 Park Pl., N. Y. C.
Johnson Co., E. F., Waseca, Minn.
Lenz Electrical Mfg. Co.
Radex Corp., 1308 Elston Ave., Chicago
Simplex Wire & Cable Corp., Cambridge, Mass.
Western Electric Co., 195 Bway, N. Y. C.

The Sensation

OF THE YEAR... IT'S ZENITH'S

NEW WAY TO PLAY RECORDS

There's a wave of excitement rolling through the radio industry, and Zenith dealers are riding its crest, right into leadership. For Zenith's *New Way to Play Records* is creating a sensation unmatched in the history of the business.

Dealers have critically examined Zenith's 30th Anniversary Line, and they know that these are the radios and radio-phonographs all America wants. Once you have enjoyed the incomparably beautiful record reproduction of Zenith's new Cobra Tone Arm—the rich, life-like fidelity of tone, free from surface noise—you can never be satisfied with any radio-phonograph offering *less* tone quality.

Dealers have seen the new Cobra dropped, even scraped on records without damage. They recognize this as a dramatic demonstration feature—and a test every buyer will insist on making. Record owners will appreciate the feather-light pressure of the Cobra (less than ⅔ of an ounce) and the vastly longer life this gives records.

But the new Cobra Tone Arm, amazing as it is, is only part of this *New Way to Play Records*. Zenith, and only Zenith, has the Silent-Speed Record Changer. It is the world's fastest, with a change cycle of less than 3½ seconds. It is gentle in action—can't chip or bind records. And, this new kind of changer plays both 10- and 12-inch records, *intermixed*. There are no gadgets or complicated adjustments. Just load records on the spindle and press a button.

The new Zenith radio-phonographs, featuring this *New Way to Play Records*, offer scores of *other* important developments. Here is genuine Armstrong F-M, on both the old and new bands, with a patented and exclusive Zenith device that makes outside antennas or dipoles unnecessary, even for table model F-M sets. Zenith offers new circuits . . . new dials . . . new cabinets . . . thrilling new performance.

Zenith has drawn on its background of 30 years of Radionics exclusively to bid for leadership with radios and radio-phonographs that are brand new, clear thru—and far better in every way.

ZENITH RADIO CORPORATION
6001 DICKENS AVE. • CHICAGO 39, ILL.

12HO92R

9HO79

Complete Line of Table Models, too, With Improved Super-Powered CONSOLTONE

Compare Zenith table models with any others. Hear the rich bass, clear treble tone Zenith's Consoltone circuit makes possible. Notice the distinctive smartness of the cabinets . . . the big, easy-to-read dials. Check feature against feature, and you'll agree with other dealers that Zenith is headed for leadership in the table model field, too.

5DO11

DESIGNED FOR SALES — ZENITH •LONG DISTANCE• RADIO — **DESTINED FOR LEADERSHIP**

CABLE, Coaxiol, Fittings

Andrew Co 363 E 75 St Chicago
Comm Prod Co 346 Bergen Av Jersey City 5 N J
Johnson Co, E. F. Waseca Minn

CABLE, Microphone, Speaker & Battery

Alden Prods. Co., Brockton, Mass.
Anaconda Wire & Cable Co., 25 Broadway, N. Y. C.
Belden Mfg. Co., 4633 W. Van Buren, Chicago
Boston Insulated Wire & Cable Co., Dorchester, Mass.
Gavitt Mfg. Co., Brookfield, Mass.
Holyoke Wire & Cable Corp., Holyoke, Mass.

CABLES, Preformed

Alden Products Co., Brockton, Mass.
Belden Mfg. Co., 4633 W. Van Buren St., Chicago
Wallace Mfg. Co., Wm. T., Rochester, Ind.
Whitaker Cable Corp Kansas City 16 Mo.

CASES, Wooden Instrument

Hoffstatter's Sons, Inc., 43 Ave. & 24 St., Long Island City, N. Y.
Tillotson Furniture Co., Jamestown, N.Y.

CASTINGS, Die

Aluminum Co. of Amer., Pittsburgh, Pa.
American Brass Co., Waterbury, Conn.
Dow Chemical Co., Dow Metal Div., Midland, Mich.

CERAMICS, Bushings, Washers, Special Shapes

Akron Porcelain Co., Akron, O.
Amer. Lava Corp., Chattanooga, Tenn.
Centralab, Div. of Globe-Union Inc., Milwaukee, Wis.
Corning Glass Works, Corning, N. Y.
Electronic Mechanics, Inc., Paterson, N. J.
Gen'l Ceramics & Steatite Corp., Keasbey, N. J.
General Electric Co., Schenectady, N. Y.
Isolantite, Inc., Belleville, N. J.
Lapp Insulator Co., Leroy, N. Y.
Lenox, Inc., Trenton, N. J.
Louthan Mfg. Co., E. Liverpool, O.
Mycalex Corp. of America, Clifton N. J.
Star Porcelain Co., Trenton, N. J.
Steward Mfg. Co., Chattanooga, Tenn.
Stupakoff Ceramic & Mfg. Co., Latrobe, Pa.
Victor Insulator Co., Victor, N. Y.
Westinghouse Elect. & Mfg. Co., E. Pittsburgh, Pa.

CHANGERS, Record

Farnsworth Telev. & Radio Corp., Ft. Wayne, Ind.
Garrard Sales Corp., 401 B'way, N. Y. C. 13
General Industries Co., Elyria, Ohio
General Instrument Corp., 829 Newark Ave., Elizabeth 3, N. J.
Maguire Industries Inc., Bridgeport, Conn.
Radio Corp. of Amer., Camden, N. J.
Seeburg Corp., J. P., 1510 N. Dayton St., Chicago
Webster Chicago Corp., 3825 Armitage Ave., Chicago 47
Wurlitzer Mfg. Co., N. Tonawanda, N. Y.

CHASSIS, Metal

See STAMPINGS, Metal

CHOKES, AF

See TRANSFORMERS, Audio & Power

CHOKES, RF

Albion Coil Co Albion Ill
Aladdin Radio Industries, 501 W. 35th, Chicago
Automatic Mfg. Corp., 900 Passaic Ave. E. Newark, N. J.
Barker & Williamson, Upper Darby, Pa.
Coto-Coil Co., Providence, R. I.
D-X Radio Prods. Co., 1575 Milwaukee, Chicago
Fast & Co., John E., 3109 N. Crawford, Chicago 41
Gen. Winding Co., 420 W. 45 St., N. Y. C.
General Radio Co., Cambridge 39, Mass.
Guthman & Co., Edwin, 15 S. Throop, Chicago
Hammarlund Mfg. Co., 424 W. 33 St., N. Y. C.
Johnson Co., E. F., Waseca, Minn.
Lectrohm, Inc., Cicero, Ill.
Magnetic Windings Co., Easton, Pa.
Meissner Mfg. Co., Mt. Carmel, Ill.
Miller Co., J. W., 5917 S. Main, Los Angeles, Cal.
Muter Co., 1255 S. Michigan, Chicago
National Co., Malden, Mass.
Ohmite Mfg. Co., 4835 W. Flournoy St., Chicago
Radex Corp., 1328 Elston Av., Chicago
Sickles Co., F. W. Chicopee, Mass.
Teleradio Eng. Corp., 484 Broome St., N. Y. C.

CLIPS, Connector

Mueller Electric Co., Cleveland, O.

CLIPS & MOUNTINGS, Fuse

Alden Prods. Co., Brockton, Mass.
Dante Elec. Mfg. Co., Bantam, Conn.
Ilsco Copper Tube & Prods., Inc., Station M., Cincinnati
Jefferson Elec. Co., Bellwood, Ill.
Jones, Howard B., 2300 Wabansia, Chicago
Littlefuse, Inc., 4753 Ravenswood, Chicago
Patton MacGuyer Co., Providence, R. I.
Sherman Mfg. Co., H. B., Battle Creek, Mich.
Stewart Stamping Co., 621 E. 216 St., Bronx, N. Y.
Zierick Mfg. Co., 385 Girard Ave., Bronx, N. Y. C.

CLOTH, Insulating

Acme Wire Co., New Haven, Conn.
Brand & Co., Wm., 276-4th Av., N. Y. C.
Endurette Corp. of Amer., Cliffwood, N. J.
Insulation Mfgrs. Corp., 565 W. Wash. Blvd., Chicago
Irvington Varnish & Insulating Co., Irvington, N. J.
Mica Insulator Co., 196 Varick, N. Y. C.

COIL FORMS, Glass

Corning Glass Works, Corning, N. Y.

COILS, Radio

See Transformers, IF, RF

CONDENSERS, Ceramic Case Mica Transmitting

Aerovox Corp., New Bedford, Mass.
Cornell-Dubilier, S. Plainfield, N. J.
RCA Mfg. Co., Inc., Camden, N. J.
Sangamo Electric Co., Springfield, Ill.
Solar Mfg. Corp., Bayonne, N. J.

CONDENSERS, Fixed

Aerovox Corp., New Bedford, Mass.
Amer. Condenser Corp., 4410 Ravenswood Ave., Chicago
Atlas Condenser Prods. Co., 548 Westchester Ave., N. Y. C.
Bud Radio, Inc., Cleveland, O.
Capacitron Co., 849 N. Kedzie Ave., Chicago 51
Centralab, Milwaukee, Wis.
Condenser Corp. of America, South Plainfield, N. J.
Condenser Prods. Co., 1375 N. Branch, Chicago
Cornell-Dubiler Elec. Corp., S. Plainfield, N. J.
Cosmic Radio Co 699 E 135th St N Y C
Crowley & Co., Henry, W. Orange, N. J.
Deutschmann Corp Tobe Canton Mass
Dumont Elec. Co., 34 Hubert St., N. Y. C.
Electrical Reactance Corp Franklinville N Y
Electro-Motive Mfg. Co., Willimantic, Conn.
Erie Resistor Corp., Erie, Pa.
Fast & Co., John E., 3109 N. Crawford, Chicago 41
General Electric Co Schenectady N Y
General Radio Co., Cambridge, Mass.
Girard-Hopkins, Oakland, Calif.
Guthman & Co., Edwin I., 15 S. Throop St., Chicago
H. R. S. Prods. 5707 W. Lake St., Chicago
Illinois Cond. Co., 1160 Howe St., Chicago
Industrial Cond. Corp., 3243 N. Calif. Ave., Chicago 18
Insuline Corp. of America, Long Island City, N. Y.
Jeffers Electronics Du Bois Pa
Johnson Co., E. F., Waseca, Minn.
Magnavox Co., Fort Wayne, Ind.
Mallory & Co., P. R., Indianapolis, Ind.
Micamold Radio Corp., 1087 Flushing Ave., Bklyn 6
Micamold Radio Corp., Brooklyn, N. Y.
Muter Co., 1255 S. Michigan, Chicago
Noma Electric Corp 55 W 13 St N Y C
Polymet Condenser Co., 699 E. 135 St., N. Y. C.
Potter Co., 1950 Sheridan Rd., N. Chicago
RCA Mfg. Co., Camden, N. J.
Sangamo Elec. Co., Springfield, Ill.
Sickles Co., F. W., Chicopee, Mass.
Solar Mfg. Corp., 285 Madison Ave., N. Y. C. 17
Sprague Electric Co., N. Adams, Mass.
Westinghouse Elect. & Mfg. Co., E. Pittsburgh, Pa.

CONDENSERS, Gas-filled

Johnson Co, E. F. Waseca Minn
Lapp Insulator Co., Inc., Leroy, N. Y.

CONDENSERS, High-Voltage Vacuum

Centralab, Milwaukee, Wis.
Eitel-McCullough, Inc., San Bruno, Calif.
Erie Resistor Corp., Erie, Pa.
General Electric Co., Schenectady, N. Y.
General Electronics, Inc., Paterson, N. J.
Jennings Radio Mfg. Co., 1098 E. William St., San Jose 12, Calif.

CONDENSERS, Small Ceramic Tubular

Centralab; Div. of Globe-Union, Inc., Milwaukee, Wis.
Electrical Reactance Corp., Franklinville, N. Y.
Solar Mfg. Corp., 285 Madison Ave., N. Y. C. 17
Erie Resistor Corp., Erie, Pa.

CONDENSERS, Transmitter Neutralizing

Hammarlund Mfg Co 424 W 34 St N Y C
Johnson Co E. F. Waseca Minn
National Co Inc Malden Mass
Millen Mfg Co Inc Malden Mass

CONDENSERS, Trimmer

Alden Prods. Co., Brockton, Mass.
American Steel Package Co., Defiance, O.
Bud Radio, Inc., Cleveland, O.
Cardwell Mfg. Corp., Brooklyn, N. Y.
Centralab, Milwaukee, Wis.
Comar Electric Co., 2701 Belmont Ave., Chicago
General Radio Co., Cambridge, Mass.
Guthman, Inc., E. I., 400 S. Peoria, Chicago
Hammarlund Mfg. Co., 424 W. 33 St., N. Y. C.
Insuline Corp. of Amer., L. I. City, N. Y.
Johnson Co., E. F., Waseca, Minn.
Meissner Mfg. Co., Mt. Carmel, Ill.
Millen Mfg. Co., James, Malden, Mass.
Miller Co., J. W., Los Angeles, Cal.
Muter Co., 1255 S. Michigan Ave., Chicago
National Co., Malden, Mass.
Potter Co., 1950 Sheridan Rd., N. Chicago
Sickles Co., F. W., Chicopee, Mass.
Teleradio Eng. Corp., 99 Wall St., N. Y. C. 5

CONDENSERS, Variable Receiver Tuning

Alden Prods. Co., Brockton, Mass.
American Steel Package Co., Defiance, Ohio
Barker & Williamson, Ardmore, Pa.
Bud Radio, Inc., Cleveland, O.
Cardwell Mfg. Corp., 81 Prospect St., Bklyn
General Inst. Corp., Elizabeth, N. J.
Hammarlund Mfg. Co., 424 W. 34th St., N. Y. C.
Insuline Corp. of Amer., L. I. City, N. Y.
Meissner Mfg. Co., Mt. Carmel, Ill.
Millen Mfg. Co., Malden, Mass.
National Co., Malden, Mass.
Oak Mfg. Co., 1267 Clybourn Ave., Chicago
Radio Condenser Co., Camden, N. J.
Rauland Corp., Chicago 41

CONDENSERS, Variable Transmitter Tuning

Barker & Williamson, Upper Darby, Pa.
Bud Radio, Cleveland, O.
Cardwell Mfg. Corp., Allen D., Brooklyn, N. Y.
Hammarlund Mfg. Co., 424 W. 33 St., N. Y. C.
Insuline Corp. of Amer., L. I. City, N. Y.
Jennings Radio Mfg. Co., E. William St., San Jose 12, Calif.
Johnson, E. F., Waseca, Minn.
Millen Mfg. Co., James, Malden, Mass.
National Co., Malden, Mass.
Radio Condenser Co., Camden, N. J.

CONNECTORS, Cable

Airadio, Inc., Stamford, Conn.
Aircraft Radio Corp., Boonton, N. J.
Alden Prods., Brockton, Mass.
Amer. Microphone Co., 1915 S. Western Av., Los Angeles
Amer. Phenolic Corp., 1830 S. 54th St., Chicago
Amer. Radio Hdware Co., Mt. Vernon, N. Y.
Andrew Co 363 E 75 St Chicago
Astatic Corp., Conneaut, Ohio
Atlas Sound Corp., 1442 39th St., Brooklyn, N. Y.
Birnbach Radio 145 Hudson St NYC
Breeze Mfg. Corp., Newark, N. J.
Bud Radio Inc., 2118 E 55 St., Cleveland 3, Ohio
Cannon Elec. Development, 3209 Humboldt, Los Angeles
Diamond Inst. Co Wakefield Mass
Eby, Inc., Hugh H., 18 W. Chelton Ave., Phila. 13
Franklin Mfg. Corp., 175 Varick St., N. Y. C.
General Radio Co., Cambridge, Mass.
Intl. Resistance Co 401 N Broad St. Phila 8
Harwood Co., 5405 S. La Brea, Los Angeles 36
Insuline Corp. of Amer., L. I. City, N. Y.
Johnson Co., E. F., Waseca, Minn.
Jones, Howard B., 2432 W. George, Chicago
Mallory & Co., P. R., Indianapolis, Ind.
Monowatt Electric Co., Providence, R. I.
Northam Warren Corp., Stamford, Conn.
Radio City Products Co., 127 W. 26 St., N. Y. C.
Remler Co., Ltd., 2101 Bryant St., San Francisco
Schott Co., W. L., 9306 Santa Monica Blvd., Beverly Hills, Calif.
Selectar Mfg. Co., L. I. City, N. Y.

CONTACT POINTS

Baker & Co., 113 Astor St., Newark 5, N. J.
Brainin Co C. S. 233 Spring St NYC
Callite Tungsten Corp., Union City, N. J.
Fansteel Metallurgical Corp., N. Chicago, Ill.
Mallory & Co., Inc., P. R., Indianapolis, Ind.
Wilson Co., H. A. 105 Chestnut St., Newark 5 N. J.

