# NATIONAL RADIO INSTITUTE

## Complete Course in PRACTICAL RADIO

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LESSON TEXT No. 38

# HOW TO OPERATE A BROADCASTING STATION

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# Radio-Trician's

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# Complete Course in Practical Radio

NATIONAL RADIO INSTITUTE, WASHINGTON, D. C.

## HOW TO OPERATE
## A BROADCASTING STATION

In years gone by, the ambitious individual who wished to become a radio engineer or a radio operator and who availed himself of some reputable course in radio, did not find any section devoted to the operation of broadcasting stations.

At the present time, the art in question is expanding and it is difficult to prophesy when the saturation point will be reached. The fact remains that radio broadcasting is now such an important phase of radio that you, who wish to become well informed on the subject in its entirety, would do well to consider the following pages with as much concentration as possible.

There are radiotelephone transmitters on shipboard, at the present time, and it is well for the modern radio operator to understand the maintenance and operation of this type of equipment. It might be pointed out here that this type of telephone transmitter does not require an absolutely distortionless audio-frequency amplifier ahead of the modulator tubes, due to the fact that it has to function chiefly in effecting satisfactory transmission of speech.

Contrasting the requirements for the standard broadcasting station with those of the ship phone transmitter, we find that the efficiency of the audio-frequency circuits in the case of the shore station are far more stringent. In this case, not only is it necessary to have amplifiers that will provide the modulator tubes with distortionless speech, but also with high quality music.

To produce satisfactory reception of music, it is necessary that the audio-frequency amplifier circuits at the transmitting station be impartial to all frequencies from 30 or 40 cycles per second to 5,000 cycles per second.

Going back to the ship telephone transmitter and the consideration of satisfactory transmission of speech, it is well to realize that the most important speech frequencies are between 200 and 2,000 cycles per second.

If the audio-frequency amplifier circuits chop off all the frequencies under 750 cycles per second, you can still understand what is being said, but you cannot distinguish the speaker.

A pertinent point to mention at this time is that there is a need for well trained men in the radio broadcasting field who are well paid for their services.

Now that the introductory remarks have been completed, it is logical to inform you how we propose to handle this subject.

First of all we will touch briefly on the consideration of the location of a broadcasting station. Then, having settled that point we will dive right into the heart of the entire subject of radic broadcasting, namely, the source of radio-frequency energy.

In discussing the methods used in establishing a source of radio-frequency energy, the primary power supply angle of the subject will be covered.

It seems logical to pick out several of the most popular standard types of broadcasting units having different power outputs and discuss them in detail, rather than treat the subject in generalities. Bearing this in mind, we will take up in detail a 500-watt General Electric Company transmitter, a 500-watt Western Electric Transmitter, a 1,000-watt General Electric transmitter and finally we will touch on a super-power station of the General Electric Company's design, having an output of 50,000 watts.

The necessity of maintaining a constant frequency of the radio-frequency output will be discussed and various methods of accomplishing this explained.

We will show how the sound waves that actuate the transmitting microphone are amplified and made to modulate the radio-frequency output from the transmitter.

Different types of microphones will be considered and the advantages and disadvantages of each explained. The high quality speech amplifier circuits and the functioning of the modulator tubes will be explained quite thoroughly.

Finally, we will consider the apparatus involved in broadcasting from a remote point and the linking up of a chain of broadcasting stations.

## THE LOCATION OF THE STATION

When an option is taken on a site for a broadcasting station, it is sound practice to determine whether the station is going to "get out," before proceeding with the expenditure of several thousands of dollars on the equipment and installation. Most of you probably know that by the ability of the station to "get out," we refer to the distance the signals will carry and we are interested in the distance they will carry in all directions.

One way of obtaining sufficient quantitative data for determining the radio possibilities of a site for a broadcasting station is to install a low power portable radio transmitter at the desired location and take intensity measurements at equal distant points in all directions from the transmitter.

From the quantitative data so obtained, a signal intensity curve may be plotted and definite conclusions can be drawn as to whether there is an abnormal amount of absorption on any particular frequency or wave-length or on all frequencies or wave-lengths.

While the test is being conducted, readings are usually taken at different frequencies or wave-lengths throughout the entire broadcast band to determine whether the location in question is partial to any particular frequency or wave-length.

A transmission curve plotted on polar co-ordinate paper should take the form of a circle, as shown in Figure 1, with the transmitting station located at the center of this circle.

You will notice that intensity values are plotted along the radii which extend out in all directions from the point of transmission. Thus, the radius $I_N$ represents the signal intensity at a definite distance due North from the transmitter, the radius $I_W$ represents the signal intensity at a definite distance due West from the transmitter, etc.

If the signal intensity at the different points varied, the curve drawn through the points plotted would not be a true circle. It is easier to determine the different values of intensity at equal distances from the station than it is to determine the different distances from the station, in all directions, where the intensity values are equal.

Of course, it is desirous that the intensity of signals from the transmitter be equal at equi-distant points in all directions from the point of transmission but it is also important that these values be sufficiently high. In other words we might have a condition where signal intensity was equally poor in all directions.

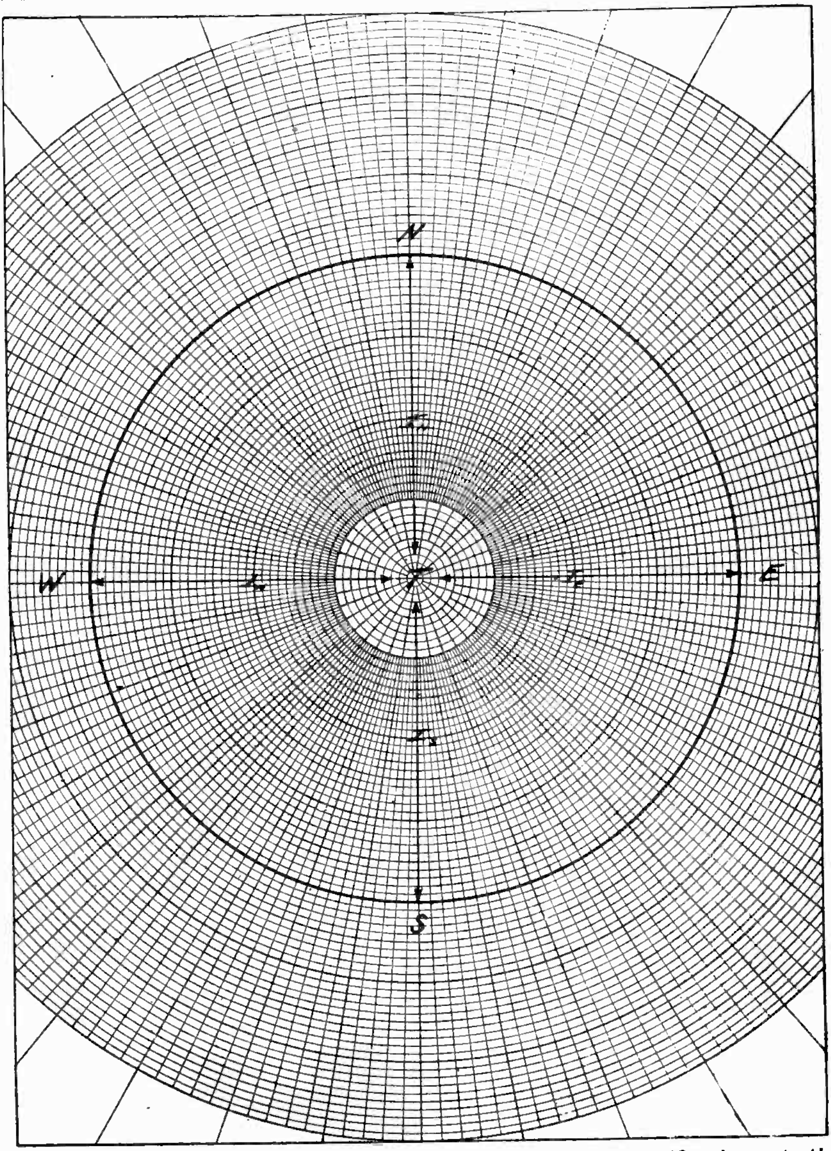


Fig. 1.—Transmission Curve, Using Polar Co-ordinate. (Station at the Center or Zero Point and Radii Represent Direction and Distance).

