PRICE—TWENTY-FIVE CENTS

FM RADIO-ELECTRONICS

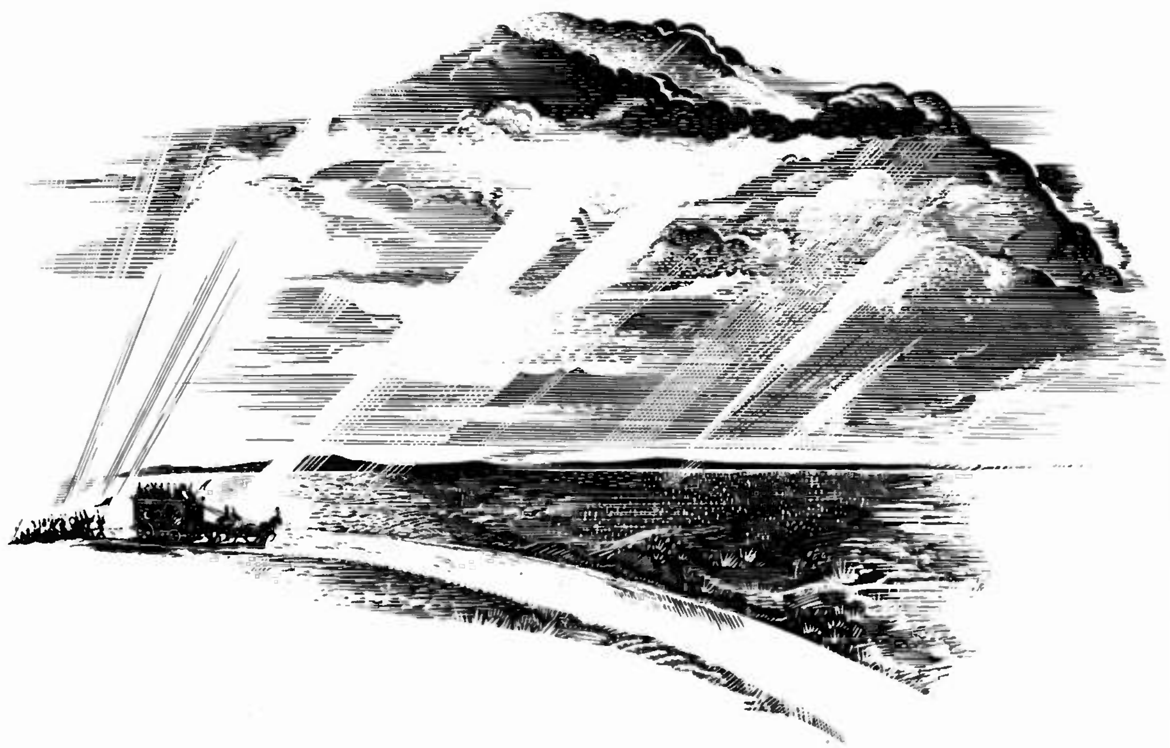
MARCH 1944

SHOCK-PROOF CRYSTALS
FOR FM BATTLE SETS

Broadcast Managers & Engineers

★ ★ *Edited by Milton B. Sleeper* ★ ★

HERE'S THAT BANDWAGON AGAIN



Once in a blue moon it comes along . . . that symbol of great opportunity dear to the heart of every progressive American—the Bandwagon! It's here again!

This time the Bandwagon is Television. You've been waiting for it. Do you recognize it now that it's time for the first seats to be taken? Better look again.

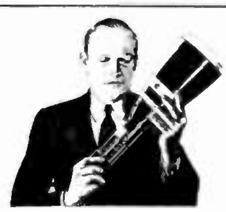
Television stands today where radio stood a few years ago . . . where movies stood a few years earlier. Those Americans who were *the first to climb* aboard are continually congratulating themselves!

Men who can judge the future by the past are already climbing aboard this 1944 Bandwagon. They know that television, which combines the best in radio and movies (plus a few things of its own), promises to confound the skeptical and reward the enterprising by soaring to the greatest heights of all . . . *soon*.

Plan *now* for your telecasting studio. Reserve that equipment *now*... equipment that insures low cost operation. These things can be done. DuMont will do them for you.

Allen B. DuMont has specialized in television since it was a laboratory curiosity. By developing the DuMont Cathode Ray Tube, he earned the title, "The Man Who Made Commercial Television Practical"; he put wheels on Television's Bandwagon. Climb aboard!

The man who made commercial television practical can make it profitable for you.



Allen B. DuMont, creator of the DuMont Cathode Ray Tube. DuMont is now providing complete plans for complete telecasting equipment . . . will custom-build your transmitting set-up, provide training for personnel at cost, equip your station, reserve your material. The very cornerstone of this service is low cost of operation. We invite your inquiries.

DUMONT *Precision Electronics and Television*

ALLEN B. DuMONT LABORATORIES, INC., GENERAL OFFICES AND PLANT, 2 MAIN AVENUE, PASSAIC, N. J.
TELEVISION STUDIOS AND STATION W2XWV, 515 MADISON AVENUE, NEW YORK 22, N. Y.

FM RADIO-ELECTRONICS

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

VOL. 4 | MARCH, 1944 | NO. 3

CONTENTS

★ ★ ★ ★ ★ ★

MILTON B. SLEEPER, *Editor and Publisher*
WILLIAM T. MOHRMAN, *Advertising Manager*
GORDON CROTHERS, *Circulation Manager*
Published by: FM COMPANY

Editorial and Advertising Office: 240 Madison Avenue, New York City, Tel. LE 2-8070
Chicago Advertising Representative:
MARIAN FLEISCHMAN, 360 N. Michigan Ave., Tel. STAte 4139

FM Magazine is issued on the 30th of each month. Single copies 25c — Yearly subscription in the U. S. A. $3.00; foreign $4.00. Subscriptions should be sent to FM Company, 240 Madison Avenue, New York City.

The publishers will be pleased to receive articles, particularly those well illustrated with photos and drawings, concerning radio-electronic developments. Manuscripts should be sent to the publication office, at New York City. Contributions will be neither acknowledged nor returned unless accompanied by adequate postage, packing, and directions, nor will FM Magazine be responsible for their safe handling in its office or in transit. Payment for contributions are made upon acceptance of final manuscripts.

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

THIS MONTH'S COVER

The quartz crystals shown on this month's cover are of a type developed and produced by Western Electric Company in quantities running into millions. They are used for Army combat radio equipment. As a protection against vibration, the crystals are mounted by fine wires soldered to plated spots on the faces.

This type of crystal is used in vehicular sets for tanks, half-tracks, tank destroyers, command cars, and scout cars. The famous SCR-508 tank set carries eighty crystals, each of a different frequency, while the SCR-608 field artillery set has 120 crystals. Both of these models employ Frequency Modulation.

WHAT'S NEW THIS MONTH

1. Demand for FM Sets
2. Important FM Booklet
3. Postwar FM Band
4. Television Frequencies

1. What will be the postwar market for sets capable of AM reception only? That is an important question to manufacturers and to broadcasters alike.

If people are thumbs down on straight AM sets, some manufacturers may be stuck badly. If there is a large demand for AM sets, the FM stations must expect a slower audience growth.

Initially, while the manufacturers have a sellers' market, we can expect that sales promotion efforts will be concentrated on the more expensive models. All plans announced so far promise FM tuning in new receivers above the low-price brackets. That is reassuring, but will there be a tendency for Mr. and Mrs. John Public to say: "I'll take one of those cheaper models. Ordinary programs are good enough for me"?

Many may have forgotten about it, but there is a precedent by which public reaction can be forecast:

I believe it was in the spring of 1930 when Pilot Radio announced the first switch-controlled all-wave receiver. I should remember, for I wrote the copy for a double-page spread in *Radio Weekly*, announcing the new model. The advertisement was headed by the statement: "If It isn't an All-Wave Receiver, It's Not a Modern Radio." To me, that line represented as much hope as confidence in the conviction it would carry!

What happened? Why, it forced the entire industry to add short-wave tuning. By fall, dealers were reluctant to buy sets that didn't have band-switches on them. The next spring, just one year after that announcement, the very cheapest sets had knobs marked for broadcast and police short-wave bands!

What good was the short-wave tuning? I never found out, and I don't know to this day. There were some foreign born listeners who wanted to hear programs in their native tongues. They would listen to European or Cuban or South American programs no matter how faint the reception, or how static-ridden. Numerically, they accounted for a tiny part of total radio sales.

To the great majority of purchasers who asked, "Does it have short-wave tuning?" this was nothing more than a point-of-

(CONTINUED ON PAGE 60)

"End of the Line" is only the Beginning

• This is the end of the Sylvania Radio Tube production line.

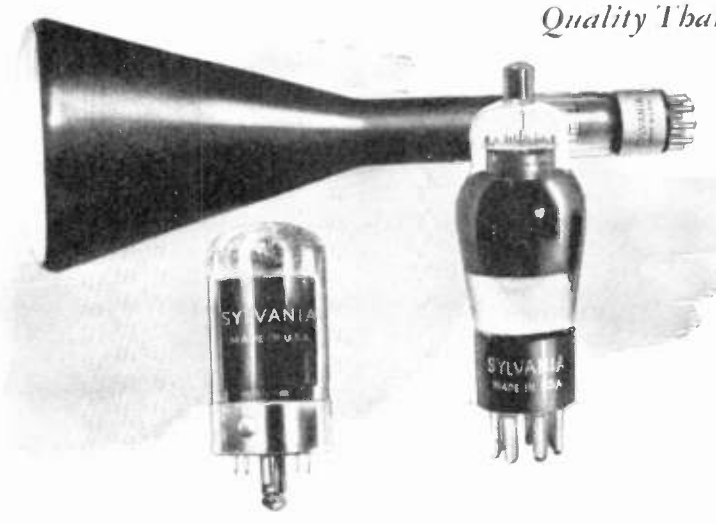
Here trained operators begin a series of tests designed to safeguard high-quality manufacture from any bit of human error.

Standardized precision testing instruments enable them quickly to determine basic radio tube fitness. The slightest defect dooms a tube to instant destruction.

Then come more exhaustive and specialized tests for any deviation at all from specification in the quality inspection and customer inspection departments.

Every Sylvania Radio Tube must pass these rigorous tests — and pass them with a perfect score — before shipment from the factory. This painstaking precision test system is your insurance for Sylvania quality that you can sell with complete confidence.

Quality That Serves the War Shall Serve the Peace



RADIO DIVISION — EMPORIUM, PENNSYLVANIA

SYLVANIA

ELECTRIC PRODUCTS INC.

RADIO TUBES, CATHODE RAY TUBES, ELECTRONIC DEVICES, INCANDESCENT LAMPS, FLUORESCENT LAMPS, FIXTURES AND ACCESSORIES

ADVERTISERS INDEX

wherever a tube is used...

For example—

Resistance Welding

Thyratron tubes, working with other thyratron or ignitron tubes and usually a relay, control the current for spot, projection, seam and other types of resistance welding for lower maintenance and better welds.

THERE'S A JOB FOR

Relays BY GUARDIAN

Your post-war product must stand the competition of *price* as well as quality. And manufacturers who use electron tubes to boost production, cut material costs, and increase product performance, have the edge on competitors. Electronic control of resistance welding is one cost-saver to consider.

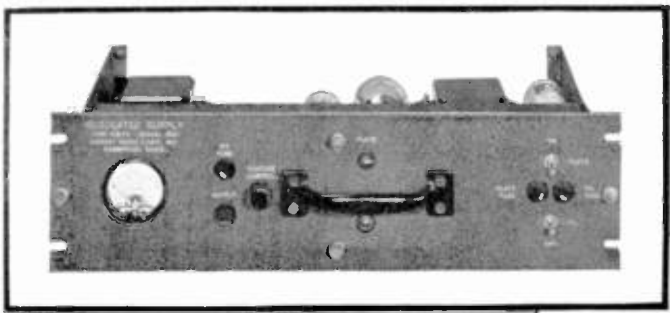
In this, as in most other tube applications, the use of a relay increases efficiency. The Series 175 DC and Series 170 AC Relays by Guardian, when used in the output of the tube circuit, control external loads in accordance with the tube operating cycle. These relays have binding post terminals in place of solder lugs. Bakelite bases, molded to reduce surface leakage, give a higher breakdown factor. Contact capacity: 12½ amps., at 110 volts, 60 cycles, non-inductive. Information on contact combinations, coil voltages, and further data is yours for the asking.

Consult Guardian wherever a tube is used. *However,* Relays by Guardian are *NOT* limited to tube applications but may be used wherever automatic control is desired for making, breaking, or changing the characteristics of electrical circuits.

GUARDIAN ELECTRIC

1637-C W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY



LOOK INTO THIS HARVEY REGULATED POWER SUPPLY

For a dependable, controllable source of laboratory D.C. power, you'll find the HARVEY 106 PA just what the doctor ordered. Designed to operate from 115 volts A.C. it has a D.C. output variable from 200 to 300 volts, and is capable of regulation *to within one per cent.*

There are separate fuses on each transformer primary as well as the D.C. output circuit; pilot lights on each switch; a D.C. volt-meter for measuring output voltage; a handy two-prong plug or binding posts for the power output. All in all this is a precision instrument that is a model of efficiency and operating convenience.

Years of specialization in the development and building of radio and electronics apparatus such as this Power Supply, I-F and Audio "Ampli-Strips", Radio Transmitters, Police and Marine Telephone Units qualify us to assist you in the development and production of electronics equipment calling for a high degree of technical knowledge and facilities. Whenever you have a problem of this character it will pay you to get in touch with

HARVEY RADIO LABORATORIES, INC.
443 CONCORD AVE., CAMBRIDGE 38, MASS.

HARVEY OF CAMBRIDGE

Here is a Frequency Meter that drives a Recorder without need for Auxiliary Amplifiers

The *Norelco* Direct Reading Frequency Meter

8 Ranges: 0 to 50,000 Cycles

This new NORELCO instrument is an accurate, sensitive and versatile tool for laboratory or factory, adaptable to many regular or special uses and capable of directly driving standard 5 milli-ampere recorders.

Both the meter and recorder (when one is in use) are protected against overload by a sensitive relay which operates instantly in case a frequency higher than maximum reading of range in use is applied to input.

Write for complete information on this new meter, so that you may be able to decide for yourself its true value in your own plant.

Easy to Use—The new NORELCO meter is supplied in either sturdy oak cabinet (main illustration) or for standard rack mounting and can be used with standard 5MA recorders.

Easy to Read—The direct reading feature throughout the eight ranges, from 0 to 50,000 cycles facilitates measurements, particularly by unskilled operators.

For Army and Navy communications we make Quartz Oscillator Plates; Amplifier, Transmitting, Rectifier and Cathode Ray Tubes. *For war industries* we make Searchray (X-ray) apparatus, X-ray Diffraction Apparatus; Electronic Measuring Instruments; Direct Reading Frequency Meters; High Frequency Heating Equipment; Tungsten and Molybdenum products; Fine Wire in many metals and various finishes; Diamond Dies.

And for Victory we say: Buy More War Bonds!

Norelco ELECTRONIC PRODUCTS by

NORTH AMERICAN PHILIPS COMPANY, INC.

Executive Offices: 100 East 42nd Street, New York 17, New York
Factories in Dobbs Ferry, New York; Mount Vernon, New York (Metalix Division); Lewiston, Maine (Elmet Division)
Represented in Canada by Electrical Trading Co., Ltd., Montreal

TOO GOOD | JUST RIGHT | NOT SO GOOD

Admit it. Like any enlightened gentleman, you too are a connoisseur when it comes to women. You can pick 'em; and no fooling. Feminine desirability we leave to you, but we do pride ourselves upon fashioning tubes "just right" for your electronic equipment.

As you know, ideal production would yield only tubes with the exact characteristics required. In practice, Hytron sets close tolerances for all characteristics, and then painstakingly controls production to hit uniformly the centers of those tolerances.

Does it seem strange that Hytron rejects not only tubes "not so good" but also "too good"? Consider a simple example. Mutual conductance is a figure of merit normally desired high. Once your circuit constants have been fixed for a standard tube, however, too great transconductance may give unstable performance.

Hytron strives, therefore, to produce for you tubes which are standardized; uniform tubes which — as originals or spares — will always be *just right* for the wartime radio and electronic applications you design.

OLDEST EXCLUSIVE MANUFACTURER OF RADIO RECEIVING TUBES

HYTRON CORPORATION ELECTRONIC AND RADIO TUBES

SALEM AND NEWBURYPORT, MASS.

HYTRON RADIO TUBES

BUY ANOTHER WAR BOND

THE IMPACT OF FM ON RADIO ADVERTISING

What Advertisers Should Know about FM's Part in Rehabilitating Distribution Systems

BY MILLER McCLINTOCK*

THERE is ample evidence that the years immediately following the War will bring an unprecedented expansion to the advertising industry of the United States. This prospect offers great opportunities to all phases of the advertising business, and it brings with it some very great challenges.

If advertising men and media respond with their usual resourcefulness, it is entirely possible that theirs may be a major role in the reestablishment of a sound economy in a peaceful world.

Any discussion of the future of radio advertising, whether by AM, FM, or television, must be predicated on the total opportunity of all advertising. Important as we may believe radio advertising to be, and as phenomenally successful as it has been in its short history, we must never lose sight of the fact that it will rise or fall in the future according to the service performed by all advertising, marketing, and merchandising activities.

As the Advertiser Sees It ★ From the standpoint of the men who are responsible for the marketing and distribution of the products of American industry, all forms of radio have a single significance. Radio emanations are useful to carry the message of the advertiser into the homes of the American people where they can have the opportunity to learn the merits of the commodity or service offered.

These messages are delivered under circumstances which make the receiving instruments generally available at a price that can be afforded by all, or practically all, of our people. These messages are delivered under circumstances which afford — heretofore, for the ear only — entertainment of the highest order, news of the most instantaneous character, and related cultural and public service features which cause so many people to be attentive to radio for so many hours each day.

Progress as a Medium ★ No proof of this universal acceptance of our present form of radio is necessary beyond very simple figures: Twenty years ago, there was practically no commercial broadcasting in the United States. A few thousand very inefficient sets were capable of picking up some very bad programming, badly transmitted. Today, there are more than 30 million homes equipped with approximately 50 million radios. The average radio set is listened to more than four hours a day. In all of this development there has been a constant and amazing perfection of facilities for transmission and listening, on the one hand and, on the other hand, the increasingly effective utilization of radio as we have come to know it.

It may be a surprise to some who are thinking in terms of new techniques to find how long the more powerful AM stations will persevere in doing a constantly better job for the public and for advertisers. This prophecy lies in the ability of such stations to deliver their programs over very wide areas, often hundreds of miles away from the point of emanation. This is a characteristic which is prevalent on cleared channels during the night hours, which are of course the most important listening hours. It is my suggestion, therefore, that advertisers will do well to think cautiously before they abandon the thought of utilizing fully what has been developed in the present radio industry.

Conversion to FM ★ This word of caution is by no means intended to disparage the remarkable capacity of Frequency Modulation, and the inevitable widespread development which it will have immediately after the War. AM, in many areas, will be first supplemented and subsequently replaced entirely by FM. This inevitable development comes out of a number of characteristics of FM which make it a much more effective and useful system of radio transmission and, therefore, much more useful and effective to advertisers.

Let us turn our attention to some of those practical realities which have an effect upon the plans and activities of marketing men. Without going into technical details, let us consider such functions of FM as may affect your activities and the activities of those who serve you in the radio medium. We can group some of the refinements into a simple statement:

FM promises a very measurable improvement in the quality of reproduction at the receiver. It is free from static, either natural or man-made. It will accommodate refinements in sound, particularly music and sound effects, not available through present forms of broadcasting. These refinements, however important they may be, are comparatively superficial from the standpoint of the advertiser who is spending his money on radio service.

Meeting Need for More Stations ★ There are, however, several inevitable impacts of FM which may have a profound effect upon advertising practices. As I see them, the most important of these lies in the fact that, because of technical characteristics, the adoption of FM permits many more stations to be licensed in the United States without the danger of interference or overlapping of signals. This means that, instead of the maximum of 800 stations, somewhat more than half of which are network-affiliated, now available to advertisers, an unlimited number, to all intents and purposes, will be available. This is desirable, for the very essence of good business operation and good advertising is the maintenance of free competition.

You are probably aware that, at the present time, the four national networks are operating at nearly full capacity. Under AM, only nominal expansion is possible, yet the growing volume of radio advertising will shortly demand additional facilities unless the broadcasting industry is to reach a ceiling and find its growth stopped.

With the coming of FM in large volume after the War, many communities now without local radio stations, or with an inadequate number of stations to serve the needs of national advertisers will be able to have new stations. Undoubtedly, in the postwar period, many inexperienced and poorly financed operators will believe that they can achieve a bonanza by the simple procedure of buying transmitters and putting them into operation. The mortality probably will be high.

The total number of stations in the future will be limited not by the present technical limitations of AM frequencies available, but will be governed only by the law of supply and demand. Thus advertisers can look ahead to a continuing situation where there always will be vigorous competition, and where there will be assurance of the delivery of advertising service at the lowest cost consistent with the maintenance of that service.

Equalizing Network Coverage ★ There is a second technical aspect of FM which has an important effect upon advertisers and ad-

* President, Mutual Network, 1440 Broadway, New York City.

vertising practices. There are, at the present time, certain artificial barriers to the equalization of services and coverage afforded by the national networks. This is inevitable because, in the historical growth of the four networks, some were able to achieve dominant power in some markets where stations of equal power were not available to competitors. Each has its own particular strong points, and each has points where it is incapable of delivering a fully equalized service.

This is not advantageous to the marketing man and the advertiser. As good as the service may be, it cannot be entirely equal and homogeneous in all the markets he would like to reach with equal force and effectiveness.

Within certain technical limitations, and in accordance with the present plans of the Federal Communications Commission, FM stations with network connections in each market will have similar, if not identical, power and coverage capacity. Thus the race for competitive preference among the existing networks will not lie in the historic *power preference*, but in current capacity to deliver a type of programming which is most acceptable to the available listeners. As a natural corollary, of course, insofar as economic demands justify, there will be an ample number of stations in each market to serve the four existing networks and such new network operations as may develop.

Lower Costs ★ There is another characteristic of FM which has a bearing upon your planning. FM transmitters can be built at a much lower cost than is required for present AM transmitters covering the same service area. One of our FM operators has indicated that this differential is as between $40,000 and $250,000 for a given service area. Power costs and certain other overhead would appear to be substantially lower for FM operation. This means, therefore, that many FM stations can be built in smaller communities than could at present justify a radio station of any kind. Many of these will undoubtedly be too small to warrant network affiliation, but will be available for the use of either the local advertiser or the national spot advertiser.

This cost factor also has a bearing upon the overall cost of radio service. It may have an immeasurable influence on the delivery of still better broadcasting at a lower cost to the advertiser. You should bear in mind, however, that the initial investment in the transmitter and the cost of power are, in the more important stations, relatively insignificant in comparison with the costs of programming, business management, and general operations. There is, therefore, no real hope that FM, per se, on the basis of its cost factor, can result in any revolution in the overall national radio advertising costs.

Local Copy, Local Tieups ★ The last element in FM which has a basic bearing upon advertising economics is one which cannot be fully appreciated at the present time. One of the technical qualities of FM, because it is operated on very high frequencies, is that it does not provide the normal long-distance night waves of cleared-channel AM transmission. This is a matter of real significance only on stations of comparatively sizeable power.

In the low-power brackets, it is probable that the normal FM station will deliver a better signal over an equal or larger area. FM cannot, however, reach out and cover great secondary areas of buying power as the larger AM stations do today.

At first, this may not seem significant from the advertiser's standpoint, but I believe it to be reasonably fundamental. At the present time in AM radio, a very considerable part of the actual radio messages delivered are by what is commonly called outside coverage. That is, by a radio signal sent into a particular community from a station not in that community but in some relatively distant community. This situation is, of course, common in the large rural areas of the country. While there are some technical qualifications to the statement, FM, by the character of its high-frequency signals, is horizon-limited. That is, its signal is limited in range by the curvature of the earth. Naturally, therefore, the coverage area of an FM station is related to the height of the antenna from which the signal emanates.

The significance of this to the advertiser is that he must begin to think of his radio advertising more and more in terms of adapting his general advertising, and his network program and message to the interests of individual communities rather than to the generalized interests of the larger areas.

In principle, indeed, the Mutual Broadcasting System, through its present 220 AM stations, has already adopted this setup of inside, or community coverage. It may perhaps be considered one of the historic accidents of the growth of this network but, if it be an accident, it is one in which we believe, and one which we are perfecting rather than destroying. If I were to expand on this particular subject, I would be in danger of becoming involved in what might be considered a competitive presentation.

In principle, however, FM will necessitate the use of many more local stations to cover the total audience than are now required in most network operations. This is not necessarily a disadvantage. Competitive and cost factors should not increase but decrease the cost of using such a multiplicity of stations for network broadcasting. It certainly will have this very real and great advantage: It will force radio advertisers to think in terms of the specific markets to which and from which their messages are broadcast.

It opens unprecedented opportunities to do two of those things in advertising which are basic to all successful advertising effort. In the first place, it opens the opportunity and, indeed, the need to design advertising copy which will, as closely as possible, identify the characteristic of the commodity with the habits, thinking, and common knowledge of the people in individual markets. And in the second place, it will inevitably result in a valuable and very necessary tendency to build greater dealer participation and identity. Those who are confronted with the rehabilitation and redistribution system of your own companies know this great problem.

Those companies which are capable of rebuilding their dealer organizations from the best merchandisers are going to have a great advantage. The dislocations of the war period have resulted in a much more critical attitude on the part of dealers toward national companies and distributors.

Time for FM Planning ★ Now, with respect to the time element: FM is already here. Some 50-odd stations are now in regular operation, many of which transmit the same network programs as the AM stations. The number of pending applications filed with the FCC is considerably over 100, and more are being submitted every week. Twenty-eight states are represented by the applications now waiting for action as soon as the manufacture of broadcasting equipment is permitted. It will not take long after peace to secure national coverage from FM stations.

In the postwar period, it is generally assumed that almost all radio sets will have the capacity to receive both AM and FM. Thus the transition from the present type of operation to FM operation should be comparatively painless. Most of the more informed people in the industry believe that FM has qualities which will make it the almost universal sound medium for radio of the future. It will bring with it a higher quality of radio performance, and it will bring with it new market planning and opportunities for the further development of radio advertising.

DOUBLE SUPERHETERODYNE FOR FM RECEIVERS

An Explanation of the Double Superheterodyne FM Receiver, and a Comparison of Its Performance with Conventional Circuits

BY J. A. WORCESTER, JR.*

THE introduction of FM in the broadcasting and communication field has resulted in the rebirth of the double superheterodyne receiver.

As originally conceived this circuit employed two converters and hence two oscillators: one variable to produce a fixed first IF frequency and the second fixed to change the first IF frequency to a second lower value. Since the possible total gain at any single IF frequency before oscillation difficulties developed was rather limited with the triode tubes then available, the double superheterodyne offered an attractive means of substantially increasing the usable sensitivity of the receiver. Serious difficulties, however, in the form of spurious signals caused by the beating of the fundamental and harmonic frequencies of the two oscillators, restricted the use of this circuit to receivers of a more or less experimental nature.

With the introduction of the screen grid tube with its much lower grid-to-plate capacity, the possible total gain at a single frequency was considerably increased. It then became a relatively simple matter to produce a receiver sensitivity with a single IF channel that permitted reception of any signal above the receiver noise level. Thus for a period of years the double superheterodyne circuit was substantially forgotten until its recent revival in improved form brought about by the peculiar requirements of Frequency Modulation reception.

Why has FM made the double superheterodyne circuit again seem attractive? A brief consideration of the fundamental design considerations involved will offer enlightenment. Experience has indicated that the optimum sensitivity for an AM broadcast receiver is approximately 3 microvolts for .5 watt audio output. A lower sensitivity than this will result in the possibility of missing certain usable signals while a higher sensitivity will result in objectionable noise output when tuning between stations.

A conventional audio system has a sensitivity of about .08 volts for .5 watt output which, assuming 30% average percentage of modulation, reasonable diode efficiency, and accounting for the fact that the diode is not a linear detector at this small output, will require perhaps 1.0 volt of IF output.

In the case of the FM receiver, however, experience indicates that a quieting signal input of approximately 3 microvolts is desirable. In other words, a signal of 3 microvolts should result in a 20 db or 10 to 1 reduction in noise output. This, in turn, requires a signal on the limiter grid of about 4 volts. The limiter, in turn, should produce a minimum gain of 5 in order to assure sufficient deviation sensitivity. Perhaps it should be pointed out that the necessary input on the limiter grid to produce 20 db limiting with a 3-microvolt signal may be decreased to perhaps 1 volt by employing a high G_m sharp cutoff limiter tube, with abnormally low screen voltage, but the gain in the limiter tube will then have to be increased proportionately to 20 in order to maintain the required deviation sensitivity. In any event, then, the IF output of an FM receiver has to be approximately 20 volts.

A comparison will indicate that an IF output of 20 volts is necessary in the FM receiver while only 1.0 volt is required in the AM case. Thus, it is evident that the stability problem in an FM receiver is much more severe due to the necessity of providing 20 times as much amplification. The situation is further aggravated by the fact that the IF amplification of AM signals can be performed at the relatively low IF frequency of 455 kc., while image and repeat point considerations of FM reception require an IF of at least 4.3 mc.

The amplification that can be realized at the intermediate frequency is, of course, limited by feedback tending to cause instability or oscillation. Feedback may occur in any or all of the ways enumerated below:

1. Through common plate, screen, AVC, or heater circuits.
2. Overall or stage-to-stage stray inductive coupling.
3. Overall or stage-to-stage stray capacitative coupling.

All of these feedback paths can be theoretically eliminated by filter networks and extensive shielding except the capacitative feedback through the plate-to-grid capacity of the tubes themselves. Formulas for determining the maximum gain of single- and multi-stage amplifiers before oscillation from plate-to-grid tube capacity occurs have been developed in the literature. Experience indicates that two stages of intermediate frequency amplification prior to the limiter are capable of supplying all the amplification that can be obtained with stability. The theoretical maximum stage gain of such an amplifier is given by the equation

$$\text{Gain} = \sqrt{\frac{G_m}{2\pi cf}}$$

where G_m is the mutual conductance of the

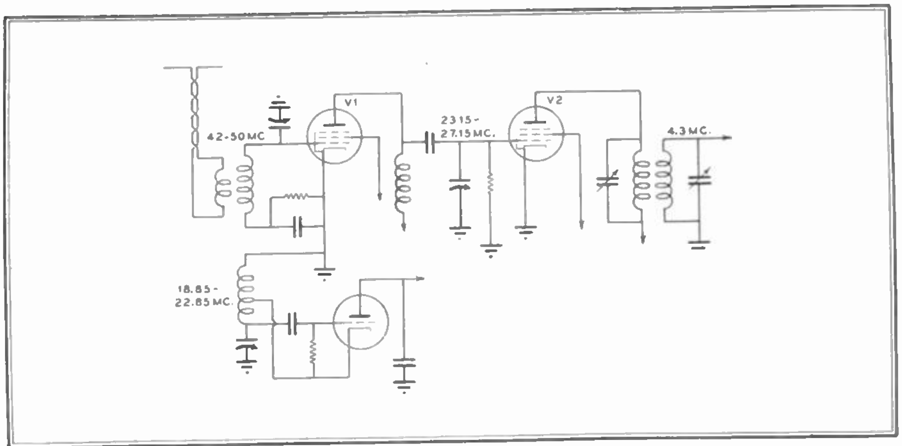


FIG. 1. FUNDAMENTAL CIRCUIT OF THE DOUBLE SUPERHETERODYNE, BY MEANS OF WHICH GREATER AMPLIFICATION IS MADE POSSIBLE BY REDUCING FEEDBACK

* Receiver Engineer, General Electric Co., Bridgeport, Conn.

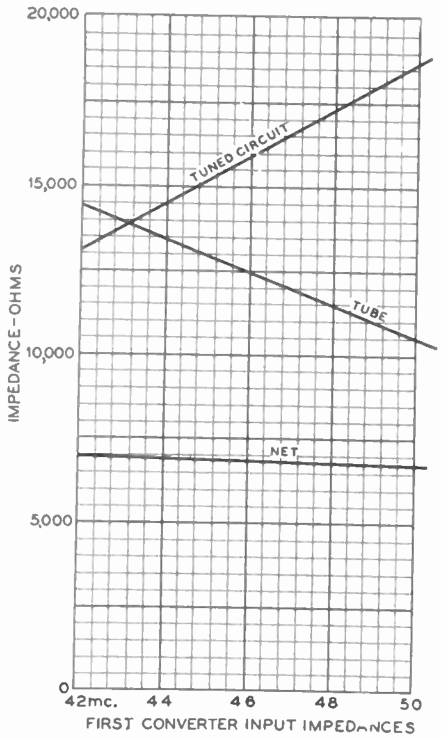


FIG. 2. COMPUTED INPUT IMPEDANCE OF THE 6AB7 TUBE AND TUNED CIRCUIT

tube; c is the grid-to-plate capacity of the tube; and f is the intermediate frequency.

It will be noted that the gain factor of the tube is G_m/c. The 6SK7 is somewhat superior to the 6AB7 (1853) in this respect and hence will be considered in the computations. The 6AC7 (1852) is slightly superior to both, but is much more costly.

The remaining factor influencing the amplication is the intermediate frequency. Since the voltage gain per stage decreases as the square root of the intermediate frequency, it is desirable to employ as low a value as possible. It should not, however, be reduced to the point where image difficulties are encountered. For a 42- to 50-mc. Frequency Modulation band, the intermediate frequency should preferably equal or exceed 4 mc. in order to preclude the possibility of images occurring within the frequency range covered. Another factor to consider is direct IF pickup. This renders 4 mc. undesirable, since it would pick up the 80-meter amateur phone band. Many other considerations are involved in the selection of a suitable intermediate frequency, which are outside the scope of this article. Many of these factors have been considered by the Radio Manufacturer's Association and they have as a result recommended an intermediate frequency of 4.3 megacycles.

With this as a basis it is found that a theoretical gain of 122 per stage is possible. This figure is, however, subject to two revisions. The first of these is a factor of 2 required to prevent oscillation during the aligning process. This assumes the use of critically coupled two-coil transformers, and comes about from the fact that until tuned to the same frequency the individual circuits of each transformer have approximately twice their normal impedance, and hence represent a condition much more susceptible to oscillation. This then reduces the theoretical gain to 61 per stage.

The second revision is to provide some safety factor for variations in tubes, inductances, line voltage, power transformers, rectifier drops and tolerances in other components. The difficulty in obtaining useful information from this formula lies in the proper evaluation of this second factor. Indications are that it should be at least 2, thus resulting in a theoretical stable gain per stage of approximately 30. Hence, the gain of the IF amplifier prior

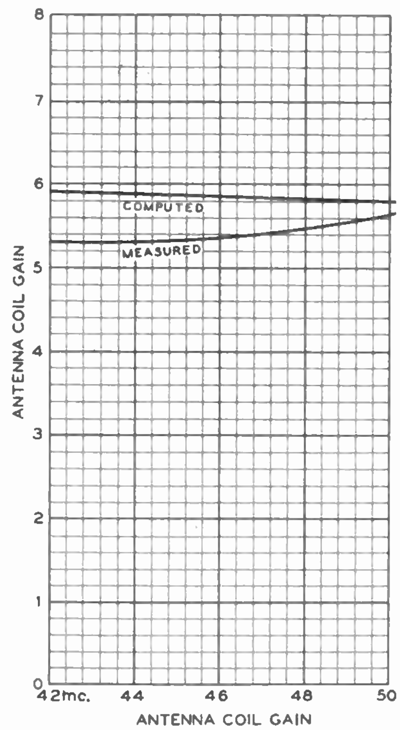


FIG. 3. ACTUAL AND CALCULATED GAIN OF ANTENNA COIL ARE REASONABLY CLOSE

to the limiter is about 900, exclusive of the converter gain. The converter voltage gain is normally included as IF amplification, but since the converter input represents essentially zero impedance to the IF, it is not involved in stability considerations.

It is obvious, therefore, that the converter gain should be made as large as possible. This indicates the use of a high G_m pentode such as the 6AB7. Operated under suitable conditions as a converter, this tube will provide about 1.25 times the gain of a 6SK7 operated as an amplifier. Thus the converter voltage gain should be about 37.5, providing a total theoretical IF voltage gain of 33,800.

It should be emphasized at this point that the voltage gain figure above assumes that all sources of feedback except that through the plate-to-grid capacitance of the tubes have been eliminated. This is never entirely true, especially when an additional IF amplification of 5 exists subsequent to the limiter. Practical experience dictates that IF voltage gains at 4.3 mc. appreciably in excess of 15,000 to the limiter input are decidedly risky from a production standpoint. It is possible that receivers made on a custom built basis could be designed with a total IF voltage gain lying somewhere between the theoretical 33,800 and the maximum practical production value of 15,000.

Suppose, for the sake of argument, that the maximum IF voltage gain permissible ahead of the limiter is 20,000. The required total gain ahead of the limiter is

$$\frac{4{,}000{,}000}{3} \text{ or } 1{,}300{,}000.$$

The necessary signal frequency amplification in a single superheterodyne would then be

$$\frac{1{,}300{,}000}{20{,}000} \text{ or } 65.$$

This RF gain would have to be provided by the RF amplification and the antenna coil gain.

The antenna coil gain that can ordinarily be obtained can be computed with a fair degree of accuracy from the formula

$$\text{Ant. coil gain} = .707\sqrt{\frac{Zs}{Zp}}$$

where Zs is the equivalent secondary impedance, and Zp is the primary trans-

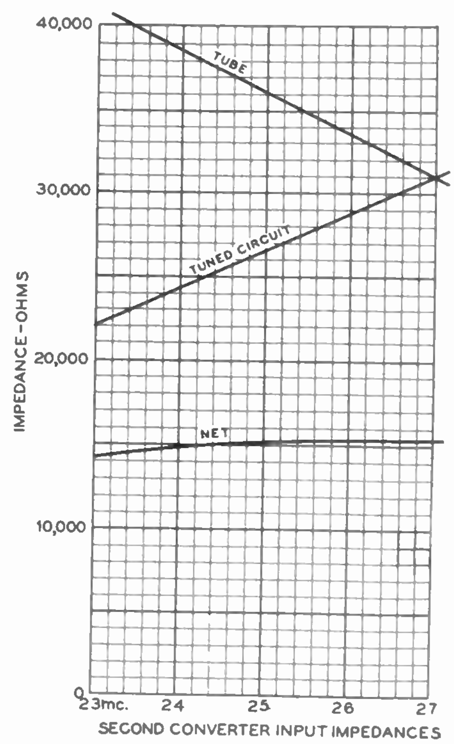


FIG. 4. IMPEDANCE OF 1ST CONVERTER AND 6AB7 2ND CONVERTER INPUT

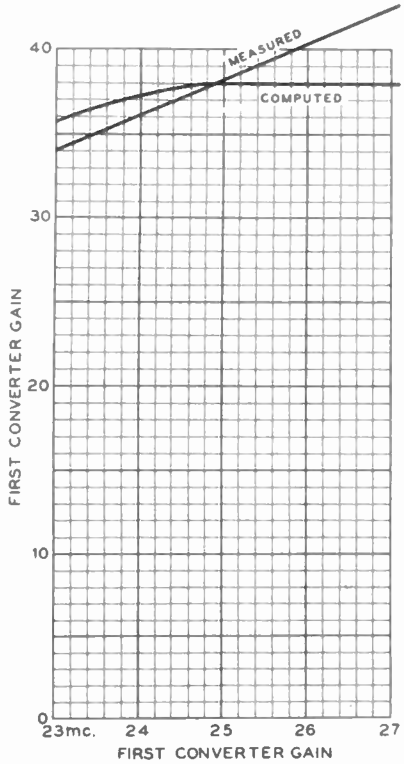


FIG. 5. THE COMPUTED AND MEASURED GAIN OF THE FIRST CONVERTER

mission line impedance of 100 ohms. The factor of .707 is necessary since the reactance in the primary circuit is not normally tuned out. *Zs* is represented by the parallel combination of the tuned circuit impedance and the input impedance of the tube. At 46 mc., the former is about 15,600 ohms with a well-designed antenna coil, and the latter about 6,650 ohms for a 6AB7 tube. This gives a net secondary impedance of 4,600 ohms.