CORES, Powdered Iron

See IRON CORES, Powdered

COUPLINGS, flexible

Cardwell Mfg. Corp., Brooklyn, N. Y.
Johnson Co., E. F., Waseca, Minn.
Hammarlund Mfg Co Inc 460 W 34 St N Y C
Millen Mfg. Co., James, Malden, Mass.
National Co., Inc., Malden, Mass.

CRYSTAL GRINDING EQUIPMENT

Cons. Diamond Saw Blade Corp., Yonkers Ave., Yonkers 2, N. Y.
Felker Mfg. Co., Torrance, Calif.

CRYSTALS, Quartz

Aircon Mfg. Corp., Kansas City, Kans.
Bausch & Lomb Optical Co., Rochester, N. Y.
Bliley Elec. Co., Erie, Penna.
Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass.
Collins Radio Co., Cedar Rapids, Iowa
Crystal Prod. Co., 1519 McGee St., Kansas City, Mo.
Crystal Research Labs., Hartford, Conn.
DX Crystal Co., 1200 N. Claremont, Chicago
Federal Engineering Co., 37 Murray St., N. Y. C.
General Electric Co. Schenectady, N. Y.
General Radio Co., Cambridge, Mass.
Harvey-Wells Communications, Southbridge, Mass.
Hipower Crystal Co., 2035 W. Charleston, Chicago
Kaar Engineering Co., Palo Alto, Cal.
Knights Co., The James, Sandwich, Ill.
Meck Industries, John, Plymouth, Ind.
Miller, August E., North Bergen, N. J.
Monitor Piezo Prod. Co., S. Pasadena, Calif.
Peterson Radio, Council Bluffs, Iowa
Precision Piezo Service, Baton Rouge, La.
Premier Crystal Labs., 63 Park Row, N. Y. C.
Quartz Laboratories, 1512 Oak St., Kansas City, Kans.
RCA Mfg. Co., Camden, N. J.
Reeves Sound Labs., 62 W. 47 St., N. Y. C.
Scientific Radio Products Co., Council Bluffs, Ia.
Scientific Radio Service, University Park, Md.
Standard Piezo Co., Carlisle, Pa.
Valpey Crystals, Holliston, Mass.
Wallace Mfg. Co., Wm. T., Peru, Ind.
Western Electric Co 195 Bway N Y C 5
Zeiss, Inc., Carl, 485 Fifth Ave., N. Y. C.

DIAL LIGHTS

See PILOT LIGHTS

DIALS, Instrument

Barker & Williamson, Upper Darby, Pa.
Bud Radio Inc., 2118 E. 55 St., Cleveland 3, Ohio
Croname Inc., 3701 Ravenswood Ave., Chicago
Etched Products Corp., 39-01 Queens Blvd., L. I. City, N. Y.
General Radio Co., Cambridge, Mass.
Gits Molding Corp., 4600 Huron St. Chicago
Gordon Spec. Co 823 S Wabash Ave Chicago
Kurz-Kasch Co., 1415 S. B'way, Dayton 1, Ohio
Mica Insul. Co., 198 Varick St., N. Y. C.
Millen Mfg. Co., Malden, Mass.
National Co., Inc., Malden, Mass.
Rogan Bros., 2003 S. Michigan Ave., Chicago
Silk Screen Supplies Inc., 33 Lafayette Ave., Bklyn

DISCS, Recording

Advance Recording Products Co., Long Island City, N. Y.
Allied Recording Products Co., Long Island City, N. Y.
Audio Devices, Inc., 444 Madison Ave., N. Y. C.
Federal Recorder Co., Elkhart, Ind.
Gould-Moody Co., 395 B'way, N. Y. C.
Pilot Radio Corp., Long Island City, N. Y.
Presto Recording Corp 242 W 55 St NYC
RCA Mfg. Co., Camden, N. J.
Wilcox-Gay Corp., Charlotte, Mich.

DYNAMOTORS — See Motor-Generators, Small

ETCHING, Metal

Croname Inc., 3701 Ravenswood Ave., Chicago
Etched Prod. Corp., 39-01 Queens Blvd., Long Island City, N. Y.
Premier Metal Etching Co., 21-03 44th Ave., Long Island City, N. Y.

FACSIMILE EQUIPMENT

Alden Products Co., Inc., Brockton, Mass.
Bunnell & Co., J. H., 215 Fulton, N. Y. C.
Federal Tel. & Radio Corp., Newark, N. J.
Finch Telecom., Inc., Passaic, N. J.
Press Wireless, Inc., 1475 B'way, N. Y. C.
R.C.A. Mfg. Co., Camden, N. J.
Radio Inventions Inc., 155 Perry St., N. Y. C. 14

FASTENERS, Separable

Boots Aircraft Nut Corp., New Canaan, Conn.
Camloc Fastener Co., 420 Lexington Ave., N. Y. C.
Dzus Fasteners Co., Inc., Babylon, N. Y.
Shakeproof, Inc., 2501 N. Keeler Ave., Chicago

FELT

Amer. Felt Co., Inc., Glenville, Conn.
Western Felt Works, 4031 Ogden Ave., Chicago

FIBRE, Vulcanized

Brandywine Fibre Prods. Co., Wilmington, Del.
Continental-Diamond Fibre Co., Newark, Del.
Insulation Mfgrs. Corp., 565 W. Wash. Blvd., Chicago
Mica Insulator Co., 196 Varick, N. Y. C.
Nat'l Vulcanized Fibre Co., Wilmington, Del.
Spaulding Fibre Co., Inc., 233 B'way, N. Y. C.
Synthane Corp., Oaks, Pa.
Taylor Fibre Co., Norristown, Pa.
Wilmington Fibre Specialty Co., Wilmington, Del.

FILTERS, Electrical Noise

Bendix Aviation Corp., Pacific Div. 11600 Sherman Way, N. Hollywood.
Cornell-Dubilier Elec. Corp. South Plainfield N J
General Electric Co Schenectady N. Y.
Mallory & Co., Inc., P. R., Indianapolis, Ind.
Miller Co., J. W., 5917 S. Main St., Los Angeles
Solar Mfg. Corp., 285 Madison Ave., N. Y. C. 17
Tobe Deutschmann Corp., Canton, Mass.

FINISHES, Metal

Airose Chemical Co., Providence, R. I.
Aluminum Co. of America, Pittsburgh, Pa.
Ault & Wiborg Corp., 75 Varick, N. Y. C.
Hilo Varnish Corp., Brooklyn, N. Y.
Maas & Waldstein Co., Newark, N. J.
New Wrinkle, Inc., Dayton, O.
Sullivan Varnish Co., 410 N. Hart St., Chicago 22

FREQUENCY STANDARDS, Primary

General Radio Co., Cambridge, Mass.

FREQUENCY STANDARDS, Secondary

Amer. Time Products, 580 Fifth Ave., N. Y. C.
Ferris Instrument Co., Boonton, N. J.
Garner Co., Fred E., 43 E. Ohio St., Chicago
General Radio Co., Cambridge 39 Mass.
Hewlett-Packard Co., Palo Alto, Calif.
Higgins Industries, Inc., 2221 Warwick Ave., Santa Monica, Calif.
James Knights Co Sandwich Ill
Lavoie Laboratories, Morganville, N. J.
Millen Mfg. Co., Inc., Malden, Mass.
Radio Corp. of Amer., Camden, N. J.

FUSES, Enclosed

Dante Elec. Mfg. Co., Bantam, Conn.
Jefferson Elec. Co., Bellwood, Ill.
Littlefuse, Inc., El Monte, Calif.

GEARS & PINIONS, Metal

Continental-Diamond Fibre Co., Newark Del.
Crowe Name Plate & Mfg. Co., 3701 Ravenswood Ave., Chicago
Gear Specialties, Inc., 2650 W. Medill, Chicago
Perkins Machine & Gear Co., Springfield, Mass.
Quaker City Gear Wks., Inc., N. Front St., Phila.
Thompson Clock Co., Bristol, Conn.

GEARS & PINIONS, Non-Metallic

Brandywine Fibre Prods. Co., Wilmington, Del.
Formica Insulation Co., Cincinnati, O.
Gear Specialties, Inc., 2650 W. Medill, Chicago
General Electric Co., Pittsfield, Mass.
Mica Insul. Co., 196 Varick St., N Y C
National Vulcanized Fibre Co., Wilmington, Del.
Perkins Machine & Gear Co., Springfield, Mass.
Richardson Co., Melrose Park, Ill.
Spaulding Fibre Co., Inc., 233 B'way, N. Y. C.
Synthane Corp., Oaks, Pa.
Taylor Fibre Co., Norristown, Pa.
Wilmington Fibre Specialty Co., Wilmington, Del.

GENERATORS, Beat Frequency

Boonton Radio Corp Boonton N J
General Radio Co Cambridge Mass

GENERATORS, Electronic AC

Communication Meas. Lab., 118 Greenwich St., N. Y. C.

GENERATORS, Gas Engine Driven

Delco App. Div., Gen. Motors Corp., Rochester 1, N. Y.
Homelite Corp., Port Chester, N. Y.
Hunter-Hartman Corp., St. Louis, Mo.
Kato Engineering Co., Mankato, Minn.
Kohler Co., Kohler, Wis.
Leland Electric Co Dayton O
Onan & Sons, Royalston Ave., Minneapolis, Minn.
Pioneer Gen-E-Motor, 5841 W. Dickens Ave., Chicago, Ill.

GENERATORS, Hand Driven

Burke Electric Co., Erie, Pa.
Carter Motor Co., 1608 Milwaukee, Chicago
Chicago Tel. Supply Co., Elkhart, Ind.

GENERATORS, Square Wave

General Radio Co., Cambridge 39, Mass.
Hewlett-Packard Co., 395 Page Mill Rd. Palo Alto, Calif.
Measurements Corp., Boonton, N. J.

GENERATORS, Standard Signal

Boonton Radio Corp., Boonton, N. J.
Ferris Instrument Co., Boonton, N. J.
General Radio Co., Cambridge, Mass.
Harvey Radio Corp., Cambridge, Mass.
Hewlett-Packard Co., Palo Alto, Calif.
Measurements Corp., Boonton, N. J.
Radio Corp. of Amer., Camden, N. J.

GENERATORS, Wind Driven

Wincharger Corp., Sioux City, Ia.

GLASS, Electrical

Corning Glass Works, Corning, N. Y.

GREASE, for Electrical Contacts & Bearings

Royal Engineering Co. (Royco Grease), East Hanover, N. J.

HANDSETS, Telephone

Automatic Electric Co., 1033 W. Van Buren, Chicago
Federal Tel. & Radio Corp., Newark, N. J.
Stromberg-Carlson Co Rochester N Y
Universal Microphone Co., Inglewood Calif.
Western Electric Co., 195 B'way, N. Y. C.

HEADPHONES

Brush Development Co., Cleveland, O.
Cannon Co., C. F., Springwater, N. Y.
Carron Mfg. Co., 415 S. Aberdeen, Chicago
Connecticut Tel. & Elec. Co., Meriden, Conn.
Consolidated Radio Prod. Co., W. Erie St., Chicago
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago
Murdock Mfg. Co., Chelsea, Mass.
Permoflux Corp., W. Grand Ave., Chicago
Telephonics Corp., 350 W. 31 St., N. Y. C.
Telex Products Co Minneapolis Minn
Trimm Radio Mfg. Co., 1770 W. Berteau, Chicago
Utah Radio Prod. Co., 842 Orleans St., Chicago
Western Electric Co., 195 B'way, N. Y. C.

HORNS, Outdoor

Altec Lansing Corp., 1680 N. Vine, Hollywood 28
Graybar Elect. Co., 420 Lex. Ave NYC 17
Jensen Radio Mfg. Co., 6601 S. Laramie Ave., Chicago
Langevin Co 37 W 65 St N Y C 23
Operadio Mfg. Co., St. Charles, Ill.
Oxford Tartak Radio Corp., 915 W. Van Buren St., Chicago
Racon Electric Co., 52 E. 19 St., N. Y. C.
RCA Mfg. Co., Camden, N. J.
University Laboratories, 225 Varick St., N. Y. C.
Western Electric Co., 195 B'way, N.Y.C.

INDUCTION HEATING EQUIPMENT

Federal Tel. & Radio Corp., Newark, N. J.
Induction Heating Corp., 389 Lafayette St., N. Y. C.
Lepel High Frequency Labs., 39 W. 60 St., N. Y. C.
Radio Corp. of Amer., Camden, N. J.

INDUCTORS, Transmitter

Barker & Williamson, Upper Darby, Pa.
Johnson Co, E. F. Waseca Minn
National Co., Inc., Malden, Mass.

INDUCTORS, Variable Tuning

Barker & Williamson, Upper Darby, Pa.
Standard Winding Co Newburgh N Y

INSTRUMENTS, Radio Laboratory

Ballantine Laboratories, Inc., Boonton, N. J.
Boonton Radio Corp., Boonton, N. J.
Ferris Inst. Corp., Boonton, N. J.
General Electric Co., Schenectady, N. Y.
General Radio Co., Cambridge, Mass.
Hewlett-Packard Co., Palo Alto, Calif.
Measurements Corp., Boonton, N. J.
Radio Corp. of Amer., Camden, N. J.

INSULATORS, Ceramic Stand-off, Lead-in, Rod Types

America Lava Corp., Chattanooga, Tenn.
Corning Glass Works, Corning, N. Y.
Electronic Mechanics, Inc., Clifton, N. J.
Gen. Ceramics & Steatite Corp. Keasbey N J
Isolantite, Inc., Belleville, N. S.
Johnson Co., E. F., Waseca, Minn.
Lapp Insulator Co., Inc., Leroy, N. Y.
Locke Insulator Co., Baltimore, Md.
Millen Mfg. Co., Malden, Mass.
Mycalex Corp. of America, Clifton, N. J.
National Co., Inc., Malden, Mass.
Stupakoff Ceramic & Mfg Co Latrobe Pa

INTERFERENCE SUPPRESSORS

See FILTERS, Electrical Noise

IRON CORES, Powdered

Aladdin Radio Industries, Inc., 501 W. 35 St., Chicago
Crowley & Co., Henry, W. Orange, N. J.
Ferrocart Corp. of Amer., Hastings-on-Hudson, N. Y.
Genl. Aniline Wks 435 Hudson St NYC
Gibson Elec. Co., Pittsburgh, Pa.
Magner Mfg. Co., Inc., 444 Madison Ave., N. Y. C.
Mallory & Co., P. R., Indianapolis, Ind.
Micro-Ferrocart Prods Greenwich Conn
Stackpole Carbon Co., St. Marys, Pa.
Western Electric Co., 195 Broadway, N. Y. C.
Wilson Co., H. A., Newark, N. J.

IRONS, Soldering

Acme Electric Heating Co., 1217 Washington St., Boston
Amer. Electrical Heater Co., 6110 Cass Ave., Detroit
Drake Elec. Wks., Inc., 3656 Lincoln Ave., Chicago
Electric Soldering Iron Co., Deep River, Conn.
General Electric Co., Schenectady, N. Y.
Hexacon Elec. Co., Roselle Park, N. J.
Sound Equipment Corp. of Calif., 6245 Lex. Ave., Los Angeles 38
Ungar, Inc., Harry A., 615 Ducommun St., Los Angeles 12
Vasco Electrical Mfg. Co., 4116 Avalon Blvd., Los Angeles
Vulcan Electric Co., Lynn, Mass.

JACKS, Telephone

Alden Prods. Co., Brockton, Mass.
Amer. Molded Prods. Co., 1753 N. Honore St., Chicago
Chicago Tel. Supply Co., Elkhart, Ind.
Guardian Elec. Mfg. Co., 1627 W. Walnut St., Chicago
Insuline Corp. of Amer., L. I. C., N. Y.
Johnson, E. F., Waseca, Minn.
Jones, Howard B., 2300 Wabansia Ave., Chicago
Mallory & Co., Inc., P. R., Indianapolis, Ind.
Mangold Radio Pts. & Stamping Co., 6300 Shelbourne St., Philadelphia
Molded Insulation Co Germantown Pa
Presto Electric Co., Union City, N. J.
Western Electric Co., 195 B'way NYC

KEYS, Telegraph

Amer. Radio Hdware Co., Mt. Vernon, N. Y.
Bunnell & Co., J. H., 215 Fulton, N Y C
Mossman, Inc., Donald P., 6133 N. Northwest Hy., Chicago
Renler Co., Ltd., 2101 Bryant St., San Francisco
Signal Electric Mfg. Co., Menominee, Mich.
Telegraph App. Co., 325 W. Huron St., Chicago
Telephonics Corp., 350 W. 31 St., N. Y. C.
Winslow Co., Inc., Liberty St., Newark, N. J.