Assuming that the value of the intensity $I_N$, Figure 1, is satisfactory, then we may say that this curve would mean that the site for the transmitting station in this case is satisfactory.

## POWER SUPPLY

After the site has been definitely decided upon, the next thing to consider is the availability of a sufficient amount of

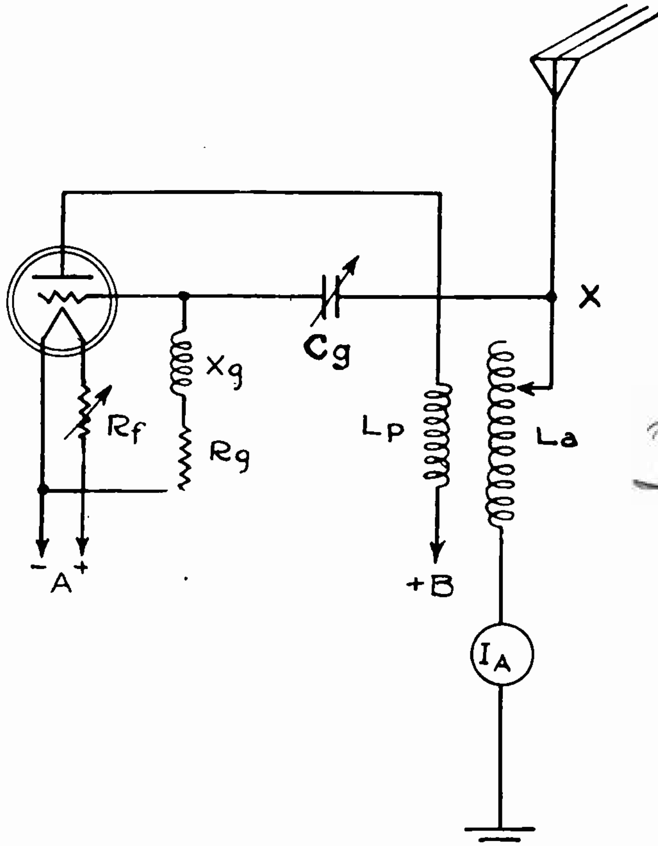


Fig. 2—Standard Tickler Coil Circuit With Inductive Plate Coupling.

electric power for operating the station of the power output contemplated.

Either direct or alternating current is satisfactory. This primary source of power is used to run motors which, in turn, actuate the generators of the proper electrical energy for applying to the points in the radio transmitter where desired.

We need low voltage alternating current for the filaments of the tubes. We need relatively high potential direct current for bias supply and we need high pressure direct current for the plates of the tubes.

In general, if the primary source of power is D. C., it is changed into low pressure A. C. for the filaments of the tubes by means of motor generator sets.

In this case, the grid bias voltage may be obtained by the following process: The low voltage D. C. is changed into low voltage A. C. by means of a motor-generator set and this supply of energy is then stepped up to the proper potential by means of a transformer. The high voltage A. C. obtained in this manner is then changed by means of suitable rectifier tubes into D. C. of sufficient potential for biasing the grids of power tubes.

## THE HEART OF BROADCASTING—THE RADIO TRANSMITTER

The first broadcasting transmitter that we will discuss is one having a 500-watt output, located in New York, and manufactured by the General Electric Company.

The circuit arrangement is a modification of the "tickler coil" circuit with inductive plate coupling.

A typical circuit diagram of this type is shown in Figure 2. In this circuit the frequency determining elements are the inductance of the antenna coil (LA), and the inductance and capacity of the antenna itself.

The grid excitation is taken from the antenna circuit on the high side of the antenna coil (LA) and the value of this potential as it is applied to the grid of the oscillator tube is controlled by the value of the capacity (Cg). The larger the value of this capacity, the less will be its impedance to the flow of radio-frequency current, the less will be the potential drop between the point (x) and the grid of the tube; hence, the higher the potential of the grid excitation energy.

Theoretically we may mention the impedance of a condenser but, practically, the values of the resistance and inductance of a condenser are so small that the condenser may be assumed to contain nothing but capacity and in this case it wouldn't be necessary to call it an impedance, but think of it as pure capacity reactance, the symbol of which is (Xc).

If the value of the condenser (Cg), Figure 2, is decreased, capacity reactance increases, there is a greater impediment to the flow of radio-frequency current from point (x) to the

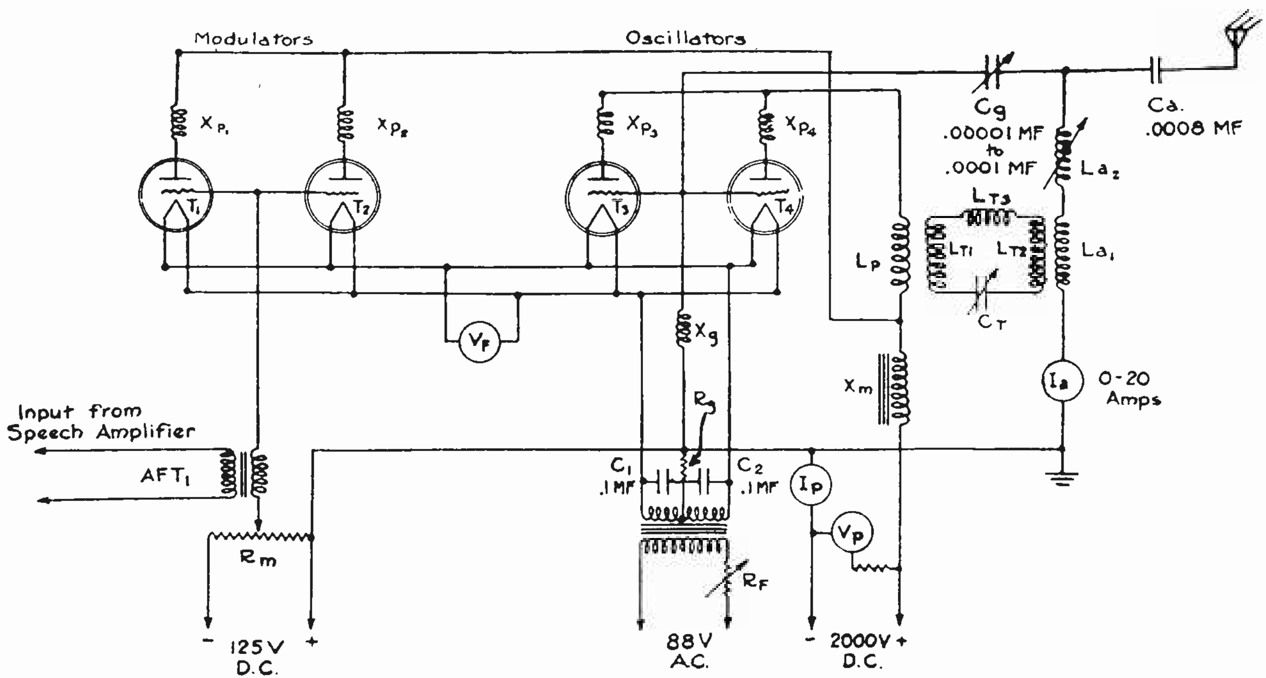


Fig. 3.—Schematic Wiring Diagram of General Electric 500 Watt Transmitter

grid of the tube, there is a greater drop in potential across the condenser (Cg), hence the potential value at the grid of the tube is decreased.

From the foregoing explanation you can see what a fine control of grid excitation can be effected by means of a variable capacity at Cg.

The choke coil Xg is connected in series with the grid biasing resistance (Rg) to keep radio-frequency currents from flowing through this circuit. Without this choke, there is a loss of about 20 watts in a 5,000 ohm bias resistance when the oscillator tube is of the 250-watt type.

This loss is 8% of the rated output of the tube so you can see that such a small unit as a radio-frequency choke coil, when applied at the proper point in the circuit, can greatly aid in the conservation of energy and hence, in the increasing of overall efficiency of operation.

When a radio-frequency choke coil is used, as at Xg the loss is decreased from 20 watts to ½ a watt which is from 8% to 2% (0.2 of 1% or 0.2%).

The plate potential is supplied through the coil (Lp) to the plate of the oscillator tube. The coil (Lp) is placed in inductive relation to the antenna tuning coil (La).