Hence
Ant. coil gain

$$= .707 \sqrt{\frac{4,600}{100}} = .707 \times 6.8 = 4.8$$

The required RF gain is then $\frac{65}{4.8} = 13.5$

The theoretical voltage gain of a single stage RF amplifier, when all sources of feedback except that due to plate-to-grid tube capacity have been eliminated, can be computed in a similar manner to that previously employed for the IF amplifier. The formula for a single stage amplifier is given by

$$G\ max = \sqrt{\frac{G_m}{\pi cf}}$$

G_m = Mutual conductance of tube $= 5,000 \times 10^{-6}$

C = Grid-to-plate capacity of tube $= .015 \times 10^{-12}$

f = RF frequency $= 50 \times 10^{-6}$

A 6AB7 tube is assumed in this instance since the computed gain cannot be readily obtained with the lower G_m 6SK7, tube. A frequency of 50 megacycles is assumed since the highest frequency would be most susceptible to oscillation from this feedback source, therefore.

$$\text{Gain} = \sqrt{\frac{5,000}{3.14 \times .015 \times 50}} = \sqrt{2,120} = 46$$

As in the case with the IF amplifier this figure is subject to revision. There are no

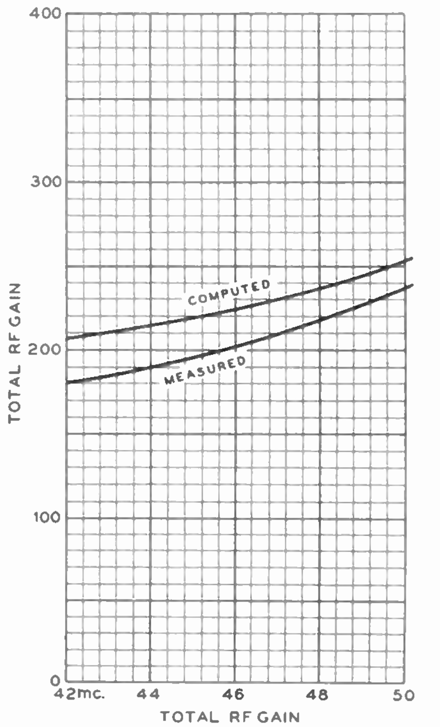
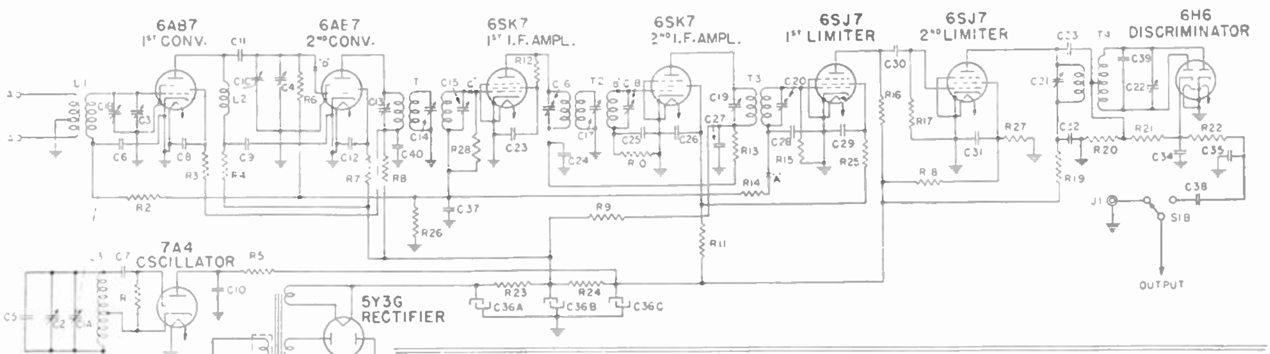


FIG. 6. TOTAL VOLTAGE GAIN AHEAD OF 2ND CONVERTER, COMPUTED AND MEASURED



Symbol	Description
C1a	Oscillator section of tuning condenser
C1b	1st converter section of tuning condenser
C1c	2nd converter section of tuning condenser
C2	5 24 mmf. oscillator air trimmer
C3	2 20 mmf. 1st converter trimmer
C4	2 20 mmf. 2nd converter trimmer
C5	40 mmf. temperature compensating capacitor
C6	470 mmf mica capacitor
C7	50 mmf. temperature compensating capacitor
C8	470 mmf. mica capacitor
C9	470 mmf. mica capacitor
C10	470 mmf. mica capacitor
C11	470 mmf. mica capacitor
C12	01 mfd. paper capacitor
C23	01 mfd. paper capacitor
C24	01 mfd. paper capacitor
C25	47 mmf. mica capacitor
C26	01 mfd paper capacitor
C27	01 mfd. paper capacitor
C28	47 mmf. mica capacitor
C29	47 mmf. mica capacitor
C30	22 mmf. mica capacitor
C31	47 mmf. mica capacitor

Symbol	Description
C32	47 mmf. mica capacitor
C33	50 mmf temperature compensating capacitor
C34	47 mmf mica capacitor
C35	220 mmf. mica capacitor
C36a	15 mfd. dry electrolytic
C36b	30 mfd. dry electrolytic
C36c	10 mfd dry electrolytic
C37	0.1 mfd. paper capacitor
C38	02 mfd paper capacitor
C39	8 mmf temperature compensating capacitor
C40	.01 mfd paper capacitor
L1	Antenna coil
L2	Interconverter coil
L3	Oscillator coil
P1	Dial lamp, MAZDA No 44
R1	33,000 ohms carbon resistor
R2	3 3 megohms carbon resistor
R3	6800 ohms carbon resistor
R4	2200 ohms carbon resistor
R5	1000 ohms carbon resistor
R6	3 3 megohms carbon resistor
R7	12,000 ohms carbon resistor
R8	1000 ohms carbon resistor
R9	1000 ohms carbon resistor
R10	47,000 ohms carbon resistor

Symbol	Description
R11	15,000 ohms carbon resistor
R12	47,000 ohms carbon resistor
R13	2200 ohms carbon resistor
R14	2 2 megohms carbon resistor
R15	47,000 ohms carbon resistor
R16	10,000 ohms carbon resistor
R17	180,000 ohms carbon resistor
R18	68,000 ohms carbon resistor
R19	22,000 ohms carbon resistor
R20	100,000 ohms carbon resistor
R21	100,000 ohms carbon resistor
R22	100,000 ohms carbon resistor
R23	1200 ohms 7.4 W. wire wound resistor
R24	3300 ohms 1 W. carbon resistor
R25	47,000 ohms carbon resistor
R26	470,000 ohms carbon resistor
R27	47,000 ohms carbon resistor
R28	47,000 ohms carbon resistor
S1a	Power switch
S1b	FM-Phono switch
T1	1st I F transformer
T2	2nd I F. transformer
T3	3rd I F. transformer
T4	Discriminator I F. transformer
T5	Power transformer for 50–60 cycles
T6	Power transformer for 25 cycles

FIG. 7. DETAILED DIAGRAM OF THE DOUBLE SUPERHETERODYNE AS IT IS USED IN THE GENERAL ELECTRIC JFM-90 CONVERTER

coupled circuits in the RF amplifier but a reduction in amplification is necessary to take account of variations in tubes and other components, variations in line voltage, etc., as enumerated previously. As before, the factor should be at least 2 to prevent manufacturing and field difficulties. This reduces the theoretical gain to 23. Again, it should be emphasized that this gain figure assumes that all sources of feedback except plate-to-grid tube feedback have been eliminated. In an RF amplifier it is even more difficult to approach this condition. The actual plate-to-grid capacity is considerably enhanced by the capacity between the antenna and RF sections of the gang condenser, as well as by the associated leads. These leads also provide inductive coupling which is difficult to eliminate entirely.

Indications are that even with considerable shielding, the effective plate-to-grid capacitance is more than doubled by these external contributing sources. As an approximation, therefore, we can assume that the practical stable gain is reduced to a value of not more than 10. The realizable gain is reduced still further by an additional source of feedback in the gang condenser of the conventional common-rotor type. This results from common impedance coupling in the ground returns, and cannot be eliminated at these frequencies by the expedient of employing individual wipers for each gang section. In practice this feedback source reduces the stable RF tube gain obtainable to a value of approximately 6. It is possible, of course, to eliminate this latter source of feedback by using a gang condenser construction with insulated rotor sections and individual wipers insulated from the frame. This construction is difficult, however, from the condenser manufacturer's standpoint, and results in a considerable cost increase.

It is evident that the RF tube voltage-gain of 6, which appears to be the highest obtainable with conventional gang construction without inviting production difficulties from oscillation, or the gain of 10 obtainable with a special gang rotor construction provides a total gain that will fall short of realizing maximum FM performance.

It is actually desirable to provide a total gain substantially in excess of that required in order to incorporate a safety factor sufficient to account for normal variations in sensitivity, alignment, drift, and other variables.

In order to provide this desirable amount of gain, a variation of the double superheterodyne receiver has been developed which requires only one oscillator, and hence avoids the serious difficulties normally encountered when double conversion is attempted.

Fig. 1 indicates a schematic diagram of the circuit employed. The tuning condensers for antenna, RF, and oscillator are ganged together as usual. The antenna circuit tunes the FM band from 42 to 50 mc., the RF circuit tunes from 23.15 to 27.15 mc., and the oscillator from 18.85 to 22.85 mc.

The oscillator voltage is inductively coupled to the grid of the first tube V_1. Or this coupling can be accomplished capacitatively. This produces, by heterodyne action, a signal to which the plate circuit is tuned. The tube also provides a gain of approximate unity for the oscillator frequency. Accordingly, oscillator voltage is also applied to the grid of V_2. This operates as a second converter, and produces in its plate circuit the IF frequency of 4.3 megacycles.

To illustrate the action by an example, consider the signal frequency of 42 mc. The oscillator frequency of 18.85 mc. produces a new frequency in the first converter plate circuit of 23.15 megacycles. This, in turn, beats with the oscillator voltage on tube V_2 producing the IF fre-

(CONTINUED ON PAGE 58)

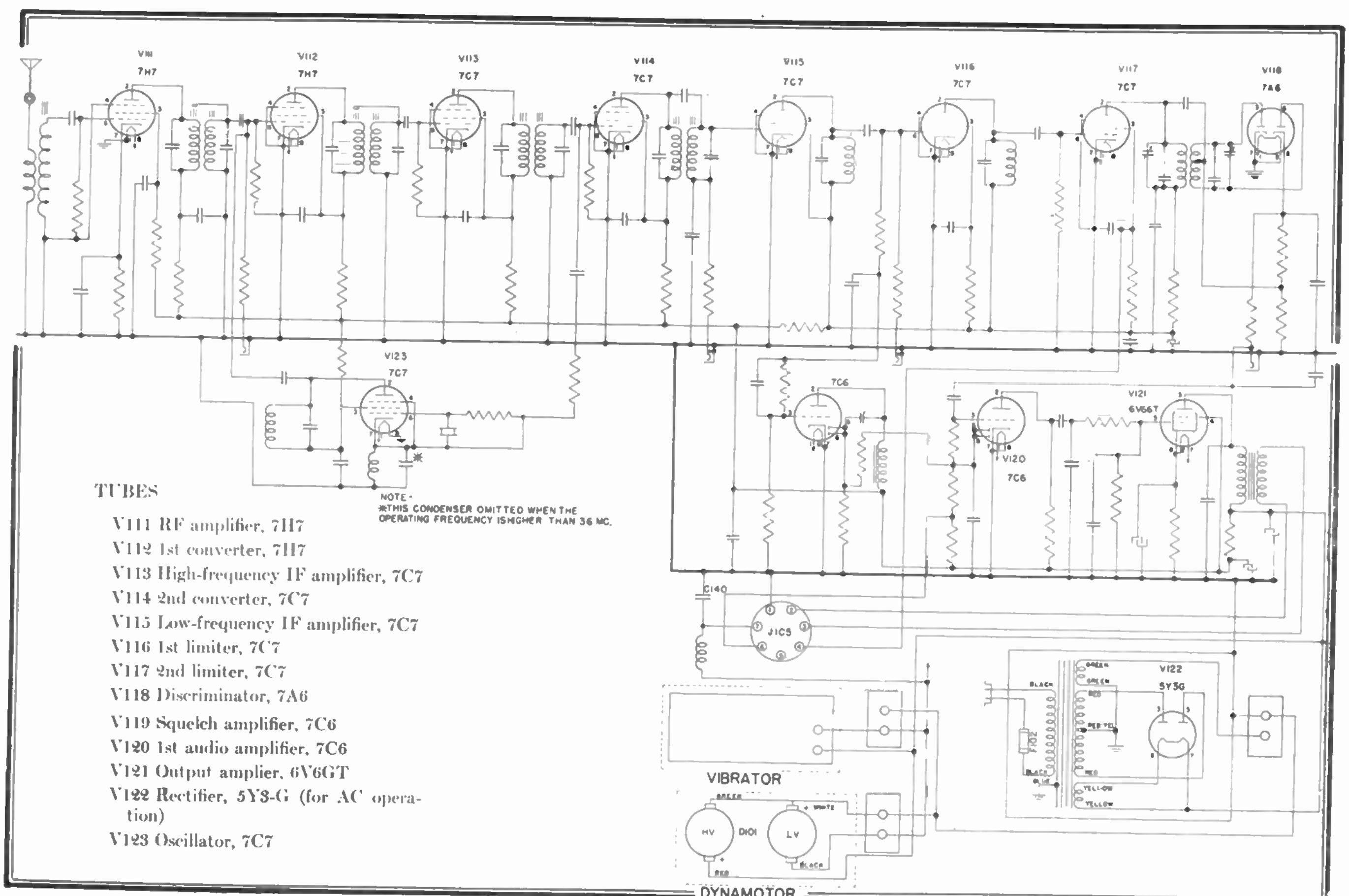
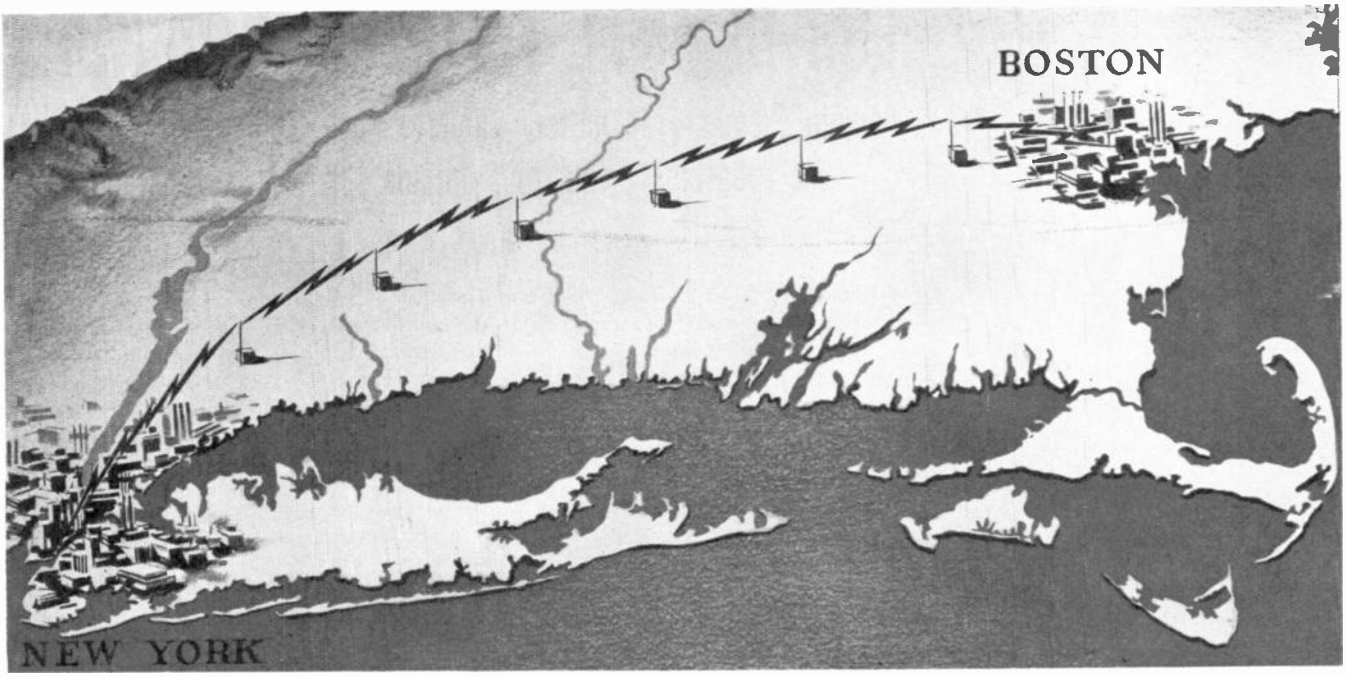


FIG. 8. DOUBLE SUPERHETERODYNE CIRCUIT IN A GENERAL ELECTRIC EMERGENCY FM RECEIVER FOR MOBILE SERVICE



NEW YORK-TO-BOSTON RADIO RELAY SYSTEM WILL PROVIDE COMPARISON WITH COST AND PERFORMANCE OF COAXIAL CABLES

AT&T WILL SET UP FIRST RADIO RELAY SYSTEM

New York to Boston Radio Relays Will Afford Comparison with Coaxial Cable Cost and Performance

DEVELOPMENT of tubes, equipment and directive antennas for radio communication at frequencies far above 100 mc. has encouraged the belief that radio relays may be far more practical, both in cost and service, than the use of coaxial cable for FM and television networks, or for carrying a large number of telephone conversations.

It is understood that coaxial cable requires repeater stations at intervals of approximately 15 miles, and that their cost is about the same as a radio relay unit capable of covering more than twice that distance. Contrary to the impression held by those unfamiliar with coaxial cable characteristics, the attenuation is extremely high. It may well be, therefore, that the repeaters come to more than the cost of the cable, and if two or three times as many repeaters are required than radio links over a given distance, it is easy to see that economy of installation and maintenance favors the radio system.

All comparisons which can be made now are theoretical, without a basis of practical experience, since no radio relay systems have been operated on a commercial service basis over any significant distance.

The announcement by the American Telephone and Telegraph Company that application has been made to the FCC for permission to erect a 2-way radio relay system from New York to Boston is of great interest to broadcast, television, and communications engineers for, when the installation is completed, we shall have practical answers to many problems which may then open the way to a number of uses for radio relays.

The New York to Boston system will require at least two years to complete, at an estimated cost of $2,000,000. This is a rather frightening sum for a circuit only 220 miles long, and may seem discouraging to those who have been considering radio relays for FM program networks. It must be remembered, however, that development and engineering costs are exceedingly high on such an initial project, compared to the expense of subsequent installations when the unknown quantities have been solved.

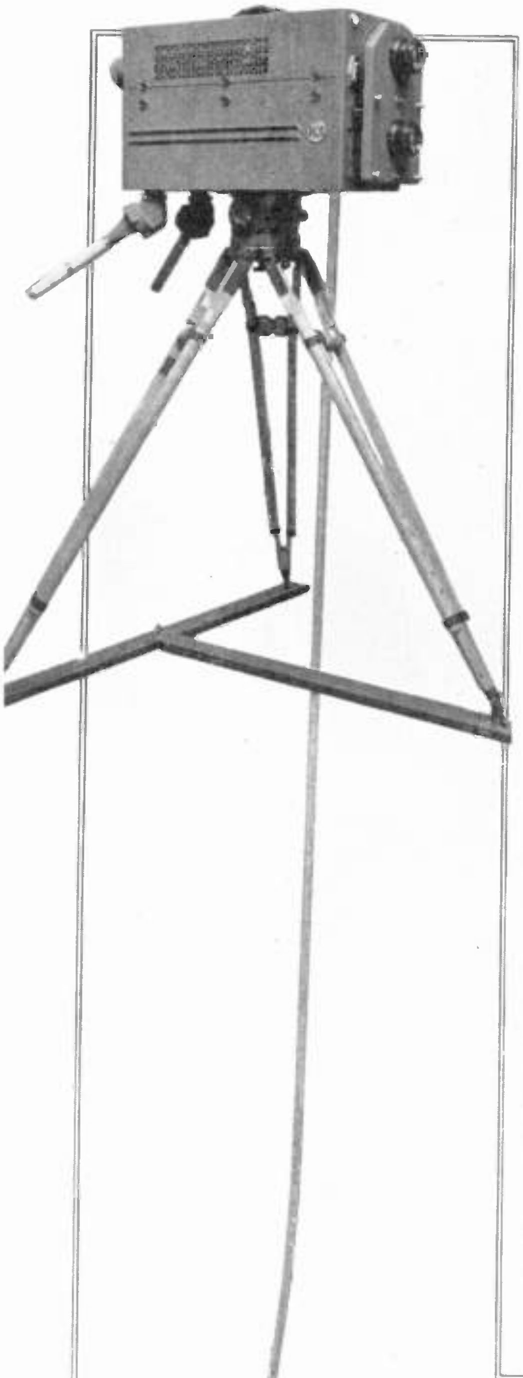
The immediate use for the system is to supplement existing long-distance telephone facilities between New York and Boston. However, it seems probable that this new move, following the announcement of plans for a national extension of coaxial cables, may have been accelerated by discussion in various quarters of setting up new public service companies to operate radio relay networks for the distribution of FM and television programs. Since AT&T retired from the amusement field by disposing of its interests in broadcasting and motion pictures, the Company assumed responsibility for furnishing the means for radio program distribution. Thus, any new organization set up to operate radio relay program networks would operate in direct competition with AT&T.

When FM broadcasting created a need for high-fidelity lines to connect studios with remote FM transmitters, the Telephone Company did not extend itself to be coöperative. In fact, its indifference to the needs of FM broadcasters forced the issue of wire lines vs. studio-to-transmitter radio links.

Whatever the reason, its failure to coöperate by providing adequate high-fidelity lines at reasonable cost, or to provide ST equipment on a rental basis put the FM broadcasters in the position of choosing between inadequate lines costing more than they could afford to pay, or exerting pressure on the manufacturers to develop ST radio links to operate at 330 mc., where the FCC reserved space for this service.

The Capitol Broadcasting Company was the first to put a 330 mc. FM link into service under these circumstances, and experience shows that the performance of the equipment is far superior to that which the local telephone company was prepared to guarantee on land lines. Of course, the

(CONTINUED ON PAGE 27)



FOR REMOTE TELEVISION PICKUPS

Remote Pickup Transmitter, Cameras, and Associated Equipment for Programs Originating Outside the Television Studio

BY H. E. RHEA*

PROGRAMMING is one of the important problems confronting the television industry. Until network television on a large scale becomes a reality, it may well be the biggest problem. Realizing this, prospective station owners are giving much thought to ways and means of providing suitable programs. The availability of remote television pickup equipment which has proved satisfactory under a wide range of operating conditions should be an important factor in this consideration.

Programs for telecasting involve techniques and problems which differ from those of sound broadcasting. Impressions conveyed by sight are usually more vivid than those created by sound; and monotonous, uninteresting programs more quickly become tiresome and boring to the listener or viewer. On the other hand, the expensive settings, the talent, and the long rehearsals required for live-talent studio shows rule these out as the solution to the local program problem. Most stations could not bear the financial burden of producing such programs during the necessary development stage; and yet a large number of stations, regularly telecasting, is a prerequisite to the establishment of television on a paying basis. It is apparent, therefore, that a source of entertaining programs, at reasonable cost, is essential if television service is to be other than a purely network development.

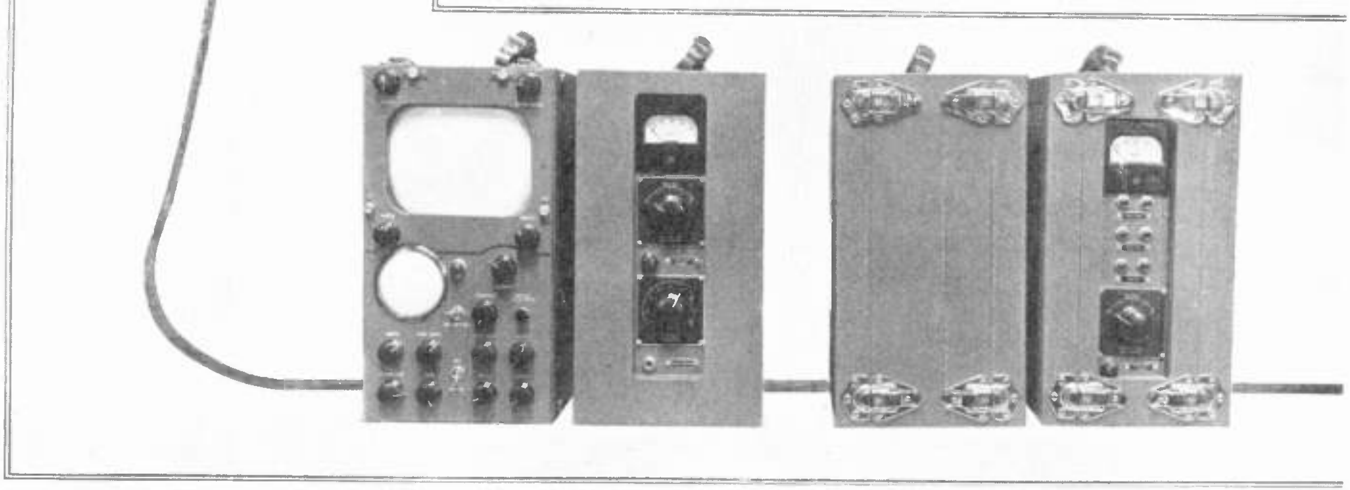
* Television Equipment Section, Radio Corporation of America, Camden, N. J.

Broadly speaking, television programs will be divided into three general classifications: film, studio, and remote pickup, the latter two being live-talent shows. From an economic standpoint, remote pickups offer the most promise. Little, if any, rehearsal is necessary; lighting is seldom a problem; and generally the extra expense entailed by televising an event which is being staged for other purposes is a small item.

Nearly all types of sporting events are naturals for telecasting material. Sports, almost without exception, are designed to provide entertainment through the sense of sight, and impressions conveyed by other senses are, at best, artificial and makeshift. Prize fights, for example, are staged for the sole purpose of extracting cash from the pocket of the fan who is convinced that the cash outlay is more than justified by the stimulation and entertainment he receives from *seeing* the combatants ferociously (he hopes) pummel each other into oblivion. He may pay \$50 for a ringside seat instead of \$5 for a stool out in the suburbs because the closer seat provides a better view and hence more entertainment value. Television can carry ringside seats to persons fifty miles away at comparatively little expense to the station owner. The same applies to baseball, football, hockey, tennis, and other games.

Other public events offer similar possibilities. Concerts, operas, night club floor

FIG. 1. TELEVISION CAMERA AND, LEFT TO RIGHT, CAMERA CONTROL AND POWER SUPPLY, SHAPING UNIT AND PULSE UNIT, AND THE REMOTE PICKUP TRANSMITTER.

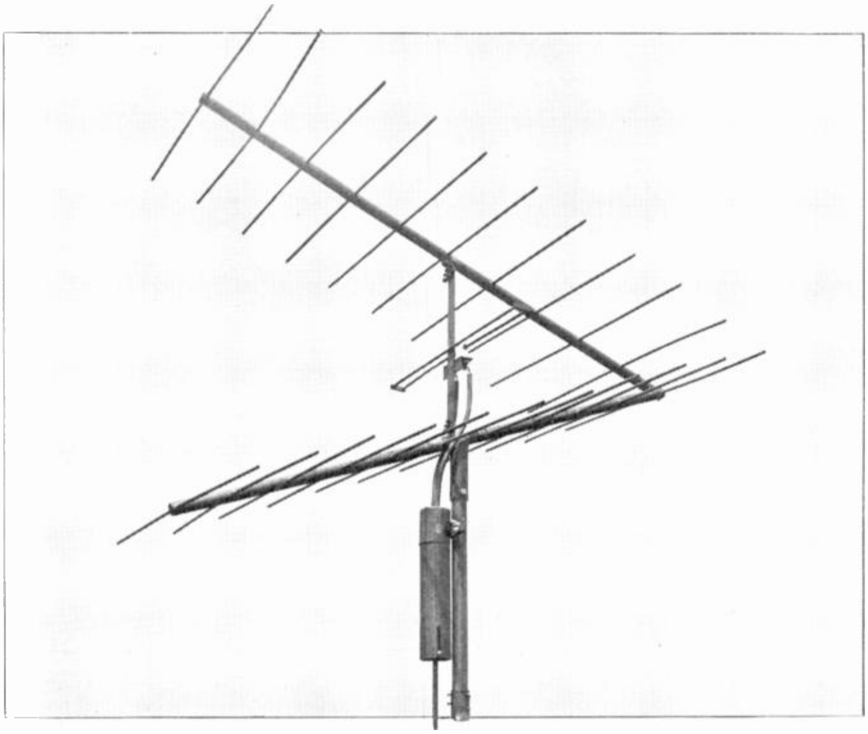


shows, spot news events — all are naturals for television. The opportunities for telecasting remote pickup programs which are both entertaining and inexpensive are almost unlimited.

Field Equipment ★ In order to take advantage of such opportunities, portable field equipment must form a part of the station's facilities. The equipment should be packaged in small, light-weight cases, capable of being transported in a station wagon. However, portability alone is not enough; there are other considerations of equal importance. The feature of easy carrying is valueless if, for example, the design and packaging are accomplished in a manner which requires hours for setting up the equipment after the location is reached. Setup time must be kept to a minimum so that no time will be lost in picking up unexpected news events and similar programs. Quality too is important. Even the most entertaining program can be ruined by inferior transmission. Some sacrifice may be possible and even desirable; but, in general, field equipment must produce pictures comparable to studio quality. Of further importance in preventing loss of detail is the radio frequency relay link which must have adequate band width and sufficient range to permit pickups at a considerable distance from the main studio and transmitter location.

Simplicity of operation is a necessity. Sight broadcasting need not be complicated and in field work it is especially important that the demands on the operating personnel be small. Following action and switching from one scene to another deserve the most attention.

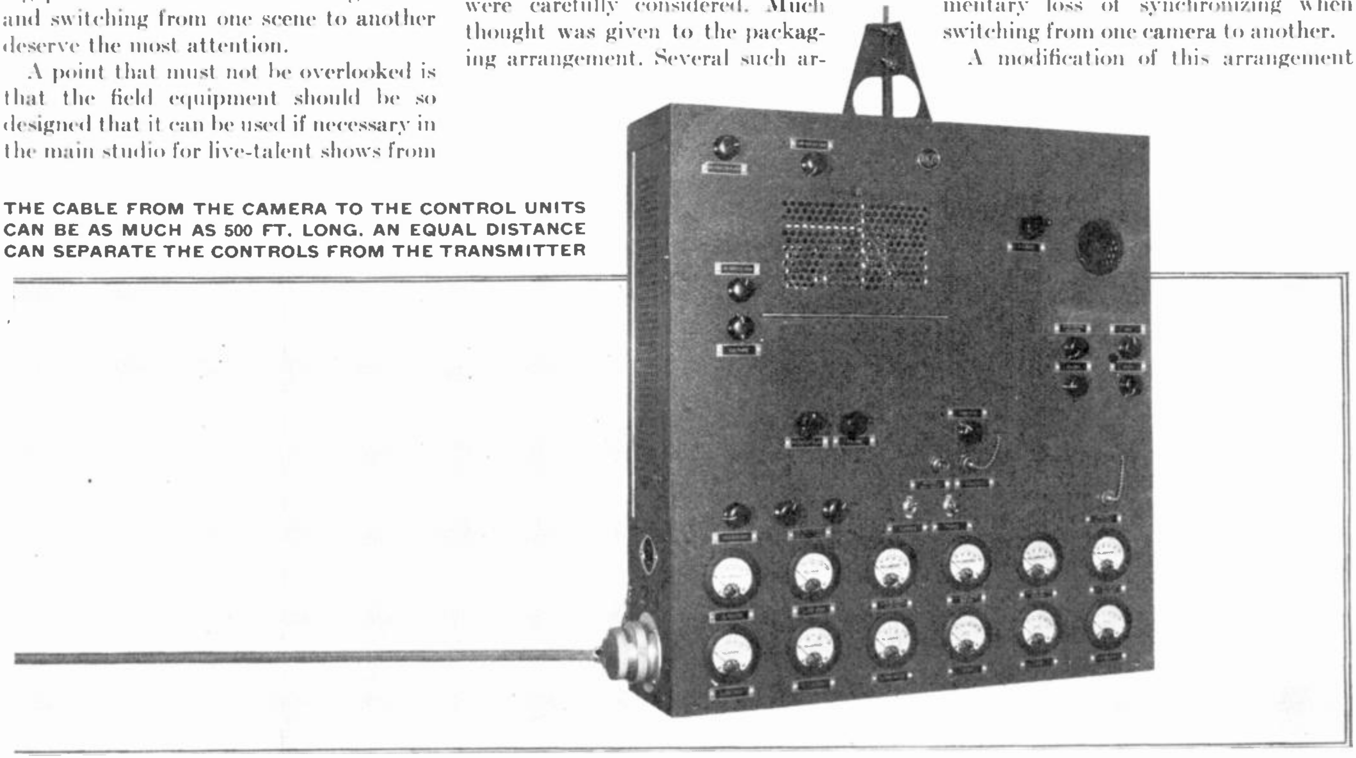
A point that must not be overlooked is that the field equipment should be so designed that it can be used if necessary in the main studio for live-talent shows from that location. In some instances, it will supplement fixed studio equipment; in others, especially in the case of small stations which are starting on a modest scale, it can take the place of fixed studio equipment until such times as the station facilities are expanded. When main studio units are added, the portable equipment can then be assigned to full-time field use.



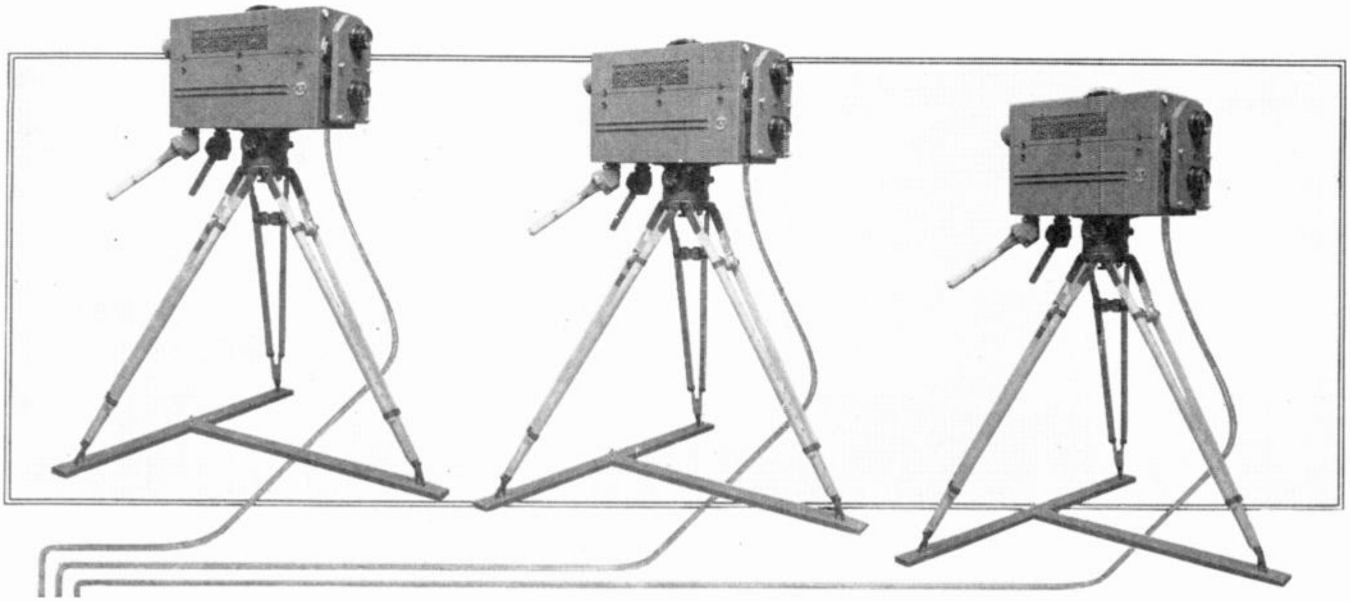
PICKUP TRANSMITTING ANTENNA. LEAD FROM TRANSMITTER SHOULD BE KEPT SHORT

In the design of the RCA television field equipment all of the above factors were carefully considered. Much thought was given to the packaging arrangement. Several such arrangements are possible. One would make each camera chain a completely self-contained unit — i.e., associated control equipment built into the camera itself. The only other individual boxes would be the transmitter and a monitor-switching unit. Such a system would have some advantages but it would necessitate bulky cameras and require duplicate synchronizing generators which, if not exactly in step with one another, would cause momentary loss of synchronizing when switching from one camera to another.

A modification of this arrangement



THE CABLE FROM THE CAMERA TO THE CONTROL UNITS CAN BE AS MUCH AS 500 FT. LONG. AN EQUAL DISTANCE CAN SEPARATE THE CONTROLS FROM THE TRANSMITTER



would be to have a common synchronizing generator, with each of the camera units otherwise completely self-contained. Again, however, the cameras would be relatively bulky and previewing of each camera before switching by the operator would not be possible unless additional monitoring units were provided.

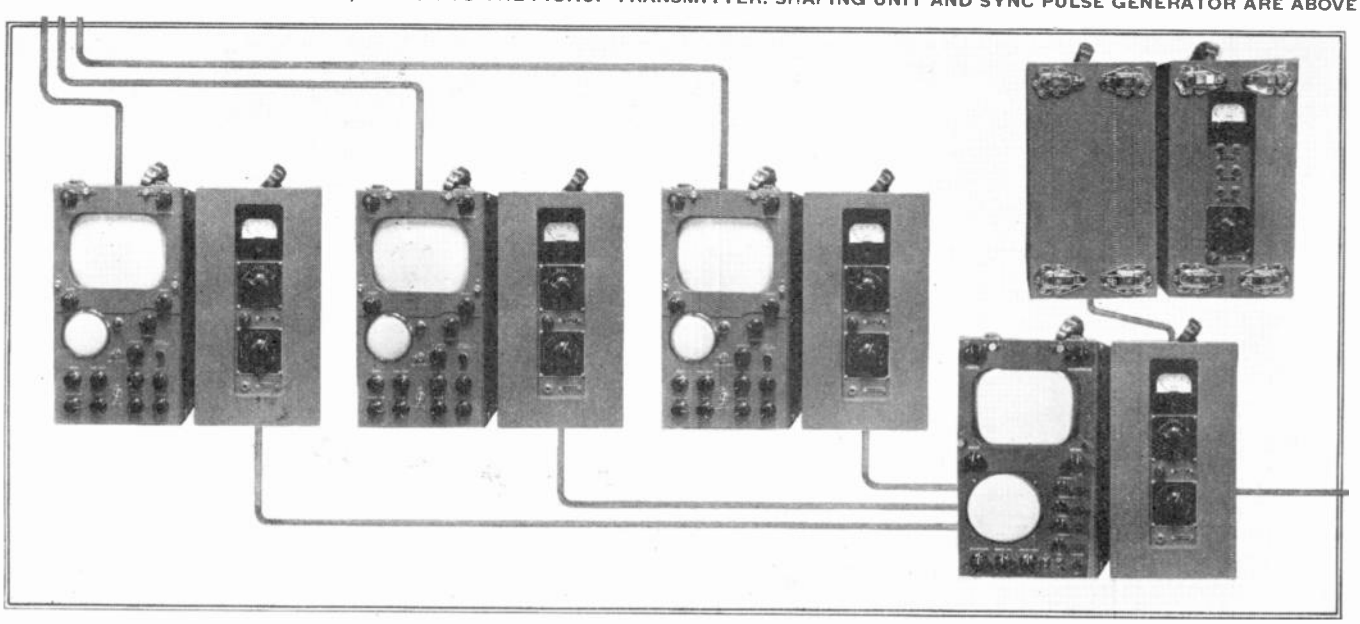
For these reasons it was decided to break the apparatus up into a larger number of units, incorporating in each camera only those circuits necessary to the functions of the pickup tube and, of course, a signal pre-amplifier. The important camera control circuits are housed in a separate case with a monitor which permits previewing at a central location with the other camera monitors and the switching unit. This arrangement results in the most compact camera unit and provides the most flexibility from the standpoint of camera scene selection. In addition, another important advantage results. In the event of obsolescence of one or two circuits, the changes necessary to bring the equipment up to date can probably be accomplished by the addition of only one or two new units.

