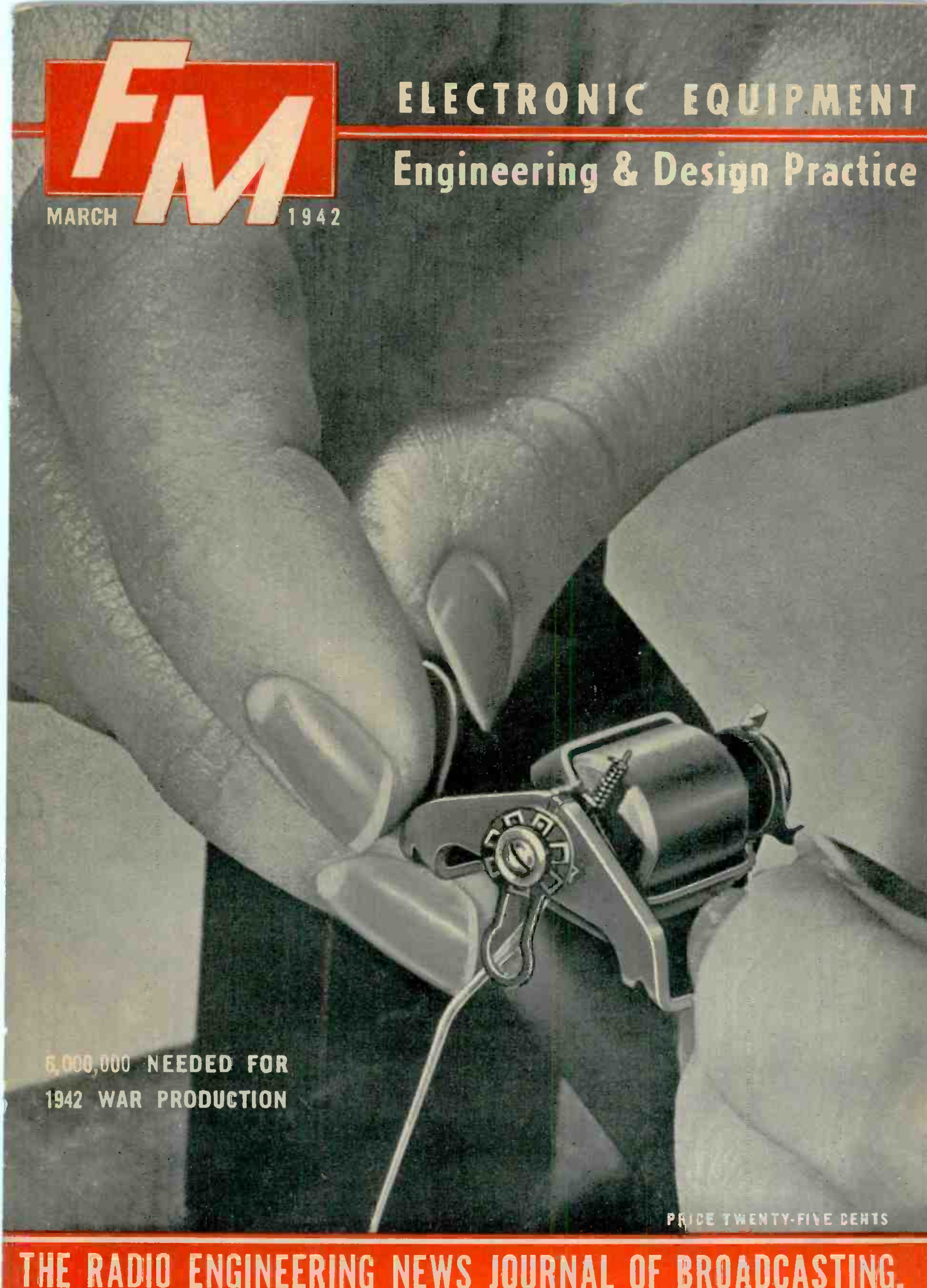
FM

MARCH 1942

ELECTRONIC EQUIPMENT

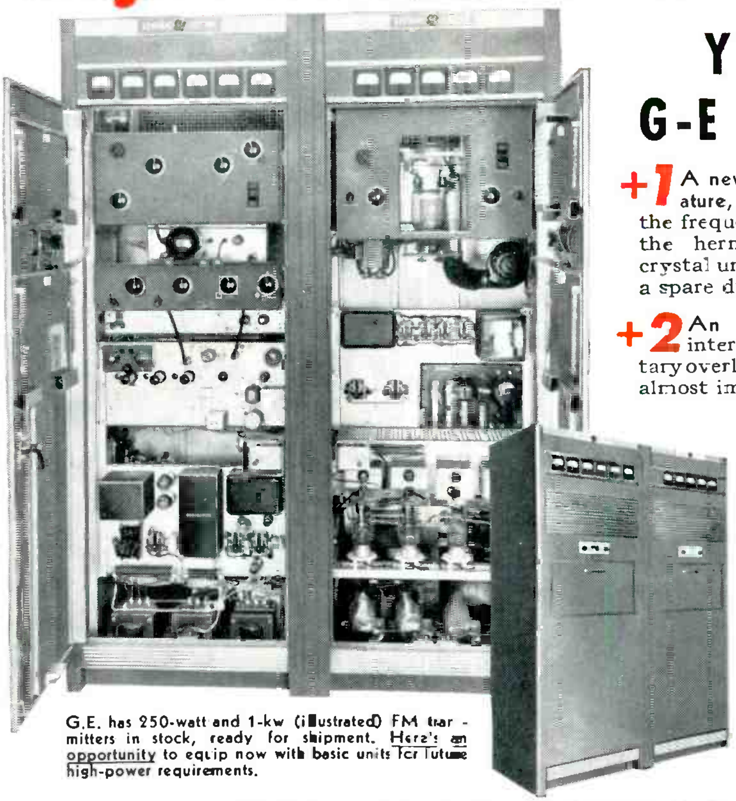
Engineering & Design Practice



THE RADIO ENGINEERING NEWS JOURNAL OF BROADCASTING, COMMUNICATIONS & TELEVISION ★ *Edited by M. B. Sleeper* ★

REG. U. S. PAT. OFF.

5 *plus* FEATURES



G.E. has 250-watt and 1-kw (illustrated) FM transmitters in stock, ready for shipment. Here's an opportunity to equip now with basic units for future high-power requirements.

YOU GET WITH G-E SIMPLIFIED FM

+1 A new method of controlling crystal temperature, which far surpasses older methods in the frequency stability obtained, is utilized in the hermetically sealed G-31 Thermocell crystal unit. Provision is made for switching to a spare during operation.

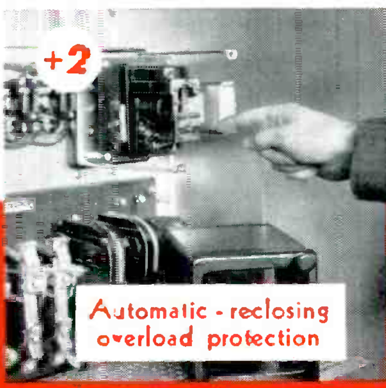
+2 An automatic recloser circuit makes the interruption of service caused by momentary overloads (removed by overcurrent relays) almost imperceptible to the listener.

+3 Telechron motor time-delay relays protect the rectifier tubes against premature application of plate voltage.

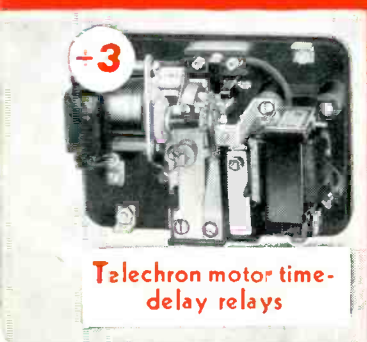
+4 Vertical-chassis construction makes every tube and soldered joint completely accessible. There is no need of removing entire units from the transmitter for detailed inspection.

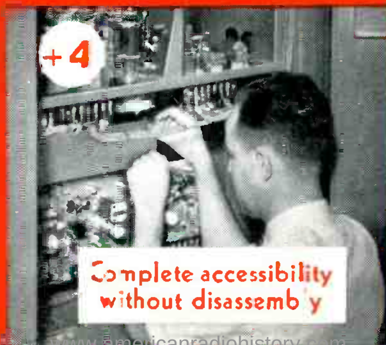
+5 Safety to operating personnel is assured by interlocks and high-voltage grounding switches on the main-access doors.

Details, yes, but important. Extras like these, standard for all G-E FM transmitters, contribute substantially in assuring you unusually excellent performance. For long dependable operation at low cost make your FM installation completely General Electric.

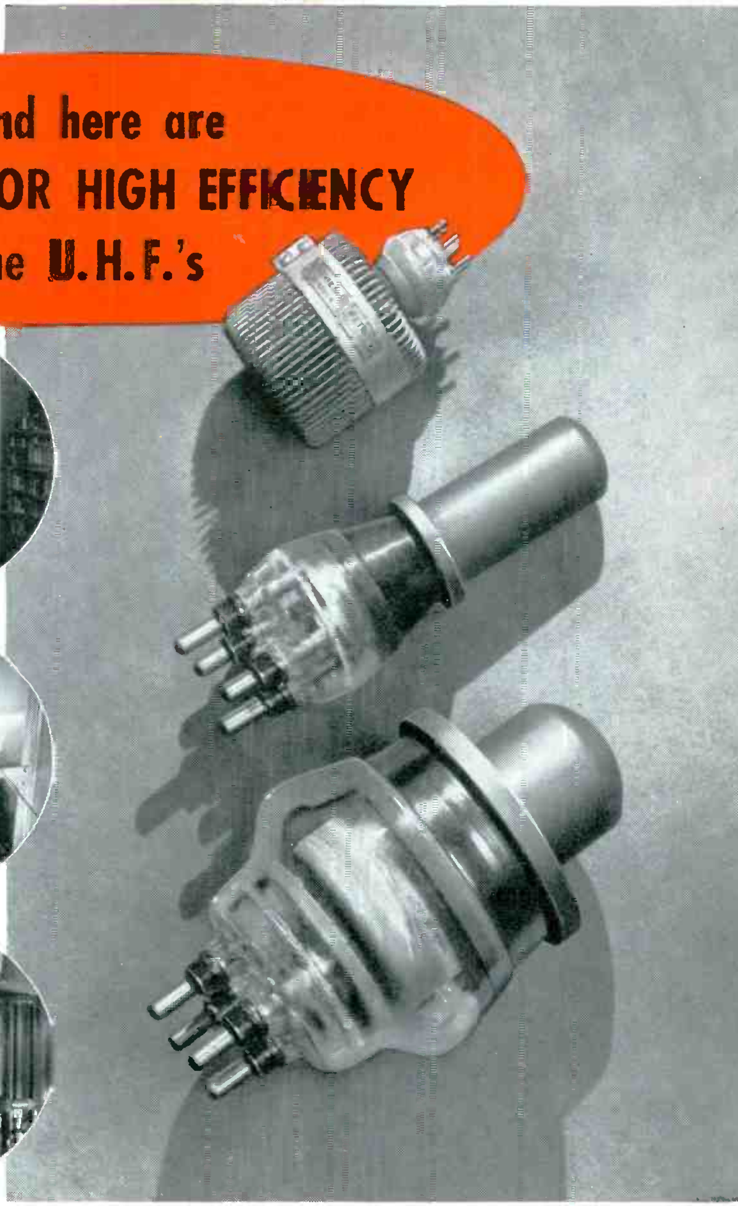


General Electric and its employees are proud of the Navy award of Excellence made to its Erie Works for the manufacture of naval ordnance.



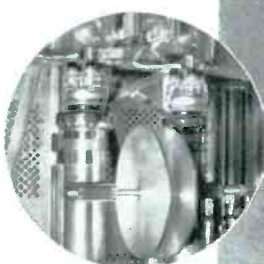


. . . and here are
THREE TUBES FOR HIGH EFFICIENCY at the U.H.F.'s



Hardly a handful, but the GL-8002R's output is 1800 watts up to 100 mc

Zenith's FM station W51C packs a 50-kw wallop with a pair of GL-880's



Twenty kilowatts of FM from these GL-889's at W47NV*

"EXCELLENT stability," "Easy to drive," "Easy to neutralize," "No cooling problems,"—that's what users are saying about these three tubes. Although built by General Electric primarily to speed the conquest of the ultra-highs, the GL-8002R, GL-889 (also available with radiator for forced-air cooling) and GL-880 provide superior performance for meeting all present-day broadcasting requirements.

Have you investigated our complete line of transmitting tubes for standard broadcasting, FM, television, and international service? Bulletin GEA-3315C will bring you the story. Get a copy from your nearby representative or dealer. Ask also for information about any of the FM equipment listed below. *General Electric Company, Schenectady, N. Y.*

**Operated by the National Life and Accident Insurance Co., Nashville, Tenn.*

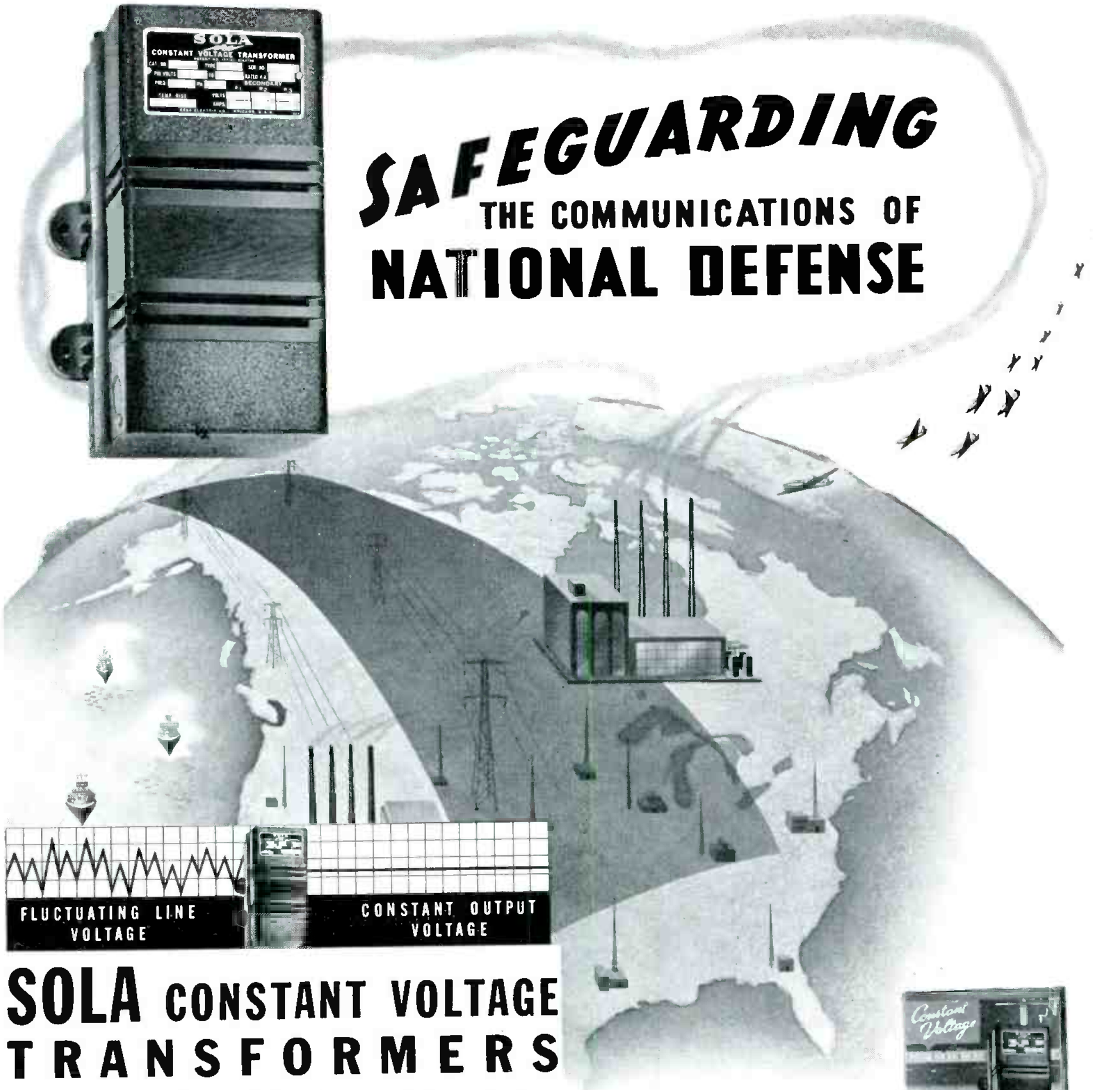
FOR ALL YOUR FM NEEDS

FM Broadcast Transmitters 250 to 50,000 Watts | S-T Transmitters | Measuring & Testing Equipment | Receivers for Home and S-T Service | FM Police and Emergency Transmitters and Receivers | Tubes

GENERAL ELECTRIC

160-21B-6914

SAFEGUARDING THE COMMUNICATIONS OF NATIONAL DEFENSE



SOLA CONSTANT VOLTAGE TRANSFORMERS

Radio communication in all its phases needs the protection of constant voltage to—

1—**insure dependable operation under emergency conditions.**
2—**protect vital equipment against damage by line surges.**
3—**ellminate the necessity of constant supervision.**

The enormous demands placed on power stations by the national defense program are already making the maintenance of stable line voltages an overwhelming problem. Success or failure of a communications system may depend upon protection against line surges, or abnormal voltage levels.

Manufacturers of defense communication equipment can provide protection against these contingencies by building CONSTANT VOLTAGE into their products.

Sola CONSTANT VOLTAGE TRANSFORMERS will deliver a perfectly stabilized output voltage, even though line voltages vary as much as 30%. No moving parts. Instantaneous in action. Self-protecting against overload or short circuit.

Sola CV TRANSFORMERS are already at work in the national defense programs of the—

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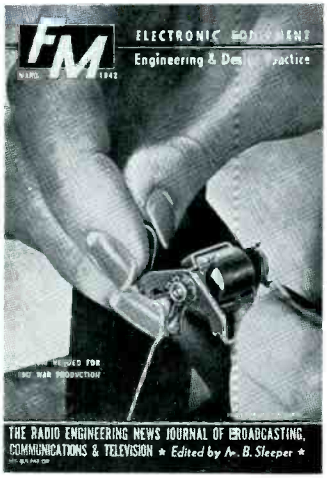
SOLA ELECTRIC COMPANY, 2525 Clybourn Ave., Chicago, Ill.



6,000,000 METERS

SOME idea of the magnitude of War Production tasks facing U. S. manufacturers can be gained from the estimate of 6,000,000 small electrical measuring instruments required for radio and other military apparatus to be built in 1942. To be produced by a dozen or more companies, these will be of the general design introduced by Weston in 1912 — the small moving-coil 301 series.

The 6,000,000 quantity is more than a figure of production requirements. It is a measure of the "electrification" of warfare.

Consider that 60 years ago, when Edison was operating the Country's first central lighting station, he had no current measuring instruments. He suspended a shingle nail, hung near one of the heavy wires supplying current to his customers' lights. Whenever the current became strong enough to draw the nail close to the wire, he readjusted the generators until the lamps seemed to be burning "about right."

The manufacture of the now familiar moving-coil instruments was not even started until 1888, when Dr. Edward Weston formed the company which bears his name. Model 1, Number 1, is today in the Museum of the Newark College of Engineering.

The quantity of this single item of meters which must be produced before the end of the year indicates the increase in the use of electrical equipment in this War over the last.

ELECTRONIC EQUIPMENT ENGINEERING & DESIGN PRACTICE

COMBINED WITH APPLIED ELECTRONIC ENGINEERING

VOL. 2 MARCH, 1942 NO. 5

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M. B. SLEEPER, *Editor and Publisher*

S. R. COWAN, *Advertising Manager*

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The publishers will be pleased to receive articles, particularly those well illustrated with photos and drawings, concerning all phases of FM 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.

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LATEST FM NETWORK SPONSOR

DR. W. R. G. BAKER, G. E. VICE PRESIDENT, SIGNS LARGEST FM TIME CONTRACT ON AMERICAN NETWORK, OF WHICH JACK LATHAM IS EXECUTIVE V. P. IN ADDITION, G. E. IS USING CBS NET TO TELL ALL LISTENERS ABOUT THE ADVANTAGES OF FM, SO THAT PUBLIC WILL BE THOROUGHLY ACQUAINTED WITH STATIC-LESS RECEPTION WHEN BROADCASTING EXPANSION AND RADIO SET SALES ARE FREE TO MOVE AHEAD AGAIN. FRAZIER HUNT, G. E.'S NEWSCASTER, WILL ALSO DISCUSS OTHER PUBLIC SERVICE DEVELOPMENTS IN THE ELECTRONIC FIELD

FRAZIER HUNT'S FIRST BROADCAST PRECEDED A MEETING IN NEW YORK WHERE LATEST ELECTRONIC DEVICES WERE DEMONSTRATED. G.E.'S PRESIDENT WILSON IS IN THE FIRST ROW, AT LEFT

G.E. BACKS FM BROADCASTING

Continued FM Progress Depends On the Industry — Not On the Public

BY DR. W. R. G. BAKER*

MORALE is vital stuff today, and the radio industry, quite naturally, occupies a place of leadership in distributing this major commodity.

But while radio is doing a splendid job for the nation, it may be treading dangerously close to neglecting its own morale. This is particularly true in FM.

Viewed from one angle, FM has suffered severe blows. But let's look at the bright side of the picture. The FCC is still licensing new FM stations at an encouraging rate. The War Productions Board, in issuing restrictions on some types of broadcast equipment, has left the door open to both FM and television. Reports of the FM Broadcasters, Inc., indicate a still sizeable number of FM receivers in stock to be sold during 1942. And transmitter manufacturers are still able to deliver a limited number of equipments.

Yes — there are shortages — and we can expect them to continue. But the important thing is that there is still progress. And only if the FM industry interprets its activities to the man-on-the-street in that term can we expect progress to continue. There must be no let-down on the part of the industry in telling the FM story to the public — and to ourselves.