The theory of the generation of radio-frequency oscillations in this circuit is quite simple. When the filament of the oscillator tube is heated up to normal temperature and the plate potential is applied, there is a surge of current in the plate circuit of the tube. The direct result of this is that the antenna is forced or shocked into feeble oscillations. The frequency of these oscillations is a function of the inductance and capacity in the antenna circuit.

Due to the fact that the grid of the tube is coupled to the antenna circuit by means of the condenser (Cg), there is an alternating potential applied to the grid of the tube and obviously, the frequency of this alternating potential is the same as the frequency of the current in the antenna circuit.

Thė effect of this grid excitation is to cause the plate current through the coil (Lp) to vary in accordance with the variations in the antenna current and when the circuits are properly adjusted, these variations in the plate circuit will add to the effect of the original surge.

You can see that the actions that have been detailed are accumulative, and the limit is a function of the tube and antenna characteristics.

Figure 3 shows the schematic wiring diagram of a 500-watt broadcasting transmitter designed by the General Electric Company. You will note that this is the general type of cir-

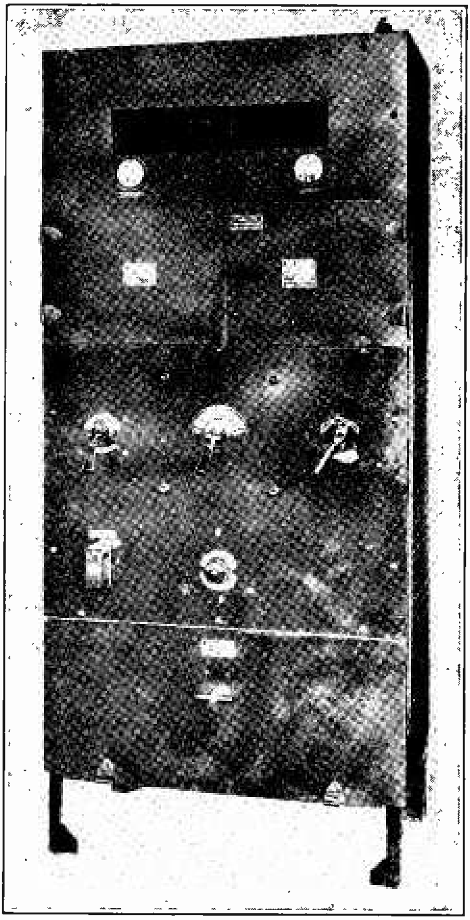

Fig. 4.—Front View of G. E. 500 Watt Transmitter Panel.

cuit that has just been discussed but there are quite a few modifications.

Four 250-watt tubes are used in this transmitter. $T_1$ and $T_2$ are modulator tubes, $T_3$ and $T_4$ are oscillator tubes. The filaments of these four tubes are all connected in parallel and they are supplied with energy from the secondary winding of the filament transformer.

The terminal voltage of this secondary winding is such that all volt potential is maintained at the filament terminals of the four 250-watt tubes.

There are two radio-frequency by-pass condensers connected in series between the two filament supply leads. These two condensers ($C_1$) and ($C_2$) each have a capacity of .1 Mfd. Their mid-point is connected to ground.

The plates of the two oscillator tubes ($T_3$) and ($T_4$) are connected to a 2,000 volt D. C. supply through the radio-frequency choke coils ($Xp_3$) and ($Xp_4$) respectively, the plate coupling coil (Lp) and the iron core choke coil (Xm). You will notice that this plate circuit is untuned, the same as was the case in the plate circuit of the fundamental diagram which preceded this one.

You will notice in Figure 3 that the plates of the oscillator tubes are not coupled directly to the antenna circuit, instead, there is an intermediate coupling circuit, which is termed a "tank" circuit. This "tank" circuit determines the frequency of the generated radio-frequency energy.

The object of the "tank" circuit is to maintain a constant radio-frequency source of energy. When the constants of the antenna circuit determine the frequency of the generated energy, there are apt to be changes in frequency due to the swinging of the antenna in heavy gales. Of course, this is sometimes counteracted by making the antenna system so rigidly secure that it is not likely to swing to any great extent.

The plate coil of the oscillator tubes is inductively coupled to the "tank" coil ($Lt_1$). The coil ($Lt_3$) is the "tank" variable tuning inductance. The coil ($Lt_2$) is used to couple the "tank" circuit to the antenna system. Ct is the "tank" tuning condenser.

$La_1$ is the antenna coupling coil which receives the energy from the "tank" circuit. $La_2$ is the antenna loading inductance, and the condenser (Ca) is inserted in series with the antenna lead to cut down the natural period of the antenna system where it is desired to transmit on a wave-length around 450 meters.

The grids of the two oscillator tubes receive the proper excitation from the antenna system through the grid coupling condenser (Cg).

The two oscillator grids are connected to ground through the grid choke coil (Xg) and the grid biasing resistance (Rg). The 2,000 volt D. C. grid current flowing through the grid resistance (Rg) supplies the proper negative bias to the grids of the oscillator tubes.

The choke coil (Xg) is put in series with the biasing resistance to keep radio-frequency current out of this circuit

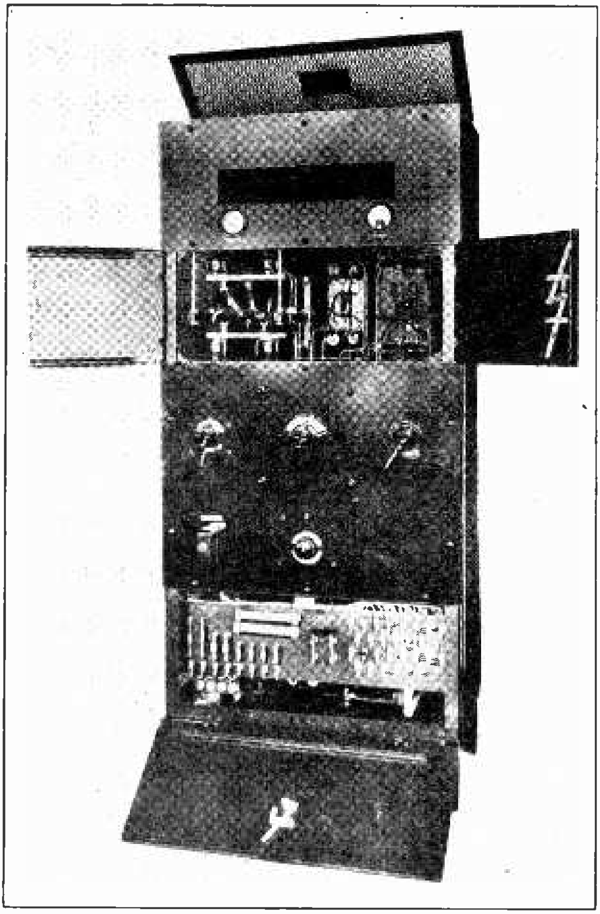

Fig. 5.—Control Panel of G. E. 500 Watt Transmitter, With Doors Opened.

and hence, decrease losses, which in turn increases the overall efficiency of operation.

The plates of the two modulator tubes ($T_1$) and ($T_2$) are connected to the 2,000 volt plate source through the two radio-frequency choke coils ($Xp_1$) and ($Xp_2$), respectively, and the iron-core plate reactor (Xm).

The grids of the two modulator tubes are connected in parallel through the secondary winding of the audio-frequency transformer ($AF_1$) to a variable contact on the modulator bias resistance (Rm).

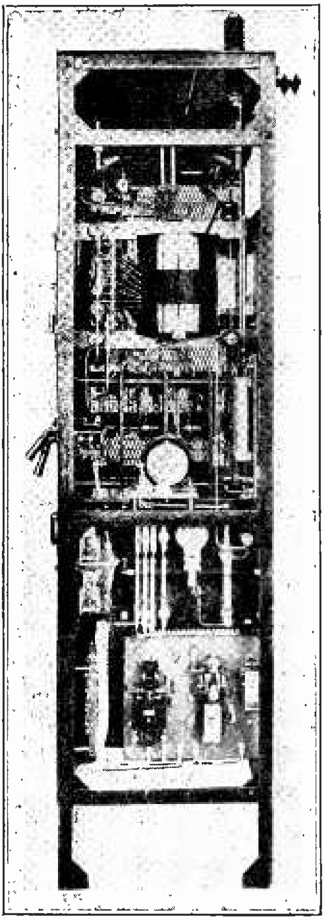

Fig. 6.—Side View of the G. E. 500 Watt Transmitter.

