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# FM RADIO-ELECTRONICS

SEPTEMBER 1943

HEAD OF NAVY'S RADIO DESIGN

Radio-Electronic Products Directory

## ENGINEERING • MANUFACTURING • OPERATION

★ ★ *Edited by M. B. Sleeper* ★ ★

# A NEW TECHNIQUE *that is* SPEEDING VICTORY

LITERALLY a one man army, the paratrooper strikes fast and hard—almost anywhere. He represents a new and deadly technique of modern warfare, one that America is utilizing to the fullest.

Industry, too, has learned new techniques. New short cuts, new refinements in design, new ways to build faster and better the tools and weapons our fighting men need.

Simpson electrical instruments and testing equipment, for example, offer a basically superior type of movement which required a slow and costly method of construction only a few years ago. Today, in the Simpson plant, this greater accuracy and stamina is a matter of mass production.

Tomorrow the many things industry has learned under the impetus of war will build a brighter, happier world. The harder we work on the job at hand, the sooner that tomorrow will come.

SIMPSON ELECTRIC COMPANY
5200-5218 Kinzie Street, Chicago 44, Illinois


Simpson

INSTRUMENTS THAT STAY ACCURATE

*Buy War Bonds and Stamps for Victory*

THIS picture might have been taken almost anywhere. All over the world small groups of soldiers are guarding our outposts against attack. Vigilant, lonely and unafraid, these men rely on their skill . . . and on radio. Radio for warnings. Radio for help when needed. Radio for coordination. Radio for entertainment. Radio for Victory.

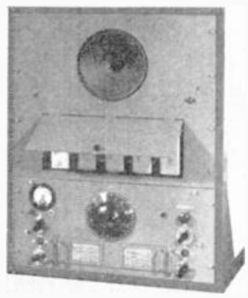

PHOTO BY
U. S. ARMY SIGNAL CORPS


A

B

C

D

# FM RADIO-ELECTRONICS

FORMERLY: FM RADIO-ELECTRONIC ENGINEERING & DESIGN
COMBINED WITH: APPLIED ELECTRONIC ENGINEERING

VOL. 3 — SEPTEMBER, 1943 — NO. 10




## CONTENTS





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Advertising correspondence, copy, and cuts should be addressed to the advertising office at New York City.



## THIS MONTH'S COVER

Commander David R. Hall, U. S. N., is Head of the Design Branch, Radio Division, Bureau of Ships. An Annapolis graduate, Class of 1925, he has a broad background of post-graduate work at the Academy and at Harvard. Today, he still has the enthusiasm for radio that dates back to the beginning of his amateur activities in 1912. His experience combines six years of duty with the fleet, and an equal length of time devoted to research work at sea, and ashore at Naval Research Laboratory, and in charge of the Underwater Sound Section.

# WHAT'S NEW THIS MONTH

THE stepped-up requirements of the Signal Corps for 1944 disclose a colossal task facing the radio industry. Total production in 1943 will amount to $3,250,000,000, two and one-half times the industry's output last year. Preparations to be completed before the end of December must provide for 1944 deliveries amounting to $4,500,000,000. This is an increase of nearly $33\frac{1}{3}\%$.

The task ahead for some contractors is even greater, for the requirements of all Air Forces signal equipment call for an increase of $66\frac{2}{3}\%$ over 1943 production.

These new levels must be achieved in the face of still greater problems of manpower shortages, further loss of engineering talent, and the prospect of changing military requirements.

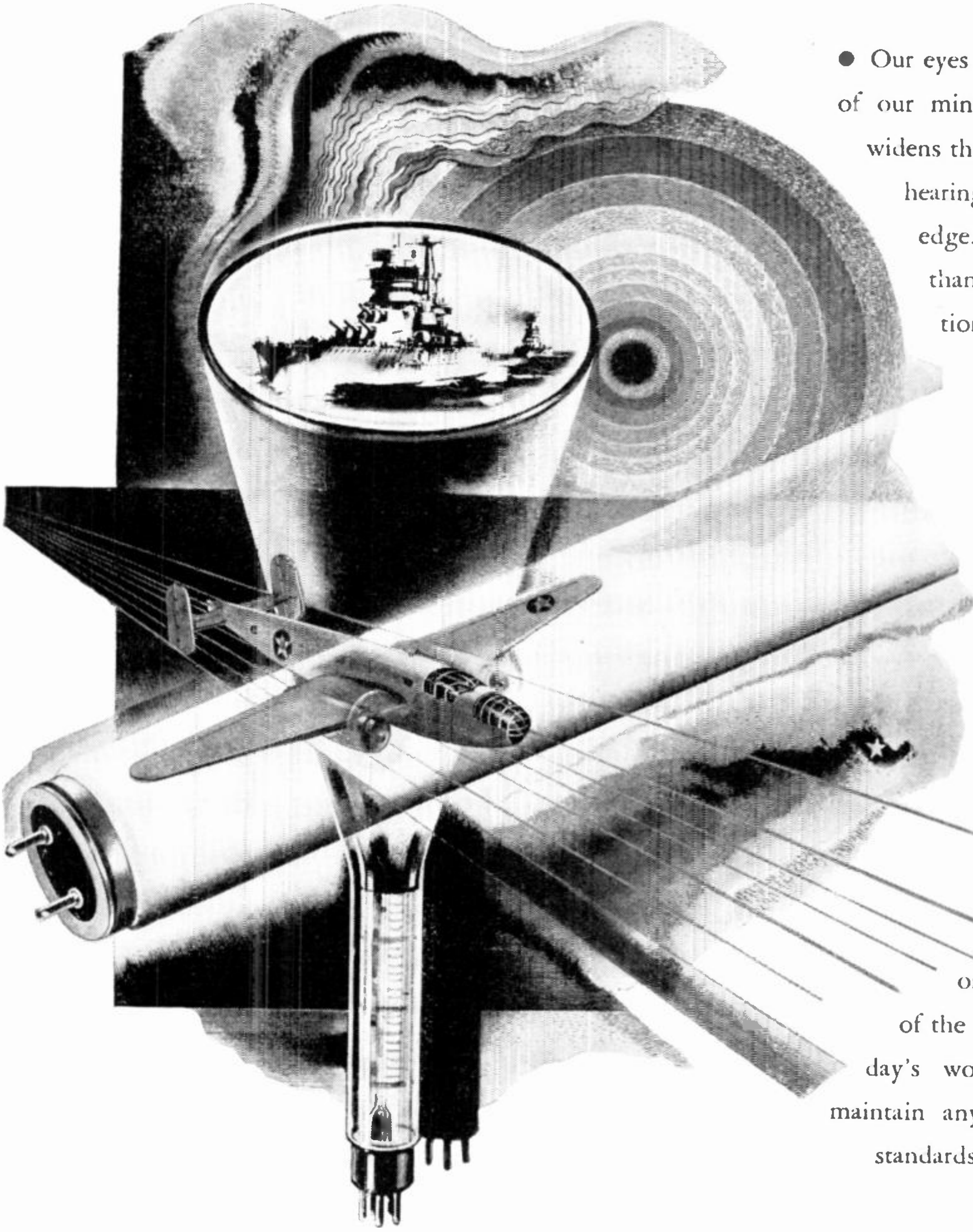
Encouraged as we may be by the continued successes of our Armed Forces, the Signal Corps, viewing the future with realism founded on information not available for publication, sees the biggest battles still ahead — battles in which the loss of men and material will be far greater than in any conquests up to this time. Looking ahead, radio manufacturers must anticipate not only the need of increased production, but production increases further complicated by changes in design details and in production schedules for different types of equipment.

By the end of next year, we shall have nearly twice as many men overseas as there will be this December. What this means in terms of production can be gleaned from the following figures:

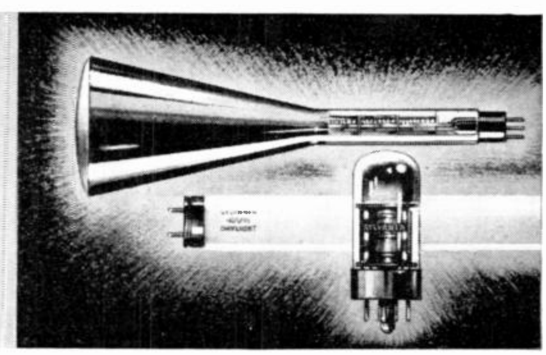
For each 12 men overseas, in order to maintain a constant flow of equipment and supplies from factories to the field, 100 tons of equipment and supplies must be provided as distribution. Of each 100 tons, 29% is held in filler depots, 6% in ports, 18% in transit, 29% in contingency theater reserves, and 18% in theater operating reserves. If our men are to have what they need when they need it, our production must keep these reserves available continuously.

In addition, "strategic reserves" are to be set up in 1944. These will be equivalent to the initial issue requirements for 20% of the maximum strength of our Army in 1943. One-half of this reserve is intended for the re-arming of fighting units in liberated countries whom we expect to join our forces as the lines of conquest move nearer Germany. The other half is a reserve for our American Forces to enable them to

(CONTINUED ON PAGE 60)

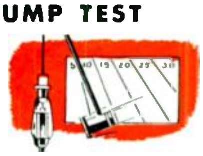






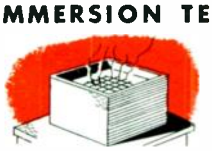

The Hytron 807—peacetime all-purpose favorite—is now a veteran. Before it joins its battle-scarred brothers, however, like all Hytron tubes it must pass Hytron factory specifications which weed out the 4-F's as efficiently as Army doctors at an induction center. Unless a Hytron 807 is in top fighting condition, it never leaves the factory. Let's look at a few of the many test hurdles it must surmount.

## BUMP TEST



Ever stop to think of what a leaping, bouncing jeep or peep can do to a tube's "innards"? One answer to the question of a tube's ability to withstand such punishment, is the Bump Test. Several resounding smacks by a heavy, swinging hammer loosens up the weak sisters pronto!

## IMMERSION TEST



A "PT" boat leaning back on its stern, and plowing a foaming furrow through steaming tropical waters would spell disaster to poorly-cemented bases and top caps. That is why Hytron 807's are thoroughly soaked in a hot bath, before they are O.K.'d.

## LIFE TEST

Day and night, Hytron 807's on life-test racks are proving that they can give long, dependable service. Soaring skyward in our big bombers, these tubes have a big investment in men and matériel to protect. Long after the big fellows have been patched for the last time, these tubes are still doing their jobs.

## VIBRATION TEST

Link-trainer for 807's aspiring to tank service is a motor-driven eccentric arm which shakes the tube like an angry terrier while a v.t. voltmeter in the plate circuit records the ability of the elements to take it like the iron men who ride those clanking, thundering monsters.

## HYTRON TOLERANCES tighter than CUSTOMER TOLERANCES

No manufacturer makes all tubes of a given type exactly alike. Hytron does manufacture its tubes to tight specifications which insure against slight inaccuracies due to meters and the human element. Engineered to these narrower limits, Hytron tubes fit exactly the circuit constants with which they must operate.

OLDEST EXCLUSIVE MANUFACTURER OF RADIO RECEIVING TUBES

HYTRON RADIO TUBES

# HYTRON CORPORATION

ELECTRONIC AND RADIO TUBES

SALEM AND NEWBURYPORT, MASS.

# The 'Game Goose' gets home . . . again

● **The old girl's done it again. She's laid her eggs where they'll count most—and in spite of hell and high flack, she'll soon be smoothing her ruffled feathers at home.** —The capacity of America's fighting men and machines to absorb punishment, as well as dish it out—to come back again, and again, and again—is no accident.

Electronic Laboratories is proud of the ***E·L*** equipment that is helping the 'Game Goose,' and every American fighting plane, get home again.

On every front where the United Nations are in combat, ***E·L*** Vibrator Power Supplies are proving themselves as rugged and reliable as the company they keep. At high altitudes, in steaming jungles or blazing deserts, they perform their appointed task with the greater efficiency and freedom from wear, characteristic of ***E·L*** Vibrator Power Supplies.

Wherever electric current must be changed in voltage, frequency or type, ***E·L*** Vibrator Power Supplies and Converters offer many definite advantages, for peace, as well as for war.

**For Operating High-Powered Radio Receivers and Transmitters, Coin-Operated Phonographs, Public Address Systems and the Like—** Standard E·L Model 264 Power Supply. Input Voltage, 115 V DC; Output Voltage, 115 V AC; Output Current, 5 amperes; Output Power, 500 Volt-Amperes; Output Frequency, 60 cycles; Dimensions, 16" x 9¾" x 6½"; Weight, 44 lbs.

E·L Standard Vibrator Power Supplies are designed with a wide range of output wattage ratings for input voltages including 6, 12, 32, 115, and 220 volts. Custom-designed and built power supplies can be provided to meet any particular needs.

**Electronic**

**LABORATORIES, INC.**

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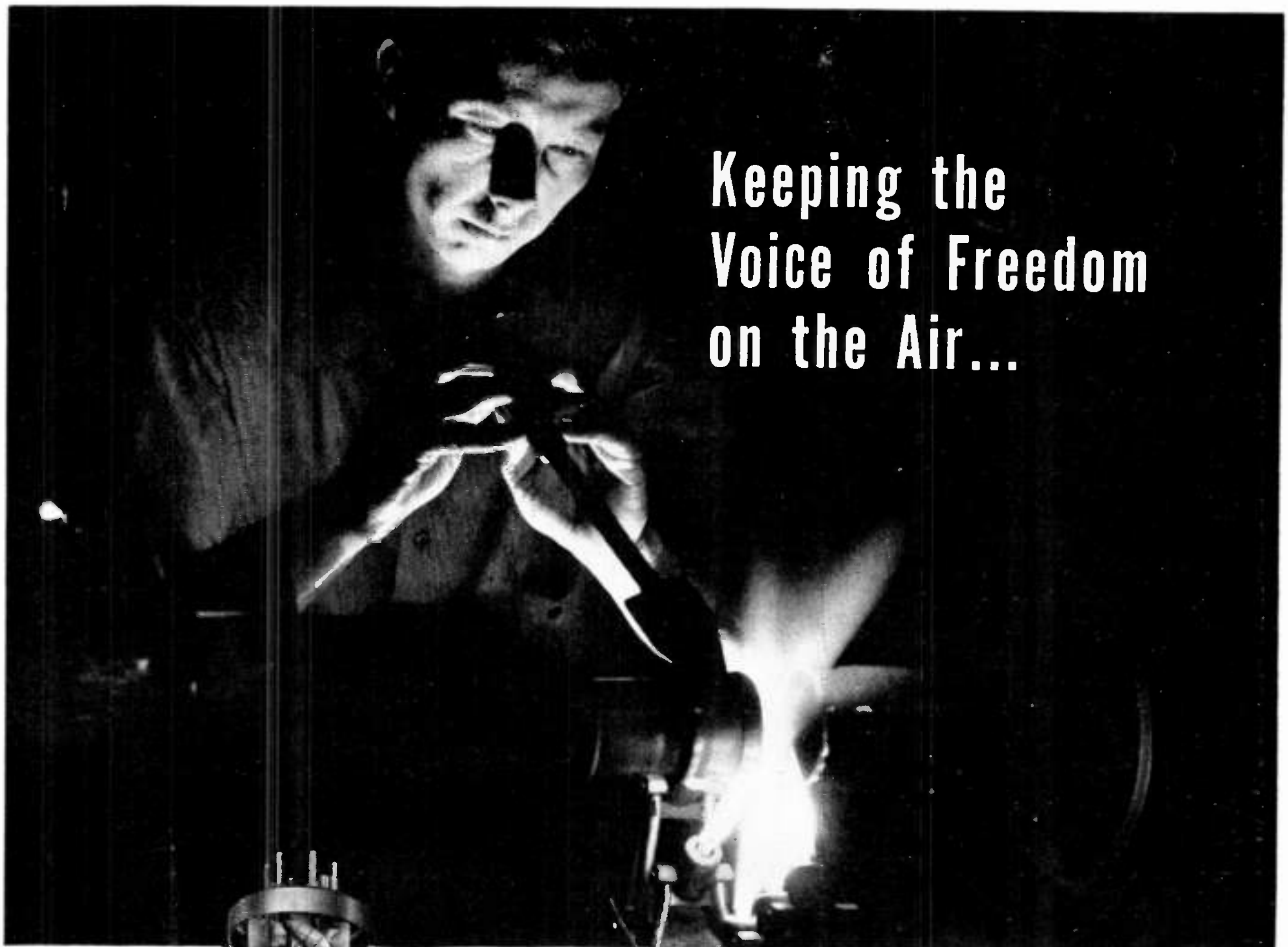
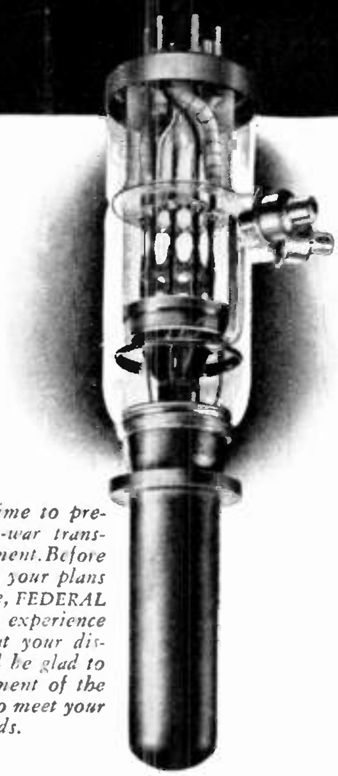
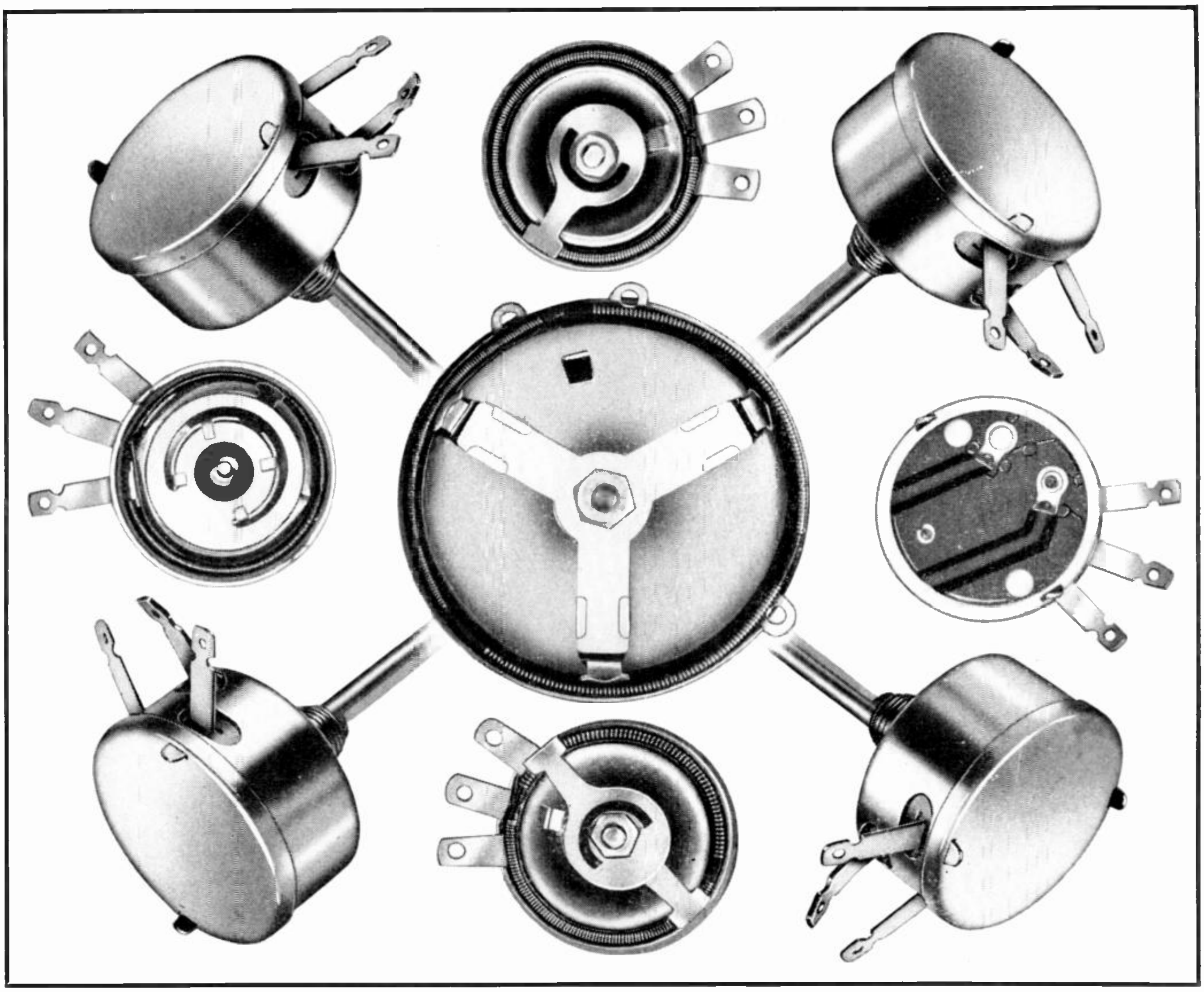
***E·L*** **ELECTRICAL PRODUCTS** — Vibrator Power Supplies for Communications . . . Lighting . . . Electric Motor Operation . . . Electric, Electronic and other Equipment . . . on Land, Sea or in the Air.


Keeping the
Voice of Freedom
on the Air...





# THESE VETERANS ARE SERVING
## ...*WHERE RESISTANCE IS IMPORTANT!*

IN MANY a war product—on land, at sea and in the air —Utah engineering and precision manufacturing safeguard the successful performance of many types of equipment. Indispensable to wartime service, Utah Wirewound Controls are passing the tough test of combat with flying colors.

Available in rheostats, potentiometers and attenuators, Utah Wirewound Controls are supplied in five sizes—3, 4, 9, 15 and 25 watts—with total resistances from 0.5 ohm to 25,000 ohms.

In all types of applications, under all kinds of operating conditions, Utah construction and design have proved their worth. In Utah Controls, high quality resistance wire is evenly wound on a substantial core, clamped tightly to the control housing. The result is a rugged and dependable variable resistor.

Typical of the Utah line is Utah Potentiometer Type 4-P. This rugged control dissipates 4 watts over the entire resistance element. Resistance elements are clamped in place in a cadmium-plated, all-metal frame, resulting in maximum heat dissipation for its size.

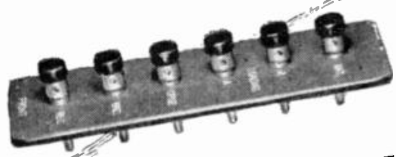
Find out if Utah controls can solve your electrical control problems. It costs nothing to get the facts—and may save you a great deal of time and money. Write today for full engineering data on Utah Wirewound Controls.

UTAH RADIO PRODUCTS COMPANY, 860 Orleans St., Chicago, Ill. Canadian Office: 560 King St. W., Toronto. In Argentine: UCOA Radio Products Co., S.R.L. Buenos Aires.

***PARTS FOR RADIO, ELECTRICAL AND ELECTRONIC DEVICES, INCLUDING SPEAKERS, TRANSFORMERS, VIBRATORS, VITREOUS ENAMELED RESISTORS, WIREWOUND CONTROLS, PLUGS, JACKS, SWITCHES, ELECTRIC MOTORS***

**CABLE ADDRESS: UTARADIO, CHICAGO**

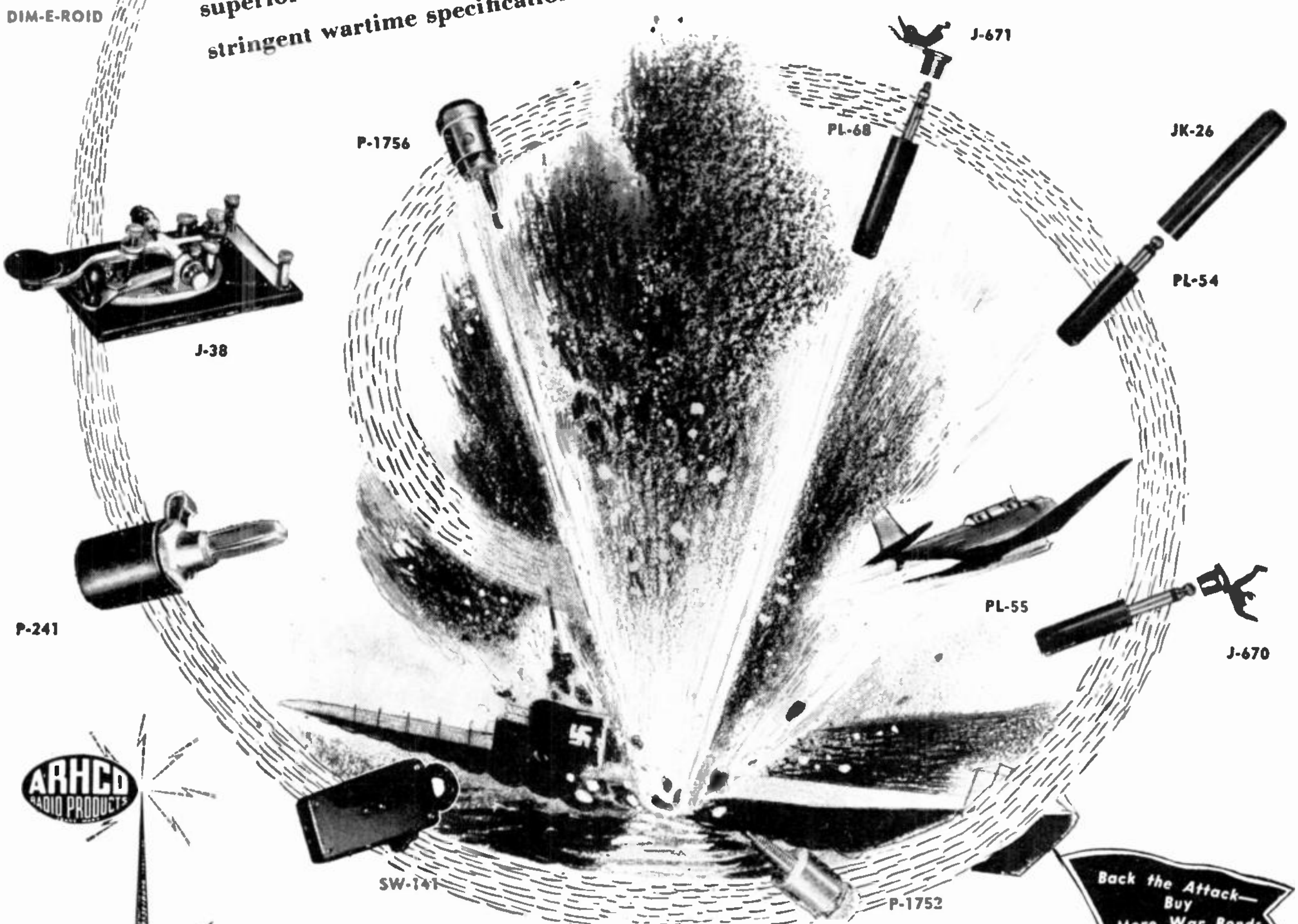
utah




# DOING A BIG JOB IN RADIONICS

Closely allied with many electronic developments during the past twenty years, it's been our assignment to provide numerous component parts to the leaders in the field. Some of these components are simple to manufacture, others are more intricate—in any event, each one is doing a big job in today's electronic applications.

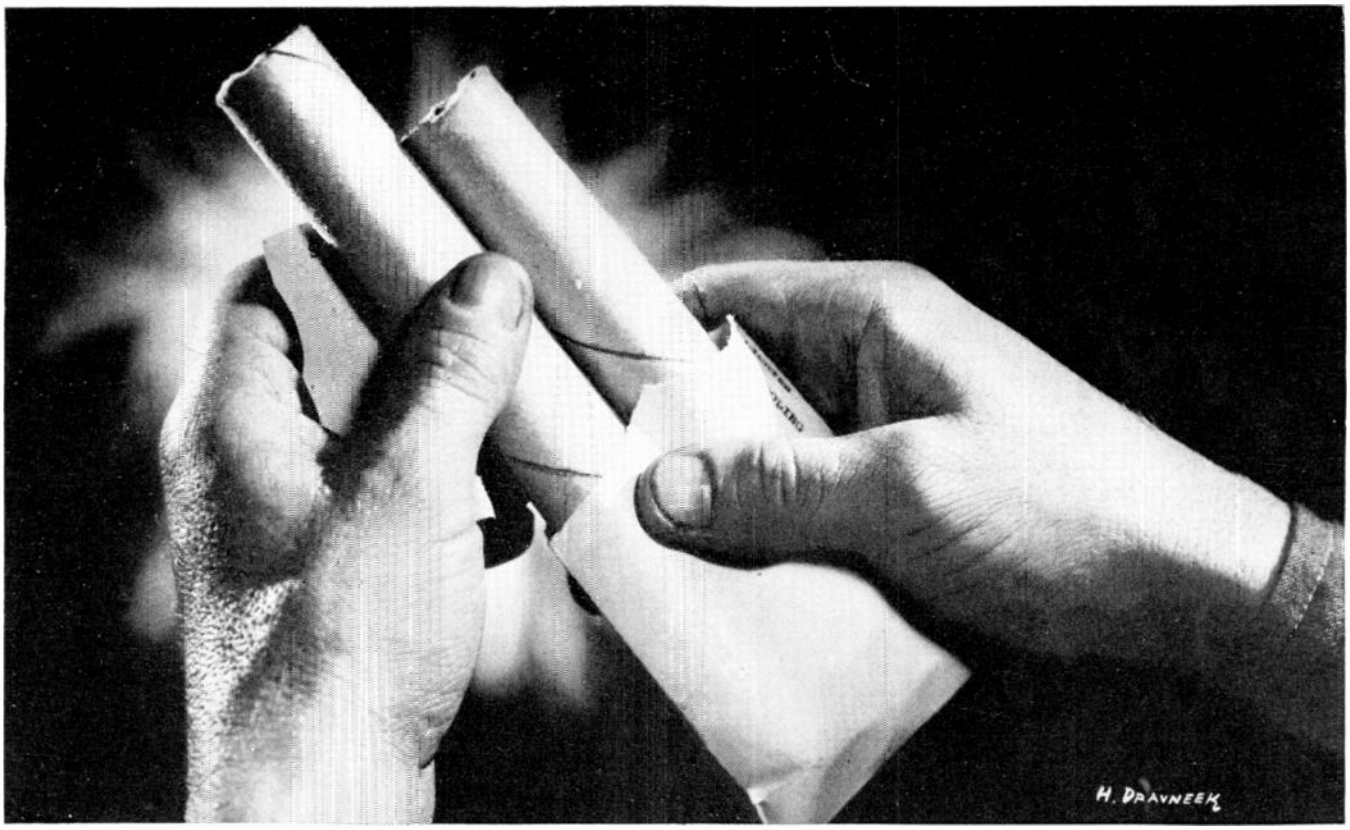
Thousands of ARHCO parts roll out of our plant every day. Always built to superior standards, they've been improved to an even higher degree because of stringent wartime specifications. We welcome your inquiries.


**American Radio Hardware Co., Inc.**

**476 BROADWAY • NEW YORK 13, N. Y.**

*MANUFACTURERS OF SHORT WAVE • TELEVISION • RADIO • SOUND EQUIPMENT*




# Mister—you're getting paid in DYNAMITE!

LET'S NOT KID OURSELVES about this. Our pay envelope today *is* dynamite.

If we handle it *wrong*, it can blow up in our face . . . lengthen the war . . . and maybe wreck *our* chances of having happiness and security *after* the war.

**The wrong way to handle it . . . and why**

The wrong way is for us to be good-time Charlies. To wink at prices that look too steep . . . telling ourselves we can afford to splurge.

We *can't* afford to—whether we're business men, farmers, or workers. And here's why:

Splurging will boost prices. First on one thing, then all along the line.

Then, wages will have to go up to meet higher prices. And higher wages will push prices up some more . . . faster and faster, like a runaway snowball.

The reason this can happen is that there is more money in pay envelopes today than there are things to buy with it. This year, we Americans will have *45 billion* dollars more income than there are goods and services to buy at present prices. *45 billion dollars extra money!*

That's the dynamite!

**The right way to handle it . . . and why**

Our Government is doing a lot of things to keep the cost of living from snow-balling.

Rationing helps. Price ceilings help. Wage-and-rent stabilization helps. Higher taxes help. They're *controls* on those dangerous excess dollars.

*But the real control is in our hands. Yours. Mine.*

It won't be fun. It will mean sacrifice and penny-pinching. But it's the only way we can win this war . . . pay for it . . . and keep America a going nation afterwards.

And, after all, the sacrifice of tightening our belts and doing without is a small sacrifice compared with giving your life or your blood in battle!

**Here's what You must do**

***Buy only what you absolutely need.*** And this means absolutely. If you're tempted, think what a front-line soldier finds he can get along without.

***Don't ask higher prices***—for your own labor, your own services, or goods you sell. Resist pressure to force YOUR prices up.