Those thoughts, plus a firm confidence in the future of FM, were the reasons that General Electric is using a network of eight FM stations — The American Network and several independent stations — in addition to the CBS network, to carry the new GE radio news program with Frazier Hunt.

We believe that we can maintain FM progress only in proportion to our faith in it. We hope that our confidence in FM as a medium to

* Vice-President, General Electric Company, Schenectady, N. Y.

FRAZIER HUNT, RIGHT, IS A MASTER AT EXPLAINING TECHNICAL SUBJECTS IN SIMPLE TERMS

reach a class audience will spread to other advertisers. And we feel that in the Frazier Hunt style, we are bringing a new kind of news reporting to FM audiences.

Frazier Hunt is no arm-chair commentator. His six-foot frame has been a familiar sight wherever news is being made. He has dodged the shrapnel of two world wars. And through it all he has built an abiding faith — and a fiery one — in America.

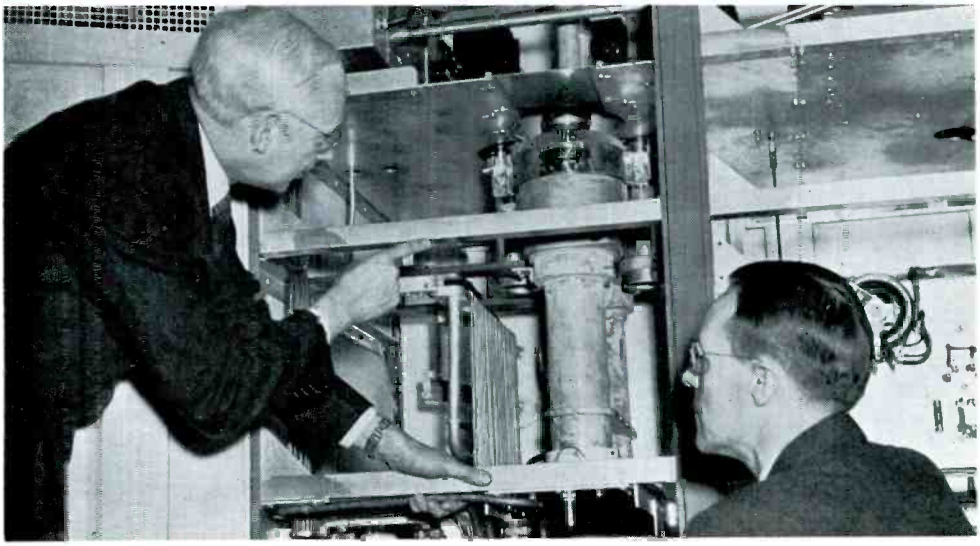
"It is a stirring sight," he said to me, "to see the radio industry of America going to war — it's a sight I want America to see as clearly as ever I can tell it."

The ultimate purpose of this program — speaking in advertising terms — is to create a public consciousness for the whole field of electronics. In doing so, we will, of course, show electronics' part in winning the war. But, more important, we expect to paint a picture of the hope for the future which electronics in all its many forms brings.

Not the least among electronic advance-

(CONTINUED ON PAGE 11)

ACTIVE IN G.E. ELECTRONICS DEVELOPMENTS ARE W. C. WHITE, TUBES, AND W. R. DAVID, SALES



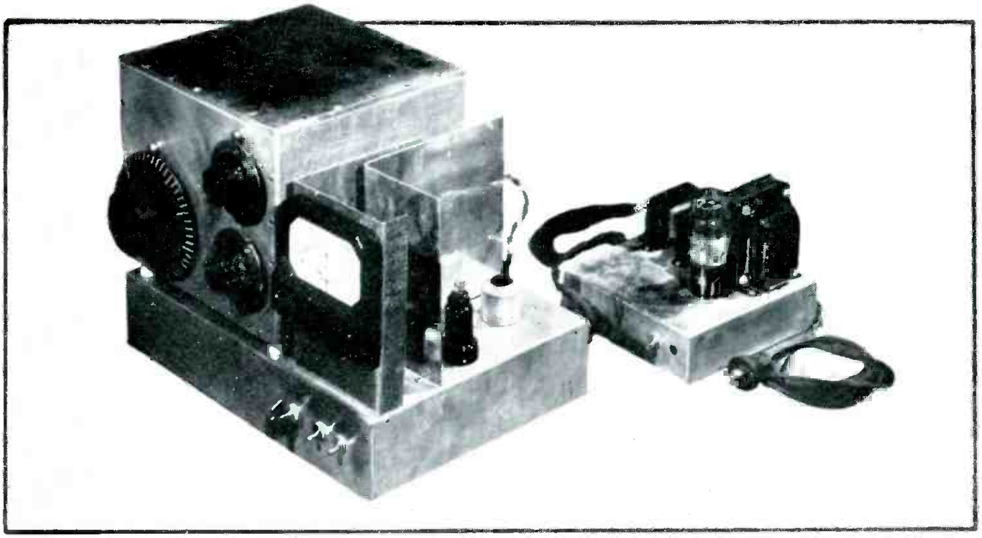


FIG. 11. THE FM CAPACITY ANALYZER, THE CIRCUIT OF WHICH APPEARS IN FIG. 10

NEW APPLICATIONS OF FM

Part 2. The Zakarias Space Charge Discriminator, and Its Use in Microphone Circuits, Mechanical and Electrical Measurements, and Industrial Applications

BY KARL RATH*

FM Microphone Characteristics ★ In the following, a comparison is made between the frequency characteristic and the noise level of the condenser microphone for low frequency operation on the one hand and for high frequency operation on the other hand. For this purpose, it is assumed that the diaphragm has no resonance point within the frequency range under consideration, i.e. that the sound pressure amplitudes are faithfully converted into diaphragm movement and in turn into capacity variations. The low frequency circuit is shown in Fig. 7. Assuming that C_o represents the normal capacity of the microphone, R the load resistance, ΔC the amplitude of the capacity variations, E the polarizing voltage and $\omega = 2\pi f$ the modulating frequency, then the theory shows the following relation for the audio frequency voltage e developed by the load resistance:

$$\text{If} \quad \omega < \frac{1}{C_o R}, \text{ then } e = \Delta CER\omega \qquad (6)$$

$$\text{If} \quad \omega > \frac{1}{C_o R}, \text{ then } e = \frac{\Delta C}{C_o} E \qquad (7)$$

As is seen from equation (6), the voltage e is directly proportional to the frequency for the lower modulating frequencies as shown by the curve, Fig. 8. The frequency characteristic was calculated under the assumption of a load resistance $R = 10$ megohms and a microphone capacity $C_o = 200$ μμf. Thus, if for 16 cycles modulating frequency it is desirable to still obtain 90% of the voltage obtainable with the higher frequencies, it would be necessary to connect a ballast capacity of 1800 μμf in parallel to the microphone, thereby reducing the voltage to 1/10th of its original value. An increase of R beyond 10 megohms is hardly possible for practical operating reasons. The noise voltage between the ends of the 10-megohm load resistance and for a condenser capacity of 200 μμf is approximately 10 microvolts.

The high frequency circuit, on the other hand, according to Fig. 1, provides a low frequency output voltage whose magnitude

*Engineer, Radio Patents Corporation, 10 E. 40th Street, New York City.

depends primarily upon the frequency deviation, i.e. the amplitude of the capacity variations as indicated by the characteristic shown in Fig. 4. A dependence upon the modulating frequency exists only in so far as the slope of the resonance curve for the *LC* circuit causes a weakening of the higher frequencies. This is a further reason to employ a *Q* which is not too high and a carrier frequency not too low. thus, if for 10,000 cycles the admissible reduction should not exceed 10%, the permissible lowest carrier frequency is found to be 400 kc. for a *Q* of 20. The magnitude of the low frequency voltage within the entire frequency range from zero frequency to the highest

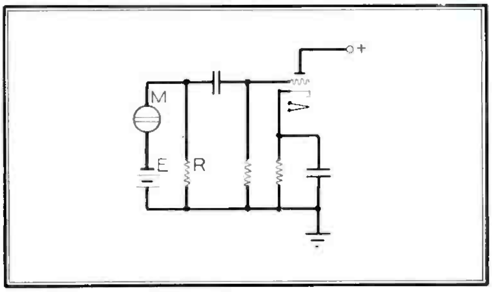


FIG. 7. LOW-FREQUENCY MICROPHONE CIRCUIT, ANALYZED IN EQUATIONS 6 AND 7

frequencies permitted by the *Q* and the carrier frequency, again assuming a current variation of 1 milliampere per 1% frequency change, i.e. 2% capacity change ($\frac{\Delta C}{C_o}$ = .02), is found to be as follows:

$$e = 50 \frac{\Delta C}{C_o} \text{ volts} \qquad (8)$$

A comparison of equations (7) and (8) shows that the low frequency operation using 50 volts polarizing voltage (use of higher voltages would be at the expense of the operating safety) yields the same output voltage to the grid of the first amplifier tube for medium and high frequencies as in the case of high frequency operation. If, however, a frequency characteristic is desired which is flat down to 16 cycles, the low frequency operation proves to be substantially inferior. As shown above, it may supply only 1/10th the voltage obtained according to equation (8).

The noise voltage in the case of high frequency operation is the same as is customary with present-day mixer tubes for 10-kc. band width and amounts to about 5 microvolts. The signal-to-noise ratio, however, can be increased about 50 times by utilizing the capacity variations of the condenser microphone to modulate the frequency of a 30-mc. oscillator, and thereafter reducing the frequency to .6 mc. by heterodyning and demodulating the lower frequency. If this method is used it is necessary to maintain the carrier frequency of 30 mc. constant within .02% by suitable stabilizing means.

A further advantage of the high frequency operation of the microphone is the fact that grid g_4 of the octode or equivalent tube is short-circuited for low frequencies by the inductance coil of the resonant circuit, whereby the circuit is substantially insensitive to alternating current hum. This renders the operation from a power circuit possible without difficulty. In the case of the low frequency operation, on the other hand, the grid of the first amplifier is extremely sensitive to hum voltage across the 10-megohm load resistance, so as to make operation from a power line in most cases impossible.

Fig. 9 shows a diagram for a 50-watt high fidelity condenser microphone amplifier for public address and similar uses, utilizing a condenser microphone circuit of the type described. In addition to the converter T_1, this amplifier comprises a pair of driver stages T_2 and T_3, followed by a pair of push-pull power amplifier tubes T_5 and T_6, with T_4 serving as a phase inverter. Resistance coupling is used throughout between the stages with the exception of the loud-speaker coupling which employs a low-frequency transformer. Special precautions should be taken to filter the supply potentials adequately for the anode and screen grid of the converter. In order to prevent motor-boating and other disturbances, it is advisable to use separate heating and anode supply sources for the converter T_1 and for the amplifier.

FM Micrometer ★ The extreme sensitivity of 10^{-6} ampere per 10^{-5} millimeter mentioned above renders the system especially suited for use as a super-sensitive micrometer by measuring distances or displacement in terms of a miniature capacity in the manner described.

For example, the discriminator described can be used for the study of the movement of different points on a loud speaker diaphragm. All that is necessary for this purpose is to provide one surface of the diaphragm with a conductive metal coating connected to the grounded end of the oscillator inductance coil. The other plate of the variable condenser can take the form of a probe of about 1 square cm. area, placed at a distance of about 1 to 2 mm. from the diaphragm.

In order to exclude the influence of extraneous fields, the fixed electrode should be shielded suitably. Furthermore, in order to interfere as little as possible with the movement of the diaphragm, it is advantageous to construct both the probe and the shield of coarse wire mesh or perforated sheet metal. The variation of the direct plate current of the octode or equivalent tube used will provide a direct indication of the excursions of the loud speaker diaphragm, independently of the frequency of the voltage impressed upon the voice coil which, if desirable, may range from zero to the highest audible frequencies. Assuming a probe of 1 square cm. area, a distance of the probe from the diaphragm equal to 1 mm., and an oscillating capacity of 50 $\mu\mu f$, and assume further a slope or conversion efficiency of 1 milliampere per 1% detuning, it is found that about .1 milliampere change of the anode current is obtained for a diaphragm excursion of .1 mm. In case of a .1-megohm plate load resistor, this will deliver an output voltage of 7 volts.

Low Frequency Generator ★ Another use of the discriminator is to provide a simple generator for very low frequencies. For this purpose a small variable speed motor is used, having mounted upon its shaft a toothed wheel which constitutes the grounded plate of a variable condenser. Opposite the teeth, at a distance of about .2 mm., there is mounted a stationary electrode, preferably shielded, having an area equal to that of a single tooth. Rotation of the motor will result in periodic capacity changes having a frequency determined by the number of teeth and the speed of rotation.

These capacity variations are converted into current changes by the discriminator. The tone frequency supplied by the load resistance of .1 megohm in case of a tooth area of .24 square cm. (1.2 x .2 cm. corresponding to a .5 $\mu\mu f$ capacity) will be of approximately 20 volts, assuming again a 50 $\mu\mu f$ oscillator capacity and 1 milliampere anode current variation per 1% detuning. The frequency can be varied from the lowest values up to the highest audio frequencies by regulating the rotating speed. This generator is much superior to the well-known tone wheel or light chopper, due to its simplicity by the elimination of the photocell, the optical apparatus, and light source of constant intensity. The carrier frequency should be between 5 and 10 mc.

Measurement Circuits ★ Furthermore, the circuit described is suited as a simple and easily operable device for measuring or checking inductance, capacitance, and loss angle in accordance with the substitution method proposed by H. M. Bach.[1]

Fig. 10 shows a diagram of a capacity analyzer of this type, designed to measure capacities from 0 to 500 $\mu\mu f$. The circuit design is such that capacities may be readily measured to 100th $\mu\mu f$. The instrument is direct reading and contains a dial calibrated from 0 to 500 $\mu\mu f$ in 1 $\mu\mu f$ per division, and a further vernier dial reading from 0 to 10 $\mu\mu f$ in .1 $\mu\mu f$ steps.

Referring to the diagram, the oscillator tube T_1 has a tank circuit tuned to 465 kc. by means of three condensers in the oscillator tank circuit. The components in the oscillator circuit are so designed that the oscillator tunes to 465 kc. with the 500 $\mu\mu f$ main tank condenser and the 10 $\mu\mu f$ vernier condenser at full capacity. Small adjustments are effected by means of a further 10 $\mu\mu f$ trimmer. The output of the

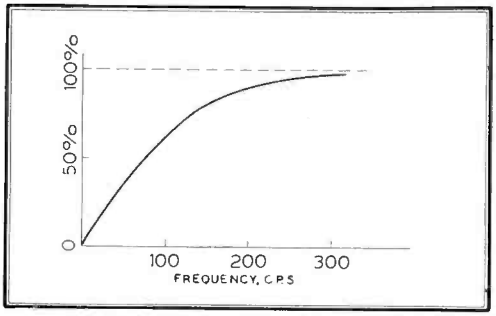


FIG. 8. FREQUENCY CHARACTERISTIC OF THE LOW-FREQUENCY TYPE OF MICROPHONE

oscillator is fed into a buffer amplifier T_2, to insure extreme oscillator stability and to give a complete decoupling between the oscillator and the measuring circuit. The output of the buffer amplifier is fed into the first grid of a 6L7 type space charge discriminator T_3, the third grid of which is suitably connected to ground through a 465-kc. quartz crystal CRY_1 or CRY_2 which takes the place of the resonant LC circuit shown in the previous illustrations.

There is further provided a second 6L7 tube T_4 which is used to balance out the steady plate current drawn by the first tube. The zero-center meter M is shown connected in a Wheatstone bridge arrangement utilizing the two 20,000-ohm resistors and the two plate-to-cathode impedances of the tubes as arms of the bridge. Zero adjustment is effected by varying the screen voltage of the tube T_4.

Preliminary work on this instrument has shown the necessity of extreme frequency stability in the oscillator. Accordingly, therefore, the small battery acorn type tubes were utilized inasmuch as they readily provide the necessary output, and operate at an extremely low temperature. Thus they tend to hold frequency drift due to temperature changes at a minimum. They likewise have high trans-

[1] U. S. Patent 2,270,243

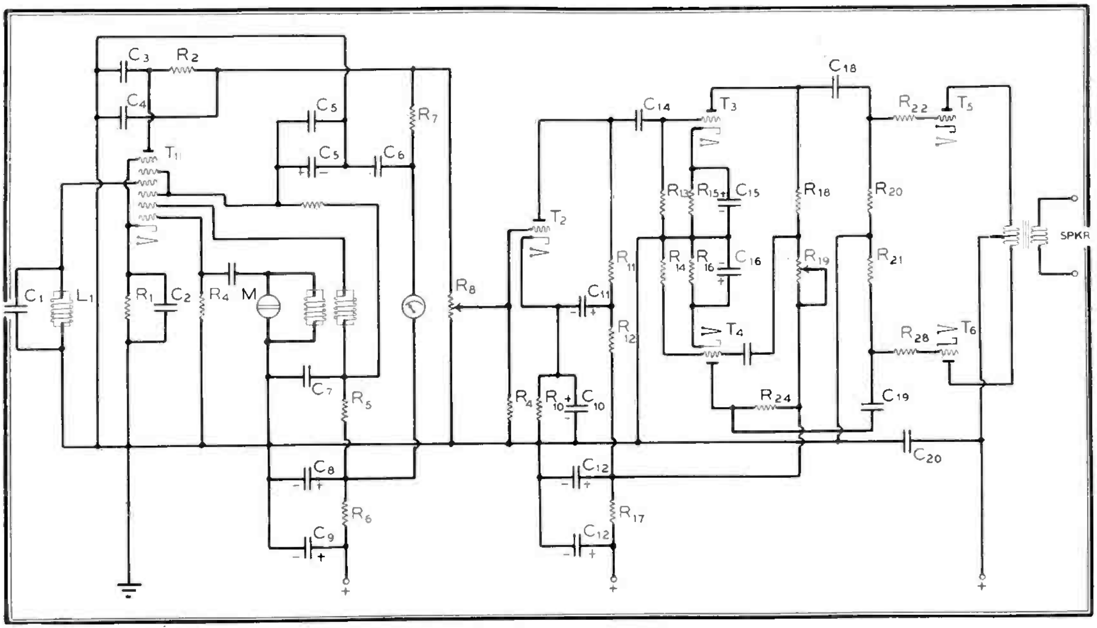


FIG. 9. CIRCUIT OF A 50-WATT HIGH-FIDELITY MICROPHONE AMPLIFIER, USING THE FM TYPE OF MICROPHONE DESCRIBED IN THIS ARTICLE. VALUES ARE SHOWN BELOW

conductance and extremely low inter-electrode capacities which further improve the oscillator stability. It was found that a tuned plate type of oscillator furnished the optimum in frequency stability. By grounding the positive rather than the negative end of the power supply, it was possible to have the unknown capacity operate at zero *DC* potential with respect to the chassis, and likewise to eliminate a great number of radio frequency chokes and condensers which might impair the frequency stability.

It was found desirable to incorporate two quartz crystals CRY_1 and CRY_2, one having a very high *Q* and the second rigidly clamped, to have a relatively low *Q* in order to measure various types of condensers. The high-*Q* crystal is utilized when extreme precision is required for measuring capacity changes of the order of a few thousandths of a $\mu\mu f$. But inasmuch as the sensitivity of this circuit is so high, it was found desirable to utilize the low-*Q* crystal for ordinary measurements, wherein it is not desirable to recheck the system and make zero adjustments after a few readings. The advantage of the balanced tube arrangement in the output is that power supply fluctuations due to changing line voltage are substantially balanced out, and the stability of the system is greatly improved.

The oscillator and buffer stage and the tuning controls are located in an aluminum box suitably heat-shielded from the rest of the circuit. The power supply is located on a separate chassis, so as to minimize heating of the crystal and oscillator circuit. The meter is a center-zero microammeter, calibrated with 100 units on each side of zero. Full-scale deflection in either direction is obtained by a change in condenser capacity 1/10th of a $\mu\mu f$.

The operation of the device is as follows: The circuit is first balanced by means of the balancing condenser of 10 $\mu\mu f$ and the plate meter is brought to zero by means of an adjustable screen potentiometer for the balancing tube T_4. In this position the main and vernier tuning dials both read zero. The unknown

VALUES OF COMPONENT PARTS SHOWN IN THE SCHEMATIC WIRING DIAGRAM, FIG. 9.

R_1	300 ohms	C_1	50 mmf.
R_2	.01 meg.	C_2	.1 mfd.
R_3	.01 meg.	C_3	100 mmf.
R_4	.02 meg.	C_4	100 mmf.
R_5	.02 meg.	C_5	10 mfd.
R_6	.01 meg.	C_6	1 mfd.
R_7	.1 meg.	C_7	.1 mfd.
R_8	.5 meg.	C_8	20 mfd.
R_9	2.0 meg.	C_9	20 mfd.
R_{10}	1000 ohms	C_{10}	100 mfd.
R_{11}	.03 meg.	C_{11}	4 mfd.
R_{12}	.01 meg.	C_{12}	20 mfd.
R_{13}	.5 meg.	C_{13}	20 mfd.
R_{14}	.5 meg.	C_{14}	.05 mfd.
R_{15}	1000 ohms	C_{15}	100 mfd.
R_{16}	1000 ohms	C_{16}	100 mfd.
R_{17}	.01 meg.	C_{17}	.05 mfd.
R_{18}	.028 meg.	C_{18}	.1 mfd.
R_{19}	5000 ohms	C_{19}	1 mfd.
R_{20}	.25 meg.	C_{20}	1 mfd.
R_{21}	.25 meg.		
R_{22}	1000 ohms		
R_{23}	1000 ohms		

VALUES OF COMPONENT PARTS SHOWN IN THE SCHEMATIC WIRING DIAGRAM, FIG. 10

R_1	50000 ohms	C_1	500 mmf.
R_2	300 ohms	C_2	10 mmf.
R_3	30000 ohms	C_3	10 mmf.
R_4	20000 ohms	C_4	250 mmf.
R_5	10000 ohms	C_5	.002 mfd.
R_6	50000 ohms	C_6	.002 mfd.
R_7	20000 ohms	C_7	.1 mfd.
R_8	.5 meg.	C_8	.1 mfd.
R_9	.5 meg.	C_9	.1 mfd.
R_{10}	300 ohms	C_{10}	.1 mfd.
R_{11}	15000 ohms	C_{11}	.1 mfd.
		C_{12}	.1 mfd.