The RCA television field equipment consists of the following units:

Cameras—one to four, as desired
Camera Controls—one for each camera
Camera Power Supply—one for each camera
Master Monitor-Switching—one
Master Monitor Power Supply—one
Synchronizing Pulse Generator—one
Synchronizing Shaping—one
Relay Transmitter—one
Relay Transmitter Power Supply—one

All of these units are relatively small in size (approximately suitcase size) except for the transmitter. They are light enough to be carried without difficulty and the whole group will go easily into a station wagon. At the scene of pickup, they are easily set up and connected by means of interconnecting cables supplied as part of the equipment. Ordinarily, the cameras are set up close to the scene of action, and the camera control units, synchronizing generator and master monitor are grouped at a central location where the scene selection is accomplished by the program director. In some instances, of course, the equipment can be as much as 500 ft. away. The antenna is mounted on a high pole or building in order to provide line of sight transmission, and the relay transmitter is generally located near the antenna so that the transmission line can be kept short. A relay receiver, intended for

FIG. 2. A CAMERA CONTROL AND POWER SUPPLY IS REQUIRED FOR EACH CAMERA. THESE FEED INTO THE MASTER CONTROL, SHOWN BELOW WITH ITS POWER SUPPLY, AND ON TO THE PICKUP TRANSMITTER. SHAPING UNIT AND SYNC PULSE GENERATOR ARE ABOVE

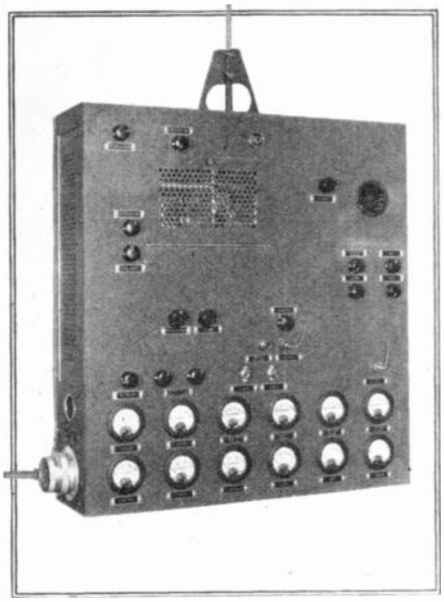


use with this equipment, is designed for standard rack mounting.

Where a single camera is used, only six units (not counting camera) are required. These are the camera control and its power supply, the two synchronizing units, and the relay transmitter and its power supply. The arrangement of these units is illustrated in Fig. 1. When more cameras are used, additional camera control units and a master control unit for mixing and switching are required. Thus a three-camera layout requires three camera control units, each with power supply; a master monitor unit with power supply; the two synchronizing units; and, of course, the transmitter and its power supply. An idea of such a setup is given in Fig. 2.

Camera ★ The orthicon-type pickup tube is employed because its greater sensitivity permits operation under conditions of low illumination. Lenses of various focal lengths can be used, thus permitting wide angle operation where the scene covers a large area or close-ups of distant objects, according to the desire of the program director. Lenses are quickly interchangeable. An especially important feature is the provision of an excellent view finder which permits accurate focusing by the cameraman and easy following of the action. The scene area in the view finder is greater than that in the television picture and as a result the cameraman can spot happenings of interest outside the picture area and redirect the camera to the point of most interesting action. A panning and tilting head on the standard movie tripod allows great freedom of movement in pointing the camera. As much as 500 ft.

BUTTONS ON MASTER CONTROL SELECT CAMERA OUTPUT TO BE TRANSMITTED



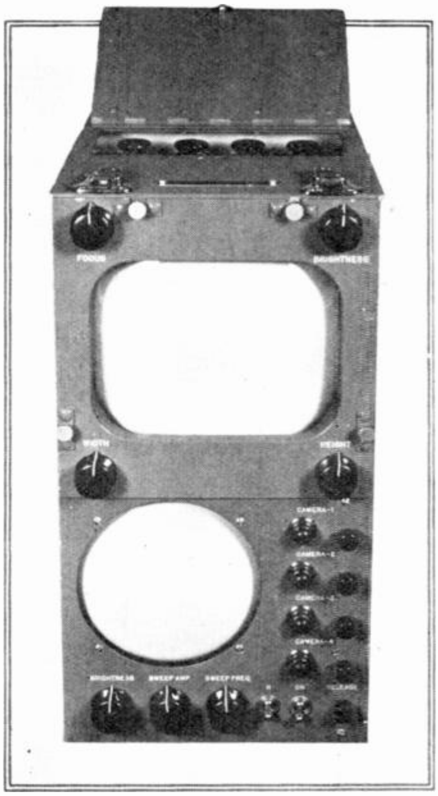


FIG. 3. CLOSE-UP OF THE MASTER CONTROL UNIT SHOWS CAMERA SELECTOR BUTTONS

separation is possible between the centrally located camera control unit and the camera. For example, the camera can be located on the sideline of the playing field while the control-monitor units are placed at a convenient spot in the grandstand. The camera unit complete with tripod and head weighs approximately 150 lbs., but disassembles into several packages for easy carrying.

Camera Control ★ This unit contains the control circuits for the camera and incorporates a 7-in. high-quality viewing monitor as well as a 3-in. oscilloscope which allows accurate adjustment of signal level. Camera driving pulses are generated in the camera control unit and transmitted to the camera through the camera cable which, as stated above, may be as much as 500 ft. in length. A video amplifier which is incorporated in the camera control unit feeds the signal by coaxial cable to the master monitor. Both of these units are of suitcase size and are light in weight. Carrying handles are provided for convenience.

Power Supplies ★ One of these supplies is used for each camera and camera control chain and an additional one is required for the master monitor unit. The power input is 110 volts, 60 cycles, single phase. The total current drain for a camera and camera control chain is only 8.5 amperes, and therefore can be obtained from almost any standard outlet. The master monitor switching unit requires approximately 5.1 amperes. The supplies are all electronically regulated to eliminate line voltage fluctuation effects.

Master Monitor Switching ★ Included in this unit are the switching circuits, the synchronizing mixer stage, and the video line amplifier. Multiple inputs are provided so that the outputs of several camera chains can be accommodated. Push-button switches are provided for selecting the camera signal which it is desired to transmit. There is a 7-in. high-quality viewing monitor and 5-in. oscilloscope for adjusting signal level and synchronizing ratio. The output of the video line amplifier is connected by means of coaxial cable to the transmitter input. A close-up view of this unit is shown in Fig. 3.

Synchronizing Generator ★ The generator is comprised of two separate cases. The first case contains the master pulse generator. It is provided with a self-contained electronically-regulated power supply and requires an input of approximately 3 amperes. Highly stabilized oscillators are utilized in order to obtain the best possible synchronizing. The second case includes circuits for generating the blanking and synchronizing voltages from the master pulses. Power for these circuits is obtained from the self-contained power supplies in the pulse unit. It is possible for several cameras to be operated from a common synchronizing generator.

Transmitter ★ This unit was designed to provide sufficient power output to permit operation over a five to ten mile range, line of sight. Less power and consequently less range would result in an unreasonable restriction of area in which remote pickups can be made. The transmitter operates on an ultra-high frequency band which permits the employment of highly directional antennas. The band width is sufficient to permit reproduction of the finest detail in the camera picture. The video input to the transmitter is accomplished by means of a coaxial cable connected to the master monitor unit. This cable can be several hundred feet in length, thus permitting setting up the transmitter at some distance from the control equipment so that the RF transmission line to the antenna can be kept as short as possible without interfering with the line of sight transmission requirement. A diode detector is provided in order to permit monitoring the RF signal output.

Receiver ★ This is of the superheterodyne type and, like the transmitter, has wide band amplifiers so that no loss in detail is

(CONTINUED ON PAGE 60)

SPOT NEWS NOTES

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

Correction: On page 3 of our February issue, it was stated that Prof. Hubert M. Turner, 1944 president of the I.R.E., is Associate Professor of Electrical Engineering at "York" University. The University is not York but "Yale." — Our apologies to Prof. Turner and to our readers for this typographical error.

Model FM Station: One of the most interesting of the new FM applications is for a model 50-kw. installation in Washington, D. C., to be operated by the FM Development Foundation. Major E. H. Armstrong will be 50% owner, and the other 50% will be held by Jansky & Bailey, enginering consultants. It is planned to use an REL transmitter, with Western Electric speech equipment and a 420-ft. G. E. antenna. Cost of the station will be $150,000. Application calls for a class D outlet, operating on 43.9 mc., over an area of 20,000 square miles.

Les Willyard: Appointed chief engineer of Universal Microphone Company, Inglewood, Calif. He has been associated with this Company since 1931. Prior to this new appointment, he was in charge of research and test laboratories.

Not Radio: The communications system being used by the Pennsylvania Railroad on the 67-mile Belvidere-Delaware branch is not radio, as some announcements have it. Neither is it a new type of system. Actually it is a Union Switch and Signal installation using a carrier current method which is so old that if it were adequate, it could have been put to use long before this.

Established manufacturers of conventional railway signalling equipment can be expected to do everything possible to discourage railroads from attempting to use radio, and to becloud the issue of railroad radio communication. The last thing they want to see is the entrance of radio manufacturers into the railway signalling business, because it will open up competition in a field where they have had absolute patent control. This situation is so serious that no radio manufacturer wants to make the first radio installation, because the electro-mechanical signal companies will do everything possible to use it as proof that radio is unsuited to railroad applications.

Circuit Demonstrator: A complete 5-tube superheterodyne, with the components laid out on a 30 by 36-in. imprinted panel, is being offered by Lafayette Radio Corporation, 901 W. Jackson Blvd., Chicago, for use in radio instruction classes. Wires are color-coded to show separate circuits. Setup includes speaker, so that signals can be received.

San Francisco: West coast headquarters have been opened by Sylvania Electric Products, Inc. Address is 111 Sutter St. B. K. Wickstrum is in charge.

DR. O. S. DUFFENDACK OF PHILIPS

Dr. O. S. Duffendack: Formerly Professor of Physics at University of Michigan is now research director of North American Philips electronics laboratory at Irvington, N. Y., focal point of Philips expansion in the radio and electronics fields.

New Television Applications: Filed with the FCC by Havens & Martin, Inc., Richmond, Va., for Channel 3, with 3-kw. for aural and 4-kw. peak for visual transmission; Louis Wasmer, Inc., Spokane, Wash., for Channel 1; Bamberger Broadcasting Service, Inc., Washington, D. C., for Channel 4; Bamberger Broadcasting Service, Inc., Philadelphia, Channel 7.

Cambridge: New chairman of the board of General Radio Company is Harold B. Richmond. Melville Eastham has retired as president, but will continue temporarily as chief engineer. Messrs. Eastham, Locke, Richmond, Shaw, and Tucker, now treasurer and secretary, comprise the new board. Arthur E. Thiessen becomes vice president in charge of sales, and Charles E. Carey, vice president in charge of manufacturing. C. E. Hills, Jr., the commercial manager, will also serve as assistant treasurer and assistant secretary.

Expansion: Phil-American, Incorporated, peacetime manufacturers of Philharmonic radio phonographs, have moved their entire plant to 528 E. 72nd St., New York City, where they will have six times the space previously occupied. This Company is now a subsidiary of American Type Founders, Incorporated, although the mangement is still in the hands of Avery R. Fisher, president, and Victor Brociner, vice president and chief engineer.

Newcomer: In the postwar receiver field is John Meck Industries, Plymouth, Ind. Well known as producers of quartz crystals for military equipment, this firm has taken out an RCA license, and is formulating plans for building sets when peace comes.

Rochester, N. Y.: A Radio City is projected by Stromberg-Carlson Company for Rochester, to be erected as soon as conditions permit. A new building will combine facilities for FM and television studios and transmitters.

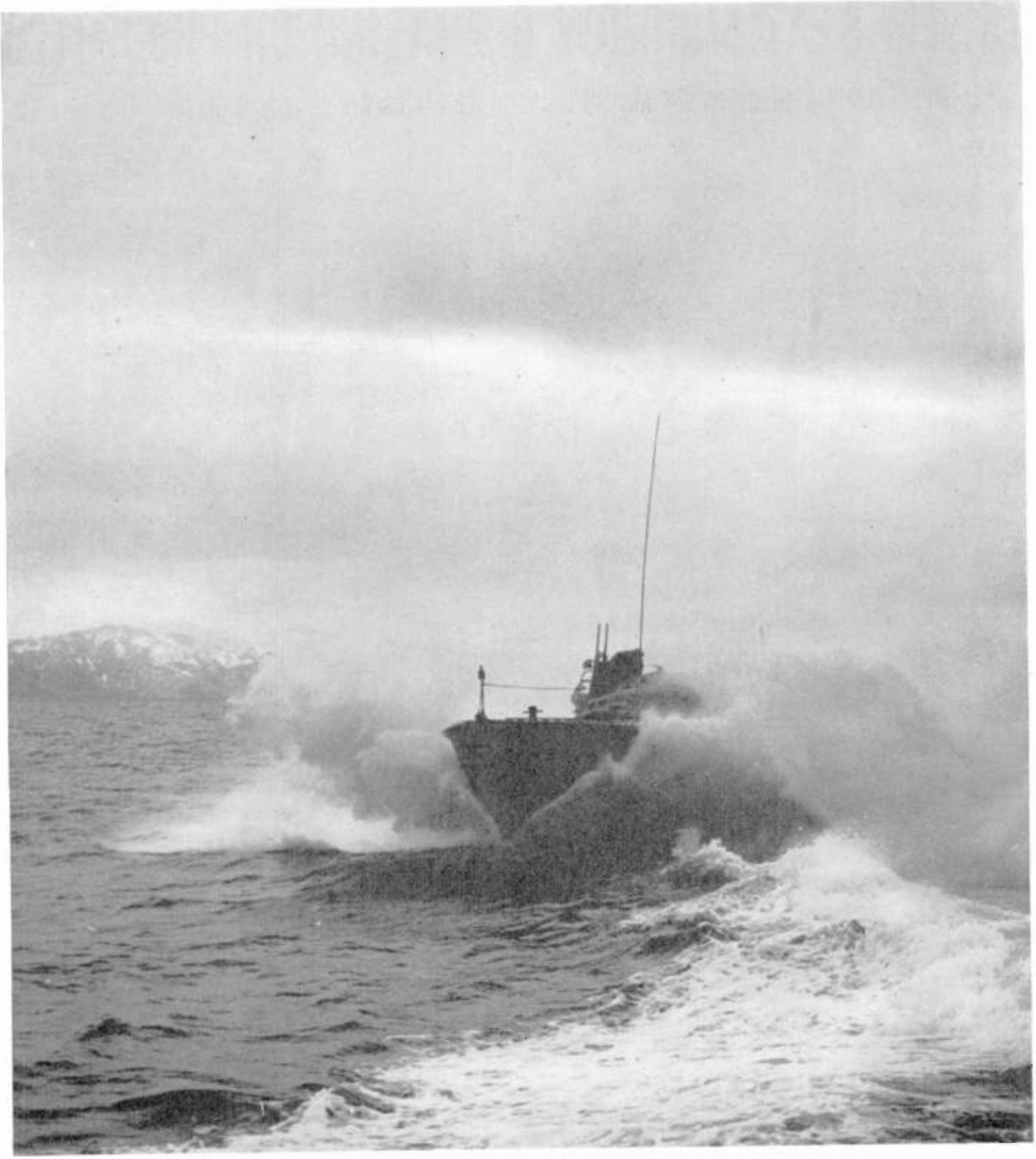
Profits: Solar Manufacturing Corporation, Bayonne, N. J. upped net profits, after taxes, from $147,000 in 1942 to $368,000 for the year 1943.

Record Attendance: Talks on television are setting attendance records at luncheon meetings in New York City. Thomas F. Joyce, manager of RCA radio, phonograph, and television department, drew the largest audience the Sales Executive Club has had in 11 years. Allen Du Mont, president of Allen B. Du Mont Laboratories, Inc., had over 500 listeners at the American Marketing Association luncheon.

Caution: If a very pleasant old fellow calls on you and introduces himself as Tom Bennet, the sourdough broadcast station operator or radio dealer from Alaska, let him have the two or three dollars he will eventually ask to borrow, if you wish, but don't waste time on him unless you like to hear some very interesting stories about the Silent North. Recently, he's been "working" in New York but he's planning to go on to Chicago. Anyway, it's not business, but just a touch.

Harvey Anhalt: Chief engineer of WGNY;

(CONTINUED ON PAGE 42)



NEWS PICTURE

ONLY the radio antenna rises above the screen of spray cast up by the low and deadly PT boat. When details instead of generalities can be written about the radio equipment on these craft, we shall have some amazing stories about one of the newest and most important developments of the art. It is easy to understand from this picture, taken in Aleutian waters, that service on the PT's taxes the dependability of radio apparatus far beyond what could be called reasonable limits. Yet it does stand up, and is one of the reasons for the effectiveness of the PT boats as a weapon of the new warfare. The credit, in this case, belongs to the equipment rather than the operator, for there is neither time nor space, when these boats are in action, to do repair and service work.

157 FM STATIONS NOW OPERATING OR PROJECTED

Call Letters Indicate Stations on the Air. 88 Cities in 31 States Are Already Represented in This List

ALABAMA

Montgomery

	Sq. Mi.	Mc.	Call
Montgomery Bcstg. Co., Inc.	17,299	43.5	

CALIFORNIA

Fresno

J. E. Rodman	24,752	44.1	

Hollywood

Columbia Bcstg. Sys., Inc.	34,000	43.1	

Los Angeles

Earle C. Anthony, Inc.	34,000	43.7	
National Bcstg. Co.		44.1	
Don Lee Bcstg. Sys.		44.5	KHJ-FM
Standard Broadcasting Co.	7,000	45.3	

San Bernardino

Sun Co. of San Bernardino	17,101	44.1	

San Francisco

Don Lee Bcstg. Sys.	18,050	43.5	
National Bcstg. Co.		43.9	
Board of Education			KLAW

COLORADO

Denver

Kiz Broadcasting Co.	31,400	43.5	
National Bcstg. Co.		43.9	

CONNECTICUT

Hartford

Travelers Bcstg. Service		45.3	WTIC-FM
WDRC, Inc.		46.5	WDRC-FM

DELAWARE

Wilmington

WDEL, Inc.	6,400	44.5	

DISTRICT OF COLUMBIA

Washington

National Broadcasting Co.		44.3	
Capital Broadcasting Co.		46.7	
Evening Star Bcstg. Co.	5,600	47.1	
Jansky & Bailey (Experimental)			W3XO

GEORGIA

Atlanta

Constitution Pub. Co.	7,380	45.3	

ILLINOIS

Chicago

WJJD, Inc.	10,800	44.7	
Zenith Radio Corp.		45.1	WWZR
WGN, Inc.		45.9	WGNB
National Bcstg. Co., Inc.	10,800	46.3	
Columbia Bcstg. System		46.7	WBBM-FM
Moody Bible Institute		47.5	WDLM
Chicago Fed. of Labor	10,800	47.9	
Oak Park Realty & Am. Co.	10,800	47.9	
Board of Education			WBEZ

Decatur

Commodore Bcstg. Co.	8,050	46.9	

Quincy

Illinois Bcstg. Co.	15,400	44.1	

Rockford

Rockford Broadcasters Inc.	6,000	45.1	

Rock Island

Rock Island Bcstg. Co.	3,000	44.5	

Springfield

Commodore Bcstg. Inc.	8,050	46.9	

Urbana

Board of Educatoin			WIUC

INDIANA

Evansville

Evansville on the Air		44.5	WMLL

Fort Wayne

Westinghouse Radio Stations, Inc.		44.9	WOWO-FM

Indianapolis

	Sq. Mi.	Mc.	Call
Indianapolis Bcstg., Inc.	13,640	45.3	
WFBM, Inc.		47.7	
Capitol Broadcasting Corp.	14,120	48.7	

South Bend

South Bend Tribune		47.1	WSBF

IOWA

Cedar Rapids

The Gazette Co.	7,400	44.7	

Dubuque

Telegraph Herald	8,060	46.5	

KENTUCKY

Ashland

Ashland Bcstg. Co.	4,160	46.1	WBKY

Beattyville

University of Kentucky			WBKY

Lexington

Amer. Bcstg. Corp. of Ky.	6,300	45.1	

Lousiville

Courier-Journal & Louisville Times Co.	13,200	45.7	

LOUISIANA

Baton Rouge

Baton Rouge Bcstg. Co.		44.5	WBRL

MAINE

Portland

Portland Bcstg. Sys., Inc.	3,980	47.1	

MARYLAND

Baltimore

Baltimore Radio Show, Inc.	5,500	45.9	
Monumental Radio Co.	4,520	47.9	
Maryland Bcstg. Co.	2,904	48.9	

MASSACHUSETTS

Boston

Columbia Bcstg. Sys., Inc.	20,200	43.5	
Yankee Network		44.3	WGTR
Westinghouse Radio Stations, Inc.		46.7	WBZ-FM
Matheson Radio Co., Inc.	3,600	47.7	

Lawrence

Hildreth & Rogers Co.	2,970	44.9	

New Bedford

E. Anthony & Sons, Inc.	1,787	45.7	

Pittsfield

Monroe B. England (WBRK)	18,100	45.7	

Springfield

Westinghouse Radio Stations, Inc.		48.1	WBZA-FM

Worcester

Worcester Telegram Pub. Co. (Exp.)			W1XTG

MICHIGAN

Battle Creek

Federated Publications, Inc.	4,100	48.1	

Dearborn

Herman Radner		49.5	

Detroit

Evening News Association		44.5	WENA
John Lord Booth		44.9	WLOU
WJR, The Goodwill Station	6,800	45.3	
James F. Hopkins, Inc.	6,790	46.5	
King-Trendle Bcstg. Corp.	6,570	47.3	

Grand Rapids

King-Trendle Bcstg. Corp.	5,300	46.9	

Jackson

WIBM, Inc.		49.5	

Lansing

WJIM, Inc.	3,800	47.7	

Muskegon

	Sq. Mi.	Mc.	Call
Ashbacker Radio Corp.	2,290	45.7	

Port Huron

Times Herald Co.	5,600	47.7	

MISSOURI

Kansas City

Commercial Radio Equip. Co.		44.9	KOZY
Midland Bcstg. Co.			W9XER

St. Louis

St. Louis University	13,500	44.3	
Globe-Democrat Pub. Co.	15,083	44.7	
Star-Times Pub. Co.	12,480	44.7	
Pulitzer Pub. Co.	13,391	45.5	
Columbia Bcstg. Sys., Inc.	13,400	45.9	

NEBRASKA

Omaha

World Publishing Co.	11,660	45.4	

NEW HAMPSHIRE

Manchester

Radio Voice of N. H., Inc.	31,630	43.5	

Mt. Washington

Yankee Network		43.9	WMTW

NEW JERSEY

Newark

New Jersey Bcstg. Corp.	6,200	49.1	

Paterson

North Jersey Bcstr. Co., Inc.	4,928	49.9	

Trenton

Mercer Bcstg. Co.	3,200	49.9	

NEW YORK

Albany

WOKO, Inc.	7,164	45.1	

Binghamton

Wylie B. Jones Advt. Agency		44.9	WNBF-FM

Brooklyn

Frequency Bcstg. Corp.	14,400	43.7	

New York

Edwin H. Armstrong (Exp.)		43.1	W2XMN
Municipal Bcstg. Sys.		43.9	WNYC-FM
Muzak Corporation		44.7	WGYN
Natl. Bcstg. Co., Inc.		45.1	W2XWG
W. G. H. Finch		45.5	
Interstate Bcstg. Co.		45.9	WQWQ
Marcus Loew Booking Agency		46.3	WHNF
Columbia Bcstg. Sys.		46.7	WABC-FM
Bamberger Bcstg. Service		47.1	WBAM
Metropolitan Television, Inc.		47.5	WABF
American Network, Inc.	8,840	47.9	
Blue Network, Inc.	8,950	47.9	
News Syndicate Co., Inc.	8,500	47.0	
WBNX Bcstg. Co., Inc.	8,730	48.3	
WMCA, Inc.	8,550	48.3	
Debs Mem. Radio Fund, Inc.	8,600	48.7	
Greater N. Y. Bcstg. Corp.	8,500	48.7	
Board of Education			WNYE

Rochester

WHEC, Inc.		44.7	WHEF
Stromberg-Carlson Tel. Co.		45.1	WHFM

Schenectady

Capitol Broadcasting Co.		44.7	WBCA
General Electric Co.		48.5	WGFM

Syracuse

Central N. Y. Bcstg. Corp.	6,800	46.3	

White Plains

Westchester Bcstg. Co.	435	49.9	

NORTH CAROLINA

Durham

Durham Radio Corp.			

Licensee	Population	Freq.	Call
Winston-Salem			
Gordon Gray	......	44.1	WMIT
Piedmont Pub. Co.	4,600	46.7	
OHIO			
Ashtabula			
WICA, Inc.	4,116	48.9	
Cincinnati			
Crosley Corp. (Exp.)	......	....	W8XFM
Cleveland			
National Bcstg. Co.	......	43.7	
WGAR Bcstg. Co.	8,500	45.5	
United Bcstg. Co.	8,420	48.5	
Board of Education	......	....	WBOE
Columbus			
WBNS, Inc.	......	44.5	WELD
Steubenville			
Valley Bcstg. Co.	......	....	
OKLAHOMA			
Oklahoma City			
WKY Radiophone Co.	21,000	44.5	
Plaza Court Bcstg. Co.	15,394	....	
PENNSYLVANIA			
Easton			
Associated Bcsters. Inc.	2,800	48.5	
Harrisburg			
Keystone Bcstg. Corp.	4,000	44.7	
Lancaster			
WGAL, Inc.	1,200	45.4	
Philadelphia			
Pennsylvania Bcstg. Co.	......	44.9	WIP-FM
WFIL Bcstg. Co.	......	45.3	WFIL-FM
Westinghouse Radio Stations, Inc.	......	45.7	KYW-FM
Gibraltar Service Corp.	9,318	46.1	
WCAU Bcstg. Co.	......	46.9	WCAU-FM
William Penn Bcstg. Co.	......	47.3	WPEN-FM
WDAS Bcstg. Station, Inc.	9,300	47.7	
Pittsburgh			
Walker-Downing Corp.	......	44.7	WTNT
Pittsburgh Radio Supply House	8,400	46.5	
Westinghouse Radio Stations, Inc.	......	47.5	KDKA-FM
Liberty Bcstg. Co.	......	....	
Reading			
Hawley Bcstg. Co.	4,275	46.5	
Wilkes-Barre			
Louis G. Baltimore (WBRE)	......	....	
York			
Susquehanna Bcstg. Co.	3,060	44.5	
York Bcstg. Co.	1,550	45.1	
RHODE ISLAND			
Providence			
Cherry & Webb Bcstg. Co.	6,207	47.5	
Outlet Co.	7,520	48.5	
SOUTH CAROLINA			
Spartanburg			
Spartanburg Advt. Co.	26,600	43.5	
TENNESSEE			
Nashville			
National Life & Accident Ins. Co.	..	44.7	WSM-FM
Nashville Radio Corp.	16,000	46.5	
TEXAS			
Amarillo			
Amarillo Bcstg. Corp.	5,600	45.1	
Beaumont			
Kric, Inc.	6,650	43.1	
Houston			
Houston Ptg. Corp.	10,500	46.5	
San Antonio			
Southland Industries, Inc.	16,500	44.5	
VIRGINIA			
Richmond			
Havens & Martin, Inc.	12,130	46.1	
WISCONSIN			
Green Bay			
Green Bay Newspaper Co.	......	....	
Milwaukee			
The Journal Co.	......	45.4	WMFM
Superior			
Head of the Lakes Bcstg. Co. (Exp.)	......	....	W9XYH

(CONTINUED FROM PAGE 19)

first FM link of all is the installation that the Yankee Network has been using since July, 1939 to beam programs from their Boston studio to the Paxton FM transmitter, a distance of 43 miles, airline.

It is unfortunate that military requirements limited the effort that could be put on the solution of new problems introduced by FM broadcasting even before the freeze order stopped this work completely. On the other hand, many of the answers will be available when or soon after the War is over, as the result of military research and development work.

CAPT. J. C. GEIST, L., WITH PIONEER TRIO OF MILITARY FM: FRED BUDELMAN, COL. GRANT A. WILLIAMS, CHIEF SIGNAL OFFICER OF THE 1ST ARMY, AND FRED M. LINK

FM PROVES "DISTINCTLY SUPERIOR" AT WAR

LONG before the first expeditionary forces left the United States, Grant A. Williams, then a Captain in the U. S. Army, championed the use of FM for tank communications, and the first FM equipment bought for this purpose was designed and built by Fred M. Link and his chief engineer, Fred Budelman.

Since then, under battle conditions on all fronts, FM equipment has won its spurs in the service of the Armored Forces, the Artillery, and in many other applications about which we may hear little until after the War is over.

Meanwhile, FM's champion has become Colonel Williams, Chief Signal Officer of the 1st Army. He is now responsible for the system of communications which will be used when our forces cross the English Channel.

While he was in the United States on a brief trip, we were able to get first-hand answers to such questions as we were permitted to ask.

The most spectacular success of FM communications, according to Col. Williams, has been in amphibious operations. "For this purpose," he said, "FM equipment is the best obtainable." This applies particularly to its dependability of performance under these most punishing service conditions.

Commenting on reports circulated here that FM did not give a good account of itself in Sicily, Col. Williams said that any such reports were untrue. "The fact is that FM performance has exceeded the specifications of Military Requirements."

Concerning criticism of the use of FM instead of AM for tanks, thus making it impossible to communicate with AM-equipped planes, he said that the difference in frequency assignments, not types of equipment, was responsible for this. In other words, if planes and tanks both used AM or both used FM, they still would not be able to talk to each other, and it was never planned that they would.

FM handy-talkies have now been in service for a sufficient length of time to establish their vast superiority over the AM designs they have replaced. They afford greater certainty of communication, as well as a "very much longer" range.

"In short," Col. Williams said, "the more we use FM, the more uses we find for it. Wherever FM and AM equipments are used for the same purpose, FM proves distinctly superior."

THE HISTORY OF FREQUENCY MODULATION

Major Armstrong's Testimony Before the Senate Interstate Commerce Committee Covers Points That Some Have Forgotten and That Many Don't Know

On December 6, 1943, Major Edwin H. Armstrong appeared before the Senate Interstate Commerce Committee which, under the chairmanship of Senator Burton K. Wheeler, was charged with investigating the need for new legislation to amend the Communications Act of 1934.

Taking part in this hearing, in addition to the Chairman, were Senators White, McFarland, Moore, and Hawkes. After the customary preliminaries, Major Armstrong was asked:

The Chairman: You might give us, briefly, your experience in connection with the radio art.

Dr. Armstrong: My experience in the radio art began in 1906, and my connection with it has been continuous since that date.

I am the inventor of the regenerative circuit, the superheterodyne method of reception, the super-regenerative circuit, and the method of eliminating disturbances in radio signaling which has become known as Frequency Modulation, or FM.

For the sake of the record, I would like to say that the regenerative circuit invention, which was made in 1912, revolutionized the then existing means of radio communication and made possible overseas reception and radio broadcasting.

The superheterodyne principle is used in practically all receivers manufactured today.

The super-regenerative circuit is widely used in portable equipment and has been used extensively in military applications in the present war.

The FM system is also being used by the Armed Forces of the United States. Since March of 1941 I have waived all royalty payments under my patents for apparatus manufactured for this use, and this waiver continues for the duration of the war.

I am the recipient of the Medal of Honor of the Institute of Radio Engineers, the Holley Medal of the American Society of Mechanical Engineers, one of the National Modern Pioneer Awards on the occasion of the one hundred and fiftieth anniversary of the American Patent System, the Franklin Medal of the Franklin Institute, the Egleston Medal from Columbia University, the John Scott Medal awarded by the Board of City Trusts, City of Philadelphia; and the Edison Medal of the American Institute of Electrical Engineers. These awards I have listed only because there exists a difference of opinion between the scientific world and the courts on a matter which may come up during the course of this hearing.

I served overseas in the Signal Corps of the A.E.F. from 1917 to 1919. With that exception, I have been continuously engaged in radio work in the Hartley Research Laboratory at Columbia University, where I am at present professor of electrical engineering.

It is my understanding that this committee is particularly interested, insofar as I am concerned, in any information which I have that bears upon the effects that the FM system may have upon postwar broadcasting and communications. There is not the shadow of a doubt but that the effect will be a revolutionary one. It has already been so, particularly in the field of broadcasting.

It seems to me, Mr. Chairman, that perhaps the best way to convey a picture of what is about to happen is to tell you something about the past history of this invention and explain how it has developed. There is, I believe, a lesson which is of great importance to the future development of the art. But I will, of course, proceed in any way which the committee would like to have me do.

The Chairman: We wanted you to go ahead and explain something about the engineering problems of FM, and any other problems of the radio art you may see fit to talk about. In other words, some of us want to get a little education as we go along.

Dr. Armstrong: Well, Mr. Chairman, I will do my best to try to make clear a complex technical principle, and I will try to forecast as best I may what the effect of the invention and the system popularly known as FM may have on the future of the broadcasting and communications art.

I suppose in order to make clear what the FM principle is, I will have to go back quite a ways in the history of radio. Along about 1914, after the invention of the regenerating circuit, which revolutionized the radio art at that time, the problem of static interference became the great problem of the radio art. Practically everyone in the engineering part of radio undertook to try to solve it. The results were unsuccessful, and for a great many years the reason for the failure was unknown. Eventually it was understood that the reason static could not be filtered out from the radio waves was because static was practically identical in nature with the waves that we were using in trying to communicate with them.

Around 1924 the problem was practically given up as an insoluble one. I had started to work on this problem in 1914, and along about 1924, after I too had concluded it was an insoluble problem, I got an idea which led me into a line of research which resulted in the discovery of a new principle. That principle was that the way to overcome the effects of static was to produce a kind of wave which was different in character from the kind of wave which static disturbance could produce. But the way it was done was by the use of a method of modulation which was very old in the art.

This method of modulation dates back to the time when I was a student at Columbia University, but by using it in a new system and in a particular way, it became possible to generate a wave which was different from the static disturbance, and to make a receiver which was immune or refused to respond to waves of the ordinary kind, or to those waves produced by static, and which was responsive only to the new type of wave. Now that system has become known as Frequency Modulation or, for short, FM.

Compared to the existing system, or the system which was in use at the time this discovery was made, the static disturbances are reduced in power by an order of 500 to 1,000 times. I do not hesitate to say that that is beyond the wildest dreams of any inventor, to ever have had the good fortune to run into a discovery of that kind.

Around 1933 I had succeeded in setting up in my laboratory a complete demonstration of the system, with measuring equipment, to demonstrate the noise-reducing capabilities of the system.

Toward the end of 1933 this invention was brought to the attention of the executives and engineering department of the Radio Corporation of America. At that time no one credited any static eliminator which was demonstrated only in the laboratory, from one room to another. So the equipment was moved in the spring of 1934 to a station owned by the National

Broadcasting Company, and located on the top of the Empire State Building in New York City. It was a relatively low power television station which was then not in operation, and I modified it to work as a frequency modulation system.

The original tests of the system were made in June 1934 over a distance of 70 miles. The results showed that, during periods of heavy static, a transmitter operating on power of only 2 kilowatts was capable of outworking a 50-kilowatt standard broadcasting station.

For a period of about a year, I continued the demonstrations but was unable to persuade the Radio Corporation of America to take the next step, which was to build a high-power transmitter which would give a strong enough signal to wipe out the bad spots which occur in the broadcasting of ultrahigh frequency waves. I should like to add here that in the long series of tests which were conducted by the Radio Corporation of America, there were found certain bad spots in the coverage pattern, and the logical next step to overcome this difficulty was the erection of a higher power transmitter.

In the end of April 1935 I decided that I would have to take the job myself of erecting a high-power station, and I wrote to the Radio Corporation of America's manufacturing department asking them to give me a quotation on some power equipment. One week later the Radio Corporation of America announced that it was starting a series of field tests of television; that a million dollars would be spent toward putting television into use.

Now, from that point the story that the committee will be particularly interested in really begins.

SENATOR MOORE: When did you say the announcement was made that experiments with television would be made by the Radio Corporation of America?

DR. ARMSTRONG: May 6, 1935, at the annual meeting of the corporation's stockholders.

THE CHAIRMAN: When was your experiment completed, or substantially completed, with reference to FM?

DR. ARMSTRONG: With respect to demonstrating it for the Radio Corporation of America?

THE CHAIRMAN: Yes.

DR. ARMSTRONG: The equipment was left there until October of 1935. I turned the equipment over to their engineers to run further tests on it themselves.

THE CHAIRMAN: Why was it that FM was never adopted?

DR. ARMSTRONG: I believe there were two reasons, Senator Wheeler: 1) That the technical advantages of this system were underestimated at the time; and 2) That perhaps it meant too many new stations on new networks. As to which of these two reasons was controlling, I do not know at the present time.

In November 1935 I read a paper before the Institute of Radio Engineers and explained fully the capabilities of this system. No one questioned, either at that time or since, any of the statements which I made.

Toward the end of the year —

FM CAME UP THE HARD WAY

MAJOR ARMSTRONG'S story of his invention of Frequency Modulation, as told in the U. S. Senate records, is an inspiration to the thousands of pioneering spirits who have carried the radio art to its high level of achievement for peace and war in the United States.

As Major Armstrong told the Senators: "It isn't ignorance that causes the trouble in this world; it's the things that folks know that ain't so." That has been, indeed, FM's greatest stumbling block.

This testimony reviews the early efforts to eliminate static; the final acceptance of the static problem, in the 1920's, as being insoluble; the Major's discovery of a method by which static was reduced in power to an extent beyond the dreams of those who had quit trying; of newspaper accounts which acknowledged that reception from the 2kw. FM station he built from an NBC television transmitter on the Empire State Building was superior at 85 miles to reception from 50-kw. AM stations, yet "Major Armstrong's new system is utterly impractical — and the quest for static elimination must go on."

Fortunately, that quest did go on. When the assistant chief engineer of the FCC refused Major Armstrong's request for permission to build a high-power FM station, he still persisted, and a construction permit was finally granted. The station was built and its performance confirmed Major Armstrong's theoretical conclusions.

The story of the fight to overcome the obstacles of opposition and indifference to the advantages of FM, as disclosed in this testimony, is a fascinating story, and supplies background to the plans now being made for the postwar expansion of FM broadcasting.

The testimony published here is taken from the 1022-page record of "Hearings before the Committee on Interstate Commerce, United States Senate, Seventy-Eighth Congress, First Session, on S. 814, a Bill to Amend the Communications Act of 1934, and for Other Purposes."

THE CHAIRMAN: What year was that?

DR. ARMSTRONG: That was in 1935, in November of that year, Mr. Chairman. I might say here that the principal objection which was raised against the system was that it could not work through the man-made electrical disturbances, such as automobile ignition, or the great variety of noises which we have in cities, electrical machinery, power lines, or the like. The obvious answer to any of those criticisms was to build a high-power station and then demonstrate that the criticism was unfounded.

When I approached the Commission, which I did informally through an interview with the assistant chief engineer, he informed me that he was not satisfied I had done anything in the public interest that would warrant the granting of a license. Not even though I was spending my own money to demonstrate this principle. He suggested that I build a 1-kilowatt low-power FM transmitter and compare it with an AM transmitter. In other words, do exactly the same thing which I had already been doing for the past 2 years.

THE CHAIRMAN: Who was that?

DR. ARMSTRONG: Mr. Andrew Ring, who was then assistant chief engineer of the Federal Communications Commission.

THE CHAIRMAN: You may proceed with your statement.

DR. ARMSTRONG: About the same time also there appeared in the Boston papers an interview with Mr. Ring labeling this invention a visionary dream. I can supply the committee with a copy of the articles as they appeared in the press, such as the Boston Globe and the Christian Science Monitor, they being the two papers I saw.

SENATOR MCFARLAND: What was the substance of that interview? I did not catch what you said.

DR. ARMSTRONG: The interview was given by Mr. Ring to one of the editors of Broadcast magazine, who syndicated it through the press. How many other newspapers carried it I do not know, sir, but I did get copies of the Boston Globe and the Christian Science Monitor.

SENATOR MCFARLAND: What was the substance of the interview?

DR. ARMSTRONG: I will look it up.

THE CHAIRMAN: You can put it in the record later on if you do not have those clippings at hand.

DR. ARMSTRONG: I am sorry. I thought I had them right here.

THE CHAIRMAN: You can furnish them to the clerk of the committee later on to be inserted in the record.

DR. ARMSTRONG: The substance of the interview was that it was an impractical invention; that the receivers required too many tubes; that it would have to work in the ultra-high frequency range, and that that had not been made commercially possible by the Commission; and, in general, if it was of any interest it was years away.

THE CHAIRMAN: When was it that you gave a demonstration at Senator White's home which I attended?

DR. ARMSTRONG: I would say about February 1940, Mr. Chairman.

SENATOR MCFARLAND: What became of Mr. Ring?

DR. ARMSTRONG: Mr. Ring has not

been with the Commission for several years. I believe he is in private consulting practice, engineering FM stations.

SENATOR MCFARLAND: That is rather surprising, Mr. Chairman, in view of the last answer by the witness I think the interview will be of especial interest to the members of this committee.

THE CHAIRMAN: Very well. It will be furnished by Dr. Armstrong when he can get opportunity to find them.

DR. ARMSTRONG: I will be glad to do that.