***Buy rationed goods only by exchanging stamps.*** Shun the Black Market as you would the plague.

***Don't pay a cent above ceiling prices.***

***Take a grin-and-bear-it attitude on taxes.*** They must get heavier. But remember, these taxes help pay for Victory.

***Pay off your debts. Don't make new ones.*** Getting yourself in the clear helps keep your Country in the clear.

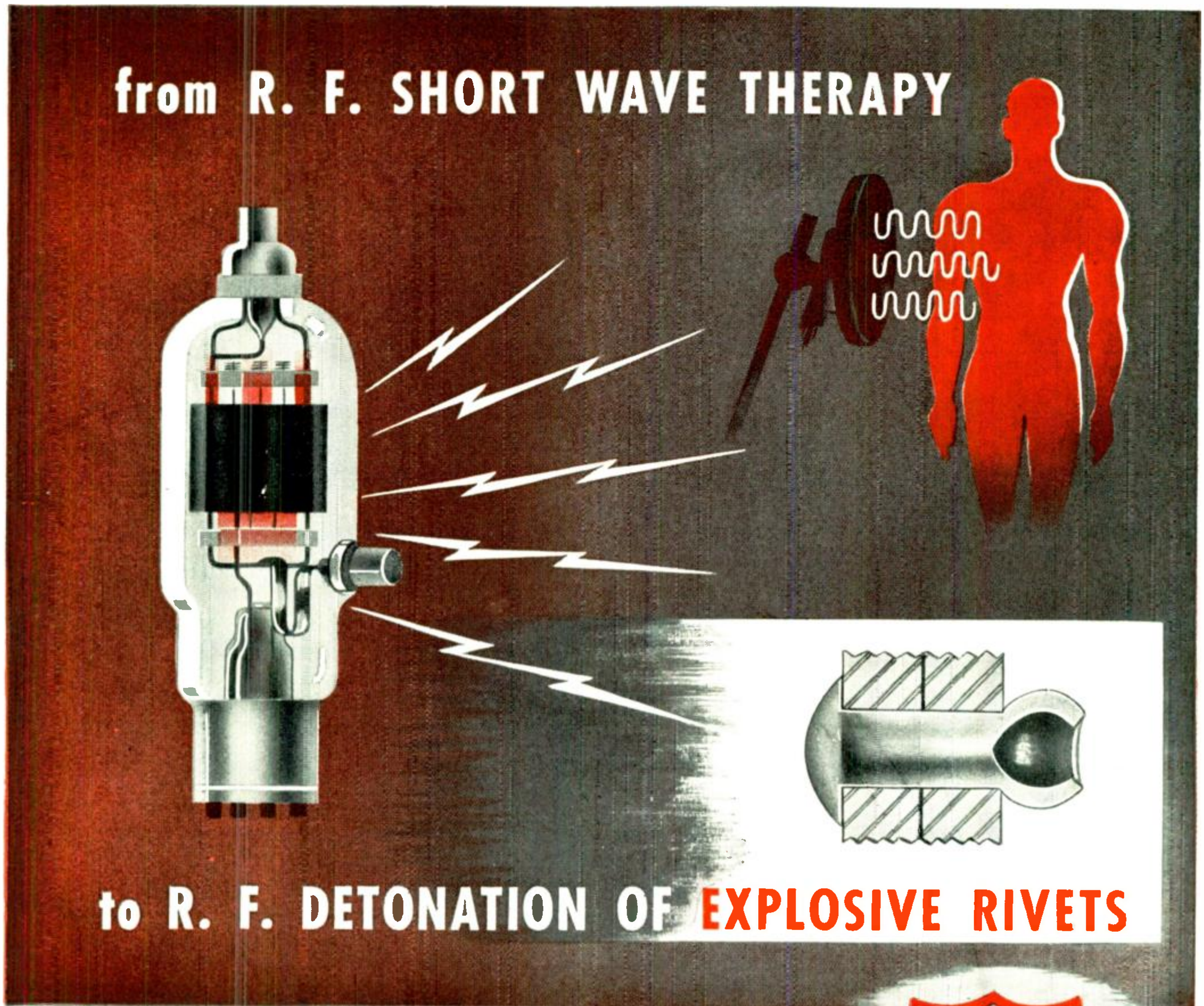
***Start a savings account. Buy and keep up adequate life insurance.*** This puts your dollars where they'll do you *good*.

***Buy more War Bonds.*** Not just a "per-cent" that lets you feel patriotic, but enough so it *really* pinches your pocket-book.

If we do these things, we and our Government won't have to fight a post-war battle against collapsing prices and paralyzed business. It's *our* pay envelope. It's up to *us*.

**KEEP PRICES DOWN!** Use it up • Wear it out · Make it do • Or do without

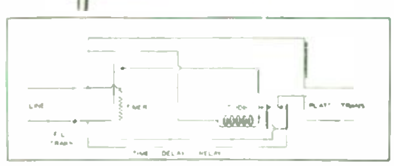
This advertisement, prepared by the War Advertising Council, is contributed by this Magazine in co-operation with the Magazine Publishers of America.




# RELAYS BY GUARDIAN

From rebuilding human bodies—to riveting aircraft structures . . . from case hardening of metals to plywood glueing . . . wherever a tube is used, there you will usually find a relay. Oscillator tubes such as are used to generate radio frequencies in diathermy machines and detonators for explosive rivets usually require a "warm up" of 20 to 30 seconds to allow the tube filaments to heat. The Guardian Time Delay Relay T-100 is frequently used in applications of this type.

The time delay is adjustable for any period between 10 and 60 seconds and is accomplished by means of a resistance wound bi-metal in series with a resistor, not shown. The contact capacity of the T-100 is 1500 watts on 110 volt, 60 cycle, non-inductive AC. The power consumption of coil and time delay during closing of thermostatic blade is approximately 10 VA; after closing, 5.5 VA. Other types of relays commonly used in conjunction with oscillator tubes are the B-100 Break-In Relay for power supply control, and the X-100 Adjustable Overload Relay for power supply and tube protection. These and other R.F. relays are described in Bulletin R-5. Send for it. No obligation.



T-100 Time Delay Relay

**GUARDIAN ELECTRIC**

1642-J WEST WALNUT STREET CHICAGO, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY

# FM FINDS NEW FIELDS TO CONQUER

## FM Walkie-Talkies—FM for Military Aircraft—W39NY Tops New York Stations for Quality—Who Invented FM?

BY MILTON B. SLEEPER

THE LATEST conquest of FM over AM is in the field of the most widely publicized piece of military radio equipment in use by our Armed Forces — the walkie-talkie.

Officially adopted by the Signal Corps in 1933, the walkie-talkie originally employed Major Armstrong's super-regenerative circuit. Now, after ten years of service, it has been modernized by the adoption of his newer system of Frequency Modulation.

**FM Walkie-Talkie** ★ The reasons for this change, and the improvements effected are interesting because they are the same as those which have brought about the shift to FM in broadcasting, police radio, and other fields of communications.

The range of dependable operation with FM walkie-talkie units is three times that delivered by the AM type, according to the War Department. Although head phones are now furnished in addition to a telephone hand set, and other improvements have been added, the total weight is still 35 lbs.

That the range could be so greatly increased without changing the weight is due to the greater efficiency of FM radiophone transmitters for a given power, large or small, compared to AM transmitters. Other factors contributing to the improvement of performance are the reduction of static interference and interference from other units working on the same frequency, and the fine clarity of speech which characterizes the new FM model.

But these are not the only reasons for the change. Comparing the performance of AM and FM walkie-talkie equipment, the former has proved to be limited to a dependable receiving range of something less than a mile during daylight hours, while at night the receiver picks up howls and squeals from stations 1,500 miles away! Such interference renders the equipment practically useless at times.

The FM unit, on the other hand, has a consistent range, night or day, far greater than can be obtained from the AM type, thus eliminating the uncertainty which has characterized walkie-talkie communication up to the present time.

Moreover, since several FM units can be used simultaneously on the same frequency in the same area without heterodyne interference, communications networks can be set up which provide a degree of effectiveness that could not be obtained with AM transmission.

**FM Needed for Military Aircraft** ★ The radio communications equipment most widely used for our military aircraft is an English AM design which, measured by our standards, leaves much to be desired. There were good reasons for its adoption by our Armed Forces in the beginning, but it is not proving adequate to the needs of our pilots.

Its most serious defect is its susceptibility to ignition interference. Filtering out electrical noise is the greatest problem encountered in aircraft radio installations and with all the experience that engineers now have, no completely satisfactory method has been found. Beside, what works on one type of plane may be worthless on another.

The only answer is a complete shift to FM for plane-to-plane and plane-to-ground communication. That, of course, would be a tremendous step for the Army and Navy to take, but the change is inevitable. It would mean selling the idea to the British, or foregoing the present advantages of interchangeability. The former course would be difficult. Somehow, the British have an infinite capacity for getting along with what they have, whether it is foggy weather or radio interference, and doing very well with them, at that. But our own forces shouldn't be limited to what may satisfy the British any longer at least than is necessary.

There is another serious disadvantage

(CONTINUED ON PAGE 54)

LUNCHING TOGETHER ARE W. J. HALLIGAN OF HALLICRAFTERS, MAJ. GEN. H. C. INGLES CHIEF OF SIGNAL CORPS, LT. COL. J. M. NIEUHOUS REGIONAL LABOR OFFICER, BRIG. GEN. E. L CLEWELL COMMANDING CHICAGO SIGNAL DEPOT, AND PAUL GALVIN PRESIDENT OF R.M.A. AND GALVIN MANUFACTURING COMPANY

# A FAMOUS FM RECEIVER

## Originally Designed for Broadcasting Stations, This Model Is Being Used to Test Military Equipment

BY LESLIE NOZDROVICZKY*

THE original purpose of the REL type 517A receiver was for checking the quality of FM broadcasting stations. In that capacity, it was used as a station monitor and by manufacturers of FM receivers for comparison purposes.

In fact, the electrical design work was done by James Day, one of Major E. H. Armstrong's associates at Columbia University, with REL engineers collaborating in the final production model.

During recent months, the demand for these sets to be used in FM research and testing has caused an acute shortage, since they are not being manufactured at this time. Accordingly, the details of the model 517A are presented here in the hope that they may be of assistance to those who are confronted with the need of building their own equipment for laboratory use in making measurements, or for performance standards.

The circuits are designed to take full advantage of the high fidelity and low noise level of FM transmission. The list of tubes and their functions gives an overall picture of the circuit:

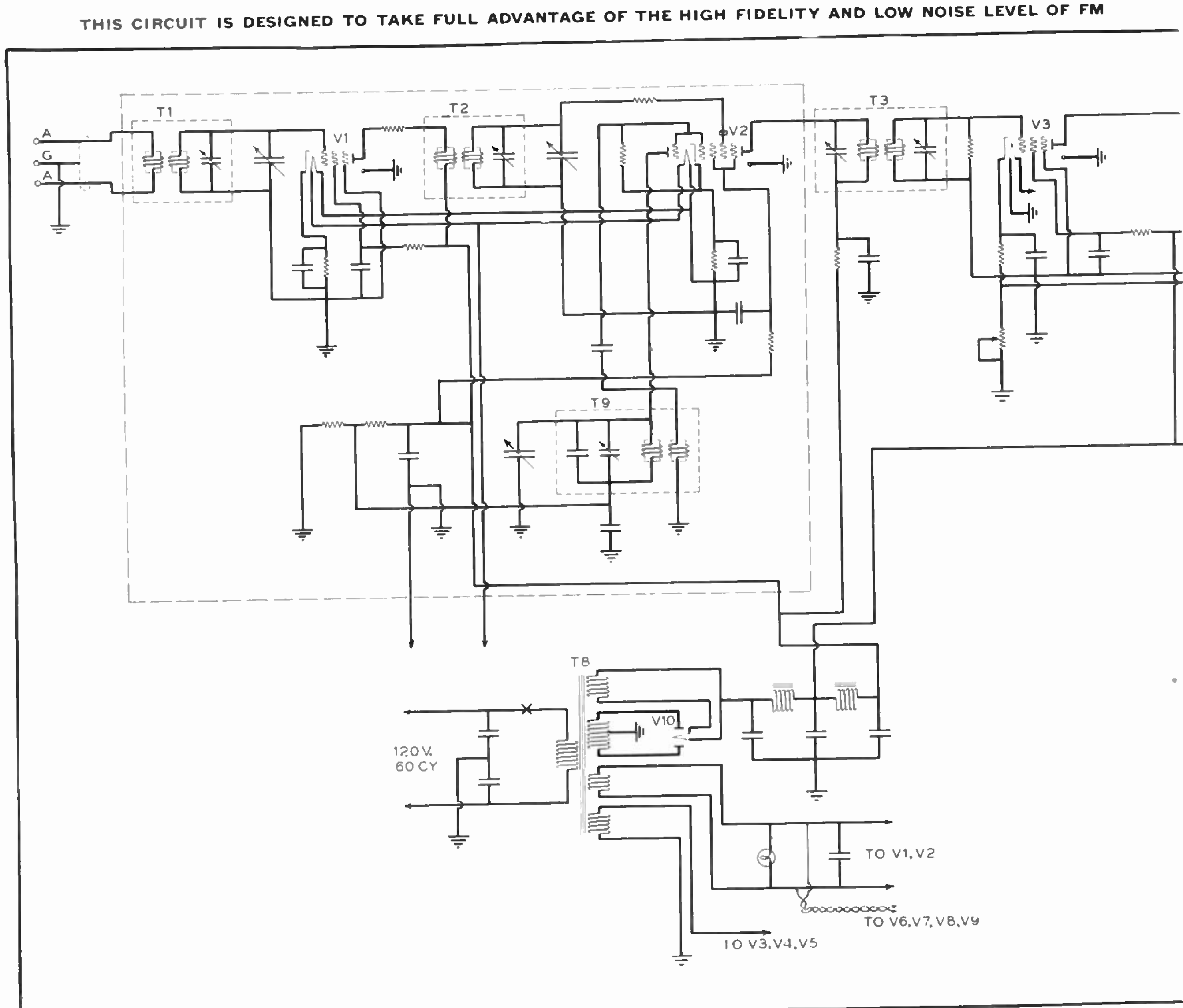
V1 — 1852 or 6AC7 RF amplifier
V2 — 6K8 Mixer and oscillator
V3 — 1852 or 6AC7 1st IF amplifier
V4 — 1852 or 6AC7 2nd IF amplifier
V5 — 6SJ7 Limiter
V6 — 6H6 Detector
V7 — 6CAG AF amplifier and phase inverter
V8 — 6V6 Output
V9 — 6V6 Output
V10 — 83V Rectifier

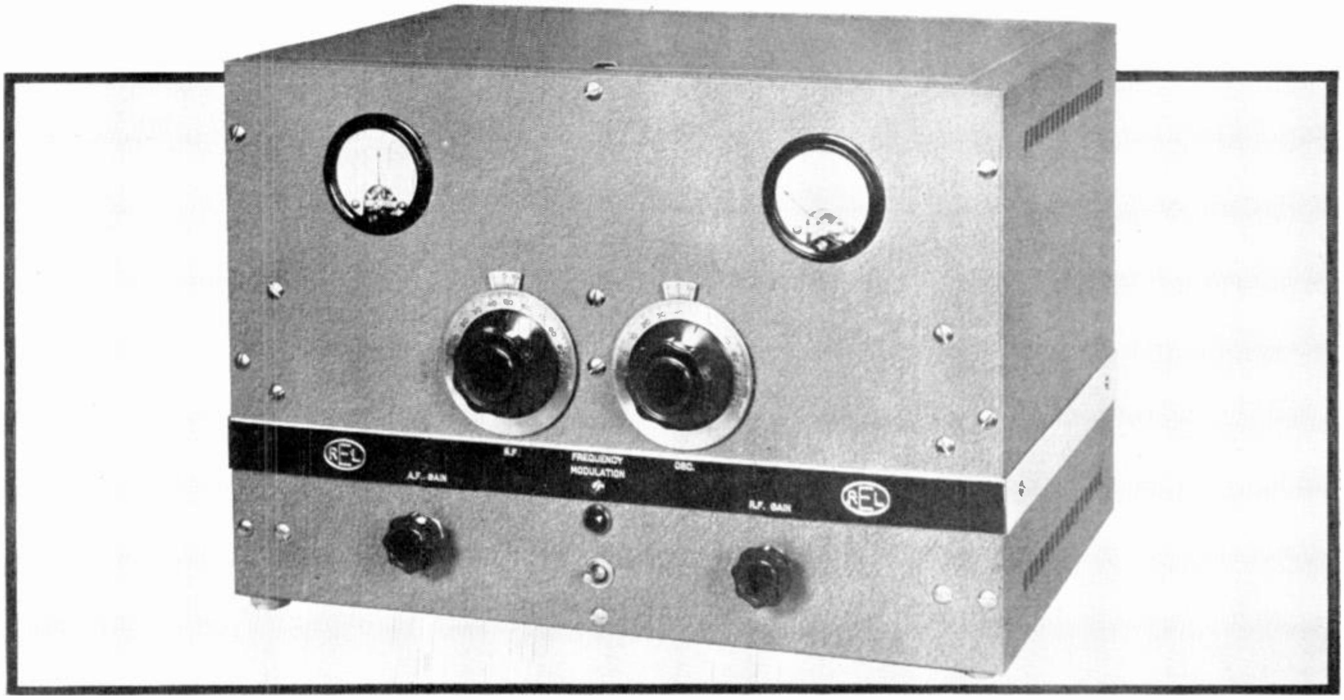
A balanced input circuit is employed, with an input impedance of approximately 100 ohms, for operation with a balanced dipole antenna.

The tuning range is 42 to 50 mc. Unlike receivers intended specifically for use in the home, this set has two tuning controls, as shown in the accompanying front view. The RF grids of the RF and mixer tubes are tuned by a two-gang condenser, while the oscillator tank circuit is tuned by a separate condenser. By this dual arrange-

*Engineering Department, Radio Engineering Laboratories, Inc., Long Island City, N. Y.

THIS CIRCUIT IS DESIGNED TO TAKE FULL ADVANTAGE OF THE HIGH FIDELITY AND LOW NOISE LEVEL OF FM





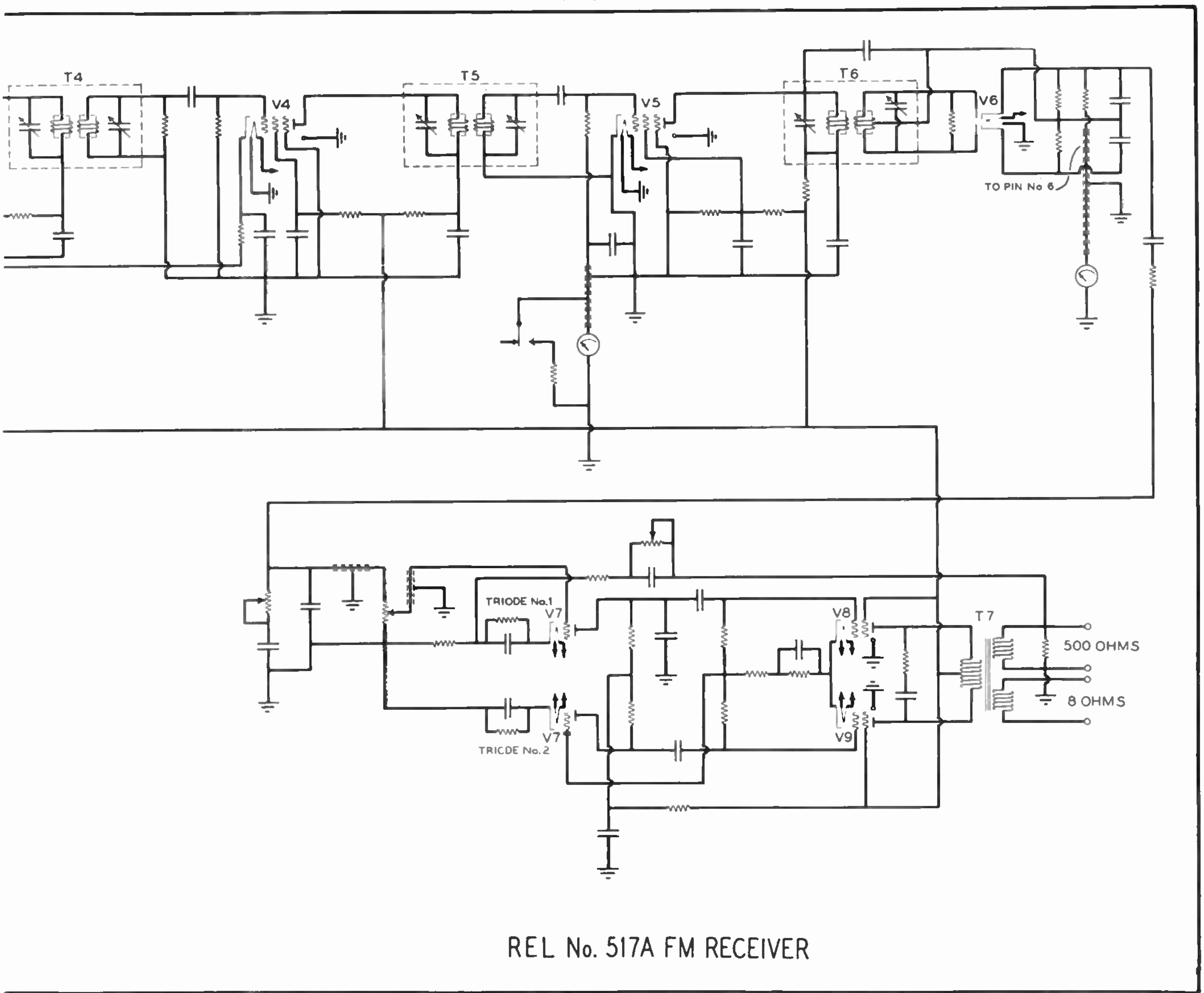

THE REL MODEL 517A FM RECEIVER, FOR 42 TO 50 MC., EMPLOYS ONE DUAL AND ONE SINGLE CONDENSER FOR TUNING

ment, the operator can tune more accurately to a given frequency. The possibility of excessive side band attenuation caused by errors in the tracking of the RF and oscillator circuits is eliminated.

A second shield encloses the RF and oscillator sections.

(CONTINUED ON PAGE 47)

THE GAIN FROM THE ANTENNA TO THE LIMITER GRID IS 1,000,000. LIMITER SATURATION IS OBTAINED WITH A 10-VOLT INPUT




REL No. 517A FM RECEIVER

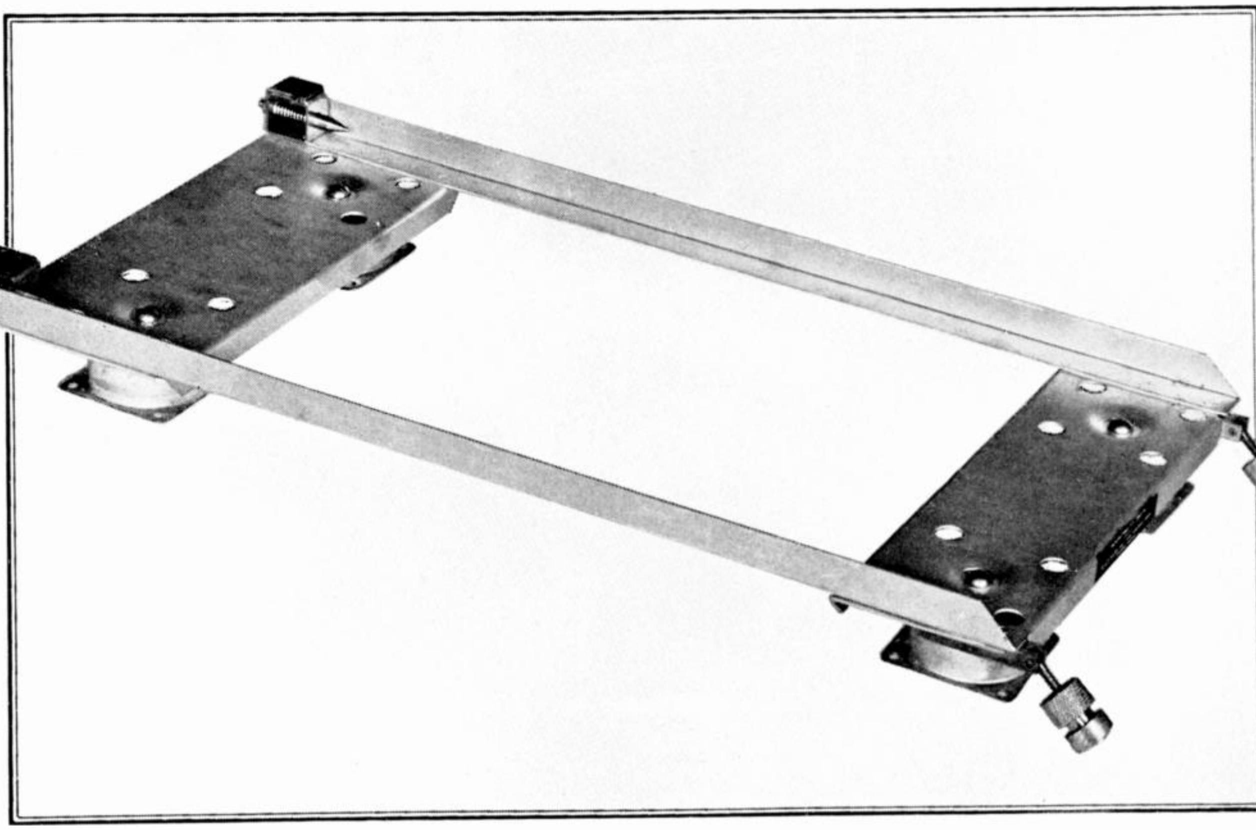


FIG. 1. AN A-N STANDARD TYPE AIRCRAFT RADIO RACK MANUFACTURED BY DELCO. NOTE ITS SIMPLICITY OF CONSTRUCTION

# DESIGN PLANNING FOR AIRCRAFT RADIO

## Part 4—Standard A-N Type of Aircraft Racks, with Notes on the Details of Materials and Construction

BY BURT L. ZIMET *

COMPARED to the elaborate types of rack mountings which have been used for aircraft equipment, the new Army-Navy design is extremely simple. However, nothing has been sacrificed, and much has been gained by eliminating trick arrangements which, experience has shown, too frequently get out of adjustment as a result of rough handling.

The A-N standard design[1] consists of front and rear shock-mounted channels, connected by angle strips which serve to guide the chassis and dust cover into place. Tapered pins at the rear are forced into holes in the chassis when the thumb nuts are tightened at the front. In this construction there is nothing to get out of adjustment, and no tolerances close enough to interfere with the quick insertion or removal of the chassis.

Fig. 1 shows the rack ready for mounting. The under side is illustrated in Fig. 4. This particular rack, manufactured by Delco, departs in some minor details from the drawings in Figs. 2 and 3. Such deviations are permissible as long as they do not affect the essential dimensions or interchangeability.

All the critical dimensions are given in Figs. 2 and 3. As the drawings show, there are four different sets of front and rear channels, corresponding to the chassis and dust cover widths A, B, C, and D, described in detail in the August, 1943 issue of *FM* RADIO-ELECTRONICS.

The same size of Lord shock absorbers are used for the A, B, and C channels, but the D channels take a larger size. The dimensions are given in the table in Fig. 2. There are holes in the channels corresponding to the mounting holes in the shock absorbers, to provide access to the mounting screws. Thus the rack can be fastened in place without being disassembled, and the rack serves as a template for locating the screws.

Cold rolled steel .062 in., with cadmium plating, is specified for all sizes of front and rear channels. The angles which connect the channels, however, are stainless steel, ¾ in. wide on both sides and .062 in. thick.

As Fig. 2 shows, the channels and angle strips are riveted together in assembly, and then spot welded. Dimension X, Fig. 2, appears in the Table of Dimensions as 19.640 ins. However, this is subject to adjustment in accordance with the depth of the chassis. Depth dimensions were given in a note on Figs. 3 and 4, Part 3 of this paper. Changes in the depth of the chassis do not affect the front and rear channels, but only the lengths of the angle strips.

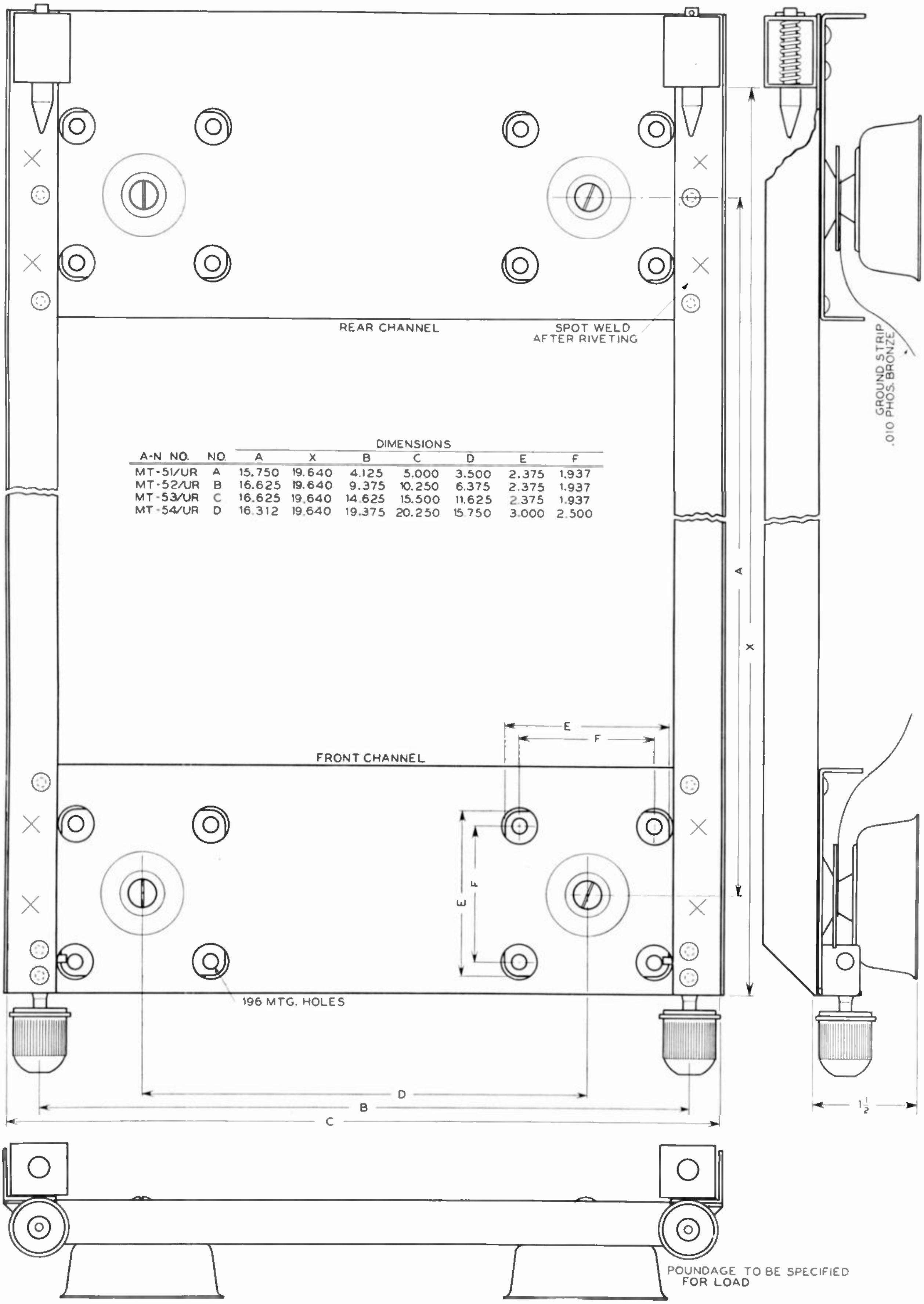
Stainless steel is required for the hardware mounted on the front channel, except for the thumb nut, which should be nickel-plated brass.

The pin brackets at the rear are also of stainless steel, but the pins are of brass. The springs which press the pins forward are .045-in. music wire, cadmium plated.

It should be noted that the full diameter of the pin heads is .306 in., while the holes in the chassis, into which the pins fit, are .213 in. in diameter. Thus the effect of tightening the thumb nuts at the front is to force the holes in the chassis against the beveled sections of the pins, but not up to the full diameter. At the same time, the pins are pushed

* Design engineer, Freed Radio Corp., 200 Hudson St., New York City.