VALUES OF COMPONENTS SPECIFIED IN THE WIRING DIAGRAMS, FIGS. 9 AND 10

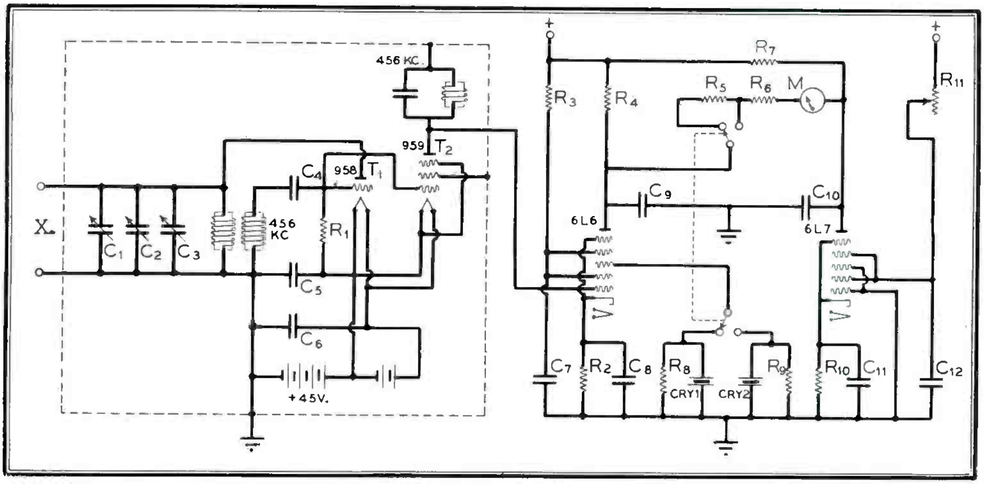


FIG. 10. FM TYPE OF CAPACITY ANALYZER. VALUES OF COMPONENT ARE LISTED ON PAGE 10

condenser *x* is then connected across the terminals as shown and the condensers are rotated until the meter returns to zero. The unknown capacity is the read directly on the tuning dials. A photograph of this capacity analyzer is shown in Fig. 11.

Since the steepness of the discriminator characteristic is dependent on the *Q* of the *CL* circuit, the device can be adapted easily for measuring the loss angle and *Q* values of inductances or circuits.

Pressure Indicator ★ Another use of this discriminator is for the direct indication or recording of gas pressure, as in the cylinder of internal combustion engines, utilizing a capacity type pressure-responsive device to frequency-modulate the oscillation impressed upon the discriminator input. Heretofore, piezo-electric crystals have been used extensively as pressure-responsive devices, but their usefulness is limited in most cases due to heat influences and other reasons.

Radio Receivers ★ Finally, the new frequency discriminator can be used advantageously in the demodulating circuits of FM receivers, or in connection with automatic frequency control systems in any type of radio receivers. In a simplified arrangement, the suppressor grid of an existing *IF* amplifier tube can be used as the outer control grid and the screen grid to develop a frequency control (discriminating) potential applied to a reactance control tube or any other frequency controlling element of the local oscillator. This eliminates a separate discriminator, for the screen current undergoes a similar variation but in opposite phase to that of the plate current, as shown in Fig. 4.

Numerous other uses and applications of the new space charge frequency discriminator described will be apparent, in particular for all such cases involving the conversion of slight frequency, capacitance, inductance and other changes directly and faithfully into relatively large current intensity changes by simple means.

G.E. BACKS FM BROADCASTING

(CONTINUED FROM PAGE 6)

ments is FM. Surveys have shown that today — even in FM listening areas — there is an amazing ignorance of FM's many advantages.

Despite the great strides made by FM station operators, there is still a surprising amount of educational work to be done. This task is one we have assigned to the GE Radio News Program — education on FM. We know that in many parts of the country FM is still far from a reality. But we know too that acceptance of this new idea by the public will take time.

The time to prepare for that post-war progress is now. In the commercial messages carried on our news program, we shall continue to point out frequently the advantages of FM, so that those listening to the AM stations will have the desire to buy sets equipped for FM reception when the present emergency is over, and we return to normal living.

The FM end of the GE broadcasts are originating at W47NY, from which they are picked up on W2XMN, and distributed on FM frequencies to W65H, and north to W43B and W39B, to W2XOY and W47A, and to W53PH. The program is transmitted on Tuesdays, Thursdays, and Saturdays at 6:30 to 6:45 P.M. on the FM stations, and at 6:00 to 6:15 P.M. on the 51 CBS stations.

PROGRESS IN RADIO PROCUREMENT

The Way Is Being Cleared to Utilize Home Radio Plants. Meanwhile, Additional Civilian Set Allotments May Be Needed

BY M. B. SLEEPER

OF THE radio manufacturers who produced the majority of the peacetime radio equipment, many have no war contracts, while some have contracts which will engage only a small part of their present employees, yet the April 22nd dead-line of home radio set production is almost here.

Officials of the WPB are being currently besieged by radio manufacturers who complain that they have been unable to get war contracts, and that they will be forced to disband their organizations unless they are permitted to continue their production of home radios.

Meanwhile, a few prime contractors have backlogs of orders which add up to enormous sums, and they are constructing new plant facilities of their own instead of sub-contracting orders among companies whose factories may soon be idle.

Obviously, there must be something wrong with this picture when a few concerns have more business than they can handle and those who need orders most get little or nothing at all.

What Are Your Facilities? ★ Manufacturers have been beating paths to Washington and other points where orders are given out, only to be shunted around to so many men of no authority and have answered, unavailingly, the question, "What are your facilities?" so many times that any day now some form-filler-outer is going to be beaten up by some manufacturer who just can't take it any longer! This condition has given rise to much criticism not voiced, however, to official ears because the Government agencies and the large prime contractors, against whom the complaints are directed, are the very sources from which relief must come.

The Procurement Problem ★ What many manufacturers do not realize is that theirs are not the only problems. They seldom meet the men at the top who could explain the real condition of affairs because these executives, responsible for procuring the radio equipment needed for our Armed Forces, are carrying such tremendous loads that, even by working twelve and fourteen hours a day six days a week, they are gaining all too slowly in their task of keeping current work moving while they improve the effectiveness of their respective organizations.

It is not possible to get a broad picture of the radio procurement problem from any single source. However, the following explanation is reliably accurate and complete:

Our entry into the war set up demands for the immediate purchase of equipment far beyond the capacity of the procurement divisions of the Army, Navy, Marine Corps, and the Coast Guard. Under those circumstances, they followed what was undoubtedly the wisest course. That is, lacking man-power of their own to follow through the separate details of placing individual contracts totalling millions upon millions of dollars, they divided the responsibilities among the few companies who had the experience and the organizations to get the orders started into production. These are the concerns who now have the bulk of the prime radio contracts.

The next step was to expand Government procurement departments at once. This was no easy task. Additional appropriations for radio equipment were being made faster than men could be hired and instructed and their efforts coördinated. So that contracts would not back up in procurement offices during this period of organization, most of these orders were handed out to the original group.

Theoretically, a substantial part of these contracts should have been parcelled out to subcontractors. In practice, that plan was partly defeated by conditions that made subcontracting necessary. That is, the prime contractors were so snowed under that they did not have enough men available to train and supervise concerns which had no experience in building equipment of the type and to the standards required by our Armed Forces. Responsibility for production to meet the rigors of Government inspection, particularly on apparatus not previously produced by prime contractors, cannot be passed on lightly.

Credit Where It Is Due ★ Considering the magnitude of the tasks involved, it seems remarkable that, within less than four months after the attack on Pearl Harbor, procurement organizations have been built up to the point

(CONTINUED ON PAGE 38)

FIG. 1. REL TRANSMITTER, RECEIVER, AND POWER SUPPLY ARE CONTAINED IN A SINGLE DUST-TIGHT UNIT

SINGLE-UNIT MOBILE FM EQUIPMENT

Part 1. Specifications, Description, and Data on Installation of New REL Victory Model

BY A. H. QUIST, JR.*

WAR conditions have brought about a tremendous demand for mobile emergency equipment for regular police systems and for a great many new services. The high efficiency of FM equipment and its superiority over similar AM apparatus is well known to radio engineers.

Since FM has been in use long enough for mobile services to provide a broad background of experience with the equipment, we undertook to design, and are now producing, a completely revised transmitter and receiver model, based on past records of performance and service.

That is, we have retained the features which showed merit, eliminated or corrected points of weakness, and added new circuit developments which simplify the design and facilitate installation and maintenance.

Appropriately, we call the new design the Victory model, for it is one of our engineering contributions toward ultimate victory over the enemies of peace and democracy. The official designation of the complete equipment is No. 565A, for which a hand microphone is supplied, and No. 565AWE when a combination handset is furnished.

Single Unit ★ The most striking feature of the Victory model is the use of a single chassis to carry the transmitter, receiver, and power supply, instead of dividing them into two or three separate units, installed individually.

As the illustrations show, the metal case containing the equipment is not fastened directly to the floor of the baggage compartment of the patrol car, but to a base plate which in turn is mounted permanently. Thus, by loosening catches at the ends of the case, the complete unit can be removed for inspection or replacement.

Since the complete radio equipment is contained in one unit, there are no interconnecting cables and plugs. As Fig. 1 shows, the cover is so designed as to protect the test jacks from dust.

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

Of the two types of the Victory design, model 565A is equipped with a hand microphone and a loudspeaker which is mounted under the dashboard of the car. Model 565AWE is identical in every respect except that it has a French phone in place of the hand microphone. A loudspeaker is supplied also, with a control to switch off the speaker, when desired.

Equipment ★ The complete car installation includes the following equipment and parts:

1 — Transmitter, receiver, and power supply unit, complete with base and cover
1 — Transmitter crystal
1 — Receiver crystal
1 — Remote control unit No. 565A or No. 565AWE. No. 565A includes REL hand microphone, while No. 565AWE is provided with a combination handset
1 — Loudspeaker
1 — Antenna rod and mounting bracket, with the rod cut to correct length for frequency ordered
1 — Fuse cut-out block, complete with 50-ampere renewable type fuse
1 — Set of interconnecting cables, including copper concentric line with Isolantite bead insulation for antenna connection
1 — Set of mounting hardware
1 — Set of operating instructions

Specifications ★ Characteristics and performance are indicated by the following specifications:

Frequency Range: 30 to 40 mc.

R.F. Output of Transmitter:
22 watts at 5.5 volts input
27 watts at 6.0 volts input

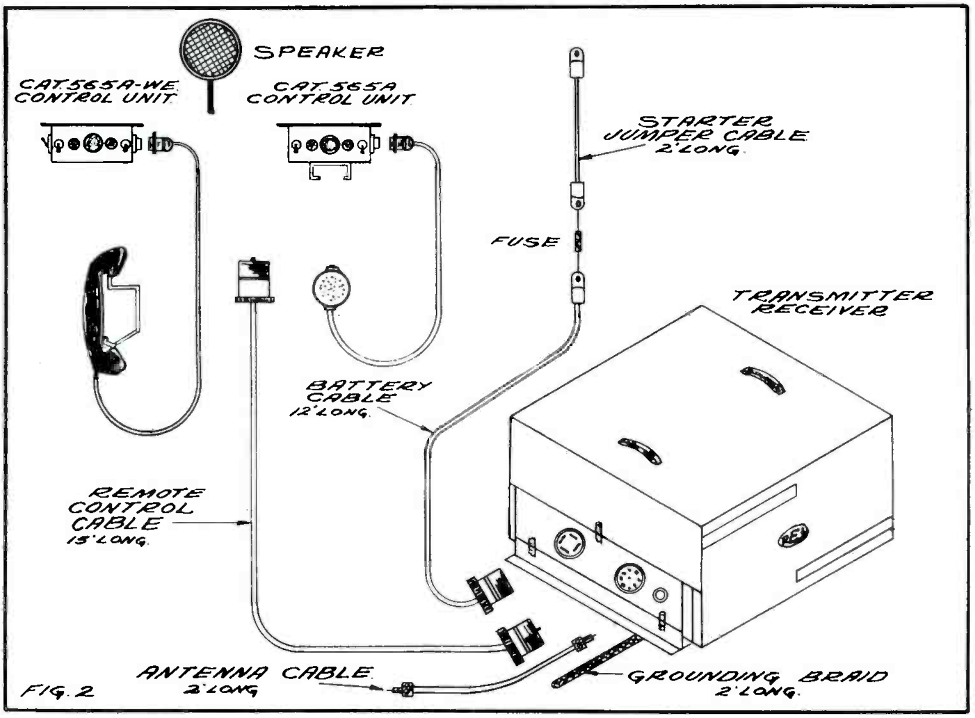


FIG. 2. THE COMPLETE CABLE SYSTEM IS STRIKINGLY SIMPLIFIED BY THE SINGLE-UNIT DESIGN, CONNECTIONS ARE SHOWN FOR THE OPTIONAL MICROPHONE OR HANDSET TYPES

Audio Output of Receiver: 1.25 to 1.5 watts.

Overall Audio Response — The transmitter pre-emphasis and the receiver de-emphasis circuits are so designed that, from microphone input, including microphone characteristic, to speaker output at receiver, the response is essentially flat from 500 cycles to 3,000 cycles, which is the most useful portion of the speech spectrum. Below 500 cycles, the audio is attenuated to reduce distortion; above 3,000 cycles, it is again attenuated to improve the signal-to-noise ratio on weak signals.

Receiver Gain: 31 million times from antenna input to first limiter grid. Any gain after this point is of no value in improving reception on FM receivers.

Receiver Limiter Action — First limiter plate current saturates with .7 microvolts at the antenna; second limiter at .5.

Receiver Squelch Action: Signals of any value above a few tenths of a microvolt can be made to open the squelch circuit.

Power Consumption: 34 amps. at 6 volts in transmit position; 14.8 amperes in receive position. This figure includes current drawn by the transmitter tube heaters.

Dimensions of Radio Unit: 17¼″ long; 14¾″ deep; 9″ high — Weight, approximately 45 pounds.

Tubes: The six tubes in the transmitter section are:

- 7A4 Oscillator
- 7F7 Modulator
- 7V7 First frequency quadrupler
- 7A7 Second frequency quadrupler
- 7C5 Frequency doubler (driver)
- 815 power amplifier (final)

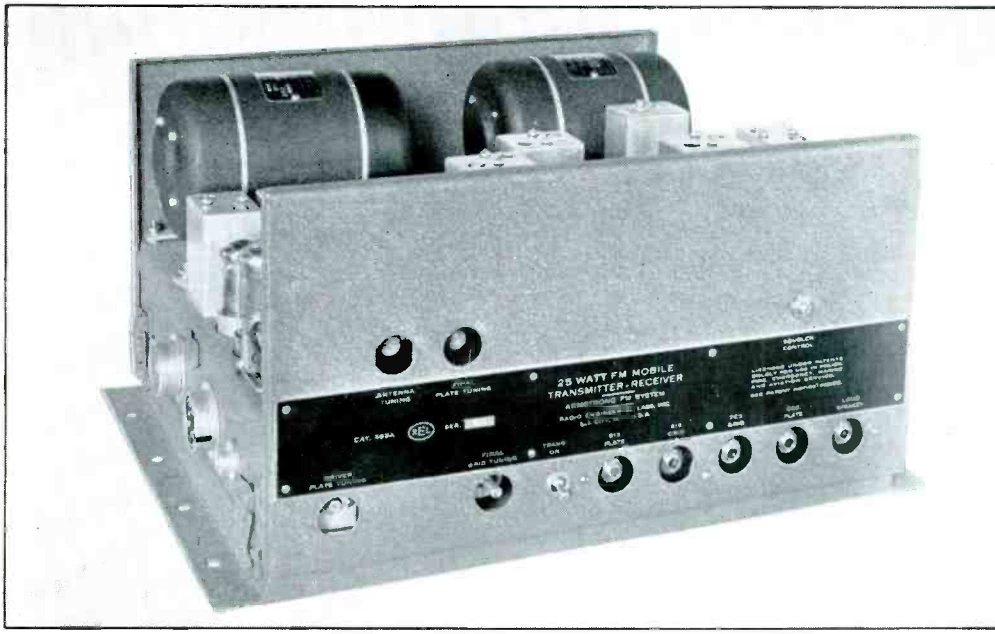
In the receiver section, there are eleven tubes, as listed below:

- 7H7 R.F. amplifier
- 7H7 Oscillator-Multiplier
- 7H7 First mixer
- 7H7 First I.F. amplifier
- 7H7 Second mixer
- 7H7 Second I.F. amplifier
- 7C7 First limiter
- 7C7 Second limiter
- 7A6 Discriminator (detector)
- 7F7 Squelch and first audio
- 7C5 Audio power amplifier

Transmitter ★ The simplicity of this transmitter is due in large measure to the improved type of phase-shift modulator, which employs only one tube. Credit for this development goes to Glenn H. Musselman, of the REL engineering staff. The complete functioning of the transmitter is herewith described.

A crystal-controlled oscillator employing a type 7A4 tube is fed to the modulator grids through a pair of 50,000-ohm resistors, shown in Fig. 3. The modulator is a dual triode, type 7F7. The phasing network, consisting of an inductance across one grid circuit and capacity across the other, is quite conventional. Modulation is fed between the two cathodes. Correction and pre-emphasis are also taken care of in this circuit.

It should be noted that a rheostat is provided in the microphone circuit, to change the degree to which a given sound level at the microphone will modulate the transmitter. This makes it easy to adjust the microphone in



THIS VIEW IS FROM THE SAME ANGLE AS THAT IN FIG. 1, BUT THE COVER HAS BEEN REMOVED TO GIVE ACCESS TO THE TEST JACKS WHICH, NORMALLY, ARE PROTECTED FROM DUST the event of a change in application. For example, when the transmitter is used in a location of severe background noise, such as would be encountered in aircraft or tank service, it is desirable to make the modulation circuit insensitive. The operator in such a case is required to shout into the microphone in order to properly modulate the transmitter. In normal automobile use, such as would be encountered by police departments, the background noise is relatively low and the microphone circuit can therefore be made more sensitive so that the operator may speak in a more normal tone of voice and still modulate the transmitter sufficiently. In this connection, it should be noted that, while this equipment was designed for police cars, it is rugged enough to meet any military applications.

The modulator is followed by a frequency quadrupler stage, utilizing a type 7V7 tube. This in turn is followed by another frequency quadrupler in the form of a type 7A7 tube. Then comes a 7C5 frequency doubler and driver tube, bringing the total frequency multiplication to 32. Finally, the 815 power amplifier tube completes this circuit. The troublesome parasitics, which made circuit design so difficult for high power output in the 807 tube, usually used for mobile service at about 25 watts, are entirely eliminated with the use of the 815 in this transmitter. The 815 is definitely a better tube for frequencies used in mobile equipment. Thus the output of this transmitter is easily made 25 watts or greater. There is no fear that a slight loss in drive, due to loss in emission of one of the preceding tubes, will cause a great loss in power output. Also, the push-pull arrangement in the 815 eliminates second harmonic radiation.

Receiver ★ The receiver in this unit is an 11-tube, double IF superheterodyne. By means of a unique circuit, both mixing frequencies are controlled by the same crystal. Scarcity of quartz makes this saving of one crystal quite an important feature. The crystal, X101, in Fig. 3, feeds into the grid of V104 and most of the low-frequency mixing takes place in V-105. V-103 is a frequency multiplier, serving as a tripler for signal frequencies between 30 and 35 mc., or a quadrupler between 35 and 40 mc. The second IF is always 2.1 mc. The following relationships between crystal frequency and carrier, and between first IF and second IF therefore hold:

For carriers between 30 and 35 mc.

$$F_x = \frac{F_c - 2.1}{4} \quad \text{Also, } F_1 = 2.1 \text{ plus } F_x$$

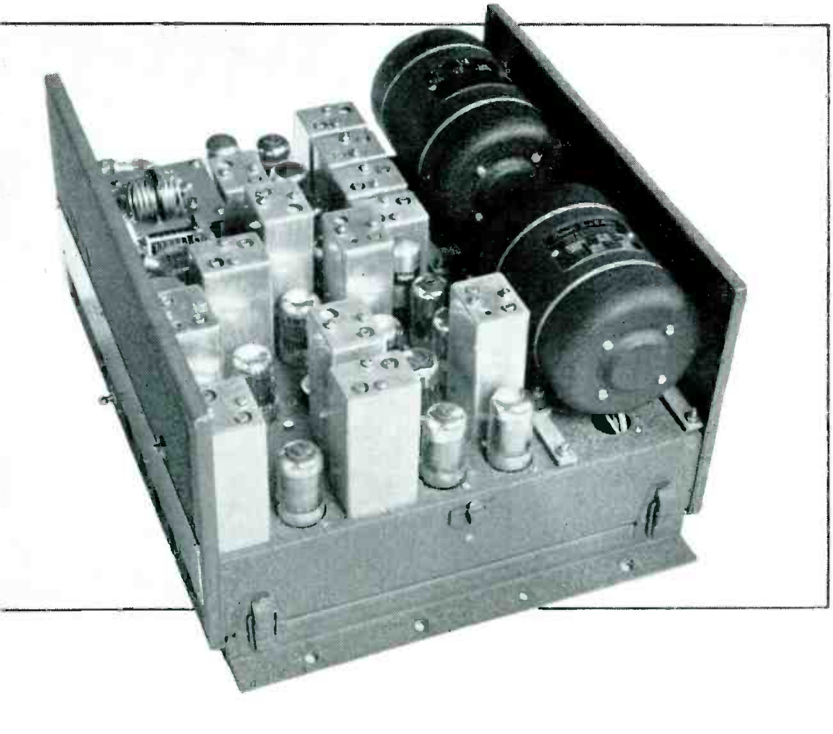
Between 35 and 40 mc.

$$F_x = \frac{F_c - 2.1}{5} \quad \text{Also, } F_1 = 2.1 \text{ plus } F_x$$

In both sets of equations above,

F_c — Carrier frequency in mc.
F_1 — First IF in mc.
F_x — Crystal frequency in mc.