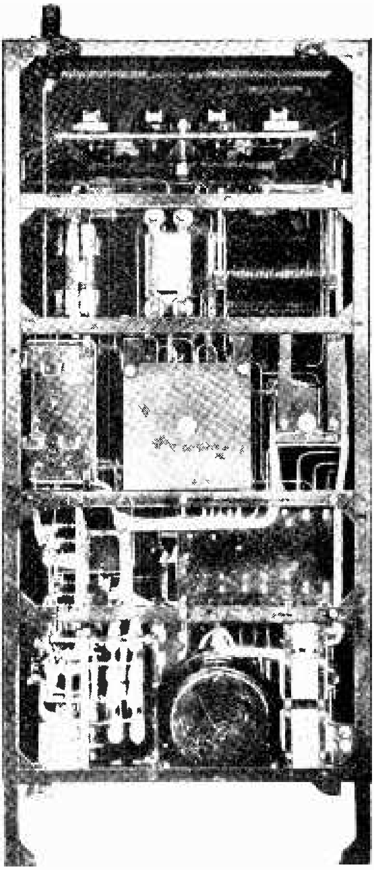

Fig. 7.—Back or Rear View of the G. E. 500 Watt Transmitter.

The extremities of this biasing resistance are connected to the positive and negative terminals of a 125 volt D. C. supply. The positive terminal of this D. C. supply is grounded; hence, it is possible to keep the modulator grids 125 volts below ground potential if so desired. In this case the grids of the

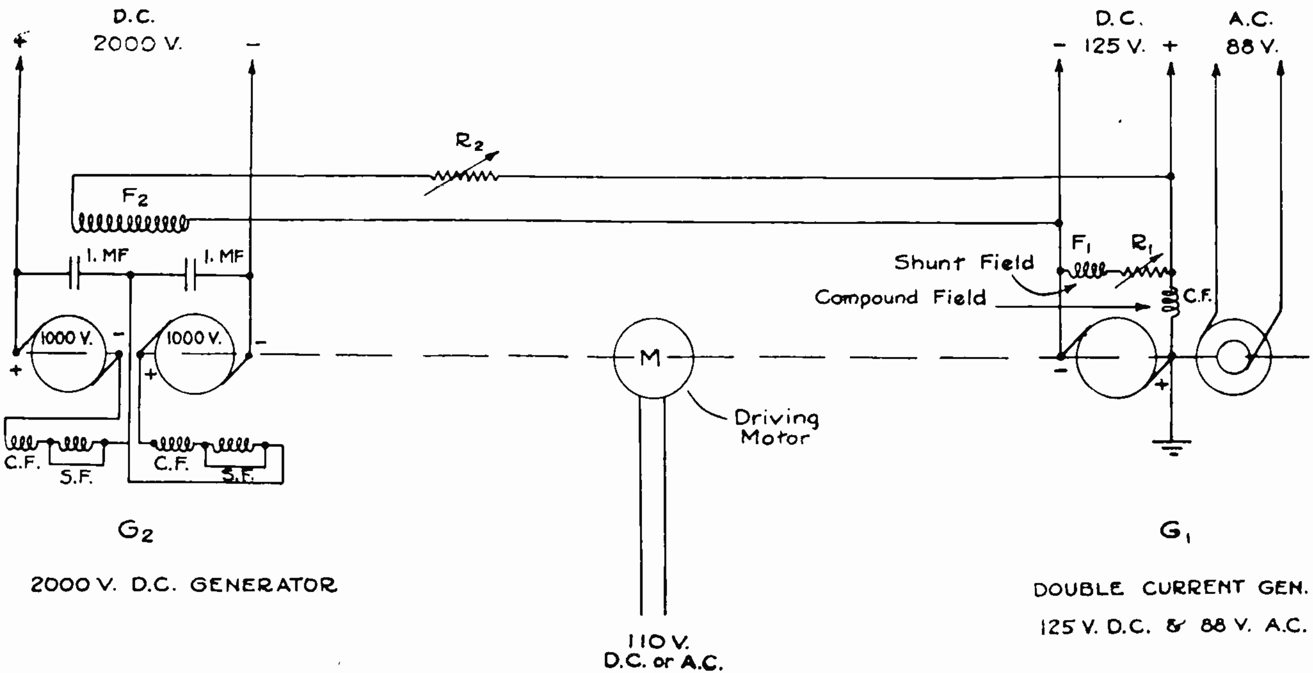


Fig. 8.—Motor-Generator for General Electric 500 Watt Transmitter. Schematic Wiring Diagram.

modulator tubes would not be kept so far negative, but the fact remains that they could be maintained at any negative potential between 0 and -125.

The audio-frequency output of the speech amplifier network is applied to the grid circuits of the modulator tubes, which are in common in this case, through the audio-frequency transformer $AF_1$. These audio-frequency currents are made to form an envelope for the constant radio-frequency energy that is generated by the oscillator tubes. This operation of controlling radio-frequency current with audio-frequency vibrations is called "modulation" and is effected by the modulator tubes ($T_1$) and ($T_2$). The way in which this is accomplished is quite simple and a discussion of the principals involved follows.

## MODULATION

The sounds which emanate in the broadcasting studio are faithfully reproduced in the grid circuits of the modulator tubes in the form of audio-frequency currents, by virtue of the microphone, speech amplifier and the transformer coupled to the input circuits of the modulator tubes.

These audio-frequency variations in the grid potential of the modulators cause corresponding audio-frequency variations in their plate current. The plates of the modulator and oscillator tubes are all supplied in common through the iron-core reactor (Xm) and by virtue of this reactor, there is practically a constant current supply to the four tubes in question.

It is an inherent characteristic of any reactance that it tends to oppose any change in the current flowing through it. The greater the reactance, the greater the opposition. Here we have a large reactance in series with the plates of both the oscillator and modulator tubes.

If the modulator grids went positive at any particular instant due to the varying audio-frequency potential imposed thereon, their plate current would increase. Here is where the reactor functions. It would tend to oppose this increase in the current for the modulator tubes and the result would be that the modulators would draw some of the current away from the oscillator tubes.

A summary of this action shows that audio-frequency variations in the grid circuit of the modulators cause corresponding variations in modulator plate current which in turn raises and lowers the oscillator plate current. Thus, an audio-frequency envelope is formed over the outgoing radio-frequency oscillations.

## POWER SUPPLY FOR 500-WATT G. E. TRANSMITTER

Figure 8 is the schematic wiring diagram of the power supply unit for the 500-watt type of transmitter which we have been discussing.

## OPERATING HINTS ON THE 500-WATT G. E. TRANSMITTER

When the transmitter is first installed and tuned up or at any time it is necessary to make adjustments, they should be made at low power. The low power condition is effected by dropping the plate voltage to around 1,200 volts, in this case.

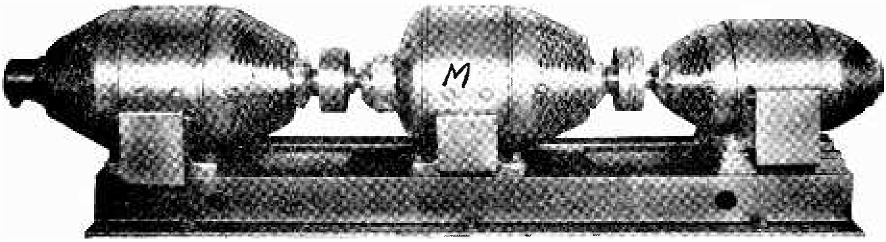


Fig. 9.—Picture of Motor-Generator Power Unit for General Electric 500 Watt Transmitter.

The plate potential is controlled by means of the rheostat ($R_2$), which is shown in Figure 8, in series with the field winding of the 2,000 volt D. C. generator.

Don't try to control the plate voltage by means of the exciter generator field rheostat ($R_1$). This rheostat should be adjusted to the point where the potential across the terminals of the exciter reads 125 volts. Then the rheostat in question should remain unchanged.

The plate voltage is recorded by means of the voltmeter (Vp Figure 3) which is virtually, a current measuring device in series with a high resistance across the 2,000 volt leads.

The filament voltage is controlled by means of the rheostat (Rf Figure 3) which is in the primary side of the filament transformer. This rheostat is so adjusted that the potential at the filament terminals of the tubes is 11.0 volts.