* * * * *

Mr. Ring's interview, afterward furnished by Dr. Armstrong, is as follows:

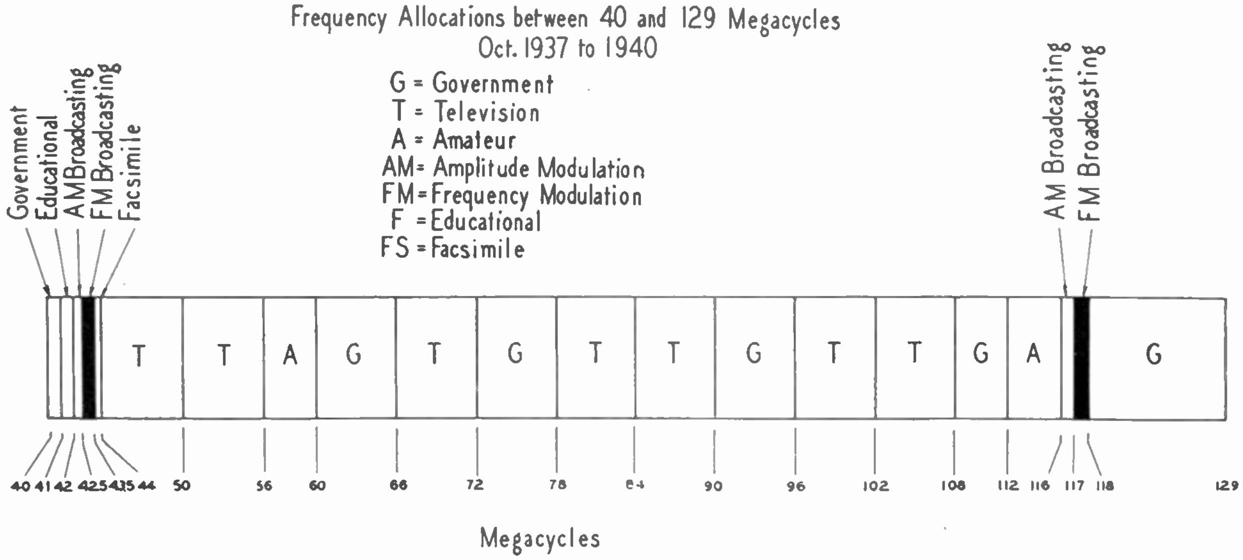


FIG. 1. FREQUENCY ASSIGNMENTS AS ESTABLISHED BY THE FEDERAL COMMUNICATIONS COMMISSION, OCTOBER, 1937 TO MAY, 1940

(*From the Christian Science Monitor, November 18, 1935*)

FINAL USE OF ULTRA-SHORT WAVES FOR STATICLESS RADIO FORECAST

A staticless era under ultra-short wave program radiocasting is foreseen by Andrew D. Ring, chief broadcast engineer of the Federal Communications Commission, after having viewed the new staticless transmitting system developed by Major Edwin H. Armstrong of Columbia University. Major Armstrong was the inventor of the super-generative circuit which is employed by most radio amateurs in 5 meters.

If the time comes when ultra-short waves are used for program radiocasting, Major Armstrong's new staticless circuit will become of value. (Ultra-short waves are those below 10 meters.) The new circuit, however, is impracticable today on the present 200–500-meter radiocasting band. It is obvious, however, that the crowded condition of the radiocast channels may one day cause entrance of radiocasters into the ultra-shorts where there will be room for many more hundreds of radio stations than there are at the moment on medium waves.

FREQUENCY MODULATION

Major Armstrong's new system, which employs frequency modulation, is too complex for the final answer, according to Mr. Ring, who sees two obstacles in the way of this new radio circuit which he calls "a visionary development years in advance of broadcasting's capacity to utilize it."

First, it requires a 200-kilocycle path of frequencies for the transmission of its interference-free and noise-free signals — and such wide avenues of the ether are simply not available today except among the plentiful ultra-short waves which are still labeled "experimental." Second, in its present stage of development it requires a receiving set employing 75 tubes which is out of the question as a commercial and marketable possibility.

Major Armstrong has been experimenting with his new system from the R.C.A. experimental ultra-short-wave station atop the Empire State Building and he demonstrated quite satisfactorily how he transmitted high fidelity voice and music for distances up to 85 miles with low power and without a trace of the buzzing and frying sounds that are characteristic of lightning and other atmospheric interference. Indeed, the reception with his system was more satisfactory than that from 50,000-watt stations over the same distance. Hitherto it has been assumed that high power is the only way to override static — and the trend in radiocasting today is toward higher and higher powers.

While those familiar with radio circuits have not been able to get intelligible descriptions of Major Armstrong's staticless circuit, the *Monitor* is indebted to Martin Codel, Washington radio writer, for a very clear description of the method the Major employs.

"Stripped of its technical ramifications," Mr. Codel says, "the system employs, a multiplicity of so-called 'carrier waves' — the tracks along which radio impulses are conveyed — in lieu of the present single carrier wave. Assume that radio sounds are comparable to a high-speed train, traveling along a monorail (single carrier wave). Then liken the 'modulation' of the carrier wave (i.e., the super imposition of sound amplitudes on it) to the right-of-way of the railroad."

OVER WIDER PATH

"The Armstrong system," Mr. Codel concludes, "While utilizing only one carrier wave, spreads this carrier during modulation over a right-of-way of 200 kilocycles. The result is a dissipation of the sound over a wider path and its transmission and reception with much greater clarity. That this is achieved by Armstrong is entirely admitted by radio engineers."

(*From the Boston Sunday Globe, November 17, 1935*)

INVENTS RADIO WITHOUT STATIC

If and when the ultra-short waves are adopted for program broadcasting, which will mean a plenitude of wave lengths for thousands of local stations as against 96 channels on which about 800 North American stations are now crowded, the new "staticless" transmitting system developed by Prof. Edwin H. Armstrong, of Columbia University, will provide a revolutionary new departure in radio. Under the present system of broadcasting on the intermediate waves between 550 and 1,500 kilocycles, Major Armstrong's new system is utterly impracticable — and the quest for static elimination must go on.

This is the conclusion of Andrew D. Ring, chief broadcasting engineer of the Federal Communications Commission, who saw the demonstration of Major Armstrong's new "frequency modulation" system before the Institute of Radio Engineers in New York last week. Though he pays high tribute to Major Armstrong's inventive genius, already demonstrated by his invention (during the war) of the superheterodyne circuit that makes modern radios so highly selective and sensitive, Mr. Ring sees two big obstacles in the way of "frequency modulation," which he calls a visionary development many years in advance of broadcasting's capacity to utilize it.

In the first place, it requires a 200-kilocycle path of frequencies for the transmission of its interference-free and noise-free signals — and such wide avenues of ether are simply not available today except among the plentiful ultra-short waves which are still labeled ex-

IN audio EQUIPMENT

FOR AM, FM, SHORT-WAVE AND TELEVISION

The RCA 44-BX Velocity Microphone and the 77-C Unidirectional Microphone—the finest in quality and the most widely used of all microphones.

The RCA 70-C Transcription Turn-table, most popular everywhere, one or more in every broadcast station—equipped with universal pickup head.

The RCA 64-B Monitoring Loudspeaker, widest frequency response and widest angle of high-frequency response of any standard model speaker.

IN studio speech input equipment RCA has led the field for the past ten years—in recent years by a wide margin.

RCA studio equipment predominates in the studios of all major networks and in a large proportion of the outstanding station installations—large and small.

All of the RCA studio equipment, and all of the RCA broadcast transmitting equipment, sold in the last ten years was designed from scratch by RCA engineers and built exclusively in RCA plants.

RCA experience in broadcast equipment—studio and transmitting—is unequaled.

And note especially—

All of the RCA studio equipment models current at the beginning of the war were designed for the wide response and high standards of FM broadcasting.

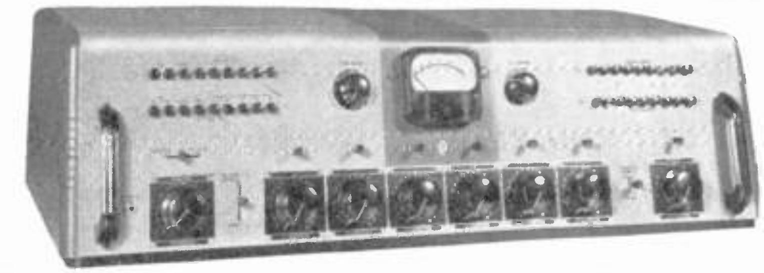
A number of commercially licensed FM stations *on the air today* are 100% RCA-equipped—from microphone to antenna.

RCA

RCA BROADCAST EQUIPMENT

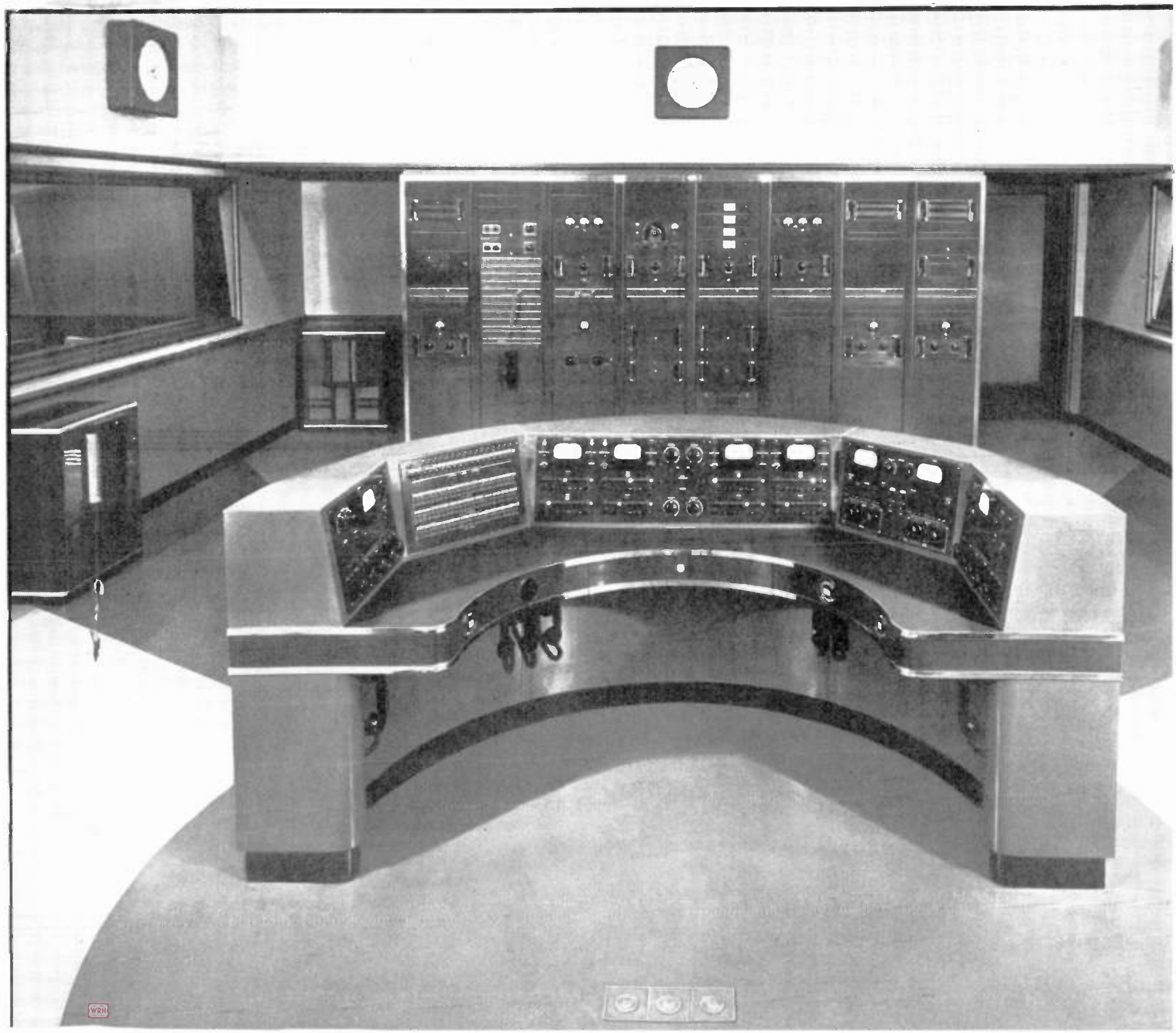
RADIO CORPORATION OF AMERICA

BUY WAR BONDS



● The RCA 76-B2 Consolette, finest, most complete studio equipment of its type. Handles two studios and announce booth. Quality equal to custom-built installations.

(BELOW) Master control room of WFBR, Baltimore. RCA custom-built studio equipments, such as that shown here, are unapproached either in utility, convenience or performance. They are made up to suit the requirements of the individual station exactly—and yet, because they are assembled largely from standard units, they often cost no more than much inferior and decidedly less convenient equipments. All RCA units such as amplifiers, racks and control panel are, of course, also available separately.



scores of lectures throughout the country, and gradually converted a large number of broadcasters to a belief that the FM system was the system of the future.

Now, those converts were not the major chains. They were the men who had small stations, who never could hope to get into the front row of broadcasting, as it were, with a 50-kilowatt station. But they were willing to go into this new development where they could get a seat in the front row.

About 150 applications had been filed in the beginning of 1940, when there was a hearing before the Communications Commission, set for mid-January of that year, to consider making permanent the television assignments shown in the chart and to make television commercial.

nel as could be sold, to block up the logical place for FM to expand.

At the hearing in March 1940 — well, I want to add just one thing before I go into the March 1940 hearing. Television had been given a limited commercial status by an order of the Commission some 6 months prior to the time I am now talking about. That order was withdrawn when it became apparent that there was an attempt being made to fill up the No. 1 television channel with receivers, so that no change in the allocation could be made without working hardship on purchasers of those receivers.

Now, getting back to the March 1940 hearing, the facts of the case and the needs of FM for greater channel space, was presented to the Commission, and as a

The Chairman: When Mr. Ring left the Commission didn't he go with the General Electric Company?

Dr. Armstrong: I believe Mr. Ring is in private consulting practice. I believe that he formerly was with the General Electric Co., Mr. Chairman.

The Chairman: You may resume your statement.

Dr. Armstrong: At this point I want to make this statement, that I have heard the chairman of the Commission has been accused of holding up FM. At this point he certainly did not hold up FM. Another chairman might well have done so, but at this point Mr. Fly gave FM its greatest boost. Later on regulations by the Commission did hold up FM, and they are still doing so.

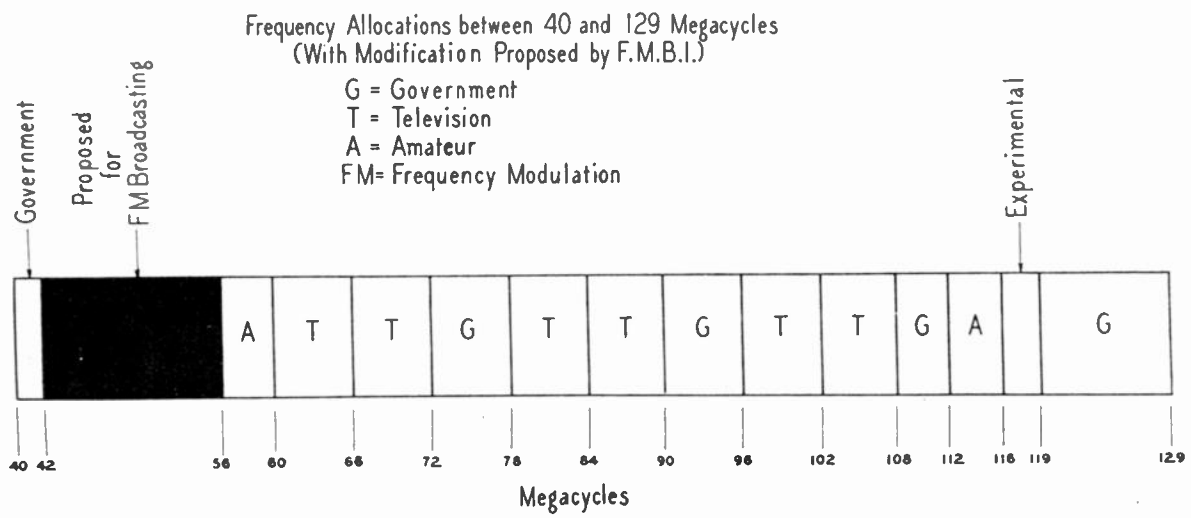


FIG. 3. REVISION OF THE FM BROADCASTING BAND, PROPOSED TO THE FCC BY FM BROADCASTERS, INC., INCLUDES PRESENT NO. 1 TELEVISION BAND

Had that been done FM would have been hamstrung for all time for lack of space. It would never have survived that. There was also set a hearing, for March 1940, in which the question of allocating more space to the service of FM broadcasting was to be taken up. That question would have been moot had the purpose of the January 1940 hearing been carried through.

I appeared before the Commission at that time and pointed out what the situation was; and I think for the first time it was brought home to the Commissioners what the situation was that had really developed from the error of the June 1936 allocation.

The Chairman, Mr. Fly, stated that the Commission would hold over its decision on making the television assignments permanent, until they had been able to hear the FM case.

Now, shortly thereafter a very great effort was made in the commercial world to launch television, and to sell as many television receivers on the number 1 chan-

result of that the Commission took the No. 1 television band,[1] allocated it to FM and gave the band marked "Government" from 60 to 66, to television. So that television had exactly the same number of channels as before, but —

Senator White: What do you mean by "the No. 1 television band"?

Dr. Armstrong: I am sorry, Senator White, as I should have explained that. The No. 1 television channel is from 44 to 50 —

Senator White: You mean the first white block on the chart, to the left, bearing a "T," do you?

Dr. Armstrong: Yes. That was moved up into the position of 60 to 66, and the television bands were renumbered. The old No. 2 television band became the new No. 1 television band. And with that the enthusiasm to promote television subsided.

[1] This band, 44 to 50 mc., was used by the R.C.A. station on the Empire State Bulding, New York City, when this station opened officially at the time of the Worlds Fair. (*Editor's Note.*)

The Chairman: In what way?

Dr. Armstrong: The invention, Mr. Chairman, is 10 years old. There are still no channels assigned for relaying programs of FM about the country. It is one of the great developments which is surely coming, and that will be the relaying of FM broadcasting around the country without the use of connecting wires.

The Chairman: How did the Commission hold it up?

Dr. Armstrong: The Commission has never allocated a band of frequencies for that purpose, although the bands which could be utilized for relaying might be anywhere in a region as far up as 300 megacycles or more. They have had it under consideration, and perhaps if it had not been for the war there would have been something done about it, but nothing yet has been done.

Senator Hawkes: Dr. Armstrong, do you mean by that to say that they could have made these available to FM without interfering with the established channels at all?

perimental. In the second place, it is so complex that it requires, at least in its present stage of development, a receiving set of 57 tubes, which is out of the question as a commercial and marketable possibility.

Impracticable At Present

Major Armstrong has demonstrated quite satisfactorily how he transmits high-fidelity voice and music for distances up to 85 miles with low power and without a trace of the buzzing and frying sounds that are characteristic of lightning and other atmospheric interference. Indeed, the reception with his system is more satisfactory than that from 50,000-watt stations over the same distance. Hitherto it has been assumed that high power is the only way to override static — and the professor, one of the veterans of wireless, is highly enthusiastic about

will have to be built up to tune them in — audiences equipped with entirely new types of receiving apparatus.

* * * * *

The Chairman: You may continue your statement, Dr. Armstrong.

Dr. Armstrong: I was unable to secure Mr. Ring's approval to construct a high power FM station, and during the early part of 1936 I made the acquaintance of Mr. Horace Lohnes, who is an attorney practicing before the Commission, who succeeded in securing for me the necessary permission in July of 1936. I believe the chief engineer of the Commission at that time, Commander Craven, overruled

was that the Commission could not at that time fully determine the needs of the different services, but that as they developed this allocation would be revised, as one service developed faster than another and showed the need for greater space.

Senator McFarland: Mr. Chairman, I regret to have to leave this very interesting discussion but it is necessary for me to go to another committee. I do not want the witness to think that my leaving the room shows a lack of interest. I will read your testimony, Dr. Armstrong.

Dr. Armstrong: Thank you.

The Chairman: You may continue your statement.

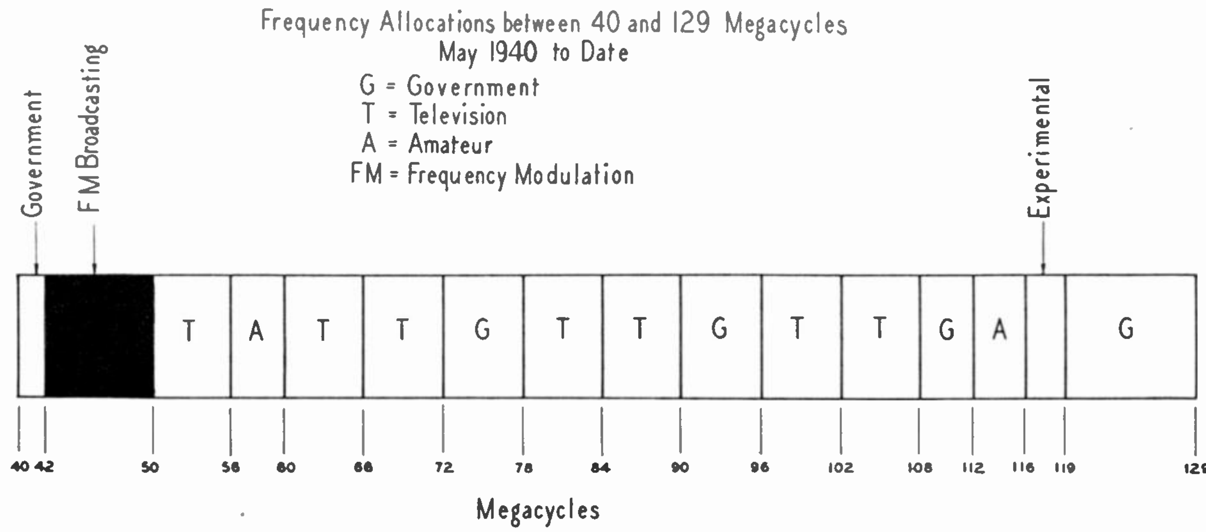


FIG. 2. FREQUENCY ALLOCATIONS, 40 TO 129 MC., AS THEY WERE SET UP BY THE FCC IN MAY, 1940. THEY ARE STILL IN EFFECT

his system as the answer to the static problem, bane of most distant reception.

The Armstrong system, while utilizing only one carrier wave, spreads this carrier during modulation over a right-of-way of 200 kilocycles. The result is a dissipation of the sound over a wider path in its transmission and reception with much greater clarity. That this is achieved by Armstrong is entirely admitted.

The possibility, however, of securing either paths as wide as 200 kilocycles is virtually nil under the present system of broadcasting. Used in the present broadcasting band, it would permit of only about 5 channels of transmission, or 1 where 20 are now available. It would render modern broadcasting entirely obsolete, quite aside from the fact that it would require brand-new types of receiving sets to pick up its signals.

On the ultra-short-wave lengths, which become more numerous and the use of which can be duplicated about every 100 miles, it is very likely that the Armstrong system could be used to good advantage. The ultra-shorts, however, have practically no audience today even for the few experimental stations operating on them. It is improbable that they ever will have substantial audience unless and until the Washington authorities decree that they shall be used for regular commercial brodcasting purposes. Even then entirely new audiences

the position which the assistant chief engineer had taken.

In June 1936 there was held a hearing by the full Commission to determine how the high frequencies, that is, frequencies from 30 megacycles up, were to be allocated. At that time only two men spoke in favor of the FM system, myself naturally, and the chief engineer of the Yankee Network, a small network operating in New England, Paul de Mars. As a result of that hearing, in which the claims of television broadcasting were also considered, an allocation was made by the Commission, under I believe General Order 19, which as finally set up in the fall of 1937 resulted in the allocation which I have blocked out on the chart I now hand to you gentlemen. The squares marked "T" are, as I have indicated, television. The "G" represents space allocated to governmental purposes, the "A" represents amateurs, and the two small black slices were all that were allocated to FM.

Now, this allocation was on an experimental basis. The theory on which the allocation was set up was a good one: it

Dr. Armstrong: While this allocation to FM was ample for the purpose of making a demonstration, yet it had a very unfortunate effect. It had the effect of leading the rest of the broadcasting art to believe that the next major development of the art would be television, that it would not be Frequency Modulation broadcasting, and that there was really no place left in the spectrum for Frequency Modulation, because obviously in either one of these small blocks it would not be possible to set up a national service, and without a national service no new broadcasting system could hope to succeed.

The Chairman: That diagram may be made a part of the record.

(*The chart entitled "Frequency allocations between 40 and 129 megacycles, October 1937 to May 1940" is shown in Fig. 1.*)

The Chairman: You may resume your statement.

Dr. Armstrong: The obvious next step was to demonstrate to as many practical broadcasters as possible the capabilities of the FM system. And during the succeeding 3 years I undertook to do that. I gave several hundred demonstrations, Dr. Armstrong: Yes, Senator Hawkes. There are vast spaces up in the upper frequencies where, prior to the war, no stations whatsoever were operating.

Senator Hawkes: What have they given as a reason for not extending that privilege, or that license, to you for FM?

Dr. Armstrong: Informally that the existing allocations system provides for the allocation of these frequencies to television and Government, and that there is no space available.

Now, that reason was given a good many years ago, when allocations were based on the theory that everything about radio was known for all time; that there was a certain limited amount of spectrum, and that it had to be allocated among the different services. But I think the engineering department of the Commission has gained wisdom since that time.

Senator Hawkes: Has gained what?

Dr. Armstrong: I think the engineering department of the Commission since that time has acquired much wisdom.

Senator Hawkes: It is to be hoped so.

Dr. Armstrong: And I believe that we will in the future have much more sympathetic treatment of that particular request for relay channels.

Senator Hawkes: But their position was at that time, when this hoped-for wisdom you are speaking about had not been acquired, was that they could not make those assignments without interfering with other assignments already made; is that correct?

Dr. Armstrong: Yes. That is, assignments which had been made over large areas of the spectrum, where you could take a receiver and listen from morning until night and never hear a station. There was plenty of room to put relays in.

There was another reason why the relay broadcasting should have been put into use. It would have been years before any demand would have arisen for these channels for the purpose to which they were allocated, and by that time we would have learned how, through using these channels, to have moved the relay stations on up into the higher part of the spectrum, out of the way of the demands of some new service.

As this art develops you see more and more the impossibility of making progress under the rigid allocations of the past, for they were made on the theory that there is a limited quantity or number of channels. That is the lesson I am trying to get across by relating the experience in FM, of getting it under way; and while at the present time FM has escaped that danger, the danger of being blocked off, I want to assure the committee that I as an inventor am not anxious to run the risks again that I ran in undertaking to put this thing into use.

The Chairman: As Senator White has just suggested to me, at that time no one knew much about these ultra high frequencies, I take it.

Dr. Armstrong: Yes; that is true, Mr. Chairman. A few of us knew, but it was not possible by the use of the English language to convert people to your point of view. I haven't that power of speech. The only way that it could ever be done was to build a station, set it up, and wipe out by the demonstration of the things that people knew that were not so. (*Laughter.*)

Senator Moore: If that could be applied to other activities of the Government, it would be very desirable.

Dr. Armstrong: I do not know of any other way of making progress in the radio art. I have been in the field of inventing since 1912.

Senator Hawkes: Your experience in proving what you knew yourself is very similar to the experience of anyone who has made a brand-new discovery in the mythical field; isn't that correct?

Dr. Armstrong: Yes; that is true. But in the ordinary type of human endeavor you are usually able to go ahead without being blocked in any way. Now, here was the case where if the engineering department of the Commission made a mistake, you never would get the opportunity to prove that you were right. That is the lesson of the development of FM. The history of all inventions is that most engineers are wrong; at the time the invention is made the only man who is right is the inventor, and everyone else is wrong. So that if you prevent him from developing what his idea is, he will never have the opportunity of making any converts. It is a tough problem.

The Chairman: The inventor has to prove that the other fellows were wrong.

Dr. Armstrong: Invention is going ahead in the face of the established rules of scientific knowledge, and in showing that it either does not apply or it is being wrongly applied. As Josh Billings has said: "It isn't ignorance that causes the trouble in this world; it is the things that folks know that ain't so." (*Laughter.*)

Senator Hawkes: You will remember that at the end of the Civil War somebody suggested we ought to close the United States Patent Office because there was nothing new to be discovered.

Dr. Armstrong: Yes, Senator, I remember that very well.

I have a few copies of another chart here which will illustrate the situation as it is at the present time, in the same frequency range of the chart I have already given you. I only have two or three copies of this chart.

Senator White: Will you state again what this is.

Dr. Armstrong: That is the existing allocation between 40 megacycles and 129 megacycles, as it stands today.

The Chairman. And it is your thought that that is not sufficient.

Dr. Armstrong: FM has developed so much more rapidly than the majority of people believed it could develop, that additional space will be required.

(*The chart entitled "Frequency allocations between 40 and 129 megacycles May 1940 to date" is shown in Fig. 2.*)

Dr. Armstrong: I have here a chart which indicates what additional space is now being asked for by the Association of FM Broadcasters. It is just the same as the charts which I have given you with the exception that the No. 1 television band is shown as allocated to FM broadcasting.

(*The chart entitled "Frequency allocations between 40 and 129 megacycles (with modification proposed by F.M.B.I.)" is shown in Fig. 3.*)

Senator Hawkes: You may have stated it before I came into the room, but how many FM broadcasting stations are there in the United States now?

Dr. Armstrong: Around 50, Senator. I do not know the exact number but it is of that order.

Senator Hawkes: And that is related to how many in the AM or standard broadcasting field?

Dr. Armstrong: Around 800, or perhaps even more than that. Under the present allocation there would be room for many thousands of FM stations scattered throughout the country, but in congested areas, such as New York, Chicago, and Los Angeles, the opinion is that there are not enough channels at the present time, and as this art develops at least an addition of the present number 1 television band [2] will be necessary.

You can see from looking at the charts what a really small part of the spectrum has been allocated to the service of FM broadcasting. The natural habitat of service such as television is in the higher frequencies, and I have a further chart which indicates that there is ample space for television to expand up into the higher frequencies.

(*The chart entitled "Frequency allocations between 40 and 129 megacycles (with modification proposed by F.M.B.I.)" is shown in Fig. 4.*)

Senator Hawkes: In order to use these higher spaces would it require a complete change in the apparatus now used for television?

Dr. Armstrong: It will require a change in the transmitter principally. The difficulties of getting high power out at the higher frequencies were very much

[2] That is, 50 to 56 mc. (*Editor's Note.*)

greater a few years ago than they are at the present time. The point I want to make, however, is that in order to get enough television channels to operate a national service, television must learn to work in the higher frequencies. So it makes very little difference whether television starts at 50 megacycles and winds up in the hundreds, or starts at 60 megacycles and winds up in the hundreds of megacycles. But it makes a very great difference to the full development of the FM system.

Senator Hawkes: In other words, the FM system can develop very much more rapidly and successfully in the lower frequencies.

Dr. Armstrong: I believe so. It can work in the higher frequencies, but I think the position it is now in is probably the best for it.

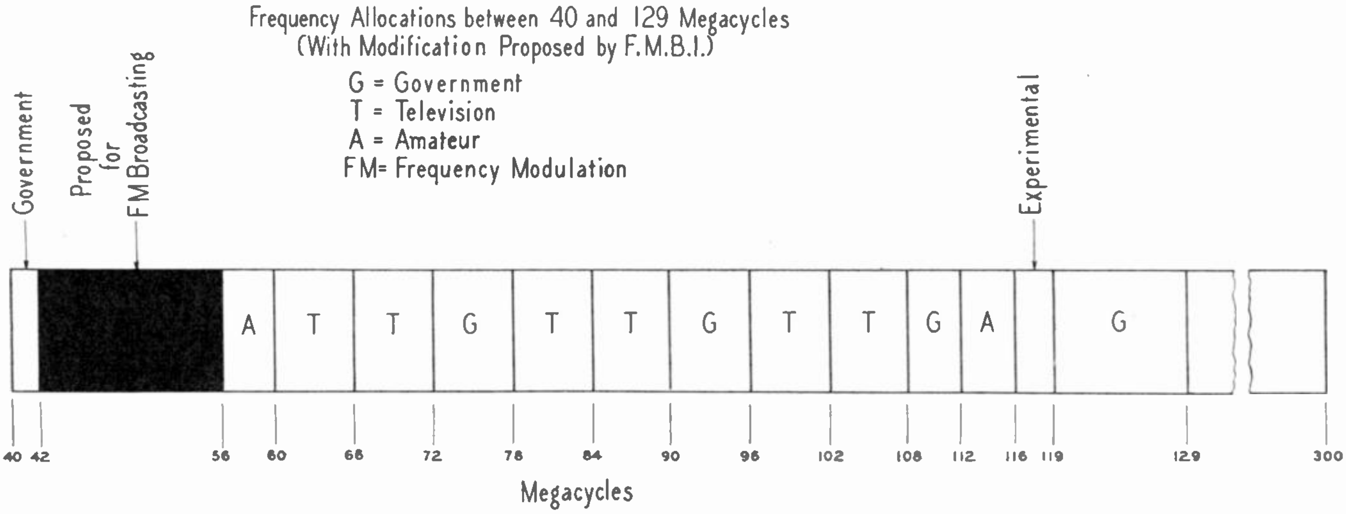


FIG. 4. AMPLE CHANNELS ARE AVAILABLE FROM 129 TO 300 MC. TO COMPENSATE TELEVISION FOR GIVING 50 TO 56-MC. BAND TO FM

The Chairman: Was it your idea that the industry engaged in AM broadcasting was blocking FM? Or, to be specific, that the Radio Corporation of America was blocking it? Was that your idea, as I gathered from your statement?

Dr. Armstrong: Senator Wheeler, I would like to answer that question this way: That if at the June 1936 hearing, that is, the hearing before the Commission which resulted in that very narrow allocation to FM (Fig. 1) the Radio Corporation of America as the recognized leader in the industry, had said one thing, and that is, that what Armstrong is saying as to the capabilities of FM is true, then we would never have had any of this trouble about allocations. I am quite sure the Commission would have had nothing left to do except to allocate a substantial band to FM.

The Chairman: Wouldn't the Radio Corporation of America make more money with FM by reason of selling more equipment, than by not having it?

Dr. Armstrong: Yes, Senator Wheeler; and there is a difference of opinion within the Radio Corporation of America. One part, I believe, wants to go into FM, and another part does not.

Senator White: I think everybody recognizes, Dr. Armstrong, that you are the final word in the development of this branch of the radio art. I am a little curious on this point, because I have no knowledge about it: What attention has FM attracted in England, or in Germany, or in other European countries? They have lagged far behind us, haven't they?

Dr. Armstrong: The British did not take it up as quickly as they should have. I believe the reason for that was that when they made inquiry to us through the established channels in this country, the possibilities were rather talked down to them. I got that impression from talking to some British engineers years later.

In Germany they fully appreciate the advantages of FM, as shown by some of their technical publications which came to my hand just before the war started. But I have no information as to what they have done with it since that time.

Senator Hawkes: Has FM developed to any appreciable extent in any other country than the United States?

Dr. Armstrong: No; I believe that Canada is probably in second place, and they are just beginning to go into it, or were, prior to the war.

The Chairman: Have you demonstrated FM in England, or in any other country? Have you tried to push FM in other countries?

Dr. Armstrong: No, Senator Wheeler. I have demonstrated it in this country after I completed the construction of the large station located at Alpine in 1939. That aroused a great deal of interest, as shown by the articles which subsequently appeared in the British technical press. I have no doubt that it will go into use throughout —

The Chairman: In what State is that station located?

Dr. Armstrong: In New Jersey, just north of the George Washington Bridge.

Senator Hawkes: Do you mean that you demonstrated FM at the Alpine Station to the representatives of Great Britain and other countries?

Dr. Armstrong: Yes. I have given countless demonstrations during the first year or two after the station went into operation. And if it had not been for the war the thing would now be in operation in all parts of the world, and particularly in the tropics where static disturbances are very great.

Senator Hawkes: Do I understand that the Alpine Station went into operation in 1939?

Dr. Armstrong: The large station that I have referred to. I had a small station erected at the home of an amateur friend of mine, with which I gave demonstrations during the period of 1936 until the big station was ready. But that was the case where the demonstrations had to be supplemented by the spoken word in order to carry the point I wanted to make.

The Chairman: Do I understand that the spectrum from 129 to 200 can be utilized in the future for FM broadcasting?

Dr. Armstrong: Yes; it can be utilized for FM, television, and various communication and relay circuits, all sorts of new forms of communication will arise in there.

The Chairman: Your idea is that you will not have to use telephone wires, that you can communicate directly; is that correct?

Dr. Armstrong: No. I do not believe I have the imagination to go that far ahead at the present time.

THE CHAIRMAN: Then I misunderstood you.

DR. ARMSTRONG: I think that a great many point-to-point communications will be set up in there, and radio relays between broadcasting stations in different regions, and perhaps eventually we will see coast-to-coast networks. But I do not want to predict at the present time when that will be.

SENATOR WHITE: Will you state for the purpose of the record whether there is any difference in the type of program that can be sent over FM transmitters and received by FM receiving sets, than for standard broadcasting?

DR. ARMSTRONG: Yes; and I thank you very much, Senator White, for reminding me of that. I shouldn't have forgotten it.

SENATOR WHITE: I got the suggestion elsewhere. It was not original with me.

DR. ARMSTRONG: The quality of the transmission is very, very much superior to anything that can be done over the existing AM system.

SENATOR WHITE: That refers to the quality of the transmission. I was interested to have you put something in the record as to the type of program, whether you can send the same type of program by FM that you can send under standard broadcasting. I think I know what the answer is, but should like to have it from you.

DR. ARMSTRONG: Yes. Of course, any program can be sent over FM. If, however, the program comes from one of the existing wire lines, while you will get the full benefit of the suppression of static, and will get a somewhat better quality than you would if the program was sent out over an AM station, you will not realize the full advantages of FM because the line transmission characteristics limit it.

SENATOR WHITE: As a practical matter any program that could be broadcast over the standard broadcast bands could be also transmitted by frequency modulation?

DR. ARMSTRONG: Yes; certainly Senator White. And a great many stations that are operating on FM now are doing that.

SENATOR HAWKES: It is your contention that the quality of these programs will be equal to or better than the quality of the programs over AM; do I understand that from your statement?

DR. ARMSTRONG: Yes, Senator; but I would go further than that. I would say that they are much better, and that it is even possible on transcriptions to put out a program which is more pleasing than the program which comes over a line of the existing character and goes out on an AM station. I have very definitely gotten that reaction from the listeners to my Alpine transmitter.

THE CHAIRMAN: You are speaking of transcriptions. Is it possible to use a transcription today which will be as good as the voice coming over the radio from a distant point over AM?

DR. ARMSTRONG: Yes, Senator; I think you can do a better job.

THE CHAIRMAN: I was going to say I had been informed that as a matter of fact today you can do a better job on transcriptions than you can by getting it from the original point over the wire, because of the technical improvements in transcriptions.

DR. ARMSTRONG: Yes; if the transcriptions are sent out over FM, that is certainly so, and transcriptions will in the post-war period be very substantially better than they are at the present time.

THE CHAIRMAN: Then, so far as concerns the announcing that a certain program is a transcription, the need for doing it or the reason for doing it will be to some extent eliminated, will it not be — that is, announcing that "This is a transcription"?

DR. ARMSTRONG: I have seen transcriptions in the laboratory that, without such an announcement, would be mistaken for a direct pick-up.

THE CHAIRMAN: Yes. Some have contended that the transcription is better than the pick-up, that it can do a better job. I was wondering whether that was correct, in your opinion.

DR. ARMSTRONG: I would not go so far as to say —

THE CHAIRMAN: You would not go that far.

DR. ARMSTRONG (continuing): That the transcription is better than the direct pick-up, but I think it can be made so nearly equal to it that most people would not know the difference.

THE CHAIRMAN: Your idea is that the transcription from FM could be made better than the direct pick-up over AM today?

DR. ARMSTRONG: Yes; that is my statement, Mr. Chairman.

THE CHAIRMAN: The main thing, one of the principal things that you do, however, in FM is to eliminate this static which you get today in case of a thunderstorm or many other things that come up?

DR. ARMSTRONG: That is one of the advantages of the system, although a large number of the listeners who have been interrogated choose the better quality as the principal advantage of the system. I think it depends to a considerable extent where the listener is located with respect to the nearest AM station. If he is out on the fringes of the AM station's range, then FM comes through clearly and he thinks that the principal advantage is in the noise-reduction feature. If he is located near an AM station, where he doesn't get much static, then the better quality is the more striking difference between the two.

THE CHAIRMAN: Now, would you explain to the committee the difference between AM and FM?

DR. ARMSTRONG: Mr. Chairman, I will try my best. It is something that I have been trying to do from the lecture platform for the last 7 or 8 years, and it is difficult because there is no good mechanical analogy between the phenomenon which occurs in Frequency Modulation and anything with which we are familiar. But I will do my best.