There is nothing unusual about the balance



NOTE THE TWO CATCHES AT THE END OF THE CHASSIS BY MEANS OF WHICH IT CAN BE DETACHED QUICKLY FROM THE BASE PLATE. THE LATTER IS MOUNTED PERMANENTLY TO THE FLOOR OF THE CAR

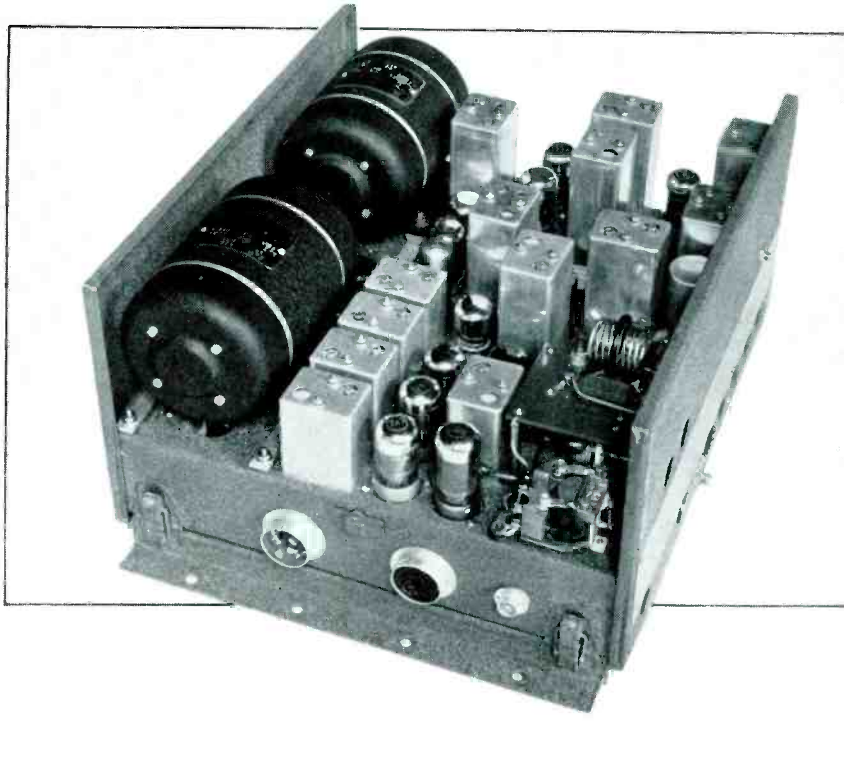
THIS ARRANGEMENT MAKES IT QUICK AND EASY TO REMOVE THE COMPLETE EQUIPMENT FOR REPAIR OR ROUTINE CHECKING of the circuit, as can be seen from the diagram. However, it seems advisable at this point to give brief mention of the limiter, discriminator, and squelch circuits.

The limiter tube functions by using circuit constants which cause plate current to saturate at low values of grid voltage. Therefore, with fairly small signals, the limiter tube cannot pass variations of amplitude modulation to any great extent. However, frequency variations pass the limiter with no difficulty. Since most noise is of an amplitude-modulated nature, practically no noise can get by the limiter as long as a relatively small voltage is impressed on the limiter grid due to an incoming signal.

The discriminator is an ingenious circuit whose function, in an FM receiver, is to demodulate the frequency-modulated carrier so that the original audio impressed on that carrier at the transmitter is recovered in the receiver. A tuned transformer with center-tapped secondary, T109 in the diagram, is connected to a double diode. If this transformer is tuned to the frequency which would normally appear across its input terminals when the carrier is unmodulated, the rectified diode current produces voltages which are equal in magnitude, but opposite in direction, across R124 and R125. Therefore, there is no input voltage to the audio system. However, when the frequency changes because of modulation of the carrier, unequal voltages appear across the two resistors, producing a voltage difference which is applied to the audio system. When the discriminator is properly balanced, the output voltage is proportional to the input frequency deviation over a sufficiently wide range to produce substantially the same audio pattern originally impressed on the transmitter modulator. For the class of service for which this equipment was designed, this would mean that the discriminator characteristic must be flat over deviations of at least 15 kc. each side of the frequency to which the discriminator is tuned, which requirement is met with this equipment.

Following the discriminator is a resistance-capacity network which provides de-emphasis to the higher frequencies. The combination of this de-emphasis with the pre-emphasis of the transmitter provides the desirable audio overall characteristic of this equipment. A condenser across the plate winding of the audio output transformer also contributes to the audio characteristic. Thus clear speech is assured under all conditions.

The squelch circuit is provided in V110 and its surrounding network. With no voltage at the grid of the limiter, the circuit is designed so that the audio portion of the squelch tube (upper section in the diagram) is operating beyond plate current cutoff. However, when a signal reaches the first limiter, negative bias is produced on the grid of the squelch portion of V110 (lower section in diagram) the amount of which is set by the potentiometer R140. The corresponding lowering of plate current in the squelch section of the tube lowers the bias on the audio section, so that it can function as an



CAREFUL ENGINEERING CONSERVES SPACE WITHOUT UNDUE CROWDING. THE THREE CONNECTORS ON THE END OF THE CHASSIS ARE, FROM LEFT TO RIGHT, FOR THE BATTERY CABLE, THE REMOTE CONTROL CABLE, AND THE CONCENTRIC ANTENNA LEAD

ALL TRIMMER ADJUSTMENTS ARE ACCESSIBLE FROM THE TOPS OF THE SHIELD CANS amplifier of the audio frequencies impressed on it.

Little need be said about the audio output, except that it is capable of delivering about 1.5 watts at full modulation into a 4-to-8-ohm speaker voice coil, with very little distortion. This is less than 10% over the useful range of 500 to 3,000 cycles.

Remote Control Unit ★ The function of the remote control unit is completely described in the section devoted to operation. The wiring of the 565A unit is shown in Fig. 4, and for the 565AWE, in Fig. 5.

Power Supply ★ One continuous duty dynamotor supplies 250 volts, normally connected to the receiver through the transmit-receive relay. In the transmit position, the relay connects the output of the 250-volt dynamotor to all of the low-power circuits of the transmitter. At the same time, 525 volts is supplied to the power output stage of the transmitter by another dynamotor. Note that, by using the receiver dynamotor to supply most of the transmitter tubes, a considerable saving in power is effected, since otherwise these voltages would have to be supplied from the high voltage dynamotor through a dropping resistor which would consume considerable power. This is a saving of roughly 5 amps. in current drawn from the battery in the transmitter position. The circuit is shown in Fig. 3.

There appears to be some controversy as to whether a vibrator or a dynamotor is superior for the receiver power supply. Arguments in favor of the vibrator are low cost, compactness, and relatively high efficiency as compared to a dynamotor. However, balanced against the vibrator's lower cost is the dynamotor's higher life expectancy. Then too, much of the vibrator's compactness is lost in the elaborate shielding and filtering required for prevention of hash. The somewhat lower efficiency of the dynamotor is compensated for by its dependability. It is our belief that the added battery drain of the dynamotor is a sort of insurance for more dependable service.

Dynamotors, when subjected to routine maintenance, seldom go bad without giving a warning by gradual falling off in performance. On the other hand, the vibrator either works or it does not work; it cannot be readily subjected to routine maintenance, and must be replaced when it fails.

Installation ★ Before installing the radio unit in the car, observe the battery ground polarity. Then check the unit with Fig. 3 and, if necessary, change the connections to C2, DY1 and DY2 in accordance with the drawing. Also check with Fig. 8.

A general plan for installation is shown in Figs. 1 and 2. Keeping this diagram in mind while executing the following instructions will greatly simplify the process of installation. The base of the radio unit should be placed in the desired position in the luggage compartment of the car in which it is to be installed. Then it should be ascertained, by reference to Fig. 2, if the location is suitable. Consideration should be given to whether or not the two cables can be maneuvered into place without undue bending, and whether the antenna transmission line and the grounding braid will be long enough to reach from the set to the antenna mounting bracket. The distance between set and antenna bracket should be small enough so that the antenna cable can have a bend put in it to take up any strain that might be put in it when the car goes over rough roads. CAUTION: Do not bend it sharply.

There should be adequate space above the base, so that difficulty will not be encountered in placing the chassis on the base, and the cover on the chassis.

When all of the foregoing requirements have been met satisfactorily, the base can be used as a template for marking the positions of the mounting holes. Four bolts are supplied. Mark two holes from the left hand flange and two from the right which will be most clear of obstructions when the holes are drilled in the car. Four holes are provided in each flange to permit a choice of the best positions for the mounting bolts. Now remove the base, and drill the four holes with a 5/16-in. drill. After this, the base can be replaced and secured with the bolts, nuts, and washers supplied.

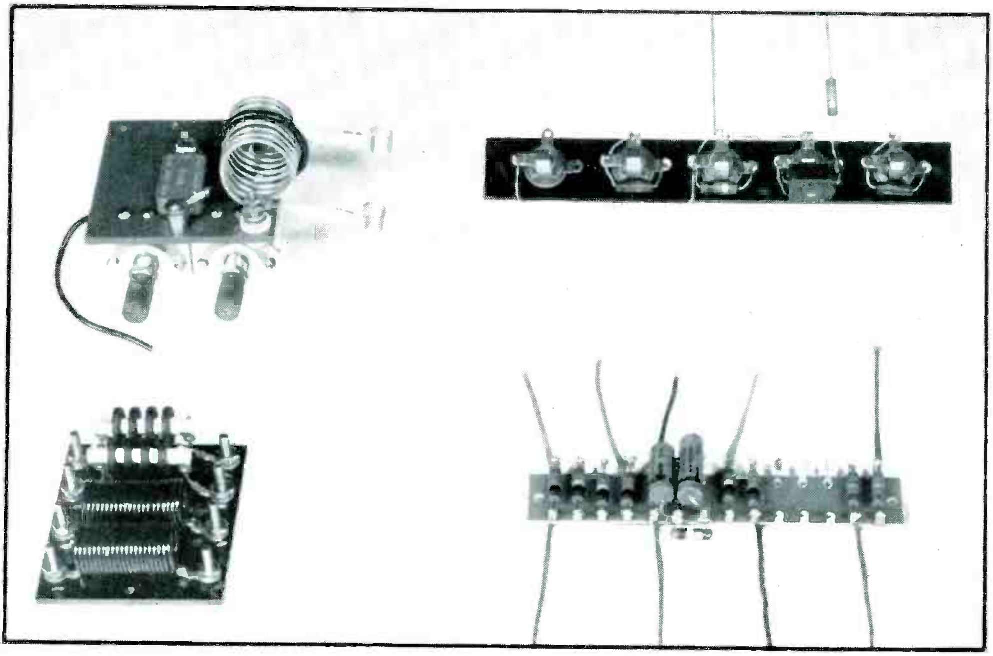
If the chassis is put on the base temporarily, the best location for dropping the battery cable and the remote control cable through the car floor can be determined and marked. The chassis should be removed, and the two holes drilled. A 1½-in. hole will be required for the remote control cable, and a ¾-in. hole for the battery cable.

The necessary holes for mounting the antenna bracket on the outside of the luggage compartment must be drilled, with the bakelite washer as a template. Note again, as previously mentioned, that the respective positions of the antenna bracket and the radio chassis should be such as to allow for connection of the antenna cable and the copper grounding braid. One 1½-in. hole and six No. 6 holes are required for the antenna mounting. Fig. 9 shows the antenna assembly. Note from Figs. 1 and 9 that the antenna can be set vertically, regardless of the contour of the car body.

The radio chassis should be put on its base and fastened down by means of the four catches. Fig. 1 plainly shows one of these catches at the front lower left of chassis. This also shows one of the two catches which hold the cover to the chassis.

Now the remote control and battery cables can be dropped through the holes which were drilled for them. Either end of the remote control cable can be passed through the hole but, for obvious reasons, the end of the battery cable containing the lug is the one which must be passed through so that the plug end is left above for connection to the chassis. Both cables and the antenna transmission line should be plugged into the chassis at this time. Likewise, the grounding braid should be connected to one of the antenna bracket mounting screws. The portion of the luggage compartment where this screw comes through should be scraped clean of paint to assure a good ground connection to the metal of the car.

The remote control and battery cables should be run along the framework of the car in such a way as to be kept clear of all sharp edges and moving parts. Where sharp edges cannot be avoided, use tape to prevent cutting of the cable. Fasten the cables to the car frame with bale wire, first wrapping the cables with tape where fastenings are to be made. When the cables reach the engine compartment, check to see how much slack is available. Such slack is best coiled up in the luggage compartment, and tied down to keep it from becoming a nuisance. In the case of the remote control cable, it will not be known how much slack there is until the cable has been brought through the firewall to the position on the dashboard where the remote control unit is to be located. Two small holes will be needed on the engine side of the firewall for mounting the fuse cutout block with the two self-tapping screws provided. The battery cable should be connected to one end of this block, while the starter jumper cable should be at the other end. The jumper cable should then be attached to the starter motor terminal. This finished, a $1\frac{1}{2}$-in. hole will be required in the firewall for the remote control cable. When the amount of cable needed has been determined, pull the slack back to the luggage compartment, as previously mentioned.



UPPER LEFT: PA TANK AND ANTENNA COUPLING COIL ASSEMBLY. RIGHT: METER JACK STRIP. LOWER LEFT: LOW-VOLTAGE DYNAMOTOR FILTER CHOKES. RIGHT, CONDENSER STRIP

Four holes will be needed on the under side of the dash so that the remote control unit can be attached with the self-tapping screws provided. Now locate a place for the loudspeaker, preferably on the firewall. Having determined this position, cut the duplex cord on the remote control unit to a suitable length. This is the speaker cable. A $\frac{5}{16}$-in. hole will be needed

(CONTINUED ON PAGE 47)

SPOT NEWS

Notes and Comments, personal and otherwise, about broadcast, communications, and television activities

More FM Broadcasting: W67B, operated by Boston's WBZ, started on March 29th a regular 6-hour schedule, from 3 P.M. to 9 P.M. daily. The 10-kw. transmitter is located at Hull, with studios in Boston, at Hotel Bradford. According to W. Gordon Swan, program director of WBZ and WBZA, "W67B will give the listeners a new station with musical features planned for the high quality reproduction that FM makes possible." This means that, with a few exceptions, W67B will be programmed independently of WBZ.

Business As Usual: Adjacent to the entrance of the Radio Manufacturers Association offices in Washington there is a door which carries the lettering: "United Service Stores — Discounts on all standard merchandise."

Iron-Glass Seal: By using 45% silicon dioxide, 14% potassium oxide, 6% sodium oxide, 30% lead oxide, and 5% calcium fluoride, glass is produced which has a rate of expansion so close to that of iron that it can be used as a seal to iron wires. Another method is to put a thin layer of lead-free glass on the metal, and then sealing it into lead-containing glass. These methods were devised by Dr. Hall and Dr. Novias, of the G.E. Research Laboratory.

FM Transmitters Available: FM transmitting equipment can still be purchased by those to whom construction permits have been granted. It was learned that two 1-kw. REL transmitters are available for immediate delivery, as well as two of 3-kw. and two of 10-kw. output.

Paul Ware: Elected president of the Radio Club of America for the 1942 term. His radio career began as an operator in 1907. In the last War, as 2nd lieutenant, he developed a 75-meter two-way trench set, in collaboration with Prof. Hazeltine. His inductive tuning system, developed while he was with P. R. Mallory, is used in the Weston ultra-frequency oscillator. Since 1939, he has been at DuMont Laboratories, working on electronic developments.

W. H. Green: Is back in the G.E. publicity department, handling advertising and sales promotion on radio transmitting and carrier current equipment, and transmitting, industrial, and special purpose tubes. Since he was graduated from Iowa State College in 1937, with a BS in electrical engineering, he has been at G.E., first in the Pittsfield plant, and then at Schenectady.

Gordon Gray: Owner of WSJS and W41MM, Winston-Salem, has volunteered for the Army despite his 3-A classification. He expects to

(CONTINUED ON PAGE 38)

TO DEMONSTRATE USE OF FM DURING TEST "BOMBING" OF DETROIT, W45D FED SIX LOCAL AM STATIONS WITH EMERGENCY TALKS BY CO-CHIEF AIR-RAID WARDEN GEORGE EDWARDS, MAYOR JEFFERIES, AND OCD OFFICIAL F. S. SCHOUMAN

NEWS PICTURE

From this eminence at 500 Fifth Avenue, New York City, CBS is now maintaining a regular FM program schedule. When the antenna is completed, the 3-kw. G.E. transmitter will cover 12,000,000 listeners. Meanwhile, with a temporary antenna, W67NY is putting out a splendid signal, and adding greatly to the entertainment of listeners in the New York area. This view shows 42nd Street, looking west toward the Hudson River

10-KW. INSTALLATION AT W53PH

Description and Data on One of the Newest FM Stations

BY ARNOLD NYGREN *

THE installation of W53PH will probably prove of interest to many engineers and executives because Frequency Modulation is still a stranger to so many in the radio field. W53PH does not lay claim to being radically different from other existing stations. However, the story of our problems, results, and methods may be useful, and a description of the various equipment used from microphone input to antenna, should be helpful to others now building or planning for the future.

General Description ★ The studios of W53PH are on the same floor as those used by WFIL, the 18th floor of the Widener Building, at Broad and Chestnut Streets, in the heart of the Philadelphia business district. The larger studio is 22 by 33 ft., and allows use of the giant Kilgen organ installed for WFIL. The FM transmitter is located on the same floor, approximately 150 ft. from the studio section. The tower, antenna, and primary power transformers are located on the roof, directly above the transmitter. The 1 kw. flashing beacon at the top of the antenna is 555 ft. above street level, and marks the highest point in Philadelphia, exceeding the famous William Penn Statue atop City Hall and directly across the street by 5 ft.

* Chief Engineer, WFIL-W53PH, Philadelphia, Pa.

Control Rooms ★ The two control rooms, Figs. 1 and 2, use RCA speech input equipment and turntables. The control consoles were designed and built by our own maintenance department. Unnecessary controls and gadgets were kept to a minimum, resulting in a design exceedingly simple to operate. Provisions are made to handle four microphones, two turntables and any one of five input lines. The VU meters used for riding gain are extensions of the percentage-of-modulation meter in the transmit-

ter room. Ordinary VU meters across the program circuits are of little value where live orchestras and high fidelity transcriptions are used, due to the pre-emphasis of high frequencies in the transmitter. Experience has shown that over modulation can easily occur when monitoring is done ahead of the transmitter. Under such conditions the line VU meter may show the equivalent of 70% modulation when actually the transmitter is being fully modulated.

The 64-B RCA loud speaker is fed from a multiple switch on the control console and can be set to the output of an REL receiver, the output of the General Electric FM monitor, transmitter input, program amplifier, or any one of the ten monitoring busses comprising the WFIL house system. Normal monitoring is done on the audio output of the FM monitor. No difference in quality can be detected between any transmitter input or output circuit.

In the transmitter control room, Fig. 1, two turntables have been installed, and are handled by the announcer. The transmitter is situated on the opposite side of the partition, and although not visible in the photograph because of reflections on the window, is clearly seen by the engineer, who can read the majority of meters without leaving his position. The three racks house all the speech input and measuring equipment.

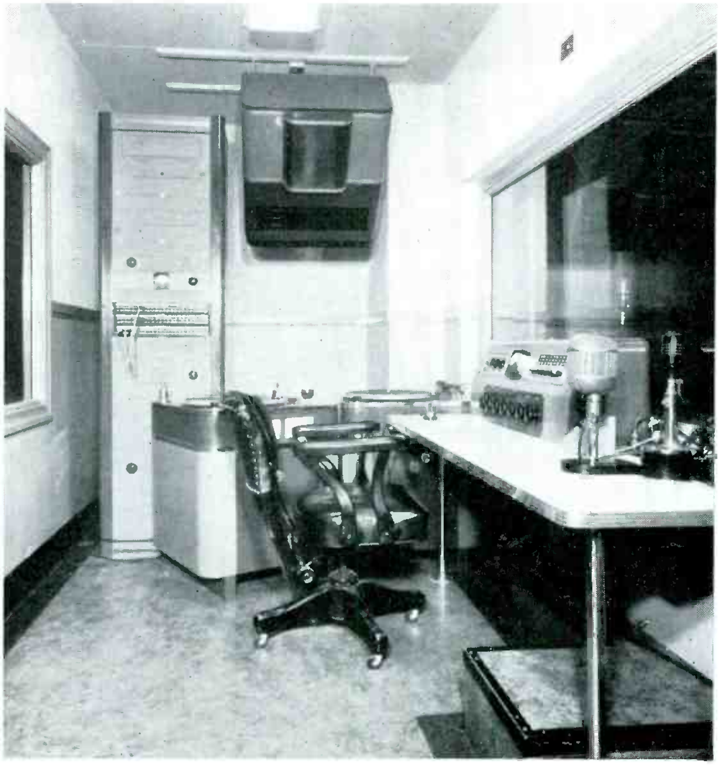
The announcer controls his own microphone by means of a relay directly at his finger tips. When closed, this relay cuts the monitor speaker and the two telephone bells and, in addition, turns on a large red warning light over the entrance door. Pilot lights on the telephones indicate incoming calls when the microphone is in use.