It is quite possible that an increase of ½ a volt in filament potential may raise the radiation a few tenths of an amp., but from an economical standpoint this is not worth while.

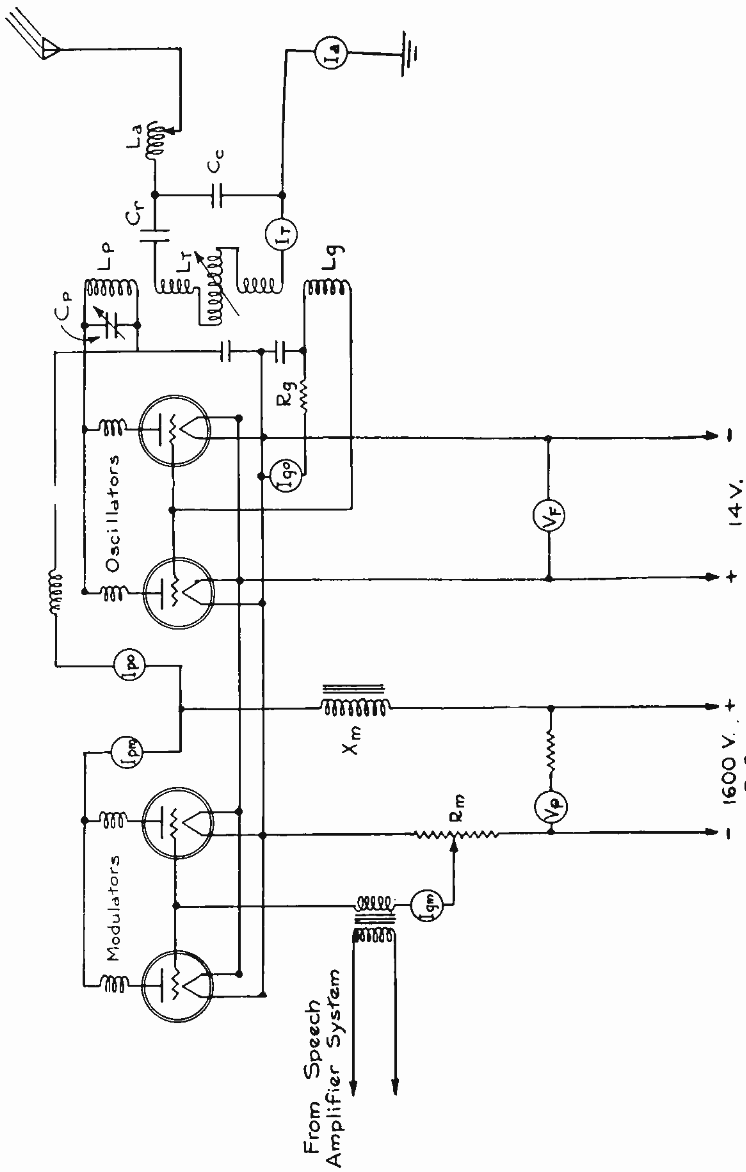


Fig. 10.—Schematic Wiring Diagram of Western Electric 500 Watt Transmitter.

If the filament voltage is left at 11.5 in this case for any length of time, it will greatly decrease the length of life of the tubes and if persisted in will cut the tube life about 50%.

The radiation current is measured by the antenna ammeter (Ia Figure 3).

The adjustments of the transmitter should be made with the aim of getting the maximum radiation with the lowest amount of plate current. The plates of these UV-204 tubes should not get hotter than is manifested by a cherry red color.

## 500-WATT WESTERN ELECTRIC BROADCAST TRANSMITTER

In the foregoing paragraphs we have covered the circuit arrangement and the theory involved of one 500-watt broadcasting transmitter. Since the fundamentals of the method of generating radio-frequency energy have been covered it seems logical now to touch, in general, several different types of transmitter circuit arrangements and then go on to the discussion of the speech amplifier circuits which function to supply distortionless audio-frequency to the grids of the transmitter modulator tubes.

Figure 10 shows the schematic wiring diagram of the Western Electric 500-watt broadcasting transmitter which is used at many broadcasting stations throughout the country.

Four 250-watt tubes are used, two modulators and two oscillators. The oscillatory circuit is of the Meissner type, with a few modifications.

In the standard type of Meissner circuit, both the plate and the grid coils are coupled to the oscillatory circuit, the plate and grid coils being untuned. We note here that there is a variable condenser shunted across the plate coil.

The function of this variable condenser is to adjust impedance conditions in the circuit to the optimum point for maximum efficiency.

The oscillator tubes are not coupled directly to the antenna circuit, but rather, they are coupled to the closed oscillatory or "tank" circuit which in turn is coupled to the antenna by means of the mutual capacity (Cc).

The "tank" circuit, or closed oscillatory circuit, is composed of the variometer (Lt), the tuning condenser (Cr) and the coupling condenser (Cc).

The antenna circuit is traced from the antenna, through the tuning inductance (La), the coupling condenser (Cc) and the antenna ammeter (Ia) to ground.

The system of modulation used in this transmitter is the same as that used in the preceding case that we have discussed.

The modulator grids are held at the proper negative potential in a somewhat unique manner. There is a resistance in series with the negative lead from the high potential plate supply generator to the negative filament terminal. The plate

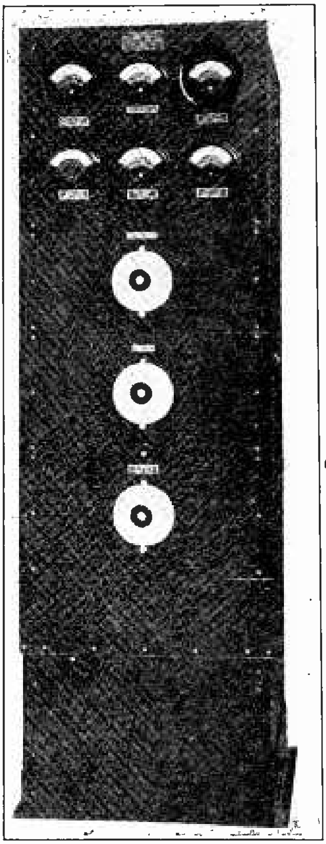

Fig. 11.—Front of Panel for 500 Watt Western Electric Transmitter.

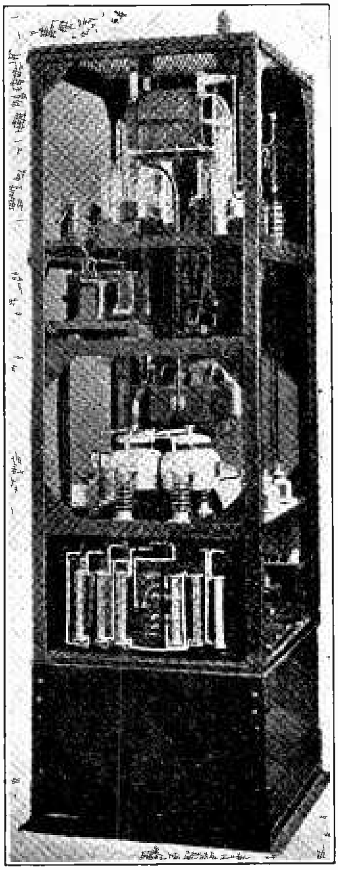

Fig. 12.—Rear View of the Western Electric Transmitter Panel.

current to all the power tubes (oscillators and modulators) passes through this resistance (Rm).

There is a drop in potential across the resistance (Rm) which is a function of the value of the resistance and the amount of direct current flowing in the plate circuit. The grid return from the modulator tubes can be tapped on to this bias-ing resistance at the point for proper negative bias.

This negative biasing voltage remains constant by virtue of the fact that the plate supply is a "constant current" supply system which in turn is due to the iron-core choke coil (Xm) in series with the positive plate supply lead.

The front view of this transmitter is shown in Figure 11. The three meters shown at the top of the panel are for oscillator plate current, antenna current and modulator plate current, reading from left to right, respectively.

These three meters are shown in the schematic wiring diagram in Figure 10 at Ipo, Ia and Ipm respectively.