THE CHAIRMAN: I should like to have you tell us what the difference is in the transmitter, too, and what the difference has to be in your receiving set. Do it in simple terms so that we can understand it.

DR. ARMSTRONG: In order to explain Frequency Modulation, I have to explain modulation; and in order to explain modulation it is necessary to explain radio transmission.

Radio transmission is really a fairly simple thing. We have at the sending end an elevated conductor of some sort which is connected to an electrical pump at its base which pumps electricity up into this conductor and sucks it out again a great many times a second. The electrical pump is what we call the transmitter. The number of times that the electricity is pumped up and down may be in the hundreds of thousands or millions of times a second.

By a process that we need not inquire into, any other conductor located at a distance has set up in it a feeble electric current which likewise goes up and down in the wire or elevated conductor in the transmitter. Now, that is electrical transmission. It is not, however, electrical communication. To get communication you must do something at the transmitter; modulate the current in the transmitter so that the effect of that can be observed in the receiver. The oldest way of doing that is to change the strength of the current which is going up and down the antenna in accordance with the fluctuations of the voice. That is called amplitude modulation. The electrical pump continues to pump at a constant rate, the same number of times per second.

Now, in Frequency Modulation you do not change the strength of the current in the transmitting antenna, but you change the speed of the pump in accordance with the fluctuations of the voice. That is, you speed the pump up or slow it down; and you may, and in practical FM broadcasting you do, change the speed of the pump from, let us say, 39,900,000 times a second to 40,100,000 times a second, and that can be done very accurately in accordance with the fluctuations of the voice.

THE CHAIRMAN: Does it eliminate the

fading that you get on radio at times, or not?

Dr. Armstrong: That is another of the advantages of the FM system, that it does not suffer within its service range from the present trouble which the AM system has, and the FM system will work beyond the fading range of our present day AM transmitters if it is constructed of high enough power and on a good elevation.

At the receiving end, we have for AM a particular kind of receiver, and for FM we have a different kind of receiver. The FM receiver must not respond to amplitude changes, nor must it respond to small frequency changes, but must respond only to the wide changes in the speed of the pump at the transmitter.

Now, I hope I shall be spared from the difficulty of undertaking to explain just how that process is brought about. When I first explained it to the best men in the industry, it usually took a week or two before it sank in.

The Chairman: We will not press you for that.

Senator White: We know as much now as we ever will. (*Laughter.*)

Senator Hawkes: Dr. Armstrong, there is a converter that might be attached to the ordinary receiving set that has been receiving AM transmission, that will receive FM; is that correct?

Dr. Armstrong: Yes, Senator, there have been a number of devices which make use of the loudspeaking part of the AM set and which do it fairly effectively. The static-reducing features of FM are retained, but of course the quality is dependent on the excellence or otherwise of the loudspeaking system in the AM set.

Senator Hawkes: Is there any necessity of having anything other than this converter we are talking about, to use the ordinary set that people possess at the present time, in order to get the results you are talking about from the FM?

Dr. Armstrong: No. That can be done, provided there is a place to connect the translator, as it is called, into the loud speaker system of the existing AM set.

Senator Hawkes: Is there a place to make that connection — that is the point I have in mind — in most of the sets that are now in existence?

Dr. Armstrong: If I had to hazard a guess, I would say that probably less than half of the sets now in existence would have a place where such a connection could be easily made.

Senator Hawkes: Thank you.

The Chairman: You could, however, have a receiving set for AM and FM in the same cabinet, could you not?

Dr. Armstrong: Yes, Mr. Chairman. And I think that at the termination of hostilities the great majority of sets will be made that way. The manufacturers are already making plans to include an FM band on all sets selling beyond a certain minimum value.

The Chairman: Now, with the development of FM can you have an unlimited number of wave lengths, so that you can have many more stations, or not?

Dr. Armstrong: Practically so, Mr. Chairman. I think that the number of wave lengths is so large that we are going to be limited by the number of stations which communities —

The Chairman: Can support.

Dr. Armstrong: Can support, rather than by the lack of wave lengths to go around.

Senator White: In your charts your top band to which you make reference is from 119, I think, to 129 megacycles. How much farther into what I will call the upper reaches of the spectrum do you think we can usefully go?

Dr. Armstrong: I hesitate to answer.

Senator White: I do not know that anybody can answer that definitely, but I thought I would like to have your notions about it.

Dr. Armstrong: Because I can remember when all the wave lengths above 1,500 kilocycles — that is 1½ megacycles — were considered so useless that they were given to the amateurs. I really do not know what the upper limit is going to be for broadcasting.

Senator White: I do not suppose anybody really knows the answer with definiteness at this time, but I was just curious. How much above 129 megacycles are we now going in any branch of the radio industry?

Dr. Armstrong: The highest frequency that I know of that was used prior to the war was around 500 megacycles. Since the war that range has been exceeded many times.

Senator White: What use, if any, is being made of the many bands between 129 megacycles and 500 megacycles? Is that area up in there being put to useful purpose now?

Dr. Armstrong: Prior to the war I do not believe there were many applications in there. Of course, now it is being put to all sorts of military uses.

Senator White: The thing that impresses one with limited understanding of all this is the tremendous advances coming from day to day almost. I don't know whether I am right about it or not, but my recollection is that at the last international conference in '38 they went only to about 30,000 kilocycles in making their allocations of the spectrum. Am I right about that?

Dr. Armstrong: I am afraid my recollection doesn't serve me on that.

Senator White: I do not say that is so, but my recollection was that we went only to about 30,000 or slightly above. All of this development beyond that really has come in 5 years of time.

Dr. Armstrong: Five or six years; yes.

Senator White: Five or six years. So that makes one a little timorous as to speculating as to the future.

Dr. Armstrong: I agree, Senator.

The Chairman: If phone lines are used to connect FM stations can any better tone quality be had on network programs over FM than is now secured on AM?

Dr. Armstrong: Senator, I am sorry. Would you repeat your question?

The Chairman: I say, if phone lines are used to connect FM stations will the reception and the quality be any better than it is over AM, in your opinion, on network programs?

Dr. Armstrong: Yes; if the existing phone lines are used the quality is better than over the existing AM stations. However, the full advantage cannot be obtained.

The Chairman: Does that complete your statement?

Dr. Armstrong: I think so, Mr. Chairman. I think that I ought to add just one thing, perhaps; that if I have been too hard on the engineering department of the Commission in the past I want to say that the engineering department of the Commission at the present time is doing everything in its power to help this FM system get under way, and I think that we will have all the channels that we need when they have completed their studies of the situation.

The Chairman: You think there will be a big development in FM after the war?

Dr. Armstrong: It will be the major development in the radio art. There isn't any question about that, Mr. Chairman. We will have television later. I am not prepared to say how long it will take to attain the same status as FM has now. There is no question at all but that we will have television, but the next development and the one which has been the logical development for the past 10 years is the FM system.

Senator White: I was going to say, I don't know where either the Commission or the industry could find a better chief engineer than the present chief engineer of the Commission.

Dr. Armstrong: I would like to agree with you on that, Senator, if I may. Mr. Jett[3] has done a very fine job in a very difficult situation.

Senator White: I think he has knowledge and ability and character.

Dr. Armstrong: I agree there also.

(This concluded the taking of testimony, and the session was adjourned.)

[3] Mr. E. K. Jett was subsequently appointed a member of the Commission. (*Editor's Note.*)

the amateur is still in radio...

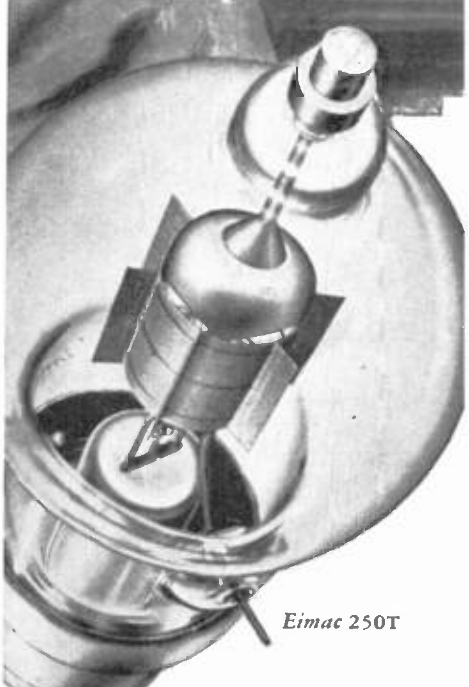
All through the development of radio communications you'll find the mark of the radio amateur. His desire to accomplish the seemingly impossible and the rough treatment he gave his "ham rig" helped create and develop better radio technique. Thus the radio amateur is directly responsible for much of the superior radio and electronic equipment being used by the military services today. Eimac tubes, created and developed in the great amateur testing ground are a good example. They had to possess superior performance capabilities in order to become first choice of the leading radio amateurs.

Their ability to withstand momentary overloads of as much as 600% and their unconditional guarantee against premature failures due to gas released internally are two potent reasons why they are today first choice of the leading electronic engineers throughout the world.

Today the radio amateur is off the air as an amateur but he's still in radio as a professional. And wherever he is... in the army, navy and marine corps... in the great electronic laboratories and factories .. he's still using Eimac tubes.

Follow the leaders to

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



Eimac 250T

EITEL-McCULLOUGH, Inc., SAN BRUNO, CALIF.

Plants at: Salt Lake City, Utah and San Bruno, California

Export Agents: FRAZAR & HANSEN, 301 Clay Street, San Francisco, California, U. S. A.

748

NEWLY REVISED ARMY-NAVY TUBE LIST

This A-N Tube List Supersedes the Previous List, Dated March 1, 1943*

February 15, 1944.

To Those Concerned with the Design and Manufacture of Army or Navy Equipment Utilizing Radio Electron Tubes:

1. The following Army-Navy Preferred List of Radio Electron Tubes sets up a group of unclassified general purpose tubes selected jointly by the Signal Corps and the Bureau of Ships. The purpose of this list is to effect an eventual reduction in the variety of tubes used in Service Equipment.

2. IT IS MANDATORY THAT ALL UNCLASSIFIED TUBES TO BE USED IN ALL FUTURE DESIGNS OF NEW EQUIPMENTS UNDER THE JURISDICTION OF THE SIGNAL CORPS LABORATORIES OR THE RADIO DIVISION OF THE BUREAU OF SHIPS BE CHOSEN FROM THIS LIST. EXCEPTIONS TO THIS RULE ARE HEREINAFTER NOTED.

3. The term "new equipments," as mentioned in Paragraph 2 above, is taken to include:

a. Equipments basically new in electrical design, with no similar prototypes.

b. Equipments having a similar prototype but completely redesigned as to electrical characteristics.

c. New test equipment for operational field use.

4. The term "new equipments," as mentioned in Paragraph 2 above, *does not* include:

a. Equipments either basically new or redesigned, that are likely to be manufactured in very small quantity, such as laboratory measuring instruments.

b. Equipments that are solely mechanical redesigns of existing prototypes.

c. Equipments that are reorders without change of existing models.

d. Equipments in the design stage before the effective date of adoption of this Preferred List.

NOTE: The foregoing statements in Paragraphs 3 and 4 above are explanatory in nature and are not intended to be all-inclusive.

5. In the event that it is believed that a tube other than one of those included in this Preferred List should be used in the design of new equipments for either the Signal Corps or Navy, specific approval of the Service concerned must be obtained.

(CONTINUED ON PAGE 58)

* See *FM Radio-Electronics*, March, 1944.

ARMY-NAVY PREFERRED LIST OF RADIO ELECTRON TUBES

RECEIVING

Miniature tubes (shown in Italics) shall be used only when essential to Service requirements.

Filament Voltage	Diodes	Diode Triodes	Triodes	Twin Triodes	Pentodes: Remote	Pentodes: Sharp	Converters	Power Output	Indicators	Rectifiers	Miscellaneous
1.4	*1A3*	1LH4	1LE3	*3A5* 3B7 1291	*1T4*	*1L4* 1LN5 *1S5*	1LC6 *1R5*	*3A4* 3D6 1299 *3S4*			**Crystals** 1N21B 1N23 1N27
5.0										5U4G 5Y3GT	
6.3	*6AL5* 6H6* 559 *9006*	*6AQ6* 6SQ7* 6SR7*	2C22 2C26 *6C4* *6J4* 6J5* 7E5/1201 *9002*	*6J6* 6SL7GT 6SN7GT	6SG7* 6SK7* *9003*	6AC7* *6AG5* 6AG7* *6AK5* 6SH7* 6SJ7* 7W7 *9001*	6SA7*	6G6G 6L6GA 6N7GT/G 6V6GT/G 6Y6G	6E5	6X5GT/G 1005	**Phototubes** 918 927
12.6	12H6*	12SQ7* 12SR7*	12J5GT	12SL7GT 12SN7GT	12SG7* 12SK7*	12SH7* 12SJ7*	12SA7*	12A6*	1629		**Voltage Regulators** OB3/VR-90 OC3/VR-105 OD3/VR-150
25 and above								25L6GT/G 28D7	991	25Z6GT/G	

TRANSMITTING

Triodes		Tetrodes	Twin Tetrodes	Pentodes	Rectifiers: Vacuum	Rectifiers: Gas	Rectifiers: Grid Control
2C26	801A	5D21	3E29	2E22	2X2	4B25	3C23
2C44	809	715B	815	803	3B24	83	3C31/C1B
6C21	811	807	829B	837	5R4GY	866A/866	C5B
15E	826	813	832A		371B	872A/872	884
VT127A	833A	814			705A		2050
327B	838	1625			836		
434A	1626				1616		
446A	8005				8016		
527	8014A				8020		
530	8025						

MISCELLANEOUS

Clipper Tubes	Gas Switching	Cathode Ray
73	1B32/532A	2AP1
719A	471A	3BP1
	532	3DP1
		3FP7
		5CP1
		5CP7
		5FP7
		5JP1
		7BP7
		12DP7
		12GP7

* Where direct interchangeability is assured "GT" and "L" counterparts of the preferred metal tubes may be used.


SYMBOLS OF QUALITY
HAMILTON
The Watch of Railroad Accuracy
THE WALDORF ASTORIA
GOOD YEAR
COLT
ALCOA
ALCOA
Marshall Field & Company
NEW YORK CENTRAL SYSTEM
STETSON
Jensen
Manufacturers and Designers of Fine Acoustic Equipment

SPOT NEWS NOTES

(CONTINUED FROM PAGE 24)

"As to the acoustics of the room in which the FM receiver is located — the ideal room would be one whose qualities match those of the originating studio. We should keep this point in mind, and not expect to hear true symphonic fidelity reproduction when the receiver is located, say, in a kitchen alcove. It should always be remembered that with Frequency Modulation the facilities are ever present for lifelike reproduction, but they cannot operate fully without some intelligent thought and care."

Dr. W. R. G. Baker: Addressing a group of industrialists and businessmen meeting under the auspices of Allied Stores Corporation: "Unless I am far wide of the mark, the advantages offered to listeners by FM will eventually obsolete the 60,000,000 radio sets in American homes. . . . Certainly television will come after the war, but how soon cannot be stated definitely. It will not blossom nationwide at once, since first a large investment must be made in television transmitters and in a system of television transmission for network programs. Whether the network will use radio, coaxial cable, or wave guides depends upon many factors. The problems will be solved, but some time will be needed to line up both economic and network technical factors."

Educational FM: Station WBEZ, operated by the Chicago Board of Education, broadcast 206 program-hours for in-school use during the first semester of 1943–1944, from October through January. A total of 1,370 students took part as actors, sound men, and announcers, or visited the studios as audience.

In addition, the Radio Council, producing department for the Board of Education, presented 147 broadcasts over local AM stations during this period. Acting director of the Radio Council and station WBEZ is George Jennings.

Henry C. Bonfig: Resigned as commercial vice president of RCA to become vice president in charge of Zenith's household radio sales division.

Tube Catalog: Issued by Continental Electric Company, Geneva, Ill., giving technical data on phototubes, rectifiers, and grid-control tubes. Copies are available on request.

Larry T. Hardy: After 12 years with Philco, has been elected vice president in charge of the Home Radio Division. This includes all radio-phonographs, consoles, table models, and small sets.

Television Record: After a dinner following the award of the Army-Navy "E" Flag to Allen B. Du Mont Laboratories, Inc., Company officials and their guests witnessed the televising of movies which had been taken during the ceremony. This is a type of programming that will be widely used for television in the future.

W. A. Elmore: Vice president in charge of engineering at Utah Products Company, Chicago, has been given the additional duties of heading the sales department, according to an announcement from Fred R. Tuerk, president. Chester L. Walker, former chief engineer, has been made sales manager in charge of the manufacturing and equipment division.

Chicago Television: General Electric Company has been commissioned to build a 40-kw. television transmitter for W-G-N, Inc., Chicago. The transmitter and elaborate studio equipment will be delivered as soon as possible after materials and manpower are released.

The complete installation, according to W-G-N president W. E. McFarlane, will represent an investment of several million dollars. A building of seven or eight stories will be constructed to house studios for the present AM and FM transmitters, and for television stages comparable to those used for movie production. Both live-talent shows and motion pictures will be telecast.

Merit Award: Given by G. E. to KOA, Denver, for having the best 1943 service record among stations operated by NBC. Station was off the air only 42 seconds out of 6,680 operating hours. WMAQ, Chicago, was in second place, with 5 minutes, 41 seconds out of 6,886 hours.

A. H. Hardwick: Is now a member of the executive sales staff at International Resistance Company. In making this change, he has relinquished the presidency of Hardwick, Hindle, Inc., where he has had an active part in the business of manufacturing resistors for the past 16 years.

News Bulletin: Now being published monthly by Allied Radio Corp., 833 W. Jackson Blvd., Chicago 7. Purchasing agents and engineers are invited to send their names and addresses for the mailing list of publication.

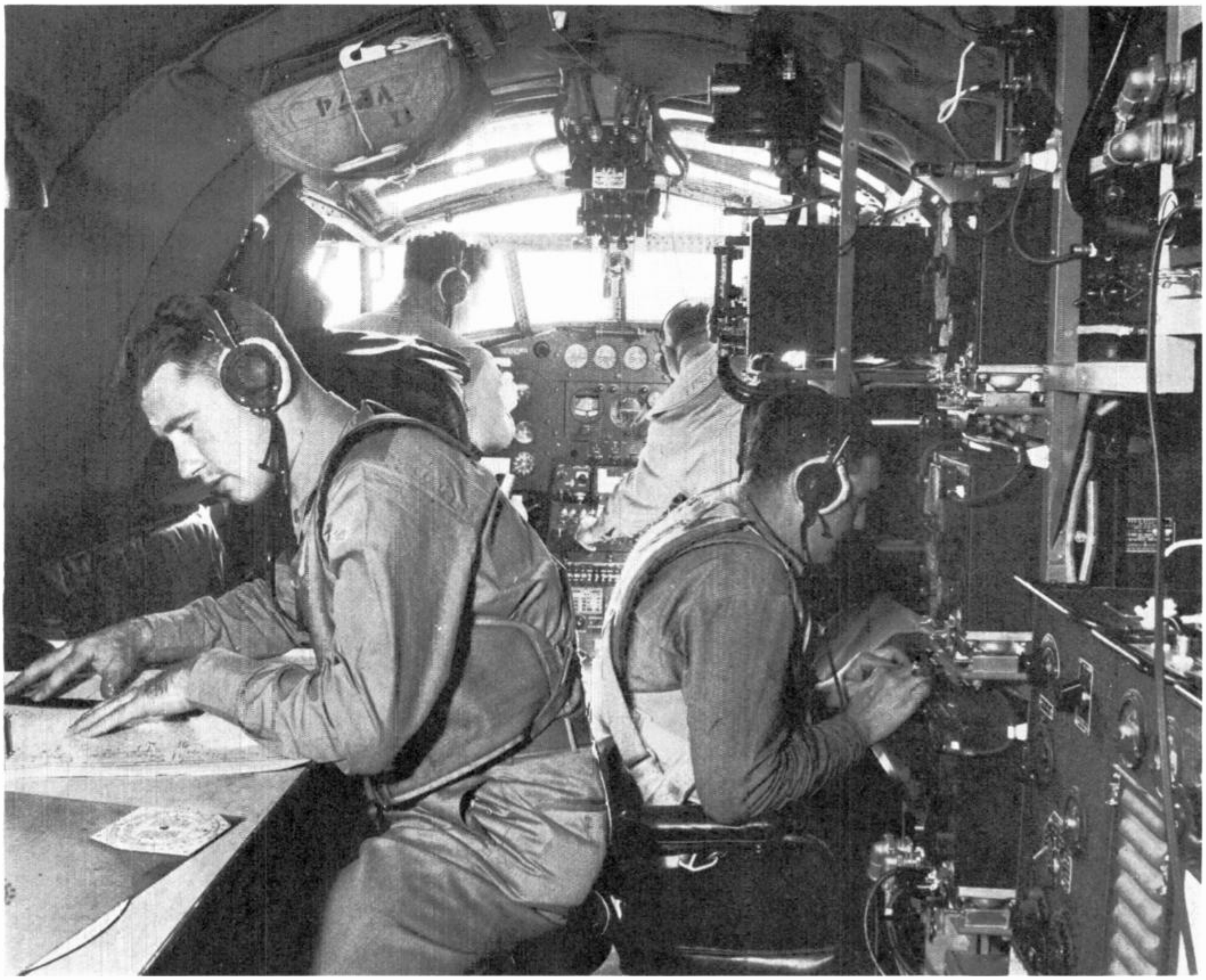
The Post Office Says: That mail bearing zone numbers is delivered much more rapidly in many instances than that which does not bear this important aid to speedy sorting. In several cases, we have found that copies of this Magazine are delivered more promptly when we have subscribers' zone numbers on the wrappers than to others who have not given us this information. If you are not getting your copies promptly, send in your name and the address to which the Magazine is now being mailed, and your zone number. Then we shall put it on your stencil. And please remember, when you send in a change of address, to give us the old address, also.

More FM Stations: In an address to a meeting of department heads and other officials of the Blue Network, president Mark Woods promised full participation by the net in FM broadcasting. Applications for FM construction permits have been filed already, and others are being prepared. In addition, affiliates of the Blue Network are being urged to start preparations for postwar entry into this field.

New Antenna: The antenna for Columbia's FM transmitter WABC-FM, atop 500 Fifth Avenue, New York, was being erected at the time of the freeze order, and delivery of the radiators was delayed just long enough to be stopped. Result was that the handsome mast (see cover photo of *FM* Magazine, April, 1942) has never been used. Transmission up to now has been a temporary rig that cannot be seen from the street.

Now WPB has granted permission for the erection of a 2-bay circular antenna on the mast. Although the original plan was to use 4 bays, the 2-bay antenna will give a tremendous boost to WABC-FM transmission. Top of the building is 670 ft. above sea level. The tower adds 90 ft. more.

Not Good Enough: FM transmission from both NBC station W2XWG and the CBS station WABC-FM is still far from full quality. While there may be practical reasons, of which two might be lack of equipment and the extra cost, such important local originations as the General Motors concert and the Philharmonic still give the definite impression of being picked up and monitored through the regular AM facilities. In fact, the difference between AM and FM reception does not seem to be any more than that due to the pre-emphasis in the transmitters. Those of us who have heard real FM know that the music of those very special programs is still dull and flat.



OFFICIAL U. S. NAVY PHOTO

BROADCASTING STATION DIRECTORY

Roster of General Managers and Chief Engineers at FM, AM, Television & Short-Wave Stations

M) Indicates General Manager C) Indicates Chief Engineer
Names will be found after call letters, and also indexed alphabetically under General Manager list and Chief Engineer list. Where name is omitted, no reply was received after second request, or was received too late to be included. Only a partial list of South American stations could be obtained.

UNITED STATES

FM Broadcasting Stations

— K —

KALW San Francisco, Calif.
KDKA-FM Pittsburgh, Pa. M) J. E. Baudino, C) T. C. Kenney
KFRE Fresno, Calif. M) Paul R. Bartlett
KHJ-FM Hollywood 38, Calif. M) Lewis Allen Weiss, C) Frank M. Kennedy
KLAW San Francisco, Calif.
KOZY Kansas City, Mo.
KPOR Riverside, Calif. M) W. L. Gleeson
KYW-FM Philadelphia, Pa. C) Ernest H. Gager
K51L St. Louis, Mo. M) Nicholas Pagliara, C) George Rueppel

— W —

WAAW Newark 1, N. J. M) Irving R. Rosenhaus, C) Frank V. Bremer
WABC-FM New York, N. Y. C) Henry Grossman
WABF New York 21, N. Y. M) L. L. Thompson
WBAM New York, N. Y. C) J. R. Poppele
WBBM-FM Chicago, Ill. C) J. J. Beloungy
WBCA Schenectady, N. Y. M) Leonard L. Asch, C) Dwelle S. Hoag
WBEZ Chicago 1, Ill. M) George Jennings
WBKY Beattyville, Ky.
WBOE Cleveland 14, Ohio M) Dr. Wm. B. Levenson, C) Nathan A. Neal
WBRL Baton Rouge, La. C) Wilbur T. Golson
WBZ-FM Boston, Mass. C) Willard H. Hauser
WBZA-FM Springfield, Mass.
WCAH Buffalo, N. Y.
WCAU-FM Philadelphia 3, Pa. M) Dr. Leon Levy
WCHI Chicago, Ill. C) Walter F. Myers
WCRS Greenwood, S. C. M) Dan Crosland
WDLM Chicago, Ill.
WDRC-FM Hartford, Conn. M) Franklin M. Doolittle, C) Italo A. Martino
WDUL Duluth 2, Minn. M) W. C. Bridges, C) Wm. H. Lounsberry
WELD Columbus, O. M) Lester H. Nafzger, C) Lester H. Nafzger
WENA Detroit 26, Mich. M) Edwin K. Wheeler, C) Carl H. Wesser
WFBL Syracuse, N. Y. C) Lt. Col. A. R. Marcy
WFIL-FM Philadelphia, Pa. M) Roger W. Clipp, C) L. E. Littlejohn
WGFM Schenectady, N. Y.
WGNB Chicago, Ill.
WGTR Boston, Mass. C) Irving B. Robinson
WGYN New York, N. Y. M) Carl J. Schaefer, C) Harvey Anhalt
WHEF Rochester, N. Y. M) Gunnary O. Wiig
WHFM Rochester, N. Y. M) William Fay
WHNF New York, N. Y.
WIP-FM Philadelphia 7, Pa. M) Benedict Gimbel, Jr., C) Clifford C. Harris
WIUC Champaign, Ill. M) Jos. F. Wright, C) A. James Ebel
WLBG Philadelphia 2, Pa. M) Edward D. Clery, C) John H. Henninger
WLOU Detroit 26, Mich. C) E. H. Clark
WMFM Milwaukee 1, Wisc. C) Phil B. Laeser
WMIT Marion, N. C. C) Paul Dillon
WMLL Evansville 14, Ind. M) Clarence Leich, C) Erwin P. Schoeny
WMTW Mt. Washington, N. H. M) John Shepard, 3rd, C) Lafayette A. Gosselin
WNBF-FM Binghamton, N. Y. M) Cecil D. Mastin, C) Lester H. Gilbert
WNYC-FM New York, N. Y. M) M. S. Novik, C) John De Prospo
WNYE New York, N. Y.
WOWO-FM Fort Wayne, Ind. M) J. B. Conley, C) Bruce H. Ratts
WPEN-FM, Philadelphia, Pa. M) Arthur Simon, C) Charles W. Burtis
WQXQ New York 19, N. Y. M) Elliott M. Sanger
WSBF South Bend, Ind. M) F. D. Schurz, C) H. G. Cole
WSM-FM Nashville 3, Tenn. M) Harry Stone, C) George A. Reynolds
WSUN-FM St. Petersburg, Fla. M) Norman E. Brown
WTAG-FM Worcester, Mass. C) E. A. Browning
WTIC-FM Hartford, Conn. M) Paul W. Morency, C) H. D. Taylor
WTNT Pittsburgh, Pa. M) Frank R. Smith
WWZR Chicago, Ill. M) Violet Kmety, C) Ross Utter
W2XMN Alpine, N. J. M) E. H. Armstrong, C) Perry H. Osborn
W2XVT New York 22, N. Y. M) Samuel H. Cuff
W2XWG New York, N. Y.
W3XO Washington, D. C.
W63C Chicago, Ill. C) H. C. Luttgens
W8XFM Cincinnati, O. M) James D. Shouse
W9XER Kansas City 6, Mo. C) A. R. Moler
W9XYH Superior, Wisc.
W47C Chicago 1, Ill. M) Ralph Atlass

Television Broadcasting Stations

— W —

WBKB Chicago, Ill. M) Elmer C. Upton, C) A. H. Brolly
WCBW New York, N. Y.
WMJT Milwaukee, Wis. C) Phil B. Laeser
WNBT New York, N. Y.
WPTZ Philadelphia, Pa.
WRGB Schenectady, N. Y.
WTZR Chicago, Ill.
W2XMT, New York, N. Y.
W2XVT Passaic, N. J. M) Samuel H. Cuff
W2XWV New York, N. Y. M) Allen B. DuMont, C) Walter J. Swenson
W3XE Philadelphia, Pa.
W3XWT Washington, D. C.
W6XAO Los Angeles, Calif. C) Harry R. Lubcke
W6XLA Los Angeles, Calif. M) & C) Klaus Landsberg
W6XYZ Los Angeles, Calif. M) & C) Klaus Landsberg
W8XCT Cincinnati, O.
W9XBK Chicago, Ill. M) Elmer C. Upton, C) A. H. Brolly
W9XBT As above
W9XPR Chicago, Ill.
W9XUI Iowa City, Ia.
W9XG West Lafayette, Ind.
W9XZV Chicago, Ill.

Short Wave

— K —

KEIS Kansas City, Mo. C) A. R. Moler
KEIT Kansas City, Mo. C) A. R. Moler
KGEI Belmont, Calif.
KIEM Eureka, Calif. M) Wm. B. Smullen
KNGW Brownwood, Texas C) A. W. Stewart
KOAH Kansas City 6, Mo. C) A. R. Moler
KTRG Houston, Texas C) King H. Robinson
KWID San Francisco, Calif. M) Lincoln Deller, C) R. V. Howard
KWIX San Francisco, Calif. M) Lincoln Deller, C) R. V. Howard

— W —

WBBM Chicago, Ill. C) J. J. Belouney
WBOS Hull, Mass. C) Willard H. Houser
WBWB Terre Haute, Ind. M) Geo. M. Jackson
WCBJ Allentown, Pa. M) B. Bryan Musselmon
WCBN Brentwood, N. Y. C) Henry Grossman
WCBX Brentwood, N. Y. C) Henry Grossman
WCDA Brentwood, N. Y. C) Henry Grossman
WCRC Brentwood, N. Y. C) Henry Grossman
WGEA Schenectady, N. Y.
WGEO Schenectady, N. Y.
WGEX Schenectady, N. Y.
WKY Oklahoma City, Okla. C) H. J. Lovell
WLWK Mason, O.
WLWO Mason, O.
WLWR Mason, O.
WLWS Mason, O.
WNBI Bound Brook, N. J.
WNRA Bound Brook, N. J.
WNRE Bound Brook, N. J.
WNRI Bound Brook, N. J.
WNRX Bound Brook, N. J.
WOOC Wayne, N. J. C) Henry Grossman
WOOW Wayne, N. J. C) Henry Grossman
WRCA Bound Brook, N. J.
WRUA Scituate, Mass.
WRUL Scituate, Mass.
WRUS Scituate, Mass.
WRUW Scituate, Mass.
WRUX Scituate, Mass.
WSUN St. Petersburg, Fla. M) Norman E. Brown

AM Broadcasting Stations

— KA —

KABC San Antonio, Tex. M) Bill Michaels
KABR Aberdeen, S. D. M) A. A. Fahy
KADA Ada, Okla.
KALB Alexandria, La. M) Edgar R. Cappellini
KAND Corsicana, Tex. M) Aubrey H. Escoe
KANS Wichita, Kans. M) Jack Todd, C) Charles C. Lucy
KARK Little Rock, Ark. M) G. E. Zimmerman, C) Dan L. Winn
KARM Fresno, Calif. M) Clyde F. Coombs, C) R. M. Dorothy
KASA Elk City, Okla.
KAST Astoria, Ore.
KATE Albert Lea, Minn.
KAVE Carlsbad, N. M. C) Carl C. Cook

— KB —

KBIX Muskogee, Okla. C) Duane W. Holsington
KBIZ Ottumwa, Ia. M) Em Owen, C) Alvin P. Johnson
KBKR Baker, Ore. C) Sidney Williams
KBND Bend, Ore. M) Frank H. Loggan
KBON Omaha, Neb. M) Paul R. Fry, C) Richard Wina
KBPS Portland, Ore. M) Mrs. Mary Elizabeth Gilmore
KBST Big Spring, Tex.
KBTM Jonesboro, Ark.
KBUR Burlington, Ia. M) G. B. McDermott
KBWD Brownwood, Tex. C) A. W. Stewart

— KC —

KCKN Kansas City, Kans. C) K. J. Marquardt
KCMC Texarkana, Tex. M) Frank O. Myers, C) Paul McCaslin
KCMO Kansas City, Mo. C) Elza Glee Runkle, Jr.
KCRC Enid, Okla. C) Paul E. Snell
KCRJ Jerome, Ariz.

— KD —

KDAL Duluth, Minn.
KDB Barbara, Calif.
KDFN Casper, Wyo.
KDKA Pittsburgh, Pa. M) J. E. Baudino
KDLR Devils Lake, N. D.
KDNT Denton, Tex.
KDON Monterey, Calif. C) E. C. Duty, Jr.
KDRO Sedalia, Mo.
KDTH Dubuque, Ia. M) K. S. Gordon
KDYL Salt Lake City, Utah

— KE —

KECA Los Angeles 4, Calif. M) W. B. Ryan
KEEW Brownsville, Tex. M) E. E. Wilson, C) Glenn McIntosh
KELA Centralia, Wash.
KELD El Dorado, Ark. M) Leon Sipes
KELO Sioux Falls, S. D.
KENO Las Vegas, Nev.
KERN Bakersfield, Calif. C) Luverne Shatto
KEUB Price, Utah
KEVE Everett, Wash. C) R. H. Hilgers
KEVR Seattle 4, Wash. C) John L. Kelley
KEX Portland 5, Ore. M) Arden X. Pangborn
KEYS Corpus Christi, Tex.

— KF —

KFAB Lincoln, Neb. M) Hugh M. Feltis, C) Mark W. Bullock
KFAC Los Angeles, Calif.
KFAM St. Cloud, Minn. C) Robert B. Witschen
KFAR Fairbanks, Alaska
KFBB Great Falls, Mont. C) Wilbur L. Myhre
KFBC Cheyenne, Wyo. M) Wm. C. Grove
KFBI Wichita 1, Kans. M) Robert K. Lindsley, C) K. W. Pyle
KFBK Sacramento, Calif.
KFDA Amarillo, Tex. C) J. R. Thomas, Jr.
KFDM Beaumont, Tex. M) C. B. Locke
KFEL Denver, Col.
KFEQ St. Joseph, Mo.
KFFA Helena, Ark. M) Sam W. Anderson, C) J. C. Warren
KFGQ Boone, Ia.
KFH Wichita, Kans. M) M. M. Murdock
KFI Los Angeles 4, Calif. M) W. B. Ryan
KFIO Spokane, Wash.
KFIZ Fond du Lac, Wis.
KFJB Marshalltown, Ia.
KFJI Klamath Falls, Ore.
KFJM Grand Forks, N. D.
KFJZ Fort Worth, Tex.
KFKA Greeley, Col.
KFKU Lawrence, Kans.
KFMB San Diego 9, Calif. C) Caleb C. Frisk
KFNF Shenandoah, Ia.
KFOR Lincoln, Neb. M) H. M. Feltis, C) Mark W. Bullock
KFOX Long Beach 2, Calif. M) Lawrence W. McDowell
KFPW Fort Smith, Ark. M) J. E. Garner
KFPY Spokane 8, Wash. M) Arthur L. Bright, C) George E. Langford
KFQD Anchorage, Alaska
KFRC San Francisco 9, Calif. M) Dan J. Donnelly, C) J. J. McArdle
KFRE Fresno, Calif. M) Paul R. Bartlett, C) Sheldon W. Anderson
KFRO Longview, Tex. M) James R. Curtis, C) James R. Curtis
KFRU Columbia, Mo.
KFSD San Diego, Calif.
KFSG Los Angeles 26, Calif. M) Rev. Jack Carmaine, C) Myron E. Kluge
KFUN Las Vegas, N. M.
KFUO Clayton, Mo. M) Herman H. Hohenstein
KFVD Los Angeles, Calif.
KFVS Cape Girardeau, Mo.
KFWB Hollywood 28, Calif. M) Harry Maizlish, C) Harry Myers
KFXD Nampa, Ida. M) Frank E. Hurt, C) Edward Hurt
KFXJ Grand Junction, Col.
KFXM San Bernardino, Calif. C) Richard T. Sampson
KFYO Lubbock, Tex.
KFYR Bismarck, N. D.

— KG —

KGA Spokane 8, Wash. C) Geroge E. Grady
KGB San Diego, Calif.
KGBS Harlingen, Tex. M) Ingham S. Roberts, C) S. L. Spencer
KGBX Springfield, Mo.
KGCU Mandan, N. D. M) M. J. Reichert, C) Lee Gunderson
KGCX Sidney, Mont.
KGDE Fergus Falls, Minn.
KGDM Stockton 39, Calif. M) E. F. Peffer, C) Lloyd R. Amoo
KGEK Sterling, Col. C) Elmer G. Beehler
KGER Long Beach, Calif. M) Merwin Dobyns, C) Ron Oakley
KGEZ Kalispell, Mont.
KGFF Shawnee, Okla. M) Maxine Eddy, C) Salvatore Ricciotti
KGFJ Los Angeles 26, Calif. M) Thelma Kirchner, C) Homer M. Obuchon
KGFL Roswell, N. M. M) W. E. Whitmore
KGFW Kearney, Neb. M) E. Anson Thomas
KGFX Pierre, S. D. M) Ida A. McNeil, C) Robert H. Dye
KGGF Coffeyville, Kans. M) Hugh J. Powell
KGGM Albuquerque, N. M.
KGHF Pueblo, Col. C) Phil Gundy
KGHI Little Rock, Ark.
KGHL Billings, Mont.
KGIR Butte, Mont.
KGIW Alamosa, Col. M) E. L. Allen, C) John Gann
KGKB Tyler, Tex. M) James G. Ulmer, C) J. B. Sheppard
KGKL San Angelo, Tex. M) Lewis O. Seibert
KGKO Fort Worth, Tex.
KGKY Scottsbluff, Neb.
KGLO Mason City, Ia.
KGLU Safford, Ariz., M. P. Merrill
KGMB Honolulu, T. H.
KGNC Amarillo, Tex.
KGNO Dodge City, Kans. M) N. C. Petersen
KGO San Francisco 2, Calif. M) Don Searle, C) T. B. Palmer
KGU Honolulu, T. H. M) & C) M. A. Mulrony
KGVO Missoula, Mont. M) A. J. Mosby
KGW Portland 5, Ore. M) Arden X. Pangborn
KGY Olympia, Wash. M) Tom Olsen, C) Charles A. Roark

— KH —

KHAS Hastings, Neb.
KHBC Hilo, T. H.
KHBG Okmulgee, Okla.
KHJ Los Angeles, Calif.
KHMO Hannibal, Mo. M) Wayne W. Cribb, C) Bob Schenke
KHQ Spokane 8, Wash. C) George E. Grady
KHSL Chico, Calif. C) Emory P. Milburn
KHUB Watsonville, Calif.