KNOBS, Radio & Instrument

Alden Prods. Co., Brockton, Mass.
American Insulator Corp., New Freedom, Pa.
Chicago Molded Prods. Corp., 1025 N. Kolmar, Chicago
General Radio Co., Cambridge, Mass.
Gits Molding Corp., 4600 Huron St., Chicago
Gordon Spec. Co 823 S Wabash Ave Chicago
Imperial Molded Prods. Corp., 2921 W. Harrison, Chicago
Kurtz Kasch, Inc., Dayton, O.
Millen Mfg. Co., James, Malden, Mass.
Nat'l Co., Inc., Malden, Mass.
Northeastern Molding, Inc., 584 Commonwealth Ave., Boston 15, Mass.
Rogan Bros., 2001 S. Michigan, Chicago

LABELS, Coding

Western Litho. Co., 600 E. 2nd, Los Angeles

LABELS, Removable

Avery Adhesives, 451 3rd St., Los Angeles
Western Litho. Co., 600 E. 2nd, Los Angeles

LABELS, Stick-to-Metal

Ever Ready Label Corp., E. 25th St., N. Y. C.
Tablet & Ticket Co., 1021 W. Adams St., Chicago
Western Litho. Co., 600 E. 2nd, Los Angeles

LABORATORIES, Electronic

Browning Labs., Inc., Winchester, Mass.
Hazeltine Electronics Corp., 1775 B'way, N. Y. C.
Sherron Electronics Corp., Flushing Ave., Brooklyn, N. Y.
Worner Electronic Devices 609 W Lake St Chicago 22

LIGHTS, Tower

Andrew Co., 363 E 75 St., Chicago 19

LOCKWASHERS, Spring Type

Natl. Lock Washer Co., Newark, N. J.

LUGS, Soldering

Cinch Mfg Corp W Van Buren St Chicago
Dante Elec. Mfg. Co., Bantam, Conn.
Ideal Commutator Dresser Co., Sycamore, Ill.
Ilsco Copper Tube & Prods., Inc., Station M, Cincinnati
Krueger & Hudepohl, Third & Vine, Cincinnati, O.
Patton-MacGuyer Co., 17 Virginia Ave., Providence, R. I.
Sherman Mfg. Co., Battle Creek, Mich.
Zierick Mfg. Co., 385 Girard Ave., Bronx, N. Y. C.

LUGS, Solderless

Aircraft Marine Prod., Inc., Harrisburg, Pa.
Burndy Eng. Co., 107 Eastern Blvd., N. Y. C.
Thomas & Betts Co., Elizabeth 1, N. J.

MACHINES, Impregnating

Stokes Machine Co., F. J., Phila., Pa.

MACHINES, Screwdriving

Detroit Power Screwdriver Co., Detroit, Mich.
Stanley Tool Div. of the Stanley Works, New Britain, Conn.

MAGNETS, Permanent

Arnold Engineering Co., 147 E. Ontario St., Chicago 11
General Elec. Co., Schenectady, N. Y.
Indiana Steel Prod. Co., 6 N. Michigan Ave., Chicago, Ill.
Thomas & Skinner Steel Prod. Co., Indianapolis, Ind.

MAIL ORDER SUPPLY HOUSES

See listing at head of Directory

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Irvington Varnish & Ins. Co., Irvington, N. J.
Minn. Mining Co., 155 Sixth Ave., N. Y. C.
Ntl. Varnished Prod. Corp., Woodbridge, N. J.

MARKING MACHINES, Letters, Numbers

Marken Machine Co., Keene, N. H.

METAL, Thermostatic

Baker & Co., 113 Astor, Newark, N. J.
G. S. Brainin Co., 20 VanDam, N. Y. C.
Callite Tungsten Corp., Union City, N. J.
Chace Co., W. M., Detroit, Mich.
Metals & Controls Corp., Attleboro, Mass.
Wilson Co., H. A., 105 Chestnut, Newark, N. J.

METERS, Ammeters, Voltmeters, Small Panel

Cambridge Inst. Co., Grand Central Terminal, N. Y. C.
De Jur-Amsco Corp., Shelton, Conn.
General Electric Co., Bridgeport, Conn.
Hickok Elec. Inst. Co., Cleveland, O.
Hoyt Elec. Inst. Works, Boston, Mass.
J-B-T Instruments Inc New Haven Conn
Marion Elect. Inst. Co. Manchester N H
M B Mfg. Co. Inc Dodge Ave East Haven Conn
McClintock Co., O. B., Minneapolis, Minn.
Norton Elect Inst Co Manchester Conn
Readrite Meter Works, Bluffton, O.
Roller-Smith Co., Bethlehem, Pa.
Simpson Elec. Co., 5218 W. Kinzie, Chicago
Triplett Elec. Inst. Co., Bluffton, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Weston Elec. Inst. Corp., Newark, N. J.
Wheelco Inst. Co., 847 W. Harrison St., Chicago

METERS, Frequency

Andrew Co 363 E 75 St Chicago 9
Bendix Radio, Towson, Md.
Browning Labs., Inc., Winchester, Mass.
Cardwell Mfg. Corp., Allen D., 81 Prospect St., Bklyn
Daven Co 191 Central Ave Newark N J
Doolittle Radio Inc., 7421 S. Loomis Blvd., Chicago
Ferris Instrument Co., Boonton, N. J.
General Electric Co., Syracuse, N. Y.
General Radio Co., Cambridge, Mass.
Harvey Radio Labs., 447 Concord Ave., Cambridge, Mass.
Hewlett-Packard Co., 359 Page Mill Rd., Palo Alto, Calif.
J-B-T Instruments Inc New Haven Conn
Lavoie Laboratories, Morganville, N. J.
Link, F. M., 125 W. 17 St., N. Y. C.
Measurements Corp., Boonton, N. J.
Millen Mfg. Co., Malden, Mass.
North Amer. Philips Co., Inc., 419 Fourth Ave., N. Y. C.
Radio Corp. of Amer. Camden N J
Weston Elect. Instrument Corp., Newark 5, N. J.

METERS, Q

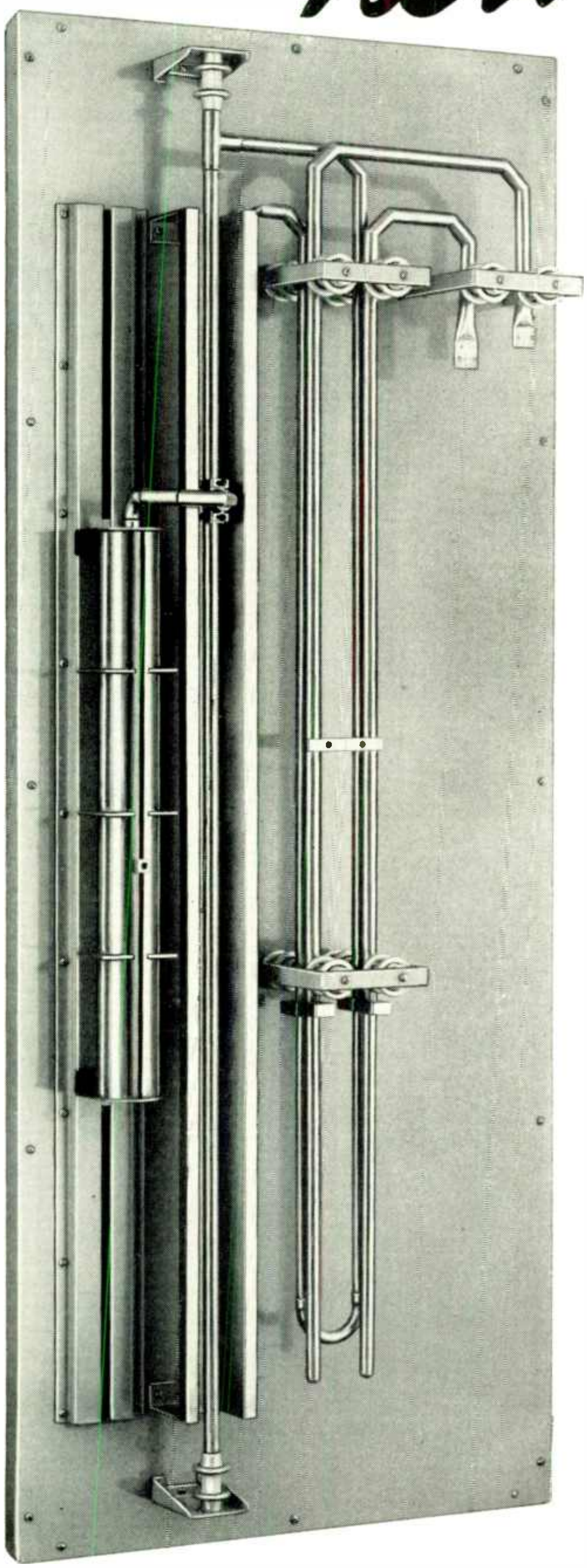
Boonton Radio Corp., Boonton, N. J.

METERS, Vacuum Tube Volt

Ballantine Labs. Inc., Boonton, N. J.
Barber Labs. 34-04 Francis Lewis Blvd Flushing N Y

new

FM ANTENNA ISO-COUPLER *By* JOHNSON



For Feeding FM Antennas Supported on Base Insulated AM Tower Antennas

The Johnson Frequency Modulation Antenna Iso-Coupler isolates the AM and FM systems and properly couples the FM transmission line across the base insulation of the AM radiator.

Shown at left is a Johnson FM Antenna Iso-Coupler ready for installation in the tuning house. Although the Iso-Coupler is normally supplied in a specially designed cabinet, it is available for mounting in an existing tuning house or can be combined with Johnson AM Antenna Coupling equipment.

POWER RATINGS:
AM up to 50 KW   FM up to 10 KW

FREQUENCY RANGES:
AM 550-1600 KC   FM 88-108 Mc

FM LINE IMPEDANCE:
Unit is available for matching either 50 or 70 ohm lines from transmitter.

AM ANTENNA IMPEDANCE:
Provision is made for correcting the effect produced by the FM Iso-Coupler.

SHIELDING REQUIREMENTS:
Low Stray fields, no shielding of Iso-Coupler is required.

PRESSURIZING:
Provisions have been made for pressurizing the FM line through the Iso-Coupler.

ADJUSTMENTS:
All adjustments within frequency range are easily made. Adjustments are broad and stable.

The Johnson FM Antenna Iso-Coupler incorporates top quality materials: high conductivity copper tubing, grade L5 steatite insulators, and aluminum corona shields. The entire unit is of rugged low-loss construction. Available for use with this coupling unit or for any FM or television installation is Johnson V.H.F. COAXIAL LINE which has extremely low loss and reflection characteristics, yet embodies superior mechanical strength.

The complete line of Johnson Broadcast products includes: AM Antenna Coupling and Phasing equipment, Coaxial Lines, Tower Lighting Filters and Chokes, Pressurized Capacitors, Variable Capacitors, Inductors, Tube Sockets, R.F. Contactors and Current Transformers.

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General Radio Co., Cambridge, Mass.
Hewlett-Packard Co., Palo Alto, Calif.
Hickok Elec. Instrument Co., Dupont Ave., Cleveland, Ohio
Measurements Corp., Boonton, N. J.
Radio City Products Co., 127 W. 26 St., N. Y. C.
Simpson Electric Co., 5218 W. Kinzie St., Chicago 44

METERS, Vibrating Reed

Biddle, James G., 1211 Arch St., Phila.
J-B-T Instruments, Inc., New Haven 8, Conn.
Triplett Elec. Inst. Co., Bluffton, O.

MICA

Brand & Co, Wm. 276 Fourth Av N Y C
Ford Radio & Mica Corp., 538 63rd St., Bklyn, N. Y.
Insulation Mfgrs. Corp., 565 W. Wash. Blvd., Chicago
Macallen Co., Boston, Mass.
Mica Insulator Corp 196 Varick N Y C
Mitchell-Rand Insulation Co., 51 Murray St., N. Y. C.
New England Mica Co., Waltham, Mass.
Richardson Co., Melrose Park, Ill.

MICROPHONES

Amer. Microphone Co., 1015 Western Av., Los Angeles
Amperite Co., 561 B'way, N. Y. C.
Astatic Corp., Youngstown, O.
Brush Development Co., Cleveland, O.
Electro Voice Mfg. Co., South Bend, Ind.
Kellogg Switchboard & Supply Co., 6650 S. Cicero, Chicago
Philmore Mfg. Co., 113 University Pl., N. Y. C.
Permoflux Corp., 4916 W. Grand Av., Chicago
Radio Corp. of Amer., Camden, N. J.
Radio Speakers, Inc., 221 E. Cullerton, Chicago
Rowe Industries, Inc., Toledo, O.
Shure Bros., 225 W. Huron St., Chicago
Telephonics Corp., 350 W. 31 St., N.Y.C.
Turner Co., Cedar Rapids, Ia.
Universal Microphone Co., Inglewood, Cal.
Western Electric Co., 195 B'way, N. Y. C.

MONITORS, Frequency

Doolittle Radio Inc., 7421 S. Loomis Blvd., Chicago 36
General Electric Co., Schenectady, N. Y.
General Radio Co., Cambridge, Mass.
RCA Mfg. Co., Camden, N. J.

MONITORS, FM

Doolittle Radio Inc 7421 S Loomis Blvd Chicago 36
General Electric Co Schenectady N Y

MOTOR-GENERATORS, Rotary Converters

Alliance Mfg. Co., Alliance, O.
Air-Way Mfg. Co., Toledo, O.
Bendix Aviation Corp., Pacific Div., 11600 Sherman Way, N. Hollywood
Black & Decker Mfg. Co., Towson, Md.
Bodine Elec. Co., 2262 W. Ohio, Chicago
Carter Motor Co., 1608 Milwaukee, Chicago
Clements Mfg. Co., Chicago, Ill.
Continental Electric Co., Newark, N. J.
Delco Appliance, Rochester, N. Y.
Diehl Mfg. Co., Elizabethport, N. J.
Dormeyer Co., Chicago, Ill.
Eclipse Aviation, Bendix, N. J.
Elcor, Inc., 1060 W. Adams, Chicago
Electric Indicator Co., Stamford, Conn.
Electric Motors Corp., Racine, Wis.
Electric Specialty Co., Stamford, Conn.
Electrolux Corp., Old Greenwich, Conn.
Eureka Vacuum Cleaner, Detroit, Mich.
General Armature Corp., Lock Haven, Pa.
General Electric Co., Schenectady, N. Y.
Jannette Mfg. Co., 558 W. Monroe, Chicago
Knapp-Monarch, St. Louis, Mo.
Leland Electric Co., Dayton, O.
Ohio Electric Co., 74 Trinity Pl., N. Y. C.
Pioneer Gen-E-Motor, 5841 W. Dickens Av., Chicago
Redmond Co., A. G., Owosso, Mich.
Russell Co., Chicago, Ill.
Small Motors, Inc., 1308 Elston Ave., Chicago
Webster Co., Chicago, Ill.
Webster Products, 3825 Armitage Ave., Chicago
Westinghouse Elect. Mfg. Co., Lima, O.
Wincharger Corp., Sioux City, Iowa

MOTORS, Very Small Types

Eastern Air Devices, Inc., 585 Dean St., Bklyn 17, N. Y.
Kollsman Instrument Div., Elmhurst, Long Island, N. Y.
Small Motors Inc., 1322 Elston Ave., Chicago 22
Utah Radio Prod. Co., 842 Orleans St., Chicago

MOUNTINGS, Shock Absorbing

Gen. Tire & Rubber Co Wabash Ind
Lord Mfg. Co., Erie, Pa.
Pierce-Roberts Co., Trenton, N. J.
Sponge Rubber Co., Shelton, Conn.
Robinson Aviation, Inc 730 Fifth Ave N Y C 19
U.S. Rubber Co., 1230–6th Ave., N.Y.C.

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Colonial Kolonite Co., 2212 W. Armitage Ave., Chicago
Electronic Mechanics, Inc Clifton Blvd Clifton N J
General Electric Co., Schenectady, N. Y.
Intl Products Corp Baltimore 18 Md
Mycalex Corp. of Amer., Clifton, N. J.
Precision Fab. Inc Rochester N Y

NAME PLATES, Etched Metal

See ETCHING, Metal

NAME PLATES, Plastic

Crowe Name Plate & Mfg. Co., 3700 Ravenswood Ave., Chicago
Hopp Press, Inc., 460 W. 34 St. N. Y. C.
Parisian Novelty Co., 3502 S. Western Ave., Chicago
Virginia Plate Co., 270 Madison Ave., N. Y. C. 16

NEEDLES, Transcription Playback, Cutting

Acton Co., Inc., H. W., 370 7th Ave., N. Y. C. 1
Harris Mfg. Co., 2422 W 7 St., Los Angeles 5
Presto Recording Corp., 242 W. 55 St., N. Y. C. 19
Recotron 212 Fifth Ave., N. Y. C. 10

NICKEL, Sheet, Rod, Tubes

Eagle Metals Co., Seattle, Wash.
Pacific Metals Co., Ltd., San Francisco, Calif.
Steel Sales Corp 3348 S Pulaski Rd Chicago
Tull Metal & Supply Co Atlanta, Ga
Whitehead Metal Prod. Co., 303 W. 10th St., N. Y. C.
Williams and Co., Inc., Pittsburgh, Pa.