[1] For details of corresponding chassis and dust covers, see Part 1, *FM* RADIO-ELECTRONICS, August, 1943.




| A-N NO. | NO. | A | X | B | C | D | E | F |
|---|---|---|---|---|---|---|---|---|
| | | DIMENSIONS | | | | | | |
| MT-51/UR | A | 15.750 | 19.640 | 4.125 | 5.000 | 3.500 | 2.375 | 1.937 |
| MT-52/UR | B | 16.625 | 19.640 | 9.375 | 10.250 | 6.375 | 2.375 | 1.937 |
| MT-53/UR | C | 16.625 | 19.640 | 14.625 | 15.500 | 11.625 | 2.375 | 1.937 |
| MT-54/UR | D | 16.312 | 19.640 | 19.375 | 20.250 | 15.750 | 3.000 | 2.500 |

FIG. 2. THE NEW A-N STANDARD RACK, SHOWING ESSENTIAL DIMENSIONS OF THE A, B, C, AND D ASSEMBLIES USED WITH THE FOUR SIZES OF CHASSIS AND DUST COVERS

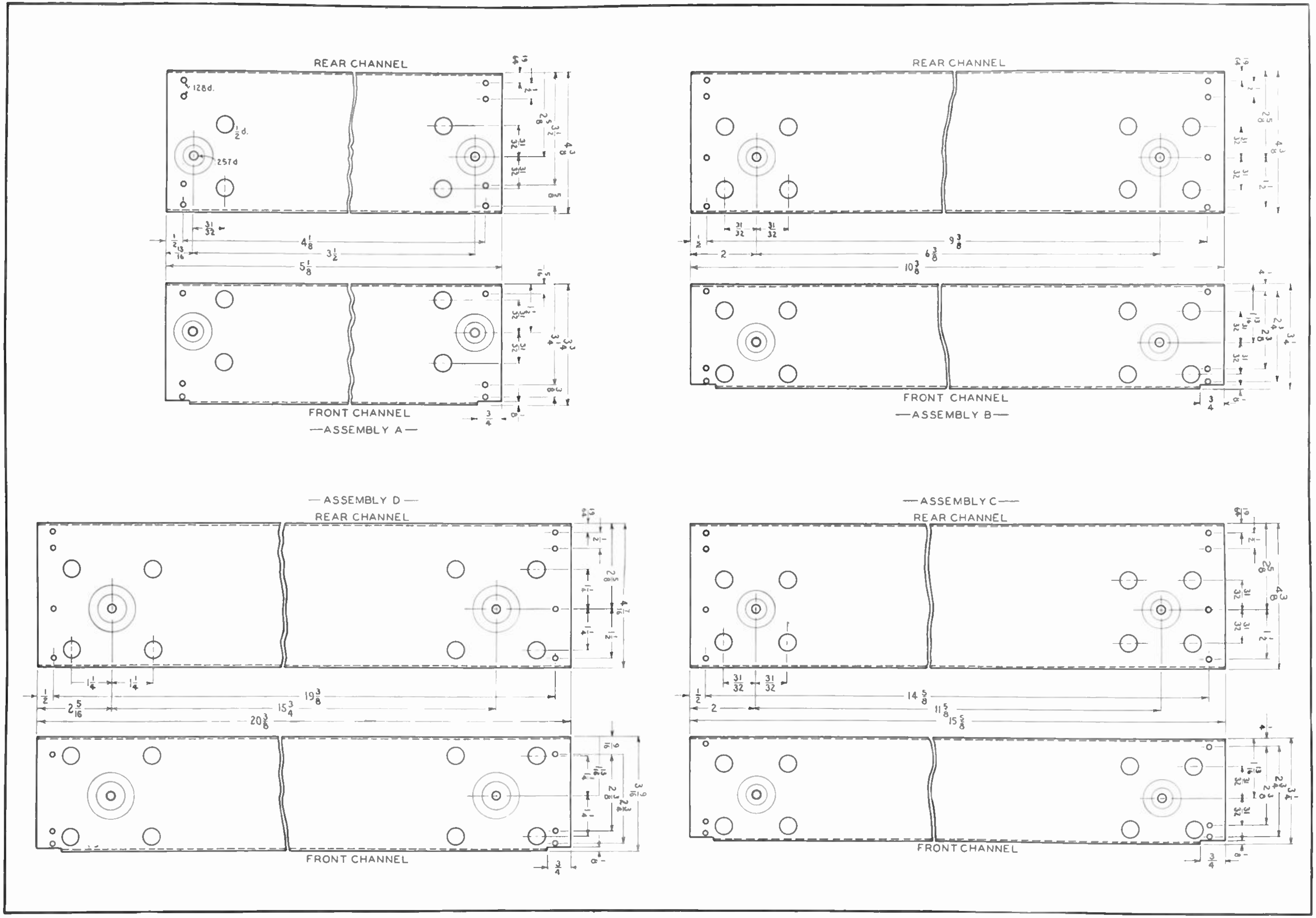



FIG. 3. ESSENTIAL DIMENSIONS OF THE FRONT AND REAR CHANNELS FOR THE A, B, C, AND D AIRCRAFT RADIO RACK ASSEMBLIES, ARRANGED FOR READY COMPARISON

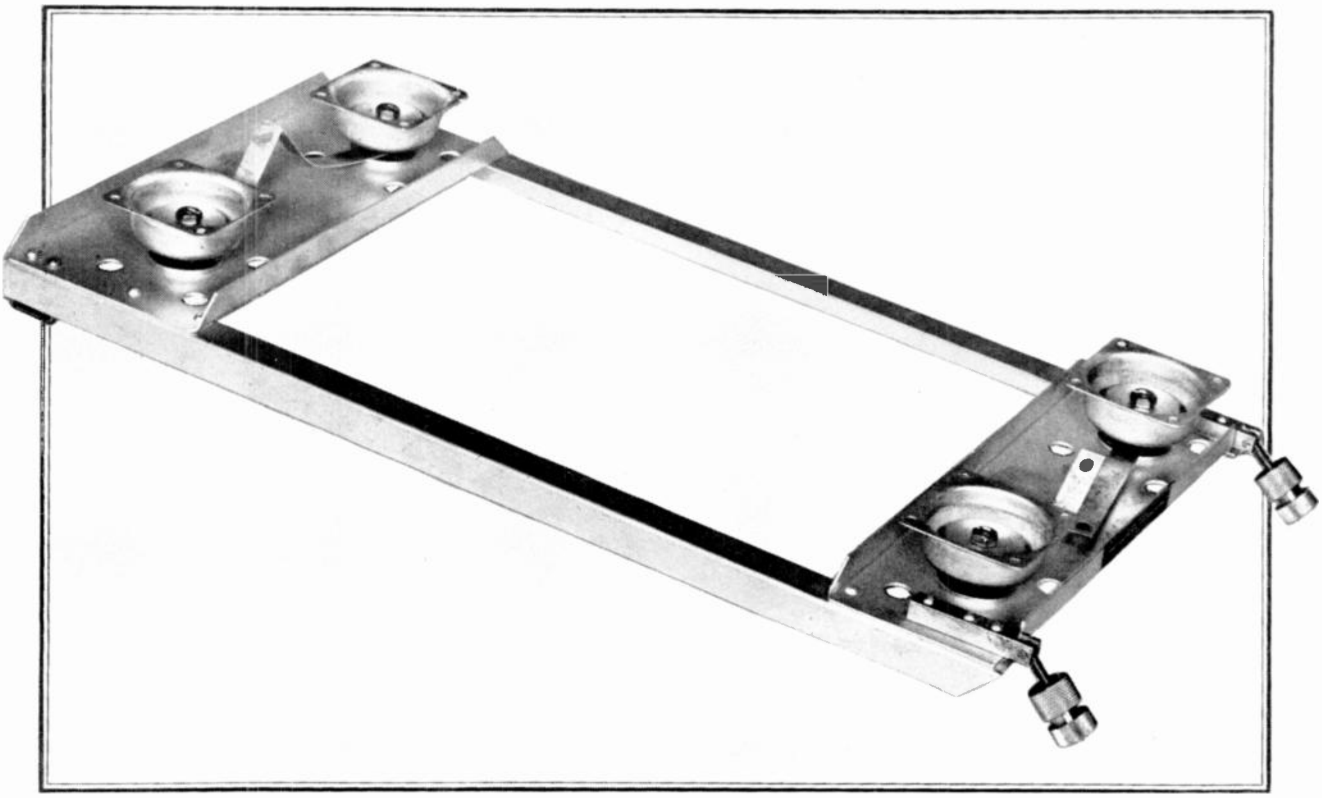


FIG. 4. THE UNDER SIDE OF THE A-N RACK, PHOSPHOR BRONZE STRIPS PROVIDE GROUND CONNECTIONS

back against the springs. In this way, spring tension is maintained against the rear of the chassis, and it is not forced back against fixed stops.

On the front of the chassis, as shown in Figs. 1 and 3 of Part 3, there are hooks against which the thumb nuts are tightened. Accordingly, the thumb nuts are counter-bored with a 10° taper, so as to provide a tight hold on the chassis hooks.

Shock absorbers of various load capacities are available in the base dimensions specified in Fig. 2. The load must be determined before the shock mountings are purchased. This is important for, if the load is too heavy for the mountings, the rack will be pressed down on the upper safety discs, and there will be no shock absorbing effect. On the other hand, if a light load is carried on heavy-duty mountings, vibration will be carried to the chassis and the apparatus on it.

All the essential dimensions for the front and rear channels are given in Fig. 3. Each channel is bent over ⅝ in. at the front and rear to provide extra strength. While the holes are moved forward or back in the different channels for A, B, C, and D assemblies, their relations to each other are unchanged except for the D channels, which use larger shock mountings. The A size carries the shock mountings so near the ends that access holes for the rack mounting screws are only provided for the inside holes. The other holes come outside the rack, in the clear.

Each front channel has one rivet hole at the back for a rivet passing through the angle strip. At the front, there are two holes for rivets which go through the angle strip and also hold the stud bracket. This is made clear in Fig. 4, although the stud bracket illustrated has three rivets instead of the two called for in the A-N drawings.

Similarly, the rear channels all have three holes for rivets at each end. One rivet passes through the channel and into the angle strip, while the other two include the pin bracket.

After the channels and angle strips have been assembled with rivets, they are spot welded at two points in the front and rear, as indicated in Fig. 2. This relieves the rivets of shearing strain, and minimizes the possible failure under vibration.

### Further Modifications

**ACCORDING to advice just received from Lt. Col. George L. Haller, Chief, Research Division, Aircraft Radio Laboratory, further modifications of the A-N chassis, dust cover, and rack designs are being made. It is evident, therefore, that the details presented in Mr. Zimet's articles require final checking before the present A-N designs are used in production.**

**We have been assured that we shall have the data on any further changes as soon as they have been made final, and they will be presented to our readers in a subsequent article by Mr. Zimet.**

Some of the earlier rack mounting designs provided female parts of separable connectors at the rear to take male parts mounted on the chassis. While such arrangements had certain advantages, they did not prove altogether satisfactory in practice. If the rack became bent, for example, the part of the connector on the chassis might not be brought into alignment with the part on the rack. In general, the alignment of connectors causes trouble if it can be affected by the misalignment of other parts.

Moreover, it was found awkward to install cables at the rear of apparatus compartments. The latest practice is to put all connectors on the front of the chassis. Then, with the cables coming up at the front where they are readily accessible, the connectors can be joined after the chassis is in place on the rack.

Although the A-N rack design is intended specifically for aircraft use, there is no reason why it cannot be applied to equipment intended for mobile service and other purposes where there is a vibration problem. This rack, with the corresponding chassis and dust cover design, would serve admirably for police patrol cars, to take a specific instance.

The rack could be fastened permanently to the floor of the baggage compartment. Then it would be easy to slip in the transmitter and receiver, or to remove them with equal dispatch for routine servicing or repair.

EDITOR'S NOTE. *Part 5 of Bert Zimet's paper on aircraft apparatus design, dealing with components, will appear in an early issue.*

# SPOT NEWS NOTES

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

**FM Walkie-Talkie:** Latest conquest of Major Armstrong's Frequency Modulation system is its replacement of AM circuits in Army's walkie-talkie equipment. Probably the first military application of small FM units was the pack set designed by F. M. Link for the Dutch Government (FM RADIO-ELECTRONICS, September, 1942). See page 15 of this issue for a further discussion of this and other new FM applications.

**C. A. Priest:** Appointed manager of the General Electric transmitter division, with headquarters at Syracuse, N. Y. One-time G.E. radio salesman in Japan, Priest has been engineering high-power transmitters since 1928.

**Production Testing:** Much interesting information is contained in a new pamphlet on the Rotobridge, concerning its operation and application to high-speed testing of vacuum tube equipment produced in large production runs. It is available from Communication Measurements Laboratory, 120 Greenwich Street, New York City.

**Parker E. Wiggin:** After serving since April, 1942 in the Office of the Chief Signal Officer as chief business advisor to the Procurement Division, he has been released at his own request, and will return to his former post as merchandise supervisor of radio and electrical instruments at the General Merchandise Offices of Sears Roebuck, Chicago. Many executives in the radio industry will be sorry to hear of this change, for Parker Wiggin did a great deal of constructive work in setting up the functions of his office on a well-organized basis, and his strict adherence to sound practices had the end result of smoothing the path for many contractors.

**Armstrong Licensees:** Following is an authorized list of the 25 companies licensed by Major Armstrong for the use of his Frequency Modulation and related patents for commercial applications. Major Armstrong has granted to the U. S. Government the right to use his patents for military equipment on a royalty-free basis.

- Cover Dual Signal Systems
- Doolittle Radio Inc.
- Espey Manufacturing Company Inc.
- Fada Radio and Electric Company, Inc.
- Finch Telecommunications, Inc.
- Freed Radio Corporation
- Garod Radio Corporation
- General Electric Company
- The Hallicrafters, Inc.
- Hammarlund Manufacturing Company
- Howard Radio Company
- Fred M. Link
- The Magnavox Company, Inc.
- Meissner Manufacturing Company
- The National Company, Inc.
- Philharmonic Radio Corporation
- Pilot Radio Corporation
- Radio Engineering Laboratories, Inc.
- E. H. Scott Radio Laboratories, Inc.
- Stewart-Warner Corporation
- Stromberg-Carlson Telephone Company
- Universal Television System
- Western Electric Company, Inc.
- Zenith Radio Corporation.

It is understood that other licenses are in process of negotiation, but no information concerning them has been released.

MCMURDO SILVER, V.P. IN CHARGE OF ELECTRONICS AT GRENBY MFG. CO., DEMONSTRATES ACCURACY OF NEW PRIMARY PRECISION STANDARD TO PRESIDENT CARL A. GRAY, LEFT, AND VICE PRESIDENT RALPH H. SOBY

**Muskegon, Mich.:** Station WKBZ has filed an application with the FCC for a new FM station to be operated on 45.7 mc., with a service area of 2,290 square miles. Application has also been made for permission to erect an FM radiator atop the present AM antenna.

FRANK W. WALKER, PRESIDENT OF APCO

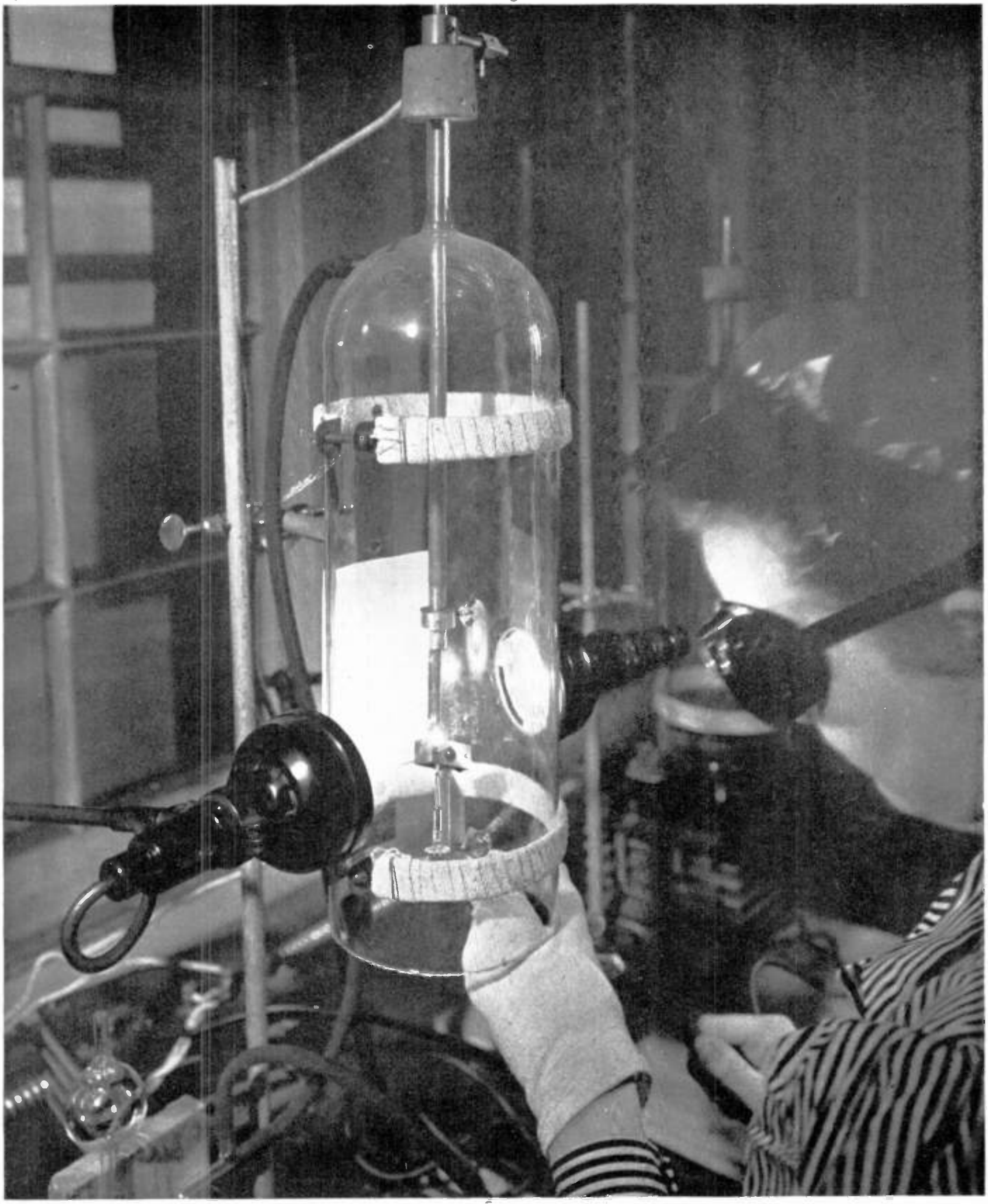
**APCO President:** Frank W. Walker, midwest's pioneer of state-wide FM police radio communication and chief engineer of the 44-station Michigan State Police FM network, was elected President of the Associated Police Communication Officers, Inc., at the close of the Tenth Annual War Communications Conference at Madison, Wisconsin on September 2, 1943.

Ero Erickson, Supervisor of the Illinois State Police Radio System at Chicago, was chosen Secretary-Treasurer, in recognition of his Chapter building work, succeeding James H. Teeter of the St. Louis police.

The three-day meeting selected a large Post War Planning Committee to prepare a program which would anticipate post-war police radio technical and frequency allocations requirements, in coöperation with the FCC, IRE, and RMA. Recent priority developments affecting radio equipment were explained by Frank McIntosh of the War Production Board, and representatives from the Office of Civilian Defense outlined the progress of the WERS program.

Ray Groenier, conference chairman, was elected 1st vice president, R. M. Jones of Birmingham, Alabama, 2nd vice president, and William E. Taylor of the Baltimore Police, Sergeant-at-Arms. J. M. Wherritt, Communications Officer of the Missouri State Highway Patrol, was again re-elected editor of the APCO Bulletin. The response by the manufacturers

(CONTINUED ON PAGE 57)



# NEWS PICTURE

EXPERIENCE shows that two primary factors determine the success of women in radio factories who are starting to work for the first time.

Most important is preliminary training adequate to give them an understanding of the operations they are to perform, so that they reach a fair rate of production without having a discouraging number of rejections. This gives them a feeling of confidence. Also necessary are well-built fixtures to help them speed their work. These give them a sense of efficiency.

The result is a realization of the importance of what they are doing, and this is the most effective means to guard against the attitude of indifference which shows as in absenteeism.

The picture above shows a woman worker performing a welding operation on Amperex transmitting tubes. This Company has been highly successful in employing women without previous factory experience. Such work calls not only for skill and precision, but for an intelligent understanding of the processes involved.

# AN EXPLANATION OF FREQUENCY MODULATION

## A Clarification and Comparison of the Characteristics of Amplitude and Frequency Modulation, Part 1

BY W. L. EVERITT *

**IN JUNE, 1940, Prof. W. L. Everitt delivered before the summer convention of the AIEE a paper on Frequency Modulation which is now considered a classic exposition on this subject.**

**Although the preparation of his paper dates back almost four years, the clarity of the data presented and the accuracy of his conclusions make this paper of great value for study and engineering reference purposes today.**

**In fact, its publication here is in response to the recommendations of engineers who have pointed out its usefulness to newcomers in the field of FM communications.**

**Prof. Everitt's paper is published in full except for the section on Spectrum Analysis, which will be found in the Proceedings of the AIEE for November, 1940.**

RADIO communication makes use of a medium common to the whole world for the transmission of many signals simultaneously. In order to accomplish this a high-frequency electromagnetic wave has one of its characteristics varied in accordance with the instantaneous variations of the signal to be transmitted. The control of these variations is called modulation. The various simultaneous messages can then be separated by:

(*a*) Differences in the frequency band used.

(*b*) Differences in signal strength.

(*c*) Differences in direction of the source.

The allocation of frequencies and geographic location to stations engaged in different services is now a matter of legislation and international agreement. This regulation is necessary in order to reduce interference to a minimum.

The range of a radio station is limited solely by the point at which undesired interference reduces the quality of the received signal below a certain minimum. The amount of interference which may be tolerated differs with different classes of service, for instance, it would be less on a broadcast program designed to produce pleasure, than on a communication service designed to convey intelligence.

There are five principal sources of interference to radio reception. They are:

(*a*) Interference from other radio stations.

(*b*) Interference from natural electrical disturbances such as thunderstorms (static).

(*c*) Interference from electrical equipment not intended for radio purposes.

(*d*) Interference between identical signals traveling from the station originating the desired signal, but over two different paths. Since radio waves are alternating phenomena resolvable into a band of frequencies, the addition of two similar signals traveling over different paths must take account of both magnitude and phase. Distortion in the resultant signal may result due to the varying phase relations between the components with the same frequency in the two signals. One of the paths is usually caused by reflection from some medium such as the ionosphere. If this path varies in length with time, fading will result. When this produces distortion the phenomenon is called selective fading.

(*e*) Interference from random noise produced in the receiver by fluctuations in the motion of the electrons in the early stages of the amplifiers.

The major problems of the radio engineer are:

I. To obtain the maximum range at the minimum cost.

II. To secure the desired quality in the reproduction of signals.

Because the range is determined by the interference, and the quality is greatly affected by it, the reduction of interference becomes of paramount importance.

The reduction of interference must be accomplished by making use of some characteristic which differentiates the desired signal to a greater or less extent from the undesired interference. Four methods of differentiation have been extensively used. Each method in turn has its limitations. These methods and their limitations are:

1. Use of high power in the transmitter so that the strength of the desired signal will dominate the undesired.

This method is limited by the cost of high powered transmitters and by the interference it introduces to other services. Furthermore it does not affect selective fading since both signals (coming over two paths) are increased by the same amount.

2. Increasing the modulation of the radio wave to the greatest possible value.

This method is limited in amplitude modulation because it is not possible to vary the magnitude of a radio wave by more than 100 per cent and interfering signals, including static, will in general be modulated by similar amounts.

3. Use of selective circuits in the receiver so that only energy in the narrow band of frequencies which includes the desired signal will be received.

This method is limited because a definite band width is necessary for any given quality of reproduction and within this band there may be some portion of the energy in the spectrum of the interference.

4. Use of directive antennas at the receiver so that it is most sensitive to electromagnetic waves coming from the direction of the transmitter creating the desired signal and is insensitive to radiations originating in other directions.

This method is limited by the expense of directional antennas and by the fact that some interference may be originating in the same direction as the desired signal.

It is apparent that the methods just mentioned, taken individually or in combination, do not offer a complete solution of the problem. In fact no complete solution would appear possible, as the ultimate range of any transmission must be determined by the tolerable interference. However, any method which offers increased possibilities in the differentiation between desired signal and interference may be used to improve transmission. Frequency modulation offers such an additional method by which interference may be separated from the desired signal and it is the purpose of this paper to outline the principles and practices by which this may be accomplished.

The use and study of frequency modulation is not new. The Poulsen arc, developed before 1914, transmitted continuous-wave telegraph signals in which the frequency was shifted from one value to another when the key was depressed. Carson [1] and Roder [2] made theoretical investigations of the effects of frequency modulation on the

* Professor of electrical engineering at Ohio State University, Columbus.

[1] "Notes on Theory of Modulation," J. R. Carson, IRE *Proceedings*, volume 10, February 1922, page 57.

[2] "Amplitude, Phase, and Frequency Modulation," H. Roder, IRE *Proceedings*, volume 19, December 1931, page 2145.

spectrum of the modulated wave. Carson's investigation was made to analyze the proposal that frequency modulation could be used to reduce the band width required for a given signal. He proved that, on the contrary, frequency modulation never reduced the band width and might greatly increase it. Mathematics provides a correct answer to questions which are asked by its means, but it cannot be expected to provide answers to questions which are not asked. What was overlooked in the early mathematical analyses was the fact, later demonstrated by Armstrong,[3] and subsequently by Carson[4] and Fry, that frequency modulation provides an important method of distinguishing between desired and undesired signals which occupy the same portion of the frequency spectrum.

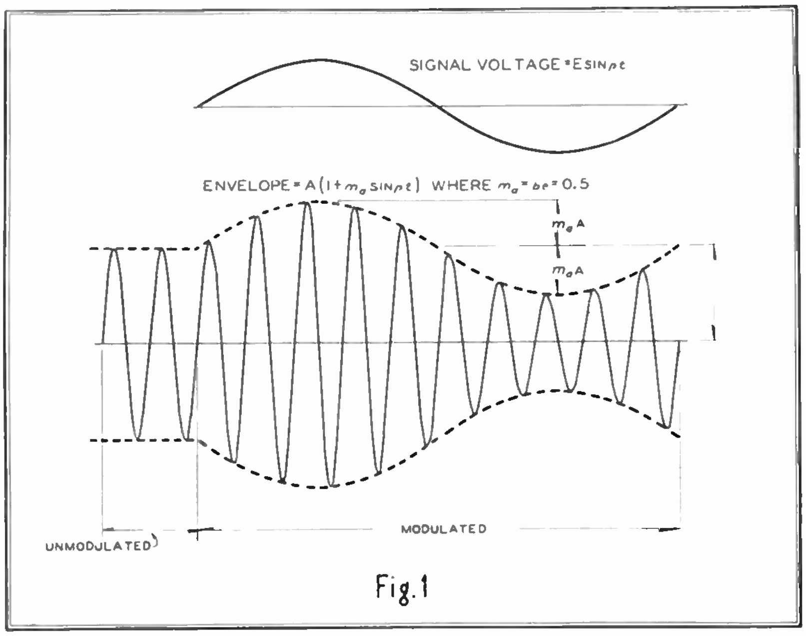



FIG. 1. AN AMPLITUDE-MODULATED WAVE, WITH AN UNMODULATED SECTION AT THE LEFT

It will be necessary to go into some details of the principles of frequency modulation in order to show the reasons for this effect.

**Modulation** ★ Modulation of a radio wave is the process by which some characteristic of the radio wave is varied in accordance with the time variation of a signal, such as the instantaneous variations associated with speech, music, or the manipulation of a telegraph key. A general alternating wave may be represented by the equation

$$e = A \sin \theta \qquad (1)$$

where $\theta$ is given by the relation

$$\theta = \omega t + \phi \qquad (1a)$$

and so

$$e = A \sin (\omega t + \phi) \qquad (1b)$$

(In this discussion the word "wave" will be used in one of its accepted meanings to denote a repetitive phenomenon.)

Two groups of modulation methods are recognized.

1. Amplitude modulation where $A$ is varied by the signal.

2. Angular modulation where $\phi$ is varied by the signal.

(Frequency modulation is a special form of angular modulation.)

**Amplitude Modulation** ★ In an amplitude-modulated wave the amplitude is varied about its mean value in proportion to the signal. Let the original signal (such as the sound pressure on the microphone) be represented by the function $f(t)$. Then the amplitude fac' or $A$ of equation $1b$ is modified by $f(t)$ to give the amplitude-modulated wave

$$e = A[1 + bf(t)] \sin (\omega t + \phi) \qquad (2)$$

where $b$ is a factor determined by the design and operation of the modulating system and has dimensions such that $[bf(t)]$ is a pure numeric. $b$ is usually a constant, but in some cases it is made a function of audio frequency. For example, if it is made to change with frequency in the proper manner, compensation may be secured for defects in the frequency characteristic of some other part of the system.

The amplitude variation cannot carry the amplitude below zero. Therefore the factor $b$ should be so chosen by the operator that $[1 + bf(t)]$ never becomes negative. Therefore $[bf(t)]$ should not exceed an absolute value of unity. This absolute value of the maximum of $[bf(t)]$ is called the amplitude modulation factor and is given the notation $m_a$.

If the signal $f(t)$ is sinusoidal with a frequency $p/2\pi$, Equation 2 becomes

$$e = A(1 + m_a \sin pt) \sin \omega t \qquad (3)$$

The curve of Equation 3 is illustrated in Fig. 1 for $m = 0.5$ and $\omega/p = 10$. It will be noted that the wave crosses the axis at regular time intervals of $2\pi/\omega$ seconds for both the modulated and unmodulated waves.

In alternating phenomena a single frequency is represented by the projection of a vector of constant length rotating with the constant angular velocity $\omega = 2\pi f$. The wave of Equation 2 could also be represented by a vector rotating with a constant angular velocity $\omega$, but the length of the vector would be changing at a low frequency rate as given by the equation

$$\text{Length of vector} = A[1 + bf(t)] \qquad (4)$$

The term $A[1 + bf(t)]$ is called the envelope of the wave. In Equation 3 the envelope would be $A[1 + m_a \sin pt]$ as is illustrated in Fig .1.

In drawing vectors which represent alternating phenomena it is common practice to consider that the observer is traveling on a platform which is also rotating about the same center with a velocity $\omega$. The original vector would then appear to be stationary and could be represented by a single drawing. However, if either the magnitude or the phase of the vector is changing with time, a series of successive drawings is necessary to illustrate what is happening.

These successive drawings of stationary vectors for the wave of Fig. 1 are shown in Fig. 3 for time intervals of one-twelfth the period of the low-frequency wave producing the modulation.

[3] "A Method of Reducing Disturbances in Radio Signaling by a System of Frequency Modulation," E. H. Armstrong, IRE *Proceedings*, volume 24, May 1936, page 689.

[4] "Variable Frequency Electrical Circuit Theory, With Application to the Theory of Frequency Modulation," J. R. Carson and T. C. Fry, *Bell System Technical Journal*, volume 16, October 1937, page 516.

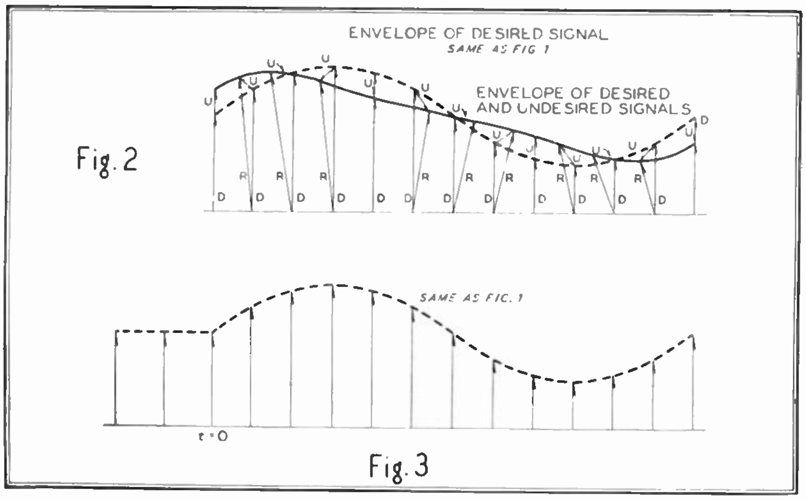



FIG. 2. INTERFERENCE WITH AN AMPLITUDE-MODULATED WAVE FROM A CARRIER OF SLIGHTLY DIFFERENT FREQUENCY. FIG. 3. VECTOR DIAGRAM OF AMPLITUDE-MODULATED WAVE

At the receiver the detector produces a response which is proportional to the envelope of the modulated wave, except for the constant component.

**Interference of Two Amplitude-Modulated Waves ★** If a second amplitude-modulated wave of the same carrier frequency and phase is added to the wave of Fig. 1 the resultant wave will have an envelope which is the sum of the envelopes of the two waves, for the vectors will be adding in phase. The interfering effect will be noticeable if the undesired signal is as much as one per cent of the desired signal. Hence it is desirable to make the value of $m_a$ as large as possible, since the operator of a given communication system cannot control the modulation of the interfering wave with the undesired signal.