— KI —

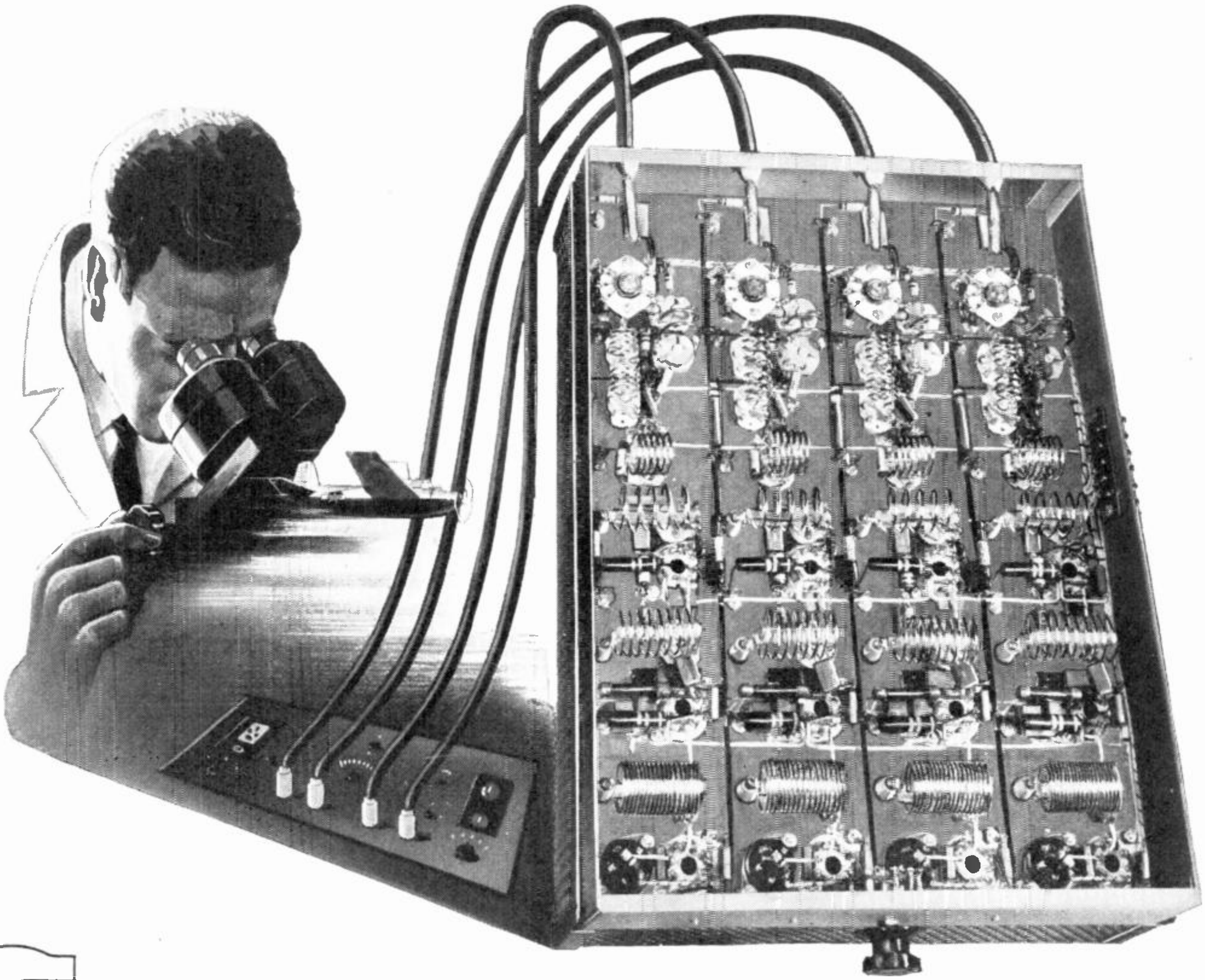
KICA Clovis, N. M.
KICD Spencer, Ia. M) L. W. Andrews
KID Idaho Falls, Ida.
KIDO Boise, Ida. M) Mrs. Georgia Phillips, C) James A. Johntz, Jr.
KIEM Eureka, Calif. M) Wm. B. Smullin
KIEV Glendale, Calif.
KILO Grand Forks, N. D.
KINY Juneau, Alaska
KIRO Seattle, Wash. M) H. J. Quilliam, C) J. B. Hatfield
KIT Yakima, Wash. M) J. A. Murphy, C) H. B. Murphy
KIUL Garden City, Kans.
KIUN Pecos, Tex. C) Carl C. Cook
KIUP Durango, Col.

— KJ —

KJBS San Francisco, Calif.
KJR Seattle 1, Wash. M) Bert F. Fisher, C) F. J. Brott

— KL —

KLBM LaGrande, Ore.
KLCN Blytheville, Ark.
KLO Ogden, Utah M) George C. Hatch, C) W. D'Orr Cozzens
KLPM Minot, N. D.
KLRA Little Rock, Ark.
KLS Oakland 12, Calif. M) S. W. Warner, C) Roger L. Roberts
KLUF Galveston, Tex.
KLX Oakland 4, Calif. M) Glenn Shaw, C) Roswell S. Smith
KLZ Denver, Col.



— KM —

KMA Shenandoah, Ia. M) J. C. Rapp, C) R. J. Schroeder
KMAC San Antonio, Tex. C) Chas. F. Harris
KMBC Kansas City, Mo. M) Arthur B. Church, C) A. R. Moler
KMED Medford, Ore C) Dave H. Rees
KMJ Fresno, Calif
KMLB Monroe, La.
KMMJ Grand Island, Neb.
KMO Tacoma 6, Wash. C) J. D. Kolesar
KMOX St. Louis 2, Mo. M) Merle S. Jones, C) Harry Harvey
KMPC Los Angeles, Calif.
KMTR Los Angeles 38, Calif. M) Kenneth O. Tinkham
KMYC Marysville, Calif.
KMYR Denver, Col.

— KN —

KNEL Brady, Tex.
KNET Palestine, Tex.
KNOW Austin, Tex. M) Hardy C. Harvey
KNX Los Angeles, Calif.

— KO —

KOA Denver, Col.
KOAC Corvallis, Ore. C) Grant S. Feikert
KOAM Pittsburg, Kans. C) Leo S. Stafford
KOB Albuquerque, N. M. C) G. S. Johnson
KOBH Rapid City, S. D. M) Robert J. Dean, C) A. E. Griffiths
KOCA Kilgore, Tex. M) Henry A. Degner, C) Albert F. Mason, Jr.
KOCY Oklahoma City, Okla. M) Matthew H. Bonebrake, C) Harold D. Durham
KODL The Dalles, Ore.
KODY North Platte, Neb.
KOH Reno, Nev. M) R. L. Stoddard, C) Tom Boland
KOIL Omaha, Neb.
KOIN Portland, Ore.
KOKO La Junta, Col.
KOL Seattle, Wash. M) Archie Taft, Sr., C) Perry C. Lind
KOMA Oklahoma City, Okla. M) F. Kenyon Brown, C) Morris W. Thomas
KOME Tulsa, Okla.
KOMO Seattle 1, Wash. M) Birt F. Fisher, C) F. J. Brott
KONO San Antonio, Tex. M) G. W. Ing, C) George W. Ing
KOOS Marshfield, Ore. M) Ben E. Stone
KORE Eugene, Ore. M) L. W. Trommlitz, C) Stanley A. Miller
KORN Fremont, Neb.
KOTN Pine Bluff, Ark. M) B. J. Parrish
KOVC Valley City, N. D.
KOVO Provo, Utah C) Gerald W. Peterson
KOWH Omaha, Neb.
KOY Phoenix, Ariz. M) Albert Johnson

— KP —

KPAB Laredo, Tex. M) Rupert S. Dougharty
KPAC Port Arthur, Tex. C) R. C. Hamilton, Jr.
KPAS Pasadena, Calif. C) Jack M. Reeder
KPDN Pampa, Tex.
KPFA Helena, Mont.
KPHO Phoenix, Ariz. M) W. T. Hix
KPLC Lake Charles, La.
KPLT Paris, Tex. C) Mitchell C. Secrest
KPMC Bakersfield, Calif.
KPO San Francisco 2, Calif. M) John W. Elwood, C) George Greaves
KPOF Denver, Col.
KPOW Powell, Wyo. M) Pat O'Halloran, C) Del Brandt
KPPC Pasadena, Calif.
KPQ Wenatchee, Wash.
KPRC Houston, Tex.
KPRO Riverside, Calif. M) W. F. Gleeson

— KQ —

KQV Pittsburgh, Pa.
KQW San Jose, Calif.

— KR —

KRBA Lufkin, Tex. M) Darrell E. Yates, C) Sam Love
KRBC Abilene, Tex C) John B. Casey
KRBM Bozeman, Mont
KRE Berkeley, Calif.
KRGV Weslaco, Tex
KRIC Beaumont, Tex. C) Ben Hughes
KRIS Corpus Christi, Tex. C) R. S. Bush
KRJF Miles City, Mont.
KRKD Los Angeles, Calif. C) Willis O. Freitag
KRKO Everett, Wash. M) William R. Taft, C) Roy C. Towne
KRLC Lewiston, Ida.
KRLD Dallas, Tex.
KRLH Midland, Tex. C) Jack Cecil
KRMD Shreveport, La
KRNR Roseburg, Ore C) H. J. Chandler
KRNT Des Moines, Ia M) Craig Lawrence, C) Paul R. Huntsinger
KROC Rochester, Minn.
KROD El Paso, Tex.
KROS Clinton, Calif
KROW Oakland, Calif.
KROY Sacramento, Calif.
KRRV Sherman, Tex.
KRSC Seattle 4, Wash. M) R. E. Priebe

— KS —

KSAC Manhattan, Kans.
KSAL Salina, Kans.
KSAM Huntsville, Tex.
KSAN San Francisco, Calif.
KSCJ Sioux City 1, Ia. C) A. H. Smith
KSD St. Louis 1, Mo. C) C. R. Yarger
KSEI Pocatello, Ida. M) H. H. Fletcher, C) H. H. Fletcher
KSFO San Francisco 6, Calif. M) Lincoln Dellar, C) R. V. Howard
KSJB Jamestown, N. D.
KSKY Dallas, Tex. C) Morris M. Ming
KSL Salt Lake City 1, Utah M) Ivor Sharp C) C. R. Evans
KSO Des Moines, Ia. M) Craig Lawrence, C) Paul R. Huntsinger
KSOO Sioux Falls, S. D.
KSRO Santa Rosa, Calif.
KSTP St. Paul 2, Minn. M) Stanley E. Hubbard, C) R. Ross Hilker
KSUB Cedar City, Utah M) Hurschell G. Urie, C) Hurschell G. Urie
KSUN Lowell, Ariz.
KSWO Lawton, Okla.

— KT —

KTAR Phoenix, Ariz. C) J. H. Haughawout
KTBC Austin, Tex.
KTBI Tacoma, Wash.
KTBS Shreveport 92, La. M) John C. McCormack, C) C. H. Maddox
KTEM Temple, Tex.
KTFI Twin Falls, Ida. M) F. M. Gardner, C) Franklin V. Cox
KTHS Hot Springs, Ark. C) C. L. Sultt
KTKC Visalia, Calif. C) B. Williamson
KTKN Ketchikan, Alaska
KTMS Santa Barbara, Calif.
KTNM Tucumcari, N. M.
KTOH Lihue, T. H.
KTOK Oklahoma City, Okla. M) R. D. Enoch, C) Clifford M. Easum
KTRB Modesto, Calif.
KTRH Houston, Tex. C) K. H. Robinson
KTRI Sioux City, Ia. C) Earl J. Huss
KTSA San Antonio, Tex. M) G. W. Johnson, C) W. G. Egerton
KTSM El Paso, Tex.
KTSW Emporia, Kans.
KTTS Springfield, Mo.
KTUC Tucson, Ariz. C) C. A. Livingston
KTUL Tulsa, Okla. M) John Esau
KTW Seattle, Wash.

— KU —

KUIN Grants Pass, Ore.
KUJ Walla Walla, Wash. M) H. E. Studebaker
KUOA Siloam Springs, Ark. M) S. Whaley
KUSD Vermillion, S. D.
KUTA Salt Lake City 3, Utah M) F. C. Carman, C) Lyle O. Wahlquist

— KV —

KVAK Atchison, Kans.
KVAN Vancouver, Wash. M) Ben E. Stone
KVCV Redding, Calif.
KVEC San Luis Obispo, Calif.
KVFD Fort Dodge, Ia. C) D. G. Sinclair
KVGB Great Bend, Kans.
KVI Tacoma, Wash. M) Mrs. E. T. Irwin
KVIC Victoria, Tex.
KVNU Logan, Utah M) Reed Bullen, C) C. N. Layne
KVOA Tucson, Ariz.
KVOD Denver, Col.
KVOE Santa Ana, Calif.
KVOL Lafayette, La. M) G. H. Thomas
KVOO Tulsa, Okla. M) Wm. B. Way, C) L. W. Stinson
KVOP Plainview, Tex.
KVOR Colorado Springs, Col. C) H. C. Strang
KVOS Bellingham, Wash. C) M. W. Featherkile
KVOX Moorhead, Minn. M) M. M. Marget, C) Richard Hanson
KVRS Rock Springs, Wyo. M) H. L. McCracken, C) Archie W. Buchanan
KVSF Santa Fe, N. M.
KVSO Ardmore, Okla.
KVWC Vernon, Tex. C) H. F. Ridgway

— KW —

KWAL Wallace, Ida.
KWAT Watertown, S. D.
KWBU Corpus Christi, Tex C) Nestor Cuesta, Jr.
KWBW Hutchinson, Kans. C) M. H. Clary
KWEW Hobbs, N. M. C) Roy Evans
KWFC Hot Springs, Ark. M) W. E. Ware, C) Melvin P. Spann
KWFT Wichita Falls, Tex. M) C. E. Clough, C) John Adams
KWG Stockton, Calif. M) George Ross
KWIL Albany, Ore. M) Chet Wheeler
KWJB Globe, Ariz. M) P. Merrill
KWJJ Portland, Ore.
KWK St. Louis, Mo. C) N. J. Zehr
KWKH Shreveport, La. M) J. C. McCormack
KWKW Pasadena, Calif.
KWLC Decorah, Ia.
KWLK Longview, Wash. M) C. O. Chatterton, C) R. H. Mietzke
KWLM Willmar, Minn.
KWNO Winona, Minn. M) L. L. McCurnin
KWOC Poplar Bluff, Mo. M) P. H. Cunningham
KWON Bartlesville, Okla.
KWOS Jefferson City, Mo. C) J. H. White
KWRC Pendleton, Ore.
KWSC Pullman, Wash. M) Eldon C. Barr
KWTO Springfield, Mo.
KWYO Sheridan, Wyo.

— KX —

KXA Seattle, Wash. M) Miss Florence Wallace, C) J. H. Dubuque
KXEL Waterloo, Ia. C) D. E. Kassner
KXL Portland, Ore. C) L. K. Ballinger
KXO El Centro, Calif.
KXOK St. Louis, Mo. M) C. L. Thomas, C) A. F. Rekart
KXOX Sweetwater, Tex. M) J. Harley Hubbard, C) G. W. Dotson
KXRO Aberdeen, Wash. M) F. G. Goddard
KXYZ Houston, Tex

— KY —

KYA San Francisco, Calif. C) P. C. Schulz
KYCA Prescott, Ariz.
KYOS Merced, Calif.
KYSM Mankato, Minn. M) J. F. Meagher, C) James Houts
KYUM Yuma, Ariz. M) H. M. Phillips, C) L. Wheeler
KYW Philadelphia, Pa. C) E. H. Gager

— WA —

WAAB Worcester, Mass.
WAAC Ft. Myers, Fla.
WAAF Chicago, Ill. C) C. W. Ulrich
WAAT Newark, N. J. M) Irving R. Rosenhaus, C) Frank Bremer
WABC New York, N. Y. C) Henry Grossman
WABI Bangor, Me.
WABY Albany, N. Y.
WACO Waco, Tex.
WADC Akron, Ohio
WAGA Atlanta, Ga. M) C. Smithgall
WAGE Syracuse, N. Y. C) C. W. Brannen
WAGF Dothan, Ala.
WAGM Presque Isle, Me.
WAIM Anderson, S. C. C) H. C. Spengler
WAIR Winston-Salem, N. C. C) L. C. King
WAIT Chicago, Ill.
WAJR Morgantown, W. Va. M) H. B. McNaughton, C) Ray C. Spence.
WAKR Akron 8, Ohio M) S. B. Berk, C) W. W. Robertson
WALA Mobile, Ala.
WALB Albany, Ga. C) DeForest T. Layton, Jr.
WALL Middletown, N. Y.
WAML Laurel, Miss. M) Hugh M. Smith
WAOV Vincennes, Ind.
WAPI Birmingham, Ala. M) Thad Holt, C) Norman Sinclair Hurley

SCHEDULE OF DIRECTORIES

RADIO-ELECTRONIC PRODUCTS

February, April, June, August, October, December

BROADCASTING STATION DIRECTORY

General Managers and Chief Engineers — March, September

POLICE RADIO COMMUNICATIONS OFFICERS

January, July

CHIEF ENGINEERS OF RADIO MANUFACTURERS

May, November

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

WAPO Chattanooga 2, Tenn. M) R. G. Patterson, C) B. B. Barnes
WARM Scranton, Pa. M) M. F. Memolo, C) A. W. Oschmann
WARW Clarksdale, Miss.
WASK Lafayette, Ind.
WATL Atlanta, Ga. C) Bob Minton
WATN Watertown, N. Y.
WATR Waterbury, Conn. M) H. Thomas, C) H. Thomas
WATW Ashland, Wis. M) J. W. Huss
WAVE Louisville, Ky. C) W. E. Hudson
WAWZ Zarephath, N. J. M) Ray B. White, C) N. L. Wilson
WAYS Charlotte 2, N. C. M) G. O. Shepherd, C) John C. Price
WAYX Waycross, Ga.
WAZL Hazleton, Pa. C) J. E. Mathiot

— WB —

WBAA West Lafayette, Ind.
WBAB Atlantic City, N. J. M) Monroe L. Mendelsohn, C) Earle Godfrey
WBBB Burlington, N. C. M) E. Z. Jones
WBAL Baltimore, Md. C) G. W. Cooke
WBAP Ft. Worth, Tex.
WBAX Wilkes-Barre, Pa. M) John H. Stenger, Jr. C) John H. Stenger, Jr.
WBBB Burlington, N. C. M) E. Z. Jones
WBBL Richmond, Va.
WBBM Chicago, Ill. C) J. J. Beloungy
WBBR Brooklyn, N. Y.
WBBZ Ponca City, Okla.
WBCM Bay City, Mich. M) Hugh Giesel, C) R. H. Carpenter
WBEN Buffalo, N. Y.
WBHP Huntsville, Ala.
WBIG Greensboro, N. C. M) Edney Ridge
WBIR Knoxville, Tenn. C) J. Rex Horton
WBLJ Dalton, Ga. M) W. V. Williams
WBLK Clarksburg, W. Va.
WBML Macon, Ga. M) C. W. Pittman, C) H. S. Goodrich
WBNS Columbus, Ohio C) Lester H. Nafzger
WBNX New York, N. Y.
WBNY Buffalo, N. Y. M) R. L. Albertson, C) T. L. Vines
WBOC Salisbury, Md. C) P. A. Alfonsi
WBOW Terre Haute, Ind. M) G. M. Jackson, C) Donald D. Aldrich
WBRC Birmingham, Ala. M) John Connally, C) Gerard P. Hamann
WBRE Wilkes-Barre, Pa. C) C. Sakoski
WBRK Pittsfield, Mass.
WBRW Welch, W. Va. M) Ralph Nash, C) John E. Timberlake
WBRY Waterbury, Conn.
WBT Charlotte, N. C. C) M. J. Minor
WBTA Batavia, N. Y. M) J. M. Ryan, C) H. D. Cochran
WBTH Williamson, W. Va. C) R. B. Ward
WBTM Danville, Va. M) R. Sanford Guyer, C) H. W. Spencer
WBYN Brooklyn, N. Y. M) William Norin, C) Peter Testan
WBZ Boston 16, Mass. M) C. S. Young, C) W. H. Hauser
WBZA Springfield, Mass.

— WC —

WCAE Pittsburgh, Pa. C) J. Schultz
WCAL Northfield, Minn.
WCAM Camden, N. J.
WCAO Baltimore, Md. M) L. Waters Milbourne, C) Martin L. Jones
WCAP Asbury Park, N. J.
WCAR Pontiac, Mich M) H. Y. Levinson, C) Wayne N. Cook
WCAT Rapid City, S. D.
WCAU Philadelphia, Pa. M) Dr. Leon Levy
WCAX Burlington, Va. M) C. P. Hasbrook
WCAZ Carthage, Ill.
WCBA Allentown, Pa.
WCBI Columbus, Miss. M) B. McRaney
WCBM Baltimore, Md.
WCBS Springfield, Ill. M) C. W. Neeld
WCBT Roanoke Rapids, N. C. C) C. W. Meares
WCCO Minneapolis, Minn.
WCED DuBois, Pa.
WCFL Chicago, Ill.
WCHS Charleston, W. Va. M) H L. Chernoff, C) Odes E. Robinson
WCHV Charlottesville, Va.
WCKY Cincinnati, Ohio
WCLE Cleveland, Ohio
WCLO Janesville, Wis. C) W. T. Havens
WCLS Joliet, Ill. M) Robert M Holt, C) Lester L. De Costa
WCMI Ashland, Ky. C) C. W. Weaver
WCNC Elizabeth City, N. C. M) J. E. Aydlett
WCOA Pensacola, Fla.
WCOC Meridian, Miss. M) D. W. Gavin, C) D. W. Gavin
WCOL Columbus, Ohio M) K. B. Johnston, C) J. Ernest Lowe
WCOP Boston, Mass. C) Roland C. Hale
WCOS Columbia, S. C. M) W. C. Bochman, C) Harry L. Clippard
WCOU Lewiston, Me. C) John T. Duty
WCOV Montgomery, Ala.
WCPO Cincinnati, Ohio
WCRS Greenwood, S. C. M) Dan Crosland, C) E. C. Niemann
WCRW Chicago, Ill.
WCSC Charleston, S. C.
WCSH Portland, Me. M) W. H. Rines

— WD —

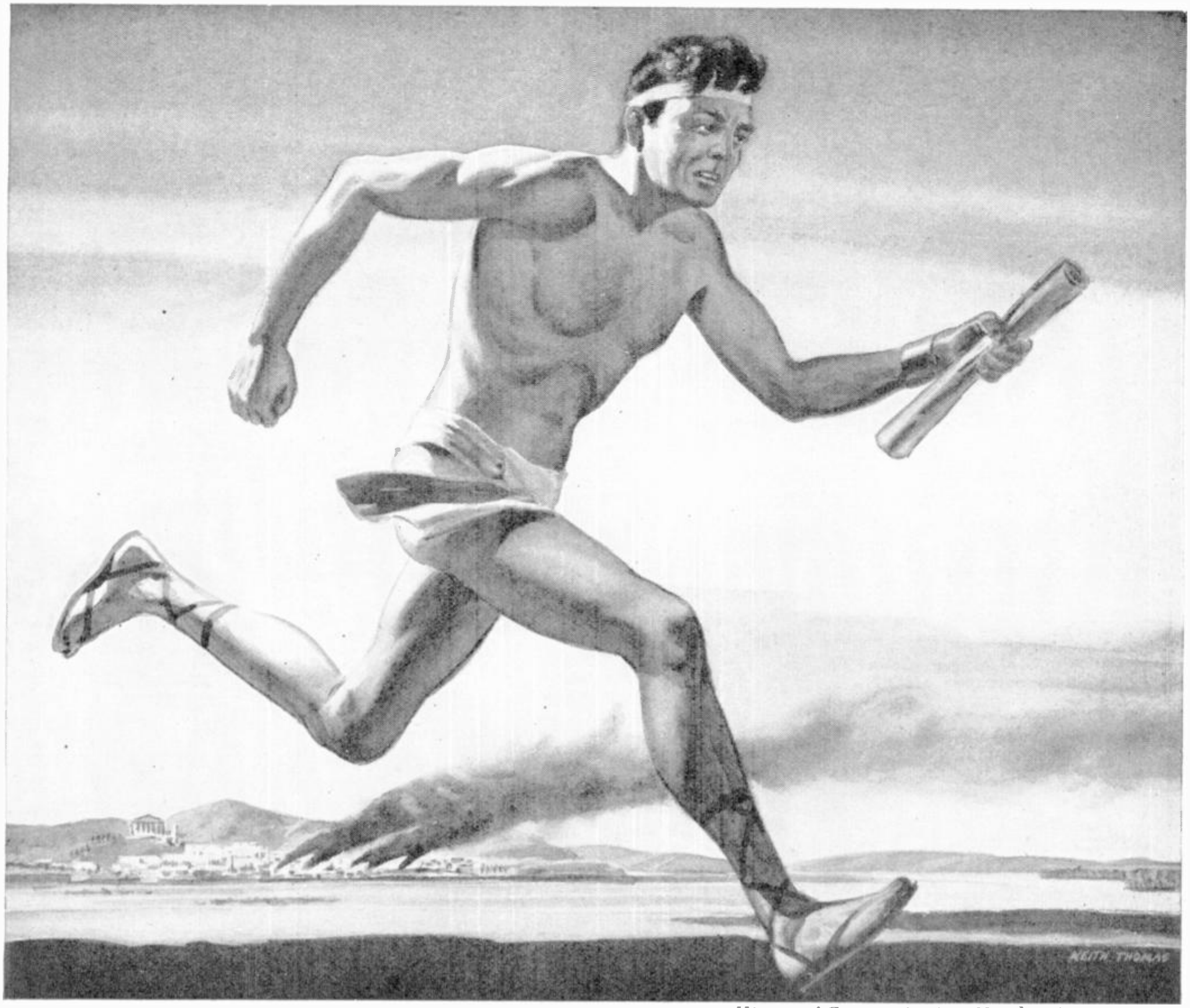
WDAE Tampa, Fla.
WDAF Kansas City, Mo. C) J. A. Flaherty
WDAK Columbus, Ga. M) L. J. Duncan
WDAN Danville, Ill. M) E. C. Hewes, C) T. G. Magin
WDAS Philadelphia, Pa.
WDAY Fargo, N. D.
WDBC Escanaba, Mich.
WDBJ Roanoke, Va. M) R. P. Jordan, C) J. W. Robertson
WDBO Orlando, Fla. M) Col. G. C. Johnston
WDEF Chattanooga 2, Tenn. M) F. S. Lane, C) B. C. Baker
WDEL Wilmington, Del. C) J. E. Mathiot
WDEV Waterbury, Vt.
WDGY Minneapolis, Minn.
WDLP Panama City, Fla. M) Pyron Hayford, C) Elmer Scott
WDMJ Marquette, Mich.
WDNC Durham, N. C. M) J. F. Jarman, C) Walter S. Hill
WDOD Chattanooga, Ten. M) Earl W. Winger, C) Julius C. Vessels
WDRC Hartford, Conn. M) Franklin M. Doolittle, C) Italo A. Martino
WDSM Superior, Wis. M) James J Conroy
WDSU New Orleans 12, La. M) Fred Weber, C) Charles Whitney
WDWS Champaign, Ill.
WDZ Tuscola, Ill

— WE —

WEAF New York, N Y C) O B Hanson
WEAN Providence, R I C) H. H. Tilley
WEAU Eau Claire, Wis C) T. O. Jorgenson
WEBC Duluth, Minn C) W. H Lounsberry
WEBQ Harrisburg, Ill
WEBR Buffalo, N Y. M) Cy King, C) R. H. Lamy
WEDC Chicago 23 Ill. M) F J Kotnour
WEED Rocky Mount, N. C.
WEEI Boston, Mass.
WEEU Reading, Pa. M) Clifford M Chafey, C) Harold O Landis
WEGO Concord, N C. M) Wayne M. Nelson
WEIM Fitchburg, Mass C) T Kalin
WELI New Haven, Conn. M) D H. Long, C) Fred King
WELL Battle Creek, Mich.
WEMP Milwaukee, Wis
WENR Chicago, Ill C) E C Horstman
WENY Elmira, N Y. M) Dale L. Taylor, C) Thurlow A. Greene
WEOA Evansville, Ind. C) Erwin P Schoeny
WERC Erie, Pa.
WEST Easton, Pa. C) J E. Mathiot
WESX Marblehead, Mass.
WEVD New York, N Y.
WEW St. Louis, Mo M) N. Pagliara, C) George Rueppel
WEXL Royal Oak, Mich. M) Ellis C. Thompson

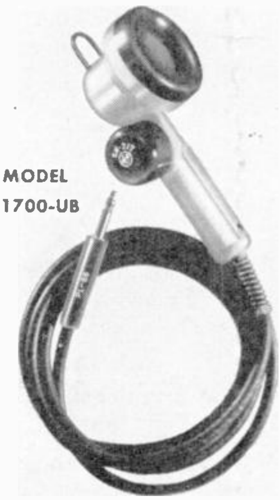
— WF —

WFAA Dallas, Tex.
WFAS White Plains, N. Y.
WFBC Greenville, S. C. M) Bevo Whitmire, C) W. C. Etheredge
WFBG Altoona, Pa C) G. R. Burgoon
WFBL Syracuse, N. Y. M) S. Woodworth, C) Col. A. R. Marcy
WFBM Indianapolis, Ind. M) F. O Sharp
WFBR Baltimore, Md. C) W. Q. Ranft
WFCI Pawtucket, R. I.
WFDF Flint, Mich. M) Howard Loeb, C) Frank D. Fallain
WFEA Manchester, N. H. C) R A. B. Schow
WFHR Wisconsin Rapids, Wis. M) Geo T. Frechette, C) Garth N. Bowker
WFIG Sumter, S. C. C) E. W. Roman
WFIL Philadelphia, 7 Pa. M) Roger W. Clipp, C) L. E. Littlejohn
WFIN Findlay, Ohio M) Fred R Hover, C) Edgar C. Smith
WFLA Tampa, Fla M) W. Walter Tison, C) Joe H. Mitchell



History of Communications Number One of a Series

A FORERUNNER OF MODERN COMMUNICATIONS



MODEL
1700-UB

One of the first known channels of message carrying was by runner, and annals of Grecian and Phoenician history describe the nimble lads who firmly grasped rolls of parchment and sped hither and yon. Clad in typical running gear of the period, they covered amazing distances with almost incredible speed. That was the forerunner of today's modern communications where scientific electronic devices are "getting the message through" on every war front. Universal Microphone Co. is proud of the part it plays in manufacturing microphones and voice communication components for all arms of the United States Armed Forces, and for the United Nations as well. Other drawings in the series will portray the development of communications down through civilization and the ages to the modern era of applied electronics.

< Model 1700-UB, illustrated at left, is but one of several military type microphones now available to priority users through local radio jobbers.

UNIVERSAL MICROPHONE CO., LTD.
INGLEWOOD, CALIFORNIA

BROADCASTING STATION DIRECTORY

WFMD Frederick, Md.
WFMJ Youngstown, Ohio
WFNC Fayetteville, N. C. M) W. C. Ewing
WFOR Hattiesburg, Miss.
WFOY St. Augustine, Fla.
WFPG Atlantic City, N. J. M) Edwin E. Kohn, C) Blair K. Thron
WFTC Kinston, N. C. M) Jonas Weiland, C) David E. Hardison
WFTL Ft. Lauderdale, Fla.
WFVA Fredericksburg, Va. C) Phil Whitney

— WG —

WGAA Cedartown, Ga.
WGAC Augusta, Ga. M) J. B. Fuqua, C) John Greenwood Lyon
WGAL Lancaster, Pa. C) J. E. Mathiot
WGAN Portland, Me. C) R. W. Hodgkins
WGAR Cleveland, Ohio M) J. F. Patt
WGAU Athens, Ga.
WGBB Freeport, N. Y.
WGBF Evansville, Ind.
WGBG Greensboro, N. C. M) R. M. Lambeth
WGBI Scranton, Pa.
WGBR Goldsboro, N. C. M) H. C. Bright, C) D. B. Trueblood
WGCM Gulfport, Miss. M) Hugh O. Jones
WGES Chicago, Ill.
WGGA Gainesville, Ga.
WGH Newport News, Va. M) E. E. Bishop, C) W. P. Grether
WGIL Galesburg, Ill. C) D. I. King
WGKV Charleston 1, W. Va. M) J. B. Matthews, C) Melvin Swillinger
WGL Ft. Wayne, Ind. C) Bruce H. Ratts
WGN Chicago, Ill.
WGNC Gastonia, N. C. C) W. C. Groves, Jr.
WGNY Newburgh, N. Y. M) Harold W. Cassill, C) Marvin Selmes
WGOV Valdosta, Ga.
WGPC Albany, Ga. M) Abner M. Israel, C) C. M. Kinnett
WGR Buffalo, N. Y.
WGRC Louisville, Ky. C) Perry W. Esten
WGRM Greenwood, Miss.
WGST Atlanta 1, Ga. M) Frank Gaither, John Fulton, C) Ben Akerman
WGTC Greenville, N. C. M) Mrs. Margaret J. Laughinghouse
WGTM Wilson, N. C.
WGY Schenectady, N. Y.

— WH —

WHA Madison, Wis.
WHAI Greenfield, Mass. C) Leland F. Wheeler
WHAM Rochester, N. Y.
WHAS Louisville, Ky. C) D. C. Summerford
WHAT Philadelphia, Pa.
WHAZ Troy, N. Y.
WHB Kansas City, Mo.
WHBB Selma, Ala.
WHBC Canton, Ohio M) Felix Hinkle, C) Kenneth L. Sliker
WHBF Rock Island, Ill. M) Leslie C. Johnson
WHBI Newark, N. J.
WHBL Sheboygan, Wis. C) H. J. Mayer
WHBQ Memphis, Tenn.
WHBU Anderson, Ind.
WHBY Appleton, Wis. C) G. E. Merkl
WHCU Ithaca, N. Y. M) M. R. Hanna
WHDF Calumet, Mich.
WHDH Boston 16, Mass. M) Ralph G. Matheson, C) Ralph G. Matheson
WHDL Olean, N. Y. M) Thomas L. Brown
WHEB Portsmouth, N. H. M) Bert George, C) Paul G. Lindsay
WHEC Rochester, N. Y. M) Gunnar O. Wiig
WHFC Cicero, Ill.
WHIO Dayton 1, Ohio M) R. H. Moody, C) Ernest L. Adams
WHIS Bluefield, W. Va. C) P. T. Flanagan
WHIT New Bern, N. C. C) G. Neuville
WHIZ Zanesville, Ohio
WHJB Greensburg, Pa. M) G. J. Podeyn
WHK Cleveland, Ohio M) H. K. Carpenter, C) Ralph H. De Lany
WHKC Columbus, Ohio
WHKY Hickory, N. C. M) Carl C. Aley
WHLB Virginia, Minn. M) O. H. Peterson
WHLD Niagara Falls, N. Y. M) E. C. Hull, C) Robert J. Wilson
WHLN Harlan, Ky.
WHLS Port Huron, Mich. M) Harmon L. Stevens
WHMA Anniston, Ala. C) James Hudson
WHN New York, N. Y.
WHO Des Moines, Ia. M) J. O. Maland
WHOM Jersey City, N. J.
WHOP Hopkinsville, Ky. M) F. E. Lackey, C) James C. Miller, III
WHP Harrisburg, Pa.
WHUB Cookeville, Tenn.
WHYN Holyoke, Mass. M) P. J. Montague, C) Thomas R. Humphrey

— WI —

WIAC San Juan, P. R.
WIBA Madison, Wis. M) E. C. Allen, C) N. H. Hahn
WIBC Indianapolis, Ind.
WIBG Philadelphia, Pa. C) John H. Henninger
WIBM Jackson, Mich. C) C. Wirtanen
WIBU Poynette, Wis.
WIBW Topeka, Kans. M) Ben Ludy, C) K. G. Marquardt
WIBX Utica, N. Y. M) Mrs. Scott H. Bowen, C) John T. Dowdell
WICA Ashtabula, Ohio
WICC Bridgeport, Conn. M) J. T. Lopez, C) George Kelch
WIGM Medford, Wis. M) Irma Meyer, C) Gerald J. Boos
WIL St. Louis, Mo. M) L. A. Benson
WILL Urbana, Ill. M) Joseph F. Wright, C) A. James Ebel
WILM Wilmington, Del. C) J. E. Mathiot
WINC Winchester, Va. C) Phil Whitney
WIND Gary, Ind. C) Victor H. Voss
WING Dayton, Ohio M) R. B. Woodyard
WINN Louisville 1, Ky. C) V. R. Nunn
WINS New York, N. Y. M) C. G. Cosby
WINX Washington, D. C. C) R. E. Cannon
WIOD Miami, Fla. C) Wilton R. Chiles
WIP Philadelphia, Pa. M) Benedict Gimbel, Jr., C) C. C. Harris
WIRE Indianapolis 6, Ind. C) E. E. Alden
WIS Columbia, S. C. C) Scott Helt
WISE Asheville, N. C. M) Harold Thoms, C) Madeline Hollerith
WISH Indianapolis, Ind. M) C. Bruce McConnell, C) Stokes Gresham, Jr.
WISN Milwaukee, Wis. M) G. W. Grignon, C) N. J. Richard
WISR Butler, Pa.
WITH Baltimore 2, Md. M) T. G. Tinsley, C) James S. Duff
WIZE Springfield, Ohio C) A. F. Martin

— WJ —

WJAC Johnstown, Pa. M) J. C. Tully, C) N. L. Straub
WJAG Norfolk, Neb.
WJAR Providence, R. I. C) T. C. J. Prior
WJAS Pittsburgh, Pa.
WJAX Jacksonville, Fla.
WJBC Bloomington, Ill.
WJBK Detroit, Mich. M) James Hopkins
WJBO Baton Rouge, La. C) W. T. Golson
WJBW New Orleans, La.
WJBY Gadsden, Ala.
WJDX Jackson, Miss.
WJEJ Hagerstown, Md. M) Grover C. Crilley, C) George W. McIntire
WJHL Johnson City, Tenn. M) W. Hanes Lancaster, C) O. K. Garland
WJHO Opelika, Ala.
WJHP Jacksonville 1, Fla. M) Wallace A. Walker, C) Beecher Hayford
WJIM Lansing 16, Mich. C) Mel Wirth
WJJD Chicago, Ill. M) Ralph Atlass, C) Walter F. Myers
WJLB Detroit, Mich. C) E. H. Clark
WJLD Bessemer, Ala.
WJLS Beckley, W. Va. C) A. J. Ginkel
WJMC Rice Lake, Wis.
WJMS Ironwood, Mich. M) J. W. Huss, C) Arne Dahlbacka
WJNO W. Palm Beach, Fla.
WJOB Hammond, Ind.
WJPA Washington, Pa. M) John M. Croft, C) Joseph M. Troesch
WJPF Herrin, Ill. M) Charles R. Cook
WJPR Greenville, Miss. M) Emmet H. McMurray
WJR Detroit 2, Mich. M) L. Fitzpatrick
WJRD Tuscaloosa, Ala.
WJTN Jamestown, N. Y. M) D. S. Wilkins
WJW Cleveland, Ohio
WJZ New York 20, N. Y. M) John Harrington McNeil, C) George O. Milne
WJZM Clarksville, Tenn. M) W. E. Williams, C) W. B. Thurman

— WK —

WKAQ San Juan, Puerto Rico
WKAR East Lansing, Mich.
WKAT Miami Beach, Fla.
WKBB Dubuque, Ia. M) Jas. D. Carpenter
WKBH LaCrosse, Wisc. M) Howard Dahl, C) Alvin Leeman
WKBN Youngstown, O. M) W. P. Williamson
WKBO Harrisburg, Pa. C) J. E. Mathiot
WKBV Richmond, Ind.
WKBW Buffalo, N. Y.
WKBZ Muskegon, Mich. C) Geo. Krivitzky
WKEU Griffin, Ga.
WKEY Covington, Va. M) Earl M. Key
WKIP Poughkeepsie, N. Y. M) Richard E. Coon
WKMO Kokomo, Ind. M) John C. Jeffrey, C) Geo. E. Palmer
WKNE Keene, N. H. M) David Carpenter, C) Ernest F. Batchelder, Jr.
WKNY Kingston, N. Y. C) Wilbur J. Fahey
WKOK Sunbury, Pa. M) Melvin Lahr
WKPA New Kensington, Pa.
WKPT Kingsport, Tenn. C) Gladwin W. Upchurch
WKRC Cincinnati, O. M) Ken Church, C) Geo. A. Wilson
WKRO Cairo, Ill.
WKST New Castle, Pa. M) A. W. Graham
WKWK Wheeling, W. Va. C) F. A. Baker
WKY Oklahoma City, Okla. M) Gayle V. Grubb, C) H. J. Lovell
WKZO Kalamazoo, Mich. C) Carl E. Lee

— WL —

WLAC Nashville, Tenn. M) F. C. Sowell
WLAG La Grange, Ga.
WLAK Lakeland, Fla.
WLAP Lexington, Ky. M) Ed. Willis, C) Sanford Helt
WLAV Grand Rapids, Mich. C) R. A. Plank
WLAW Lawrence, Mass. M) Irving E. Rogers, C) Geo. A. Hinckley
WLAY Muscle Shoals City, Ala.
WLB Minneapolis, Minn. C) B. A. Holmberg
WLBC Muncie, Ind. M) D. A. Burton
WLBJ Bowling Green, Ky.
WLBL Stevens Point, Wisc.
WLBZ Bangor, Me.
WLDS Jacksonville, Ill.
WLEU Erie, Pa.
WLIB Brooklyn, N. Y. M) Elias I. Godofsky, C) Arthur Faske
WLLH Lowell, Mass. M) Robt. F. Donahue, C) Ralph B. Newton
WLNH Laconia, N. H.
WLOF Orlando, Fla.
WLOG Logan, W. Va.
WLOK Lima, O. M) Ralph G. Elvin
WLOL Minneapolis, Minn. M) E. S. Mittendorf
WLPM Suffolk, Va. M) Fred L. Hart
WLS Chicago, Ill. M) Glenn Snyder, C) Thomas L. Rowe
WLVA Lynchburg, Va.
WLW Cincinnati, O. M) Jas. D. Shouse

— WM —

WMAL Washington, D. C. M) K. H. Berkeley, C) Dan Hunter
WMAM Marinette, Wis. M) J. D. Mackin
WMAN Mansfield, O.
WMAQ Chicago, Ill. M) Harry C. Kopf, C) H. C. Luttgens
WMAS Springfield, Mass. M) W. M. Greenwood, C) Earle G. Hewinson
WMAZ Macon, Ga.
WMBD Peoria, Ill. M) Edgar L. Bill, C) Ted Giles
WMBG Richmond, Va.
WMBH Joplin, Mo. M) D. J. Poynor
WMBI Chicago, Ill.
WMBO Auburn, N. Y. M) Fred L. Keesee
WMBR Jacksonville, Fla. M) Frank King, C) Ernest B. Vordermark
WMBS Uniontown, Pa. C) W. J. Henzly
WMC Memphis, Tenn. M) H. W. Slavick, C) E. C. Frase, Jr.
WMCA New York, N. Y. C) Frank L. Marx
WMEX Boston, Mass.
WMFD Wilmington, N. C. M) R. A. Dunlea, C) E. L. Herring
WMFF Plattsburgh, N. Y. M) Geo. F. Bissell, C) John M. Nazak
WMFG Hibbing, Minn. C) W. H. Lounsberry
WMFR High Point, N. C. M) H. M. Lambeth
WMGA Moultrie, Ga. M) F. R. Pidcock, C) Jas. M. Wilder
WMIN St. Paul, Minn. M) Edward Hoffman
WMIS Natchez, Miss. C) Thomas W. Patterson
WMJM Cordele, Ga.
WMMN Fairmont, W. Va. C) Robt. D. Hough
WMOB Mobile, Ala.
WMOG Brunswick, Ga.
WMPC Lapeer, Mich.
WMPS Memphis, Tenn. M) K. R. Krebetein, C) H. R. Krebstein
WMRC Greenville, S. C. M) W. Ennis Bray, C) Geo. D. Tate
WMRF Lewistown, Pa.
WMRN Marion, O.
WMRO Aurora, Ill. C) Vincent G. Cofey
WMSL Decatur, Ala.
WMT Cedar Rapids, Ia.
WMUR Manchester, N. H. C) Vincent H. Chandler
WMVA Martinsville, Va. M) John W. Shultz, C) Dewey W. Muse

— WN —

WNAB Bridgeport, Conn.
WNAC Boston, Mass. C) I. B. Robinson
WNAD Norman, Okla.
WNAX Yankton, S. D. C) Clifton Todd
WNBC Hartford, Conn. C) Rogers B. Holt
WNBF Binghamton, N. Y. M) Cecil O. Mastin, C) L. H. Gilbert
WNBH New Bedford, Mass. M) H. R. Norman, C) E. Parker
WNBZ Saranac Lake, N. Y.
WNEL San Juan, Puerto Rico
WNEW New York, N. Y. M) B. Judis, C) M. J. Welner
WNLC New London, Conn. M) G. J. Morey, C) G. J. Morey
WNOE New Orleans, La.
WNOX Knoxville, Tenn. C) J. L. Cole, Jr.
WNYC New York, N. Y. C) John De Prospo

— WO —

WOAI San Antonio, Tex.
WOC Davenport, Ia. C) C. D. Rayburn
WOI Ames, Ia.
WOKO Albany, N. Y.
WOL Washington, D. C. C) H. H. Lyon
WOLF Syracuse, N. Y.
WOLS Florence, S. C.
WOMI Owensboro, Ky.
WOMT Manitowoc, Wisc.
WOOD Grand Rapids, Mich. M) Stanley W. Barnett, C) Fred W. Russell
WOPI Bristol, Tenn.
WOR New York, N. Y. C) J. R. Poppele
WORC Worcester, Mass.
WORD Spartanburg, S. C. M) W. J. Brown, C) M. D. Coleman
WORK York, Pa. C) J. E. Mathiot
WORL Boston, Mass. C) J. W. Parker
WOSH Oshkosh, Wisc. C) Nathan Williams
WOSU Columbus, O. M) Robt. C. Higgy
WOV New York, N. Y.
WOW Omaha, Neb.
WOWO Ft. Wayne, Ind. M) J. B. Conley, C) Bruce H. Ratts

— WP —

WPAD Paducah, Ky. M) P. E. Lackey, C) V. C. Morris
WPAR Parkersburg, W. Va.
WPAT Paterson, N. J.
WPAX Thomasville, Ga.
WPAY Portsmouth, O. M) Paul Wagner, C) Maurice L. Myers
WPDQ Jacksonville, Fla. M) Robt. R. Feagin
WPEN Philadelphia, Pa. M) Arthur Simon, C) C. W. Burtis
WPIC Sharon, Pa. C) A. C. Heck
WPRA Mayaguez, P. R. M) Andres Camara
WPRO Providence, R. I.
WPTF Raleigh, N. C.