NOISE FILTERS

See FILTERS, Electrical Noise

NUTS, Self-locking

Boots Aircraft Nut Corp., New Canaan, Conn.
Elastic Stop Nut Corp., Union, N. J.
Palnut Co., Inc., Irvington, N. J.
Standard Pressed Steel Co., Jenkintown, Pa.

OSCILLATORS, AF

General Radio Co., Cambridge, Mass.
Hewlett-Packard Co., Palo Alto, Calif.
Jackson Electrical Inst. Co. Dayton O.
Western Electric Co., 195 B'way N. Y. C.

OSCILLOSCOPES, Cathode Ray

Du Mont Laboratories, Inc., Allen B., Passaic, N. J.
General Electric Co., Schenectady, N. Y.
General Radio Co., Cambridge, Mass.
Millen Mfg. Co., Malden, Mass.
Panoramic Radio Corp., 242 W. 55 St., N. Y. C.
RCA Mfg. Co., Inc., Camden, N. J.
Radio City Products Co., Inc., 127 W. 26 St., N. Y. C.
Sherron Electronics Co 1201 Flushing Ave Bklyn 6

OVENS, Industrial & Laboratory

General Elec. Co., Schenectady, N. Y.
Trent Co., Harold E., Philadelphia

PANELS, Metal Etched (See Etching, Metal)

PHONOGRAPH RECORDING BLANKS

See DISCS, Recording

PHONOGRAPH RECORD PLAYERS

See TURNTABLES, Phonograph

PICKUPS, Phonograph

Astatic Corp., Conneaut, Ohio
Audak Co., 500 Fifth Ave., N. Y. C. 18
Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio
Fairchild Camera & Inst. Corp., Jamaica 1, N. Y.
Rek-O-Kut Co., 146 Grand St., N. Y. C. 13
Shure Bros., 225 W. Huron St., Chicago 10
Tech Research of Amer., 1526 Cahuenga Blvd., Hollywood 28 Calif.
Zenith Radio Corp., 6001 Dickens Ave., Chicago

PILOT LIGHT MOUNTINGS

Alden Prods. Co., Brockton, Mass.
Amer. Radio Hdware Co., Mt. Vernon, N. Y.
Dial Light Co. of Amer., 90 West, N. Y. C.
Drake Mfg. Co., 1713 W. Hubbard, Chicago
General Control Co., Cambridge, Mass.
Gothard Mfg. Co., Springfield, Ill.
Herzog Miniature Lamp Works, 12–19 Jackson Av., Long Island City, N.Y.
Kirkland Co., H. R., Morristown, N. J.
Mallory & Co., P. R., Indianapolis, Ind.
Signal Indicator Corp., 140 Cedar St., N. Y. C.

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Bunting Brass & Bronze Co., Toledo, O.
Driver-Harris Co., Harrison, N. J.
Phosphor Bronze Smelting Co., Philadelphia
Revere Copper & Brass, 230 Park Av., N. Y. C.
Seymour Mfg. Co., Seymour, Conn.

PLATING, Metal on Molded Parts

Metaplast Corp., 205 W. 19 St., N. Y. C.

PLATINUM

Sigmund Cohn & Co 44 Goldt St N Y C
Wilson Co., H. A., 105 Chestnut St., Newark 5, N. J.

PLUGS (Banana), Spring Type

Amer. Radio H'dw're Co., Mt. Vernon, N. Y.
Birnbach Radio Co., 145 Hudson St., N. Y. C.
Eastman Kodak Co., Rochester, N. Y.
Eby, Inc., Hugh H., Philadelphia, Pa.
Franklin Mfg. Corp., 175 Varick St., N. Y. C.
General Radio Co., Cambridge, Mass.
Johnson Co., E. F., Waseca, Minn.
Mallory & Co., Inc., P. R., Indianapolis, Ind.
Ucinite Co., Newtonville, Mass.

PLUGS, Coaxial

Andrew Co 363 E 75 St Chicago 19

PLUGS, Miniature Battery

Intl. Resist. Co 429 N Broad St Phila 8

PLUGS, Telephone Type

Alden Prods. Co., Brockton, Mass.
Amal. Radio Television Corp 476 Bway N Y C 13
American Molded Prods. Co., 1753 N. Honore, Chicago
Chicago Tel. Supply Co., Elkhart, Ind.
Guardian Elec. Mfg. Co., 1400 W. Wash. Blvd., Chicago
Insuline Corp. of Amer., L. I. City, N. Y.
Johnson Co., E. F., Waseca, Minn.
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Mallory & Co., Inc., P. R., Indianapolis, Ind.
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Trav-Ler Karenola Corp., 1030 W. Van Buren St., Chicago 7
Utah Radio Prod., Orleans St., Chicago

PLYWOOD, Metal Faced

Haskelite Mfg. Corp., 208 W. Washington St., Chicago

POINTS, Contact

See Contact points

PUMPS, Dry Air

Andrew Co., 363 E. 75 St., Chicago, 19

QUARTZ, Rods, Tubes, Plates

Hanovia Chem. & Mfg Co Newark 5 N J

RACKS & PANELS, Metal

See STAMPINGS, Metal

RADIO RECEIVERS & TRANSMITTERS

Abbott Instrument, Inc., 8 W. 18 St., N. Y. C. 3
Admiral Corp Chicago Ill
Aireon Mfg Corp., Funston Rd., Kansas City, Kans.
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Bendix Aviation Corp., Pacific Div., 11600 Sherman Way, N. Hollywood
Bendix Radio, Div. of Bendix Aviation Corp., Baltimore, Md.
Boes Co., The W. W., Dayton, O.
Browning Laboratories, Inc., Winchester, Mass.
Bunnell & Co., J. H., 215 Fulton St., N. Y. C.
Collins Radio Co Cedar Rapids Ia
Colonial Radio Corp., Rano St., Buffalo, N. Y.
Com Equip Corp 134 W Colorado St Pasadena Calif
Communications Co Inc Coral Gables Fla
Conn. Tel. & Elec. Co., Meriden, Conn.
Continental Radio & Telev. Corp., 3800 W. Cortland St., Chicago
Cover Dual Signal Systems, Inc., 125 W. Hubbard St., Chicago
Crosley Radio Corp., Cincinnati, O.
de Forest Labs, Lee, 5106 Wilshire Blvd., Los Angeles
Delco Radio, Kokomo, Ind.
Detrola Corp., 1501 Beard Ave., Detroit, Mich.
De Wald Radio Mfg. Corp., 436 Lafayette St., N. Y. C.
Dictaphone Corp., 420 Lexington Ave., N. Y. C.
Doolittle Radio Inc, 7421 S. Loomis Blvd., Chicago, 36
DuMont Labs., Inc., Allen B., Passaic, N. J.
Echophone Radio Co., 201 E. 26 St., Chicago
Eckstein Radio & Telev. Co., Inc., 1400 Harmon Pl., Minneapolis, Minn.
Elect. Research Lab Inc Evanston Ill.
Electronic Communications Co., 36 N. W. B'way, Portland, Ore.
Electronic Specialty Co Glendale Blvd Los Angeles
Emerson Radio & Phone Corp., 111 8th Ave., N. Y. C.
Erco Radio Labs. Inc Hempstead N Y
Espey Mfg Co Inc 33 W 46 St N Y C
Fada Radio & Elec. Corp. 30–20 Thomson Ave., Long Island City, N. Y.
Farnsworth Tele. & Radio Corp., Ft. Wayne 1, Ind.
Federal Electronics Div., 209 Steuben St., B'klyn, N. Y.
Federal Tel. & Radio Corp., Newark, N. J.
Finch Telecommunications, Inc., Passaic, N. J.
Fisher Research Lab., Palo Alto, Calif.
Foote Pierson & Co Inc 75 Hudson St Newark 5 N J
Freed Radio Corp., 200 Hudson St., N. Y. C.
Galvin Mfg. Corp., 4545 Augusta Blvd., Chicago
Garod Radio Corp., 70 Washington St., B'klyn, N. Y.
Gates Radio & Supply Co., Quincy, Ill.
General Communication Co., 681 Beacon St., Boston, Mass.
General Electric Co., Schenectady, N. Y.
General Telev. & Radio Corp., 1240 N. Homan Ave., Chicago
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Gilfillen Bros., Inc., 1815 Venice Blvd., Los Angeles, Calif.
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Hallicrafters Co., 2611 Indiana Ave., Chicago
Hamilton Radio Corp., 510 Sixth Ave., N. Y. C.
Hammarlund Mfg. Co., 460 W. 34th St., N. Y. C.
Harvey Machine Co., Inc., 6200 Avalon Blvd., Los Angeles
Harvey Radio Labs, Inc., Cambridge, Mass.
Harvey-Wells Com., Inc., Southbridge, Mass.
Hazeltine Electronics Corp., Great Neck, N. Y.
Herbach & Rademan Co., 522 Market St., Phila.
Hoffman Radio Corp 3330 S Hill St Los Angeles
Howard Radio Co., 1731 Belmont Ave. Chicago
Howard Pacific Corp 923 N Western Av Los Angeles
Intl Detrola Corp Beard & Chatfield Sts Detroit 9
Jefferson, Inc., Ray, Freeport, N. Y.
Jefferson-Travis Radio Mfg. Corp., 245 E 23 St., N. Y. C.
Karadio Corp., 1400 Harmon Pl., Minneapolis, Minn.
Kemlite Labs., 1809 N. Ashland Ave., Chicago
Lear Inc., 230 E. Ohio St., Chicago
Lewyt Corp., 60 B'way, B'klyn, N. Y.
Link, F. M., 125 W. 17 St., N. Y. C.
Machlett Labs., Inc., Springdale, Conn.
Magnavox Co., Indianapolis, Ind.
Majestic Radio & Tel. Corp., 2600 W. 50 St., Chicago
Megard Corp., 381 W. 38 St., Los Angeles, Calif.
Meissner Mfg Co Mt Carmel Ill
Midwest Radio Corp., Cincinnati, O.
Millen Mfg. Co, Inc., Malden, Mass.
National Co., Inc., Malden Mass.
Noblitt-Sparks Ind. Inc., Columbus, Ind.
North Amer. Philips Co., 100 E. 42 St., N. Y. C.
Operadio Mfg. Co., St. Charles, Ill.
Packard Bell Co 1115 S Oak St Los Angeles
Panoramic Radio Corp., 245 W. 55 St., N. Y. C. 19
Philco Corp., Tioga & C Sts., Phila.
Pilot Radio Corp., L. I. City, N. Y.
Powers Electronic & Communication Co., Glen Cove, N. Y.
Press Wireless, Inc 1475 B'way N Y C
Radio Corp. of Amer., Camden, N. J.
Radio Craftsmen, 1340 S. Mich. Ave., Chicago
RadioEngineering Labs L I City N Y
Radio Frequency Labs., Inc., Boonton, N. J.
Radio Mfg. Engineers, Inc., Peoria, Ill.
Radiomarine Corp. of Amer., 75 Varick St., N. Y. C.
Radio Receptor Co., Inc., 251 W. 17 St., N. Y. C.
Radio Transceiver Labs., 86–27 115th St., Richmond Hill, L. I.
Remler Co Ltd 2101 Bryant St San Francisco
Richardson-Allen Corp., 15 W. 20 St. N. Y. C.
Rosen Co., Raymond, 32 & Walnut Sts., Phila.
Rauland Corp., Chicago, Ill.
Sanborn Co., Cambridge 39, Mass.
Schuttig & Co., 9th & Kearny Sts., Washington, D. C.
Scott Radio Labs, Inc., 4450 Ravenswood Ave., Chicago
Seeburg Corp., J. P., 1500 N. Dayton St., Chicago
Sentinel Radio Corp., Evanston, Ill.
Setchell-Carlson, Inc., 2233 University Ave., St. Paul, Minn.
Smith Co., Maxwell, 1027 N. Highland Ave., Hollywood, Calif.
Sonora Radio & Telev. Corp., 325 N. Hoyne Ave., Chicago
Sparks-Withington Co., Jackson, Mich.
Sperry Gyroscope Co Garden City N Y
Sperti, Inc., Cincinnati, O.
Stewart-Warner Corp., 1826 Diversey Pkwy., Chicago
Stromberg-Carlson Co., Rochester, N. Y.
Tech. Radio Co 275 9th St San Francisco 3
Templetone Radio Co., Mystic, Conn.

Every Communications System and Broadcast Station Needs a

BROWNING WWV FREQUENCY CALIBRATOR

EVERY frequency meter, regardless of make, must be checked periodically against the primary standard frequency signals transmitted from the Bureau of Standards station WWV, in Washington. This is the only method of maintaining a frequency meter at the degree of accuracy required by the FCC.

The BROWNING model RH-10 Frequency Calibrator is designed specifically for WWV reception, and is equipped with the special circuits required to use WWV standard frequency signals for calibration purposes.

It is intended for use by supervisors of communications systems and broadcast engineers. It is equally useful in development and research laboratories, since the Calibrator can be used to check meters of any frequency range. Accuracy of this method is 1 part in 5,000,000. Reception of WWV is possible throughout the U. S. A.

Following are the general specifications:

★ Pre-tuned for both 5- and 10-mc. reception of radio station WWV. Either frequency may be selected by switch.

★ Sensitivity better than ½ microvolt on either band.

★ Selectivity 10 db down at 5 KC. off resonance.

★ Excellent image rejection minimizes interference. Rejection ratio is more than 50 db.

★ Provisions are made for coupling secondary RF standard or any RF source and comparing its fundamentals or harmonics with WWV carrier on 5 or 10 mc. Comparisons can be made to accuracy of at least one part in five million.

★ A dual filter system allows the selection at will of either the 440 or 4000 cycle modulation of WWV. Either may be employed as a primary frequency standard. Output voltage adjustable from 0 to 5 volts.

★ Cathode ray indicator is employed to determine zero beat accurately.

★ Voltages supplied to stable local oscillator are regulated to reduce frequency drift to a minimum.

★ Panel speaker has a separate control which allows the output to be varied at will.

★ 100-125 volts AC operation. 85 volt-amperes input.

★ Supplied in either standard rack panel with dust cover or in a steel cabinet. Aluminum panel is finished in black leatherette with engraved labels.

★ Panel connectors are standard universal binding posts which will also accommodate banana-type plugs.

★ Dimensions: Cabinet Mounting — Height 9", Width 19", Depth 11". Rack Mounting — Height 8¾", Width 19", Depth 10½".

★ Weight: Cabinet Mounting 30 lbs., Shipping Weight 45 lbs. Rack Mounting 25 lbs., Shipping Weight 40 lbs.

For additional technical data and information on prices and deliveries, address:

BROWNING LABORATORIES, Inc.

751 MAIN STREET WINCHESTER, MASS.

Transmitter Equip. Mfg. Co., 345 Hudson St., N. Y. C.
Trav-Ler Karenola Corp 1030 W Van Buren St Chicago
United Cinephone Corp Torrington Conn
Warwick Mfg. Corp., 4640 W. Harrison St., Chicago
Watterson Radio Mfg. Co., 2608 Ross Ave., Dallas, Tex.
Waugh Laboratories, 420 Lexington Ave., N. Y. C.
Wells-Gardner & Co., 2701 N. Kildare Ave., Chicago
Western Electric Co 195 B'way N Y C
Westinghouse Elec. & Mfg. Co., Wilkens Ave., Baltimore, Md.
Wilcox Electric Co., 14th & Chestnut Sts., Kansas City, Mo.
Wilcox-Gay Corp Charlotte Mich
Zenith Radio Corp., 6001 Dickens Ave., Chicago, Ill.

RECORD CHANGERS

See CHANGERS, Record

RECORDS, Blank

See DISCS, Recording

RECTIFIERS, Metallic Current

Benwood Linze Co., St. Louis, Mo.
Continental Elec. Co., 903 Merchandise Mart, Chicago
Electronics Labs., Indianapolis, Ind.
Fansteel Metallurgical Corp., N. Chicago, Ill.
Federal Tel. & Radio Corp Newark 1 N J
General Electric Co., Bridgeport, Conn.
Green Elect. Co., Inc., 130 Cedar St., N. Y. C.
Mallory & Co., P. R., Indianapolis, Ind.
Selenium Corp. of Amer., 1800 W. Pico Blvd., Los Angeles
United Cinephone Corp., Torrington, Conn.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

RECTIFIERS, Metallic Instrument & Relay

Bradley Labs. Inc New Haven 10 Conn
Conant Elect. Labs. Lincoln Nebr
Selenium Corp. of Amer., 1800 W. Pico Blvd., Los Angeles

REGULATORS, Temperature

Allen-Bradley Co., Milwaukee, Wis.
Dunn, Inc., Struthers, 1321 Cherry, Philadelphia
Fenwal Inc., Ashland, Mass.
General Electric Co., Schenectady, N. Y.
Mercoid Corp., 4217 Belmont, Chicago
Minneapolis-Honeywell Regulator, Minneapolis, Minn.
Spencer Thermostat Co., Attleboro, Mass.