If the frequency of the interfering wave is slightly different from the desired wave (the difference being too small to eliminate it by selective circuits) then the interfering wave will produce a variation in the envelope which variation has an amplitude equal to the magnitude of the interfering wave, even if it is unmodulated. This additional variation will occur at a frequency which is equal to the difference between the carrier frequencies of the desired and undesired signals, and will produce a squeal which is further superimposed on the resultant envelope. This is illustrated by the vector diagrams in Fig. 2, where the undesired signal has a frequency which exceeds the frequency of the desired signal by $1.5p/2\pi$. It is seen that the resultant envelope is modified by an additional component equal to the magnitude of the undesired wave, and so introduces interference proportional to the magnitude of the interfering wave.

Again it is apparent that the amplitude of the envelope of the desired signal should be kept as large as possible in order that the interference may be minimized. If Equation 2 represents current or voltage, the amplitude of the envelope may be increased by increasing either the power or the amount of modulation ($m_a$).

**Angular Modulation ★** In angular modulation, of which frequency modulation is a subdivision, the angle $\phi$ of equation 1*b* is given by a function of time which is related, but not in all cases, directly proportional, to the signal function $f(t)$. The two principal subdivisions of angular modulation which have been extensively studied are phase modulation and frequency modulation.

(*a*) Phase Modulation

In this type of modulation the phase angle $\phi$ is made to vary in accordance with the signal. That is

$$\phi = b_1 f(t) \qquad (5)$$

where $b_1$ is a constant determined by the design and operation of the modulating system. When Equation 5 is inserted in equation 1*b* the wave becomes

$$e = A \sin\left[\omega t + b_1 f(t)\right] \qquad (6)$$

The maximum value of $b_1 f(t)$ is called the phase modulation factor $m_p$. It is the maximum number of radians by which the phase of the carrier is altered during modulation. If the signal is sinusoidal with a frequency $p/2\pi$, Equation 6 becomes

$$e = A \sin\left[\omega t + m_p \sin pt\right] \qquad (7)$$

(*b*) Frequency Modulation

In this type of modulation the instantaneous frequency is varied about the average value $\omega/2\pi$ in proportion to the instantaneous value of the signal. By definition, the use of the word "frequency" is extended to the general equations 1 and 1*b* by the relation

$$2\pi f_{\text{inst}} = \frac{d\theta}{dt} = \omega + \frac{d\phi}{dt} \qquad (8)$$

Since $\omega$ is a constant ($2\pi$ times the carrier frequency) the signal must modify $d\phi/dt$ so that the instantaneous frequency is given by the relation

$$f_{\text{inst}} = \frac{\omega}{2\pi} + b_2 f(t) \qquad (9)$$

where $b_2$ is a design and operating constant. The maximum value of $b_2 f(t)$ is the maximum deviation in instantaneous frequency of the modulated wave from the unmodulated one and is called the frequency modulation factor, or frequency deviation, $m_f$. If $f(t)$ is a sine wave with a frequency $p/2\pi$ then

$$b_2 f(t) = m_f \sin pt \qquad (10)$$

If Equation 10 is combined with Equations 8 and 9

$$2\pi f_{\text{inst}} = \omega + 2\pi m_f \sin pt = \omega + \frac{d\phi}{dt}$$

which gives

$$\phi = \int 2\pi m_f \sin pt\,dt = -\frac{m_f}{f\rho}\cos pt$$

where $f$ is the frequency of the modulating signal. If this phase angle is inserted in equation 1*b* the result will be

$$e = A \sin\left[\omega t - \frac{m_f}{f\rho}\cos pt\right] \qquad (11)$$

Equations 11 and 7, which apply to a signal with a single frequency, do not differ appreciably (except for a 90-degree shift in the modulation phase). In Equation 11 the maximum shift in phase (corresponding to the phase modulation factor $m_p$) will be

$$m_p = \frac{m_f}{f\rho} \qquad (12)$$

where $m_f$ is the frequency deviation and $f\rho$ the modulating audio frequency. The value of $m_f$ when $f\rho$ is the maximum audio or signal frequency to be transmitted is called the deviation ratio.

$m_p$ in phase modulation and $m_f$ in frequency modulation are arbitrary design factors. Unlike amplitude modulation they are not restricted to a maximum value of unity, for $m_p$ may be hundreds of radians or $m_f$ thousands of cycles per second if desired. The limitations on $m_p$ and $m_f$ will be determined by the allowable frequency spectrum and will be discussed later.

The distinction between phase and frequency modulation is as follows: if the fre-

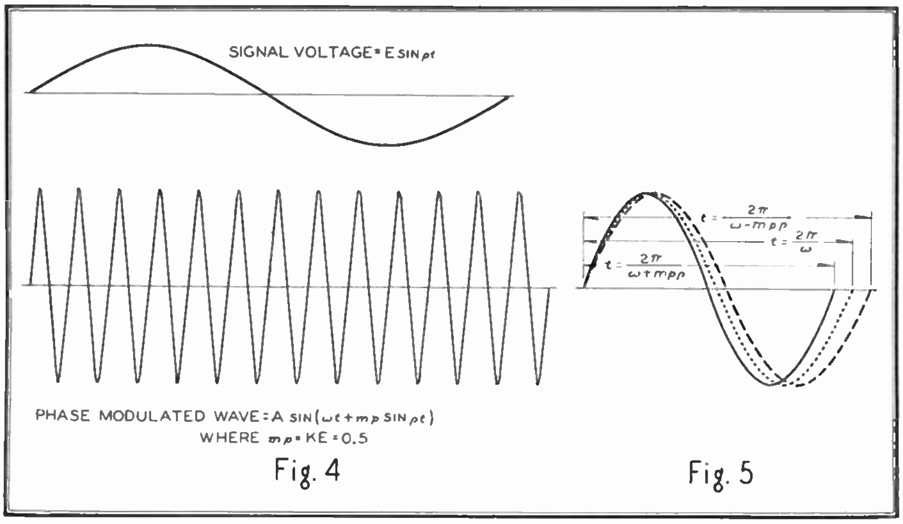



FIG. 4. ANGULAR-MODULATED WAVE. FIG. 5. EXPANSION OF FIG. 4, WITH SOLID LINE REPRESENTING CYCLES 1 AND 13, SHORT DOTS REPRESENTING CYCLES 4 AND 10, AND LONG DOTS REPRESENTING CYCLE 7

quency, but not the intensity of the modulating signal changes

$m_p$ is constant in phase modulation.
$m_f$ is constant in frequency modulation.

It follows from Equation 12 that in frequency modulation the phase deviation $m_p$ is inversely proportional to the modulating frequency. On the other hand in phase modulation the frequency deviation is directly proportional to the modulating frequency.

Fig. 4 is an illustration of the angular modulation as represented by equation 7 for the case where $m_p = 0.5$ and $\omega/p = 12$. On a casual examination this would appear to be a single frequency wave. However, the intervals at which it crosses the axis vary throughout the audio cycle. In order to show this the 1st, 4th, 7th, 10th, and 13th cycles are expanded and shown in Fig. 5. It is seen that the varying shift in phase also produces a change in frequency which varies throughout the low-frequency cycle.

The successive vector diagrams for the angular-modulated wave of Fig. 4 (corresponding to the diagrams of Fig. 2 for an amplitude-modulated wave) are shown in Fig. 6. The signal wave is included for identification of the various instants.

The difference between phase and frequency modulation may be illustrated by the way the motion of the resultant vector would appear to an observer riding with the carrier vector. In phase modulation, two audio signals of equal amplitude, but of different frequencies, would produce equal angular *amplitudes* in the apparent swing of the resultant vector. In frequency modulation two audio signals of equal amplitude would produce equal maximum angular *velocities* in the apparent swing of the resultant vector. In this latter case (frequency modulation) the maximum angle of swing would be inversely proportional to the audio frequency (as is indicated by Equation 12). This is illustrated by Fig. 7 where the vectors for both frequency and phase modulation are drawn for two signals with an audio-frequency ratio of two to one. Note that in phase modulation the maximum angle $\phi_m$ is the same for both signals while for frequency modulation the maximum angle $\phi_m$ for signal $A$ (the lower frequency) is twice that for signal $B$. Since the angular *velocity* is proportional to the instantaneous value of the signal in frequency modulation the vector reaches its maximum angle of deviation when the signal is zero while in phase modulation it reaches its maximum angle of deviation when the signal is a maximum.

**Other Types of Angular Modulation ★** Phase and frequency modulation are not the only possible types of angular modulation, but are only two members of an infinite group. Other possible types are:

(*c*) Angular Acceleration Modulation

In this type of modulation the second time derivative of $\phi$ is directly proportional to the signal function

$$\frac{d^2\phi}{dt^2} = b_3 f(t)$$

In this type $m_p$ would be inversely proportional to the square of the audio frequency.

(*d*) nth Order Modulation

In this general type of angular modulation the *n*th derivative of $\phi$ is directly proportional to the signal function.

$$\frac{d^n\phi}{dt^n} = b_{n+1} f(t) \qquad (13)$$

In this type $m_p$ would be inversely proportional to the *n*th power of the frequency for modulating signals of equal intensity.

In radio transmission by angular modulation means are provided at the receiver so that the detected signal is proportional to the angular modulation (of the particular subdivision selected) and at the same time this detected signal is made unresponsive to amplitude variations. These means will be discussed in more detail later.

**Interference of Two Angular-Modulated Waves ★** When two angular-modulated waves of the same carrier frequency are added together, the total angular modulation is not the sum of the two individual modulations. This is in distinct contrast to amplitude modulation where the resultant envelope is the sum of the individual envelopes.

This can be illustrated by Fig. 8 where an angular-modulated wave $B$ is represented by a vector whose angle is changing with time. This is added to a larger vector $A$ which for the moment will be assumed to be unmodulated. The resultant vector $R$ will be the sum of the two vectors.

It is apparent that if $B$ is less than $A$, then no matter what the total angular variation of $B$ may be (even if it is hundreds of radians) the total angular variation between $R$ and $A$ cannot exceed $\tan^{-1}(B/A)$. For instance if $B/A = 0.5$ the maximum value of $m_p$ for the vector $R$ when $A$ is unmodulated is $m_p = 0.46$. If $B/A = 0.5$ and $A$ in turn has its angle modulated, then the difference between the angle of $A$ and that of $R$ cannot exceed 0.46 radian at any instant. If the modulation factor ($m_p$) of $A$ is made large in comparison with 0.46, the interference of $B$ becomes negligible, in spite of the fact that the magnitude of $B$ is by no means negligible in comparison with $A$.

This analysis justifies the experimental results which show that when two frequency-modulated signals are picked up by a receiver, there is no appreciable interference between the two signals if the stronger exceeds the weaker by a ratio of 2 to 1 or more.

It will be seen that the greater the value of $m_p$ used for the desired signal the greater is the discrimination against the

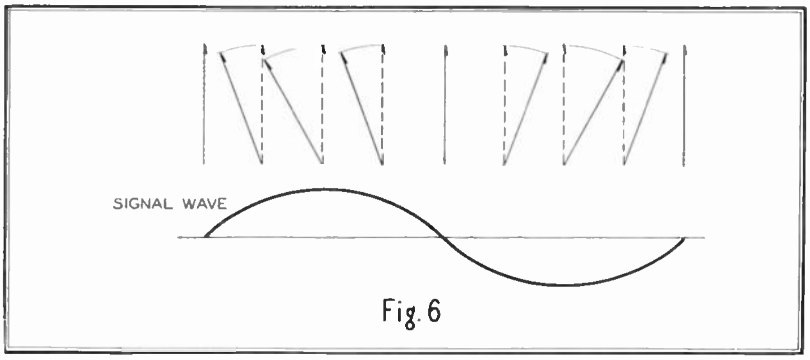



FIG. 6. VECTOR DIAGRAMS OF THE ANGULAR-MODULATED WAVE IN FIG. 4. SOLID LINES ARE VECTORS OF MODULATED WAVE. DOTTED LINES ARE VECTORS OF UNMODULATED WAVE

undesired signal, but this discrimination is not affected by the value of $m_p$ used in the undesired signal.

The discrimination against interference obtained by angular modulation applies to all five types of interference enumerated in the early part of the paper. In particular static may be represented as a vector of varying phase and magnitude. The selective circuits of the receiver admit only those components within the band to which it is receptive. If the amplitude of the admitted noise does not exceed half the amplitude of the desired wave, a very small amount of noise will be introduced into the output. The greater the average phase deviation in comparison with the angle 0.46 (approximately 0.5) the greater will be the discrimination against the noise. It should also be observed that components of the noise vector which differ in frequency from the carrier by superaudible frequencies, will produce superimposed angular velocities above audibility and so do not contribute to the noise, as long as the noise is small compared with the signal.

In radio operation it will be found that if a portable receiver is driven in an automobile away from a frequency-modulated transmitting station, no appreciable noise will be experienced until the desired field strength drops to twice the noise field strength, taking into account only those components of noise accepted by the selective circuits of the receiver. The noise then rises rapidly, so that a sharp threshold is experienced.

Within the distance limited by the threshold, the signal-to-noise ratio can be improved by either increasing the power or increasing the modulation factor (either phase or frequency). Since power is proportional to the square of voltage or current in a given system, doubling the frequency deviation in frequency modulation has the same effect on the signal-to-noise ratio as increasing the transmitted power four times. In general an increase in the maximum frequency deviation by a ratio $n$ would be equivalent in its effect on the signal-to-noise ratio to an increase in power by the ratio $n^2$.

The actual voltage produced by noise in the amplifier of a radio receiver increases with the width of the band accepted, the rate of increase depending on the type of noise. This introduces some disadvantage to the use of a wide band, because a stronger desired wave is necessary to insure that the desired voltage shall exceed the noise voltage.

R. F. Guy of the National Broadcasting Company reported before the Federal Communications Commission that in experiments with a one-kw. transmitter and an antenna 1,000 feet high, the threshold for a value of $m_f$ equal to 75 kilocycles was at 86 miles, while with an $m_f$ of 15 kilocycles the threshold was at 100 miles due to the smaller noise voltage accepted by a more selective receiver. Within the threshold distances, however, there is a greater discrimination against noise with the greater frequency deviation.

## Practical Considerations in Frequency Modulation ★

It has been shown that the reduction of interference makes frequency-modulated transmitters most desirable for the transmission of high-quality signals. However, these transmitters require relatively large frequency bands. Therefore frequency modulation, or FM, does not appear to be feasible in the present broadcast band. For high-quality broadcasting they should be allocated to high frequencies where band widths of 200 kc. are available. The Federal Communications Commission has assigned the frequencies from 42 to 50 mc. for this service or a total of 40 channels. This is in the range of the so-called ultra-high frequencies.

Radio waves with frequencies of the order of 40 mc. and above are not reflected from the ionosphere, and so their range is limited by the curvature of the earth. For the same reason static is greatly reduced at these frequencies because the energy which lies in the ultra-high-frequency spectrum and which is originated by electrical disturbances at distant points on the earth's surface cannot travel to the receiver over long distances. Other factors also reduce static at high frequencies. As an average, the static voltage producing interference in a receiver with a given band width and tuned to 40 mc. is about 1/40 of the static voltage* which would be

* This does not take into account strong local interference from man-made static.—EDITOR'S NOTE.

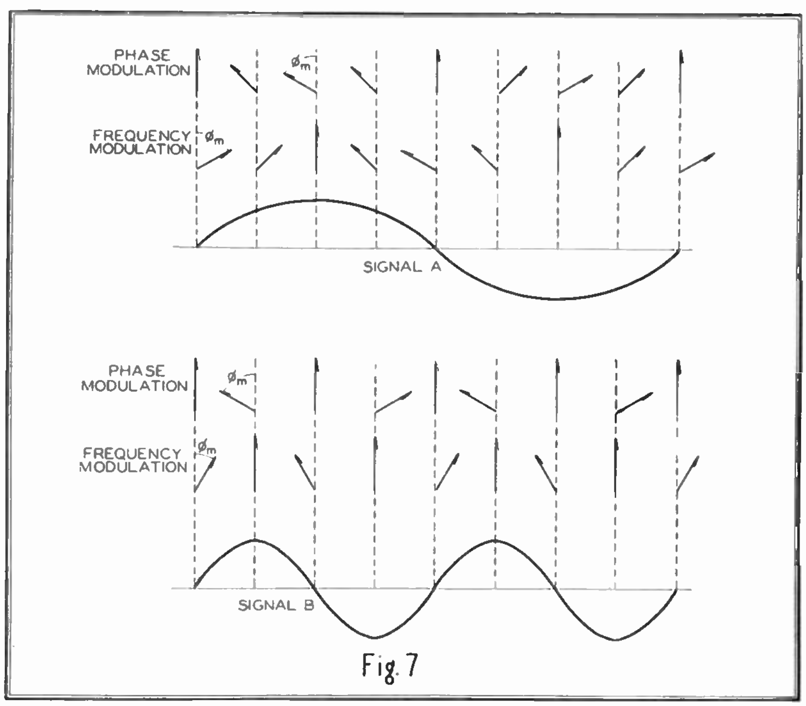



FIG. 7. SHOWING THE COMPARISON OF PHASE MODULATION AND FREQUENCY MODULATION, BY MEANS OF VECTOR DIAGRAMS

picked up by a receiver of the same band width tuned to 1,000 kc. It is also possible to transmit a wide-band audio signal which requires corresponding wide side bands at ultra-high frequencies because for practical reasons it is not desirable to assign carrier frequencies as close together as in the standard broadcast band and so sufficient band width is available for high-quality transmission. Therefore ultra-high frequencies inherently offer an improvement in quality whether amplitude or frequency modulation is used.

However, there are three important difficulties with ultra-high frequency transmission for broadcasting purposes. The first difficulty is the effect of the curvature of the earth on ultra-high frequencies. Because there is no reflection from the ionosphere, it is frequently stated that the limit of transmission for these frequencies is the distance from the transmitting antenna to the horizon. The equation for this distance is

$$d = 1.22\sqrt{H} \qquad (14)$$

where

$d$ is the distance to the horizon in miles
$H$ is the height of the transmitting antenna in feet

For a height of 400 ft. the distance to the horizon would be only 24.4 miles.

Within this distance the field strength of the signal is given approximately by the equation[6]

$$E = \frac{0.0105\sqrt{WGHAF}}{D^2} \qquad (15)$$

where

$E$ = field strength in microvolts per meter
$W$ = power in watts
$G$ = gain of the antenna over a half-wave dipole
$A$ = receiver antenna height in feet
$F$ = frequency in megacycles
$D$ = distance in miles

The formula and the statement that the transmission is limited to the horizon are not strictly true because it is found that diffraction and refraction of the waves produce a signal[7] beyond the horizon, but this signal falls off more rapidly than the inverse-distance-squared term of Equation 15.

The second difficulty with ultra-high frequency transmission is the noise produced locally by electrical apparatus. The principal sources of this noise are automobile ignition and fever therapy machines. These sources might be eliminated in time by legislation requiring adequate shielding.

A third difficulty with ultra-high frequency transmission is the sharp shadows thrown by buildings, hills, etc. Sharp shadows are produced in the field of any wave motion when the interfering bodies have dimensions large in comparison with the wave length, and so are particularly apparent at ultra-high frequencies (short wave lengths).

Because of these difficulties the transmission of amplitude-modulated waves at ultra-high frequencies has not made very much progress for broadcast transmission. However, these difficulties are only aspects of the fundamental problem pointed out at the beginning of the paper, that radio transmission is limited by the ratio of interference to signal. It has been shown that frequency modulation offers an important improvement in the solution of this problem. By its means the signal-to-noise ratio at any fixed distance may be increased. It seems probable an increase in transmission range may be secured by frequency modulation due to the greater signal-to-noise ratio and this may make economically feasible the use of ultra-high frequencies for broadcasting purposes.

In field tests, adequate signals for the operation of an FM receiver at two to three times the horizon distance are regularly reported when the transmitter is a high-powered one.

The wide band width which is required for frequency modulation is compensated for by the reduction in interference between two stations on the same channel. In amplitude modulation, interference is caused if an undesired signal is one per cent of the desired signal. It has been shown that in FM a ratio of two to one between desired and undesired signals is sufficient. If two stations of equal power and located in neighboring cities should operate on the same channel, there would be only a small territory about half way between the two stations where there would be any interference. Even in this territory, relatively simple directional antennas would be sufficient to pick out one station or the other. Therefore numerous stations could be located throughout the nation on the same carrier frequencies.

I. R. Weir, of the General Electric Company, reported before the Federal Communications Commission that in their experiments they used a 150-watt transmitter at Albany and a 50-watt transmitter at Schenectady, a distance of 14.5 miles. They operated both transmitters on the same frequency with both frequency and amplitude modulation. In driving a car equipped with a receiver along a line between the two stations the following results were obtained:

| Type of Modulation | Interference-Free Range of Albany Station | Transitional Distance With Interference | Interference-Free Range of Schenectady Station |
|---|---|---|---|
| Frequency . . . | 10.5 | 1.0 | 3.0 |
| Amplitude . . . | 3.3 | 11.7 | 0.5 |

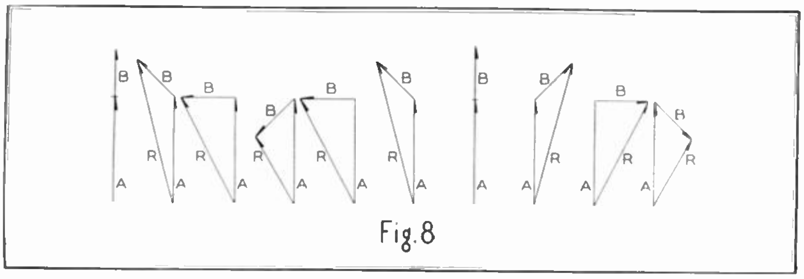



FIG. 8. VECTOR DIAGRAMS SHOWING THE EFFECT OF INTERFERENCE IN ANGULAR MODULATION OF RADIO WAVES

A further advantage of frequency modulation in the operation of the transmitter and receiver is that nonlinear distortion in frequency modulation is not affected by the nonlinearity of the tubes, as their nonlinearity is a function of amplitude. In FM, nonlinear distortion depends only on circuit design, that is, on nonlinear relations which are a function of frequency. For that reason it is claimed that high-quality reproduction is more practicable.

**Frequency-Modulation Receivers** ★ In the discussion of FM receivers and transmitters, a certain familiarity with communication theory must be assumed in order to conserve space. The discussion will deal with present commercial practice.

Frequency-modulated receivers differ from amplitude-modulation receivers in three important respects. They are:

(*a*) The inclusion of a *limiter* to remove any amplitude modulation resulting from an interfering signal.

(*b*) The use of a special detector circuit, called the discriminator, to change the frequency modulation into a variable-amplitude signal.

(*c*) The use of a wide-band intermediate amplifier.

[6] "Ultra-High-Frequency Propagation Formulas," H. O. Peterson, *RCA Review*, volume 4, October 1939, page 163.

[7] "Ground Wave Field Intensity Over a Finitely Conducting Spherical Earth"; "A Theory of Tropospheric Wave Propagation"; "Summary of Statements on Ultra-High-Frequency Wave Propagation," K. A. Norton, Reports before the Federal Communications Commission, April 1940.

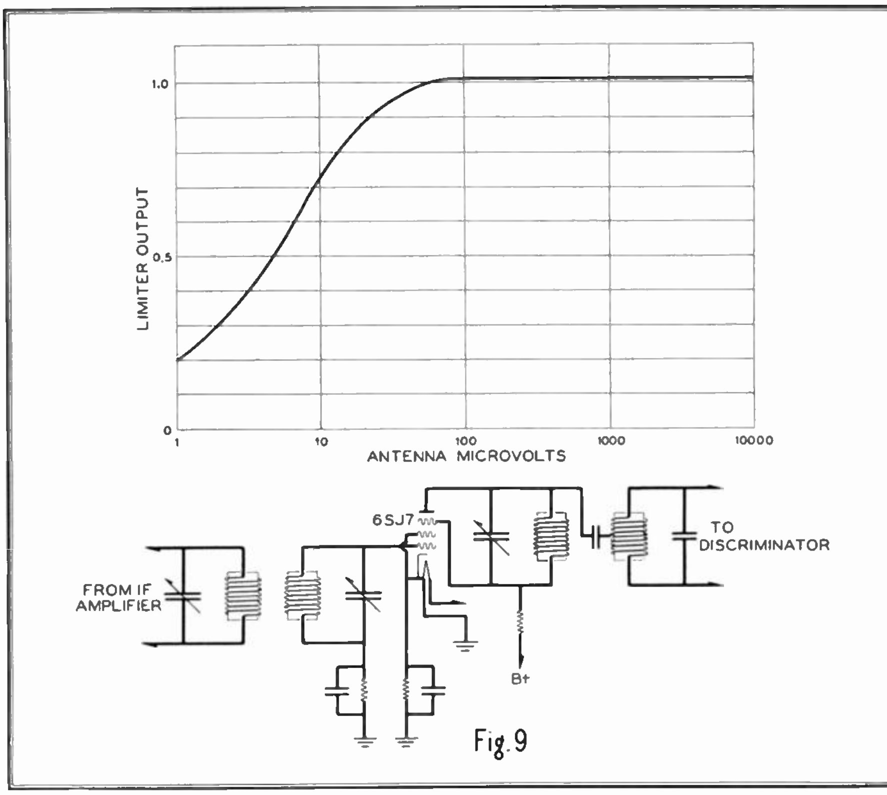



FIG. 9. CHARACTERISTIC CURVE OF A LIMITER, AND A TYPICAL LIMITER CIRCUIT SUCH AS IS EMPLOYED IN FREQUENCY MODULATION RECEIVERS

**Practically all the contentions of those who have opposed the use of Frequency Modulation are answered in Prof. Everitt's paper. Some of these answers are found in the course of mathematical explanations, so that it is necessary to read the text with great thoroughness.**

**It is interesting to note that all the pertinent theory reviewed by Prof. Everitt was known to students and engineers long before the preparation of this paper. Many of the objections raised against Frequency Modulation imply, therefore, either a lack of knowledge of basic theory, or a disregard of it.**

**When Prof. Everitt prepared this paper, he had to rely chiefly upon mathematics for his conclusions, for applications of FM to communications were limited prior to 1940. Subsequently, however, his conclusions have been confirmed not only in the field of broadcasting but in police and military applications.**

In addition it is much more important in a frequency modulation receiver to have a high-gain IF amplifier, because the operation of the limiter is dependent upon a certain minimum signal being applied to its input. Also, if advantage is to be taken of the high-quality transmission which is possible with FM, a better-than-average audio system and loud speaker should be included.

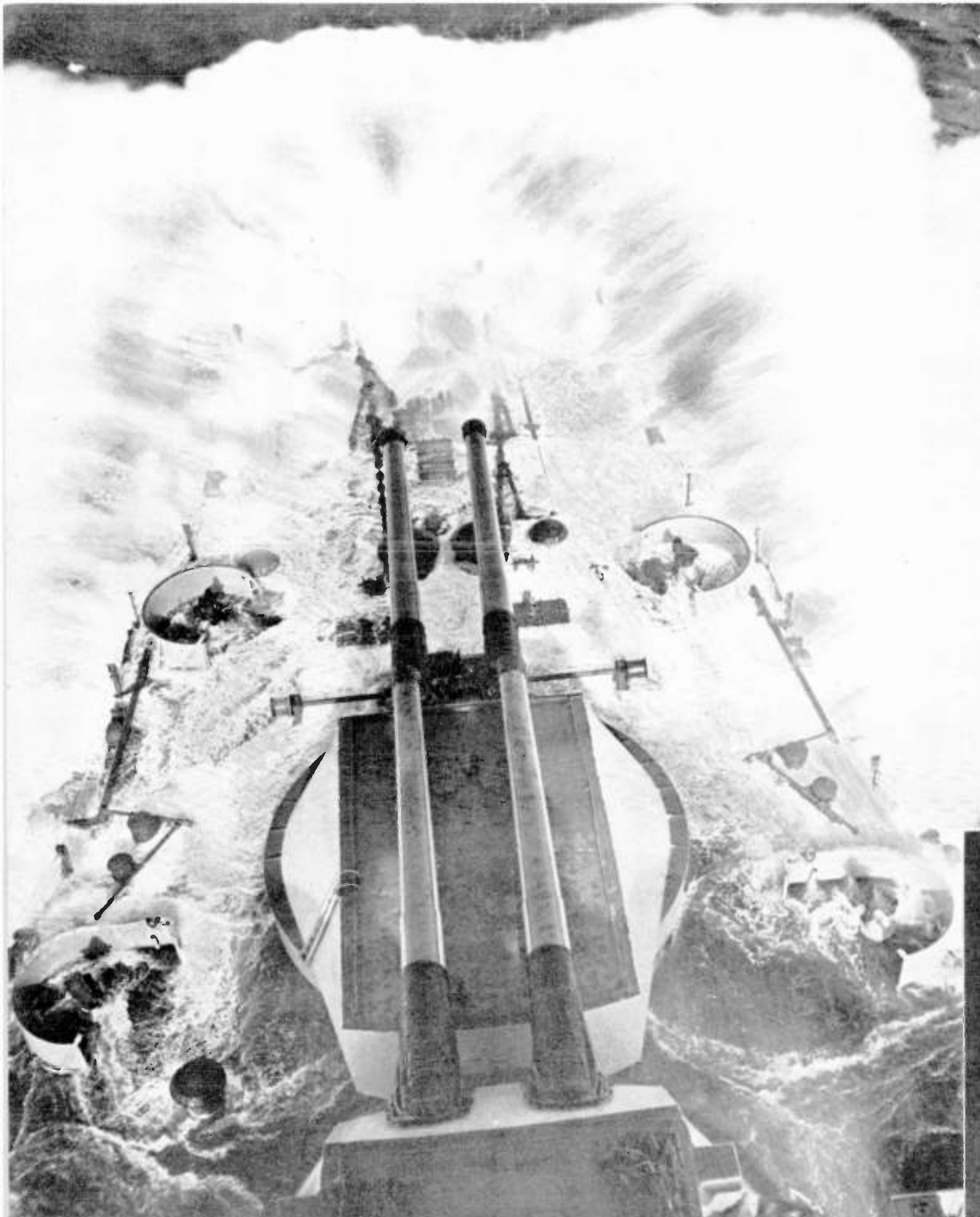
Except for these differences, the FM receiver will follow the practice of amplitude-modulated receivers. The use of superheterodyne receivers is universal.

If a tuned-radio-frequency amplifier has impressed upon its grid a high-frequency voltage exceeding a certain minimum amplitude, the RF current in the tuned plate circuit will be practically independent of the magnitude of the input. This is because after the RF component of voltage in the plate circuit has reached an amplitude equal to the DC component of the plate voltage no further increase in the RF component can be obtained, for the instantaneous value of plate voltage cannot be driven negative. By the use of a high-gain tube and low values of plate voltage, saturation at relatively low values of grid excitation may be obtained. Fig. 9 shows the circuit and the limiting action for a typical commercial FM receiver. The operation of the limiter is the same as that of a class *C* amplifier [5] and the use of a bias obtained by a resistance in the grid circuit assists in securing a flat curve.

The use of a limiter is necessary because any amplitude modulation which reaches the detector will also produce amplitude variations in the reproduced signal. *The use of the limiter or its equivalent at the receiver is the most important component in an FM system, for no reduction in interference will occur without its operation.* The limiter is possible in frequency modulation because the saturation does not affect the instantaneous frequency of the output.

The elimination of hum due to the use of AC supplies in receivers has also been a problem for many years. The principal source of this hum is amplitude modulation produced in the receiver by the hum component of the rectified DC plate supply and by the heating of the cathodes by alternating current. If this occurs in the early stages of the receiver it is amplified along with the signal. While this hum level is reasonably well controlled in modern receivers, the limiter in a frequency-modulated receiver provides an additional improvement. This is particularly important because the elimination of other sources of interference makes the reduction of hum to an extremely low level much more desirable.

Because the audio amplifier and loudspeaker must reproduce the amplitude variations of the original signal, the discriminator or detector circuit must change the frequency variations into amplitude variations. The most common discriminator circuit in use is that of Fig. 10. The tuned transformer $L_1$, $L_2$ has a split secondary feeding two diode plates with the resistance loads $R_1$ and $R_2$. The voltage $E_3$ will be 90 degrees out of phase with the voltage across $L_2$ at the resonant frequency of $L_2$, $C_2$. The radio frequency across diode 1 in series with resistance $R_1$ is represented by the vector $E_a = E_1 + E_3$ while that across diode 2 in series with resistance $R_2$ is $E_b = E_2 + E_3$. When the output of the discriminator is at the intermediate frequency the phase relations will be those shown in diagram *A*. However, when the frequency shifts, the voltage across $L_2$, $(E_1 - E_2)$, shifts in phase. It can be shown that this voltage will follow the locus indicated by the circles. Hence $E_a$ and $E_b$



# RADIO vs FATHER NEPTUNE

**Salt Spray** The photograph at the right conveys a fair impression of conditions which are reproduced in the Navy's salt spray test, in a way that can be understood by radio engineers who have never gone to sea.

In such weather, a heavy salt-laden dampness permeates the ship, and finds its way into every delicate part of radio equipment that is susceptible to failure.

Moreover, the salty condensation sets up electrolytic action between dissimilar metals, establishing a second-front attack on all electrical apparatus.