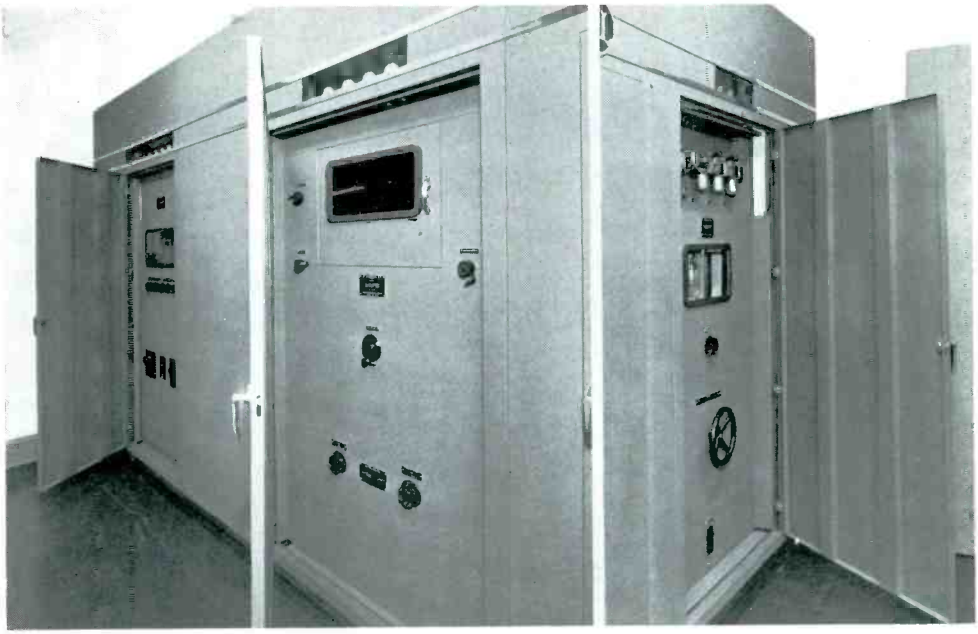
The control console in the transmitter room handles, in addition to the microphone and turntables, any incoming network plus a remote pickup line. The signal switching system in use throughout W53PH indicates when any input or output circuit is picked up or released by other control rooms. In addition, all switches are indicated on the master control board of WFIL. This system of indicating lights, when used in conjunction with the head set monitoring provided in all control rooms, allows perfect coördination of programs.

At the extreme right of the transmitter console can be seen the six remote switches controlling the transmitter. All speech input and measuring equipment is conveniently available directly in front of the operator.

FIG. 1, LEFT. MAIN CONTROL ROOM. THE TRANSMITTER IS AT THE OTHER SIDE OF THE LARGE WINDOW, AND THE OPERATOR CAN READ THE METERS FROM HIS POSITION AT THE CONSOLE. THE MICROPHONE, ON A SWINGING ARM, CAN BE USED BY THE OPERATOR OR THE ANNOUNCER

FIG. 2, RIGHT. THE SMALLER CONTROL ROOM IS COMPLETE IN ITS EQUIPMENT AND IS ARRANGED COMPACTLY. WITH TWO TURNTABLES AVAILABLE, RECORDINGS AND TRANSCRIPTIONS CAN BE USED IN CONJUNCTION WITH LIVE STUDIO PROGRAMS



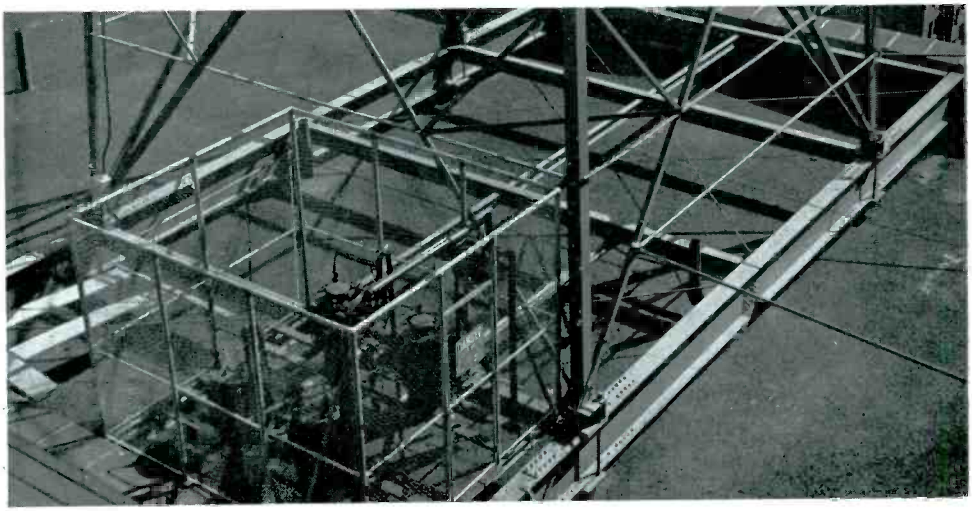


FIGS. 3 AND 4. THESE THREE UNITS ARE ACTUALLY IN ONE LINE, BUT IT WAS NECESSARY TO PHOTOGRAPH THEM SEPARATELY. THEY ARE, FROM LEFT TO RIGHT: MODULATOR AND 1-KW. DRIVER, 10-KW. AMPLIFIER, AND RECTIFIER AND POWER CONTROL PANEL

All racks were wired and painted by our own maintenance department. Not shown in any photographs, but located directly behind the engineer's position, are all AC circuit controls. A remote flashing indicator for the tower beacon is also on this wall. A large storage closet for the exclusive use of FM equipment completes the control room. Every effort has been made to completely separate W53PH operating activities from those of WFIL.

Transmitter ★ The transmitter, Figs. 3 and 4, is a 10-kw. REL type 520 DL, described in the June 1941 issue of *FM* Magazine. The three transmitter units take up the complete width of the room, 5 ft. being allowed in front and

FIG. 6. THIS VIEW SHOWS CLEARLY THE METHOD USED TO ANCHOR THE STEEL TOWER. AT THE LEFT, FENCED IN, ARE THE FOUR PRIMARY POWER TRANSFORMERS, OPERATING ON 2,200 VOLTS



in back of the equipment for tuning purposes. A pent house type roof ventilator has been installed directly over the transmitter, and is capable of removing 4,400 cubic feet of air per minute. This is more than sufficient to take care of heat removal on the hottest summer days. The installation of the transmitter provided no particular problem with the exception of widening doors.

Tuning is easily and quickly accomplished despite the high frequency used. The high Q of the final tank circuit is obtained by using large copper cylinders as tube mountings and a tank circuit for the 889-R's. Individual blower motors at the base of each cylinder give excellent ventilation as shown by the fact that temperatures seldom exceed 105° C.

The frequency stability has been excellent, the variation not exceeding 150 cycles during a day's operation. A well-liked feature of the transmitter is the ability to vary the filament voltage of the 889 R's individually. In operating the two power tubes, we strive for equal plate currents, even though the filament voltages differ by as much as .4 volt.

To provide a balanced output circuit while feeding a single-ended concentric line, a large quarter-wave cylinder was placed over the last quarter wave of the transmission line at the transmitter end. The cylinder was grounded to the outer conductor of the transmission line at the top, or one-quarter wave from the end of the transmission line. This removes the outer conductor from ground, and provides a more balanced output circuit.

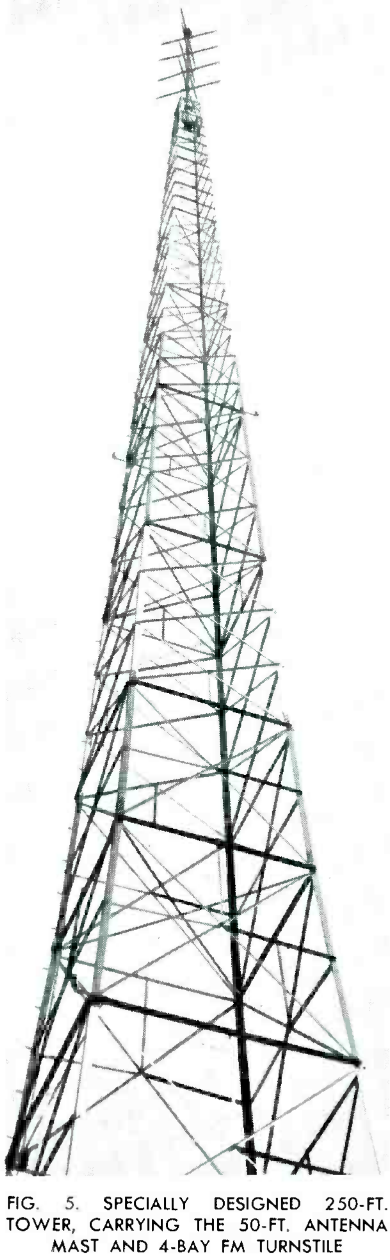


FIG. 5. SPECIALLY DESIGNED 250-FT. TOWER, CARRYING THE 50-FT. ANTENNA MAST AND 4-BAY FM TURNSTILE

Tower and Antenna ★ Although the top floor of the building housing W53PH is 255 ft. above street level, adjacent buildings made it necessary to think of heights over 500 ft. in order to insure good coverage. Investigation proved our building capable of supporting many times the weight of the tower and foundation. The city zoning board was finally convinced that such an installation would not prove a hazard to the public and the airlines, and finally granted permission for its erection. After careful consideration, it was decided that a 250-ft. tower supporting a 50-ft., 4-bay antenna would be more than sufficient for the coverage of 9,300 square miles assigned to Philadelphia. This gave a total height of 300 ft. above the roof, Fig. 5. Because of the location at Philadelphia's busiest corner, it was felt that extra safety factors should be provided. As a result, the supporting tower was specially designed by the Blaw-Knox Company to have substantially more than the usual safety factor.

The antenna itself was built and installed by the John E. Lingo Company. The pole socket and mounting details were designed in coöperation with Blaw-Knox. As to the operation of the antenna, it is sufficient to say that it was in operation within 15 minutes after the transmission line was connected to the transmitter, and has not required any alteration or adjustment since its installation last November. It is fed with approximately 300 ft. of $1\frac{5}{8}$-in. concentric line. This size line has a loss of .18 db per 1,000 ft. at 1,000 kc., or a total of .36 db for 300 ft. at 45 mc. This represents a loss of approximately 500 watts at the power used. The antenna itself has a field gain of 1.66 or a power gain of 2.75. No field measurements have been made up to this time.

Working on the tower and antenna hundreds of feet above a crowded thoroughfare, and only 15 ft. from the street edge of the building meant great care and all precautions had to be taken during the erection. As a tribute to the men who worked on the tower and antenna, it can be said only one article was dropped during the erection, and that was a workman's glove which landed several hundred feet away on the top of a building.

was mounted on a large circular plate which fitted over the top section of the pole after the pole was in place.

Power ★ The four primary power transformers can be seen in Fig. 6. Two 25-KVA 2200/220 3-phase transformers supply power for the transmitter. Two 37.5-KVA transformers sup-

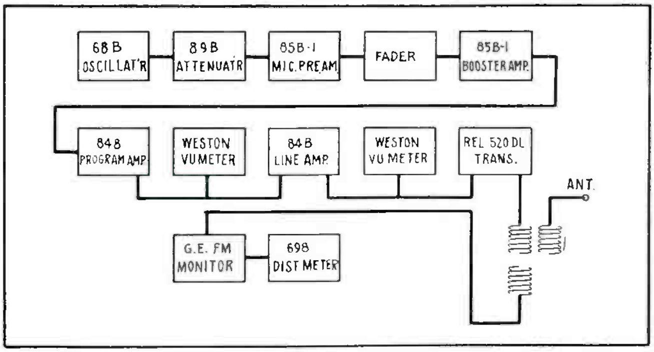


FIG. 7. BLOCK DIAGRAM OF EQUIPMENT USED TO MEASURE OVERALL DISTORTION, FROM MICROPHONE TO ANTENNA. DISTORTION WAS FOUND TO BE WELL WITHIN THE LIMITS SET BY THE FCC, AS SHOWN IN FIG. 7A

It was necessary to assemble the transmission line in 125-ft. sections on the roof before hoisting. Experiments showed that solderless couplings were not suitable as they would cause the section to buckle when hoisting. Soldered couplings were substituted, and gave us sections that could be bent freely in hoisting. After the two sections were in place, a solderless coupling was used to join the two.

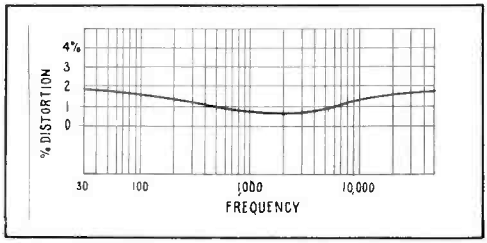


FIG. 7A. OVERALL DISTORTION FROM MICROPHONE TO ANTENNA AT STATION W53PH

The foundation for the tower was constructed of 24-in. I beams, anchored to the steel columns of the building by opening up the roof in six places. All steel for the foundation, tower, and antenna was hoisted up the outside of the building. It was necessary to block off the street for an entire Sunday. The antenna pole was raised in one section to the roof and then fed up the inside of the tower and dropped into its mounting socket. The pole measured 50 ft. in length, 8 ins. in diameter at the bottom, 3 ins. at the top, and weighed approximately 2,200 lbs. The 300-m/m beacon

ply power for all AM and FM studios. The tower foundation provided a convenient place for their location. The 2,200-volt primary circuit was extended from the sub-basement of the building. The metering and service cubicle was housed in a fire-proof room, also in the basement. This method of running power to the top floor proved to be cheaper and more efficient than placing the transformers in the basement, and extending the secondary lines. The arrangement in use gives excellent regulation and voltage.

Performance ★ Proof of performance tests from microphone terminals to antenna were well within the limits set up by the FCC. The General Electric FM monitor was received just prior to the tests, and was quickly and easily put in service. It has proved an excellent instrument for monitoring frequency deviation and percentage of modulation.

Fig. 7 shows the lineup of the testing equipment used for making distortion measurements and the results obtained. Overall distortion was actually less than that shown, when using a special REL battery-operated discriminator. Distortion under these conditions did not exceed .8%. However for each frequency measured, very careful trimming of the intermediate and discriminator circuits was necessary. Although more distortion was measured when using the General Electric monitor, the results obtained with the monitor were used as they were within the limits allowed and were more easily made and repeated.

The inherent distortion of the RCA 68-B oscillator was found to be as follows:

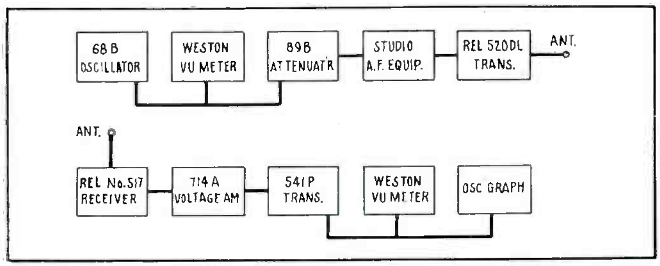


FIG. 8. SETUP OF EQUIPMENT USED TO MEASURE FREQUENCY RESPONSE AT 25, 50, 75, AND 100% MODULATION. DATA IS PLOTTED IN FIG. 8A

50 cycles	.13%
100 "	.17%
400 "	.15%
1,000 "	.1%
5,000 "	.1%
10,000 "	.8%
15,000 "	.6%

The above results were taken into consideration when making the final measurements. It should be unnecessary to point out that the results obtained can be no better than the measuring equipment used.

Fig. 8 shows the setup used in making frequency response measurements with modulation percentages of 25, 50, 75 and 100, and the results obtained. The percentage of modulation indicator on the General Electric monitor was first checked against the band width of the carrier as registered on a General Radio heterodyne meter, using various percentages of modulation. The two methods proved to be in very close agreement. Next the response of all measuring equipment used was taken with the following results:

30 cycles	−.5 db
50 "	−.3 "
100 "	0 "
400 "	0 "
1,000 "	0 "
5,000 "	0 "
10,000 "	0 "
15,000 "	−.3 "

Overall response must be within two db of 1,000 cycles for any frequency between 50 and 15,000, so it can be seen that this requirement is easily met. From experience we know that with careful equalization of the speech input equipment, these curves can be even bettered, if it should be necessary.

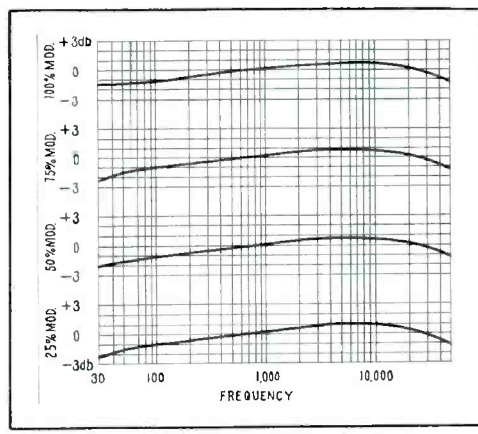


FIG. 8A. FREQUENCY RESPONSE CURVES

Fig. 9 shows the lineup of the equipment used in making noise measurements. The transmitter proved to be consistently 70 db or better. The two control rooms were brought

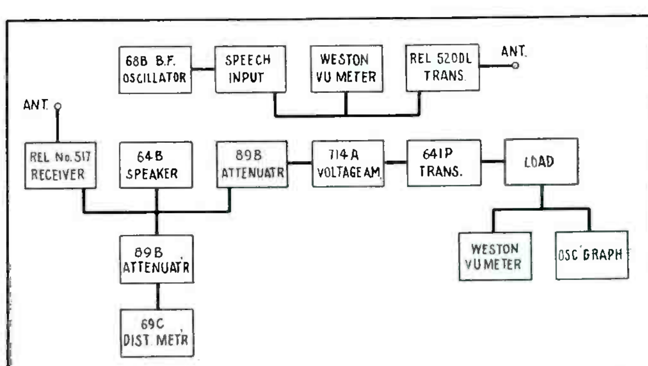


FIG. 9. THIS EQUIPMENT WAS USED TO MEASURE THE NOISE LEVEL AT W53PH. RESULTS SHOWED NOISE WAS CONSISTENTLY BELOW 70 DB. AFTER A FURTHER CHECK ON THE TUBES THE NOISE LEVEL WAS BROUGHT DOWN TO 68 DB

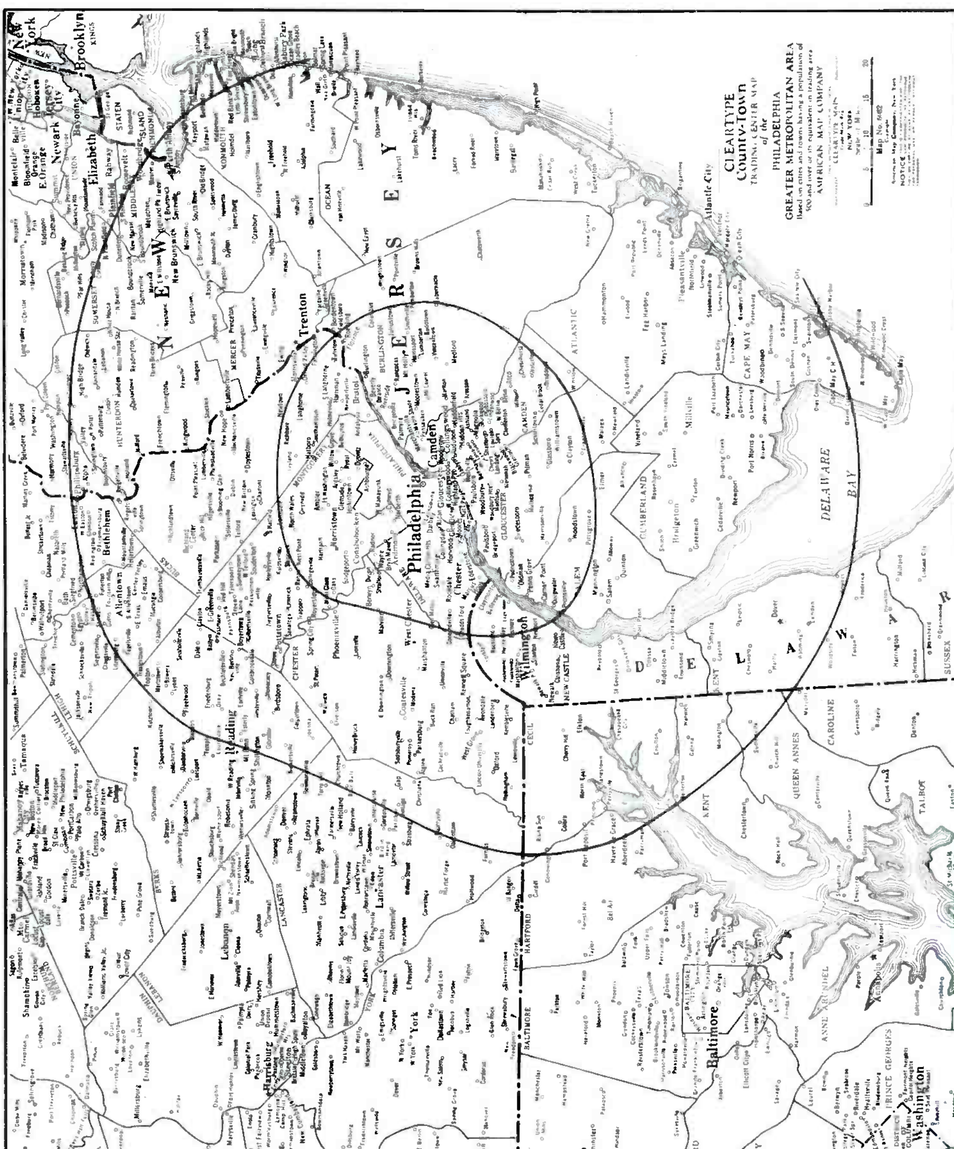


FIG. 10. CALCULATED CONTOURS AT 1,000 AND AT 50 MICROVOLTS. ACTUAL RANGE IS MUCH GREATER, FOR W53PH IS BEING HEARD REGULARLY IN WASHINGTON, D. C.

down to 68 db after a careful selection of tubes. Several days were spent in selecting the proper tubes but, since they were put in operation, few tube difficulties have been encountered. A word of advice in this connection will not be out of order: have plenty of tubes available before starting noise measurements.

Programming ★ The location of W53PH puts over four million people within its 50-microvolt contour. We began our program schedule with the definite policy of giving listeners good music plus programs of unusual interest. Very few programs are duplicated with WFIL. Network programs of outstanding importance or interest are broadcast when not carried by WFIL, and are occasionally duplicated. The results of our policy have been very satisfactory. With an estimated 17,000 receivers in our area, we have already had voluntary congratulatory letters from approximately 10% of these homes.

Beginning in January, 1942, W53PH inaugurated a monthly program booklet listing in detail all programs for the entire month. The response to this service was very gratifying. The first copy of the booklet is offered free for the asking. In the booklet is a subscription card asking listeners to send ten cents for the following month's copy, or to send a dollar for a year's subscription. Over 1,300 subscribers received the February booklet, and that number has been slowly but steadily increasing.