REGULATORS, Voltage

Acme Elec. & Mfg. Co., Cuba, N. Y.
Adams & Westlake Co., Elkhart, Ind.
Amperite Co., 561 Broadway, N. Y. C.
Ferranti Elec., Inc., 30 Rockefeller Plaza, N. Y. C.
General Elec., Co., Schenectady, N. Y.
H-B Electric Co., 6122 N. 21 St., Phila.
Sola Electric Co., 2525 Clybourn Av., Chicago
United Transformer Corp., 150 Varick St., N. Y. C.

RELAYS, Hermetically Sealed

Allied Control Co Inc 2 E End Ave N Y C
Betts & Betts Corp 551 W 52 St N Y C 19
Clare & Co, C. P. 4719 Sunnyside Ave Chicago 30
Cook Electric Co., 2700 Southport Ave., Chicago
Sigma Instruments Inc 70 Ceylon St Boston 21

RELAYS, Plug-in

Clare & Co. C. P. 4719 Sunnyside Ave Chicago 30
Leach Relay Co 5915 Avalon Blvd Los Angeles
Sigma Instruments Inc 70 Ceylon St Boston 21

RELAYS, Small Switching

Advance Elec. Co., 1260 W. 2nd, Los Angeles
Allied Control Co Inc 2 W End Ave N Y C
Amperite Co., 561 Broadway, N. Y. C.
Automatic Elec. Co., 1033 W. Van Buren, Chicago
Bendix Aviation Corp., Pacific Div., 11600 Sherman Way, N. Hollywood
Birtcher Corp., 5087 Huntington Dr., Los Angeles 32
Cook Elec. Co., 2700 Southport Ave., Chicago
Electrical Prod. Supply Co., 1140 Venice Blvd., Los Angeles 15
Guardian Elec. Co., 1400 W. Wash. Blvd., Chicago
Potter & Brumfield Co., Princeton, Ind.
Sigma Instruments, Inc., 76 Freeport St., Boston, Mass.
Struthers Dunn, Inc., 1326 Cherry St., Philadelphia
Ward-Leonard Elec. Co Mt Vernon N Y
Western Electric Co., 195 B'way, N. Y. C.

RELAYS, Small Telephone Type

Advance Elec. Co., 1260 W. 2nd, Los Angeles
Allied Control Co 2 E End Ave N Y C
Automatic Elect. Co., 1033 W. Van Buren, Chicago
Clare & Co., C. P., 4719 W. Sunnyside Ave., Chicago
Cook Elec. Co., 2700 Southport Ave., Chicago
Guardian Elec. Co., 1400 W. Wash. Blvd., Chicago
Western Electric Co., 195 B'way, N. Y. C.
Wick Organ Co., Highland, Ill.

RELAYS, Stepping

Automatic Elect. Co., 1032 W. Van Buren St., Chicago
Autocall Co., Shelby, O.
Federal Tel. & Radio Corp., Newark, N. J.
Guardian Elect. Mfg. Co., 1620 W. Walnut St., Chicago
Presto Elect. Co., N. Y. Ave., Union City, N. J.
Struthers Dunn, Inc., Arch St., Phila.
Western Electric Co., 195 B'way, N. Y. C.

RELAYS, Time Delay

Advance Elec. Co., 1260 W. 2nd, Los Angeles
Amperite Co., 561 Broadway, N. Y. C.
Automatic Elec. Co., 1033 W. Van Buren, Chicago
Haydon Mfg. Co., Inc., Forestville, Conn.
H-B Electric Co., 6122 N. 21 St., Phila.
Industrial Timer Corp., Newark, N. J.
Sangamo Elec. Co., Springfield, Ill.
Ward-Leonard Elec. Co., Mt. Vernon, N. Y.

RELAYS, Transmitter Switching and Keying

Gordon Spec. Co 823 S Wabash Ave Chicago
Johnson Co., E. F. Waseca Minn
Leach Relay Co., 5915 Avalon Blvd., Los Angeles

RELAYS, Vacuum

Ind & Com Electronics Belmont Calif
Struthers Dunn Inc 1326 Cherry St Phila

RELAY TESTERS, Vibration

Kurman Electric Co., Inc., 3030 Northern Blvd., L. I. City, N. Y.

RESISTORS, Fixed

Acme Elec. Heating Co., Boston, Mass.
Aerovox Corp., New Bedford, Mass.
Allen-Bradley Co., Milwaukee, Wis.
Atlas Resistor Co., 423 Broome St., N. Y. C.
Carborundum Co., Niagara Falls, N. Y.
Centralab, Milwaukee, Wisconsin
Clarostat Mfg. Co., 130 Clinton St., Bklyn, N. Y.
Cont'l Carbon, Inc., Cleveland, O.
Daven Co., 158 Summit St., Newark, N. J.
Dixon Crucible Co., Jersey City, N. J.
Elco Resistors Co 114 W 18 St N Y C
Erie Resistor Corp., Erie, Pa.
Globar Div. Carborundum Co., Niagara Falls, N. Y.
Groves Corp Cape Girardeau Mo
Hardwick, Hindle, Inc., Newark, N. J.
Instrument Resistors Co., Little Falls, N. J.
Intern'l Resist. Co 401 N Broad St Phila
Jeffers Electronics Du Bois Pa
Lectrohm, Inc., Cicero, Ill.
Mallory & Co., Inc., P. R., Indianapolis, Ind.
Ohmite Mfg. Co., 4835 W. Flournoy, Chicago
Sensitive Research Inst., Corp., 4545 Bronx Blvd., N. Y. C.
Shallcross Mfg. Co., Collingdale, Pa.
Speer Resistor Corp., St. Marys, Pa.
Sprague Specialties Co., N. Adams, Mass.
Stackpole Carbon Co., St. Marys, Pa.
Utah Radio Prod. Co., 842 Orleans St., Chicago
Ward-Leonard Elec. Co., Mt. Vernon, N. Y.
White Dental Mfg. Co., 10 E. 40th St., N. Y. C.
Wirt Co., Germantown, Pa.

RESISTORS, Fixed Precision

General Radio Co Cambridge Mass
Inst. Resistors, Inc., Little Falls, N. J.
Intern'l Resist. Co 401 N Broad St Phila
Ohmite Mfg. Co., 4835 Flournoy St., Chicago
Presto Electric Co., Union City, N. J.
Shallcross Mfg. Co., Collingdale, Pa.

RESISTORS, Flexible

Clarostat Mfg. Co., Inc., Brooklyn, N. Y.

RESISTORS, Variable Laboratory Type

Biddle Co., J. G., 1211 Arch St., Phila.
General Radio Co Cambridge Mass
Leeds & Northrup Co., 4970 Stenton Ave., Phila. 44
Sticht Co Inc H. H., 27 Park Pl N Y C
Tech Labs. 7 Lincoln St., Jersey City, N. J.

RESISTORS, Variable

Aerovox Corp., New Bedford, Mass.
Allen-Bradley Co., Milwaukee, Wis.
Amer. Inst. Co., Silver Spring, Md.
Atlas Resistor Co., N. Y. C.
Biddle Co., James G., Arch St., Phila.
Centralab, Milwaukee, Wis.
Chicago Tel. Supply Co., Elkhart, Ind.
Cinema Eng. Co., Burbank, Cal.
Clarostat Mfg. Co., 130 Clinton, Bklyn, N. Y.
Cutler-Hammer, Inc., Milwaukee, Wis.
Daven Co., Central Ave., Newark 4, N. J.
DeJur Amsco Corp., Shelton, Conn.
Electro Motive Mfg. Co., Willimantic, Conn.
General Radio Co., Cambridge, Mass.
Inst. Resistors, Inc., Little Falls, N. J.
Intern'l Resist. Co 401 N Broad St Phila
Lectrohm, Inc., 5125 W. 25th, Cicero, Ill.
Mallory & Co., P. R., Indianapolis, Ind.
Ohio Carbon Co., Cleveland, Ohio
Ohmite Mfg. Co., 4835 W. Flournoy St., Chicago
Shallcross Mfg. Co., Collingdale, Pa.
Stackpole Carbon Co., St. Marys, Pa.
Utah Radio Prods. Co., 820 Orleans St., Chicago
Ward-Leonard Elec. Co., Mt. Vernon, N. Y.
Wirt Co., Germantown, Pa.

RESISTORS, Variable, Ceramic Base

Lectrohm, Inc., 5125 W. 25th, Cicero, Ill.
Ohmite Mfg. Co., 4835 Flournoy St., Chicago
Presto Electric Co. Union City, N. J.

SCREW MACHINE PARTS, Brass, Steel

Chicago Aviation Co., 1200 N. Claremont, Chicago
Ward Products Corp., E. 45 St., Cleveland, O.

SCREW MACHINE PARTS, Non-Metallic

Continental-Diamond Fibre Co., Newark, Del.

SHAFTING, Flexible

Breeze Corps., Inc., Newark, N. J.
Mall Tool Co., 7708 S. Chicago Ave., Chicago
Steward Mfg. Corp., 4311 Ravenswood Ave., Chicago
Walker-Turner Co., Inc., Plainfield, N. J.
White Dental Mfg. Co., 10 E. 48 St., N. Y. C.

SHEETS, Electrical

Amer Rolling Mill Co Middletown Conn
Carnegie-Illinois Steel Corp Pittsburgh Pa
Follansbee Steel Corp Pittsburgh Pa
Granite City Steel Co Granite City Ill
Newport Rolling Mill Co. Newport, Ky.
Republic Steel Corp Cleveland O
Ryerson & Son Inc Jos T Chicago
Westinghouse Elect & Mfg Co E Pittsburgh Pa

SHIELDS, Tube

Eby Inc H H 18 W Chelton Av Phila 44
Goat Metal Stampings Inc 314 Dean St Brooklyn N Y
Cinch Mfg Corp 2335 W Van Buren St Chicago 12
Hammarlund Mfg Co Inc 460 W 34 St N Y C

SHOCK ABSORBERS

See MOUNTINGS Shock Absorbing

SIGNAL GENERATORS

See GENERATORS Standard Signal

SOCKETS, Cathode Ray Tube

Franklin Mfg Corp 175 Varick St N Y C

SOCKETS, Tube

Aladdin Radio Industries 501 W 35th St Chicago
Alden Prods Co Brockton Mass
Amer Phenolic Corp 1830 S 54th Av Chicago
Amer Radio Hdware Co Mt Vernon N Y
Birnbach Radio Co 145 Hudson N Y C
Bud Radio Inc Cleveland O
Cinch Mfg Co 2335 W Van Buren St Chicago
Cont'l-Diamond Fibre Co Newark Del
Eagle Elec Mfg Co Brooklyn N Y
Eby Inc H H Philadelphia
Federal Screw Prods Co 26 S Jefferson Chicago
Franklin Mfg Corp 175 Varick N Y C
Hammarlund Mfg Co 424 W 33 St N Y C
Johnson Co E F Waseca Minn
Jones Howard B 2300 Wabansia Chicago
Micarta Fabricators Inc 4619 Ravenswood Chicago
Millen Mfg Co James Malden Mass
Miller Co J W Los Angeles Cal
Nat'l Co Malden Mass
Remler Co San Francisco Cal

SOCKETS, Tube, Ceramic Base

Electronic Mechanics Inc., Clifton, N. J.
Hammarlund Mfg Co Inc 460 W 34 St N Y C
Johnson Co E F Waseca Minn
National Co Inc Malden Mass
Nat'l Fabricated Products W Belden Ave Chicago
Ucinite Co Newtonville Mass

SOLDER, Self-fluxing

Garden City Laboratory 2744 W 37th Pl Chicago
Gardiner Metal Co S Campbell Ave Chicago
General Elec Co Bridgeport Conn
Kester Solder Co 4209 Wrightwood Ave Chicago
Ruby Chemical Co Columbus O

SOLDER POTS

Elec Soldering Iron Co Inc Deep River Conn
Lectrohm Inc Cicero Ill
Sound Equip Corp of Calif 6245 Lex Ave Los Angeles 38
Westinghouse Elect & Mfg Co E Pittsburgh Pa

SPEAKERS, Cabinet Mounting

Altec Lansing Corp., 250 W. 57 St., N. Y. C. 19
Best Mfg. Co Inc Grove St Irvington 11 N J
Cinaudagraph Speakers Inc 3911 S Michigan Ave Chicago
Crescent Industries Inc Belmont Ave Chicago
General Instrument Corp Elizabeth 3 N J
Jensen Radio Mfg Co 6601 S Laramie St Chicago
John Meck Industries Plymouth Ind
Langevin Co 37 W 65 St N Y C 23
Magnavox Co Fort Wayne Ind
Operadio Mfg Co St Charles Ill
Quam-Nichols Co 33rd Pl Chicago 16
Rola Co Inc Superior St Cleveland O
Utah Radio Prod Co 842 Orleans St Chicago

SPEAKERS, Outdoor Type

Altec Lansing Corp 250 W 57 St N Y C 19
Cinaudagraph Speakers Inc 3911 S Michigan Ave Chicago
Jensen Radio Mfg Co 6601 S Laramie St Chicago
Langevin Co 37 W 65 St N Y C 23
University Labs 225 Varick St N Y C

SPEAKERS, Broadcast Studio

Altec Lansing Corp., 250 W. 57 St., N. Y. C. 19
Clark Radio Equip. Corp., 4313 N. Lincoln Ave., Chicago 18
General Electric Co., Schenectady, N. Y.
Jensen Radio Mfg. Co., 6601 S. Laramie St., Chicago
Radio Corp. of Amer., Camden, N. J.
Western Electric Co., 195 B'way, N. Y. C.

SPRINGS

Accurate Spring Mfg Co 3817 W Lake Chicago
Ace Mfg Corp 1255 E Erie Ave Phila 24
American Spring & Mfg Corp Holly Mich
American Steel & Wire Co Rockefeller Bldg Cleveland O
Barnes Co Wallace Bristol Conn
Crescent Industries Inc 4132 W Belmont Ave Chicago
Cuyahoga Spring Co Cleveland O
Gibson Co Wm D 1800 Clybourn Av Chicago
Hubbard Spring Co M D Pontiac Mich
Hunter Pressed Steel Co Lansdale Pa
Instrument Specialties Co Little Falls N Y
Muehlhausen Spring Corp Logansport Ind
Peck Spring Co Plainville Conn
Raymond Mfg Co Corry Pa
Security Steel Equip Corp Avenel N J
Standard Spring & Mfg Co Inc 236-42 St Brooklyn N Y
Willor Mfg Corp 794 E 104 St N Y C 54

STAMPINGS, Metal

Bud Radio Inc E 55 St Cleveland O
Goat Metal Stampings Inc 314 Dean St Brooklyn N Y
Hadley Co R M 707 E 61st Los Angeles
Insuline Corp of Amer Long Island City N Y
Par-Metal Prod Corp Long Island City N Y
Stewart Stamping Corp 621 E 216 St N Y C
Willor Mfg Corp 288-A Eastern Blvd N Y C

STANDS, Microphone

Eastern Mike-Stand Co., 56 Christopher Ave., Bklyn 12
Meletron Corp., 950 N. Highland Ave., Los Angeles 32
Shure Bros., 225 W. Huron St., Chicago 10

STEATITE, See Ceramics

SUPPRESSORS, Parasitic

Ohmite Mfg Co 4835 Flournoy St Chicago

At *FM* AND TELEVISION, we didn't benefit from the flood of wartime advertising and Government-paid subscriptions. We had to earn our progress from the special services rendered exclusively by this Magazine. ★ ★ As a result of that effort, our circulation is growing faster than at any period since 1940, when this journal was established as *FM* Magazine. ★ ★ In fact our subscription files have become a virtual directory of "The Men Who Set the Pace the Industry Follows" in each field of postwar radio activity. ★ ★ Detailed information on any circulation group is available to advertising managers who are revising publication lists to obtain greater effectiveness from smaller budgets.