The three meters just below are for oscillator grid current, "tank" circuit current and modulator grid current, read-

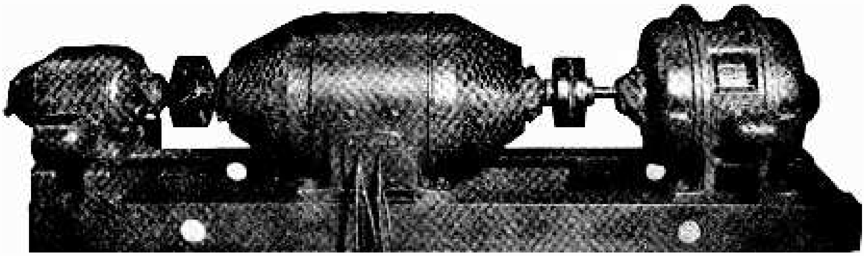

Fig. 13.—Western Electric Power Unit for 500 Watt Transmitter.

ing from left to right respectively. These three meters are also shown on the schematic diagram, Figure 10, as Igo, It and Igm.

The three control dials which appear on the view of the front panel, Fig. 11, are, reading from top to bottom, the antenna tuning control, the frequency control and the oscillator adjustment.

The first control mentioned varies the inductance of the antenna tuning coil (La), Figure 10. The frequency control varies the inductance of the "tank" coil (Lt) and the oscillator adjustment is for changing the value of the variable capacity (Cp) which is shunted across the oscillator plate coil.

Figure 12 is a rear view of this transmitter and gives you a good idea of the arrangement of the apparatus.

## POWER SUPPLY FOR WESTERN ELECTRIC 500-WATT TRANSMITTER

The power supply unit is shown in Figure 13. The driving motor is located on the right and may be of either A. C. or D. C. design as conditions warrant.

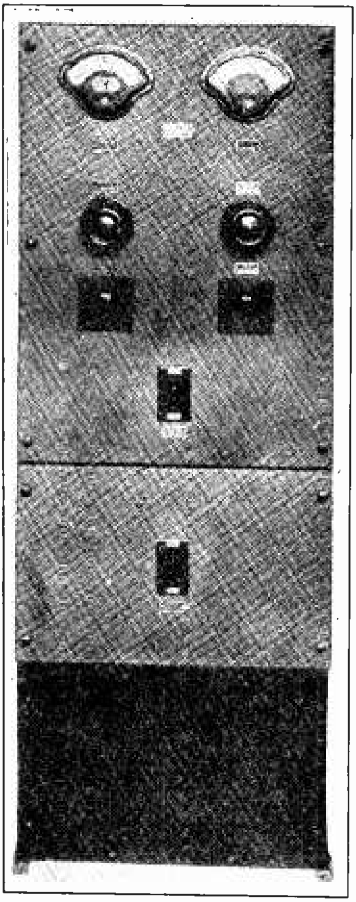

Fig. 14.—Front View of the Power Panel for the Western Electric 500 Watt Set.

The machine in the middle is a 1,600 volt generator having a capacity of 1.25 amperes, for supplying the plates of the tubes. This generator is of similar construction to the one in the case of the first transmitter described. It has two 800 volt armature windings and employs two commutators. The G. E. tubes require a somewhat higher voltage on the plates of the tubes (2,000), hence the plate supply generator has two 1,000 volt armature windings.

The machine at the left is a 16 volt, 30 amp. generator for supplying the filaments. The field current for the high volt-generator is supplied by the low voltage unit which is self-excited.

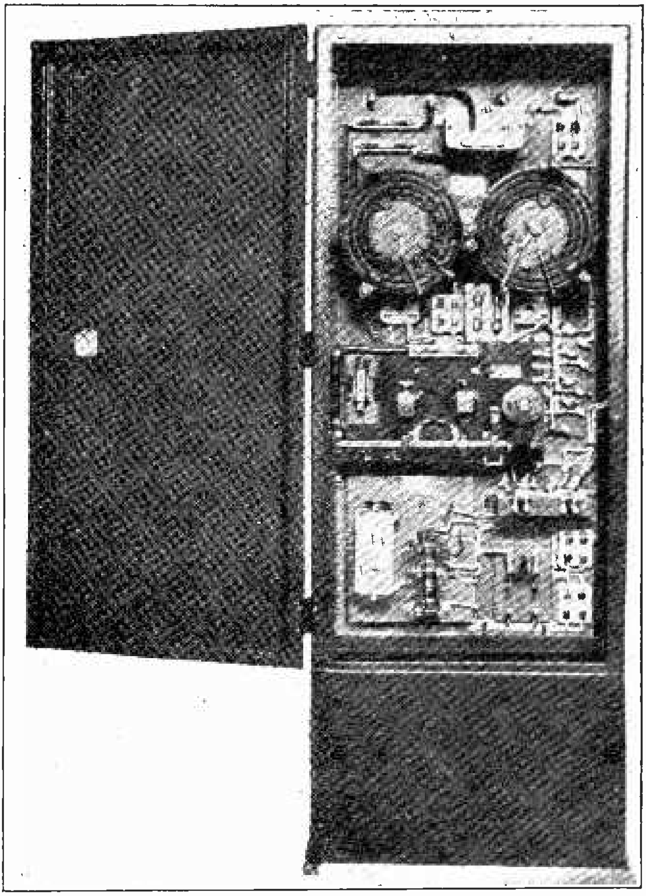

Fig. 15.—Rear View of the Western Electric Power Panel.

It might be noted here that the G. E. 250-watt tubes require 11.0 volts at the filament terminals and 2,000 volts on the plates; whereas, the W. E. 250-watt tubes require 14.0 volts on the filaments and 1,600 volts on the plates.

The front view of the power panel is shown in Figure 14. The filament voltmeter is shown at the top left and the plate voltmeter is shown at the top right. These meters are designated on the schematic as Vf and Vp respectively.

Figure 15 is a rear view of the power panel.

## ONE KILOWATT GENERAL ELECTRIC BROADCASTING TRANSMITTER

Figure 16 shows the schematic wiring diagram for a 1 K. W. General Electric type of ship broadcasting transmitter. The power input to this transmitter consists of A. C. at a potential of 110 volts. The frequency may be either 60 cycle or 500 cycles with subsequent changes in the transformer design.

All the desired voltages are obtained by means of transformers and rectifiers with the proper filter circuits.

First of all, the 110 volt supply is stepped up to 25,000 volts by means of the plate transformer. This 25,000 volt winding is tapped at the mid-point and should be grounded on the wire running from the mid-point of the filament transformer to the ground. The extremities of this winding are connected to the plates of two 2.5 K. W. kenotron rectifier tubes, thus supplying a potential of 12,500 volts to each plate. This potential is controlled by means of the primary rheostat (Rp).

Next, the 110 volt A. C. supply is stepped down to 11.0 volts for the filaments of the rectifier tubes. This winding must be insulated for 15,000 volts since it is at plate potential.

The mid-point of this kenotron filament secondary winding is the positive terminal of the 10,000 volt D. C. plate supply. It is connected to the plates of the modulator and oscillator through the filter reactor (Xf) and the modulator reactor (Xm). Two filter condensers ($C_1$) and ($C_2$) are used to smooth out the ripple in the rectified supply to the plates. The primary rheostat (Rfk) controls the potential of the kenotron filament supply.

The closed oscillatory circuit is closely coupled to the antenna system through the coupling condenser (Cc). The antenna circuit is tuned by means of the variable inductance (La).

Up to this point we have considered the source of radio-frequency energy. Now we are going to consider the source of audio-frequency energy and the circuits used for amplifying it to the proper value for applying to the grid of the modulator tube.