The program department of W53PH operates independently of the WFIL department. Personnel familiar with music were hired at the beginning to formulate the program policy and to lay out the daily programs. In issuing a monthly program booklet, we naturally endeavor to make as few changes as possible. Where important changes are made that warrant calling them to the listeners attention, mimeographed post cards are mailed to each subscriber.

The announcers work only on FM. The transcription library is also used only on FM. Commercial copy is kept to a minimum. On sustaining programs we have featured a seven-piece string ensemble in conjunction with our studio organ.

Having now created an enthusiastic audience, W53PH will do its utmost to maintain their interest in Frequency Modulation, even though we shall all be faced with a curtailment of new receiver sales for the duration of the war. Our program department contemplates no change in its present policy of offering good music plus outstanding programs available from WFIL or the network.

FOR THE INFORMATION OF OUR READERS

ANNOUNCEMENT of the modified title of *FM* MAGAZINE seemed to set off a string of changes and rumors of changes among radio publications.

The plan to modify the name of *FM* MAGAZINE effective with this issue was made known in advance to McGraw-Hill Publishing Company, by way of courtesy to our esteemed contemporary, ELECTRONICS. This was in keeping with the ethical standards established for *FM* MAGAZINE, and set forth in the following letter, published here with the consent of Mr. Howard Ehrlich:

Mr. Howard Ehrlich, Vice President
McGraw-Hill Publishing Co.
New York City

Dear Mr. Ehrlich,

With this letter is a proof of the modified title of *FM* MAGAZINE, as it will appear on the cover of our March issue.

My own opinion is that no confusion with your paper ELECTRONICS would have resulted from our use of the title APPLIED ELECTRONICS ENGINEERING & DESIGN PRACTICE. However, I specifically want to avoid the use of a title which would give anyone the impression that I am trying to encroach upon the rights of another publisher. My policy in this respect was set forth very clearly in a recent letter to Messrs. Caldwell and Clements, in which I said:

"It is my intention to operate my business in an ethical and democratic manner. By this I mean that I have no intention of trying to make capital of the efforts of others or to encroach upon their fields of activity. At the same time, I am prepared to fight at the drop of the hat, and with everything I've got, with anyone who does not accord me the same consideration. The publishing field is broad and wide, and there is plenty of room for all of us and more to come, in the publication of magazines which do not interfere with each other."

It is in this spirit of fair play that I have had the cover plate for the March issue remade, and have held up the issue so as to use ELECTRONIC EQUIPMENT instead of APPLIED ELECTRONICS to modify the title of *FM* MAGAZINE.

Cordially

MILTON SLEEPER
Editor and Publisher

Fortunately, *FM* MAGAZINE has not been affected adversely by War conditions. In fact its opportunity for service to radio engineers and executives has become greater. At the same time, the Editor has been accorded the privilege of serving as liaison engineer for War Production at Freed Radio Corporation whose facilities for manufacturing A-FM home radio receivers are now being converted to the production of military equipment for our Armed Forces.

This responsibility must, of course, take precedence over every other consideration. However, this will occasion no interruption in the publication of *FM* MAGAZINE.

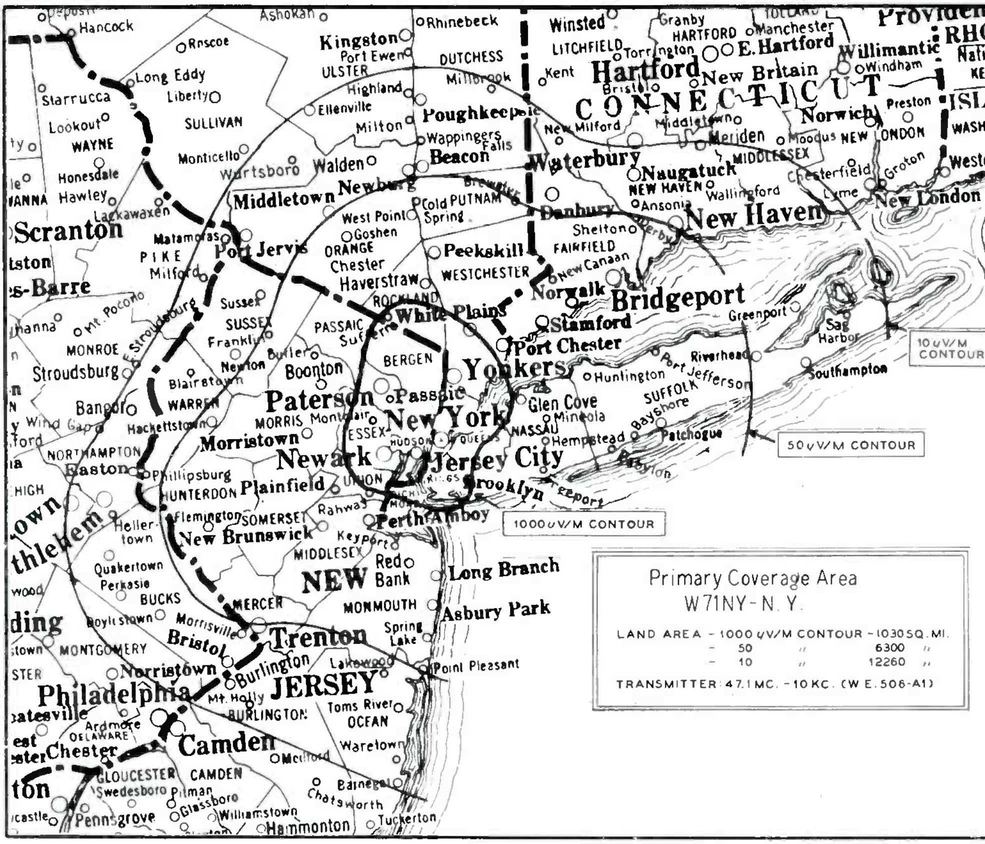


FIG. 18. MEASURED CONTOURS OF SIGNALS FOR 10, 50, AND 1,000 MICROVOLTS FROM STATION W71NY

FIELD STRENGTH SURVEY METHODS

Part. 2. Measurements Made on W71NY, and Conclusions Drawn from the Data Obtained

BY CHARLES SINGER *

5. Summary of Records ★ Records were made with our field strength measuring equipment along eight radials, spaced at approximately 45 degrees about the transmitter. Upon completion of the survey, the records made on each radial were broken up into sections which varied in length from one-tenth of a mile, near the transmitter to four or five miles, at the far end of the radial. This was desirable because of the logarithmic decrease of the field with distance. These sections were then projected onto the radial.

The airline distance from the transmitter to the far end of each of these sections was then measured and tabulated as in Table 1, 3rd column. This particular tabulation was on radial No. 1, plotted in Fig. 12. Associated with each of these distances was the median field strength for the section, column 4. One way of determining this average would have been to use a planimeter; however, the amount of labor and time involved would have been enormous and entirely out of proportion, with the accuracy required. Consequently, values were estimated as closely as possible so as to lie equally above and below an average value of field strength, and were so recorded in Table 1,

* Technical Supervisor, WOR-W71NY, Carteret, N. J.

column 4. The summaries thus determined for each radial were plotted as shown in the specimen charts Figs. 12 to 15.

In Table 1, column 5 equals column 2 times column 4 times the antenna constant 6. Column 6 was then obtained by multiplying column 5 by a factor of 2, the factor indicated on Fig. 16 for the conversion of a vertically polarized signal from a receiving height of 10 ft. to 30 ft.

Automobile ignition noise was completely eliminated by bonding of all electrical apparatus in the car and by thoroughly by-passing all noise sources.

While making previous field strength surveys, considerable trouble was experienced with ignition interference from passing automobiles. The recorder needle went off scale under such conditions.

In this survey, no trouble was encountered except with certain cars at very low field intensities — 3 to 5 microvolts per meter. This appeared to be due to the use of a narrow-band receiver — 50 kc. — and also to the use of a shielded transmission line. The narrow band width of the receiver required a slight reduction in the modulation of the transmitter during the survey. No trouble was experienced with signals as low as 5 microvolts per meter.

We also charted and plotted the peak field for each section along each radial. The values along radial No. 1 appear in column 7 of Table 1, with the values for the maximum field at 10 ft. and 30 ft. obtained in the manner already described.

6. Organization of Data ★ It is customary to present data on field strength converted to a height of 30 ft., since this is a representative value for the average home installation. Because it was impractical to use an antenna of such a height on a survey car, it was necessary to determine a multiplying factor to be applied to the data.

For horizontal polarization, the variation of field strength is a linear function of the height for all heights above one-quarter wave-length from the ground to a certain limit. Consequently, to correct the results of a survey using horizontal polarization from a height of 10 ft. to 30 ft., it is merely necessary to multiply all readings by three.

When vertical polarization is used, this multiplier is not three, but a smaller value, since for average ground constants the field does not begin to increase linearly with height until the

RADIAL NO. 1 - N. 29° E.

Section Number	Attenuator Setting	Distance to End of Sector MILES	Median Field Reading	Median Field at 10 mv/m	Median Field at 30 mv/m	Max. Field Reading	Max. Field at 10 mv/m	Max. Field at 30 mv/m	Location of End of Sector.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	10,000	0.6	10.0	600,000	1,200,000	10.0	600,000	1,200,000	64 St. & Madison Ave.
2	10,000	0.9	4.0	240,000	480,000	6.4	348,000	768,000	67 St. & Madison Ave.
3	10,000	1.16	1.8	108,000	216,000	3.9	234,000	468,000	
4	2,000	2.0	1.6	192,000	38,400	4.0	48,000	96,000	88 St. & Madison Ave.
5	500	2.26	2.0	6,000	12,000	4.8	14,400	28,800	
6	100	2.8	1.0	3,000	6,000	1.7	5,100	10,200	
7	100	3.10	5.4	3,240	6,480	10.0	6,000	12,000	109 St. & Park Ave.
8	100	3.8	6.0	3,600	7,200	10.0	6,000	12,000	124 St.
9	100	5.0	6.0	3,600	7,200	10.0	6,000	12,000	149 St. & Grand Concourse
10	500	6.0	1.8	5,400	10,800	5.3	15,900	21,800	
11	500	6.6	1.2	3,600	7,200	2.6	7,800	15,600	170 St. & Grand Concourse
12	100	7.4	4.4	2,640	5,280	5.0	3,000	6,000	
13	100	8.4	5.0	3,000	6,000	8.8	5,280	10,560	Fordham Rd. & Grand Con
14	100	9.2	2.8	1,680	3,360	2.6	1,560	3,120	
15	100	9.7	1.4	840	1,680	3.0	1,800	3,600	Jerome Avenue, Bronx
16	100	11.2	3.0	1,800	3,600	4.3	2,580	5,160	
17	100	11.8	5.0	3,000	6,000	6.3	3,780	7,560	Yonkers, New York
18	100	12.6	4.0	2,400	4,800	6.2	3,720	7,440	
19	100	13.4	1.0	600	1,200	3.8	2,280	4,560	
20	100	14.9	1.2	720	1,440	3.1	1,860	3,720	Bronxville, New York
21	100	16.8	1.8	1,080	2,160	2.5	1,500	3,000	
22	100	18.8	0.6	360	720	.83	498	996	Near Hartsdale, N. Y.
23	20	21.9	4.0	480	960	15.0	1,800	3,600	White Plains, N. Y.
24	20	24.7	1.0	120	240	4.2	504	1,008	Kensico Dam, N. Y.
25	20	28.8	3.0	360	720	3.2	384	768	Armonk, N. Y.
26	20	31.4	1.0	120	240	.95	114	228	
27	20	33.5	4.0	480	960	6.0	720	1,440	
28	20	34.4	0.4	48	96	.91	109	208	Near Bedford
29	5	37.4	2.0	60	120	4.9	145.0	290	
30	5	43.0	2.0	60	120	9.4	285.0	570	Grant, Conn.
31	1	46.2	2.0	12	24	9.7	582	116.4	Intersection 121-206
32	1	50.6	5.0	30	60	4.0	24	48	Danbury
33	1	56.6	1.6	9.6	19.2	2.3	13.8	27.6	Brookfield
34	1	62.2	1.2	7.2	14.4	2.2	13.2	26.4	New Milford, Conn.
35	1	67.1	0.6	3.6	7.2	1.5	9.0	18.0	

TABLE 1. COMPLETE DATA TAKEN ON RADIAL NO. 1, TYPICAL OF MEASUREMENTS TAKEN IN THIS SURVEY. FIG. 12 SHOWS THE CURVES MADE FROM THESE VALUES

TABULATED RESULTS - AVERAGE FIELD INTENSITY MEASUREMENTS

Radial Number	Distance to 50,000 mv/m Contour	Distance to 10,000 mv/m Contour	Distance to 5,000 mv/m Contour	Distance to 1,000 mv/m Contour	Distance to 500 mv/m Contour	Distance to 100 mv/m Contour	Distance to 50 mv/m Contour	Distance to 22.5 mv/m Contour	Distance to 10 mv/m Contour
1	1.5	2.3	7.5	16.5	26	37	43	60	62
2	1.5	2.7	3.4	9.5	18.5	28	54	74	91
3	1.2	3.2	4.8	10.0	12.8	24	-	-	-
4	1.20	2.3	4.0	8.8	12.4	-	-	-	-
5	.95	1.6	3.0	15	21	38	45	53	63
6	.82	2.2	8.5	18	25	45	52	59	71
7	1.06	2.0	2.8	25	32	37	39	49	53
8	1.13	5.4	8.0	24	28	43	52	60	65
Area	5.75	21.1	86	865	1590	3790	5730	8120	10290

TABLE 2. RADIUS AND AREA OF COVERAGE FOR SIGNALS OF VARIOUS AVERAGED VALUES

antenna has been raised approximately two wavelengths from the ground.

If ground constants are known, it is possible to compute the proper multiplier for vertical polarization. C. R. Burrows has published curves which are most useful for this purpose. These curves were used in constructing Fig. 16, which shows a plot of the gain to be expected when an antenna is raised from 10 ft. to 30 ft., for a wide range of dielectric constants. Curves are shown for both vertical and horizontal polarization. In computing the values in Fig. 16, the following assumptions were made:

1. The receiving antenna is much lower than the transmitting antenna.
2. The earth is substantially a pure dielectric; that is, the dielectric constant is much greater than the conductivity.
3. The height of the antenna is small compared to the distance between them.

These assumptions are usually quite permissible in practice. In selecting the proper multiplier for vertical polarization, it is necessary to have some idea of the range of dielectric constants encountered in transmission overland at these frequencies. The following are approximate values obtained from tables published by Burrows [1] and Feldman.[2] More than

TABULATED RESULTS - AVERAGED MAXIMUMS, FIELD INTENSITY MEASUREMENTS

Radial Number	Distance to 50,000 mv/m Contour	Distance to 10,000 mv/m Contour	Distance to 5000 mv/m Contour	Distance to 1,000 mv/m Contour	Distance to 500 mv/m Contour	Distance to 100 mv/m Contour	Distance to 50 mv/m Contour	Distance to 22.5 mv/m Contour	Distance to 10 mv/m Contour
1	1.9	5.0	11	22	28	45	50	56	66
2	2.0	3.1	4.9	14.5	21	33	55	83	95
3	2.3	3.8	4.9	7.8	12.0	33	-	-	-
4	1.75	3.95	4.4	14.5	-	-	-	-	-
5	1.5	4.0	10.8	14	15.4	36	44.5	57	70
6	1.35	8.0	11.7	20	28.5	51	59	69	80
7	1.5	2.9	7.3	20	30	38	42.5	52	61
8	3.1	5.0	15.0	28.5	32	45	51	60	72
Area	12.5	62.4	263	1030	1750	4500	6300	8600	12260

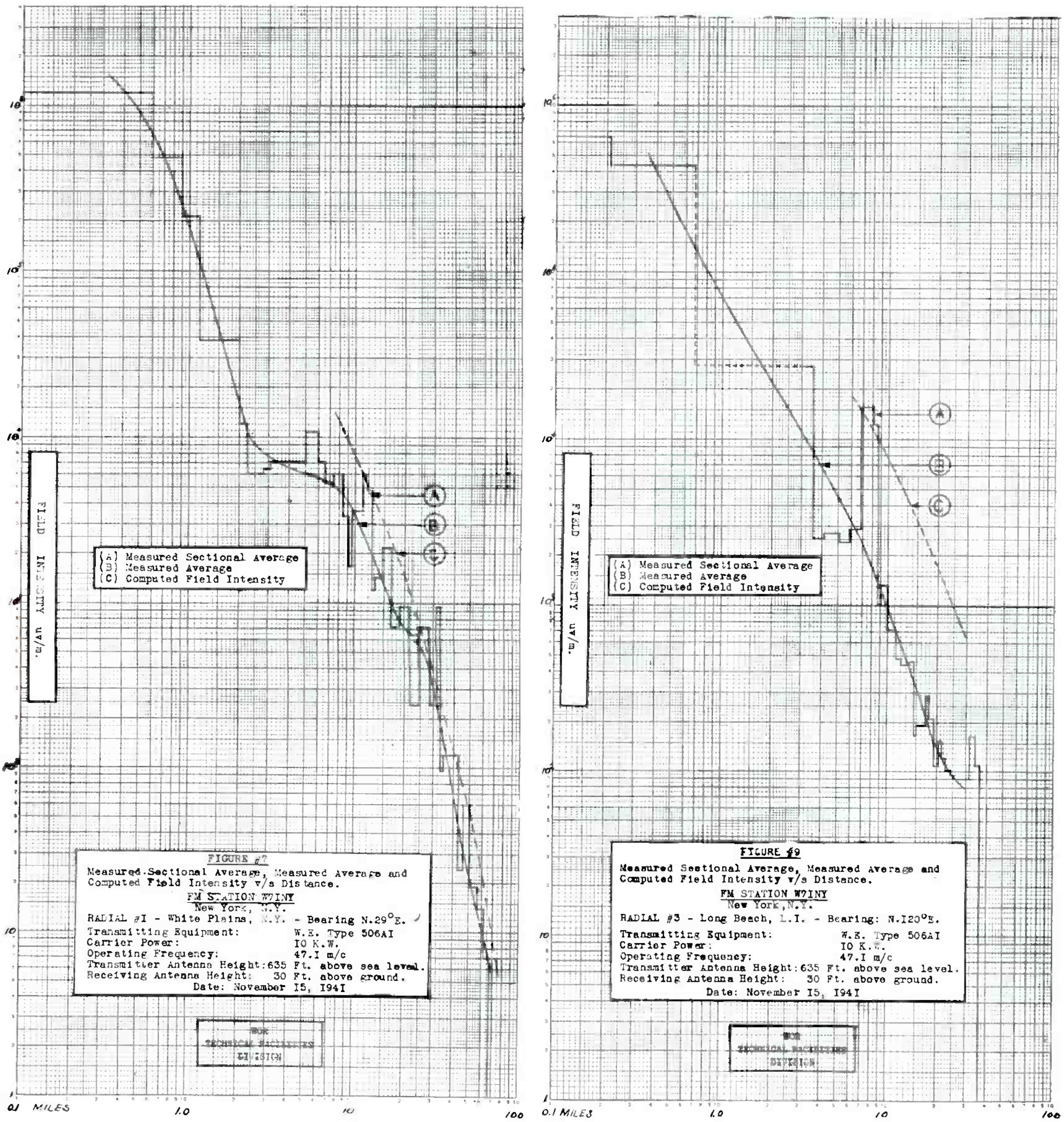
TABLE 3. THIS TABLE IS SIMILAR TO TABLE 2, EXCEPT THAT AVERAGED MAXIMUMS ARE SHOWN

[1] See reference 5 in Section 10.
[2] See reference 11 in Section 10.

COMPUTED FIELDS - 10 KW.