SWITCHES, Aircraft Push

Square D Co Kollsman Inst Div Elmhurst N Y

SWITCHES, Key

Audio Development Co Minneapolis Minn
Chicago Tel Supply Co Elkhart Ind
Federal Tel. & Radio Corp Newark 1 N J
General Control Co Cambridge Mass
Mossman Inc Donald P 6133 N Northwest Hy Chicago
Presto Electric Co Union City N J
Western Electric Co 195 B'way N Y C

SWITCHES, Midget Snap

Allied Control Co Inc E End Ave N Y C
Aero Electric Co 3167 Fulton Rd Cleveland
General Electric Co Schenectady N Y
Micro Switch Corp Freeport Ill
Spencer Thermostat Co Attleboro Mass
Ucinite Co Newtonville 60 Mass

SWITCHES, Rotary, Bakelite Wafer

Mallory & Co Inc P R Indianapolis Ind
Stackpole Carbon Co St Marys Pa

SWITCHES, Rotary, Ceramic Wafer

Centralab Milwaukee Wis
Comm Prods Co 744 Broad Newark N J
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SWITCHES, Time Delay

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Sangamo Elect Co Springfield Ill

SYNTHETICS, Wood & Metal Finish

Sullivan Varnish Co 410 N Hart St Chicago 22

TERMINALS, Hermetically Sealed

See BUSHINGS Terminal Sealing

TERMINALS, Soldered or Solderless

See LUGS Soldering and Solderless

TERMINALS (Turret Lugs)

Cambridge Thermionic Corp 443 Concord Ave Cambridge 38 Mass
Manufacturers Screw Prod 216 W Hubbard St Chicago 10
Ucinite Co Newtonville Mass

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Burke Electric Co Erie Pa
Cinch Mfg Corp W Van Buren St Chicago
Cook Electric Co 2700 Southport Ave Chicago 14
Curtis Devel & Mfg Co N Crawford Ave Chicago
Franklin Mfg Corp 175 Varick St N Y C
Jones H B 2432 W George Chicago
Kulka Electric Mfg Co Mt Vernon N Y

TEST CHAMBERS, Temperature, Humidity, Altitude, Salt Spray

American Coils Co 25 Lexington St Newark N J
Industrial Filter & Pump Mfg. Co., W. Carroll Ave., Chicago
Kold-Hold Mfg. Co., 446 N. Grand Ave., Lansing, Mich.
Mobile Refrigeration, Inc., 630-5th Ave., N. Y. C.
Northern Engineering Labs., 50 Church St., N. Y. C.
Tenney Engineering Inc Montclair N J

THERMISTERS

Western Electric Co 195 Bway N Y C

TRACING PAPERS, CLOTH, CELLOPHANE

Arkwright Finishing Co., Providence, R. I.
Brown & Bro., Arthur, 67 W. 44 St., N. Y. C.
Keuffel & Esser, Hoboken, N. J.

TRANSFORMERS, Constant-Voltage

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General Electric Co., Schenectady, N. Y.
Raytheon Mfg. Co., Waltham, Mass.
Sola Electric Co., 2525 Clybourn Ave., Chicago

TRANSFORMERS, IF, RF

Albion Coil Co Albion Ill
Aladdin Radio Industries, 501 W. 35th St., Chicago
Automatic Mfg. Co., 900 Passaic Ave E Newark, N. J.
Browning Labs., Inc., Winchester, Mass.
Cambridge Thermionic Corp., Concord Ave., Cambridge, Mass.
Caron Mfg. Co., 415 S. Aberdeen, Chicago
D-X Radio Prods. Co., 1575 Milwaukee, Chicago
Essex Electronics 1060 Broad St Newark N J
Gen'l Winding Co 420 W 45 St N Y C
Guthman & Co., 15 S. Throop, Chicago
Hammarlund Mfg. Co., 424 W. 33 St., N. Y. C.
Meissner Mfg. Co., Mt. Carmel, Ill.
Millen Mfg. Co., James, Malden, Mass.
Miller Co., J. W., 5917 S. Main, Los Angeles, Cal.
Nat'l Co., Malden, Mass.
Radex Corp., 1308 Elston Ave., Chicago
Sickles Co., F. W., Chicopee, Mass.
Sound Equip. Corp. of Calif., 6245 Lex. Ave., Los Angeles 38
Standard Winding Corp Newburgh N Y
Super Elec. Prod. Corp., Jersey City, N. J.
Teleradio Eng. Corp., 99 Wall St N Y C
Triumph Mfg. Co 4017 W Lake Chicago

TRANSFORMERS, Audio & Power

Acme Elec. & Mfg. Co., Cuba, N. Y.
Airdesign & Fabrication Inc., Upper Darby, Pa.
Altec Lansing Corp., 1680 N. Vine, Hollywood 29
Amer. Transformer Co., Newark, N. J.
Amplifier Co. of Amer., 396 B'way, N. Y. C.
Audio Devel. Co., N. Minneapolis, Minn.
Chicago Transformer Corp., 3501 Addison St., Chicago
Cinaudagraph Speakers, Inc., 3911 S. Michigan, Chicago
Cons. Radio Prod. Co 350 W Erie St Chicago 10
Dinion Coil Co., Caledonia, N. Y.
Dongan Elec. Co., 2987 Franklin St., Detroit
Electronic Trans. Co., 207 W. 25 St., N. Y. C.
Ferranti Elec., Inc., 30 Rockefeller Plaza, N. Y. C.
Foster Co., A. P. Lockland O
Freed Trans. Co., 72 Spring St., N. Y. C.
Gen'l Radio Co., Cambridge, Mass.
General Trans. Corp., 1250 W. Van Buren, Chicago
Hadley Co., R. M., 707 E. 61st, Los Angeles
Halldorson Co., 4500 Ravenswood, Chicago
Hercules Elec. & Mfg Co 2500 Atlantic Ave Bklyn 7
Jefferson Elec Co Bellwood Ill
Kenyon Trans Co 840 Barry St N Y C
Kyle Corp South Milwaukee Wis
Langevin Co 37 W 65 St N Y C 23
Magnetic Windings Co Easton Pa
Merit Coil & Trans Corp 4427 N Clark Chicago 40
Newark Transformer Co., Newark, N. J.
N Y Transformer Co 22 Waverly Pl N Y C 3
Peerless Elec Prod Co 6920 McKinley Av Los Angeles
Permoflux Corp 4900 W Grand Ave Chicago 39
Raytheon Mfg Co Waltham Mass
Rola Co Inc Superior St Cleveland O
Standard Transformer Corp 1500 N Halsted Chicago
Super Elect Prod Co Jersey City N J
Superior Elec Co Bristol Conn
Swain Nelson Co., Glenview, Ill.
Thermador Elect & Mfg Co Riverside Dr Los Angeles
Thordarson Elec Mfg Co 500 W Huron Chicago
United Trans Co 150 Varick St N Y C
Utah Radio Prods Co 820 Orleans St Chicago
Westinghouse Elect & Mfg Co E Pittsburgh Pa

TRANSFORMERS, Variable Voltage

Amer Transformer Co Newark N J
General Radio Co Cambridge Mass
Superior Electric Co Bristol Conn

TRANSMITTERS, FM

Collins Radio Co., Cedar Rapids, Ia.
Communications Co Inc Coral Gables Fla
Doolittle Radio, Inc 7421 Loomis Blvd Chicago 36
Federal Tel. & Radio Corp Newark 1 N J
Galvin Mfg. Corp Chicago 51
General Electric Co Schenectady 5 N Y
Harvey Radio Labs., Cambridge, Mass.
Harvey-Wells Southbridge Mass
Kaar Engineering Co Palo Alto Calif
Link, F. M. 125 W 17 St N Y C 11
Press Wireless Inc., 1475 B'way, N. Y. C. 18
RCA Victor Camden N J
Radio Engineering Labs. Inc Long Island City N Y
Transmitter Equipment Mfg. Co., Inc., 345 Hudson St., N. Y. C. 14
Western Electric Co 195 Bway N Y C
Westinghouse Electric Corp Pittsburgh 30 Pa

TRANSMITTERS, Television

Du Mont Labs, Inc, Allen B., 2 Main Ave Passaic N J
General Electric Co Schenectady N Y
RCA Victor Camden N J
Sherron Electronics Co., 1201 Flushing Ave., Bklyn 6

TUBE MANUFACTURING MACHINES

Hilton Eng Labs Redwood City Calif
Eisler Eng Co 7518 13th St Newark N J

TUBES, Cathode Ray

Dumont Labs Allen B Passaic N J
Electronic Tube Corp 1200 E Mermaid Phila 18
Farnsworth Tele & Radio Corp Ft Wayne Ind
General Elec Co Schenectady N Y
Nat'l Union Radio Corp Newark N J
North Amer Philips Co Inc Dobbs Ferry N Y
Rauland Corp Chicago Ill
RCA Mfg Co Camden N J
Sylvania Elect Prod Inc Emporium Pa
Westinghouse Elect & Mfg Co E Pittsburgh Pa
Western Electric Co., 195 B'way, NYC

TUBES, Current Regulating

Amperite Co 561 Broadway N Y C
Champion Radio Works Danvers Mass
Hytron Corp & Hytronic Labs Salem Mass
RCA Mfg Co Camden N J
Sylvania Elec Prod Inc Emporium Pa
Western Elec Co 195 B'dway N Y C

TUBES, Photo-Electric

Cont'l Elec Co Geneva Ill
De Jur-Amsco Corp Shelton Conn
De Vry Herman A 1111 W Center Chicago
Electronic Laboratory Los Angeles Cal
Emby Prods Co Los Angeles Cal
General Elec Co Schenectady N Y
General Scientific Corp 4829 S Kedzie Av Chicago
G-M Labs 4313 N Knox Av Chicago
Leeds & Northrop Co Philadelphia
Nat'l Union Radio Corp Newark N J
Photobell Corp 123 Liberty St N Y C
RCA Mfg Co Camden N J
Rectron Corp 2159 Magnolia Av Chicago
Westinghouse Lamp Div Bloomfield N J
Western Elec Co 195 B'way N Y C
Weston Elec Inst Corp Newark N J

TUBES, Receiving

General Elec Co Schenectady N Y
Ken-Rad Div. of G. E. Owensboro, Ky.
Hytron Corp Salem Mass
Nat'l Union Radio Corp Newark N J
RCA Mfg Co Camden N J
Raytheon Prod Corp 420 Lexington Av N Y C
Sylvania Elect Prod Inc Emporium Pa
Tung-Sol Lamp Works Newark N J
Western Electric Co 195 B'way N Y C

TUBES, Transmitting

Amperex Electronic Corp 25 Washington St Bklyn 1
Eitel-McCullough Inc San Bruno Cal
Electronic Enterprises Inc 65-67 Av Newark N J
Federal Telephone & Radio Corp Newark N J
General Elec Co Schenectady N Y
Gen'l Electronics Inc 101 Hazel St Patterson N J
Heintz & Kaufman S San Francisco Cal
Hytron Corp Salem Mass
Lewis Electronics Inc., Los Gatos, Calif.
Machlett Labs Inc Norwalk Conn
Nat'l Union Radio Corp Newark N J
North Amer Philips Co Inc Dobbs Ferry N Y
RCA Mfg Co Camden N J
Raytheon Prod Corp 420 Lexington Av N Y C
Slater Electric & Mfg Co Brooklyn N Y
Sperry Gyroscope Co Inc Brooklyn N Y
Sylvania Elect Prod Inc Emporium Pa
Taylor Tubes Inc 2341 Wabansia Chicago
United Electronics Co Newark N J
Western Elec. Co., 195 B'way, N. Y. C.
Westinghouse Lamp Div., Bloomfield, N. J.

TUBES, Voltage-Regulating

Amperite Co., 561 Broadway, N. Y. C.
Hytron Corp., Salem, Mass.
RCA Mfg. Co., Camden, N. J.
Sylvania Elec. Prod., Inc., Salem, Mass.

TUBES, X-Ray

Genl. Elec. X-Ray Corp 2012 Jackson Blvd Chicago
Machlett Labs. Inc South Norwalk Conn

LONG SCALE, WIDE RANGE VOLT-OHM-MILLIAMMETER

DOUBLE SENSITIVITY D. C. VOLT RANGES
0-1.25-5-25-125-500-2500 Volts, at 20,000 ohms per volt for greater accuracy on Television and other high resistance D.C. circuits.
0-2.5-10-50-250-1000-5000 Volts, at 10,000 ohms per volt.

A. C. VOLT RANGES
0-2.5-10-50-250-1000-5000 Volts, at 10,000 ohms per volt.

OHM-MEGOHMS
0-400 ohms (60 ohms center scale)
0-50,000 ohms (300 ohms center scale)
0-10 megohms (60,000 ohms center scale)

DIRECT READING OUTPUT LEVEL DECIBEL RANGES
−30 to +3, +15, +29, +43, +55, +69 DB

TEMPERATURE COMPENSATED CIRCUIT FOR ALL CURRENT RANGES D.C. MICROAMPERES
0-50 Microamperes, at 250 M.V.

D. C. MILLIAMPERES
0-1-10-100-1000 Milliamperes, at 250 M.V.

D. C. AMPERES
0-10 Amperes, at 250 M.V.

OUTPUT READINGS
Condenser in series with A.C. Volts for output readings.

ATTRACTIVE COMPACT CASE
Size: 2½" x 5½" x 6". A readily portable, completely insulated, black, molded case, with strap handle. A suitable black, leather carrying case (No. 629) also available, with strap handle.

LONG 5" SCALE ARC
For greater reading accuracy on the Triplett RED ● DOT Lifetime Guaranteed meter.

SIMPLIFIED SWITCHING CIRCUIT
Greater ease in changing ranges.

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Precision first ...to last

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North Amer. Philips Co Inc 100 E 42 St N Y C
Picker X-Ray Corp 300 4th Ave N Y C
Westinghouse Elec & Mfg Co E Pittsburgh

TUBING, Laminated Phenolic

Brandywine Fibre Prods. Co., Wilmington, Del.
Formica Insulation Co., Cincinnati, O.
General Electric Co., Pittsfield, Mass.
Insulation Mfgrs. Corp., 565 W. Washington Blvd., Chicago
Mica Insulator Co., 196 Varick, N. Y. C.
Nat'l Vulcanized Fibre Co., Wilmington, Del.
Richardson Co., Melrose Park, Ill.
Spaulding Fibre Co., 233 B'way, N. Y. C.
Synthane Corp., Oaks, Pa.
Taylor Fibre Co., Norristown, Pa.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Wilmington Fibre Specialty Co., Wilmington, Del.

TUBING, Precision Metal

Superior Tube Co., Norristown, Pa.

TUBING & SLEEVING, Varnished Cambric, Glass-Fibre, Spaghetti

Bentley-Harris Mfg. Co., Conshohocken, Pa.
Brand & Co., Wm., 276 Fourth Av., N. Y. C.
Electro Tech. Prod., Inc., Nutley, N. J.
Endurette Corp. of Amer., Cliffwood, N. J.
Insulation Mfgrs. Corp., 565 W Washington Blvd., Chicago
Irvington Var. & Ins. Co., Irvington, N.J.
Mica Insul. Co., 196 Varick St., N. Y. C.
Mitchell-Rand Insulation Co., 51 Murray St., N. Y. C.
Surprenant Elect. Ins. Co 84 Purchase St Boston 10 Mass
Varflex Corp., Rome, N. Y.

TURNTABLES, Record

Alliance Mfg. Co., Alliance, Ohio
Fairchild Camera & Inst. Co., 475 Tenth Av N. Y. C.
Gates Radio Co., Quincy, Ill.
General Industries Co., Elyria, O.
General Inst. Corp., Elizabeth 3, N. J.
Presto Recording Corp., 242 W. 45 St., N. Y. C.
R C A Mfg. Co., Camden, N. J.
Russell Electric Co 362 W Huron St Chicago 10
Seeburg Corp., J. P., 1510 N. Dayton St., Chicago
Webster Products, 3825 Armitage Ave., Chicago
Western Electric Co., 125 B'way, N. Y. C.
Wilcox-Gay Corp Charlotte Mich

VARNISHES, Fungus Resistant

Comm. Prod. Co Inc 744 Broad St Newark
Insl X Co Inc 857 Meeker Ave Bklyn
Maas & Waldstein Co Newark N J

VARNISHES, Insulating, Air-Drying & Baking

Comm Prods Co 744 Broad Newark N J
Dolph Co., John C., Newark, N. J.
Irvington Var. & Ins. Co., Irvington, N.J.
Mitchell-Rand Insulation Co., 51 Murray St., N. Y. C.
Stille-Young Corp., 2300 N. Ashland Av., Chicago
Zophar Mills, Inc., 112–26 St., Bklyn, N. Y.

VARNISHES, Wrinkle Finish

Sullivan Varnish Co., 410 N. Hart St., Chicago

VIBRATION TEST EQUIPMENT

All American Tool & Mfg. Co., 1014 Fullerton Ave., Chicago
Vibration Specialty Co., 1536 Winter St., Philadelphia

VIBRATORS, Power Supply

Amer. Telev. & Radio Co., St. Paul, Minn.
Electronic Labs., Indianapolis, Ind.
Mallory & Co., Inc., P. R., Indianapolis, Ind.
Radiart Corp., W. 62 St., Cleveland, O.

Turner Co., Cedar Rapids, Ia.
Utah Radio Prod. Co., Orleans St. Chicago

WAXES & COMPOUNDS, Insulating

Irvington Varnish & Ins. Co., Irvington, N. J.
Western Elec. Co., 195 B'dway, N. Y. C.
Zophar Mills, Inc., 112–26 St., Bklyn

WELDING, Gas, Aluminum & Steel

Treitel-Gratz Co., 142 E. 32 St., N. Y. C.

WIRE, Bare

Amer. Steel & Wire Co., Cleveland, O.
Anaconda Wire & Cable Co., 25 B'dway N. Y. C.
Ansonia Elec. Co., Ansonia, Conn.
Belden Mfg. Co., 4633 W. Van Buren, Chicago
Copperweld Steel Co., Glassport, Pa.
Crescent Ins. Wire & Cable Co., Trenton, N. J.
General Elec. Co., Bridgeport, Conn.
Phosphor Bronze Smelting Co., Phila.
Rea Magnet Wire Co., Fort Wayne, Ind.
Roebling's Sons Co., John, Trenton, N. J.
Velliff Mfg. Corp., Southport, Conn.