## MICROPHONE CIRCUITS AND SPEECH AMPLIFIERS

While it is a comparatively easy task to build electrical equipment for a single desired frequency, the problem is greatly

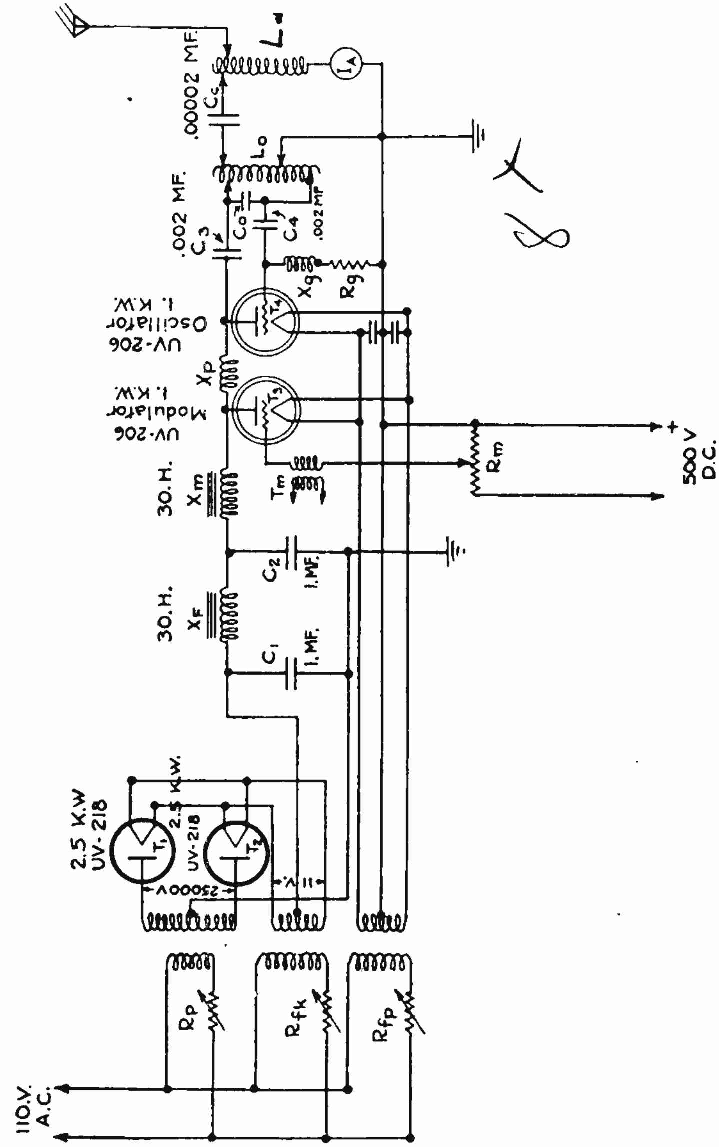


Fig. 16.—Schematic Wiring Diagram of General Electric Co., 1 Kw. Ship Broadcasting Set.

complicated where a large range of voice and musical frequencies are to be handled without distortion. Most of the poor broadcasting today is to be found in the reproduction rather than the transmitting end; and the same care that the builders of broadcasting transmitters employ would permit a more perfect condition to exist in reception.

The standard type of microphone today is the double button carbon, or push pull. This type comes more closely to supplying distortionless signals at all audio-frequencies with the exception of the condenser microphone. As all the faults of the microphone are amplified many times, regular inspection and test should be made to determine its condition. It should be opened and removed from its case only when it has ceased to function properly. If it has been overloaded, it will be found that the trouble is caused by the "freezing" of the diaphragm. This necessitates removal, and cleaning, and if seriously damaged, replacements.

In the studio usually two microphones are installed, one for the announcer and the other for the artist. In large studios where concert orchestras perform, two or more microphones are placed. The announcer's table usually holds a control box, or "mixing panel," whereby he switches the control from himself to the artist. The control room which contains the monitoring equipment is adjacent, and a window is usually placed to enable the operator to follow the studio activities. In the case of remote control, the operator in charge at the distant point must endeavor to supply a constant signal level to the line. In other words correct for the artist who is too near or far from the microphone.

The remote control equipment will be found to usually contain three microphones, the mixing or control panel, a two or three stage line amplifier and necessary batteries. Wherever possible an additional line is installed to which are attached the standard telephone and ringer box in order to enable operating instructions to be given during the period of broadcasting. The control panel is operated by the announcer while the operator devotes his entire attention to maintaining a steady outgoing signal. Figure 17 is a schematic diagram of the general layout for remote control operation.

In the control room of the broadcasting station will be found an equalizer panel and a three or four stage speech amplifier. (See Figure 18). This equipment is usually installed in duplicate not only for the purpose of maintaining constant operation, but in a case of remote control it permits

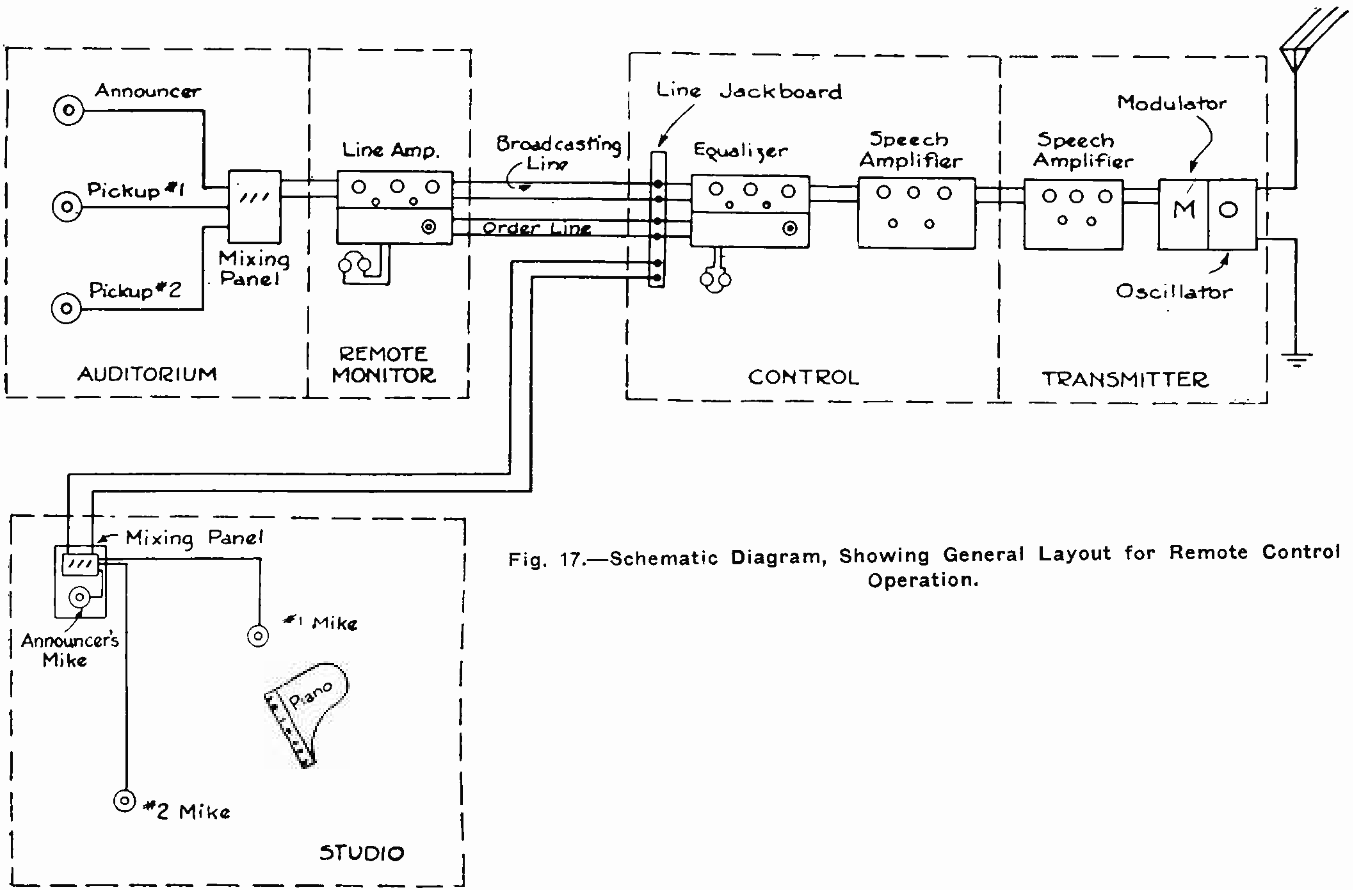


Fig. 17.—Schematic Diagram, Showing General Layout for Remote Control Operation.

the actual hooking up of the circuit previous to changing over from the studio program. In one of the New York stations the monitor panel contains fifteen amplifying panels. The need for so many being due to the large number of remote pick-ups and telephone interconnecting programs.

The equalizer panel contains artificial line circuits whereby a pick-up from a nearby point giving a signal of too great a volume may be reduced to the proper level without sacrificing quality. The artificial line is built of resistance coils and capacity until it similates a line of the desired length; usually twenty miles. Another use of the equalizing panel is that of balancing long lines which have a tendency of cutting off the higher frequencies. In an unbalanced line it is usually found that the lower notes predominate, and it is by use of the equalizer that these are retarded, and higher frequencies strengthened. The growing importance of pick-up programs means that the broadcasting engineer should lay particular stress on this phase of his profession.