**Temperature Variations** The U. S. Navy has no use for fair-weather ships or radio equipment. Operating today in every ocean from the Equator to ports above the Arctic Circle, our ships are exposed to every extreme of service at sea.

During a single voyage, the paint on a ship may be peeling off under blistering heat, and before it puts back to port the crew may be out chopping ice from the rigging. Through it all, there is no time out for repairs. The worse the conditions, the greater the need for uninterrupted radio communication.

It must be borne in mind that heat and cold, in themselves, do only a part of the damage caused by temperature variations. Expansion and contraction may cause mechanical parts to loosen enough that they can then be attacked by vibration.

Moreover, materials actually breathe in moisture when they are heated, and only expel a part of it when they are cooled again. This effect is frequently the cause of electrical failures in components which are not hermetically sealed.

**Shock** No radio engineer would deliberately treat a piece of apparatus to the punishment it takes on a battleship when the guns are fired. But stand it it must, if the Navy is going to use it.

The standard shock test called for in Navy specifications may seem overly severe, but if you were on deck when the heavy guns are fired, you would wonder how the ship itself can take such a beating.

Nor is the Navy satisfied with equipment that is all right if it doesn't get too much. In our attacks on Sicily and the Italian peninsula, for instance, our ships shelled shore targets continuously, all day long, and the radio equipment on board took far more abuse than it ever received at the hands of a Navy inspector!

# A REPORT ON CONTRACT TERMINATION

## How the War Department Is Preparing to Implement Speedy Postwar Conversion

BY BRIGADIER GENERAL A. J. BROWNING*

**"M DAY" found the radio industry woefully unprepared to mobilize its forces to meet the impact of war. However far away "C Day" may be, the very certainty of our ultimate victory carries a warning that the machinery and the methods of handling contract cancellations must be ready, in reserve, to enable our industry to shift quickly to civilian production. General Browning's discussion of this subject is of the greatest importance to every contractor.**

AT THE end of the war this country will face serious economic problems. Over one-half of our entire industrial capacity and economic resources are now devoted to production for war. When eventually the need for war supplies will end, our economy must then — and not before then — return without delay to peacetime production. In our planning on this problem we must bear in mind that the future of every industrial worker, as well as that of every industry, requires the avoidance of unnecessary delay in giving our people employment in civilian production before their savings are consumed for subsistence.

**1. The Problem ★** The speedy and orderly conversion of these industries to peacetime production and the satisfactory adjustment of all the interim human and social problems will depend upon many factors. We are acutely conscious of their presence and of their importance, and we recognize that their intelligent treatment is necessary if unemployment and serious social dislocation are to be avoided. Their complete solution will require action by Congress and other governmental agencies, but perhaps none will be more important in its direct and indirect effects upon both industry and labor than the manner of handling termination of war contracts. Since this phase of demobilization must be carried out to a large extent by the War Department, you are entitled to learn about the plans which we have been developing and the principles which are guiding our thinking. We have as our basic aim to keep the wheels of industry turning without unnecessary interruption so that business can get over the hump and employment be maintained.

The magnitude of this problem is indicated by the fact that the War Department probably has more than 100,000 important prime contracts. There are at least a million relatively important subcontracts. Larger total figures on both subs and primes are frequently quoted, but I believe these are practical figures to use in considering the termination job at the end of the war.

We will undertake the task with the benefit of experience both in the last war and in this one. During the present war, while we are actually increasing our overall production, it becomes necessary to cancel numerous contracts, and as a result we are already accumulating a very large amount of such experience. As of August 31, 1943, the War Department in accomplishing necessary adjustments in the production program had completely or partially cancelled 8,520 contracts and had finally settled 6,191 of these, or more than 70%. The face value of these 8,520 contracts terminated so far in this war is $5,800,000,000. This is nearly $2,000,000,000 more than the total face amount of the 27,000 terminated contracts in the first World War.

Experience in the last war and in the present one emphasizes that a satisfactory solution of two great problems is vital to maintain continuity of production and employment. First, the need for fair and prompt settlements of the contractors' termination settlement proposals; and second, the need for interim financing of contractors and subcontractors pending the final settlements.

**2. Prompt and Fair Settlements ★** The first step was our contract article for termination which, we believe, evidences our intention to treat contractors fairly. This article is included in practically every War Department contract of any size. Under this article, if the Government terminates the contract, the contractor may be required to discontinue all work and to cancel all existing orders and subcontracts and to transfer to the Government all completed supplies and all work in process and materials relating to the performance of the contract which are not disposed of or retained by the contractor with the approval of the contracting officer. The Government must pay the contractor the contract price for all completed articles and all actual expenditures and costs incurred on the uncompleted part of the contract or in settling obligations and commitments related to the uncompleted portion, plus an amount for profit on the work in process proportionate to the work done on it. In addition, the Government agrees to pay the contractor for its approved expenditures after termination in protecting the Government property and in making the settlement. Furthermore, at the end of the war the Government must terminate under this article instead of terminating for any default, unless the default of the contractor has been gross or willful and has caused substantial damage to the Government. Except in such cases the contractor is therefore assured that on termination at the end of the war he will receive his reasonable costs and a fair profit on the work done on the uncompleted part of the contract.

In spite of these provisions, fair both to the contractor and the Government, many contractors seem to fear that they will not receive a fair settlement from the Government. This feeling is partially based on the unfounded belief that after the last war the Government settled with contractors for an average of 14% of the amount due them. That is not true. The settlement was an average of 14% of the face amount of the contracts. Failure to distinguish between the face value of the cancelled contract and the amount due as a result of termination has led to this misunderstanding. The importance of this distinction is clearly shown by some figures on current cancellations. Many of the contracts cancelled to date were in their early stages. Final settlement by the Government to date represents payment of 11.2% of the face value of the cancelled contracts. However, a check of current settlements, indicates that the payment to the contractors averaged 75% of the contractor's own proposed settlements. This average figure is also misleading. Where the contractor has carefully and fairly computed this settlement proposal he receives very nearly 100%. Where contractors' settlement proposals show excessive amounts to which they are not entitled these must, of course, be adjusted to a fair basis. It is not the policy of the War Department to attempt to make any settlement that is not entirely fair to both parties.

We recognize, however, that the contractor is as much interested in a prompt settlement as a fair one. He needs working capital to get his plant in peacetime operation and to give jobs to his employees. In meeting this objective there are several major obstacles to overcome. The first is getting the settlement proposal from the prime contractor. An analysis of the August settlements where the amount involved was over $10,000 showed

* Director of the Purchases Division, A.S.F., Washington, D. C.





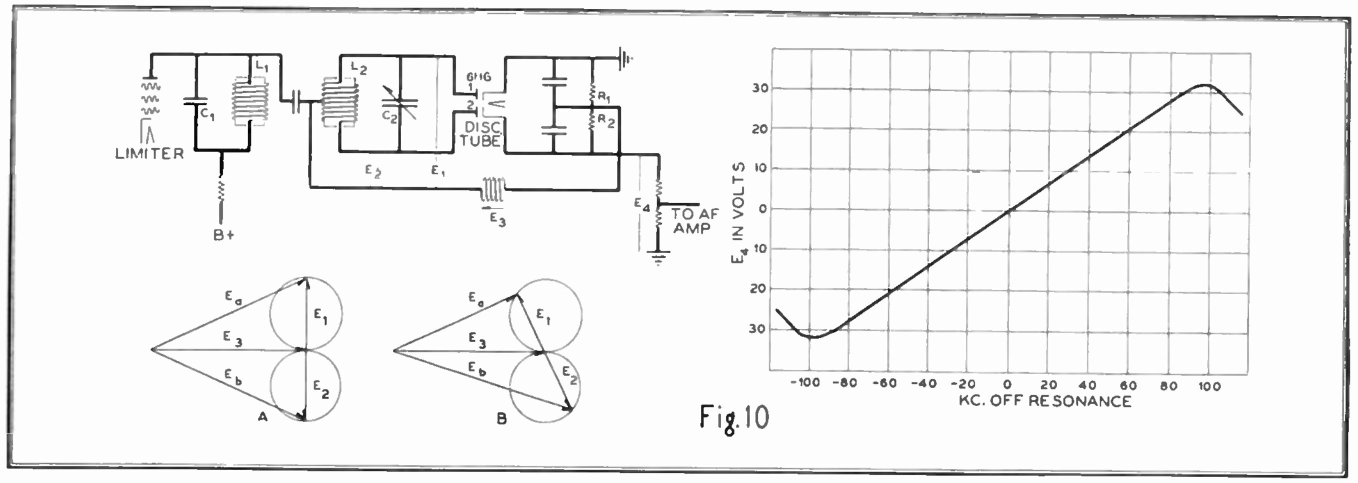



FIG. 10. TYPICAL DISCRIMINATOR CIRCUIT OF A FREQUENCY MODULATION RECEIVER, AND ITS CHARACTERISTIC CURVE

change in magnitude, one decreasing and the other increasing. By detector theory[5] the instantaneous value of the voltage across $R_1$ is proportional to $E_a$ while that across $R_2$ is proportional to $E_b$. Therefore the instantaneous voltage $E_4$ supplied to the audio amplifier changes. Increases in frequency make $E_4$ positive and decreases make it negative.

The relation between the frequency deviation and the instantaneous value of $E_4$ is also shown in Fig. 10 for a typical receiver. The circuit constants must be selected so that the straight-line portion of the characteristic will accommodate the frequency shift which is used at the transmitter. The linearity of this characteristic affects the nonlinear distortion in the reproduced signal. It should be observed that its linearity is not a function of the tube characteristic. This makes it apparent that it is necessary to adopt standards at both receiver and transmitter which will be co-ordinated.

After a hearing before the Federal Communications Commission where all the problems were thoroughly discussed, the band width of 200 kilocycles per channel was adopted as standard.

Because the intermediate amplifier must amplify a wider band of frequencies than is necessary in amplitude modulation, a higher intermediate frequency is used. The present standard adopted is 4.3 mc. for the intermediate carrier frequency.

EDITOR'S NOTE: The conclusion of Prof. Everitt's paper will appear in the October issue of *FM RADIO-ELECTRONICS*.

# TWO HANDBOOKS FOR RADIO ENGINEERS

REFERENCE DATA FOR RADIO ENGINEERS, edited by H. T. Kohlhaas, H. H. Buttner chairman of the reference book committee. 200 pages, illustrated with diagrams, curves, and charts. Cloth bound, 8⅝ by 5½ ins. Published by Federal Telephone and Radio Corporation, 67 Broad Street, New York City. Price $2.00.

The members of the committee who selected the material in this volume have performed a distinct service to radio engineers. Their task was not an easy one, for great discrimination must be exercised in picking out from the store of data available that which is most often needed.

Going over the pages, it is surprising to find so much information that one has habitually culled a dozen volumes to locate, now available in this reference data book.

The editors successfully resisted the temptation to expand the scope of this book beyond pocket size, in which case its feature of convenience would have been lost, and yet it might have fallen short of being a complete handbook — which it was not intended to be.

However, an astonishing amount of reference data is contained in the 200 pages of formulas, tables, and charts. These are grouped under the headings of general engineering tables, engineering and material data, audio and radio design, vacuum tubes and amplifiers, telephone transmission, radio frequency transmission lines, radio propagation and antennas, noise and noise measurements, non-sinusoidal waveforms, dimensional expressions, the Greek alphabet, mathematical formulas and general information, and mathematical tables.

The information collected under these headings is of value not only in engineering departments but in laboratories and drafting rooms as well.

RADIO ENGINEERS' HANDBOOK, by Frederick Emmons Terman, Sc.D. 1,017 pages, profusely illustrated, cloth-bound, 9 by 6 ins. Published by McGraw-Hill Book Company, 330 West 42nd Street, New York City. Price $6.00.

Dr. Terman states that the purpose of this book is to provide a reference volume summarizing the body of engineering knowledge that is the basis of radio and electronics.

He is well qualified to carry out such an ambitious undertaking successfully, as indicated by his position as Professor of Electrical Engineering and executive head of the Electrical Engineering Department at Stanford University (now on leave), and director of the Radio Research Laboratory at Harvard University. He is also a past president of the Institute of Radio Engineers.

A unique feature of the Handbook is the fact that it is a one-man job. This must have made the preparation a formidable task, but has had the result of making possible the close coördination of the various sections.

An idea of the comprehensive scope of this work can be gained from the fact that Dr. Terman lists nearly a thousand authors whom he has quoted in the text. These names represent several thousand individual references. The subject index occupies fifteen pages. From this it can be seen that the author has been consistent in carrying out his proposal to include the body of engineering knowledge that is the basis of radio and electronics.

Following are the chapter headings: tables, mathematical relations, and units; circuit elements; circuit theory; vacuum tubes and electronics; vacuum tube amplifiers; oscillators; modulation and demodulation; power supply systems; radio transmitters and receivers; propagation of radio waves; antennas; radio aids to navigation; measurements.

A most commendable feature of the Handbook is that, for all the tremendous amount of data collected in it, the arrangement of each individual element has been planned with such care and thoughtfulness that there is no confusion, but rather a sense of accessibility throughout.

The author apologizes for the absence of a coördinated presentation of television systems, although television material appears in various sections.

that the contractor took an average of 4.2 months to submit his proposal for settlements. The second problem is the disposition of materials. At present we try to dispose of materials rather than taking title to them for the Government. This, of course, requires considerable work by the contractor and contracting officer in order to locate purchasers. The third problem is in clearing subcontractors' settlement proposals and that will undoubtedly remain one of the biggest jobs under termination. The extent of integration of American industry is not always fully understood. When you realize that each of the three or four hundred major prime contractors of the War Department may have an average of 2,000 or more customers and 6,000 subcontractors, you will get a picture of the complex relationships which cannot be settled simply under any system.

If we are to surmount these problems and obtain prompt settlements, two things will be required. First, simple and workable procedures and second, a trained organization.

We are now seeking to forge a sound procedure in the fire of actual practice. In Procurement Regulation 15 we have issued a handbook on cancellation management, which should be treated as a tentative guide. I say "tentative" advisedly because we will continue to revise and rework it in the light of our experience until we are sure that it is a thoroughly practical, workable operating handbook. As a guide to termination accounting, a manual has been published by the Fiscal Division for use where auditing is necessary.

One basic principle is the keystone of this procedure. The job can be done only by negotiation on a business-like basis between representatives of the Government and individual contractors. We are convinced that the crucial need for speed in settlements will not permit excessive use of auditing and accounting. Reasonable data are of course needed for negotiation, and for this purpose selective accounting investigations will generally be necessary, but the use of detailed audit, except in unusual cases, would seriously delay settlements and impede the return to peacetime production. Undoubtedly, reliance on negotiation will result in some mistakes and some overpayments, but these must be balanced against the costs of delay in terms of wages and other income. At some point the desire for exactness and perfection in settlements must give way to the need for speed. The difference between settlements on this basis and the most carefully audited settlements could not possibly justify the terrible cost of an extended period of idleness for industry and labor.

In addition to sound procedures, we need a capable organization and personnel to do the job. At present we are setting up the organizations and training our personnel for this purpose. A special Termination Branch has been created in the War Department and there will be termination branches in the contracting offices. Every month each district office is now required to submit a complete report showing the status of every terminated contract on which final settlement has not been reached.

**3. Financing Terminations** ★ Even with efficient procedure and personnel, however, termination and settlement of the enormous volume of contracts and subcontracts will inevitably require a considerable period. Consequently, the second great problem of termination is to see that contractors and subcontractors all the way down the line get cash at once to release their own working capital from frozen war inventory and receivables and to permit them to return to peacetime business and continue to furnish employment to their workers. Substantial amounts of such cash must begin to flow out within a week or so after termination.

None of the methods now being used to finance war production is completely satisfactory for termination financing. Of these methods private bank loans, RFC loans and Federal Reserve Bank 13-B loans, even if available, do not protect the borrower during the settlement period from the danger that the loan will be called before final settlement. Neither does it make working capital immediately available.

Only advance payments and guaranteed loans now give a contractor or subcontractor some protection on termination. Advance payments made for war production do have their maturity extended and become interest free on termination, but since they do not free cash to permit the borrower to go about his normal business, they fail to give adequate relief. Likewise, partial payments on the contractor's settlement proposal for settlement are of only limited value for termination financing. The present reluctance of contracting officers to make substantial partial payments without exhaustive accounting for fear of personal liability can be corrected by pending legislation. But, while partial payments may finance the prime contractor with only a few contracts, they are not adequate for contractors with hundreds of small purchase orders from several procurement agencies and from various branches within each agency, or for companies which have contracts, subcontracts and third, fourth and fifth tier subcontracts. Eighty per cent of the producers of war material fall into this class.

Regulation V-loans made by local banks and guaranteed by the procurement agencies through the Federal Reserve banks do give a contractor considerable relief on termination. Maturity of the loan is extended and the contractor is relieved from paying interest. Moreover, the guaranteed loan can be used for overall working capital to finance receivables, inventory, work in process and amounts payable to subcontractors. The procurement agencies have recently made V-loans available not only for financing production, but for freeing frozen inventory and receivables on terminated contracts.

In order to achieve adequate financing of termination settlements it seems to me three things are required. First, interest must be allowed on the termination settlement to equalize the position of contractors who use private financing rather than public. Second, the type of financing must be extremely simple. Third, the method must permit advancing of money against inventory, receivables, work in process and payments to the tier of contractors immediately below.

This type of financing can be done in either of two ways. One is by a very simplified form of guaranteed loan made through existing channels along the lines of the present V-loan system with a high degree of decentralization. The other is direct loans made to industry either by the procurement agency with the major interest in the borrower or by another Government agency on the basis of the simplest sort of security, such as the assignment of the producer's termination receivables.

All of these methods of financing are now receiving careful study by the War Department. It is probable that no one method will provide a complete answer and we may find it necessary to use a number of different methods in order to achieve complete coverage of the problem.

**4. Coöperation** ★ Let me conclude by reminding you of three important points: In the first place we will continue to need the active help and suggestions from management and labor. We must learn all that we can from the practical experience of current terminations in order to make the final task as simple as is humanly possible.

In the second place, you must set up termination departments in your own organizations. These departments must be manned by men who are fully familiar with termination procedures and these groups must include responsible officers of your company in whom you have confidence. This is necessary if we are to avoid a fatal waste of time when mass settlements become necessary.

Finally, industry must itself be prepared to settle the enormous volume of subcontracts which will be terminated in connection with the cancellation of prime contracts. The personnel of your termination departments must get their training in this difficult operation of making termination settlements of subcontracts.

With your active help, gentlemen, we hope and believe that the job can and will be done promptly and fairly.

FIG. 1. AEROVOX USES BAKELITE CASES FOR HIGH-VOLTAGE OIL CONDENSERS

# RADIO DESIGNERS' ITEMS

## Notes on Methods and Products of Importance to Design Engineers

**Use of Dummy Tubes:** A very large percentage of the failures of miniature vacuum tubes has been traced to the sockets in which the tubes are mounted. There has been so much trouble with tubes cracking at the bases that a directive has been issued to manufacturers on this subject.

The new requirements call for putting dummy tubes with steel contact pins into the sockets while the leads are being soldered to the contacts.

In the past, the socket contacts have been pulled out of alignment by the wires. Then, when a tube is inserted, the misaligned contacts bend the tube pins, putting a strain on the glass. As a result, the glass cracks, sometimes in an hour or two, sometimes within a few days.

By using a dummy tube with steel pins in the sockets during soldering operations, the contacts are brought into line and held against distortion.

Hard wood is a better material for the dummies than metal. The latter, if they fall off the bench, are so heavy that the pins are broken. Flat sides are recommended, to prevent them from rolling.

**Bakelite-Cased Condensers:** High-voltage capacitors with Bakelite cases, as shown in Fig. 1, are being produced by the Aerovox Corporation for X-ray machines, impulse generators, carrier-coupler condensers, and test equipment where intermittent DC or continuous AC service is required.

These condensers are oil-impregnated and filled with Hyvol vegetable oil to provide the minimum size and weight for a given capacity, with an adequate breakdown safety factor.

Matched condenser sections, of uniform capacity, are connected in series. Thus the voltage stresses are equalized in the sections, and a uniform voltage gradient is obtained throughout the length of each unit. The sections are dried and impregnated under vacuum in a long, closely-controlled cycle. This eliminates voids, and assures high resistance values with low losses. High-purity aluminum foil, with a generous number of connecting tabs, are used to obtain high conductivity and low inductive reactance.

Cases are of laminated Bakelite tubing, fitted with two-piece cast aluminum end caps. Cork gaskets assure leak-proof, hermetic sealing. This design, providing a maximum leakage path, protects the units from external flash-over.

These condensers are intended for operation at ambient temperatures up to 65° C.

**Phenolic Grommets:** A line of phenolic grommets, in four standard sizes, has been brought out to replace the rubber types used to carry wires through steel chassis and other metal parts. These are shown in Fig. 2. It is claimed that they can be put in place more rapidly, as they are less awkward to handle. The holes are chamfered to prevent chafing of the insulation. Both the grommets and phenolic nuts have clean threads so as to speed assembly. A dab of Glyptol on the threads prevents the nuts from coming loose under vibration. This avoids the necessity for spending extra time to tighten them in place.

Samples and further data can be obtained from Creative Plastics Corporation, 970 Kent Avenue, Brooklyn 5, N. Y.

**Postscript to Notes on HF Losses:** Last month, in this department, we published some notes on high-frequency losses which were apparently due to defective silver plating.

It was stated that the excessive losses disappeared when an improved method of plating was adopted. Now we have word of further investigation, showing that while the condition was improved, only a part of the trouble was eliminated.

And, as sometimes happens, the main source of the trouble was not discovered by the engineers who had theorized about it at great length. Instead, it was a tester who, following his natural bent, put an ohmmeter across the contacts on the miniature tube sockets and discovered leakage paths between the contacts as low as 30,000 ohms.

The leads to the contacts had been soldered with rosin-core solder, and cleaned with alcohol — not carbon tet. However, the operators held the units in such a position that the sockets were upside down when they brushed off the joints. As a result, alcohol frequently flowed down under the washer at the bottom of the socket, carrying with it rosin and dirt particles.

When this happened, low-resistance paths were created which, rather than the plating on the associated tuning condenser, accounted for the mysterious losses in the circuit. A little more care in soldering and in cleaning the joints have now eliminated the trouble entirely.

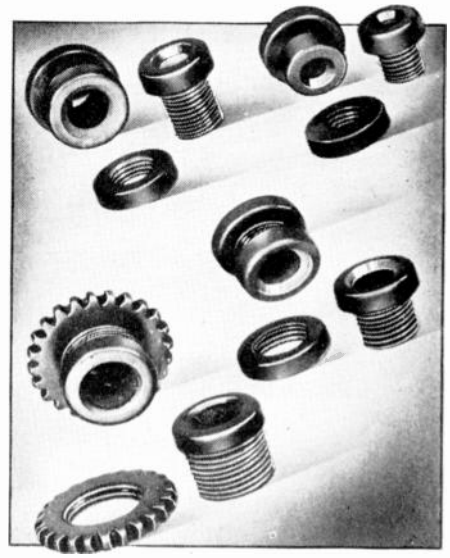


FIG. 2. PHENOLIC GROMMETS IN STANDARD SIZES, FROM CREATIVE PLASTICS


FIG. 3. 50,000-VOLT CONDENSER

**Steatite Parts:** A new directive calls for the maximum use of Steatite for all suitable applications.

In this connection, it is interesting to note that Henry L. Crowley & Company, West Orange, N. J., has issued a detailed listing of standard pressed Steatite parts for which tools are already available. Dimensions are shown for trimmer condenser bodies, bushings, terminal strips, tube sockets, tube parts, coil bases, variable condenser end plates, and oscillating-crystal cases.

More than 100 standard parts are listed, and others will be included in supplementary bulletins to be issued later. The special advantage in using these parts is that, with tools already in use, delivery time is greatly reduced.

**Heavy-Duty Condensers:** Special condensers for 24-hour continuous service at working voltages up to 150,000 are being produced by the Industrial Condenser Corp., Chicago.

A .5 mfd. unit of this series, rated at 50,000 volts DC is shown in Fig. 3. It is 28 ins. high, and weighs 175 lbs. The case is intended to withstand total submersion in salt water. Hermetic sealing of the leads is provided by the use of Westinghouse solder-seal terminal bushings.

**Cockpit Trouble:** That is the term our pilots use when faults develop which are blamed on the equipment, but are actually due to its misuse. Radio design engineers ought to have a similar term to use when they are blamed for trouble that develops as a result of improper operation at the hands of unskilled or indifferent personnel.

**Coaxial Cable in Long Lengths:** Continuous lengths of $\frac{7}{8}$-in. soft-tempered copper coaxial cable, up to several thousand feet, are available from the Andrew Company, 363 E. 75th Street, Chicago 19. This cable, Fig. 4, is electrically identical to rigid cables of the same size. Furnished on wooden reels, it affords great convenience because it can be uncoiled and bent by hand into any desired contours.

This eliminates the need for connectors, junction boxes, and expansion fittings to join short lengths. Gas-tight joints, also, are eliminated, except at the extremities.

To prevent the condensation of moisture in the cable during transit, the cable can be fitted with glass-insulated terminals and filled with gas under pressure. Thus the installation of the coaxial cable is greatly simplified.

**Socket-Locking Ring:** Details of an ingenious socket-locking ring are shown in Fig. 5. Its purpose is to afford a positive lock to hold sockets to the chassis, and at the same time to permit the removal of any socket without damage to the component or the need of special operations.

As the illustrations show, the ring has four locking tongues which, in the locked position, fit into four slots in the socket base. Eight springs bent up from the ring

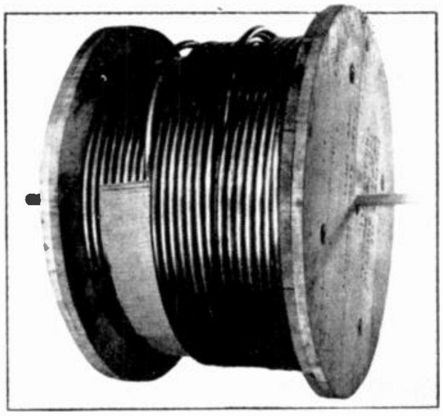


FIG. 4. ANDREW $\frac{7}{8}$-IN. COAXIAL CABLE

press against the under side of the bosses on the socket base, drawing the socket down, under tension, on the top of the chassis.

The two lower sketches show the positions of the tongues and springs in the unlocked and locked positions. In the latter position, the tongues are held in the deep grooves, so that there is no possibility for them to work loose. However, the ring can be loosened and the socket removed simply by bending out the tongues and rotating the ring $\frac{1}{8}$ turn.

**Moisture Absorption:** Some very interesting information on the absorption of moisture by phenolic sheet has been furnished by F. S. Grazen, chief chemist at the Spaulding Fibre Company, Tonawanda, N. Y.

Specifications for military equipment frequently call for coating phenolic terminal plates and similar pieces with Kauri varnish, Glyptol, or other materials to prevent the absorption of moisture. There has been much discussion as to the need of this extra process, and the amount of difference in moisture absorption between pieces that are and are not protected in this manner.

Accordingly, Mr. Grazen ran a series of tests to obtain quantitative data. The test pieces were smooth-sawed from $\frac{1}{4}$-in. and $\frac{1}{2}$-in. grade XX and CE Spauldite, each 3 ins. long by 1 in. wide.

Three pieces of each material and each thickness were used. The first was coated on the edges with Glyptol cement No. 1276, thinned with butyl acetate. The second was similarly coated with Larcoloid, which is said to be a phenolic-base varnish. Experience has shown this varnish to be highly resistant to the absorption of moisture. The third was left uncoated, and free to absorb as much moisture as possible.

The actual absorption was determined by weighing each piece before the tests, and again after the various periods enumerated in the tables following. The percentage increase in weight was taken as the measure of absorption.

During the tests, each piece was totally

(CONTINUED ON PAGE 51)

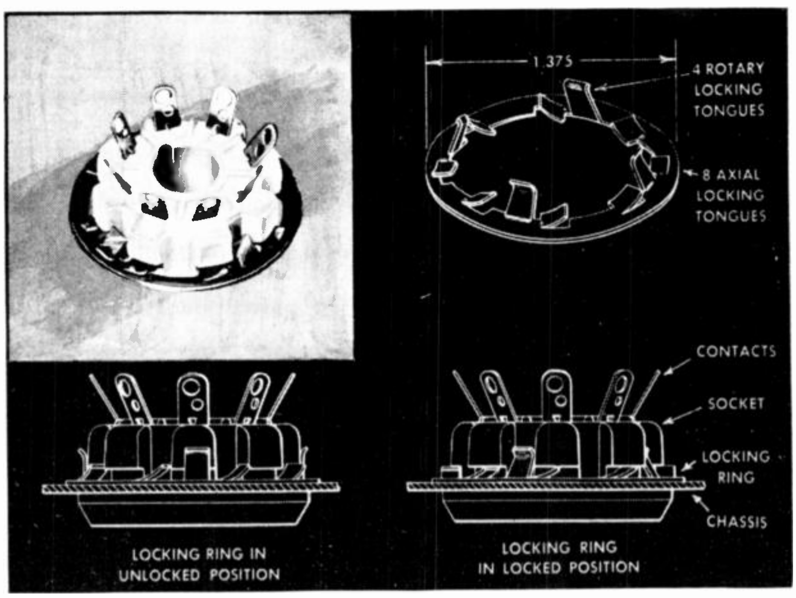



FIG. 5. DETAILS OF THE FRANKLIN LOCKING RING FOR VACUUM TUBE SOCKETS

# RADIO-ELECTRONIC PRODUCTS DIRECTORY

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

★ Indicates advertiser in this issue of FM Radio-Electronics

**AIRPORT RADIO INSTALLATIONS**

Air Associates, Inc., Los Angeles, Calif.
Bendix Radio, Towson, Md.
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.

**ANTENNAS, Mobile Whip & Collapsible**

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., Noble & Darien Sts., 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.
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.
★ International Resistance Co., 429 Broad St., Phila.
Malbry & 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 Laboratories, 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.
Dunn, Inc., Struthers, 1321 Cherry, Phila., Pa.
Star Porcelain Co., Trenton, N. J.
Steward Mfg. Co., Chattanooga, Tenn.

**BEARINGS, Glass Instrument**

Bird, Richard H., Waltham, Mass.

**BINDING POSTS, Plain**

★ Amer. Hdware Co., 476 B'way, N. Y. C.
Radex Corp., 1308 Elston Ave., Chicago

**BINDING POSTS, Push Type**

★ Amer. Radio Hdware Co., 476 B'way, N. Y. C.
Eby, Inc., H. H., W. Chelten Ave., Phila.

**BLOWERS, for Radio Equipment**

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.
Pitman Pub. Corp., 2 W. 45 St., N. Y. C.
Radio Tech. Pub. Co., 45 Astor Pl., 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.

### NEW LISTINGS ADDED THIS MONTH

**Company addresses will be found in the Directory listings**

**We shall be pleased to receive suggestions as to company names and hard-to-find items which should be added to this Directory**

**AIRPORT RADIO INSTALLATIONS**

Air Associates, Inc.
Bendix Radio
Communications Equipment Corp.
Erco Radio Laboratories, Inc.
Radio Receptor Company, Inc.

**BEARINGS, Glass Instrument**

Richard H. Bird

**BLOWERS, for Radio Equipment**

L-R Manufacturing Co.
Trade-Wind Motorfans, Inc.

**BUSHINGS, Terminal Sealing**

Corning Glass Works
Peerless Electrical Products Co.
Westinghouse Electric & Mfg. Co.

**CABLES, Preformed**

Belden Manufacturing Co.

**CONDENSERS, Fixed**

Edwin I. Guthman & Co.

**CONDENSERS, High-Voltage Vacuum**

General Electronics, Inc.

**CONNECTORS, Cable**

Northam Warren Corp.
W. L. Schott Co.

**CRYSTAL GRINDING EQUIPMENT**

Cons. Diamond Saw Blade Corp.

**CRYSTALS, Quartz**

Aircraft Accessories Corp.
Henney Motor Co.
The James Knights Co.
Reeves Sound Laboratories
Wm. T. Wallace Mfg. Co.

**ENAMELS, Wood & Metal Finish**

Sullivan Varnish Co.

**FILTERS**

J. W. Miller Co.

**FINISHES, Metal**

Sullivan Varnish Co.

**GENERATORS, Electronic AC**

Communication Measurement Laboratories

**INDUCTORS, Transmitter**

Barker & Williamson

**IRON CORES, Powdered**

Magner Manufacturing Co.

**LACQUERS, Wood & Metal Finish**

Sullivan Varnish Co.

**MAGNETS, Permanent**

Arnold Engineering Co.
Indiana Steel Products Co.

**MARKING MACHINES, Letters, Numbers**

Marken Machine Co.

**METERS, Frequency**

North American Philips Co., Inc.

**METERS, Vibrating Reed**

J-B-T Instruments, Inc.

**MICA**

Ford Radio & Mica Corp.

**MOTOR-GENERATORS**

Electric Indicator Co.
Webster Products

**MOTORS, Very Small**

Kollsman Instrument Division

**MYCALEX**

Colonial Kolonite Co.
Precision Fabricators, Inc.