WIRE, Glass Insulated

Bentley, Harris Mfg. Co., Conshohocken Pa.
Gavitt Mfg. Corp., Brookfield, Mass.
Holyoke Wire & Cable Corp., Holyoke, Mass.
Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6
Owens-Corning Fiberglas Corp., Toledo, O.

WIRE, HOOKUP

Ansonia Elec. Co., Ansonia, Conn.
Bentley, Harris Mfg. Co., Conshohocken, Pa.
Gavitt Mfg. Co., Brookfield, Mass.
Lenz Elec. Mfg. Co., 1751 N. W. Av., Chicago
Rockbestos Prod. Corp., New Haven, Conn.
Runzel Cord & Wire Co., 4723 Montrose Ave., Chicago
Surprenant Elect. Ins. Co 84 Purchase St Boston 10, Mass
Whitney Blake Co., New Haven, Conn.

WIRE & CABLE

Acme Wire Co., New Haven, Conn.
Amer. Steel & Wire Co., Cleveland, O.
Anaconda Wire & Cable Co., 25 B'dway, N. Y. C.
Ansonia Elec. Co., Ansonia, Conn.
Belden Mfg. Co., 4633 W. Van Buren, Chicago
Bentley, Harris Mfg. Co Conshohocken Pa
Collyer Ins. Wire Co., Pawtucket, R. I.
Consolidated Wire Co., 1634 Clinton St., Chicago
Crescent Ins. Wire & Cable Co., Trenton N. J.
Elec. Auto-Lite Co., The, Port Huron Mich.
Essex Wire Corp Ft Wayne 6 Ind
General Cable Corp., Rome, N. Y.
General Elec. Co., Bridgeport, Conn.
Hazard Ins. Wire Works, Wilkes-Barre, Pa.
Holyoke Wire & Cable Corp., Holyoke, Mass.
Hudson Wire Co., Winsted, Conn.
Rea Magnet Wire Co., Fort Wayne, Ind.
Rockbestos Prods. Corp., New Haven, Conn.
Roebling's Sons Co., John, Trenton, N.J.
Runzel Cord & Wire Co., 4723 Montrose Ave., Chicago
Simplex Wire & Cable Co., Cambridge, Mass.
Surprenant Elect. Ins. Co 84 Purchase St Boston 10 Mass
Western Ins. Wire, Inc., 1000 E. 62 St., Los Angeles
Wheeler Insulated Wire Co., Bridgeport, Conn.

WIRE, Silver Jacketed on Steel Copper, Invar

Wilson Co H A 105 Chestnut St Newark 5 N J

WOOD, Laminated & Impregnated

Canfield Mfg. Co., Grand Haven, Mich.
Formica Insulation Co., Cincinnati, O.

WOOD PRODUCTS, Cases, Parts

Hoffstatter's Sons, Inc., 43 Ave. & 24 St., Long Island City, N. Y.

160-MC. SATELLITE OPERATION FOR RAILROAD YARDS

(CONTINUED FROM PAGE 43)

directly by means of space radio, and also through the satellite station as an alternate when required by the central station. In the latter case, our signal was picked up by the satellite receiver and automatically fed via the induction transmitter and wayside wires to the central station. To demonstrate reception of either the satellite transmitter or central station transmitter while within or near the Ford yards, transmissions were conducted alternately with and without the satellite operating simultaneously.

As expected, the signal from the satellite, while we were in the vicinity of the Ford yards, was considerably stronger than the signal from the central station 13 miles away. However, with very few exceptions, reliable communication was possible without the use of the satellite. The satellite served to provide positive coverage.

Contact was established also with the diesel locomotive, about 7 miles distant. All contacts between the two locomotives during the tests were made by space radio.

At the midpoint between the satellite and the central station, the signals received from the two fixed transmitters were approximately of equal intensity. During normal operations the satellite would not be energized to cover this area, but it was operated simultaneously with the central station transmitter to demonstrate the behavior of the receiver while transferring from one signal to the other when near an equal-signal zone. The critical area in which the receiver would respond to both signals was very narrow, possibly ¼ mile on the route followed in this test. At no time, however, did we lose intelligibility of transmission.

The test run continued into the Flat Rock yards and, via another route, back into the Ford yards. As a final test the demonstration coach was backed into the huge EE Ford building. From this point it was still possible to contact the central station without the use of the satellite, and also to communicate with the diesel about 8 miles distant.

Conclusions ★ The tests demonstrated that excellent communications can be obtained by the use of frequency modulation on 160 mc. within an industrialized area. Except under unusual conditions, it appears that a low-power transmitter with an antenna 150 ft. or more in height can cover a radius of at least 10 to 12 miles over favorable terrain with little difficulty. By taking advantage of both space and induction radio or other satellite-controlled techniques, positive coverage of large areas can be obtained with low-power satellite transmitters located at intervals of 25–35 miles along the tracks.

Presto Cutting Needles in a "Trouble-Proof" Container

at no extra cost

NEW! A transparent lucite container keeps Presto Cutting Needles *safe*. Nothing can harm the precision ground point and cutting edges.

TIGHT! This ingenious chuck holds the needle *tight*—no chance of damage to the point in shipment.

EASY! Just slip used needles (safe in their containers) into this handy mailing bag and send them off to Presto for resharpening.

FOR YOUR CONVENIENCE! Presto Sapphire Recording Needles *now* come to you in a *new* package, designed for utmost needle protection in shipping and handling.

FREE! To Presto-equipped recording studios: a convenient rack holding six Presto Cutting Needles, with special "point-control" chart recording number of hours each needle is used.

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RECORDING CORPORATION

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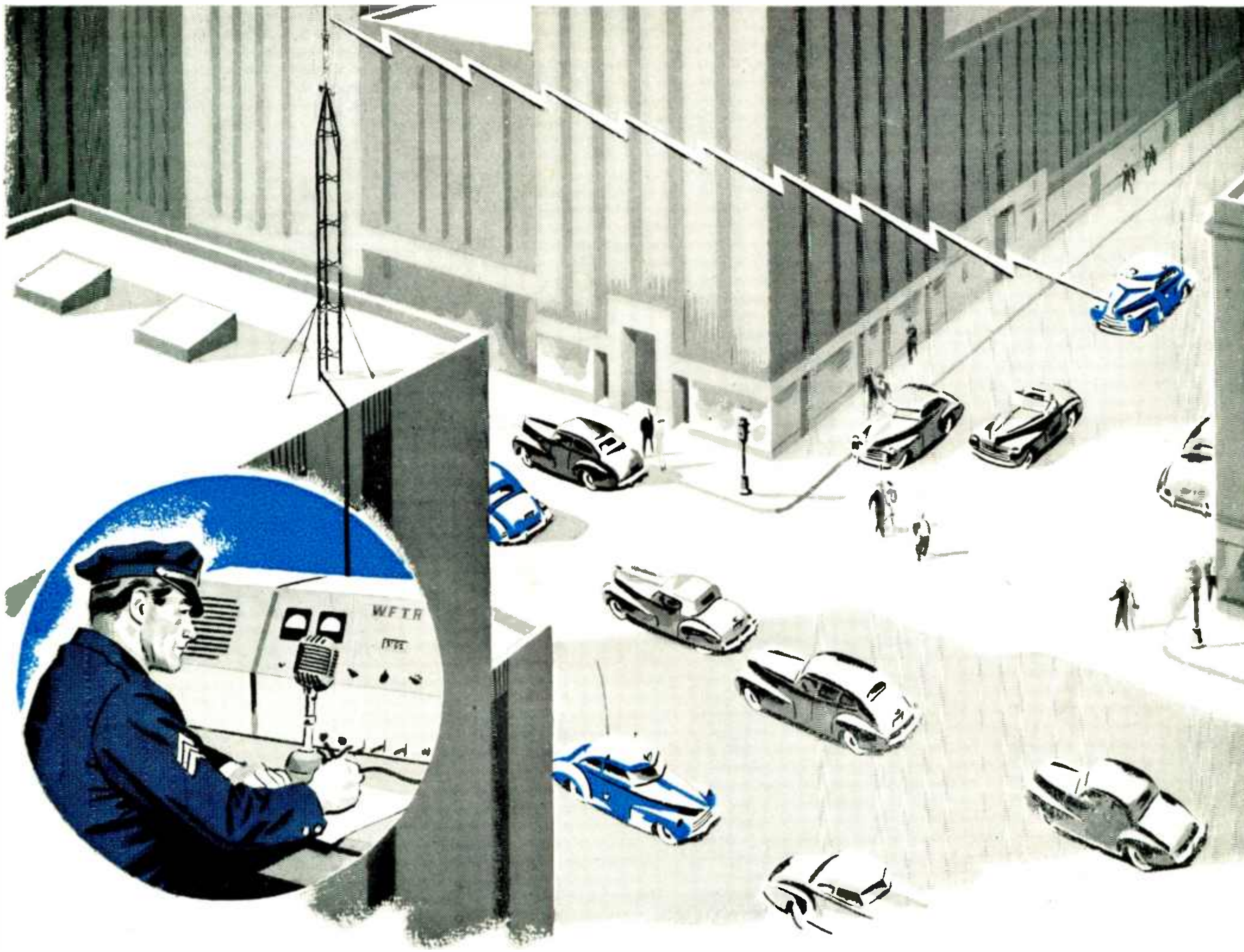
WALTER P. DOWNS, LTD., *in Canada*

WORLD'S LARGEST MANUFACTURER OF INSTANTANEOUS SOUND RECORDING EQUIPMENT AND DISCS



Now...he "*Selecto-calls*" the ONE car he wants

with FEDERAL's "SELECTO-CALL"

...the complete FM radio telephone system that works like a private line

Like a private telephone, the receiver unit of Federal's new mobile communication system remains silent until its "number" is called... no matter how many radio transmitters may be operating in the same area... even on the same frequency!

Thus, "Selecto-Call" now makes it possible to talk to any one car... or to all of them... at the flick of a switch... with blanket coverage for emergency service.

Employing a wholly new type of squelch circuit, "Selecto-Call" eliminates responses to unwanted signals and interference from adjacent channels. Batteries and tubes actually "loaf" except when their "number" is called... which means longer life for the equipment and lower operating costs.

Built to serve tomorrow's communication needs, "Selecto-Call" is available now, in one small, compact unit that plugs in as simply as a desk drawer. Write for complete information. Federal Telephone and Radio Corporation, Newark 1, N. J.

Federal Telephone and Radio Corporation

Export Distributor:
International Standard Electric Corporation

Newark 1, New Jersey

AN IT&T ASSOCIATE

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Conjured up in the crystal ball lies the answer to your radio frequency insulation and industrial ceramic problems. Consult with us on the possibilities of using STEATITE . . . the material of the future . . . TODAY.

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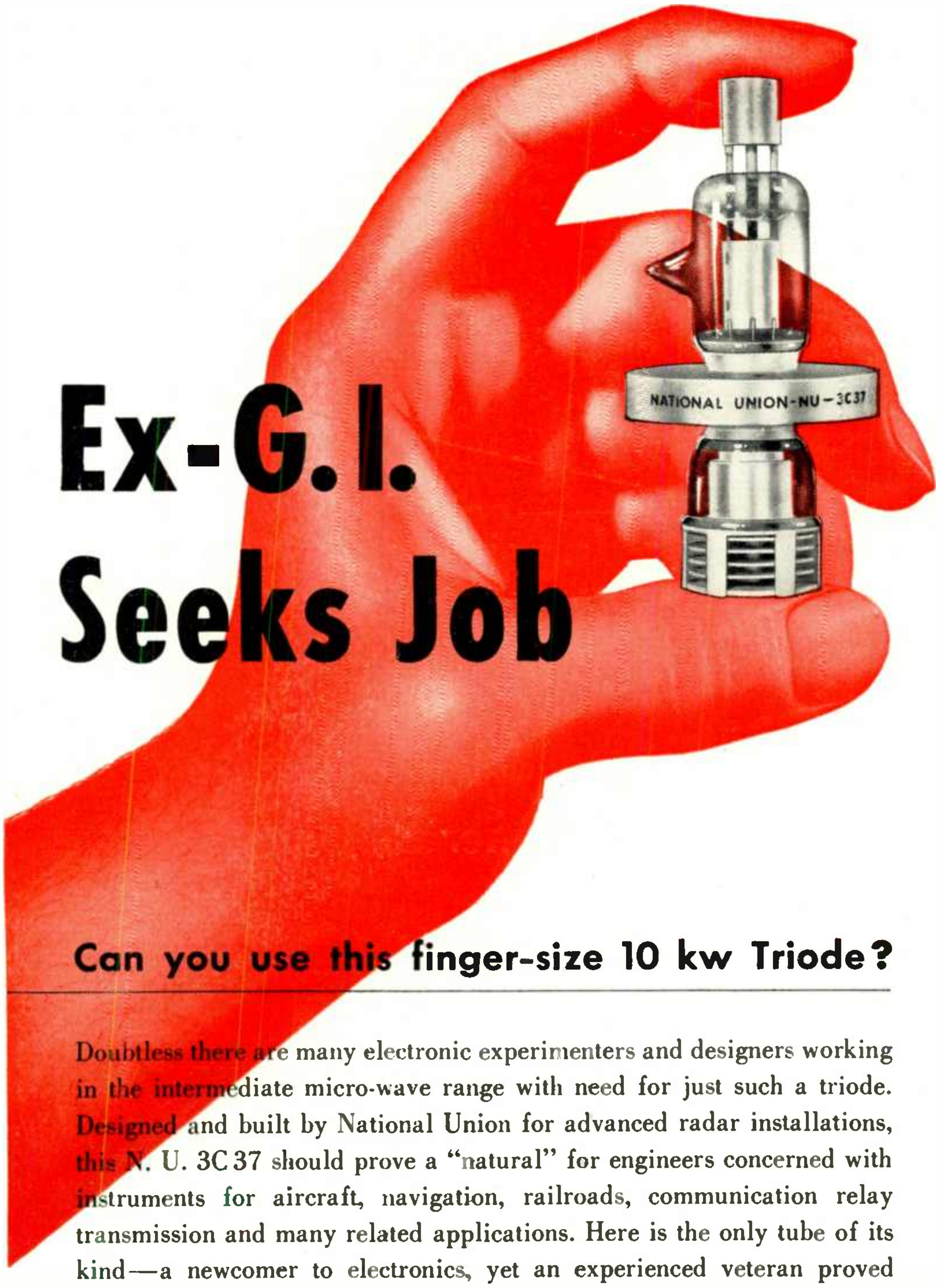
Variable Resistors
Bulletin 697

Tubular Ceramic Capacitors
Bulletins 630 and 586

Selector Switches
Bulletin 722



Ex-G.I. Seeks Job

Can you use this finger-size 10 kw Triode?

Doubtless there are many electronic experimenters and designers working in the intermediate micro-wave range with need for just such a triode. Designed and built by National Union for advanced radar installations, this N. U. 3C 37 should prove a "natural" for engineers concerned with instruments for aircraft, navigation, railroads, communication relay transmission and many related applications. Here is the only tube of its kind—a newcomer to electronics, yet an experienced veteran proved under the most rigorous service conditions. There are electronic jobs it can do better than they have ever before been done—problems it can solve for the first time. Why not write us about the N. U. 3C 37? Or come to our laboratories and talk it over with a National Union engineer.

Qualifications of the N. U. 3C 37

- Delivers 10 KW peak RF power output at frequencies as high as 1150 megacycles.
- Anode and grid dissipation capabilities are adequate to enable the tube to withstand large momentary overloads without damage or distortion of electrical characteristics.
- Internal and external surfaces are silver plated to minimize skin resistance and RF losses.
- Specially constructed radiator greatly reduces RF losses. Permits operation at duty cycles of 1% with air-blast cooling.
- Anode radiator of silver plated copper efficiently transfers heat to any resonator of which it becomes a part.
- Negligible frequency drift due to cylindrical construction and closely controlled mechanical tolerances.
- Maximum mechanical strength.

NATIONAL UNION
RADIO AND ELECTRON TUBES
NATIONAL UNION RADIO CORPORATION • NEWARK 2, N. J.

Left: WDOD is one of many network stations using Federal's five kw Transmitter, Type 165A, a pre-war installation.