Radial Number	Distance to 10,000 mv/m Contour	Distance to 5,000 mv/m Contour	Distance to 1,000 mv/m Contour	Distance to 100 mv/m Contour	Distance to 10 mv/m Contour
1	8.5	12.0	22.5	43	69
2	8.8	12.6	23.5	49	85
3	8.4	12.4	24.5	-	-
4	8.5	12.6	24.8	-	-
5	8.3	12.5	24	50	83
6	6.0	12.5	22	48	77
7	7.8	13.0	22	35	52
8	7.0	12.0	23	39	64

TABLE 4. THESE COMPUTED VALUES ARE SURPRISINGLY CLOSE TO THE MEASURED VALUES IN TABLE 2

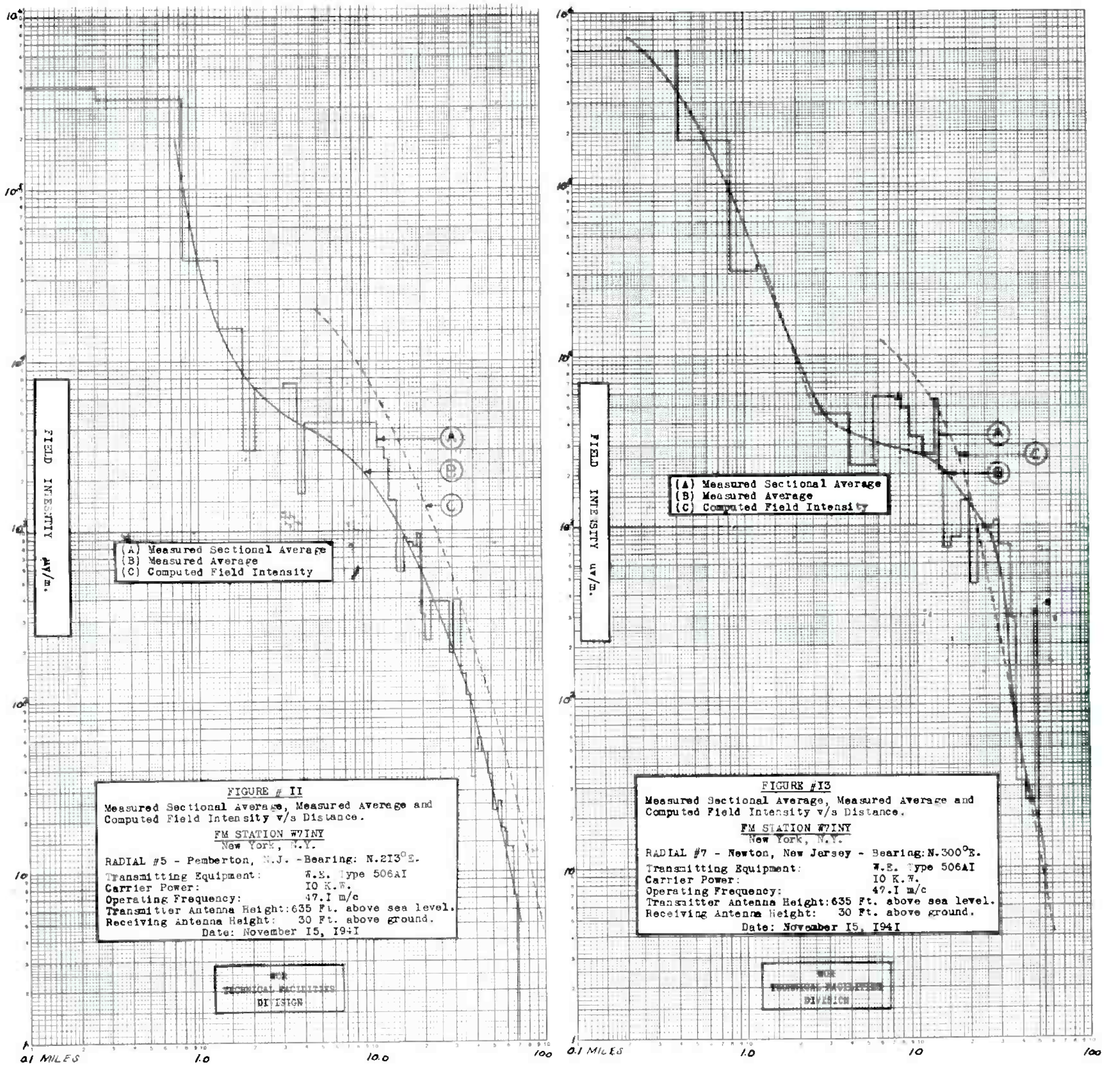


FIGS. 12 AND 13. MEASURED AND COMPUTED SIGNAL INTENSITIES ALONG RADIALS 1 AND 3

one value is shown in most cases:

Dry soil	3 to 4
Dry topsoil	12
Sandy soil	11
Dry subsoil clay	13.5
Dry clay (mixed)	19.5
Dry clay and stone	7 to 10
Moist soil	10, 30, 40
Wet topsoil	23
Wet subsoil	28
Wet clay	29
Black loam (moist)	16
Sea water	80, 78
Fresh water	80, 78

It is evident that the effect of water added to dry soil is to increase the dielectric constant. Conductivity in all cases is in the vicinity of 1×10^{-13} e.m.u. The proper factor will depend therefore, to a large extent, on the weather. Under dry conditions, an average value of E would be 10, with a corresponding multiplier of 2. In wet weather E might rise to 20, reduc-



FIGS. 14 AND 15. MEASURED AND COMPUTED SIGNAL INTENSITIES ALONG RADIALS 5 AND 7

ing the multiplier to 1.65, as shown in Fig. 16.

It seemed advisable to obtain an experimental check of the theoretical curves shown in Fig. 16. G. H. Brown [3] has done some work along these lines and shows a set of computed graphs, comparing horizontally and vertically polarized heights vs. intensity curves, for a particular set of ground constants in the vicinity of Camden, New Jersey, viz.:

$$E = 20$$

$$\text{e.m.u.} = .5 \times 10^{-13}$$

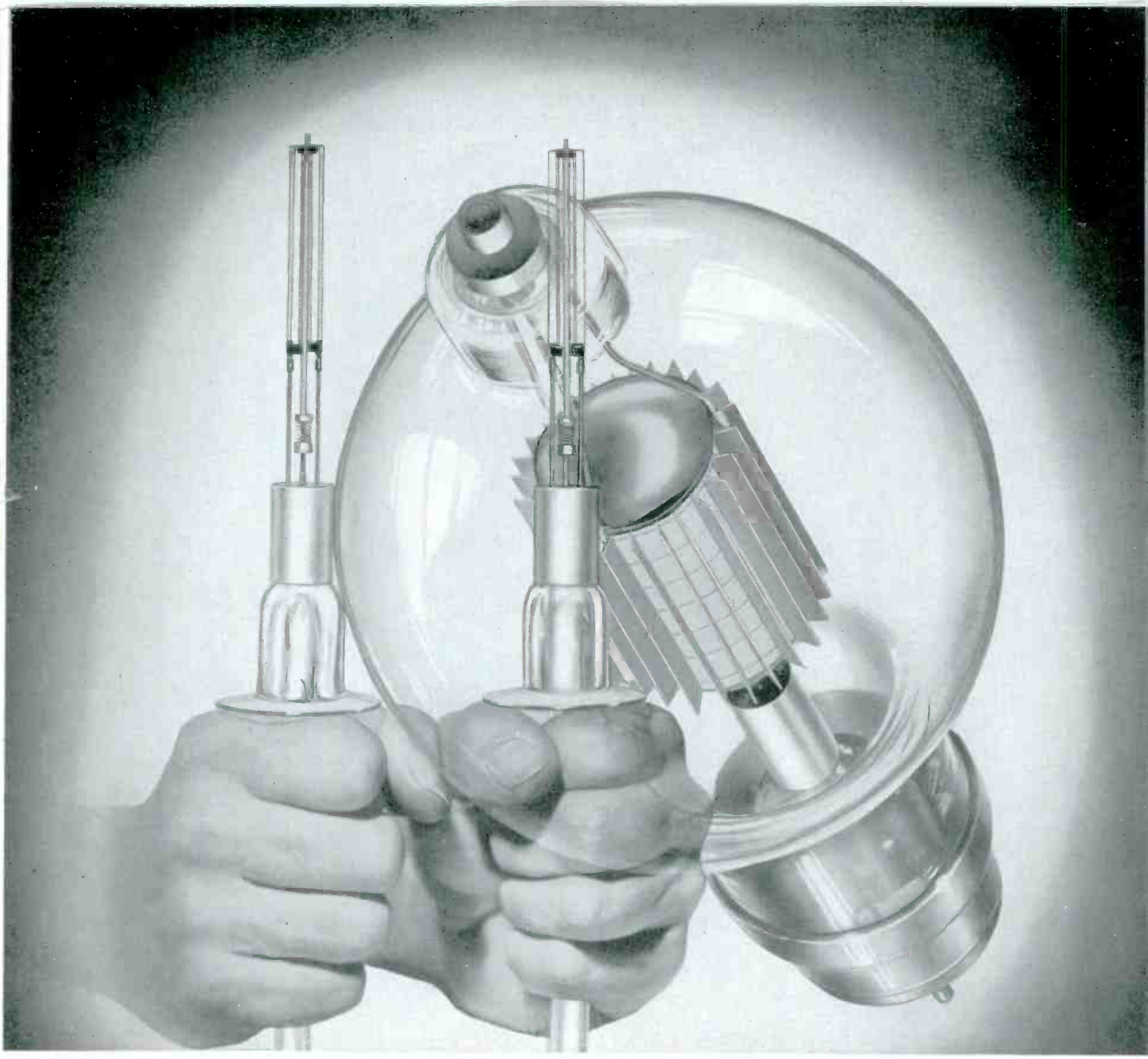
Together with these computed curves, he has plotted experimental points which are in close agreement with his data. The following multipliers for transferring from a 10-ft. to a 30-ft. height were deduced:

Horizontal	3.08
Vertical	2.08

As a further check, a similar experiment was conducted at Carteret, New Jersey by the WOR Technical Facilities Staff, using the horizontally polarized signals of W2XMN and the vertically polarized signals from W71NY, as shown in Fig. 17. These stations were 30.5 and 18.5 miles distant, respectively, from the receiving points. The following multipliers were obtained:

(CONTINUED ON PAGE 40)

[3] See reference 9 in Section 10.



How Important is a Filament?

It's a well known fact that the vacuum tube is the heart of radio communications, but it is important to remember that the filament is the heart of the vacuum tube! Thus, the efficiency with which these tiny strands of tungsten wire perform may mean the difference between success and failure of the tube itself...victory and defeat for tanks or battleships . . . life and death for millions of people.

You can't always tell by appearance whether a filament is efficient or not. The two assemblies shown above look exactly alike but when put to the test one may not do its job. Into the production of filament for Eimac tubes has gone much research and experimentation. Among the many special instruments designed and perfected by Eimac to insure perfect filaments, none is more interesting than the electron microscope which virtually gives a moving picture of how a filament works under actual operating conditions.

Behind every Eimac tube is the assurance that its filament will function at top efficiency. Contributing factors to this efficiency are: Tantalum plates and grids and the super-vacuum which removes all contaminating gas particles. All these factors and more are what make it possible for Eimac tubes to carry the unconditional guarantee against emission failure caused by gas released internally.

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In addition to commenting on the news, every Frazier Hunt broadcast will contain a dramatic Electronics story.

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3 TIMES A WEEK
156 TIMES A YEAR

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EVERY TUESDAY — THURSDAY — SATURDAY

A MESSAGE FROM DR. W. R. G. BAKER

Vice President, Radio and Television Department

Why a General Electric Radio Program—now?

That's a natural question—knowing, as you do, the outlook for civilian radio—and knowing that General Electric's radio production machine is now geared up to an all-out war effort.

Today, we are up against the grim problem of fighting and winning the war. Tomorrow we will be up against the equally grim task of fighting post-war unemployment. *Electronics will help win both these fights.* Out of Electronics' contribution to the nation's war effort will come many new developments—as did radio in the last war.

America *must* be ready to launch new peacetime industries when the war is over. Recognizing this, General Electric has organized a Post-war Planning Committee to make sure we are ready. We have only begun to discover the ways in which the Electronic tube will serve mankind in the future.

Electronics offers hundreds of new peacetime products which are already practical—ready to use—ready to create employment when it will be most needed. FM Radio and Television, to name but two which dealers will be most interested in, can quickly be developed into great employment-giving industries.

Surely no advertising program could have a more worthy objective than to create a *strong* and *widespread* desire for the new things General Electric *knows* it can produce and you can sell when the war is over.

*These stations will carry the program as rapidly as they can be cleared. In some cases the time stated here will vary slightly. See your local newspaper for exact time.

***6:00** TO 6:15 P.M. EASTERN WARTIME

Akron	WADC	1350
Albany	WOKO	1460
Atlanta	WGST	920
Baltimore	WCAO	600
Boston	WEEI	590
Buffalo	WKBW	1520
Cincinnati	WCKY	1530
Cleveland	WGAR	1480
Columbus	WBNS	1460
Dayton	WHIO	1290
Detroit	WJR	760
Hartford	WDRC	1360
New York City	WABC	880
Philadelphia	WCAU	1210
Pittsburgh	WJAS	1320
Providence	WPRO	630
Richmond	WRVA	1140
Rochester	WHEC	1460
Syracuse	WFBL	1390
Washington	WJSV	1500

***9:45** TO 10:00 P.M. CENTRAL WARTIME

Cedar Rapids	WMT	600
Chicago	WBBM	780
Dallas	KRLD	1080
Des Moines	KRNT	1350
Houston	KTRH	1320
Indianapolis	WFBM	1260
Kansas City	KMBC	980
Lincoln	KFAB	780
Louisville	WHAS	840
Minneapolis-St. Paul	WCCO	830
Nashville	WLAC	1510
New Orleans	WWL	870
Oklahoma City	KOMA	1520
Omaha	KOIL	1290
San Antonio	KTSA	550
Shreveport	KWKH	1130
Sioux City-Yankton	WNAX	570
St. Louis	KMOX	1120

***8:45** TO 9:00 P.M. MOUNTAIN WARTIME

Colorado Springs	KVOR	1300
Denver	KLZ	560
Salt Lake City	KSL	1160

***7:45** TO 8:00 P.M. PACIFIC COAST WARTIME

Fresno	KARM	1430
Los Angeles	KNX	1070
Portland	KOIN	970
Sacramento	KROY	1240
San Francisco	KQW	740
Seattle	KIRO	710
Spokane	KFPY	920

GENERAL ELECTRIC

RADIO AND TELEVISION DEPARTMENT, BRIDGEPORT, CONNECTICUT

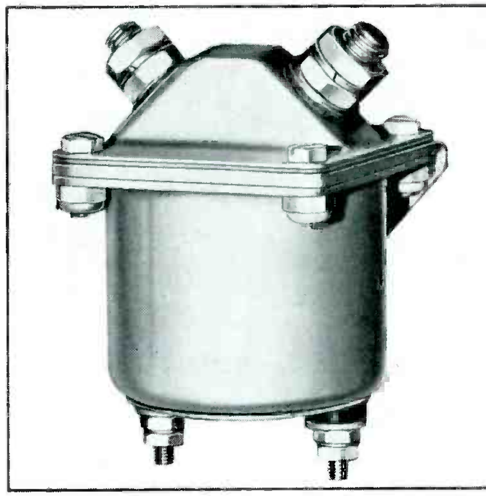
(CONTINUED FROM PAGE 20)
leave with the next group of trainees from his city. Just received at this office is a most interesting article on the progress of his FM station on Clingman's Peak, which will be published in the April issue of FM.

Harry A. Ehle: Previously manager of the industrial division of International Resistance Company has been made a vice-president, according to an announcement from Ernest Searing, president of I.R.C. Harold G. Beck is now in charge of the industrial division, through which a large part of the Company's Government business is handled.

Defense Problem: Col. Charles H. Schoeffel, superintendent of the New Jersey State Police, is confronted with this one: He must maintain lights on the transmitter towers of the police FM communications system, but means must be available to turn them out during air-raid alarms. Some of the transmitters, located at remote points, are unattended. Thus the Colonel is confronted with the need of keeping guards on duty from sunset to sunrise, unless permission is granted to switch off the lights for the duration, or an electro-mechanical system of light switching is devised.

To Arms: The FCC has lost four more executives through voluntary enlistment. Robert G. Seaks, assistant to the Chairman, is now Lieut. (j.g.) at Naval headquarters in Philadelphia. deQuincy V. Sutton, formerly head broadcasting accountant, is 1st Lieutenant in the Signal Corps material section at Washington. Broadcast engineer Julian Phillips has become 1st Lieutenant in the Field Artillery. William C. Boese, engineer in charge of FM and television, is at the Army War College, Washington, as 2nd Lieutenant in the Signal Corps material section.

Aircraft Switch: Illustrated here is a new GE aircraft dynamotor switch operating on 12 or 24 volts, DC. It is approximately 2½ ins. square by 4 ins. high, and weighs 2.3 lbs. Totally enclosed, it can be mounted in any position. This design meets Signal Corps vibration test of 5 to 55 cycles per second at a maximum amplitude of 1/16 in. total travel, applied in any direction. The single-pole contacts, normally open, will stay open when the coil is not energized, or closed when the current is on, even under a linear acceleration of 10 G. in any direction. Ambient temperatures of −40° C. to +60° C. can be withstood without failure. Contact rating is 50 amps. on an 8-hour basis. Inrush current is 500 amps. at 32 volts, DC.



G.E. AIRCRAFT DYNAMOTOR SWITCH

PROGRESS IN RADIO PROCUREMENT

(CONTINUED FROM PAGE 12)
where, now, they are entering upon the next phase of their activities.

That is, some of the procurement offices are already able to carry more and more of the responsibilities which, under force of necessity, they had been putting upon the prime contractors. Now, they are beginning to control the procurement situation within their own organizations, instead of asking a few prime contractors to take all the orders, and subcontract what they can't handle.

This means that an increasing amount of new orders can be placed with manufacturers who have not had prime contracts before, and that the various procurement officers can now investigate bottlenecks in the larger plants, and require the subcontracting of orders which can be handled effectively in small factories.

Gradually, too, those in charge of procurement are coming to a correct evaluation of the usefulness of the smaller companies. They are learning that they cannot see the true picture of the small plants by looking down their noses and asking: "How many engineers do you employ, and what degrees do they have?" That is no proper yardstick. The ratio of engineers to output is about the same in all plants, and small plants have enough engineers to handle the work that they can take on.

(CONTINUED ON PAGE 47)

Forward March

WITH ELECTRONIC POWER SUPPLIES FOR YOUR FM OR SHORT WAVE EQUIPMENT!

You in the rapidly growing and developing FM broadcast field have one problem you do not have to worry about! That's Power Supplies for your mobile transmitters and receivers, and for operation of station equipment from emergency power source.

● There's an Electronic Vibrator-Type Power Supply to meet your exact requirements. You will find Electronic Power Supplies unfailing and dependable, accurate and efficient. They use less current, reducing battery drain and prolonging battery life. They conserve weight and space, too. No lubrication is required, and servicing is seldom needed. Replacement is quickly and easily made.

Recently, George Grammer of the American Radio Relay League recommended specifications for 112-Megacycle Emergency Gear; and within thirty days Electronic was able to offer the S-1040—a complete Power Supply to meet these exact specifications! Electronic engineers are ready to do the same for you, too.

Impressive evidence of the satisfactory performance of Electronic products is their wide usage by the armed forces of the United States, Great Britain, and other United Nations, as well as in numerous commercial applications! Let Electronic answer your Power Supply problems for you!

Model S-1040—complete power supply for 112-megacycle emergency radio communication. Specifications: **INPUTS:** 6-volt DC, or 115-volt AC. **OUTPUT:** 300-volt DC, 100 Milliamperes. **FILAMENT SUPPLY:** 6-volt AC @ 2½ amperes. **VIBRATOR:** Std. Electronic 120-cycle Heavy Duty. Tube filaments are fed from Converter. Switch permits instant change over, AC to DC, or DC to AC. Separate AC input connection for 115-volt operation.

ELECTRONIC LABORATORIES, INC.

INDIANAPOLIS, INDIANA

(CONTINUED FROM PAGE 34)

Horizontal	3.06
Vertical	1.70

A sample of the soil at the receiving site was tested on a type 160-A Q-meter and E was found to be 21. The soil was a wet, reddish substance, almost like clay, and contained no stone. For this value of E, Fig. 16 gives ratios:

Horizontal	3.00
Vertical	1.63

This is in excellent agreement with the above experimental values.

A factor of 2 was decided upon for converting the results of the survey to a 30-ft. antenna

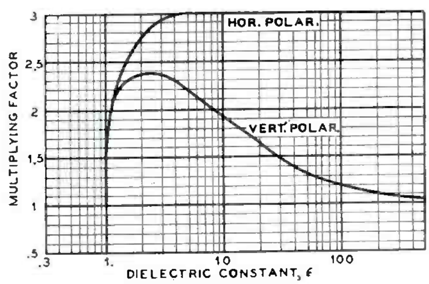


FIG. 16. COMPUTED MULTIPLYING FACTOR

height. It is apparent that this assumes dry weather conditions. In wet weather or in certain localities, this factor will be somewhat high. It will also be in error in the immediate vicinity of the transmitter.

In constructing average contour lines, the medians of the sections were used. The distance to a particular contour depends somewhat on the particular route followed in making the record for the radial. The existence of "pools," due to the topography of the land and other factors, complicates matters considerably, since a given field strength may be obtained at more than one point. When such a condition was encountered, the several sectors over which this condition occurred were averaged into a single sector so that a new median was established. Somewhat the same result can be accomplished by drawing an average line through the medians for the sectors.

Maps drawn in either case were found to be practically identical. Fig. 18 shows the contour map of the 10-kilowatt transmitter.

From measurements made on the radials, the data for plotting the desired contours was obtained and charted in Table 2. Also included in Table 2 is the land area coverage of the various contours.

Table 3 contains the necessary data for plotting average maximum field intensity contours. The land area coverage for the various contours also appears on this chart.

The computed distances to the various contours, as determined by the FCC method of computation, appear in Table 4. This data has been presented for comparison purposes, against Tables 2 and 3.

7. Population Summary ★ The following tables show the population included within the 1,000-, 50-, and 10-microvolt contours of W71NY:

	(Total)	(Rural)
1000mv/m Contour:		
New York	6,850,000	
New Jersey	1,172,000	
	8,022,000	
50mv/m Contour:		
New York	8,762,000	8,652,000
New Jersey	3,362,000	3,179,000
Connecticut	261,000	52,000
	12,385,000	11,883,000*
10mv/m Contour:		
New York	8,976,000	8,750,000
Connecticut	955,000	429,000
New Jersey	3,484,000	3,142,000
Pennsylvania	518,000	466,000
	13,913,000	12,787,000

* Population including cities of 5,000 or more persons.

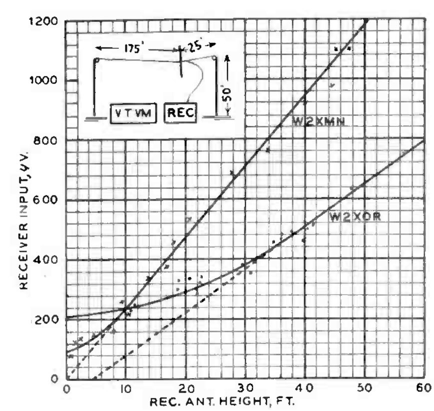


FIG. 17. EXPERIMENTAL DATA FROM FIELD TESTS

8. Discussion of Results ★ The field strength at the base of 444 Madison Avenue was observed to be less than that encountered at few hundred feet from this point, as the antenna came into optical view.

Severe and frequent variations in signal strength were present in the Manhattan area as well as in all populated and congested areas. Fig. 19 is a sample from Sections 6 and 7 of Radial No. 5, located between 6th Street and Maiden Lane on Broadway, Manhattan, New

Partial List of Purchasers of Browning Monitors

Police Departments

- Arlington, Mass.
- Atchison, Kansas
- Big Spring, Texas
- Bloomington, Indiana
- Bremerton, Washington
- Centralia, Washington
- Coffeyville, Kansas
- Columbia, Missouri
- Crawfordsville, Indiana
- Emporia, Kansas
- Fitchburg, Mass.
- Fond du Lac County, Wisconsin
- Great Bend, Kansas
- Klamath Falls, Oregon
- Leominster, Mass.
- Marathon County, Wisconsin
- Milton, Pa.
- Nampa, Idaho
- Sharon, Mass.
- Shelby County, Indiana
- Sidney, Ohio
- St. Charles, Missouri
- Twin Falls, Idaho

General Electric Company

Graybar Electric Company

Burdick Corp., Milton, Wis.