**NAME PLATES, Plastic**

Crowe Name Plate & Mfg. Co.
Hopp Press, Inc.
Parisian Novelty Co.

**OSCILLATORS, AF**

Hewlett-Packard Co.
General Radio Co.
Jackson Electrical Instrument Co.

**PLASTICS, MOLDED**

Arnold Brilhart Co.

**PLASTICS, Transparent**

Dow Chemical Co.

**PLUGS, (Banana) Spring Type**

E. F. Johnson Co.

**PLUGS, Telephone Type**

Trav-Ler Karenola Corp.

**RACKS, Standard Aircraft Type**

Delco Radio

**RECTIFIERS, Current**

Green Electric Co., Inc.

**RELAYS, Small Switching**

Birtcher Corp.
Electrical Products Supply Co.

**RESISTORS, Variable Laboratory Type**

J. G. Biddle Co.
H. H. Sticht Co., Inc.

**SCREWS, Clutch Head**

United Screw & Bolt Corp.

**SPEAKERS, Cabinet Mounting**

John Meck Industries
Rola Company, Inc.

**STAMPINGS, Metal**

Ace Manufacturing Corp.
Security Steel Equipment Corp.
Willor Manufacturing Corp.

**SYNTHETICS, Wood & Metal Finish**

Sullivan Varnish Co.

**TERMINAL STRIPS**

Burke Electric Co.
Kulka Electric Manufacturing Co.

**TRANSFORMERS, IF, RF**

Standard Winding Corp.

**TRANSFORMERS, Receiving Audio & Power**

Merit Coil & Transformer Corp.
Rola Company, Inc.

**TRANSFORMERS, Variable Voltage**

American Transformer Co.
General Radio Co.
Superior Electric Co.

**TUBES, Transmitting**

Federal Telephone & Radio Corp.
Slater Electric & Mfg. Co.
Sperry Gyroscope Co., Inc.

**TUBING, Precision Metal**

Superior Tube Co.

**TURNTABLES, Phonograph**

General Industries Co.
RCA Manufacturing Co.
Western Electric Co.

**VARNISHES, Wrinkle Finish**

Sullivan Varnish Co.

**VIBRATION TEST EQUIPMENT**

All American Tool & Mfg. Co.

**WIRE, Bare**

Jelliff Manufacturing Corp.

**WIRE, Glass Fibre Insulated**

Bentley, Harris Mfg. Co.
Garritt Manufacturing Co.
Holyoke Wire & Cable Corp.
Insulation Manufacturers Corp.

**WIRE, Hookup**

Runzel Cord & Wire Co.

**BUSHINGS, Hermetic Sealing**

Corning Glass Works, Corning, N. Y.
Westinghouse Elect. & Mfg. Co., E. Pittsburgh, Pa.

**BUSHINGS, Terminal Sealing**

Corning Glass Works, Corning, N. Y.
Peerless Electrical Prod. Co., 6920 McKinley Ave., Los Angeles 1
Westinghouse Elect. & Mfg. Co., E. Pittsburgh, Pa.

**CABLE, Coaxial**

American Phenolic Corp., 1830 S. 54 Av., Chicago
Anaconda Wire & Cable Co., 25 B'way, N. Y. C.
★ Andrew Co., Victor J., 363 E. 75 St., Chicago
Belden Mfg. Co., 4673 W. Van Buren, Chicago
Boston Insulated Wire & Cable Co., Boston
Communications Prods. Co., Jersey City, N. J.
Cornish Wire Co., 15 Park Row, N. Y. C.
★ Doolittle Radio, Inc., 7521 S. Loomis Blvd., Chicago
General Cable Corp., 420 Lexington, N. Y. C.
General Insulated Wire Corp., 53 Park Pl., N. Y. C.
★ Johnson Co., E. F., Waseca, Minn.
Radex Corp., 1308 Elston Ave., Chicago
Simplex Wire & Cable Corp., Cambridge, Mass.

**CABLE, Coaxial, Solid Dielectric**

American Phenolic Corp., 1830 S. 54 Ave., Chicago
★ Federal Tel. & Radio Corp., E. Newark, N. J.
Simplex Wire & Cable Corp., Cambridge, Mass.

**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.
Gavett Mfg. Co., Brookfield, Mass.
Holyoke Wire & Cable Corp., Holyoke, Mass.

**CABLES, Preformed**

Belden Mfg. Co., 4633 W. Van Buren St., Chicago

**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**

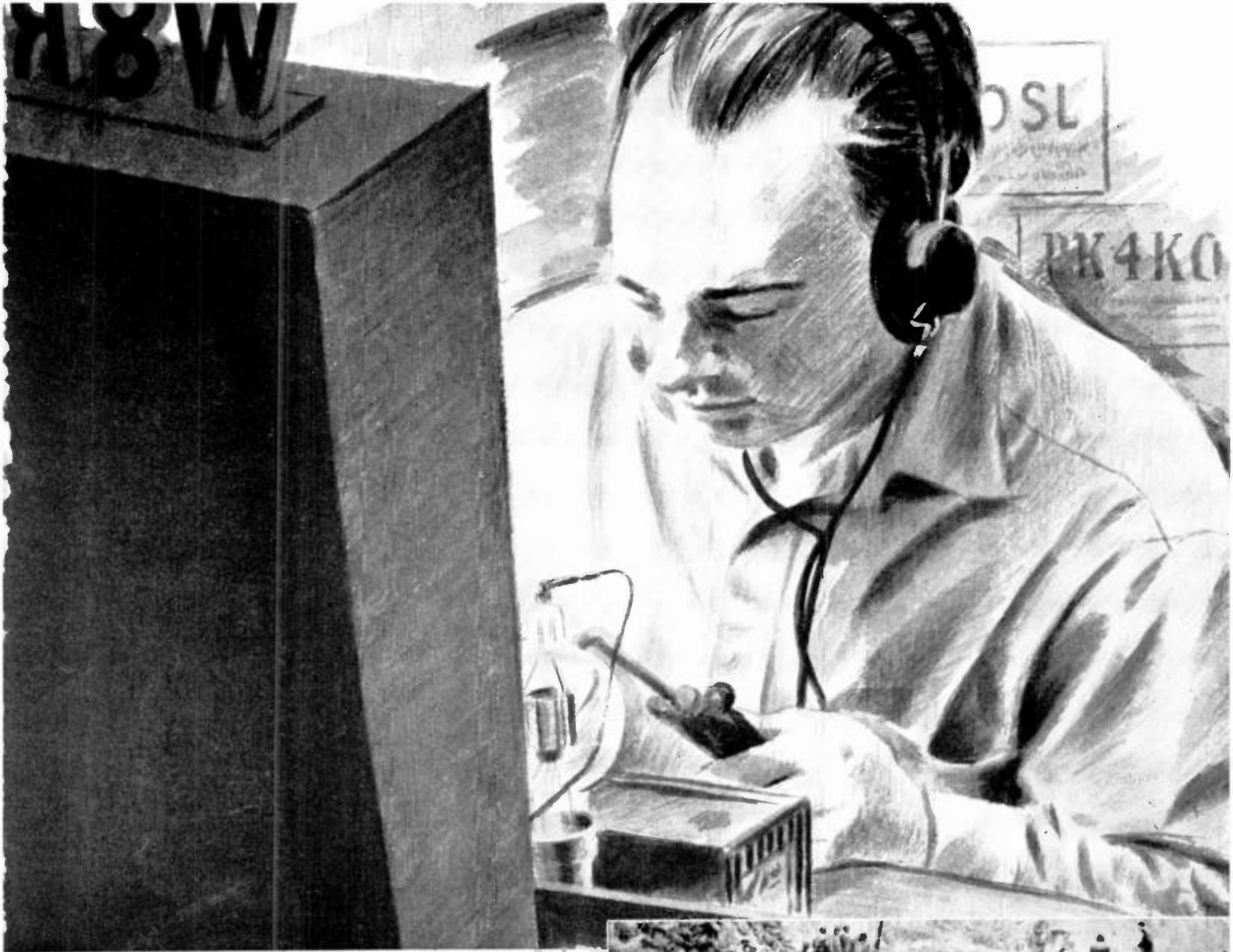
Akron Porcelain Co., Akron, O.
Amer. Lava Corp., Chattanooga, Tenn.
Centralab, Div. of Globe-Union Inc., Milwaukee, Wis.
Corning Glass Works, Corning, N. Y.
Electronic Mechanics, Inc., Paterson, N. J.
Gen'l Ceramics & Steatite Corp., Keasbey, N. J.
Isolantite, Inc., Belleville, N. J.
Lapp Insulator Co., Leroy, N. Y.
Louthan Mfg. Co., E. Liverpool, O.
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.

**CHASSIS, Metal**

*See* STAMPINGS, Metal

**CHOKES, RF**

Aladdin Radio Industries, 501 W. 35th, Chicago
Alden Prods. Co., Brockton, Mass.
American Communications Corp., 306 B'way, N. Y. C.
Barker & Williamson, Upper Darby, Pa.
Coto-Coil Co., Providence, R. I.
D-X Radio Prods. Co., 1575 Milwaukee, Chicago
Gen. Winding Co., 420 W. 45 St., N. Y. C.
Guthman & Co., Edwin, 400 S. Peoria, Chicago
Hammarlund Mfg. Co., 424 W. 33 St., N. Y. C.



# the amateur is still in radio

He's not at his haywire rig in the attic...he's holding down key engineering spots in the laboratories, the factories, the army, navy and marine corps. Today the radio amateur is the top electronic engineer who is doing the impossible for his country and for the world. And why not?...the radio amateur has always done the impossible. He's the one who refused to obey the rules...demanded more and ever more from his "ham" rig. The equipment that he used...especially the tubes...had to have greater stamina and vastly superior performance capabilities. Thus the radio amateur literally forced electronics forward. For the products created to stand up under his gruelling treatment represented real advancement. Eimac tubes are a good example, for Eimac tubes were created and developed in the great amateur testing grounds. That's one reason why Eimac tubes have proved so vastly superior for commercial and war uses. Yesterday the leading radio amateurs throughout the world preferred Eimac tubes. Today these radio amateurs are off the air as amateurs but wherever they are, as the leaders in electronics, they're still using Eimac tubes.

*Follow the leaders to*

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

**TUBES**

ARMY E NAVY

**EITEL-McCULLOUGH, INC. · SAN BRUNO, CALIFORNIA**

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

★ Johnson Co., E. F., Waseca, Minn.
Lectrohm, Inc., Cicero, Ill.
★ Meissner Mfg. Co., Mt. Carmel, Ill.
Miller Co., J. W., 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.
Triumph Mfg. Co., 4017 W. Lake St., Chicago

## 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, Phenolic, Cast without Molds

★ Creative Plastics Corp., 963 Kent Ave., B'klyn, 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.
American Condenser Corp., 2508 S. Michigan, Chicago
Art Radio Corp., 115 Liberty, N. Y. C.
Atlas Condenser Prods. Co., 548 Westchester Ave., N. Y. C.
Automatic Winding Co., E. Newark, N. J.
Bud Radio, Inc., Cleveland, O.
Cardwell Mfg. Corp., Allen D., Brooklyn, N. Y.
Centralab, Milwaukee, Wis.
Condenser Corp. of America, South Plainfield, N. J.
Condenser Prods. Co., 1375 N. Branch, Chicago
Cornell-Dubilier 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.
Electro-Motive Mfg. Co., Willimantic, Conn.
Erie Resistor Corp., Erie, Pa.
Fast & Co., John E., 3123 N. Crawford, Chicago
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., 1725 W. North Av., Chicago
Insuline Corp. of America, Long Island City, N. Y.
★ Johnson Co., E. F., Waseca, Minn.
Kellogg Switchb'd & Supply Co., 6650 Cicero, Chicago
Magnavox Co., Fort Wayne, Ind.
Mallory & Co., P. R., Indianapolis, Ind.
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. 139 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., Bayonne, N. J.
Sprague Specialties Co., N. Adams, Mass.
Teleradio Engineering Corp., 484 Broome St., N. Y. C.
Westinghouse Elect. & Mfg. Co., E. Pittsburgh, Pa.

## CONDENSERS, Gas-filled

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.

## CONDENSERS, Small Ceramic Tubular

Centralab: Div. of Globe-Union, Inc., Milwaukee, Wis.
Erie Resistor Corp., Erie, Pa.

## 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., Allen D., Brooklyn, N. Y.
General Instrument 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, Ill.

## 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.
★ Johnson, E. F., Waseca, Minn.
Millen Mfg. Co., James, Malden, Mass.
★ National Co., Malden, Mass.
Radio Condenser Co., Camden, N. J.

## CONDENSERS, Variable 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.
Fada Radio & Elec. Corp., Long Island City, N. Y.
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 America, Long Island City, N. Y.
★ Johnson Co., E. F., Waseca, Minn.
Mallory & Co., Inc., P. R., Indianapolis, Ind.
★ Meissner Mfg. Co., Mt. Carmel, Ill.
Millen Mfg. Co., James, Malden, Mass.
Miller Co., J. W., Los Angeles, Cal.
Muter Co., 1255 S. Michigan Av., Chicago
★ National Co., Malden, Mass.
Potter Co., 1950 Sheridan Rd., N. Chicago
Sickles Co., F. W., Chicopee, Mass.
Solar Mfg. Corp., Bayonne, N. J.
Teleradio Eng. Corp., 484 Broome, N. Y. C.

## CONNECTORS, Cable

Aero Electric Corp., Los Angeles, Calif.
Alradio, Inc., Stamford, Conn.
Alden Prods., Brockton, Mass.
Amer. Microphone Co., 1915 S. Western Av., Los Angeles
Amer. Phenolic Corp., 1830 S. 54th St., Chicago
★ American Radio Hardware Co., 476 B'way, N. Y. C.
Andrew, Victor J., 363 E. 75 St., Chicago
Astatic Corp., Youngstown, O.
Atlas Sound Corp., 1442 39th St., Brooklyn, N. Y.
Birnbach Radio, 145 Hudson St., N. Y. C.
Breeze Mfg. Corp., Newark, N. J.
Brush Development Co., Cleveland, O.
Bud Radio, Cleveland, Ohio
Cannon Elec. Development, 3209 Humboldt, Los Angeles
Eby, Inc., Hugh H., Philadelphia
Electro Voice Mfg. Co., South Bend, Indiana
Franklin Mfg. Corp., 175 Varick St., N. Y. C.
General Radio Co., Cambridge, Mass.
Harwood Co., 747 N. Highland Ave., Los Angeles
Insuline Corp. of Amer., L. I. City, N. Y.
Jones, Howard B., 2300 Wabansia, Chicago
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., 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.
★ Universal Microphone Co., Ltd., Inglewood, Calif.

## CONTACT POINTS

Brainin Co., C. S., 233 Spring St., N. Y. C.
Callite Tungsten Corp., Union City, N. J.
Mallory & Co., Inc., P. R., Indianapolis, Ind.

## COUPLINGS, flexible

Cardwell Mfg. Corp., Brooklyn, N. Y.
★ Johnson Co., E. F., Waseca, Minn.
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.

## CRYSTAL HOLDERS

REC Mfg. Co., Holliston, Mass.

## CRYSTALS, Quartz

Aircraft Accessories Corp., 9 Rockefeller Plaza, N. Y. C.
Bausch & Lomb Optical Co., Rochester, N. Y.
Bliley Elec. Co., Erie, Penna.
Collins Radio Co., Cedar Rapids, Iowa
Crystal Prod. Co., 1519 McGee St., Kansas City, Mo.
Crystal Research Labs., Hartford, Conn.
DX Crystal Co., W. Carroll Ave., Chicago
Electronic Research Corp., 800 W. Washington Blvd., 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.
Henney Motor Co., Omaha, Nebr.
Higgins Industries, Santa Monica, Calif.
Hipower Crystal Co., 2035 W. Charleston, Chicago
Hunt & Sons, G. C., Carlisle, Pa.
Jefferson, Inc., Ray, Westport, L. I., N. Y.
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.
Radell Corp., Guilford Ave., Indianapolis, Ind.
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, Hyattsville, Md.
Standard Piezo Co., Carlisle, Pa.
Valpey Crystals, Holliston, Mass.
★ Wallace Mfg. Co., Wm. T., Peru, Ind.
Zeiss, Inc., Carl, 485 Fifth Ave., N. Y. C.

## DIAL LIGHTS

*See* PILOT LIGHTS

## DIALS, Instrument

Crowe Name Plate Co., 3701 Ravenswood Ave., Chicago
General Radio Co., Cambridge, Mass.
Gits Molding Corp., 4600 Huron St., Chicago
Mica Insul. Co., 198 Varick St., N. Y. C.
★ National Co., Inc., Malden, Mass.
Rogan Bros., 2003 S. Michigan Ave., Chicago

## DISCS, Recording

Advance Recording Products Co., Long Island City, N. Y.
Allied Recording Products Co., Long Island City, N. Y.
Audio Devices, Inc., 1600 B'way, N. Y. C.
Federal Recorder Co., Elkhart, Ind.
★ Gould-Moody Co., 395 B'way, N. Y. C.
Presto Recording Corp., 242 W. 55 St., N. Y. C.
★ RCA Mfg. Co., Camden, N. J.

## DYNAMOTORS — See Motor-Generators

## ENAMELS, Wood & Metal Finish

★ Sullivan Varnish Co., 410 N. Hart St., Chicago 22

## ENGRAVING MACHINES

★ Auto-Engraver Co., 1776 B'way, N. Y. C.

## ETCHING, Metal

Crowe Name Plate & Mfg. Co., 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.

## FASTENERS, Separable

Camloc Fastener Co., 420 Lexington Ave., N. Y. C.
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.
Taylor Fibre Co., Norristown, Pa.
Wilmington Fibre Specialty Co., Wilmington, Del.

## FILTERS, Electrical Noise

Avia Products Co., 737 N. Highland Ave., Los Angeles
Com. Equip. & Eng. Co., N. Parkside Ave., Chicago
Freed Radio Corp., 200 Hudson St., N. Y. C.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago
Mallory & Co., Inc., P. R., Indianapolis, Ind.
Miller Co., J. W., 5917 S. Main St., Los Angeles
Tobe Deutschmann Corp., Canton, Mass.

## FINISHES, Metal

Alrose 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 METERS

Bendix Radio, Towson, Md.
★ Browning Labs., Inc., Winchester, Mass.
General Radio Co., Cambridge, Mass.
Lavoie Laboratories, Long Branch, N. J.
★ Link, F. M., 125 W. 17 St., N. Y. C.
Measurements Corp., Boonton, N. J.
North Amer. Philips Co., Inc., 419 Fourth Ave., N. Y. C.

## FREQUENCY STANDARDS, Primary

General Radio Co., Cambridge, Mass.

## FREQUENCY STANDARDS, Quartz Secondary

Garner Co., Fred E., 43 E. Ohio St., Chicago
Hewlett-Packard Co., Palo Alto, Calif.
Millen Mfg. Co., Inc., Malden, Mass.

## FUSES, Enclosed

Dante Elec. Mfg. Co., Bantam, Conn.
Jefferson Elec. Co., Bellwood, Ill.
Littlefuse, Inc., 4753 Ravenswood Av., Chicago

## GEARS & PINIONS, Metal

Continental-Diamond Fibre Co., Newark, Del.
Gear Specialties, Inc., 2650 W. Medill, Chicago

# SCHEDULE OF DIRECTORIES

## RADIO-ELECTRONIC PRODUCTS

**January, March, May, July, September, November**

## CHIEF ENGINEERS OF BROADCAST STATIONS

**February, August**

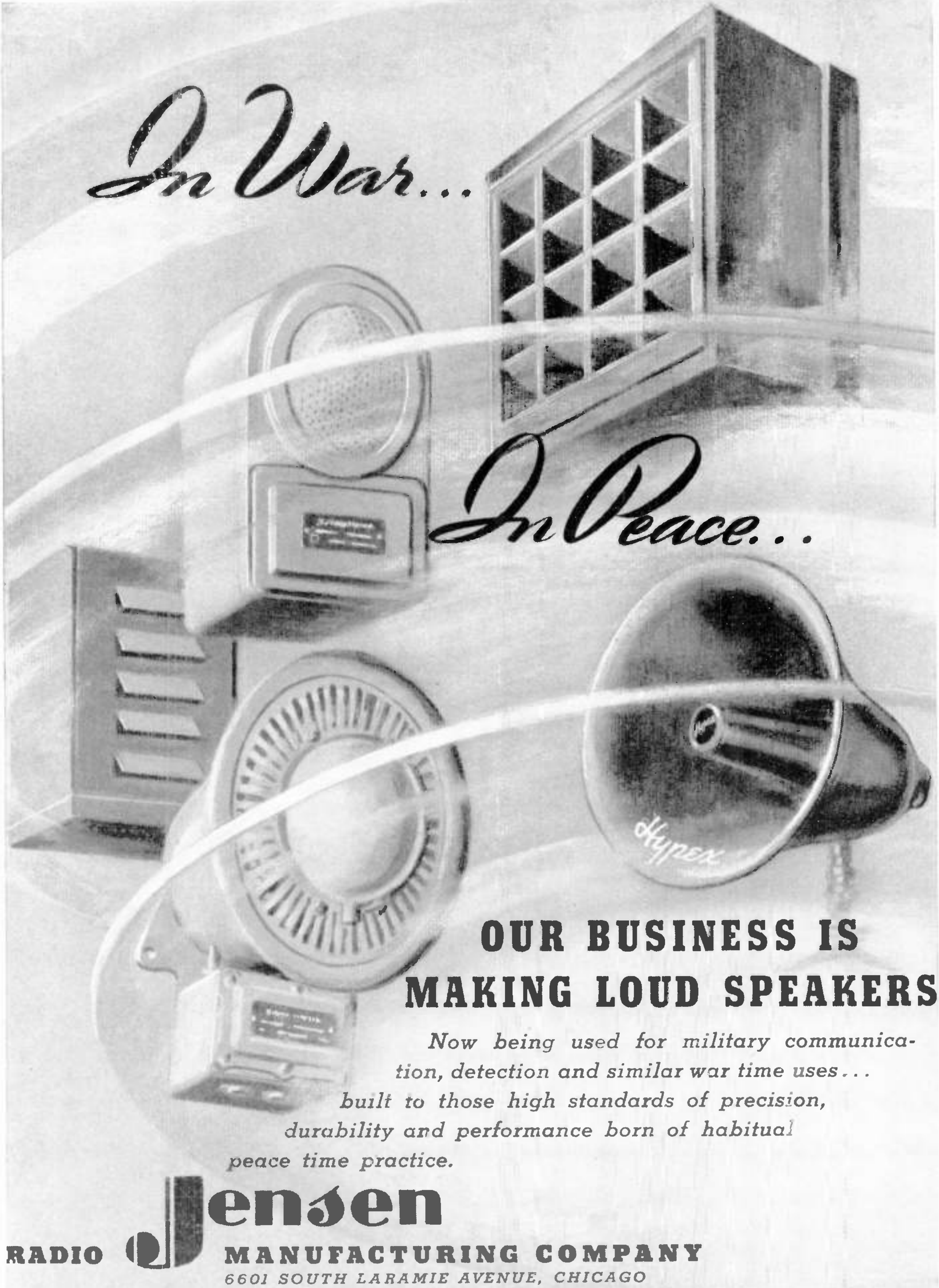
## POLICE RADIO COMMUNICATIONS OFFICERS

**June, December**

## CHIEF ENGINEERS OF RADIO MANUFACTURERS

**April, October**

**Under this schedule, FM RADIO-ELECTRONICS presents up-to-date listings, with complete corrections and additions, which are available in no other publication.**


In War...
In Peace...
Hypex
OUR BUSINESS IS
MAKING LOUD SPEAKERS
Now being used for military communication, detection and similar war time uses... built to those high standards of precision, durability and performance born of habitual peace time practice.
Jensen
RADIO MANUFACTURING COMPANY
6601 SOUTH LARAMIE AVENUE, 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 Insulator 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, Electronic AC

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

## GENERATORS, Gas Engine Driven

Hunter-Hartman Corp., St. Louis, Mo.
Kato Engineering Co., Mankato, Minn.
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., Elkart, Ind.

## GENERATORS, Standard Signal

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

## GENERATORS, Wind-Driven, Aircraft

General Armature Corp., Lock Haven, Pa.

## GLASS, Electrical

Corning Glass Works, Corning, N. Y.

## GREASE, for Electrical Contacts & Bearings

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

## HEADPHONES

Brush Development Co., Cleveland, O.
Conn. Tel. & Electric Co., Meriden, Conn.
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
Elec. Ind. Mfg. Co., Red Bank, N. J.
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.
Trimm Radio Mfg. Co., 1770 W. Berteau, Chicago
★ Universal Microphone Co., Inglewood, Cal.
★ Utah Radio Prod. Co., 842 Orleans St., Chicago

## HORNS, Outdoor

Graybar Elect. Co., Lexington Ave. at 43 St., N. Y. C.
★ Jensen Radio Mfg. Co., 6601 S. Laramie Ave., Chicago
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.

## INDUCTION HEATING EQUIPMENT

Induction Heating Corp., 389 Lafayette St., N. Y. C.
Lepel High Frequency Labs., 39 W. 60 St., N. Y. C.

## INDUCTORS, Transmitter

Barker & Williamson, Upper Darby, Pa.

## INDUCTORS, Variable Tuning

Barker & Williamson, Upper Darby, Pa.

## INSTRUMENTS, Radio Laboratory

Ballantine Laboratories, Inc., Boonton, N. J.
General Radio Co., Cambridge, Mass.
Hewlett Packard Co., Palo Alto, Calif.
★ Measurements Corp., Boonton, 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.
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.
★ National Co., Inc., Malden, Mass.

## 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., N. Y. C.
Gibson Elec. Co., Pittsburgh, Pa.
Magner Mfg. Co., Inc., 414 Madison Ave., N. Y. C.
Mallory & Co., P. R., Indianapolis, Ind.
Pyroferric Co., 175 Varick St., N. Y. C.
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.
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.
★ Universal Microphone Co., Inglewood, Calif.
★ Utah Radio Prod. Co., Orleans St., Chicago

## KEYS, Telegraph

★ Amer. Radio Hardware Co., Inc., 476 Broadway, N. Y. C.
Bunnell & Co., J. H., 215 Fulton St., N. Y. C.
Mossman, Inc., Donald P., 6133 N. Northwest Hy., Chicago
Remler Co., Ltd., 2101 Bryant St., San Francisco
Signal Electric Mfg. Co., Menominee, Mich.
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
Imperial Molded Prods. Corp., 2921 W. Harrison, Chicago
Kurtz Kasch, Inc., Dayton, O.
Mallory & Co., Inc., P. R., Indianapolis, Ind.
Millen Mfg. Co., James, Malden, Mass.
★ Nat'l Co., Inc., Malden, Mass.
★ Radio City Products Co., 127 W. 26 St., N. Y. C.
Rogan Bros., 2001 S. Michigan, Chicago

## LABELS, Removable

Avery Adhesives, 451 3rd St., Los Angeles

## LABELS, Stick-to-Metal

Ever Ready Label Corp., E. 25th St., N. Y. C.
Tablet & Ticket Co., 1021 W. Adams St., Chicago

## LABORATORIES, Electronic

★ Browning Labs., Inc., Winchester, Mass.
Hazeltine Electronics Corp., 1775 B'way, N. Y. C.
Sherron Metallic Corp., Flushing Ave., Brooklyn, N. Y.
Worner Electronic Devices, 848 N. Noble St., Chicago, 22

## LACQUERS, Wood & Metal Finish

★ Sullivan Varnish Co., 410 N. Hart St., Chicago 22

## LOCKWASHERS, Spring Type

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

## LUGS, Soldering

Burndy Engineering Co., 459 E. 133rd St., N. Y. C.
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 Av., Providence, R. I.
Sherman Mfg. Co., Battle Creek, Mich.
Thomas & Betts Co., Elizabeth, N. J.
Zierick Mfg. Co., 385 Girard Ave., Bronx, N. Y. C.

## LUGS, Solderless

Aircraft Marine Prod., Inc., Elizabeth, N. J.
Burndy Eng. Co., 107 Eastern Blvd., N. Y. C.

## 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

Allied Radio Corp., 901 W. Jackson Blvd., Chicago
★ Burstein-Applebee Co., Kansas City, Mo.
Harrison Radio Corp., 12 W. B'way, N. Y. C.
★ Lafayette Radio Corp., 901 W. Jackson Blvd., Chicago
Sun Radio Co., 212 Fulton St., N. Y. C.

## MARKERS, Wire Identification

Brand & Co., Wm., 276 4th Ave., N. Y. C.
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.
C. 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.
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, Q

Boonton Radio Corp., Boonton, N. J.

## METERS, Vacuum Tube Volt

Ballantine Laboratories, Inc., Boonton, N. J.
Ferris Instrument Corp., Boonton, N. J.
General Radio Co., Cambridge, Mass.
Hewlett-Packard Co., Palo Alto, Calif.
★ Measurements Corp., Boonton, N. J.
★ Radio City Products Co., 127 W. 26 St., N. Y. C.

## 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.
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
Radio Speakers, Inc., 221 E. Cullerton, Chicago
Philmore Mfg. Co., 113 University Pl., N. Y. C.
Permoflux Corp., 4916 W. Grand Av., 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.

## MONITORS, Frequency

★ General Electric Co., Schenectady, N. Y.
General Radio Co., Cambridge, Mass.
★ RCA Mfg. Co., Camden, N. J.

## MOTOR-GENERATORS, Dynamotors, Rotary Converters

Alliance Mfg. Co., Alliance, O.
Air-Way Mfg. Co., Toledo, O.
Bendix, Red Bank, N. J.
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

## MOTOR-GENERATORS

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

Kollsman Instrument Div., Elmhurst, Long Island, N. Y.
★ Utah Radio Prod. Co., 842 Orleans St., Chicago

## MOUNTINGS, Shock Absorbing

Lord Mfg. Co., Erie, Pa.
Pierce-Roberts Co., Trenton, N. J.
U. S. Rubber Co., 1230-6th Ave., N. Y. C.

## MYCALEX

Colonial Kolonite Co., 2212 W. Armitage Ave., Chicago
★ General Electric Co., Schenectady, N. Y.
Mycalex Corp. of Amer., Clifton, N. J.
Precision Fabricators, 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

## NICKEL, Sheet, Rod, Tubes

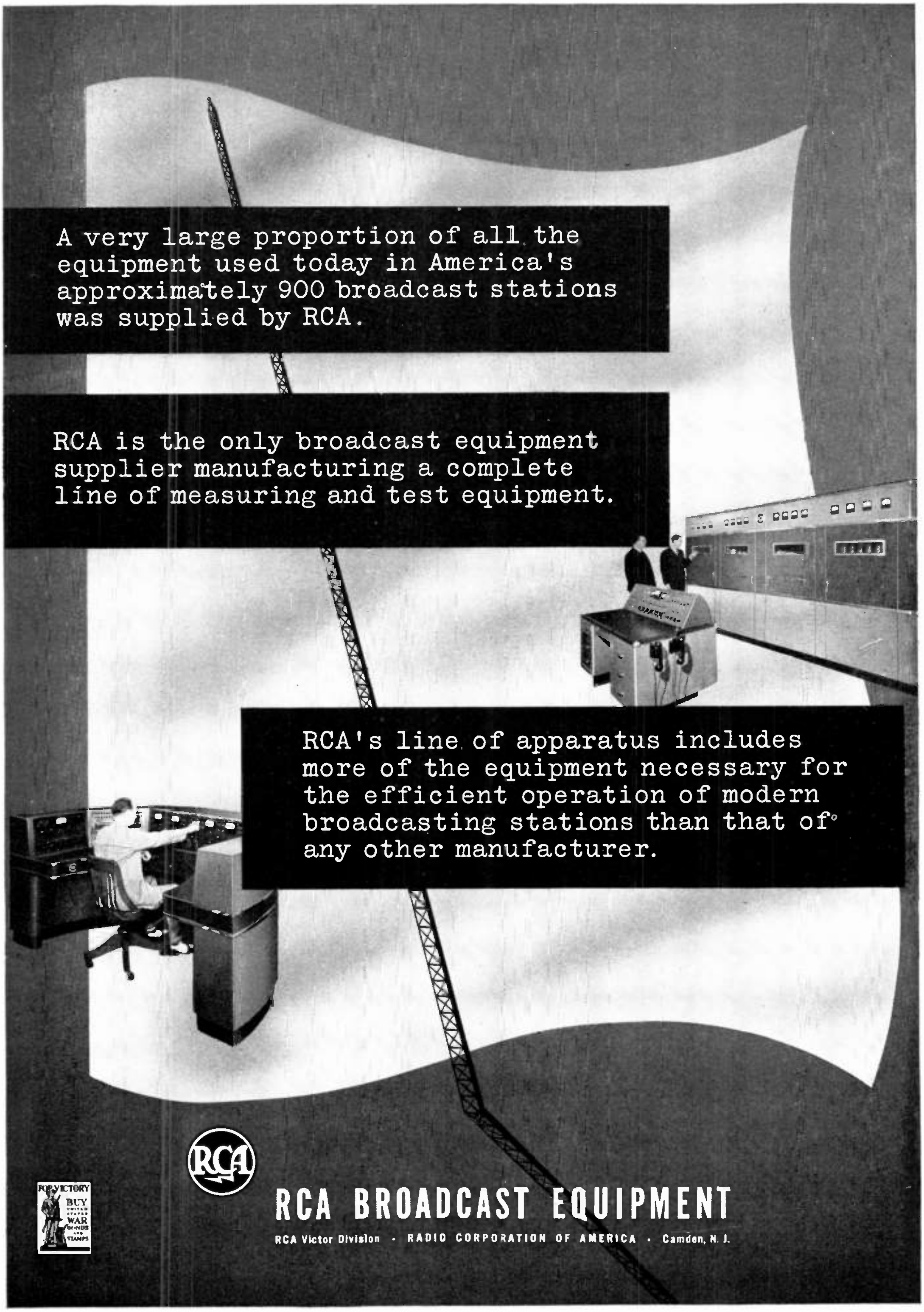
Eagle Metals Co., Seattle, Wash.
Pacific Metals Co., Ltd., San Francisco, Calif.
Steel Sales Corp., 129 S. Jefferson St., Chicago
Tull Metal & Supply Co., J. M., Atlanta, Ga.
Whitehead Metal Prod. Co., 303 W. 10th St., N. Y. C.
Williams and Co., Inc., Pittsburgh, Pa.