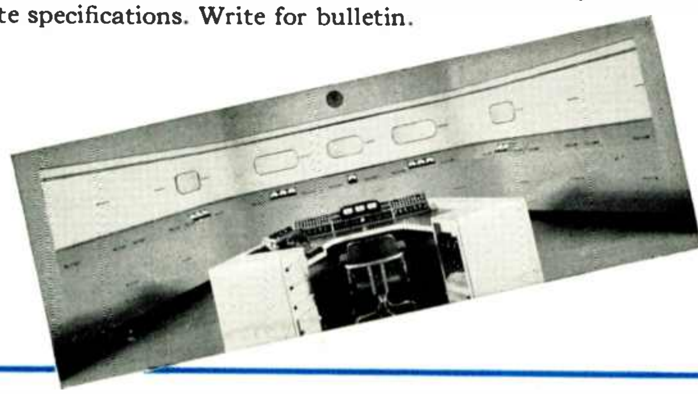
Federal engineering offers you

1. Modern Design
2. Higher Efficiency
3. Lower Operating Cost

. . . IN 5-, 10- AND 50-KW STANDARD AM BROADCAST TRANSMITTERS

Federal's vast time-tested engineering and manufacturing facilities are now engaged in production of standard AM radio transmitters for early delivery . . . 5, 10 and 50 KW . . . with station equipment from microphone to antenna. A Federal engineer will be glad to give you complete specifications. Write for bulletin.

Now in Production for Early Delivery

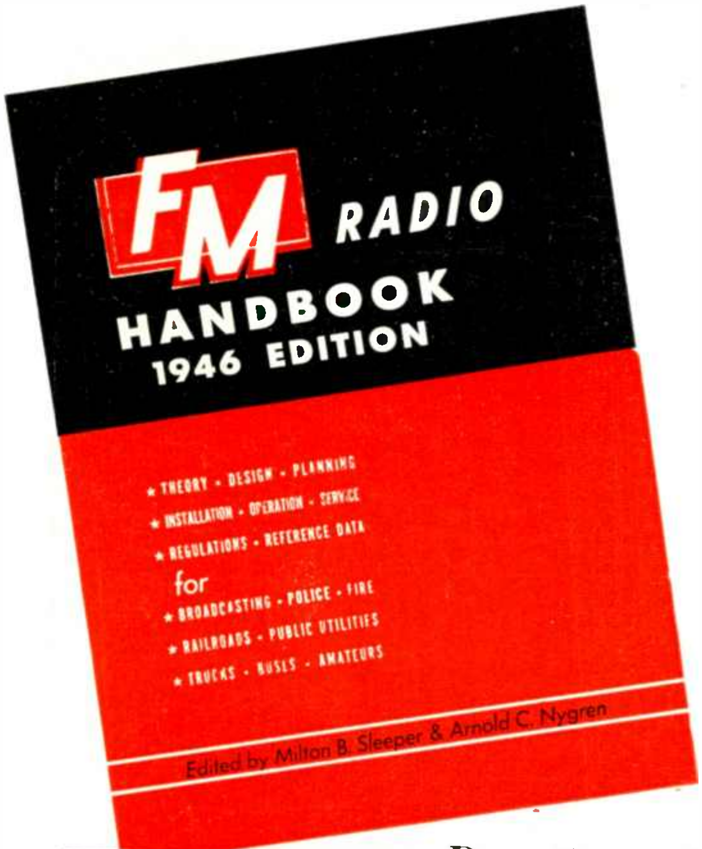


Right: WABC is one of many leading stations using Federal's 50-kw Transmitter, Type 162. Similar installations built to your order.

Federal Telephone and Radio Corporation

Export Distributor: *International Standard Electric Corporation*

Newark 1, New Jersey



Essential Information for COMMUNICATIONS ENGINEERS *in:*

The Standard Handbook of

FM RADIO

Detailing Systems for 30 to 160 Mc. for Police, Fire, Railroads, Public Utilities

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For six years, FM and TELEVISION Magazine has been the leading source of information on FM communications equipment and installations. More articles and more detailed working data on these subjects have appeared in FM and TELEVISION than in all other radio publications combined.

These articles, written by specialists in the communications field, cover the design, installation, operation, maintenance, and performance of new equipment and systems incorporating new features of outstanding interest to communications engineers.

A subscription to FM and TELEVISION Magazine will keep you abreast of all developments in the rapidly expanding radio communications field. If you use the coupon on this page, we'll send you, without charge, a copy of the new FM HANDBOOK. Take advantage of this offer NOW, for it will be withdrawn without notice.

FM communications has become the most rapidly expanding field of radio development. With an enormous increase in frequencies made available by the FCC for this service, much new equipment has been brought out since the end of the war. New uses are being found for 2-way FM at such a rate that the FCC is swamped with license applications. In addition, many prewar AM installations are being replaced with FM systems.

All these postwar developments, from theory to application, are covered in the completely new FM RADIO HANDBOOK. This large volume, edited by men of long experience in FM communications, gives detailed, working information on all phases of 2-way installations, including the latest fixed and mobile equipment for operation on all the newly-assigned frequencies, antennas, unattended relays, selective dial calling, and maintenance methods. Also included is a complete Emergency Station Directory, listing details of all municipal, county, state, zone, fire, forestry, public utility, and special communications systems.

Individual chapters were written by men chosen for their outstanding achievements and experience in various branches of communications work. The FM RADIO HANDBOOK is no pocket-size compilation of condensed data, but a volume 8¾ by 11⅝ inches, profusely illustrated with hundreds of handsomely printed photographs and drawings.

All equipment and installations described are of postwar design. Thus the HANDBOOK is a completely up-to-date guide to the very latest advances in communications practice.

In short, it is an essential book for engineers engaged in the manufacture, installation, operation, or service of communications equipment.

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FIVE YEARS FROM TODAY, will you be in the knee-pants era of radio or will you be "up and on to" every new development? The matter is as pointed as that. True, most receivers cannot reproduce the full range of FM broadcasts yet. But soon they will.

MODERNIZE! Start now to monitor your full FM range with the Altec Lansing Loudspeaker System. Make your improvements — your refinements — now. So when tomorrow comes, you will not just be growing up to standards, you will be *setting* them. See your dealer.

THE ALTEC LANSING DUPLEX LOUDSPEAKER SYSTEM

Both high and low frequency units are combined in one horn, reproducing the entire FM range, from 50 to 15,000 cycles, without intermodulation effects or distortion.

ALTEC LANSING CORPORATION

1161 N. Vine St., Hollywood, Cal.
250 W. 57th St., N. Y. 19, N. Y.


NEW SIMPSON
WIDE RANGE
SIGNAL GENERATOR
FOR AM AND FM
Simpson
SIGNAL GENERATOR
MODEL 415
MADE IN U.S.A.
WATCH FOR NEW SIMPSON DEVELOPMENTS . . . THEY ARE WORTH WAITING FOR

We're coming in...

Astatic has made a lot of "pick-ups" along the line and here we are ... breezing through the azure blue ... headed for the Show ... and you. It's going to be fun ... shaking hands with the old gang again ... and the new-comers, too. We'll be holding forth at the Stevens, where you'll find Astatic Microphones, Phonograph Pickups and Cartridges ... including many new and improved models ... on display. We'll be seein' you!

Hotel Stevens
CHICAGO, ILL.
Headquarters for
Radio Parts National Trade Show
May 13, 14, 15 and 16

ASTATIC

THE Astatic CORPORATION
CONNEAUT, OHIO
In Canada: Canadian Astatic, Ltd., Toronto, Ont.

ENGINEERING SALES

(CONTINUED FROM PAGE 8)

Memphis; Edwin Lewis Simon, 827 Mart Bldg., San Francisco; and Hal F. Bersche, 621 S. Hope Street, Los Angeles.

Jensen: Karl Kramer has been transferred from engineering to the sales department. In his new position, he will act as liaison engineer with equipment manufacturers who use Jensen speakers. A specialist in acoustics, he has an M.Sc. degree from Ohio State University. Kramer joined the Jensen Company in 1935.

Hytron: Donald G. Haines, former RCA tube design engineer, has joined Hytron as sales and commercial engineer. He will make his headquarters at 4000 W. North Avenue, Chicago.

Lear: Sales office has been moved from the Furniture Mart Building, Chicago, to the Company's executive and manufacturing headquarters in Grand Rapids, Mich.

Parts Show: Despite the fact that sales of radio parts and sets got off to such a poor start this year, there is a prevailing conviction that the Parts Show at Chicago will do much to set the ball rolling. For one thing, this will be the first postwar get-together of parts and set manufacturers and parts jobbers, and it is felt that many problems will be resolved in the light of the overall industry picture that will be presented there.

More exhibitors have applied for space than was ever expected when the show was announced. Every inch of available space will be filled with booths displaying new products.

Another favorable effect of the show is that it has set a dead-line for manufacturers to get their new products ready to display. This has resulted in speeding up plans which, otherwise, might have dragged along until fall. If one is to judge from advance registrations, this will be the most successful Parts Show ever held, both as to attendance and actual volume of business transacted.

SUBSCRIPTION EXPIRATIONS

Each issue of *FM* AND TELEVISION mailed to you shows the expiration date of your subscription just below your address. This is the month and year of the last issue you will receive on your present subscription. When we receive your renewal, the date is changed accordingly. In this way, you can always tell the status of your subscription. Also, in case you wonder what the other numbers mean, they show your classification in our records as being connected with broadcasting, sales, manufacturing, etc. In case the number is 13, it means that, although we have asked you for this information, you didn't give it to us!

SPOT NEWS NOTES

(CONTINUED FROM PAGE 34)

mits have been granted to the El Paso School District for a 2.15-kw. transmitter, and to the Sacramento School District for a .37-kw. transmitter.

William Reagh Hutchins: Has been appointed manager of FM broadcasting activities for E. Anthony & Sons, of New Bedford, Mass. For the past several years, he has been associated with Major Armstrong on FM and radar research and development at Columbia University and at Alpine, N. J.

Revising Television Sets: Allen B. DuMont Laboratories has started to change over television receiving sets of their manufacture so that they will cover the new frequencies assigned to WABD, WNBT, and WCBW. A flat charge will be made to cover the cost of this service, together with pickup and delivery, since the work will be done at the DuMont factory. Set owners who make application promptly should have their receivers back by the time the stations are back on the air at their new frequencies.

Adelbert R. Morton: Former chief engineer of Ansley Radio and production manager of Ford Instrument Company has joined Insuline Corporation of America as chief engineer of the electronics division.

London, England: Electronic Valves, Limited, a new company formed by A. C. Cossor, Ltd., English radio manufacturers, will produce Sylvania receiver and cathode-ray tubes in London, for the British markets, using Sylvania techniques.

RMA Appeal to OPA: Eleven months ago, the radio manufacturers were urging Paul A. Porter, then FCC chairman, to help avoid unemployment and reconversion delays but rendering a prompt decision on FM broadcast frequencies. Now, RMA has delivered a carefully organized, factual appeal to OPA administrator Porter for relief from pricing troubles which have stymied the efforts of set manufacturers to get under way with radio set production.

We recall that Mr. Porter wouldn't let radio executives testify on propagation matters because he didn't consider them qualified propagation experts. Yet Mr. Porter, having been educated as a lawyer, presumes to settle propagation or production problems of the most involved nature with equal facility.

This is one of the wonders and fallacies of government-controlled economy. However, no amount of propaganda will ever explain how a tap on the shoulder from our President can make any man so wise in a field of which he knows nothing that he can take over the economic control of even one type of business, and be wiser than men who have specialized in it all their lives.

WGHF: Equipment tests are under way at the Finch FM and facsimile station at 10 East 40th Street, New York City. Operating on 99.7 mc., this transmitter has been heard at our Monterey, Mass. receiving station, a distance of approximately 105 miles. Herbert C. Florance is chief engineer of the station.

WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 4)

license renewal. A typical example of this attitude is contained in the statement: "It has been the consistent intention of the Commission to assure that an adequate amount of time *during the good listening hours* shall be made available to meet the needs of the community in terms of public expression and of local interest."

In the introductory paragraphs on "Commission Jurisdiction with Respect to Program Service", it is stated that "The Communications Act, like the Radio Act of 1927, directs the Commission to grant licenses and renewals of licenses only if public interest, convenience and necessity will be served thereby. The first duty of the Federal Radio Commission, created by the Act of 1927, was to give concrete meaning to the phrase

(CONTINUED ON PAGE 84)

WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 82)

public interest by formulating standards to be applied in granting licenses for the use of practically all the then available radio frequencies."

The formulation of standards, if it had been done in 1927, might have headed off most of the present abuses of which certain broadcasters are now unquestionably guilty. By formulating such standards now *for application to all stations*, the FCC could stop abuses in the future. The NAB could contribute much practical guidance in setting up standard percentage of time allotments to various program categories. The matter could be resolved at an FCC hearing in which controlling factors could be made known by the broadcasters.

But, so far as the Blue Book reveals the FCC's intentions, that is not the plan. Instead, the Commissioners propose that the same devious methods introduced by Paul Porter are to be applied to reaching decisions on license renewals. In other words, an analysis of program composition will be used as justification for issuing or refusing a renewal, although the actual decision may be dictated by the applicant's political attitude or affiliations, his relations with some pressure group, or the administration's need of rewarding some competing applicant.

As the FCC proposal stands, it is another example of extending political control over private enterprise. Whether the broadcasters will act aggressively in self defense will be determined by their willingness to step out of the state of intellectual subservience into which they were cowed by James Lawrence Fly during his administration as FCC Chairman.

2. Published estimates set the annual cost to broadcast of AFM depredations at $20,000,000. That is not the wages paid to AFM members for services on radio programs. It is the *extra* expense paid to AFM at the point of come-across-or-else demands.

Since the extent and the scope of sustaining programs aired by any station must be related to operating profit beyond a reasonable return on capital investment, it is clear that the AFM is a directly contributing factor in limiting the amount which stations can spend on public service features. Yet the Commissioners continue to wear the blinders which shut out cognizance of this condition when they turn appraising eyes on the broadcast business.

Each time AFM makes a new raid on radio stations, it seems encouraged to devise another effort. Its progress up to this point indicates that, unless it is curbed by Congressional action, some stations will be faced with the choice of

(CONCLUDED ON PAGE 86)

WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 84)

cramming programs with still more spot announcements, thereby risking license renewals, or being forced out of business because of the rising cost of keeping peace with AFM.

The refusal of the Commissioners to recognize this condition, or to take part in correcting it, points up the difference in thinking between men who are appointed to their positions and draw their wages from the taxpayers, and men whose income is determined by the difference between the price at which they can sell their products and the cost of producing them.

3. The International Allied Printing Trades Association continues to maintain an active lobby at Congress to urge that the use of radio for advertising has cut into printed sales promotion and, therefore, broadcast station profits beyond 15% should be paid to the Treasury to reduce the public debt, and radio salaries should be limited to $25,000.

From this it would be inferred that the printing trades are taking a serious licking. What are the facts?

The truth is that the demand for printing is greater today than at any previous time. The demand for printing is now greater than the capacity of existing presses to turn it out. One of the serious reconversion problems confronting manufacturers is the difficulty of getting catalogs and sales literature printed. To a magazine publisher, an established connection with a printer is equivalent to a broadcaster's station license. If it is lost, he is out of business. Therefore, the publisher takes abuse from his printer in the same spirit of resignation that the broadcaster faces new demands and restrictions from the FCC.

After the brief skirmish between employing printers and the unions in the middle-west, other printers have been quick to accept union demands and to pass them on to their customers. Nor have the increases been limited to those resulting from higher wages.

If the printing trades have any justifiable complaint, it is against OPA for this agency has set a ceiling on printing machinery so low that the manufacturers continue to keep their plants closed down, rather than operate at a loss.

Publishers would be pleased to join the Printing Trades Association in a complaint not against radio but against OPA, for they are caught between Scilla and Charybdis of costs which are not limited by OPA, and by the continued postponement of full-scale advertising schedules on products that will not be manufactured until OPA sets prices at profitable levels, or is eliminated from the list of Government agencies. — *Milton B. Sleeper.*

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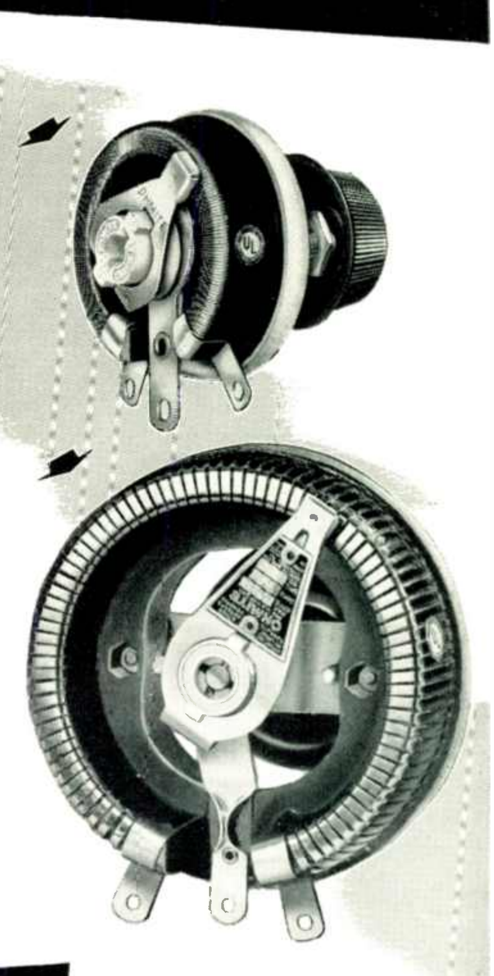

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