Cleveland Railway Company
Cleveland, Ohio

Water Supply Commission
Belchertown, Mass.

Hygrade Sylvania Corp.
Salem, Mass.

San Antonio Public Service
San Antonio, Texas

San Diego Gas & Electric
San Diego, California

Southern California Edison
Los Angeles, California

Toledo Edison Company
Toledo, Ohio

Transmitter Mfg. Company, Inc.
New York City

United Electric Light Company
Springfield, Mass.

United Illuminating Company
New Haven, Connecticut

University of Maryland
College Park, Md.

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BROWNING FREQUENCY MONITOR, FOR FM AND AM EMERGENCY STATIONS

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★ ★

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For All Emergency Transmitters

The new Type S-2 Browning Frequency Monitor provides the greater precision now required by the FCC for all emergency transmitters. Suitable for both FM and AM, the Browning Monitor is built with one to four bands, for any frequencies between 1.5 and 60 mc. Prices:

1 Band........	**$125.00**	3 Bands.......	**$165.00**
2 Bands.......	**145.00**	4 Bands.......	**185.00**

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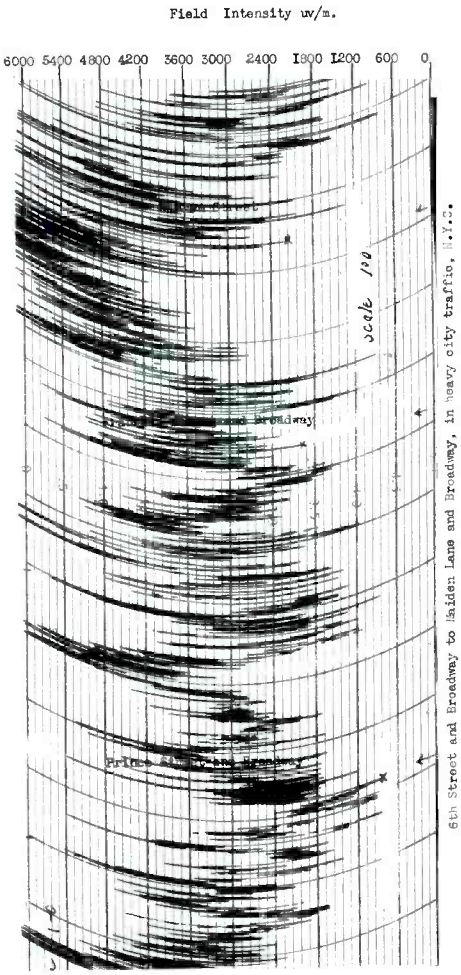
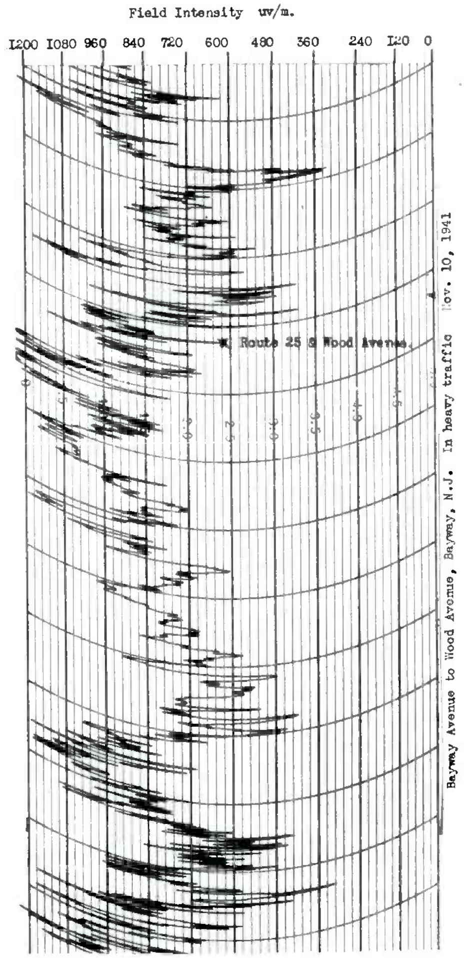




FIGS. 19 AND 20. SIGNALS RECORDED WITH THE EQUIPMENT SHOWN IN FIG. 3. THESE CHARTS REFLECT THE RECEIVING CONDITIONS INDICATED ALONG THE RIGHT HAND EDGES

York, and illustrates these severe variations. The less severe variations encountered in less congested areas is shown in Fig. 20, a section of recording taken on Route 25 between Bayway Avenue and Wood Avenue, Bayway, New Jersey. The automobile traffic was quite heavy on this main highway during the time this recording was made.

In wooded areas, rapid but less severe variations were present. The pine belt of New Jersey on Route 5 illustrates this condition.

Only in clear, flat, open regions was the signal at all steady and constant, as in Fig. 21. Examples of this condition existed for considerable distances along the Southern shore of Long Island. A very interesting condition observed to exist on such open country is an unusually large increase in signal intensity on slight elevations over bridges. A very noticeable characteristic of field intensity variation is the prominent increase found as a hill is climbed. If another hill is present between the hill being climbed and the transmitter, the field intensity will not increase appreciably until the second hill elevation is sufficient to overcome the shielding effect of the first hill. As soon as the receiving antenna drops below the crest of the hill again on the far side from the transmitter, the signal drops almost immediately to a very low value and remains low until the shielding effect of the hill decreases. Fig. 22 illustrates this effect very well. The effect of the topography of the land becomes more pronounced as the distance to the transmitter approaches the optical distance from the transmitter antenna.

ELECTRONIC EQUIPMENT

Engineering & Design Practice

FM

10. AN almost unbelievable acceleration has been given by the War to the development of new electron tube applications and to the quantity production of new types of tubes never used commercially before.

Those in a position to know are already predicting revolutionary post-war changes in radio broadcasting and communications.

Of these, the greatest advances are expected in frequency modulation and television, when wartime developments can be applied to peacetime services.

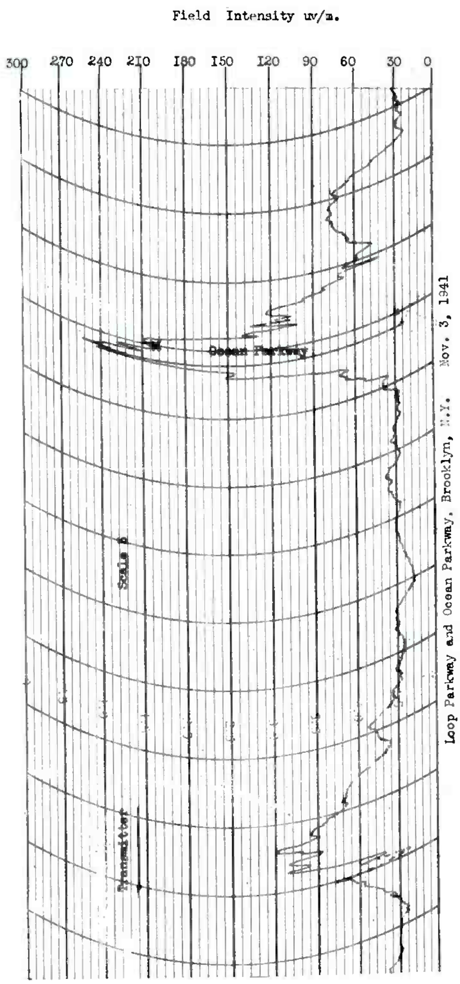
From its inception, *FM* Magazine has held an outstanding and exclusive position in the radio engineering field. Now, in step with present progress of radio and electronic engineering, and looking toward post-war developments, the name of this publication has been modified by the explanatory title: Electronic Equipment Engineering & Design Practice.

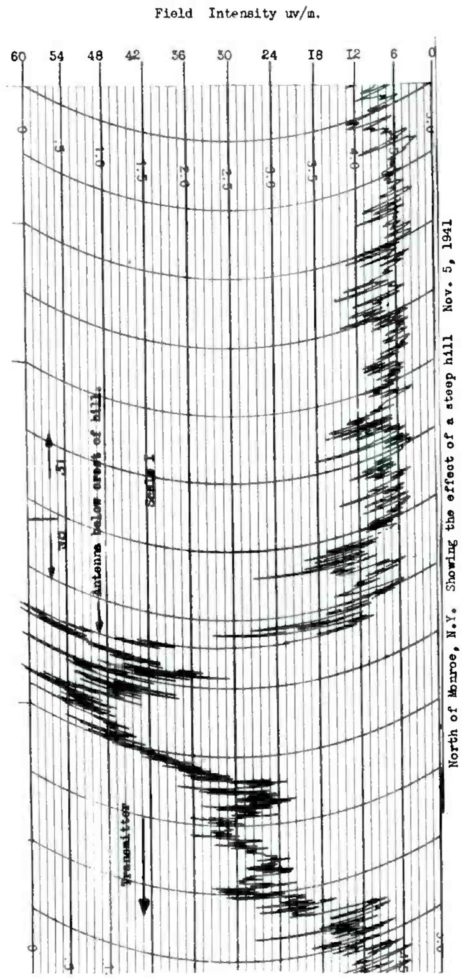
Next, effective with the May issue, the size will be increased to the new standard of $8\frac{3}{4}$ inches by $11\frac{5}{8}$ inches.

Because it is truly "the magazine of greatest usefulness to radio engineers and executives", wartime activities have accelerated the steady growth of *FM* Magazine.

M. B. SLEEPER, *Editor and Publisher*

JOURNAL OF RADIO BROADCAST, COMMUNICATIONS, AND TELEVISION ENGINEERING AND DESIGN PRACTICE





FIGS. 21 AND 22. IN THE OPEN COUNTRY, THE SIGNAL RECORDS ARE MORE REGULAR. NOTE THE RESULT OF PASSING OVER A HILL, AS SHOWN IN FIG. 22 BY THE SLOW RISE AND CUTOFF

The presence of many tall buildings in lower New York City was very evident in our measurements. The measured field in this direction dropped 10 or 12 db below the theoretical value. Burrows, Decino, and Hunt [4] found a similar condition in a survey made in Boston, where this field was decreased by 10 to 12 decibels in heavily built-up localities. They state that the computed and measured field strength could be made to agree if the height of the transmitting antenna were taken *above the roof*, instead of above sea level. They stated further that this effect tended to be local, the field rising to the theoretical value when open country was reached.

The photographs in Part 1 bear out this argument rather nicely. The many tall buildings are so closely packed that they might easily produce a sort of "pseudo-terrain" which is only slightly lower than the transmitting antenna.

One might expect a similar drop in field strength to the north on Madison Avenue. The reason it does not appear is probably due to the relatively straight and unobstructed path in this direction, as can be seen in the view looking north.

The higher values along Radial 7, to the west, carry the effect of the shielding due to the RCA building, 975 feet high, which lies directly on the radial. This shielding effect disappears on the lower field intensity contours.

Except for the deviations explained above,

[4] See reference 7 in Section 10.

the theoretical contours agree very well with the measured contours with the exception of Radial 5. This radial passes through the New Jersey pine belt and sandy soil area which is well known for its unusually high attenuation of all radio signals. This condition was not taken into account in deriving the computed contours.

Due to the effect of topography, many "islands" or isolated contours really exist. However, by taking the averages over a number of miles, the result indicates that many of these so-called islands are eliminated. The selection of the position and the length of the sections determine the number of "islands" which will appear on the plotted contours. An area of considerably elevated land will cause an island, but a great many measurements would be necessary to permit a plot of it to be drawn. One prominent example of such a condition exists on Radial number 8. For a number of miles the signal intensity averaged about 15 microvolts-per-meter, when a steep high mountain was reached. After climbing for about 8 miles to an elevation of over 2,000 ft., the signal had reached a value of over 1,000 microvolts-per-meter. Just on the other side, the intensity immediately dropped to about 6, and remained at this low level for many ensuing miles.

9. Conclusions ★ The measured contours proved to be in very close agreement with the contours as computed by the FCC Method. Where a deviation occurred, it can be explained as a departure from the assumptions made in the method. The two chief causes of deviations result from (1) the presence of a region of unusually high attenuation; (2) the presence of many buildings, tending to increase the effective average elevation of the ground plane.

An area of 865 sq. miles is included within the 1000mv/m contour, which area contains a population of 8,022,000.

The 50mv/m contour contains an area of 5,730 sq. miles, a total population of 12,385,000 and an urban population of 11,838,000.

The 10mv/m contour covers an area of 10,290 square miles, a total population of 13,913,000 and an urban population of 12,787,000.

A surprisingly small difference exists between the two methods — average (median) and averaged maximum field intensity.

The 48 kw-50 mv/m contour obtained from these measurements indicates that this is about the correct power required to cover the specified area of 8,500 sq. miles.

To plot the 50 and 10 mv/m contours with any degree of accuracy, more measurements are necessary. The reason for this is because the radials are too widely spaced at some distance from the transmitter. This is especially true where considerable change in topography and geology is present between radials. It is

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recommended that additional data be secured in future surveys. These additional measurements required are as follows:

1. Along the south shore of Connecticut (near Norwich or New London).
2. Towards Philadelphia or Morristown.
3. Along the east Atlantic coast of New Jersey.
4. Almost due north — up the Hudson River Valley.

10. References ★ The following references contain much valuable information on the subject of field strength calculations and measurements:

1. Schelling, Burrows and Ferrell — "Ultra Short Wave Propagation," Proc. of the IRE, March, 1933.
2. K. A. Norton — "Ground Wave Field Intensity Over Finitely Conducting Spherical Earth."
3. H. H. Bevarage — "Some Notes on Ultra High Frequency Propagation," RCA Review, January, 1937.
4. M. Katzin — "Ultra High Frequency Propagation" — Radio at Ultra High Frequencies, RCA Institute's Technical Press.
5. C. R. Burrows — "Radio Propagation Over Plane Earth," Bell System Technical Journal, January, 1937.
6. G. H. Brown — "A Comparison of Horizontally and Vertically Polarized Waves at Ultra High Frequencies" — Wave Polarization For Television, RCA Manufacturing Company.
7. Burrows, Decino and Hunt — "Ultra Short Waves in Urban Territory," Electrical Engineering, May, 1935.
8. G. S. Wickizer — "Mobile Field Strength Recordings," RCA Review, April, 1940.
9. G. S. Wickizer — "Field Strength Survey 52.75 MC. From Empire State Building," Proc. of IRE, July, 1940.
10. Field Intensity Survey of Ultra High Frequency Broadcasting Stations. Federal Communications Commission.
11. C. B. Feldman — "The Optical Behavior of Ground for Short Wave," Proc. of the IRE, June, 1933.
12. R. W. George — "Field Strength Measuring Equipment at 500 MC.," RCA Review, July, 1940.
13. B. Trevor — "Ultra High Frequency Propagation Through Woods and Underbrush," RCA Review, July, 1940.
14. Raymond F. Guy — "Frequency Modulation Field Tests," RCA Review, October, 1940.
15. Trevor and Carter — "Notes on Propagation of Waves Below Ten Meters in Length," Proc. of the IRE, March, 1933.
16. L. F. Jones — "A Study of the Propagation of Wavelengths Between Three and Eight Meters," Proc. of the IRE, March, 1933.
17. Burrows, Decino and Hunt — "Ultra-Short-Wave Propagation over Land," Proc. of the IRE, December, 1935.

(CONTINUED FROM PAGE 19)

for speaker mounting. After this has been drilled, it will be necessary to bring the speaker cable through the grommet in the speaker housing, and to solder it to the voice coil terminals. The loudspeaker can then be mounted on the firewall. This completes the installation, except for inserting fuse, tubes, and crystals which should be done at this time if they are not already in place.

EDITOR'S NOTE: *Part 2 of this article will appear in the April issue.* This will include the schematic wiring diagram, referred to as Fig. 3.

PROGRESS IN RADIO PROCUREMENT

(CONTINUED FROM PAGE 38)

Small Plants Are Needed ★ Many small orders of great importance are being shuffled around by large contractors which could be handled quickly by the more flexible and adaptable small concerns. As attention can be given to getting them started, the usefulness of the smaller factories to the war effort will be more clearly understood, and their facilities will be used more effectively.

It would be a grievous mistake to stop their production of civilian radio sets, and force them to disband their workers now, just when the procurement officials are getting to the point of being able to take advantage of the fast service they can perform, thereby leaving the large companies free to concentrate on big runs and heavy equipment.

This means that:

1. Prime contracts already let for limited quantities of equipment small enough in physical dimensions to be moved along benches should be put out on subcontracts to concerns whose normal business will be stopped by the April 22nd edict.
2. Emergency allotments of materials should be given to these companies to keep them going on their normal production until they can get military orders.
3. Then they will be available for war production on equipment that cannot be handled as quickly or as cheaply by the big factories.
4. Recognition must be given to the fact that, while some factories have little manufacturing machinery of their own, each one, over a period of years, has built around it a group of suppliers, forming a complete organization for production that can compete favorably with manufacturers having such facilities under their own roofs.

To let the smaller plants go out of business now will prove to be a serious mistake when, perhaps in a matter of weeks, the progress of the organizations for procurement will be such that they can use these production facilities to great advantage.

ARMY, NAVY, MARINE CORPS, COAST GUARD

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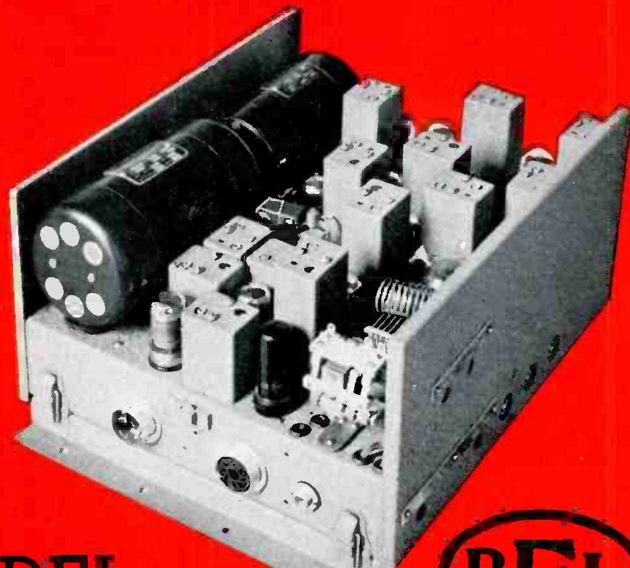

V...— ICTORY MODEL

REL

FM 2-Way Radio for All Emergency Services

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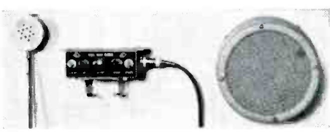
THIS newly perfected **REL** model is the first FM emergency equipment with the receiver and transmitter combined on a single chassis—an arrangement which affords many mechanical and electrical improvements which increase efficiency and simplify installation and service. These improvements cannot be found in the older multi-chassis construction.

Greater range, higher quality, and better signal-to-noise ratio and squelch action result from increased efficiency obtained by simplified circuits of compact design. The 807 tube, source of troublesome parasitics, has been replaced by the new 815 power tube, designed specifically for ultra-frequencies.

Simplified construction, based on 10 years of field experience with mobile equipment, makes the **REL** Victory Model the last word in ruggedness and dependability. Loose connections in inter-chassis cables are eliminated. Test jacks are protected from dust by the snap-on cover.



Hours are saved in installation and servicing.

Low-voltage receiver dynamotor supplies power to all transmitting tubes except power amplifier, thus avoiding plate voltage dropping-resistor loss and its resulting storage battery drain.

Finally, the improvements in the **REL** Victory Model are geared to new production methods which assure fast deliveries for all emergency service needs.

565-A SPECIFICATIONS

Frequency: Any frequency in the 30–40 mc. band. **Drain:** 14 amps. receiving, 34 amps. transmitting from 6v. battery. **Size:** 17¼″ long, 14¾″ deep, 9″ high. **Weight:** 50 lbs. **Accessories:** Supplied complete with all cables, antenna and support, control unit, speaker, choice of hand-grip microphone or French type hand set.

Receiver: 11 tubes, double IF superheterodyne, single-crystal control, limiter acts on signals of less than 1 microvolt, with squelch action on less than .5 microvolt.*

Transmitter: 6 tubes, output in excess of 25 watts, crystal-control phase shift, new single-tube modulator in newest FM circuit development.

Cat. No. 565A: Supplied with loudspeaker and press-to-talk hand grip microphone as illustrated.

Cat. No. 565AWE: Supplied with loudspeaker and french type press-to-talk hand set microphone and earphone.

* Measurements made on production receiver with General Radio 804-B signal generator. Still greater sensitivity is indicated by other types of measuring instruments.

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IN REPLY REFER TO
CASE NO. ______

March 17, 1942

Mr. Fred M. Link
125 West 17th Street
New York, New York

Dear Mr. Link:

You, no doubt, will be interested to know that due to increased wartime activities in our department, transmissions on the Connecticut State Police FM System have now reached the point where we are averaging sixty thousand (60,000) transmissions a month from the main stations.

This, undoubtedly, is the most efficient use of a single frequency channel in the emergency services. The ability to handle such a large number on one channel with eleven stations is an indication of what can be done with F M.

When it is considered that this number of transmissions are from the main stations only and the cars (235 three-way) operate on another single channel, the whole picture is still more amazing. Despite the fact that this tremendous volume of traffic is handled, there are only five technical men to take care of the maintenance of the whole system again proving that FM not only makes efficient use of the frequency spectrum but the results are accomplished at a very economical maintenance cost.

Yours very truly,

Sydney E. Warner
Sydney E. Warner
SUPERVISOR OF RADIO MAINTENANCE

SEW/ac

PROOF OF PERFORMANCE: In its third year of operation, the Connecticut State Police radio system is setting the pace for efficient operation. The first state-wide system to be installed in the USA, Connecticut has used Link FM equipment exclusively from the beginning. New Jersey and New York have recently joined Connecticut, Delaware and Maryland in the growing list of state-wide FM systems using Link equipment *throughout*.

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