## 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.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**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.
RCA Mfg. Co., Inc., Camden, N. J.
★ Radio City Products Co., Inc., 127 W. 26 St., N. Y. C.

**OVENS, Industrial & Laboratory**

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

**PANELS, Metal Etched (See Etching, Metal)**

**PANELS, Phenolic, Cast without Molds**

★ Creative Plastics Corp., 963 Kent Ave., B'klyn, N. Y.

**PILOT LIGHTS**

Alden Prods. Co., Brockton, Mass.
★ Amer. Radio Hardware Co., Inc., 467 B'way, N. Y. C.
Dial Light Co. of Amer., 90 West, N. Y. C.
Drake Mfg. Co., 1713 W. Hubbard, Chicago
General Control Co., Cambridge, Mass.
★ General Elec. Co., Lamp Dept., Nela Specialty Div., Hoboken, N. J.
Gothard Mfg. Co., Springfield, Ill.
Herzog Miniature Lamp Works, 12–19 Jackson Av., Long Island City, N. Y. C.
Kirkland Co., H. R., Morristown, N. J.
Mallory & Co., P. R., Indianapolis, Ind.
Signal Indicator Corp., 140 Cedar St., N. Y. C.

**PHOSPHOR BRONZE**

American Brass Co., Waterbury, Conn.
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.

**PLASTICS, Cast without Molds**

★ Creative Plastics Corp., 963 Kent Ave., B'klyn, N. Y.

**PLASTICS, Extruded**

Blum & Co., Inc., Julius, 532 W. 22 St., N. Y. C.
Brand & Co., Wm., 276 4th Ave., N. Y. C.
Extruded Plastics, Inc., Norwalk, Conn.
Industrial Synthetic Corp., Irvington, N. J.
Irvington Varnish & Insulator Co., Irvington, N. J.

**PLASTIC SHEET, for Name Plates**

Mica Insulator Co., 200 Varick St., N. Y. C.

**PLASTICS, Injection Molded**

Remler Co., Ltd., 2101 Bryant St., San Francisco
Tech-Art Plastics, 41-01 36th Ave., Long Island City, N. Y.
Universal Plastics Corp., New Brunswick, N. J.

**PLASTICS, Laminated or Molded**

Acadia Synthetic Prods., 4031 Ogden Av., Chicago
Alden Prods. Co., Brockton, Mass.
American Cyanamid Co., 30 Rockefeller Plaza, N. Y. C.
American Insulator Corp., New Freedom, Pa.
American Molded Prods. Co., 1753 N. Honore, Chicago
Auburn Button Works, Auburn, N. Y.
Barber-Colman Co., Rockford, Ill.
Brandywine Fibre Prods. Co., Wilmington, Del.
Brilhart Co., Arnold, Great Neck, N. Y.
Catalin Corp., 1 Park Av., N. Y. C.
Celanese Celluloid Corp., 180 Madison Av., N. Y. C.
Chicago Molded Prods. Corp., 1024 N. Kolmar, Chicago
Continental-Diamond Fibre Co., Newark, Del.
★ Creative Plastics Corp., 963 Kent Ave., B'klyn, N. Y.
Dow Chemical Co., Midland, Mich.
Durez Plastics & Chemicals, Inc., N. Tonawanda, N. Y.
Extruded Plastics, Inc., Norwalk, Conn.
Formica Insulation Co., Cincinnati, O.
★ General Electric Co., Plastics Dept., Pittsfield, Mass.
General Industries Co., Elyria, O.
Gits Molding Corp., 4600 Huron St., Chicago
Imperial Molded Prods. Co., 2921 W. Harrison, Chicago
Industrial Molded Prods. Co., 2035 Charleston, Chicago
Kurz-Kasch, Inc., Dayton, O.
Macallen Co., Boston, Mass.
Mica Insulator Co., 196 Varick, N. Y. C.
Monsanto Chemical Co., Springfield, Mass.
National Vulcanized Fibre Co., Wilmington, Del.
Northern Industrial Chemical Co., Boston, Mass.
Printloid Corp., 93 Mercer St., N. Y. C.
★ Radio City Products Co., 127 W. 26 St., N. Y. C.
Remler Co., Ltd., 2101 Bryant St., San Francisco
Richardson Co., Melrose Park, Ill.
Rogan Bros., 2000 S. Michigan Ave., Chicago
Rohm & Haas Co., Philadelphia
Spaulding Fibre Co., Inc., 233 B'way, N. Y. C.
Stokes Rubber Co., Joseph, Trenton, N. J.
Surprenant Elec. Ins. Co., Boston
Synthane Corp., Oaks, Pa.
Taylor Fibre Co., Norristown, Pa.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Wilmington Fibre Specialty Co., Wilmington, Del.

**PLASTICS, Materials**

Bakelite Corp., 30 E. 42 St., N. Y. C.
Carbide & Carbon Chemicals Corp., 30 E. 42 St., N. Y. C.

**PLASTICS, Transparent**

Carbide & Carbon Chemicals Corp., 30 E. 42 St., N. Y. C.
Celanese Celluloid Corp., 180 Madison Ave., N. Y. C.
Dow Chemical Co., Midland, Mich.
du Pont de Nemours & Co., E. I., Arlington, N. J.
Plax Corp., Hartford, Conn.
Printloid Corp., 93 Mercer St., N. Y. C.
Rohm & Haas Co., Washington Sq., Philadelphia

**PLATING, Metal on Molded Parts**

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

**PLUGS (Banana), Spring Type**

★ Amer. Radio H'dw're Co., 476 B'way, N. Y. C.
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, Telephone Type**

Alden Prods. Co., Brockton, Mass.
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.
Jones, H. B., 2300 Wabansia, Chicago
Mallory & Co., Inc., P. R., Indianapolis, Ind.
Remler Co., Ltd., Bryant St., San Francisco
Trav-Ler Karenola Corp., 1030 W. Van Buren St., Chicago 7
★ Universal Microphone Co., Ltd., Inglewood, Calif.
★ Utah Radio Prod., Orleans St., Chicago.

**PLYWOOD, Metal Faced**

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

**RACKS, Standard Aircraft Types**

Delco Radio, Kokomo, Ind.

**RACKS & PANELS, Metal**

*See* STAMPINGS, Metal

**RECTIFIERS, Current**

Benwood Linze Co., St. Louis, Mo.
Continental Elec. Co., 903 Merchandise Mart, Chicago
★ Electronics Labs., Indianapolis, Ind.
Fansteel Metallurgical Corp., N. Chicago, Ill.
★ General Electric Co., Bridgeport, Conn.
Green Elect. Co., Inc., 130 Cedar St., N. Y. C.
International Tel. & Radio Mfg. Corp., E. Newark, N. J.
Mallory & Co., P. R., Indianapolis, Ind.
Nothelfer Winding Labs., Trenton, N. J.
United Cinephone Corp., Torrington, Conn.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

**RECTIFIERS, Instrument & Relay**

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.
Amperite Co., 561 Broadway, N. Y. C.
Ferranti Elec., Inc., 30 Rockefeller Plaza, N. Y. C.
★ General Elec. Co., Schenectady, N. Y.
H-B Elec. Co., Philadelphia
Sola Electric Co., 2525 Clybourn Av., Chicago
★ United Transformer Corp., 150 Varick St., N. Y. C.

**RELAYS, Small Switching**

Allied Control Co., Inc., 223 Fulton St., N. Y. C.
Amperite Co., 561 Broadway, N. Y. C.
Birtcher Corp., 5087 Huntington Dr., Los Angeles 32
Electrical Prod. Supply Co., 1140 Venice Blvd., Los Angeles 15
G-M Laboratories, Inc., 4313 N. Knox Ave., Chicago
★ 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.

**RELAYS, Small Telephone Type**

Amer. Automatic Elect. Sales Co., 1033 W. Van Buren St., Chicago
Clare & Co., C. P., 4719 W. Sunnyside Ave., Chicago
★ Guardian Elec. Co., 1400 W. Wash. Blvd., Chicago
Wick Organ Co., Highland, Ill.

**RELAYS, Stepping**

Advance Elect. Co., 1260-A W. 2nd St., Los Angeles
Automatic Elect. Co., 1032 W. Van Buren St., Chicago
Autocall Co., Shelby, O.
★ 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.

**RELAYS, Time Delay**

Amperite Co., 561 Broadway, N. Y. C.
Haydon Mfg. Co., Inc., Forestville, Conn.
Industrial Timer Corp., Newark, N. J.
Sangamo Elec. Co., Springfield, Ill.
Ward-Leonard Elec. Co., Mt. Vernon, N. Y.

**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., Brooklyn, N. Y.
Cont'l Carbon, Inc., Cleveland, O.
Daven Co., 158 Summit St., Newark, N. J.
Dixon Crucible Co., Jersey City, N. J.
Erie Resistor Corp., Erie, Pa.
Globar Div. Carborundum Co., Niagara Falls, N. Y.
Hardwick, Hindle, Inc., Newark, N. J.
Instrument Resistors Co., Little Falls, N. J.
★ Intern'l Resistance Co., Philadelphia
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**

Instrument Resistors, Inc., Little Falls, N. J.
★ Intern'l Resistance Co., Philadelphia
Ohmite Mfg. Co., 4835 Flournoy St., Chicago
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.
Sticht Co., Inc., H. H., 27 Park Pl., N. Y. C.

**RESISTORS, Variable**

★ Aerovox Corp., New Bedford, Mass.
Allen-Bradley Co., Milwaukee, Wis.
Amer. Instrument Co., Silver Spring, Md.
Atlas Resistor Co., N. Y. C.
Biddle Co., James G., Arch St., Phila., Pa.
Centralab, Milwaukee, Wis.
★ Chicago Tel. Supply Co., Elkhart, Ind.
Cinema Eng. Co., Burbank, Cal.
Clarostat Mfg. Co., Brooklyn, N. Y.
Cutler-Hammer, Inc., Milwaukee, Wis.
★ DeJur Amsco Corp., Shelton, Conn.
Electro Motive Mfg. Co., Willimantic, Conn.
General Radio Co., Cambridge, Mass.
G-M Labs., Inc., Chicago, Ill.
Hardwick, Hindle, Inc., Newark, N. J.
Instrument Resistors, Inc., Little Falls, N. J.
★ Intern'l Resistance Co., Philadelphia
Kellogg Switchboard & Sup. Co., 6650 S. Cicero Ave., Chicago
Lectrohm, Inc., 5125 W. 25 St., 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**

Hardwick, Hindle, Inc., Newark, N. J.
Lectrohm, Inc., 5125 W. 25 St., Cicero, Ill.
Ohmite Mfg. Co., 4835 Flournoy St., Chicago

**SCREW MACHINE PARTS, Brass, Steel**

Ward Products Corp., E. 45 St., Cleveland, O.

**SCREW MACHINE PARTS, Non-Metallic**

Continental-Diamond Fibre Co., Newark, Del.

**SCREWS, Clutch Head**

United Screw & Bolt Corp., 71 Murray St., N. Y. C.

**SCREWS, Recessed Head**

American Screw Co., Providence, R. I.
Bristol Co., The, Waterbury, Conn.
Chandler Prods. Co., Cleveland, O.
Continental Screw Co., New Bedford, Mass.
Corbin Screw Corp., New Britain, Conn.
Federal Screw Prod. Co., 224 W. Huron St., Chicago
International Screw Co., Detroit, Mich.
Lamson & Sessions, Cleveland, O.
National Screw & Mfg. Co., Cleveland, O.
New England Screw Co., Keene, N. H.
Parker Co., Charles, The, Meriden, Conn.
Parker-Kalon Corp., 198 Varick, N. Y. C.
Pawtucket Screw Co., Pawtucket, R. I.
Pheoll Mfg. Co., Chicago
Russell, Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
Scovill Mfg. Co., Waterbury, Conn.
Shakeproof, Inc., 2501 N. Keeler Av., Chicago
Southington Hardw. Mfg. Co., Southington, Conn.
Whitney Screw Corp., Nashua, N. H.

**SCREWS, Self-Tapping**

American Screw Co., Providence, R. I.
Central Screw Co., 3519 Shields Av., Chicago
Continental Screw Co., New Bedford, Mass.
Federal Screw Prod. Co., 224 W. Huron St., Chicago
Parker-Kalon Corp., 198 Varick, N. Y. C.
Shakeproof, Inc., 2501 N. Keeler, Chicago

**SCREWS, Set and Cap**

Allen Mfg. Co., Hartford, Conn.
Federal Screw Prod. Co., 224 W. Huron St., Chicago
Parker-Kalon Corp., 198 Varick, N. Y. C.
Republic Steel Corp., Cleveland, O.
Shakeproof, Inc., 2501 N. Keeler Av., Chicago

**SCREWS, Hollow & Socket Head**

Allen Mfg. Co., Hartford, Conn.
Central Screw Co., 3519 Shields, Chicago
Federal Screw Prod. Co., 224 W. Huron St., Chicago
Parker-Kalon, 198 Varick, N. Y. C.
Standard Pressed Steel Co., Jenkintown, Pa.

**SELENIUM**

Federal Tel. & Radio Corp., S. Newark, N. J.
Benwood Linze Co., St. Louis, Mo.
Selenium Corp. of Amer., 1800 W. Pico Blvd., Los Angeles

**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.


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Goat Metal Stampings, Inc., 314 Dean St., Brooklyn, N. Y.

### SHOCK ABSORBERS

*See* MOUNTINGS, Shock Absorbing

### 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 Hardware Co., 476 B'way, N. Y. C.
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

★ 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.
Westinghouse Elect. & Mfg. Co., E. Pittsburgh, Pa.

### SPEAKERS, Cabinet Mounting

Cinaudagraph Speakers, Inc., 3911 S. Michigan Ave., Chicago
Crescent Industries, Inc., Belmont Ave., Chicago
★ Jensen Radio Mfg. Co., 6601 S. Laramie St., Chicago
John Meck, Industries, Plymouth, Ind.
Magnavox Co., Fort Wayne, Ind.
Rola Co., Inc., Superior St., Cleveland, O.
★ Utah Radio Prod. Co., 842 Orleans St., Chicago

### SPEAKERS, Outdoor Type

★ Jensen Radio Mfg. Co., 6601 S. Laramie St., Chicago
University Labs., 225 Varick St., 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., Ind., 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.
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.

### STEATITE, See Ceramics

### SUPPRESSORS, Parasitic

Ohmite Mfg. Co., 4835 Flournoy St., Chicago

### SWITCHES, Aircraft Push

Square D Co., Kollsman Inst. Div., Elmhurst, N. Y.
★ Universal Microphone Co., Inglewood, Calif.

### SWITCHES, Key

Audio Development Co., Minneapolis, Minn.
Chicago Tel. Supply Co., Elkhart, Ind.
General Control Co., Cambridge, Mass.
Mossman, Inc., Donald P., 6133 N. Northwest Hy., Chicago

### SWITCHES, Micro

Allied Control Co., Inc., E. End Ave., N. Y. C.
Aero Electric Co., 3167 Fulton Rd., Cleveland
Micro Switch Corp., Freeport, Ill.

### SWITCHES, Rotary Gang, Bakelite Wafer

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

### SWITCHES, Rotary Gang, Ceramic Wafer

Oak Mfg. Co., 1267 Clybourn Ave., Chicago
Ohmite Mfg. Co., 4835 Flournoy St., Chicago
Shallcross Mfg. Co., Collingsdale, Pa.

### SWITCHES, Time Delay

Haydon Mfg. Co., Inc., Forestville, Ct.
Industrial Timer Corp., 115 Edison Pl., Newark, N. J.
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

### TERMINAL STRIPS

Burke Electric Co., Erie, Pa.
Cinch Mfg. Corp., W. Van Buren St., Chicago
Curtis Devel. & Mfg. Co., N. Crawford Ave., Chicago
Franklin Mfg. Corp., 175 Varick St., N. Y. C.
Jones, H. B., 2300 Wabansia, 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.

### 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 Power

Dongan Elec. Co., 74 Trinity Pl., N. Y. C.
★ General Electric Co., Schenectady, N. Y.
Raytheon Mfg. Co., Waltham, Mass.
Sola Electric Co., 2525 Clybourn Ave., Chicago

### TRANSFORMERS, IF, RF

Aladdin Radio Industries, 501 W. 35th St., Chicago
Amer. Transformer Co., Newark, N. J.

## A FAMOUS FM RECEIVER

(CONTINUED FROM PAGE 17)

An IF frequency of 1,700 kc. is employed in this receiver. The circuits are adjusted to a band width of 150 kc.

The two meters on the front panel have proved to be most useful, particularly when the receiver is used for laboratory purposes. One measures the DC detector output voltage, and serves as a resonance indicator for tuning. This meter reads 0 at resonance. The other shows the limiter grid current, thus indicating the signal level. A resistor is provided to shunt around this meter, to reduce its sensitivity.

Overloading and blocking can be controlled by adjusting the IF gain with the variable resistor in the first IF stage.

The detector is a conventional type, using the Foster-Seeley frequency discriminator circuit.

The AF amplifier phase inverter and the output stage require no explanation, since they are of standard design. Inverse feed-back is obtained through a network comprising the adjustable resistor shunted by a fixed condenser, connected in series with a fixed resistor, and by an adjustable resistor in series with a fixed condenser. The high and low-frequency response can be adjusted anywhere within the limits of the network. With these controls, the overall frequency response of the audio amplifier can be set for the particular loudspeaker it is to operate. The dual output circuit operates into either 8 or 500 ohms.

Maximum audio output power is about 8 watts, with less than 5 per cent harmonic distortion. At setting below full volume, the audio distortion is negligible.

One reason for the fine performance of this receiver is that a gain of 1,000,000 times is obtained from the antenna to the grid of the first limiter. This assures an ample signal to operate the limiter, even on distant stations. Complete saturation of the limiter occurs with an input of 10 volts.

The circuit of the 517A is simple and straightforward. Trick features have been avoided deliberately so as to assure high fidelity and maximum stability of performance. Thus it is suited to quantitative measurements and tests which require that readings be duplicated from day to day.

For such purposes, therefore, the circuit shown in the accompanying diagram can be used as a basis in new set designs requiring similar characteristics.

## Police Communications Officers

The December issue of *FM* will carry a complete roster of police communications officers, as well as those in charge of other emergency radio services. This is the first directory of its kind ever published in any magazine, and will be continued as a semi-annual feature hereafter. It will appear again in June, 1944, with up-to-date revisions and additions.

Automatic Windings Co., E. Passaic, 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 Specialty Co., Inc., Broad St., Newark, N. J.
Gen'l Winding Co., 420 W. 45 St., N. Y. C.
Greyhound Equip. Co., 1720 Church Ave., Brooklyn, N. Y.
Guthman & Co., 400 S. Peoria St., 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., Los Angeles, Cal.
★ Nat'l Co., Malden, Mass.
Radex Corp., 1308 Elston Ave., Chicago
Sickles Co., F. W., Springfield, Mass.
Standard Winding Corp., Newburgh, N. Y.
Super Elec. Prod. Corp., Jersey City, N. J.
Teleradio Eng. Corp., 484 Broome St., N. Y. C.
Triumph Mfg. Co., 4017 W. Lake, Chicago

## TRANSFORMERS, Receiver Audio & Power

Acme Elec. & Mfg. Co., Cuba, N. Y.
Amer. Transformer Co., Newark, N. J.
Amplifier Co. of Amer., 17 W. 20th St., N. Y. C.
Audio Devel. Co., N. Minneapolis, Minn.
Chicago Transformer Corp., 3501 Addison St., Chicago
Cinaudagraph Speakers, Inc., 3911 S. Michigan, Chicago
Dinion Coil Co., Caledonia, N. Y.
Dongan Elec. Co., 74 Trinity Pl., N. Y. C.
Electronic Trans. Co., 515 W. 29 St., N. Y. C.
Ferranti Elec., Inc., 30 Rockefeller Plaza, N. Y. C.
Freed Trans. Co., 72 Spring St., N. Y. C.
Gen'l Radio Co., Cambridge, Mass.
General Trans. Corp., 1250 W. Van Buren, Chicago
Halldorson Co., 4500 Ravenswood, Chicago
Jefferson Elec. Co., Bellwood, Ill.
Kenyon Transformer Co., 840 Barry St., N. Y. C.
Magnetic Windings Co., Easton, Pa.
★ Merit Coil & Trans. Corp., 311 N. Desplaines St., Chicago 6
Newark Transformer Co., Newark, N. J.
New York Transformer Co., 51 W. 3rd, N. Y. C.
Norwalk Transformer Corp., S. Norwalk, Conn.
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.
Thermador Elect. & Mfg. Co., Riverside Dr., Los Angeles
Thordarson Elec. Mfg. Co., 500 W. Huron, Chicago
★ Utah Radio Prods. Co., 820 Orleans St., Chicago
★ United Transformer Co., 150 Varick St., N. Y. C.
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.

## 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.
Farnsworth Tele. & Radio Corp., Ft. Wayne, Ind.
★ General Elec. Co., Schenectady, N. Y.
Ken-Rad Tube & Lamp Corp., Owensboro, Ky.
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.

## 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

Bradley Labs., New Haven, Conn.
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.
★ Hytron Corp., Salem, Mass.
Ken-Rad Tube & Lamp Corp., Owensboro, Ky.
Nat'l Union Radio Corp., Newark, N. J.
Raytheon Prod. Corp., 420 Lexington Av., N. Y. C.
★ RCA Mfg. Co., Camden, N. J.
★ Sylvania Elect. Prod., Inc., Emporium, Pa.
Tung-Sol Lamp Works, Newark, N. J.

## TUBES, Transmitting

Amperex Electronic Prods., Brooklyn, N. Y.
★ Eitel-McCullough, Inc., San Bruno, Cal.
★ Electronic Enterprises, Inc., 65 Sixth Av., N. Y. C.
★ Federal Telephone & Radio Corp., Newark, N. J.
★ General Elec. Co., Schenectady, N. Y.
Heintz & Kaufman, S. San Francisco, Cal.
★ Hytron Corp. Salem, Mass.
Ken-Rad Tube & Lamp Corp., Owensboro, Ky.
Nat'l Union Radio Corp., Newark, N. J.
North Amer. Philips Co., Inc., Dobbs Ferry, N. Y.
Raytheon Prod. Corp., 420 Lexington Av., N. Y. C.
★ RCA Mfg. Co., Camden, N. J.
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.

## 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.
★ General Elec. Co., Bridgeport, Conn.
Insulation Mfgrs. Corp., 565 W. Washington Blvd., Chicago
Irvington Var. & Ins. Co., Irvington, N. J.
Mica Insul. Co., 196 Varick St., N. Y. C.
Varflex Corp., Rome, N. Y.

## TURNTABLES, Phonograph

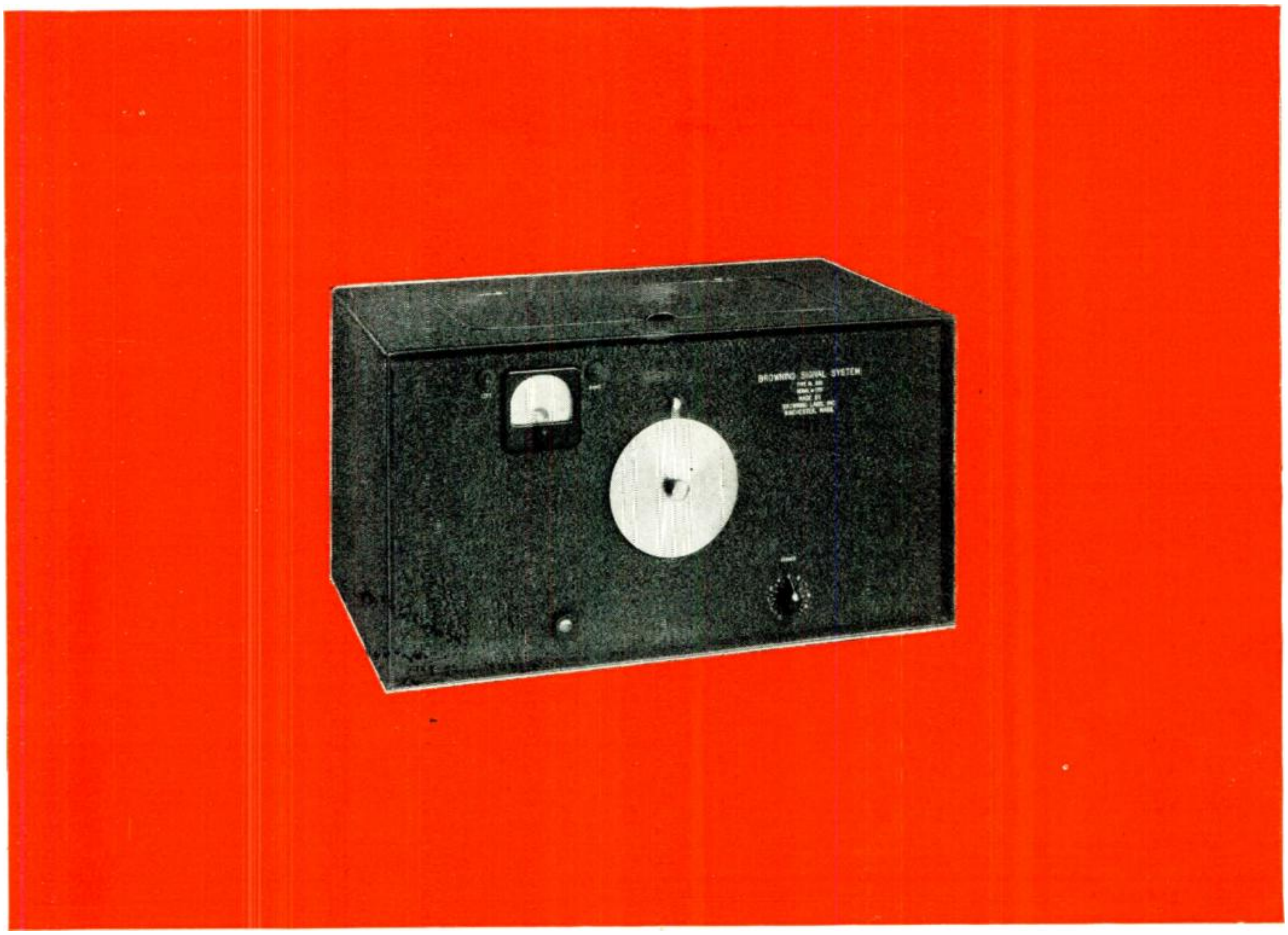
General Industries Co., Elyria, O.
★ R C A Mfg. Co., Camden, N. J.
Western Electric Co., 125 B'way, N. Y. C.

## VARNISHES, Insulating, Air-Drying

John C. Dolph Co., Newark, N. J.
Irvington Var. & Ins. Co., Irvington, N. J.
Stille-Young Corp., 2300 N. Ashland Av., Chicago
★ Zophar Mills, Inc., 112–26 St., Bklyn., N. Y.

## VARNISHES, Insulating, Baking

John C. Dolph Co., Newark, N. J.
Irvington Var. & Ins. Co., Irvington, N. J.
Stille-Young Corp., 2300 N. Ashland Av., Chicago
★ Zophar Mills, Inc., 112–26 St., Bklyn., N. Y.




# DANGER!
## Impenetrable Wall

"Product of Browning Laboratories Research"

THE Browning Signal System employs a small instrument of rugged construction, yet so enormously is its sensitivity multiplied by electronic circuits that it makes the boundary of any property into a continuous "wall" that cannot be approached without giving an alarm and actuating a location indicator!

Public utilities and war plants where the Browning Signal System is in use report that it has greatly decreased the cost and increased the effectiveness of guard protection. Information is available to authorized officials.

**BROWNING LABORATORIES, INC.**
751 Main Street Winchester, Mass.

**VARNISHES, Wrinkle Finish**

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

**VIBRATION TEST EQUIPMENT**

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

**VIBRATORS, Power Supply**

Amer. Telev. & Radio Co., St. Paul, Minn.
★ Electronic Labs., Indianapolis, Ind.
Mallory & Co., Inc., P. R., Indianapolis, Ind.
Radiant Corp., W. 62 St., Cleveland, O.
Turner Co., Cedar Rapids, Ia.
★ Utah Radio Prod. Co., Orleans St., Chicago

**VOLTMETERS, Vacuum Tube**

Ballantine Labs., Inc., Boonton, N. J.
General Radio Co., Cambridge, Mass.
Hewlett Packard Co., Palo Alto, Calif.
★ Measurements Corp., Boonton, N. J.
★ Radio City Prod. Co., Inc., 127 W. 26 St., N. Y. C.

**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., N. Y

**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.
Garitt 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**

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
Whitney Blake Co., New Haven, Conn.

**WIRE, Magnet**

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
Collyer Ins. Wire Co., Pawtucket, R. I.
Crescent Ins. Wire & Cable Co., Trenton, N. J.
Elec. Auto-Lite Co., The, Port Huron, Mich.
General Cable Corp., Rome, N. Y.
★ General Elec. Co., Bridgeport, Conn.
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.
Wheeler Insulated Wire Co., Bridgeport, Conn.

**WIRE, Rubber Covered**

Crescent Ins. Wire & Cable Co., Trenton, N. J.
General Cable Corp., Rome, N. Y.
Hazard Ins. Wire Works, Wilkes-Barre, Pa.
Simplex Wire & Cable Co., Cambridge, Mass.

**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.
Tillotson Furniture Co., Jamestown, N. Y.

## When You Change Your Address

PLEASE GIVE US YOUR OLD ADDRESS AS WELL AS YOUR NEW ADDRESS.

IF YOUR COPIES ARE UNDELIVERED BECAUSE YOU DID NOT NOTIFY US IN ADVANCE, WE SHALL NOT BE ABLE TO REPLACE YOUR LOST COPIES.

*FM* RADIO-ELECTRONICS

240 Madison Avenue New York 16, N. Y.

## THE PROCUREMENT "BIBLE"

OF THE

## RADIO-ELECTRONICS INDUSTRY

This month, 210 different items are listed in the Radio-Electronics Directory. Under these headings are more than 1,150 sources of supply.

Revised and augmented in each issue for the past eighteen months, this Directory has become the most complete and accurate source of information on procurement that is available to engineers and purchasing agents.

Every entry is checked with the greatest care to avoid the listing of items that are made by manufacturers only for their own use. That is, if a company makes condensers for its own equipment but does not sell them to others, that concern is not listed as a condenser manufacturer. That is the most serious source of errors in other directories.

The listing of various items is not planned according to some arbitrary indexing system, but in the way that engineers and purchasing agents would naturally expect them to appear. This requires more space, but is a great time-saver, since the Directory can be used without studying the system or referring to code letters.

This Directory is now being published every other month. We shall be glad to receive suggestions, corrections, and additions which can be incorporated in the next issue.

## RADIO DESIGNERS' ITEMS

(CONTINUED FROM PAGE 37)

immersed in water. Here is the tabulation of results:

| Stock | Coating | % Moisture Absorption after 24 hours | % Moisture Absorption after 96 hours |
|---|---|---|---|
| 1/4-in. | None | .9 | 2.1 |
| grade | Glyptol | .9 | 2.0 |
| XX | Larcoloid | .8 | 1.7 |
| 1/2-in. | None | .5 | 1.1 |
| grade | Glyptol | .5 | 1.0 |
| XX | Larcoloid | .4 | .9 |
| 1/4-in. | None | 1.1 | 1.8 |
| grade | Glyptol | 1.0 | 1.6 |
| CE | Larcoloid | .8 | 1.5 |
| 1/2-in. | None | .5 | 1.0 |
| grade | Glyptol | .4 | .9 |
| CE | Larcoloid | .4 | .9 |

Carrying the tests still further to obtain higher degrees of absorption, the immersion periods were extended to one week and two weeks. Here are the results:

| Stock | Coating | % Moisture Absorption after 1 week | % Moisture Absorption after 2 weeks |
|---|---|---|---|
| 1/4-in. | None | 2.6 | 4.7 |
| grade | Glyptol | 2.6 | 4.6 |
| XX | Larcoloid | 2.0 | 3.8 |
| 1/2-in. | None | 1.4 | 2.6 |
| grade | Glyptol | 1.3 | 2.3 |
| XX | Larcoloid | 1.1 | 2.0 |
| 1/4-in. | None | 2.1 | 3.1 |
| grade | Glyptol | 1.9 | 2.9 |
| CE | Larcoloid | 1.8 | 2.8 |
| 1/2-in. | None | 1.1 | 1.8 |
| grade | Glyptol | 1.0 | 1.7 |
| CE | Larcoloid | 1.0 | 1.7 |

After 96 hours of immersion, the report continues, the Glyptol coating started to peel off.