Most broadcasting transmitters function best when between 50% and 70% of the carrier is modulated. It will be seen that even in a 500-watt set that our audible frequency current must be amplified many times, and that the results will be dependent upon supplying the modulator tubes with undistorted amplified current from the microphones. Like the broadcast receiver there have been many types of speech amplifiers and similarly they are all good if properly made and skillfully handled. The transformer and choke coupled type predominate due to the fact that fewer stages are necessary. Some stations are equipped with resistance coupled units and with proper care give good results. Figure 19 is a wiring diagram of a standard type of line amplifier.

Line amplifiers differ from speech amplifiers inasmuch as their output does not have to be as high. Two stages of transformer coupling are employed usually and this is more than sufficient for a good telephone or telegraph line. At the studio control room this is fed into a three stage speech amplifier, thence to a 50-watt tube at the transmitting station and then in the case of a 500-watt station to the 250-watt modulator tubes. For the higher power stations there is a progressive arrangement of speech amplifier power tubes starting with the 5 or 7½-watt tubes at the control room and then into a 50, 250, 1 kilowatt, and in the case of the super-power stations a 5 kilowatt, and then a 20 kilowatt water cooled tube. It is a

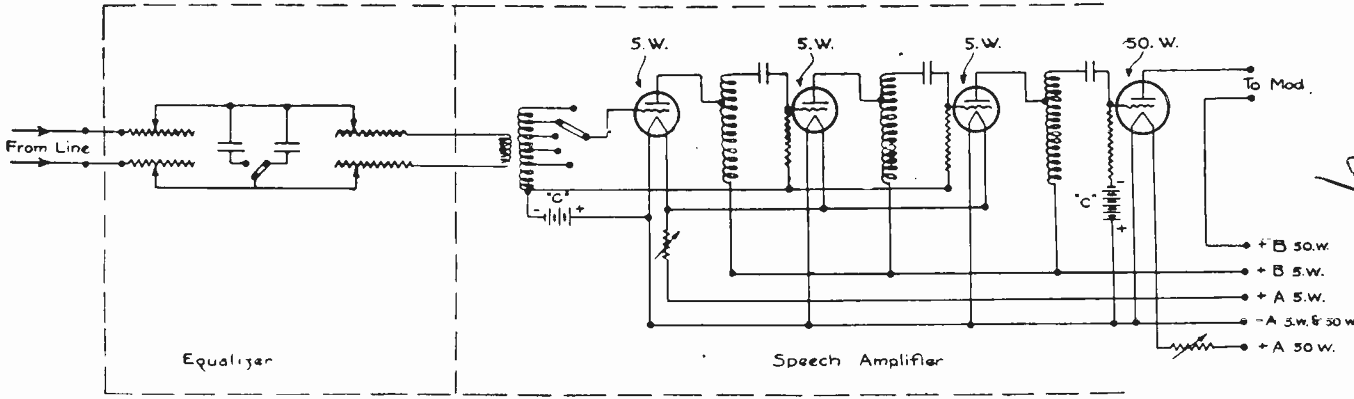


Fig. 18.—Wiring for the Equalizer and Speech Amplifier.

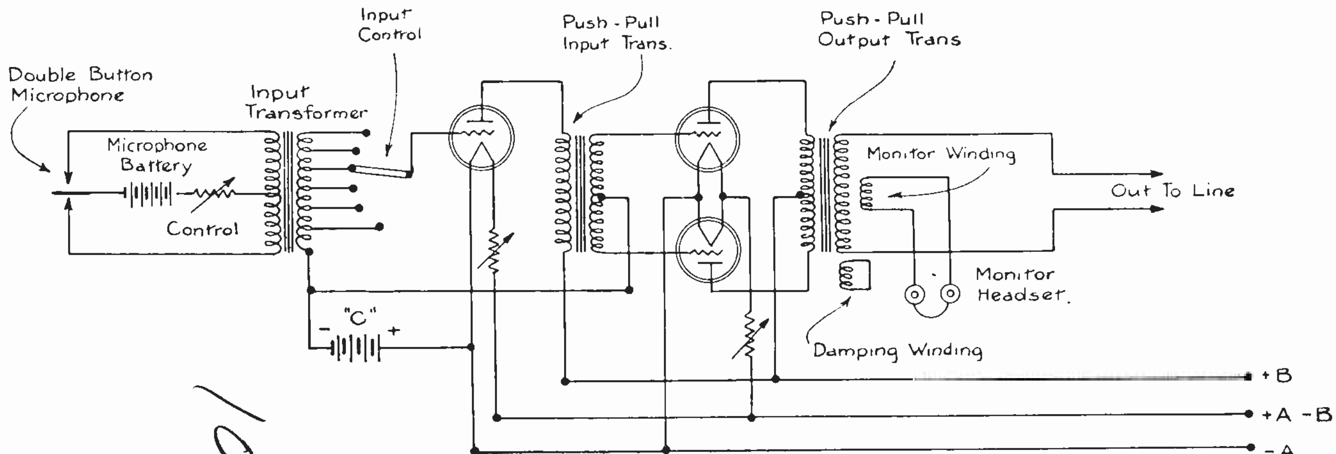


Fig. 19.—Wiring Diagram of a Standard Type of Line Amplifier.

usual practice to have equal modulator and oscillator tubes, and the final speech amplifier tube is about one-fifth of the output of the modulator tubes.

Today it is a general practice to build the transmittng station at some distance from the city that it is desired to serve, and we have the problem in the case of a pick-up program of a double line amplification and final speech amplification at the distant transmitter. This offers no difficulty if the lines are properly balanced between the remote pick-up point, and control room, and again between control room and transmitter. Several pairs are usually provided so that uninterrupted service may be given.

In many stations an instrument called an oscillograph is installed for showing visually the quality and quantity of modulation. The percentage of modulation is the measure by which the transmission station determines the efficiency of the modulating tubes, and is that portion of the carrier wave that is enveloped by the modulating current. The type of oscillograph usually furnished is of the string type; that is the moving element is a metallic string suspended between strong field poles. The incoming signal causes the string to vibrate, and its amplitude is proportional to that of the signal. In order to secure the true wave form it is necessary to employ rotating mirrors which give the proper lateral movement to the string image. There are many ways in which the oscillograph can be employed to advantage in order to determine the distortion not only of the amplifiers but also that of improper placing of the artists and instruments. Each instrument while tuned to a certain frequency will show the proper number of vibrations per second, but not the overtones and harmonics in sufficient amplitude. If an oscillograph is installed the broadcasting engineer should thoroughly instruct himself in its uses so he will have no reason to doubt his hearing.

As has been previously stated the broadcasting engineer will find many types of line and speech amplifiers, but they will all conform to the general layout as described here. In the matter of volume control several stations use a resistance box shunted across both line and speech amplifier. This simply absorbs a quantity of the outgoing signal. Many engineers prefer to control the input of the first tube, and claim that the equality is better. The types shown here are the transformer push pull line amplifier with input control, and the auto choke coupled speech amplifier with a similar volume control. These two types are recognized as probably being of the best type and if properly constructed show the flat frequency curve which is desired.

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## TEST QUESTIONS

Number Your Answers 38 and add Your **Student Number**

Never hold up one set of lesson answers until you have another set ready to send in. Send each lesson in by itself before you start on the next lesson.

In that way we will be able to work together much more closely, you'll get more out of your course, and better lesson service.

1. What is the range of frequency required of the amplifier circuits when broadcasting music?
2. Plot a curve showing the intensity of signals around a Broadcasting Station.
3. Draw a typical one-tube circuit to illustrate the theory of operation of the 500-watt General Electric transmitter and state how the plate and grid are coupled to the antenna circuit.
4. Name by letters the tank circuit in Figure 3 and explain its use.
5. Name of a few of the essential operating hints for the General Electric 500-watt transmitter.
6. Explain by reference to Figures 10 and 11 the three control dials for the 500-watt transmitters.
7. Explain in a brief manner the power unit used for the two types of 500-watt transmitters.
8. Give a diagram and brief description of the power supply for the General Electric 1,000-watt transmitter.
9. Show a wiring diagram for the equalizer speech amplifier panels in a broadcasting studio.
10. Draw a diagram and name the essential parts of a standard line amplifier.

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