— WQ —

WQAM Miami, Fla.
WQAN Scranton, Pa.
WQBC Vicksburg, Miss. M) O. W. Jones, C) C. E. Drake
WQXR New York, N. Y. M) Elliott M. Sanger

— WR —

WRAK Williamsport, Pa.
WRAL Raleigh, N. C. C) S. H. Brown
WRAW Reading, Pa. M) R. A. Gaul, C) Harold O. Landis
WRBL Columbus, Ga. M) J. W. Woodruff, Jr., C) Wilfred T. Siddle
WRC Washington, D. C. C) D. H. Cooper
WRDO Augusta, Me. M) Arthur Owens
WRDW Augusta, Ga. C) Harvey Aderhold
WREC Memphis, Tenn.
WREN Lawrence, Kans. M) Verl Bratton
WRGA Rome, Ga.
WRJN Racine, Wis.
WRLC Toccoa, Ga. M) Virgle E. Craig
WRNL Richmond, Va.
WROK Rockford, Ill.
WROL Knoxville, Tenn. C) J. N. Gilbert
WRR Dallas, Tex. C) Durward J. Tucker
WRRF Washington, N. C. C) G. P. Martin
WRRN Warren, O.
WRUF Gainesville, Fla.
WRVA Richmond, Va.

— WS —

WSAI Cincinnati, O.
WSAJ Grove City, Pa.
WSAM Saginaw, Mich. C) V. T. Seaman
WSAN Allentown, Pa. M) B. Bryan Musselman, C) R. H. Musselman
WSAP Portsmouth, Va. M) T. W. Aydlett, C) Denzil Pulley
WSAR Fall River, Mass. M) Wm. T. Welch
WSAU Wausau, Wisc. M) Ben F. Hovel, C) Roland W. Richardt
WSAV Savannah, Ga. C) M. E. Thompson
WSAY Rochester, N. Y. M) G. P. Brown, C) G. P. Brown
WSAZ Huntington, West Va. C) John E. Csensich
WSB Atlanta, Ga. M) J. M. Outler, C) C. F. Daugherty
WSBA York, Pa. M) Louis Vyner, C) Willis N. Weaver
WSBC Chicago, Ill.
WSBT South Bend, Ind. M) F. D. Schurz, C) H. G. Cole
WSFA Montgomery, Ala. M) H. E. Pill
WSGN Birmingham, Ala. C) G. F. Bishop
WSIX Nashville, Tenn. M) Jack M. Draughon, C) Bascom E. Porter
WSJS Winston-Salem, N. C.
WSKB McComb, Miss.
WSLB Ogdensburg, N. Y.
WSLI Jackson, Miss. C) C. A. Perkins
WSLS Roanoke, Va.
WSM Nashville, Tenn. M) Harry Stone, C) George Reynolds
WSMB New Orleans, La.
WSNJ Bridgeton, N. J. C) Francis C. Fekel
WSNY Schenectady, N. Y.
WSOC Charlotte, N. C.
WSON Henderson, Ky. M) H. S. Lackey
WSOO Sault Ste. Marie, Mich. M) Stanley R. Pratt, C) Eugene T. Kaari
WSOY Decatur, Ill. C) Paul A. Wnorowski
WSPA Spartanburg, S. C. M) Walter J. Brown, C) H. R. Beckholt
WSPB Sarasota, Fla. M) John B. Browning, C) Wm. Stringfellow
WSPD Toledo, O. M) E. Y. Flannigan, C) Wm. Stringfellow
WSPR Springfield, Mass. M) Q. A. Brackett
WSRR Stamford, Conn. M) H. H. Meyer
WSTP Salisbury, N. C. C) Carl Watson
WSTV Steubenville, O. M) J. J. Laux, C) J. M. Troesch
WSUI Iowa City, Ia. M) Carl H. Menzer, C) S. J. Ebert
WSUN St. Petersburg, Fla. M) Norman L. Brown, C) Louis J. Link
WSVA Harrisonburg, Va.
WSYB Rutland, Vt. M) J. H. Weiss
WSYR Syracuse, N. Y. C) A. G. Belle Isle

— WT —

WTAD Quincy, Ill. M) C. Arthur Fifer, C) Francis Wentura
WTAG Worcester, Mass. C) E. A. Browning
WTAL Tallahassee, Fla. M) Mrs. Teresa M. Myers
WTAM Cleveland, Ohio
WTAO Green Bay, Wis. C) W. J. Stangel
WTAR Norfolk, Va. M) Campbell Arnoux, C) J. L. Grether
WTAW College Station, Tex. M) Ted Hills, C) H. C. Dillingham
WTAX Springfield, Ill. M) Jay A. Johnson
WTBO Cumberland, Md.
WTCM Traverse City, Mich.
WTCN Minneapolis, Minn.
WTEL Philadelphia, Pa.
WTHT Hartford, Conn. M) C. Glover DeLaney, C) Charles S. Masini
WTIC Hartford, Conn. C) H. D. Taylor
WTJS Jackson, Tenn. M) Albert A. Stone
WTMA Charleston, S. C. M) Robert E. Bradham, C) Douglass M. Bradham
WTMC Ocala, Fla. M) T. S. Gilchrist, Jr.
WTMJ Milwaukee, Wis. C) W. H. Hebal
WTMV E. St. Louis, Ill.
WTNJ Trenton, N. J.
WTOC Savannah, Ga. M) W. T. Knight, Jr., C) Claude M. Gray
WTOL Toledo, Ohio
WTOP Washington 4, D. C. M) Carl J. Burkland
WTRC Elkhart, Ind. M) R. R. Baker, C) Lester W. Zellmer
WTRY Troy, N. Y.) Waldo P. Whitman
WTSP St. Petersburg, Fla. M) Lev L. D. Herron, C) William D. Mangold
WTTM Trenton, N. J. C) Wm. R. Petz

— WW —

WWDC Washington, D. C.
WWJ Detroit, Mich.
WWL New Orleans 12, La. M) W. H. Summerville, C) J. D. Bloom
WWNC Asheville, N. C. M) Don C. Elias, C) C. B. Hoskins
WWNY Watertown, N. Y.
WWPG Palm Beach, Fla.
WWRL Woodside, N. Y.
WWSR St. Albans, Vt.
WWSW Pittsburgh, Pa. M) Frank R. Smith
WWVA Wheeling, W. Va.

— WX —

WXYZ Detroit, Mich.

CANADA

AM Broadcasting Stations

— CB —

CBA Sackville, N. B.
CBF Montreal, Que.
CBJ Chicoutimi, Que. M) V. Fortin
CBK Watrous, Sask.
CBL Toronto, Ont.
CBM Montreal, Que.
CBO Ottawa, Ont.
CBR Vancouver, B. C.
CBV Quebec, Que. M) Maurice Valiquette, C) Charles Frenette

BROADCASTING STATION DIRECTORY

— CF —

CFAC Calgary, Alta.
CFAR Flin Flon, Man.
CFBR Brockville, Ont.
CFCF Montreal, Que. M) R. M. Brophy
CFCH North Bay, Ont.
CFCN Calgary, Alta.
CFCO Chatham, Ont.
CFCY Charlottetown, P. E. I. C) R. F. Large
CFGP Grande Prairie, Alta.
CFJC Kamloops, B. C. C) R. J. Tate
CFNB Fredericton, N. B.
CFOS Owen Sound, Ont. M) William N. Hawkins
CFPL London, Ont. M) Charles Thomas, C) John C. Warder
CFPR Prince Rupert, B. C.
CFQC Saskatoon, Sask. M) A. A. Murphy, C) Stan Clifton
CFRB Toronto, Ont. M) Harry Sedgwick
CFRC Kingston, Ont.
CFRN Edmonton, Alta. M) G. R. A. Rice, C) F. G. Makepeace

— CH —

CHAB Moose Jaw, Sask.
CHAD Amos, Que.
CHEX Peterborough, Ont. C) A. E. Crump
CHGB St. Anne de la Pocatiere, Que. M) G. T. Desjardins
CHGS Summerside, P. E. I.
CHLN Three Rivers, Que. M) Emile Jean, C) Leon Trepanier
CHLP Montreal, Que.
CHLT Sherbrooke, Que. M) A. Gauthier, C) Romeo Paquette
CHML Hamilton, Ont. C) Wm. Crawford
CHNC New Carlisle, Que. M) Dr. Charles H. Houde
CHNS Halifax, N. S.
CHOV Pembroke, Ont.
CHPS Parry Sound, Ont. M) G. E. Smith, C) W. A. Mitchell
CHRC Quebec, Ont. M) J. Narcisse Thivierge C) Arsene Nadeau
CHSJ St. John, N. B.

— CJ —

CJAT Trail, B. C.
CJBC Toronto, Ont.
CJBR Rimouskim Que. C) J. E. d'Assylva
CJCA Edmonton, Alta.
CJCB Sydney, N. S.
CJCJ Calgary, Alta.
CJCS Stratford, Ont.
CJFX Antigonish, N. S.
CJGX Yorkton, Sask. C) Arthur Mills
CJIC Sault Ste. Marie, Ont.
CJKL Kirkland Lake, Ont. C) T. G. Watson
CJLS Yarmouth, N. S.
CJMH Medicine Hat, Alta.
CJOC Lethbridge, Alta. C) J. C. Stewart
CJOR Vancouver, B. C. C) A. H. Chandler
CJRL Kenora, Ont.
CJVI Victoria, B. C.

— CK —

CKAC Montreal, Que. C) Leonard Spencer
CKBI Prince Albert, Sask. M) Lloyd Moffat
CKCH Hull, Que. M) Georges Bourassa
CKCK Regina, Sask. M) Harold A. Crittenden
CKCL Toronto, Ont. C) E. O. Swan
CKCO Ottawa, Ont. M) G. M. Geldert, C) Wm. McLellan
CKCR Kitchener, Ont.
CKCV Quebec, Que. M) Paul LePage
CKCW Moncton, N. B. M) F. A. Hynds
CKGB Timmins, Ont.
CKLN Nelson, B. C.
CKLW Windsor, Ont. C) W. J. Carter
CKMO Vancouver, B. C. M) W. R. Gardner C) Ross L. Whiteside
CKNB Campbellton, N. B.
CKNX Wingham, Ont. M) W. T. Cruickshank, C) Scott Reid
CKOC Hamilton, Ont. M) W. T. Cranston, C) Leslie Horton
CKOV Kelowna, B. C. M) J. W. B. Browne, C) J. H. B. Browne
CKPC Brantford, Ont.
CKPR Port Arthur, Ont. C) R. H. Parker
CKRC Winnipeg, Man. M) G. Gaetz
CKRM Regina, Sask. C) Wm. McDonald
CKSO Sudbury, Ont.
CKTB St. Catharines, Ont. C) W. H. Allen
CKUA Edmonton, Alta.
CKVD Vald'Or, Que. C) J. W. Peters
CKWS Kingston, Ont. M) Jack K. Cooke C) G. E. McCurdy
CKWX Vancouver, B. C.
CKX Brandon, Man. C) E. R. Collins
CKY Winnipeg, Man.

— VO —

VONF St. Johns, Nfd. M) William F. Galgay

Shortwave

CBFW Montreal, Que.
CBFX Montreal, Que. M) R. M. Brophy
CBFY Montreal, Que.
CBFZ Montreal, Que.
CBRX Vancouver, B. C.
CFCX Montreal, Que.
CJCX Sydney, N. S.
CFRX Toronto, Ont.
CFVP Calgary, Alta.
CHNX Halifax, N. S.
CKFX Vancouver, B. C.
CKRX Winnipeg, Man.

CUBA

CMAC, Guanajay, José M. Alvarez Valdés
CMBA, Santiago de las Vegas, Rafael Prieto
CMBF, Havana, Humberto Anderes Peña
CMHM, Cienfuegos, Jose R. Fementas, Jr.
CMJK, Camagüey, Mario Rivero
CMJW, Camaguey, Manuel Manen Olmo
CMK, Havana, Liberto Cao Alarcón
CMKF, Holguin, Manuel J. de Góngora Mason
CMKY, Puerto Padre, Ote. Pedro Zacca
CMOX, Havana, Edward E. Chisholm
COBF, Havana, Humberto Anderes Pena
COJK, Camaguey, Vincent P. Jones

HONDURAS

HRPI, San Pedro Sula, Jorge Monterrosa

MEXICO

XEAC, Tijuana, B. C. Manuel Aguna Varela
XEB, Mexico City, Juan Cross Buchanan
XEBG, Tijuana, B. C. Manuel Rojo L.
XEBH, Hermosillo, Son. Jose Remigio Agraz
XEBR, Hermosillo, Son. Jose Remigio Agraz
XEBW, Chihuahua, Enrique Ricart Corts
XECF, Los Mochis Sin. Francisco Perez, Jr.
XEH, Monterrey, N. L. Constantino de Tarnava, Jr. E.E.
XEFW, Tampico, Tam. J. E. Martinez
XEHR, Puebla, Pue. Angel Valera Gonzalez
XEIW, Chihuahua, Enrique Ricart Corts
XELO, Juarez, W. E. Branch
XELZ, Mexico City, Manuel Zetina
XEMO, Tijuana, Lower Calif. Fred Ferreira
XEN, Mexico City, S. Del Conde
XENN, Mexico City, S. Del Conde
XEP, C. Juarez, Chih. Esteban Parra
XERC, Mexico, D. F. M. M. Huerta
XESM, Mexico City, Salvador San Martin
XETS, Tapachula, Chis. Napoleon Correa
XETM, Naco, Son. Hector Campoy

NICARAGUA

Gilillan, Leon, Dionisio E. Gallo
La Voz de los Lagos, Managua, R. Ernesto Gutierrez
La Voz de la America Central, Mangua, Mendoza y Hnos
La Voz de la Sultana, Granada, Jose F. Tercero Z.
La Voz del Mombacho, Granada, Leonidas A. Tenorio

PERU

OAX4C, Bellavista, Lima, Alvarado y Urteaga
OAX4E, Oeona 58, Lima, Juan P. Goycochea
OAX4K, Lima, Juan P. Goycochea

PORTO RICO

WKAQ, San Juan, A. P. del Valle

VENEZUELA

YV1RA, Maracaibo, Manuel Arraez
YV1RC, Maracaibo, Hermilio Cabrera
YV1RF, Maracaibo, G. Nouel Debrot
YV1RK, Maracaibo, Manuel Belisario
YV1RL, Maracaibo, Manuel Belisario
YV1RT, Maracaibo, Hermilio Cabrera
YV1RV, Maracaibo, Manuel Arraez
YV1RW, Coro, Victor Jaime R.
YV1RX, Maracaibo, G. Nouel Debrot
YV1RY, Coro, Victor Jaime R.
YV2RB, San Cristobal, Diaz Gonzalez
YV2RN, San Cristobal, Diaz Gonzalez
YV3RE, Barquisimeto, Amilcar Segura
YV3RN, Barquisimeto, Amilcar Segura
YV4RA, Valencia, Ramon Nunez, h.
YV4RL, Maracay, Atilio Ormezzano
YV4RK, Maracay, Atilio Ormezzano
YV4RO, Valencia, Ramon Nunez, h.
YV5RA, Caracas, J. Marcano C.
YV5RB, Caracas, G. Siblesz
YV5RH, Caracas, P. Castillo Rey
YB5RG, Caracas, Ramon T. Barrios
YV5RI, Caracas, Rivero, Armando
YV5RL, Caracas, M. Rodriquez B.
YV5RM, Caracas, G. Siblesz
YV5RN, Caracas, J. Marcano C.
YV5RQ, Caracas, H. Degwitz
YV5RS, Caracas, H. Degwitz
YB5RU, Caracas, Ramon T. Barrios
YV5RV, La Guaira, M. Cisneros S.
YV5RW, Caracas, M. Rodriquez B.
YV5RX, Caracas, P. Castillo Rey
YV5RY, Caracas, Rivero, Armando
YV5RZ, La Guaira, M. Cisneros S.
YV6RC, Barcelona, Areaza Almenar
YV6RE, Barcelona, Arreaza Almenar

UNITED STATES

General Managers

— A —

Albertson, Roy L. WBNY
Aley, Carl C. WHKY
Allen, E. C. WIBA
Allen, E. L. KGIW
Anderson, Sam W. KFFA
Andrews, L. W. KICD
Armstrong, Edwin H. W2XMN
Arnoux, Campbell WTAR
Asch, Leonard L. WBCA
Atlass, Ralph WJJD, W47C
Aydlett, J. E. WCNC
Aydlett, T. W. WSAP

— B —

Baker, R. R. WTRC
Barnett, Stanley W. WOOD
Barr, Eldon C. KWSC
Bartlett, Paul R. KFRE
Baudino, J. E. KDKA, KDKA-FM
Benson, L. A. WIL
Berk, S. Bernard WAKR
Berkeley, Kenneth H. WMA
Bill, Edgar L. WMBD
Bishop, Edward E. WGH
Bissell, George F. WMFF
Bonebrake, Matthew H. KOCY
Bochman, W. C. WCOS
Bowen, Mrs. S. H. WIBX
Brackett, Quincy A. WSPR
Bradham, Robert E. WTMA
Bratton, Verl WREN
Bray, W. Ennis WMRC
Bridges, W. C. WDUL
Bright, Arthur L. KFPY
Bright, Harry G. WGBR
Brown, F. Kenyon KOMA
Brown, Gordon P. WSAY
Brown, Norman E. WSUN
Brown, Thomas L. WHDL
Brown, Walter J. WORD, WSPA
Browning, John B. WSPB
Bullen, Reed KVNU
Bowen, Mrs. Scott H. WIBX
Burkland, Carl J. WTOP
Burton, D. A. WLBC

— C —

Camara, Andres WPRA
Cappellini, Edger R. KALB
Carmaine, Rev. Jack KFSG
Carman, Frank C. KUTA
Carpenter, David WKNE
Carpenter, H. K. WHK
Carpenter, James D. WKBB
Cassill, Harold W. WGNY
Chafey, Clifford M. WEEU
Chatterton, C. O. KWLK
Chernoff, Howard L. WCHS
Church, Arthur B. KMBC
Church, Ken WKRC
Clery, Edward D. WLBG
Clipp, Roger W. WFIL, WFIL-FM
Clough, Chas. E. KWFT
Conley, J. B. WOWO, WOWO-FM
Connally, John WBRC
Conroy, James J. WDSM
Cook, Chas. R. WJPF
Coombs, Clyde F. KARM
Coon, Richard E. WKIP
Cosby, Clarence G. WINS
Craig, Virgle E. WRLC
Cribb, Wayne W. KHMO
Crilley, Grover C. WJEJ
Croft, John M. WJPA
Crosland, Dan. WCRS
Cuff, Samuel H. W2XVT
Cunningham, P. H. KWOC
Curtis, James R. KFRO

— D —

Dahl, Howard WKBH
Dean, Robert J. KOBH
Degner, Henry A. KOCA
DeLaney, C. Glover WTHT
Dellar Lincoln, KSFO, KWID, KWIX
Dobyns, Merwin KGER
Donahue, Robert F. WLLH
Donnelly, Dan J. KFRC
Doolittle, Franklin M. WDRC, WDRC-FM
Dougharty, Rupert S. KPAB
Draughon, Jack M. WSIX
DuMont, Allen B. W2XWV
Duncan, L. J. WDAK
Dunlea, R. A. WMFD

— E —

Eddy, Maxine KGFF
Elias, Don S. WWNC
Elvin, Ralph G. WLOK
Elwood, John W. KPO
Enoch, Robert D. KTOK
Esau, John KTUL
Escoe, Aubrey H. KAND
Ewing, W. C. WFNC

— F —

Fahy, A. A. KABR
Fay, William WHFM
Feagin, Robert R. WPDQ
Feltis, Hugh M. KFAB, KFOR
Fifer, C. Arthur WTAD
Fisher, Birt F. KJR, KOMO
Fitzpatrick, Leo WJR
Flannigan, E. Y. WSPD
Fletcher, Henry H. KSEI
Frechette, Geo. T. WFHR
Fry, Paul R. KBON
Fulton, John WGST
Fuqua, J. B. WGAC

— G —

Gaither, Frank WGST
Gardner, F. M. KTFI
Garner, J. E. KFPW
Gaul, Raymond A. WRAW
Gavin, D. W. WCOC
Georges, Bert WHEB
Giesel, Hugh WBCM
Gilchrist, T. S., Jr. WTMC
Gilmor, Mrs. Mary E. KBPS
Gimbel, Benedict, Jr. WIP, WIP-FM
Gleeson, W. L. KPRO
Goddard, Fred G. KXRO
Godofsky, Elias I. WLIB
Gordon, K. S. KDTH
Graham, A. W. WKST
Greenwood, Warren M. WMAS
Grignon, G. W. WISN
Grove, Wm. C. KFBC
Grubb, Gayle V. WKY
Guyer, R. Sanford WBTM

— H —

Hahn, N. H. WIBA
Hanna, Michael R. WHCU
Hart, Fred L. WLPM
Harvey, Hardy C. KNOW
Hasbrook, C. P. WCAX
Hatch, George C. KLO
Hayford, Byron WDLP
Herron, Lex L. D. WTSP
Hewes, E. C. WDAN
Higgy, Robert C. WOSU
Hills, Ted WTAW
Hinkle, Felix WHBC
Hix, W. T. KPHO
Hoffman, Edward WMIN
Hohenstein, Herman H. KFUO
Holt, Robert M. WCLS
Hopkins, James WJBK
Holt, Thad WAPI
Hovel, Ben F. WSAU
Hover, Fred R. WFIN
Hubbard, Harley KNOX
Hubbard, Stanley E. KSTP
Hull, Earl C. WHLD
Hurt, Frank E. KFXD
Huss, J. W. WJMS, WATW

— I —

Irwin, E. T., Mrs. KVI
Israel, Abner M. WGPC

— J —

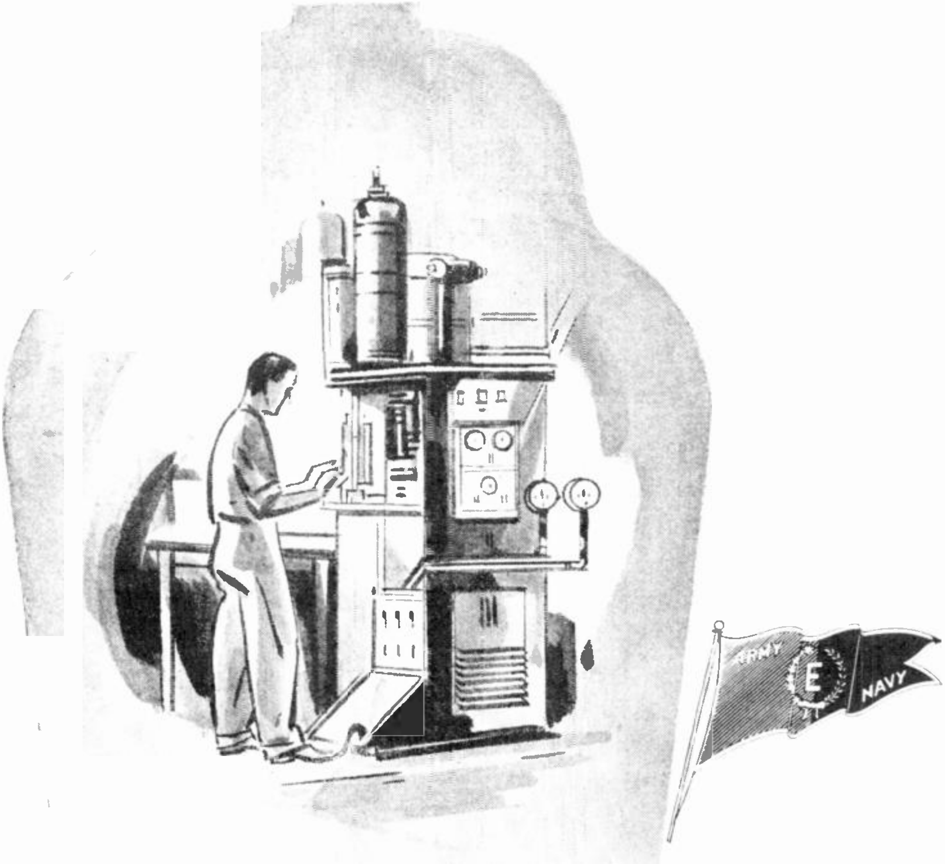
Jackson, George M. WBOW, WBWB
Jarman, J. Frank WDNC
Jeffrey, John Carl WKMO
Jennings, George WBEZ
Johnson, Albert KOY
Johnson, George W. KTSA
Johnson, Leslie C. WHBI
Johnson, Jay A. WTAX
Johnston, George C., Col. WDBO
Johnston, Kenneth B. WCOL
Jones, E. Z. WBBB
Jones, Hugh O. WGCM
Jones, Merle S. KMOX
Jones, O. W. WQBC
Jordan, Ray P. WDBJ
Judis, B. WNEW

— K —

Keesee, Frederick L. WMBO
Key, Earl M. WKEY
King, Cy WEBR
King, Frank WMBR
Kirchner, Thelma KGFJ
Kmety, Violet WWZR
Knight, W. T., Jr. WTOC
Kohn, Edwin E. WFPG
Kopf, Harry C. WMAQ
Kotnour, Frank J. WEDC
Krebstein, H. R. WMPS

— L —

Lackey, F. E. WHOP
Lackey, Hecht S. WSON
Lackey, Pierce E. WPAD
Lahr, Melvin WKOK
Lambeth, H. M. WMFR
Lambeth, Ralph M. WGBG



E-E Electronic Tubes...

...EPITAPH OF THE GREMLINS!

Through the years Dielectric, Hysteresis and Eddy current Gremlins bedeviled electrical designs. New visions, broader concepts and electronic vacuum tubes tamed this trio of power losses. Now, under the incognito of High Frequency Heating they play important roles in industry.

The widespread application of E-E power tubes and rectifiers in induction heating attests to their rugged, uniform characteristics—a result of precise engineering and rigid inspection. E-E specialization in power amplifiers and rectifiers has resulted in designs of unusual efficiency and merit. Why not investigate?

Complete information is contained in the informative E-E data book. Write for your copy today—there is no obligation.

Illustration of
Type 836 Half Wave
High Vacuum Rectifier
Peak Inverse Voltage 5000
Peak Plate Current 1.0 Amp.

ELECTRONIC ENTERPRISES, INC.

GENERAL OFFICES: 65-67 SEVENTH AVENUE, NEWARK, 4, N. J.
EXPORT DIVISION: 25 WARREN STREET, NEW YORK, 7, NEW YORK
CABLE ADDRESS: SIMONTRICE NEWYORK

ELECTRONIC ENTERPRISES

BROADCASTING STATION DIRECTORY

Lancaster, W. Hanes WJHL
Lansberg, Klaus W6XYZ, W6XLA
Lane, Frank S. WDEF
Laughinghouse, Margaret J., Mrs. WGTC
Laux, John J. WSTV
Lawrence, Craig, KSO, KRNT
Leich, Clarence, WMLL
Levenson, Wm. B., Dr. WBOE
Levy, Leon, Dr. WCAU, WCAU-FM
Levinson, H. Y. WCAR
Lindsley, Robert K. KFBI
Locke, C. B. KFDM
Loeb, Howard WFDF
Loggan, Frank H. KBND
Long, D. H. WELI
Lopez, Joseph T. WICC
Ludy, Ben WIBW

— M —

Mackin, Joseph D. WMAM
Maizlish, Harry KFWB
Maland, J. O. WHO
Marget, M. M. KVOX
Mastin, Cecil D. WNBF, WNBF-FM
Matheson, Ralph G. WHDH
Matthews, Joseph B. WGKV
McConnell, C. Bruce WISH
McCormack, John C. KTBS, KWKH
McCracken, H. L. KVRS
McCurnin, L. L. KWNO
McDermott, G. B. KBUR
McDowell, Lawrence W. KFOX
McMurray, Emmet H. WJPR
McNaughton, Henry B. WAJR
McNeil, Ida A. KGFX
McNeil, John Harrington WJZ
McRaney, Bob WCBI
Meagher, John F. KYSM
Memolo, Martin F. WARM
Mendelsohn, Monroe L. WBAB
Menzer, Carl H. WSUI
Merrill, Paul KWJB, KGLU
Meyer, Harold H. WSRR
Meyer, Irma WIGM
Michaels, Bill KABC
Milbourne, L. Waters WCAO
Mittendorf, E. S. WLOL
Montague, Patrick J. WHYN
Moody, Robert H. WHIO
Morency, Paul W. WTIC-FM
Morey, Gerald J. WNLC
Mosby, A. J. KGVO
Mulrony, M. A. KGU
Murdock, M. M. KFH
Murphy, J. A. KIT
Musselman, B. Bryan WSAN, WCBJ
Myers, Frank O. KCMC
Myers, Teresa M., Mrs. WTAL

— N —

Nafzger, Lester H. WELD
Nash, Ralph WBRW
Neeld, C. W. WCBS
Nelson, Wayne M. WEGO
Norins, William WBYN
Norman, Hugh R. WNBH
Novik, M. S. WNYC-FM

— O —

O'Halloran, Pat KPOW
Olsen, Tom KGY
Outler, John M. WSB
Owen, Em. KBIZ
Owens, Arthur WRDO

— P —

Pagliara, Nicholas WEW, K51L
Pangborn, Arden X. KGW, KEX
Parrish, B. J. KOTN
Patt, John F. WGAR
Patterson, R. G. WAPO
Peffer, E. F. KGDM
Petersen, N. C. KGNO
Peterson, Oscar H. WHLB
Phillips, Georgia, Mrs. KIDO
Phillips, Harper M. KYUM
Pidcock, F. R. WMGA
Pill, Howard E. WSFA
Pittman, Chas. W. WBML
Podeyn, George J. WHJB
Powell, Hugh J. KGGF
Poynor, D. J. WMBH
Pratt, Stanley R. WSOO
Priebe, Robert E. KRSC

— Q —

Quilliam, H. J. KIRO

— R —

Rapp, J. C. KMA
Reichert, M. J. KGCU
Reynolds, George A. WSM-FM
Ridge, Edney WBIG
Rines, William W. WCSH
Roberts, Ingham S. KGBS
Rogers, Irving E. WLAW
Rosenhaus, Irving R. WAAT, WAAW
Ross, George KWG
Ryan, Joseph M. WBTA
Ryan, W. B. KFI, KECA

— S —

Sanger, Elliott M. WQXR, WQXQ
Schaefer, Carl J. WGYN
Schurz, F. D. WSBT, WSBF-FM
Searle, Don KGO
Seibert, Lewis O. KGKL
Sharp, Frank O. WFBM
Sharp, Ivor KSL
Shaw, Glenn KLX
Shepherd, G. O. WAYS
Shepard, John III WMTW
Shouse, James D. WLW, W8XFM
Shultz, John W. WMVA
Slavick, H. W. WMC
Simon, Arthur WPEN, WPEN-FM
Sipes, Leon KELD
Smith, Frank R. WTNT, WWSW
Smith, Hugh M. WAML
Smithgall, Charles WAGA
Smullin, Wm. B. KIEM
Snyder, Glenn WLS
Sowell, F. C. WLAC
Stenger, John H., Jr. WBAX
Stevens, Harmon L. WHLS
Stoddard, R. L. KOH
Stone, Albert A. WTJS
Stone, Ben E. KOOS, KVAN
Stone, Harry WSM, WSM-FM
Studebaker, H. E. KUJ

— T —

Taft, Archie, Sr. KOL
Taft, William R. KRKO
Taylor, Dale L. WENY
Thomas, C. L. KXOK
Thomas, E. Anson KGFW
Thomas, George H. KVOL
Thomas, Harold WATR
Thompson, Ellis C. WEXL
Thompson, L. L. WABF
Thoms, Harold WISE
Tinkham, Kenneth O. KMTR
Tinsley, T. G. WITH
Tison, W. Walter WFLA
Todd, Jack KANS
Trommlitz, L. W. KORE
Tully, J. C. WJAC

— U —

Ulmer, Jas. G. KGKB
Upton, Elmer C. WBKB, WGXBK, WGXBT
Urie, Hurschell G. KSUB

— V —

Vyner, Louis WSBA

— W —

Wagner, Paul WPAY
Walker, Wallace A. WJHP
Wallace, Florence KXA
Ware, Wm. E. KWFC
Warner, S. W. KLS
Way, Wm. B. KVOO
Weber, Fred WDSU
Weiland, Jonas WFTC
Weiss, J. H. WSYB
Weiss, Lewis Allen KHJ-FM
Welch, Wm. T. WSAR
Whaley, Storm KUOA
Wheeler, Edwin K. WENA
Wheeler, Chet KWIL
White, Ray B. WAWZ
Whitmire, Bevo WFBC
Whitmore, W. E. KGFL
Wiig, Gunnar O. WHEC, WHEF
Wilkins, Dayton S. WJTN
Williams, W. E. WJZM
Williams, W. V. WBLJ
Williamson, W. P., Jr. WKBN
Willis, Ed WLAP
Wilson, E. E. KEEW
Winger, Earl W. WDOD
Woodruff, J. W., Jr. WRBL
Woodworth, Samuel WFBL
Woodyard, Ronald B. WING
Wright, Jos. F. WIUC, WILL

— Y —

Yates, Darrell E. KRBA
Young, C. S. WBZ

— Z —

Zimmerman, G. E. KARK

CANADA

Brophy, R. M. CFCF, CFCX
Browne, J. W. B. CKOV
Bourassa, Georges CKCH
Cooke, Jack K. CKWS
Cranston, W. T. CKOC
Crittenden, Harold A. CKCK
Cruickshank, W. T. CKNX
Desjardins, G. T. CHGB
Fortin, V. CBJ
Gaetz, G. CKRC
Galgay, William F. VONF
Gardner, W. R. CKMO
Gauthier, A. CHLT
Geldert, G. M. CKCO
Hawkins, Wm. N. CFOS
Houde, Dr. Chas. H. CHNC
Hynds, F. A. CKCW
Jean, Emile CHLN
LePage, Paul CKCV
Moffat, Lloyd CKBI
Murphy, A. A. CFQC
Rice, G. R. A. CFRN
Sedgwick, Harry CFRB
Smith, G. E. CHPS
Thivierge, J. Narcisse CHRC
Thomas, Charles CFPL
Valiquette, Maurice CBV

UNITED STATES

Chief Engineers

— A —

Adams, Ernest L. WHIO
Adams, John KWFT
Aderhold, Harvey WRDW
Akerman, Ben WGST
Alden, E. E. WIRE
Aldrich, Donald D. WBOW
Alfonsi, Peter A. WBOC
Amoo, Lloyd R. KGDM
Anderson, Sheldon W. KFRE
Anhalt, Harvey WGYN

— B —

Baker, B. C. WDEF
Baker, Fred A., WKWK
Ballinger, Louis K. KXL
Barnes, B. B. WAPO
Batchelder, Ernest F., Jr. WKNE
Beckholt, H. R. WSPA
Beehler, Elmer G. KGEK
Belle Isle, A. G. WSYR
Beloungy, J. J. WBBM, WBBM-FM
Betz, William R. WTTM
Bishop, Gordon F. WSGN
Bloom, J. D., Jr. WWL
Boland, Tom KOH
Boos, Gerald J. WIGM
Bowker, Garth N. WFHR
Bradham, Douglass M. WTMA
Brandt, Del KPOW
Brannen, Charles W. WAGE
Bremer, Frank V. WAAT, WAAW
Brolly, A. H. WBKB, W9XBK, W9XBT
Brott, F. J. KJR, KOMO
Brown, Gordon P. WSAY
Brown, Stanley H. WRAL
Browning, E. A. WTAG, WTAG-FM
Buchanan, Archie W. KVRS
Bullock, Mark W. KFAB, KFOR
Burgoon, George R. WFBG
Burtis, Charles W. WPEN
Bush, R. S. KRIS

— C —

Carpenter, Ralph H. WBCM
Casey, John B. KRBC
Cannon, Ralph E., Jr. WINX

...in Magnetic Structures

By the time we finish our present contract for headphones, Shure Engineers will have effected a 3½ ton saving in critical magnetic alloys. Redesign of the magnetic structure effected a saving of three-quarters—so that, today, the magnetic material generally required for one headphone is now enough for four headphones. This has been accomplished with full maintenance of the operating characteristics with the added advantage of decrease in weight. Shure Engineering continues to lead the way to better microphones and headphones for your postwar needs.