One important factor which seems to be brought out by these tests is that the thinner material, in every case, absorbed a higher percentage of moisture than the thicker pieces.

If the tests had been conducted with pieces 3/32 in. or 1/8 in. thick, such as are generally used for small terminal boards, the percentage of absorption would have been much higher, indicating that serious losses at ultra-high frequencies can be expected from this source.

However, the difference in the amount of moisture absorbed by treated and untreated pieces is surprisingly small. It appears that some more effective coating is required than the materials used by Mr. Grazen.

One of the most commonly-used meth-

(CONTINUED ON PAGE 52)

(CONTINUED FROM PAGE 51)

ods is to bake the phenolic pieces at 100° C. for one hour. Then they are sprayed evenly with Kauri No. 74 varnish, permitted to air-dry until the varnish is set, and then they are baked again for one hour at 100° C. The air-drying period is important because, if the pieces are put into the oven right after spraying, the varnish draws up into wrinkles, and is not effective for protection. Data on the absorption of moisture after this treatment is not available, but would be highly interesting.

However, the really important and significant information would be data showing the losses incurred by moisture absorption at ultra-high frequencies. On the other hand, it is possible that no general conclusions could be drawn from tests made on different pieces at various frequencies. Perhaps the most informative tests would be to take measurements with the terminals mounted on phenolic strips and then run another set of measurements with terminals held in air by their lead wires.

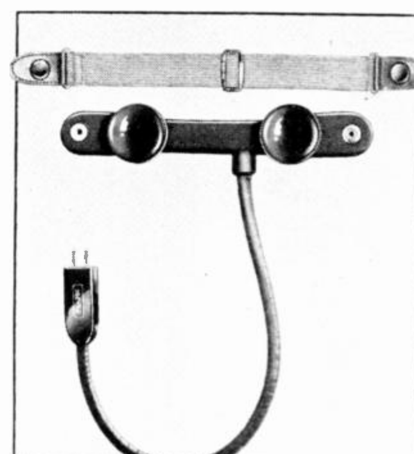


FIG. 6

**Throat Microphone:** Production of Signal Corps type T-30 throat microphone has reached the stage of big-quantity output at Universal Microphone Company. This is a particularly interesting development because wide postwar applications are expected for this device.

As the illustration in Fig. 6 shows, dual carbon elements are mounted on a synthetic rubber neckpiece, held to the throat by an adjustable snap-on elastic neckband. Perfect voice pickup is obtained. This design gives the operator the free use of both hands. Electrical connection is made through a non-locking, breakaway plug, type PL-291. Also required are an extension cord CD-354 and press-to-talk switch assembly CD-318 or CD-508. Complete details can be obtained from Universal Microphone Company, Inglewood, Calif.





# Three Years of Service to the Radio Industry

THE high standing of *FM* RADIO-ELECTRONICS as a radio engineering publication is an honor earned by service to the industry. From its inception, *FM* has been *the complete and authoritative source of information on Frequency Modulation.* It constitutes the only published record of what has proved to be the greatest contribution to broadcasting, communications, facsimile, and television, and to plans for postwar aircraft radio.

Before Pearl Harbor, many engineers were dubious about the future of Frequency Modulation. But its extraordinary performance in one military application after another has turned doubters into enthusiastic supporters.

This change in attitude is recorded by orders from engineers and engineering executives for "all available back numbers of *FM* Magazine." Last month, for example, these orders totalled over 600 copies!

Since Frequency Modulation has become the subject of major importance to the radio industry, *FM* Magazine has gained a corresponding position among radio publications.

As a result, producers of radio and associated equipment, components, materials, and supplies are finding *FM* RADIO-ELECTRONICS the most effective advertising medium for reaching the most progressive minds in all branches of radio engineering, manufacturing, broadcasting and communications.

**FM RADIO-ELECTRONICS**

## WILLIAM T. MOHRMAN IS NEW HEAD OF FM RADIO-ELECTRONICS ADVERTISING

EFFECTIVE this month, William T. Mohrman takes over the duties of advertising manager of *FM* RADIO-ELECTRONICS. Over a period of twenty years, he has won the friendship and respect of advertising managers and agency executives throughout the radio industry.

His experience in the mechanics and methods of the publishing business was gained on Electrical Record and on Electrical Manufacturing.

In the years following, as eastern advertising representative of Universal Commerce, he took a very active part in the development of Latin American markets for U. S. radio manufacturers, and is known as an authority in this field.

Now, as advertising manager of *FM* RADIO-ELECTRONICS, his ability and high reputation will aid in accelerating the future growth of this Magazine. In addition, Bill Mohrman will carry forward plans already projected for extending the influence of *FM* RADIO-ELECTRONICS into the Latin-American countries where tremendous potential postwar markets are being built up not only for home radios of U. S. manufacture, but for broadcast transmitters, communications equipment, tubes, components, supplies, and materials.

Marian Fleischman will continue to carry on as Chicago advertising representative as long as Bill Fleischman is on duty with the Navy, but she will be happy to turn the job back to her husband when he returns. Ensign Fleischman sailed from New York recently for parts unknown.

## FM FINDS NEW FIELDS TO CONQUER

(CONTINUED FROM PAGE 15)

to the use of AM communications equipment on certain types of American planes. They cannot communicate with the FM-equipped tanks. Since, in so many cases, coördinated action is required, the common use of FM would aid enormously.

In designing FM equipment for aircraft, two courses are open. Greater range can be obtained for the same power input, or the same range with a substantial reduction in power consumption. The weight of the FM equipment would be less than that of equivalent AM apparatus, in either case.

When it will be practical to put this change into effect only our military men can decide, but from the engineering point of view the shift to FM is inevitable, for there is no other answer to the shortcomings of equipment now in use.

**Elimination of Heterodyning** ★ The elimination of heterodyne squeals is proving to be as

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## FM FINDS NEW FIELDS TO CONQUER

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important a feature of Major Armstrong's FM system as the reduction of static. This is true of police and military applications, and will make possible the operation of hundreds of new broadcasting stations, without interference, after the War.

A recent incident in New York City brought home this point. The municipal stations WNYC and W39NY were both carrying a Sunday evening concert from Carnegie Hall. About 9:30, during a break in the program, the announcer told his audience that the AM station would have to close down at 10:00, because it heterodynes with the Minneapolis station WCCO, and interferes with reception out there. However, the concert would be continued without interruption on W39NY.

Similarly, WCCO interferes with reception of WNYC, outside its primary service area. As a result, the effective coverage of FM station W39NY is substantially greater than its AM counterpart — because of heterodyne interference with another AM station nearly half-way across the continent.

**FM Broadcast Quality** ★ The discussion of W39NY brings up another point. This station is now giving the New York City area its finest reproduction of live-talent shows. While the NBC station W2XWG is performing a great service to listeners by giving them static-free reception of the best network programs, the audio quality is better than WEAF only to the extent that background noise is absent.

Of course, little difference can be expected on network programs, since the fidelity is limited by the characteristics of the telephone lines. But W2XWG listeners are not getting the benefit of FM quality on programs originating at New York.

This can be checked, for example, by listening to the Bayer program at 9:30 on Sunday evenings over W2XWG, and then switching over to W39NY's concert program. Frank Munn's voice and the instrumental music sound dull and colorless compare to the voices and instruments heard from W39NY. Both are local programs with live talent.

Special pickup facilities might be necessary to provide the full FM quality of broadcasts from the NBC studios, but they would seem justified by the extra enjoyment that would be afforded to many thousands of homes equipped with FM receivers in W2XWG's service area. The cost to NBC would be a tiny fraction of what is being spent on television.

WQXR also has local live-talent shows available, but the quality on FM is so poor that the realism of the announcer's voice on W59NY is startling by comparison.

The most serious complaint registered

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## NAVY CALLS FOR RADIO ENGINEERS

STILL more men are needed by the Navy to carry out its electronic engineering and radio programs. Commissions are available to those with engineering degrees and industrial experience with radio manufacturers or broadcasting stations, or to those who have reached engineer's level through work with manufacturing or operating companies.

Applicants must be American citizens up to 50 years of age. They must be sound physically, but special consideration will be given to men with minor physical defects other than those which are organic.

The Navy asks that qualified engineers apply, and that they bring this need to the attention of others who are eligible for service.

Requests for application forms should be addressed to

Director of Naval Officer Procurement
33 Pine Street
New York City
Att: Commander J. C. Latham

Appointments for interviews with Cmdr. Latham can be made by mail or by telephoning WHitehall 3-4060, extension 59.

## FM FINDS NEW FIELDS TO CONQUER

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by New Yorkers is against CBS. This net has the exclusive privilege of broadcasting the renowned Sunday afternoon concerts played by the Philharmonic Orchestra from Carnegie Hall. WABC's FM affiliate, W67NY, is available for this purpose, but the CBS policy is not to broadcast programs by FM that are carried by WABC. Consequently, thousands of families owning FM receivers are denied the radio equivalent of choice seats at these concerts.

**Who Invented FM?** ★ Since the Army and Navy clamped down on the publication of advertising and editorial references to radar, the claims and counterclaims to credit for its invention have subsided. Now, perhaps by way of having something to argue about, the question has been raised as to who invented FM.

It appears that Raymond F. Guy may have settled this question. Writing in *Communications* for August, 1943, he traced the sequence of patents dealing with frequency modulation back to an application filed by Cornelius Ehret in 1902. Few of us, including Raymond Guy, have any first-hand knowledge of the radio art of that period.

At any rate, Mr. Ehret's patent called for varying the frequency of "electro-radiant energy waves" by means of the changing resistance of a telephone transmitter.

It appears that, in those days, spark coils or transformers were the only source for generating the "electrostatic and electromagnetic energies . . . ranging from 100,000 cycles to several million," as referred to in the application. It does not appear that Mr. Ehret was ever able to harness a spark coil to a telephone transmitter, or that he made a transmitter with sufficient variation of resistance to modulate the frequency of radio waves, except on paper. No evidence is offered to that effect. Beside, there is nothing to indicate that Mr. Ehret or anyone else knew if speech could be transmitted in that manner, since no suitable receiving means was available at that time.

However, those of us who are only starting to get gray hair remember that frequency modulation was employed commercially and with complete success by Poulsen for arc transmitters. The first of these transmitters were in use before World War I, and during that War they handled a great volume of message traffic.

This was a very simple system. A telegraph key was shunted across one or more turns of the transmitter tuning inductance. When the key was pressed, the inductance in the circuit was reduced, and the frequency was increased accordingly.

At the receiving end, the tuning was adjusted to resonance at the higher frequency. Signals, in the form of dots and dashes, were then heard when the key was operated. The use of this system was necessary because the arc was kept burning continuously during the period of transmission.

Major Armstrong, whose name has become identified with the practical use of Frequency Modulation for radio communications, has never claimed the invention of frequency modulation. What he did invent is aptly described by the title of his original paper delivered before the members of the I.R.E. in 1936. This was: "A Method of Reducing Disturbances in Radio Signaling by a System of Frequency Modulation." In fact, he did not intend that his method of reducing disturbances in radio signaling should be called Frequency Modulation. This title was applied by others, and it stuck.

Various investigators had considered the use of frequency modulation as an alternative for amplitude modulation, and found no merit in substituting the former for the latter.

Major Armstrong's interest in frequency modulation, on the other hand, was only as a means to an end. He undertook to perfect a communications system that would be free of the interference that beset all previous systems. To accomplish this result, he employed frequency modulation instead of the alternate method of amplitude modulation.

Incidental to the invention of a method of reducing disturbances in radio signaling, he has provided additional benefits which are, in themselves, highly useful contributions to the radio art.

The question as to who invented frequency modulation has no particular bearing on his work.

## SPOT NEWS

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of police radio equipment, both component parts and complete systems, oversubscribed the scheduled exhibition space. Correspondence concerning APCO activities should be addressed to Ero Erickson, Secretary-Treasurer, 7135 Irving Park Road, Chicago 34, Ill.

**General Knudsen:** Word-picturing the spirit of American boys as he saw them in New Guinea: "There you see men working as you and I have never seen before. I was tremendously impressed. There is the climate, there is the jungle, the insects and the sticky heat, and here are all these people you got over here working and fighting without a bit of complaint. I remember seeing a fellow operating a bulldozer all by himself out there, making a road. He did not have anything on but a pair of shorts and a pair of shoes and a trash hat and he sat on that bulldozer and was singing to beat the band."

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## SPOT NEWS

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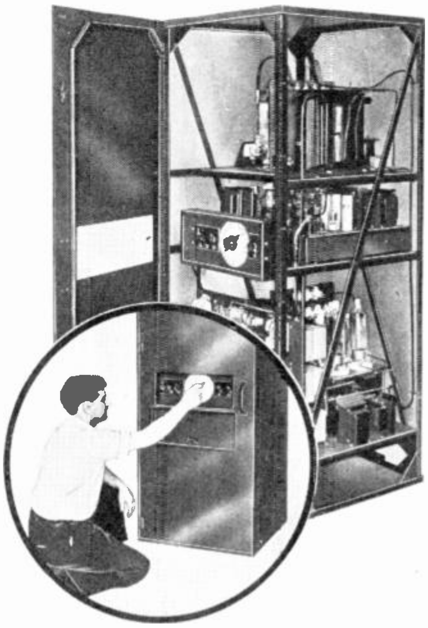
**Electronic Generator:** Communications Measurements Laboratory is producing a variable-frequency generator for laboratory and test purposes. Rated at 1.4 kw., it delivers 120 volts RMS at 300 to 3500 cycles. Output is substantially constant from no load to full load. The generator employs an adjustable oscillator, followed



ELECTRONIC GENERATOR DELIVERS 1.4 KW., 120 V. AT 300 TO 3500 CYCLES

by driver stages and two 833-A tubes in the output. While the regulation of such generators is ordinarily poor, this unit has a special control circuit to maintain constant voltage with variable loads.

**Sayre M. Ramsdell:** President of Sayre M. Ramsdell Associates passed away at his home at Churchville, Pa., on October 4th. Joining the Philadelphia Storage Battery Company in 1919, he became Philco vice-president in charge of advertising and sales promotion in 1934. Eight years later, he resigned to organize the advertising agency which bears his name. Principal clients were Philco and National Union. The Ramsdell agency has received widespread recognition for its creative work in the series of Philco advertisements portraying the industrial might of the U. S. overcoming the terrorism of Axis leaders. One of these was adjudged among the 50 best advertisements in 1942.

**FM Educational Channels:** Chairman Fly, speaking to the Federal Radio Education Committee at Washington: "The ether is far too crowded, the pressure from other interests far too great, to permit continued reservation of those (five educational FM) channels unless educators actually get busy and fill them with educational stations." Chairman Fly further

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## SPOT NEWS

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stated that equipment will be readily available after the War, and that plans should be worked out now for putting them to use. Such stations now operating are: City of Buffalo, 42.9 mc.; City of New York, 42.1 mc.; City of Chicago, 42.5 mc.; City of Memphis, 42.1 mc.; City of San Francisco, 42.1 mc.; City of Cleveland, 42.5 mc.; City of San Diego, 42.3 mc.; University of Illinois, Urbana, 42.9 mc.; and University of Kentucky, Beattyville, 42.9 mc.

**Ideas Wanted:** Prizes in $100, $50, and $25 War Bonds are being offered by Hudson American Corporation, 62 W. 47th Street, New York City, for ideas on electronic devices applicable to municipal signal systems. Requests for further information should be mailed to F. H. Pinkerton at the address above.

**New Offices:** North American Philips Company, Inc. will move its commercial and administrative offices from Dobbs Ferry to the Pershing Square Building, 100 East 42nd Street, New York City at the end of November. This concern, together with Philips Metalix Corporation, Philips Export Corporation, and the Industrial Electronics Equipment Division of North American Philips will occupy the entire fourth floor. The purchasing department of North American Philips will remain at Dobbs Ferry, N. Y.

**Microphone Data:** Booklet just published by Universal Microphone Company, Inglewood, Calif., shows construction details of T-30-S throat microphone, together with circuits, electrical information, and repair instructions.

**Appointments:** Herman Smith, president of Radio Essentials, Inc., has announced the appointment of Ben Miller as Chicago sales engineer with offices at 149 W. Ohio Street, while Irving Rosen will hold a similar position in New York.

**Measuring Q of Mica:** Instruments have been developed by NDRC for checking mica electrically, supplementing standard visual tests. Preliminary results appear very favorable, and a program of checking the instruments for production service is now underway.

One instrument determines whether or not electrically conducting stains are present in a piece of mica under test. The other measures the Q of the mica more rapidly and easily than can be done on a standard Q meter. It is expected that the former instrument will be available at approximately $50, and the latter at $350. Further information can be obtained from S. A. Montague, Chief, Mica-Graphite Division, WPB, Social Security Building, Washington, D. C.

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## SPOT NEWS

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**Los Angeles:** Information concerning activities of "The Representatives" in the Los Angeles area can be obtained from V. T. Rupp, Secretary, or Don C. Wallace, chairman of the Press committee, 4214 Country Club Drive, Long Beach 7, Calif.

**WMCA:** New York City's "top-of-the-dial" station has been sold to Nathan Straus, one-time newspaper reporter and ensign in the U. S. Navy during World War I. As New York State Senator and later as a member of the New York City Housing Authority, and President Roosevelt's Administrator of the U. S. Housing Authority, he is well known for his work in that field. In private business, he is president of Straus-Duparquet, supplying hotel and restaurant equipment. Price of the WMCA property was $1,255,000, as announced by Edward J. Noble, the former owner, and the recent purchaser of the Blue Network.

**Induction Heaters:** For soldering, heat-treating, and other production purposes are described in a new booklet available from General Electric's Electronics Division, Schenectady, N. Y.

**T. H. Wickenden:** Appointed manager of the development and research division of International Nickel Company at their laboratories in Bayonne, N. J.

**Name Changes:** Sam Schwartz, looking ahead to broader activities of Sun Radio, one of the oldest radio distributors in New York City, has announced that his concern is now to be known as Sun Radio & Electronics Company.

## WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 4)

exploit their successes to the fullest, or to offset reverses in field operations. This, in brief, is a picture of conditions which will call for a $1,250,000,000 increase in the Signal Corps' 1944 needs over 1943.

Radio manufacturers are inclined to resent changes in design details or in production schedules when they are straining every facility to meet delivery requirements already projected. There will be more of such changes during the next twelve months than in the past year.

These must be met and accepted as an obligation to our Armed Forces, which must meet ever-changing conditions in the field. Only by making these changes can the Signal Corps give effect to lessons learned through failures in action.

If we are to give adequate support to our men, we must give them equipment that is not one jump or two jumps ahead of that supplied to the armies which op-

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## WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 60)

pose them. We must give them equipment of definite superiority.

Aircraft manufacturers, building far more complicated products than radio apparatus, using a wider range of materials and parts that are difficult to manufacture, have a way of taking changes in their stride.

To cite just one example: With B-17's and B-24's in full swing, and production scheduled for months ahead, word came back that pilots of German FW-190's had discovered a vulnerable angle from which they could attack our planes with great success.

A new nose turret, with a wider angle of fire, was developed quickly, and change orders were issued to contractors to put the new turret into production without holding up delivery a single day. This was necessary because the strategic plans of our Armed Forces must proceed without interruption. If the aircraft manufacturers had taken time out to grouse and argue in an attempt to save themselves a few headaches, the ratio of Allied to enemy plane losses in Europe and the Pacific islands would have been changed accordingly.

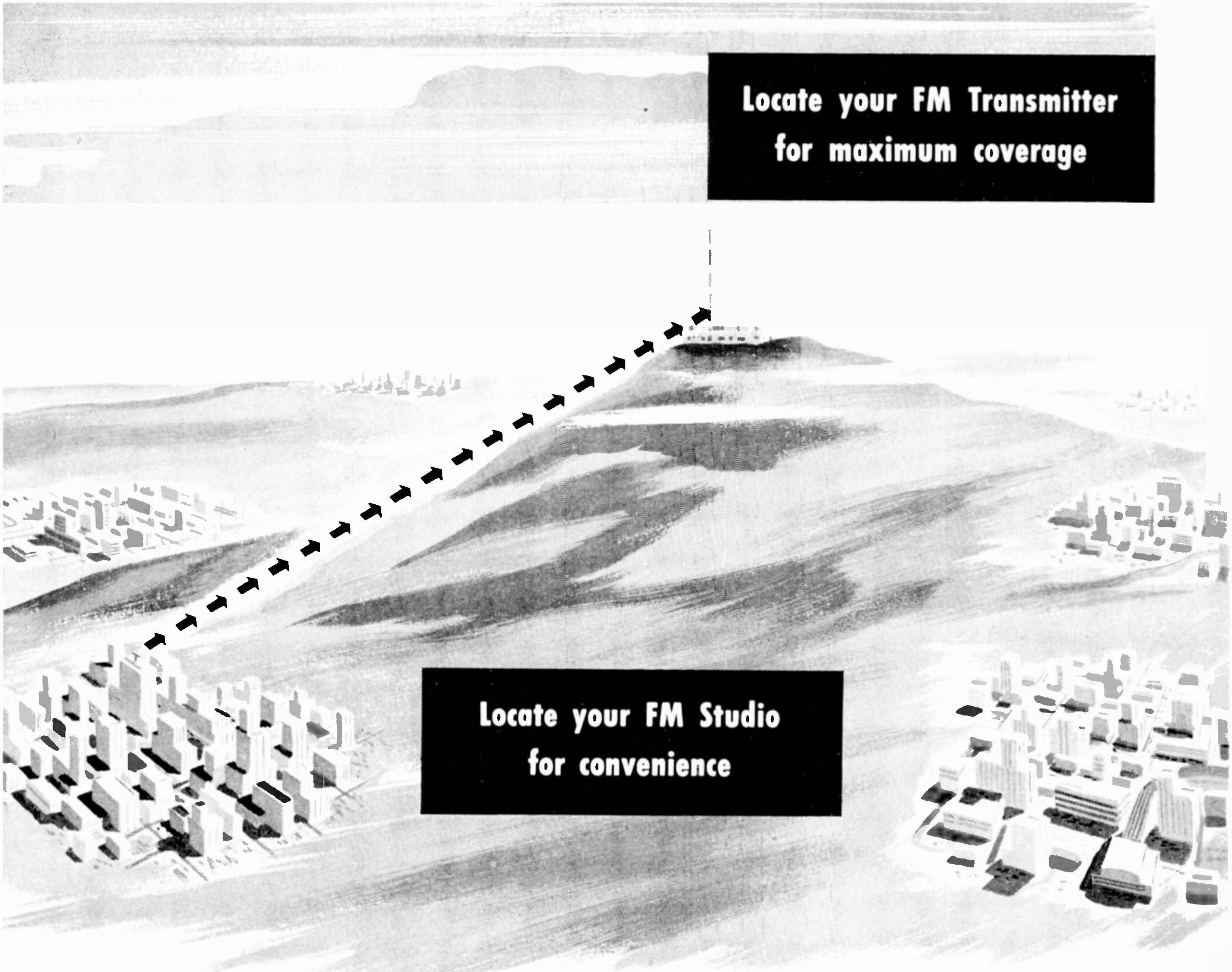
The requirements of the Signal Corps are being screened constantly, every month, every week, sometimes every day, in order to scale down or increase the requirements of various items and to maintain a balance over all.

Such changes are made in the light of tangible but shifting factors. They may result from new battle experiences and consequent revisions of strategy which dictate the discarding of some models and increased demand for others. There may be quick changes in troop strength. Abnormal wear and tear may call for unexpectedly heavy replacements or additional stocks of spare parts.

Each new type of terrain on which our men fight calls for readjustments in projected schedules. For instance, we can expect that there will be no more desert warfare, so that hundreds of special items which had to be produced with great haste for this type of fighting are no longer necessary.

Now, as we move more deeply into enemy territory, both in Europe and in the Pacific, radio manufacturers will have to organize for much greater adaptability. Designs will be modified with increasing frequency. Many contracts will be suddenly cut down, while others will be stepped up, yet the total production must move up and up.

With new battles, altered terrain, and shifting strategy to alter the plans of the Signal Corps, the only constant factor in 1944 on which the radio industry can depend is the urgency for moving faster than the manufacturers who supply the armies opposing us. — *Milton Sleeper*




## Bridge the gap without wires with a G-E *ST relay*

PROGRAMS from W41MM, the Gordon Gray studio at Winston-Salem, N. C., are today being relayed, *without wires*, to its 3-kw transmitter high on Clingman's Peak 110 *miles away*. A G-E Station-to-Transmitter unit makes this wireless relaying possible. In similar use at FM stations in Chicago and Schenectady, and at international short-wave stations in Boston and New York, the S-T relay has proved its economy, reliability, and unequaled transmitting fidelity in months of flawless day-in, day-out service.

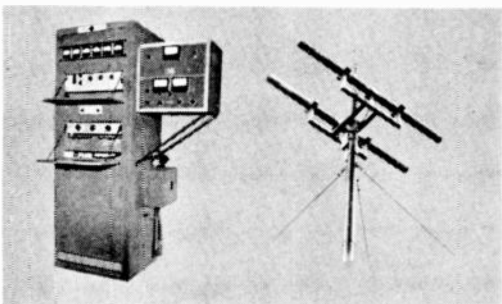
General Electric S-T equipment permits complete FM program fidelity from 30 to 15,000 cycles . . . the total range of the human ear. This apparatus takes the place of technically inadequate or prohibitively expensive wire-line construction . . . for *no* connecting wires are needed! General Electric alone has pioneered and developed this wireless type of equipment . . . and G. E. is the only manufacturer who can supply it.

A complete General Electric S-T relay-equipment installation includes:

1. **A 25-watt FM transmitter.**
2. **A rack-mounted station monitor.**
3. **A double-conversion, crystal-controlled superheterodyne FM receiver.**
4. **Special directional antennas that provide a 100-fold power gain between studio and transmitter.**

It's not too soon now to start locating the site for your post-war FM transmitter. G. E. has the experienced engineering personnel to help you find the best location, the S-T relay transmitter and receiver to reach it, and the studio and antenna equipment to operate it . . . plus broadcast and programming experience to help you select and train your future FM engineering and studio staffs. We welcome your inquiries. *Electronics Department, General Electric, Schenectady, New York.*

*Tune in "THE WORLD TODAY" and hear the news direct from the men who see it happen, every evening except Sunday at 6:45 E.W.T. over CBS. On Sunday listen to "The Hour of Charm" at 10 P. M. E.W.T. over NBC.*



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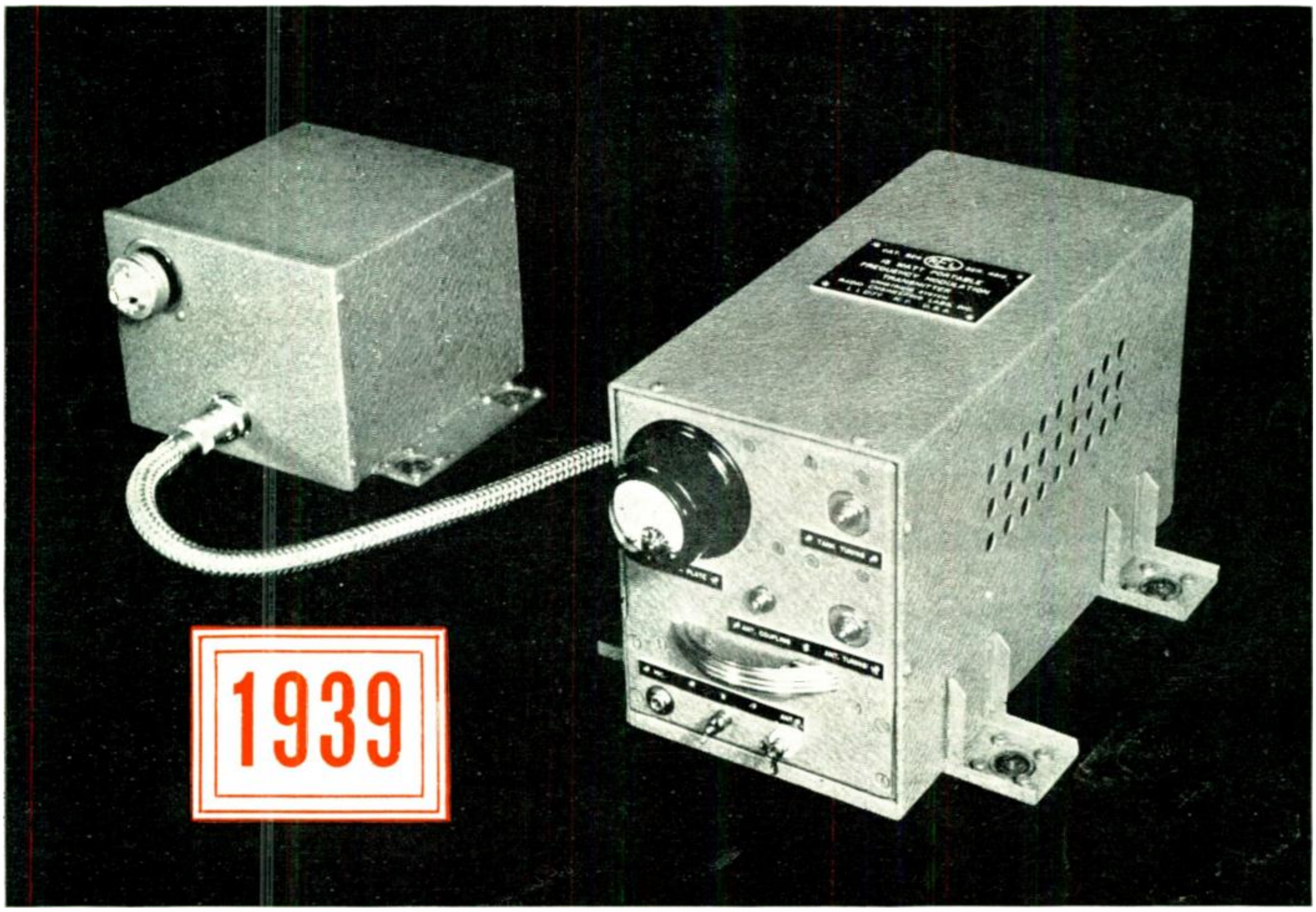


# The First FM Mobile Transmitter

IN 1939, REL set up two milestones in the progress of FM communication. In addition to delivering the Paxton transmitter, the world's first commercial FM broadcasting installation, REL built the first mobile, crystal-controlled FM transmitter, illustrated above.

This 15-watt unit, with a battery-operated power supply, was demonstrated to the U. S. Armed Forces at Fort Knox in October, 1939, to show the adaptability of Frequency Modulation to radio communication for tanks.

The circuit employed Armstrong phase-shift modulation. Its stable frequency characteristics set the pattern for all mobile FM transmitters used today by police departments and public utilities, and by various branches of our Armed Forces.

To broadcast station operators now making plans for participation in the postwar FM expansion, REL offers unequalled engineering experience and manufacturing facilities. This includes the most advanced types of audio systems, turntable installations, transmitters, power supplies, antennas, and ST relay equipment.

Do you require a mountain-top installation such as we built for the Yankee Network on snow-capped Mt. Washington? Or an office-building station similar to that used by The Detroit News? Or an installation in the open country, of which the Milwaukee Journal's station is a typical example?

The success of these and many other installations are proof of REL leadership in the design and manufacture of FM broadcasting equipment.

## LOOK TO REL FOR PEACETIME LEADERSHIP

Engineering improved equipment for War today, REL is planning further improvements for Peace tomorrow. Among these will be REL "packaged" FM broadcast stations, low in cost and easy to erect, for communities which now lack adequate, enjoyable, static-free radio entertainment.

REL

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The "E" Flag with Star For "Continued Excellence in War Production"


**TODAY**, the war tempo on all fronts stimulates us to meet the demands for Radio Communication Equipment and other Electronic Devices. These units work shoulder to shoulder with our Fighting Men—for freedom, decency and ultimate victory. **TOMORROW**, we can again fill the requirements of our many friends in the Radio Communication and kindred fields.

Necessity has sharpened our skill. War work has given us a liberal education. We look forward to peace time innovations. Sincerely then—we feel that **OUR WARTIME EXPERIENCE** is the journeyman "Link" between Today and Tomorrow. We promise no super colossal electronic rockets or such, but as proven in the past—Link FM radio communication equipment will be "Preferred."

**Fred M. Link**

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