SHURE BROTHERS, 225 West Huron Street, Chicago

Designers and Manufacturers of Microphones and Acoustic Devices

SHURE MICROPHONES

BROADCASTING STATION DIRECTORY

Cecil, Jack KRLH
Chandler, H. J., Jr. KRNR
Chandler, Vincent H. WMUR
Chiles, Wilton R. WIOD
Clippard, Harry L. WCOS
Clark, E. H. WJLB, WLOU
Clary, Millard H. KWBW
Cochran, Howard D. WBTA
Cofey, Vincent G. WMRO
Cole, H. G. WSBT, WSBF
Cole, John L., Jr. WNOX
Coleman, Murray D. WORD
Cook, Carl C. KAVE, KIUN
Cook, Wayne N. WCAR
Cooke, Gerald W. WBAL
Cooper, Donald H. WRC
Cox, Franklin V. KTFI
Cozzens, W. D'Orr KLO
Csensich, John E. WSAZ
Cuesta, Nestor, Jr. KWBU
Curtis, James R. KFRO

— D —

Dahlbacka, Arne WJMS
Daugherty, C. F. WSB
De Costa, Lester L. WCLS
De Lany, Ralph H. WHK
De Prospo, John WNYC, WNYC-FM
Dillingham, H. C. WTAW
Dillon, Paul WMIT
Dorothy, R. M. KARM
Dotson, George W. KNOX
Dowdell, John T. WIBX
Drake, C. E. WQBC
Dubuque, John H. KNA
Duff, James S. WITH
Durham, Harold D. KOCY
Duty, E. C., Jr. KDON
Duty, John T. WCOU
Dye, Robert H. KGFX

— E —

Easum, Clifford M. KTOK
Ebel, A. James WILL, WIUC
Ebert, S. J. WSUI
Egerton, W. G. KTSA
Esten, Perry W. WGRC
Etheredge, W. C. WFBC
Evans, C. Richard KSL
Evans, Roy KWEW

— F —

Fahey, Wilbur J. WKNY
Fallain, Frank D. WFDF
Faske, Arthur WLIB
Featherkile, M. W. KVOS
Fekel, Francis C. WSNJ
Feikert, Grant S. KOAC
Flaherty, Joseph A. WDAF
Flanagan, P. T. WHIS
Fletcher, Henry H. KSEI
Frase, E. C., Jr. WMC
Freitag, Willis O. KRKD
Frisk, Caleb C. KFMB

— G —

Gager, Ernest H. KYW, KYW-FM
Gann, John KGIW
Garland, O. K. WJHL
Gavin, D. W. WCOC
Gilbert, James N. WROL
Gilbert, Lester H. WNBF, WNBF-FM
Giles, Ted WMBD
Ginkel, A. J. WJLS
Godfrey, Earle WBAB
Golson, Wilbur T. WJBO, WBRL
Goodrich, H. S. WBML
Gosselin, Lafayette A. WMTW
Grady, George L. KGA, KHQ
Gray, Claude M. WTOC
Greaves, George KPO
Greene, Thurlow A. WLNY
Gresham, Stokes, Jr. WISH
Grether, J. L. WFAR
Grether, W. P. WGH
Griffiths, A. E. KOBH
Grossman, Henry WABC, WABC-FM, WOOW, WOOC, WCEN, WCBN, WCDA, WCRC
Groves, W. C., Jr. WGNC
Gunderson, Lee KGCU
Gundy, Phil KGHF

— H —

Hahn, A. H. WIBA
Hale, Roland C. WCOP
Hamann, Gerard P. WBRC
Hamilton, R. C., Jr. KPAC
Hanson, O. B. WEAF
Hanson, Richard KVOX
Hardison, David E. WETC
Harris, Charles E. KMAC
Harris, Clifford C. WIP, WIP-FM
Harvey, Harry KMON
Hatfield, J. B. KIRO
Haughawout, J. H., KTAR
Hauser, Willard H., WBZ, WBZ-FM, WBOS
Havens, W. T. WCLO
Hayford, Beecher WJHP
Hebal, W. H. WTMJ
Heck, A. C. WPIC
Helt, Sanford, WLAP
Helt, Scott, WIS
Henninger, John H., WIBG, WLBG
Henzly, William J. WMBS
Herring, E. L. WMFD
Hewinson, Earle G. WMAS
Hilgers, R. H. KEVE
Hilker, B. Ross KSTP
Hill, Walter S. WDNC
Hinckley, George A. WLAW
Hoag, Dwelle S. WBCA
Hodgkins, Roger W. WGAN
Hosington, Duane W. KBIX
Hollerith, Madeline WISE
Holmberg, Berten A. WLB
Holt, Rogers B. WNBC
Horstman, F. C. WENR
Horton, J. Rex WBIR
Hoskins, Cecil B. WWNC
Hough, Robert D. WMMN
Houts, James KYSM
Howard, R. A. KSFO, KWIX
Hudson, James WHMA
Hudson, Wilbur E. WAVL
Hughes, Ben KRIC
Humphrey, Thomas R. WHYN
Hunter, Dan WMAL
Huntsinger, Paul R. KSO, KRNT
Hurley, Norman Sinclair WAPI
Hurt, Edward KFND
Huss, Earl J. KTRI

— I —

Ing, George W., KONO

— J —

Johnson, Alvin P. KBIZ
Johnson, George S. KOB
Johntz, James A., Jr. KIDO
Jones, Martin L. WCAO
Jorgenson, T. O. WEAU

— K —

Kaarl, Eugene T. WSOO
Kalin, Theodore WEIM
Kassner, Don E. KXEL
Keich, George WICC
Kelley, John L. KEVR
Kennedy, Frank M. KHJ-FM
Kenney, T. C. KDKA-FM
King, Dale L. WGIL
King, Fred WELI
King, Lee C. WAIR
Kinnett, C. M. WGPC
Kluge, Myron E. KFSG
Kolesar, J. D. KMO
Krivitzky, George WKBZ

— L —

Laeser, Phil B. WMFM, WMJF
Lamy, Raymond H. WEBR
Landis, Harold O. WEEU, WRAW
Landsberg, Klaus W6XYZ, W6XLA
Langford, George E. KFPY
Layne, C. N. KVNU
Layton, DeForest T., Jr. WALB
Lee, Carl E. WKZO
Leeman, Alvin WKBH
Lind, Perry C. KOL
Lindsay, Paul G. WHLB
Link, Louis J. WSUN
Littlejohn, L. E. WFIL, WFIL-FM
Livingston, Clifford A. KTUC
Lounsberry, Wm. H. WEBC, WDUL, WMFG
Love, Sam KRBA
Lovell, H. J. WKY
Lowe, J. Ernest WCOL
Lubcke, Harry R. W6XAO
Lucy, Charles C. KANS
Luttgens, H. C. WMAQ, W63C
Lyon, Henry H. WOL
Lyon, John Greenwood, WGAC

— M —

Maddox, C. H. KTBS
Magin, Theodore G. WDAN
Mangold, William D. WTSP
Marcy, Lt. Col. A. R. WFBL, WFBL-FM
Marquardt, K. G. WIBW, KCKN
Martin, Arthur F. WIZE
Martin, George P. WRRF
Martino, Italo A. WDRC, WDRC-FM
Marx, Frank L. WMCA
Masini, Charles S. WTHT
Mason, Albert F., Jr. KOCA
Matheson, Ralph G. WHDH
Mathiot, J. E. WILM, WDEL, WEST, WGAL, WORK, WAZL, WKBO
Mayer, Herbert J. WHBL
McArdle, J. J. KFRC
McCaslin, Paul KCMC
McIntire, George W. WJEJ
McIntosh, Glenn KEEW
Meares, Claude W. WCBT
Merkl, George E. WHBY
Mietzke, R. H. KWLK
Milburn, Emory P. KHSL
Miller, James C., III WHOP
Miller, Stanley A. KORE
Milne, George O. WJZ
Ming, Morris M. KSKY
Minor, M. J. WBT
Minton, Bob WAIT
Mitchell, Joe H. WELA
Moser, A. R. KMBC, W9XER, KFIS, KFIT, KOAH
Morey, Gerald J. WMLC
Morris, V. C. WPAD
Mulrony, M. A. KGU
Murphy, H. B. KIT
Muse, Dewey W. WMVA
Musselman, Revel H. WSAN
Myers, Harry KFWB
Myers, Maurice L. WPAY
Myers, Walter L. WJJD, WCHI
Myhre, Wilbur E. KFBB

— N —

Nafzger, Lester H. WBNS, WELD
Nazak, John M. WMFF
Neal, Nathan A. WBOI
Neuville, Glen WHIT
Newton, Ralph B. WEEH
Niemann, E. C. WCRS
Nunn, Vernon R. WINN

— O —

Oakley, Ron KGLR
Obuchon, Homer M. KGEJ
Osborn, Perry H. W2XMN
Oschmann, A. W. WARM

— P —

Palmer, George E. WKMO
Palmer, T. B. KGO
Pangborn, Arden X. KGW, KEX
Parker, John W. WORL
Parker, S. WNBH
Patterson, Thomas W. WMIS
Perkins, C. A. WSLI
Peterson, Gerald W. KOVO
Plank, R. A. WLAV
Poppele, J. R. WOR, WBAM
Porter, Bascom E. WSIX
Prior, Thomas C. J. WJAR
Price, John C. WAYS
Pulley, Denzil WSAP
Pyle, K. W. KFBI

— R —

Ranft, William Q. WEBR
Ratts, Bruce H. WOWO, WOWO-FM, WGL
Rayburn, Charles D. WOC
Reeder, Jack M. KPAS
Rees, Dave H. KMED
Rekart, A. E. KNOK
Reynolds, George WSM, WSM-FM
Ricciotti, Salvatore KGEI
Richard, N. J. WISN
Richardt, Roland W. WSAU
Ridgway, H. F. KVWC
Roark, Charles A. KGY
Roberts, Roger E. KFS
Robertson, J. W. WDBJ
Robertson, W. W. WAKR

OHMITE RESISTORS

A Type and Size for Every Electronic Need

- Lug Type Fixed Resistors
- Dividohm Adjustable Resistors
- Wire Lead Resistors
- Flexible Lead Resistors
- "Corrib" Resistors
- Ferrule Resistors
- Edison Base Resistors
- Precision Resistors
- Bracket Resistors
- Non-Inductive Resistors
- Tapped Resistors
- Cartridge Type Resistors
- Strip Type Resistors

WHATEVER your resistance problems may be . . . you are sure to find the right answer at Ohmite. Our extensive range of types and sizes makes possible an almost endless variety of regular or special resistors to meet every requirement. Core sizes range from 2½" diameter by 20" long to 5/16" diameter by 1" long . . . and are produced with standard or special windings, terminals and other features. Many are stock units.

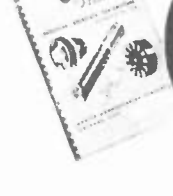
Because of their extra dependability under the most critical operating conditions, Ohmite Resistors are used today in all types of electronic and electrical applications . . . in planes, tanks, ships, in laboratory research and development, in scientific instruments and in the production tools of war.

Cut-away view of Ohmite Vitreous Enameled Resistor

The resistance wire is evenly wound on porcelain core, rigidly held in place, insulated and protected by Ohmite vitreous enamel. Dissipates heat rapidly—prevents hot spots and failures. Core sizes range from 2½" diameter by 20" long to 5/16" diameter by 1" long.

Send for Catalog and Engineering Manual #40

Write on company letterhead for complete helpful 96-page guide in the selection and application of resistors, rheostats, tap switches, chokes and attenuators.



OHMITE MANUFACTURING COMPANY
4854 Flournoy Street • Chicago 44, U.S.A.

BE RIGHT WITH OHMITE
RHEOSTATS • RESISTORS • TAP SWITCHES

BROADCASTING STATION DIRECTORY

Robinson, Irving B. WNAC, WGTR
Robinson, King H. KTRH
Robinson, Odes E. WCHS
Roman, Edwin W. WFIG
Rowe, Thomas L. WLS
Runkle, Elza Glee, Jr. KCMO
Rueppel, George WEW, K51L
Russell, Fred W. WOOD
Ryan, J. M. WBTA

— S —

Sakoski, Charles WBRE
Sampson, Richard T. KFXM
Schenke, Bob KHMO
Schoeny, Erwin P. WEOA, WMLL
Schroeder, R. J. KMA
Schow, R. A. B. WFEA
Schultz, James WCAE
Schulz, Paul C. KYA
Scott, Elmer WDLP
Seaman, V. T. WSAM
Secrest, Mitchell C. KPLT
Seimes, Marvin WGNY
Shatto, Luverne KERN
Siddle, Wilfred T. WRBL
Sinclair, David G. KVFD
Sliker, Kenneth L. WHBC
Smith, Alvin H. KSCJ
Smith, Edgar C. WFIN
Smith, Roswell S. KLX
Snell, Paul E. KCRC
Spann, Melvin P. KWFC
Spence, Ray C. WAJR
Spencer, H. W. WBTM
Spencer, S. L. KGBS
Spengler, Harold C. WAIM
Stafford, Leo S. KOAM
Stangel, Wallace J. WTAQ
Stenger, John H., Jr. WBAX
Stewart, A. W. KBWD, KNGW
Stinson, L. W. KVOO
Strang, H. C. KVOR
Straub, N. L. WJAC
Stringfellow, William WSPD
Sutt, Cecil L. KTHS
Summerford, D. C. WHAS
Summerville, W. H. WWL
Swenson, Walter J. W2XWV
Swillinger, Melvin WGKV

— T —

Tate, George D. WMRC
Taylor, H. D. WTIC, WTIC-FM
Testan, Peter WBYN
Thomas, Harold WATR
Thomas, J. R., Jr. KFDA
Thomas, Morris W. KOMA
Thompson, Meredith E. WSAV
Thron, Blair K. WFPG
Thurman, W. B. WJZM
Tilley, Harry H. WEAN
Timberlake, John E. WBRW
Todd, Clifton WNAX
Towne, Roy C. KRKO
Troesch, Joseph M. WJPA, WSTV
Trueblood, Daniel B. WGBR
Tucker, Durward J. WRR

— U —

Ulrich, Carl W. WAAF
Upchurch, Gladman W. WKPT
Urie, Hurschell G. KSUB
Utter, Ross WWZR

— V —

Vessels, Julius C. WDOD
Vines, Thomas L. WBNY
Vordermark, Ernest B. WMBR
Voss, Victor H. WIND

— W —

Wahlquist, Lyle O. KUTA
Ward, Robert Brown, WBTH
Warren, J. C. KFFA
Watson, Carl WSTP
Weaver, Clarence William WCMI
Weaver, Willis N. WSBA
Weiner, M. J. WNEW
Wentura, Francis WTAD
Wesser, Carl H. WENA
Wheeler, Leavenworth, KYUM
Wheeler, Leland F. WHAI
White, J. Harold KWOS
Whitman, Waldo P. WTRY
Whitney, Charles WDSU
Whitney, Phil WFVA, WINC
Wilder, James M. WMGA
Williams, Nathan WOSH
Williams, Sidney KBKR
Williamson, Bert KTKC
Wilson, George A. WKRC
Wilson, N. L. WAWZ
Wilson, Robert J. WHLD
Winn, Dan L. KARK
Wirtanen, Charles WIBM
Wirth, Mel WJIM
Witschen, Robert B. KFAM
Wina, Richard KBON
Wnorowski, Paul A. WSOY

— Y —

Yarger, C. R. KSD

— Z —

Zehr, N. J. KWK
Zeilmer, Lester W. WTRC

CANADA

Allen, W. H. CKTB
Browne, James H. B. CKOV
Carter, W. J. CKLW
Chandler, A. H. CJOR
Clifton, Stan CFQC
Collins, E. R. CKX
Crawford, William CHML
Crump, A. E. CHEX
d'Assylva, J. E. CJBR
Frenette, Charles CBV
Horton, Leslie CKOC
Large, R. F. CFCY
Makepeach, F. G. CFRN
McCurdy, G. E. CKWS
McDonald, Wm. CKRM
McLellan, Wm. CKCO
Mills, Arthur CJGX
Mitchell, W. A. CHPS
Nadeau, Arsene CHRC
Paquette, Romeo CHLT
Parker, R. H. CKPR
Peters, J. W. CKVD
Reid, Scott CKNX
Spencer, Leonard CKAC
Stewart, John C. CJOC
Swan, E. O. CKCL
Tate, R. J. CFJC
Trepanier, Leon CHLN
Warder, John C. CFPL
Watson, T. G. CJKL
Whiteside, Ross L. CKMO

CUBA

Alarcon, Liberto Cao, Monzana de Gomez 508, Havana. CMK
Chisholm, Edward E., 10 N 423, Vedada, Havana. CMOX
Femenias, Jose R., Jr., Prado 190, Cienfuegos. CMHM
Gongora Mason, Manuel J. de, P. O. Box 152, Holguin. CMKF
Jones, Vincent P., P. O. Box 320, Camaguey. COJK
Olmo, Manuel Manen, Lope Recio 8, Camaguey. CMJW
Pena, Humberto Anderes, Radio Universal, Havana. CMBF, COBF
Prieto, Rafael, 40 CMBA, Santiago de las Vegan. CMBA
Rivero, Mario, c/o CMJK, Camaguey. CMJK
Voldez, Jose M. Alvarez, Agramonte 62, Guanajay. CMAC
Zacca, Pedro, P. O. Box 39, Puerto Padre, Ote. CMKY

HONDURAS

Monterrosa, Jorge, San Pedro Sula. HRP1

MEXICO

Agraz, Jose Remiglo, P. O. Box 68, Serdan 144, Hermosillo, Son. XEBH, XEBR
Branch, W. E., Box 188, El Paso, Texas. XELO
Buchanan, Juan Cross, Apartado Postal 7944, Mexico City. XEB
Campoy, Hector, P. O. Box 3, Maco, Son. XETM
Correa, Napoleon, Apartado Postal 57, Tapachula, Chis. XETS
Corts, Enrique Ricart, Apartado 273, Chihuahua. XEIW, XEBW
Del Conde, S., V. Carranza 30, Mexico City. XEN, XENN
Ferreira, Fred, P. O. Box 117, San Ysidro, Calif. XEMO
Gonzalez, Angel Valera, Apartado Postal 282, Puebla, Pue. XEHR
Huerta, M. M., Oriente 63, 269 Col. Iztaccihuatl, Mexico, D. F. XERC
Martinez, J. E., Apartado 797, Tampico, Tam. XEFW
Parra, Esteban, Apartado Postal 89, C. Juarez, Chih. XEP
Perez, Francisco, Jr., P. O. Box 37, Los Mochis Sin. XECF
Rojo L., Manuel, c/o XEBG, Tijuana, B. C.
San Martin, Salvador, Enrique Rebsamen 241, Mexico City. XESM
Tarnava, Constantino de Jr., E. E. Apartado P. O. Box 147, Monterrey, N. L. XEH
Varela, Manuel Aguna, P. O. Box 111, Tijuana, B. C.
Zetina, Manuel, Delegacion de Ixtacalco, Mexico City. ZELZ

NICARAGUA

Gallo, Dionisio E. Leon Gilfillan
Gutierrez, R. Ernesto, Managua, La Voz de los Lagos
Hnos, Mendoza y, Managua, La Voz de la America Central
Tenorio, Leonidas A., Granada, La Voz del Mombacho
Tercero Z., Jose F., Granada, La Voz de la Sultana

PERU

Goycochea, Juan P., Ocana 58, Lima OAX4E, OAX4K
Urteaga, Alvarado y, Saenz Pena 1488, Bellavista, Lima. OAX4C

PORTO RICO

del Valle, A. P., Telephone Bldg., San Juan. WKAQ

VENEZUELA

Almenar, Arreaza, ral6noceBa, YVRC YV6RE
Arraez, Manuel, c/o YV1RV, Maracaibo. XV1RV, YV1RA
Barrios, Ramon T., c/o YB5RG, Caracas. YB5RG, YB5RU
Belisario, Manuel, c/o YV1RK, Maracaibo. YV1RK, YV1RL
Cabrera, Hermillo, c/o YV1RT, Maracaibo. YV1RT, YV1RC
Cisnoeros S., M., c/o YV5RV, La Guaira. YV5RV, YV5RZ
Debrot, G. Nouel, c/o YV1RX, Maracaibo, YV1RX, YV1RF
Degwitz, H., c/o YV5RV, Caracas. YV5RS, YV5RQ
Gonzalez, Diaz, c/o YV2RB, San Cristobal. YV2RB, YV2RN
Marcano C., J., c/o YV5RA, Caracas. YV5RA, YV5RN
Nunez, Ramon h., c/o YV4RA, Valencia. YV4RA, YV4RO
Ormezzano, Atilio, c/o YV1RL, Maracay. YV4RL, YV4RK
Rey, P. Castillo, c/o YV5RX, Caracas. YV5RX, YV5RH
Rivero, Aramando, c/o YV5RW, Caracas. YV5RY, YV5RI
Rodriquez B., M., c/o YV5RL, Caracas. YV5RL, YV5RW
Segura, Amilcar, c/o YV3RN, Barquisimeto. YV3RN, YV3RE
Siblesz, G., c/o YV5RM, Caracas. YV5RM YV5RB
Victor, Jaime R., c/o YV1RY, Coro. YV1RY, YV1RW

REVISED ARMY-NAVY TUBE LIST

(CONTINUED FROM PAGE 40)

Such approval, when Signal Corps equipment is concerned, is to be requested from the Signal Corps Laboratory concerned with such equipment; the said Laboratory will then make known its recommendations in the matter to the Signal Corps Standards Agency where the final decision will be made and returned to the laboratory for transmittal to the party requesting the exception. When Navy equipment is concerned, the request for exception shall be addressed to the Radio Division, Bureau of Ships, Code 930-A, Navy Department.

6. The publication of this list is in no way intended to hamper or restrict development work in the field of radio electron tube or radio electron tube applications.

7. This list is to take effect immediately.

Office of the Chief Signal Officer,
Headquarters, Army Service Forces,
War Department.

Chief of the Bureau of Ships,
Navy Department

DOUBLE SUPERHETERODYNE FOR FM

(CONTINUED FROM PAGE 18)

quency of 4.3 megacycles. Formulas for determining the oscillator and 1st IF frequencies for any signal and 2nd IF frequencies may be obtained as follows:

Let

f = signal frequency
f_1 = 1st IF frequency
f_0 = oscillator frequency
F = 2nd IF frequency

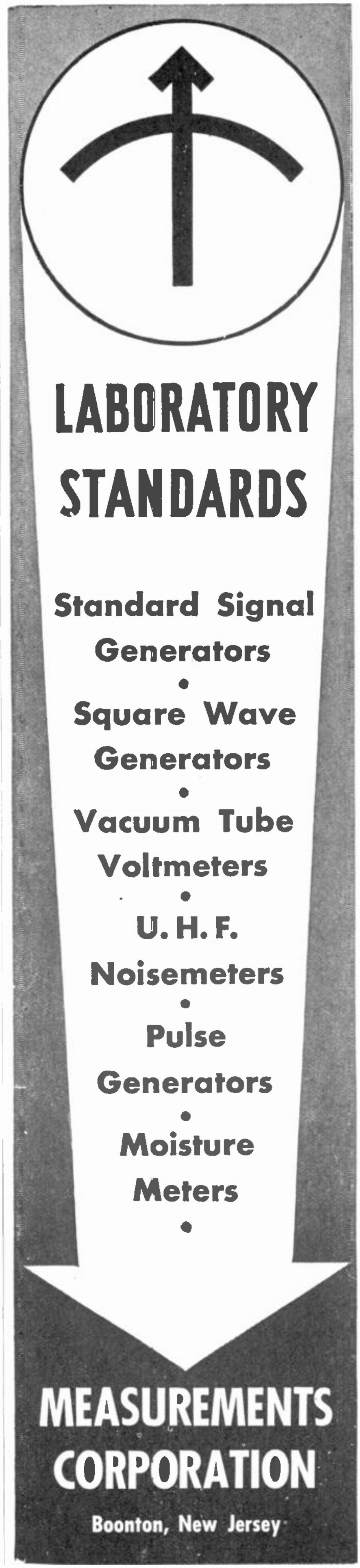
then $f - f_0 = f_1$ and $f_1 - f_0 = F$

solving $f_1 = \frac{f + F}{2}$ and $f_0 = \frac{f - F}{2}$

This circuit was the basis of the G.E. JFM-90 Translator, and was likewise employed in the subsequent LF-115, 116, 1118, 1128, and 1228 receivers.

The performance of this circuit, as used in the JFM-90, will now be considered in some detail. Fig. 2 indicates the computed input impedance of the 6AB7 tube and the computed tuned circuit impedance, both plotted against frequency. The input conductance of the 6AB7 was first computed as an amplifier using the formula $G = .3f + .065f^2$. This conductance was then halved since the tube, operated as a converter, has only half its normal mutual conductance. The reciprocal was then taken to obtain input impedance and the result plotted. The tuned circuit impedance was computed, knowing the inductance to be .45 microhenrys and the effective circuit Q to be 120 with the primary loaded with 100 ohms. The net result of these two parallel impedances is shown,

(CONTINUED ON PAGE 59)



DOUBLE SUPERHETERODYNE FOR FM

(CONTINUED FROM PAGE 58)

and is seen to be nearly constant at 7,000 ohms.

The antenna coil gain, computed in the manner previously discussed, is shown in Fig. 3. The actual measured antenna coil gain is also plotted. The computed gain is nearly constant at 5.8 while the actual gain varies from 5.2 to 5.6. The agreement is seen to be reasonably close. It should be noted that the antenna gain computed previously assuming the 6AB7 tube to be operated as an amplifier was 4.8. The difference, of course, is due to the higher input impedance of the tube when operated as a converter.

The impedance of the 1st converter tuned circuit and the 6AB7 second converter input impedance are plotted against 1st IF frequency and are shown in Fig. 4. The net equivalent of these two impedances is plotted, and is shown to be approximately constant at 15,000 ohms. The first converter gain can then be computed assuming the G_c of the 1st converter to be 2,500 micromhos. This is shown in Fig. 5 along with the amplification as actually measured. It is again seen that the agreement is good, the computed voltage gain varying from 36 to 38 and the actual voltage gain from 34 to 42.5.

The total voltage gain ahead of the second converter is shown in Fig. 6. The computed gain is seen to vary from 210 to 242 and the actual gain varies from 182 to 228.

It is evident from the above that the required total RF gain of 65 is realized with a very considerable factor of safety. Manufacturing final-test limits are generally about 2 times that of a representative normal receiver, and additional reductions in sensitivity are likely to occur in storage, shipment and normal use. It is thus evident that some receivers in actual service will be deficient in sensitivity possibly by a factor of 3 to 5 times. The effect of such sensitivity loss on quieting signal input was determined for the JFM-90 by adding adjustable bias to the IF amplifier to reduce the IF sensitivity by the desired amounts, and then the quieting signal input was measured. The result of these measurements indicated that the required quieting input does not change for the JFM-90 with gain reductions of as much as 5 to 1, while that of an ordinary superheterodyne FM will increase in approximately linear fashion.

Fig. 7 shows the schematic diagram of the circuit used in the JFM-90 converter.

Although satisfactory operation of a somewhat marginal nature is possible on the FM band with an ordinary single superheterodyne, the double superheterodyne circuit appears to be a virtual necessity for FM emergency communication service. The reduction of the frequency

(CONTINUED ON PAGE 60)

DOUBLE SUPERHETERODYNE FOR FM

(CONTINUED FROM PAGE 59)

deviation to 15 kc. for this service permits a quieting signal input of approximately .4 microvolt and under certain conditions a .1 microvolt signal is readable. Consequently, most commercial receivers designed for this use have sensitivity sufficient to open the squelch with a .1 microvolt signal and provide 20 db noise reduction with a .4 microvolt signal.

The schematic diagram of a typical receiver for emergency service is shown in Fig. 8. This differs from the circuits previously considered in several details. The fundamental oscillator frequency is applied to the grid of the second converter, while a tank circuit in the plate of the oscillator tube, tuned to the sixth harmonic of the oscillator, is coupled to the grid of the first converter. To provide the necessary increased gain, a stage of high IF frequency amplification is inserted between the two converter tubes.

FOR REMOTE TELEVISION PICKUPS

(CONTINUED FROM PAGE 23)

incurred. AVC circuits are provided in order to minimize the effects of signal fluctuations. The receiver is ordinarily located in the main studio or transmitter building and is designed so that it can be mounted in a standard rack. Highly directional antennas are employed.

RCA field television systems have been successfully employed in the field for a considerable period of time. Among the programs that have been put on the air by means of this equipment are ceremonies at the New York World's Fair, baseball games, football games, ceremonies at motion picture premieres, hockey games, basketball games, operas, religious services, circuses, a panoramic view of New York City from an aeroplane and conventions.

WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 4)

sale feature. Few dealers could demonstrate in their stores anything more than horrible squeaks, shrieks, cat-calls, and code signals. After the sets were bought and installed, few listeners ever spent more than a small part of the first evening listening to short waves. There was no entertainment on those bands. Yet the demand for those band-switch knobs compelled the set manufacturers to build some kind of short-wave circuits in every model.

How much more insistent people will be about having FM tuning in sets they expect will incorporate the accumulated wartime progress of the radio art! When that time comes, just what will be the difference

(CONTINUED ON PAGE 61)

(CONTINUED FROM PAGE 60)

between prewar and postwar models? For all the "electronics" ballyhoo that is being fed to the public, there will be no demonstrable difference in AM performance. In order to keep their promises, manufacturers will have to make FM reception the No. 1 feature because *that* is both an improvement in performance and an added service which can be demonstrated. Not only that, but the worse the AM receiving conditions in the dealer's store, the more advantageously FM reception will show up by comparison with AM.

Bearing in mind what happened when all-wave tuning was introduced, it is easy to see that any radio salesman worthy of the name will be able to make his customers ashamed to even consider the purchase of a straight AM set.

The old technique of telling the customer, "Yes, I have a few left over, but I wouldn't advise you to buy one," will be used to stop off any inclination to pay less and forego FM reception. During the first year after the sale of radio sets is resumed, it is safe to plan that 95% of all sets sold will have FM tuning, even where transmission is not yet available. After the second year, the shift to FM broadcasting will have progressed to a point where no more straight AM sets will be produced. This will apply to portables, as well, for excellent FM reception is already possible in many rural sections where AM portables have never given satisfaction.

Unless buying habits have changed during the War period, and we know they haven't, we can expect the FM audience to grow in almost direct proportion to the number of new radios sold.

2. A very thorough and well prepared booklet on the characteristics of FM broadcast coverage and reception has just been issued by RCA. The information presented, and the comparisons with AM performance show clearly the superiority of the FM system over AM. In this respect, RCA did not spare AM, nor attempt to minimize its failings.

It should be pointed out that the advantageous transmission characteristics of FM described in this booklet are based on the present FCC standard of 200-kc. channel width, and a swing of 75 kc. each side of the center frequency. However, RCA has repeatedly advocated, in the past, a reduction of the channel width.

The publication of FM performance data based on a 150-kc. modulation swing may indicate that RCA engineers have been converted to agreement with the present standards. Certainly it would not be consistent to emphasize that wide-swing FM affords increased coverage, and reduced static and inter-station interference with less power output and, at the same time, call for a sacrifice of these very

(CONTINUED ON PAGE 62)

WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 61)

advantages by urging the use of narrow-swing transmission.

In other words, we can't have the superiority obtained from the 200-kc. channel width if we cut down the channel width in order to crowd more stations into the 42- to 50-mc. band.

Many broadcasters do not realize that the 200-kc. band represented a compromise at the time it was established. Further advantages could be obtained by making it 250 or 300-kc. wide. It was a matter of arriving at an optimum width, balancing the advantages of frequency swing against the practical use of the 42- to 50-mc. band, which dictated the adoption of the 200-kc. channel in May, 1940.

At that time it was necessary to give FM the 44- to 50-mc. band that had already been assigned to television. If the 50- to 56-mc. band had been open in 1940, FM might have had that also, and the FM channel width would probably have been set at 250-kc. That would have afforded still better FM performance characteristics.

Very few engineers will remember it, but the AM channel width was, at one time, reduced from 10 kc. to 9 kc. in an effort to crowd more stations into the broadcast band. Results showed that the gain was more than offset by inferior performance, and the idea was abandoned.

As Chairman Fly has pointed out, we must not "destroy the great advantages of FM", but rather "plan the optimum in terms of public service made possible by this great invention."

3. And speaking of plans for public service: No one would want to be importunate over the impending increase of the FM band width, but an early report from RTPB and a decision from the FCC will do much to assure prompt delivery of FM receivers after permission to resume production is granted.

Until the set manufacturers know what band width their receivers must cover, they cannot start to consider postwar designs. Neither RF nor IF circuits nor the mechanical designs of tuning mechanisms and dials can be planned until the band width is settled. If a decision is not made during this war period, there is no telling how long it may be held up after peace comes.

As matters stand now, television has the 50- to 56-mc. band, and the amateurs have the space from 56 to 60 mc. There are two possibilities: 1) extending the FM band from 42 to 56 mc. This would take away television's No. 1 channel and leave the amateurs undisturbed or, 2) extending the FM band from 42 to 54 mc. Then the No. 1 television band could be moved up to 54 to 60 mc. That would mean a loss of the amateurs' 5-meter band.

(CONTINUED ON PAGE 63)

WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 62)

Either one will cause bitter complaint, but the need for broadening the FM band is made clear by the general acceptance of the plan of gradually shifting local, regional, and some of the clear-channel AM stations to FM, as expounded before the FCC by such broadcasting experts as O. B. Hanson, NBC's chief engineer, and consulting engineers John V. L. Hogan and C. M. Jansky, Jr. Commander Paul de Mars, former chief engineer of the Yankee Network, is also known to favor this shift from AM to FM.

With the present number of FM channels, such conversion will not be possible in the more densely populated areas. It would be manifestly unfair, however, to freeze some of the AM stations which have been on the air for many years, and to cut them off from going to FM because no channels are available for them.

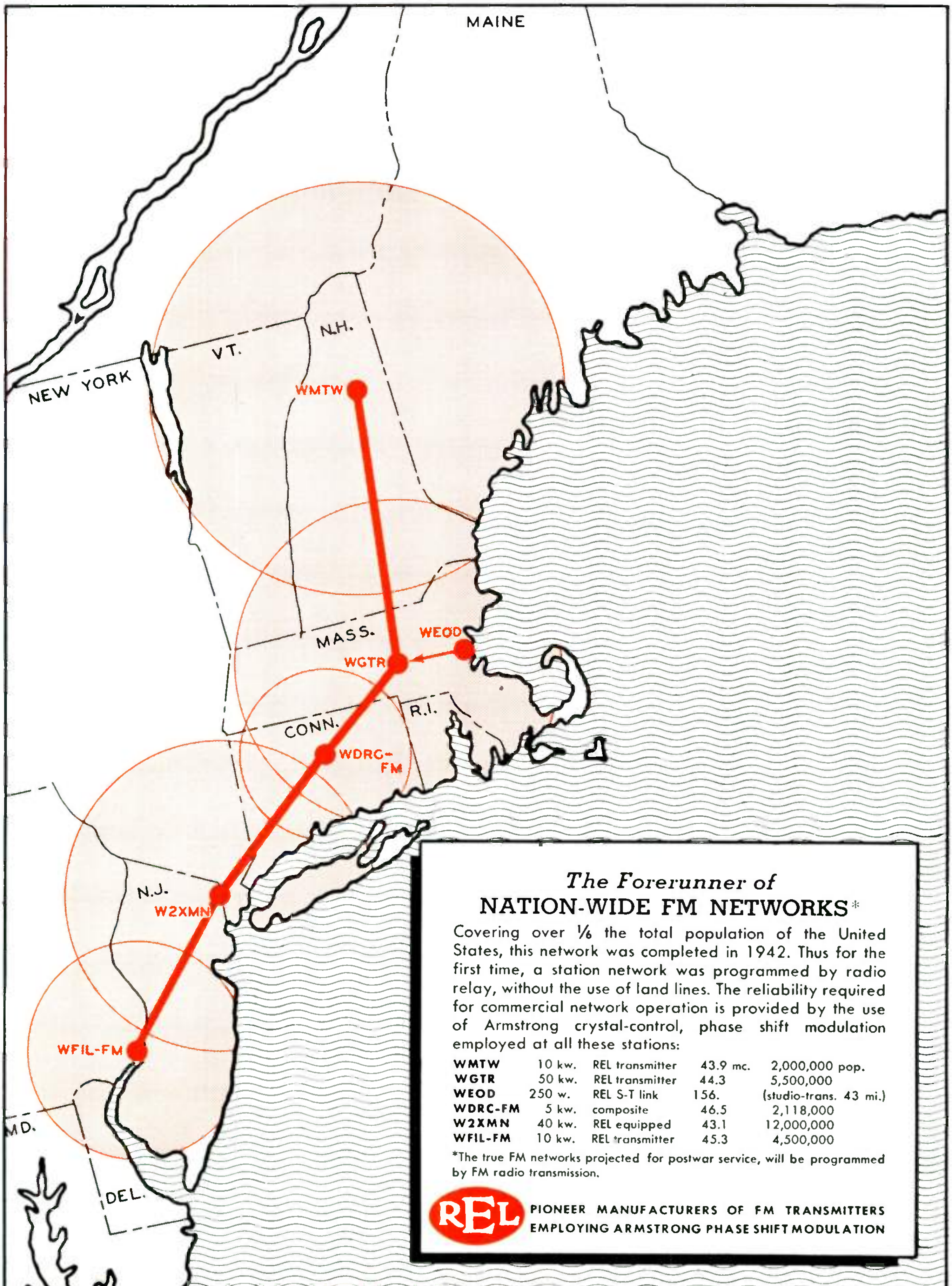
4. There is a definite feeling among Army and Navy engineers who are experienced in handling frequencies up in the thousands of megacycles that television will find its permanent place in the spectrum above 500 mc. They believe that problems besetting television transmission at frequencies below 100 mc. can be overcome if this shift is made.

Some civilian engineers have argued that the lack of transmitting tubes capable of adequate power output in the 500-mc. region would hold up television progress for the indefinite length of time required to develop suitable tubes. The fact is that tubes for 500 to 1,000 mc., with outputs up to 50 kw. are now being produced. They are probably not available for other than military equipment, but neither are many of the special components needed for building any type of television transmitter.

Most serious result of such a frequency shift would be that present television receiving sets would be obsolete. That is not too serious, though, because all television sets now in use have their original AM sound channel receivers, although the sound is being transmitted on FM. Altogether, such sets will be relatively obsolete, anyway, when postwar designs are made available.

A similar situation will confront a much larger number of people who own FM receivers, if the FM band is extended. But we cannot let past beginnings limit essential future growth. Nor does the American public think that way. There was a certain amount of grumbling when the AM broadcast band was extended beyond the range of sets then in use. Today, even the engineers who had to make the changes in receiver designs have forgotten all about it. Such changes, however terrifying they are to contemplate, appear to be of minor magnitude when considered in retrospection.


Official U. S. Navy Photo
THE SALT SPRAY TEST!
Hammarlund Navy type radio components are put through a mock trip to sea to determine beforehand their ability to take it. The final proof of their quality is the excellent record established in commercial and naval ships.
THE SIGN OF QUALITY
THE HAMMARLUND MANUFACTURING CO., INC.
460 WEST 34th ST., NEW YORK, N. Y.
Established 1910



The Forerunner of
NATION-WIDE FM NETWORKS*

Covering over 1/6 the total population of the United States, this network was completed in 1942. Thus for the first time, a station network was programmed by radio relay, without the use of land lines. The reliability required for commercial network operation is provided by the use of Armstrong crystal-control, phase shift modulation employed at all these stations:

WMTW	10 kw.	REL transmitter	43.9 mc.	2,000,000 pop.
WGTR	50 kw.	REL transmitter	44.3	5,500,000
WEOD	250 w.	REL S-T link	156.	(studio-trans. 43 mi.)
WDRC-FM	5 kw.	composite	46.5	2,118,000
W2XMN	40 kw.	REL equipped	43.1	12,000,000
WFIL-FM	10 kw.	REL transmitter	45.3	4,500,000

*The true FM networks projected for postwar service, will be programmed by FM radio transmission.

REL — PIONEER MANUFACTURERS OF FM TRANSMITTERS EMPLOYING ARMSTRONG PHASE SHIFT MODULATION

RADIO ENGINEERING LABS., INC.
Long Island City, N.Y.