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LESSON TEXT No. 35

OPERATING PRINCIPLES OF COMMERCIAL AND BROADCASTING TRANSMITTERS

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A COMMERCIAL RADIOTELEPHONE TRANSMITTER

Having discussed the fundamentals of radiotelephone transmitter circuits, we are now going to consider a standard installation in detail. The schematic diagram of a commercial transmitter is shown in Figure 1.

Power is derived from the motor-generator set shown in Fig. 2. The 6¼ horse power driving motor is located in the center of the unit and requires either A. C. or D. C. supply according to local conditions. If the supply is D. C., 115 volts are required. If A. C. is available, a repulsion induction motor that will run on either 110 or 220 volts, 50 or 60 cycle single phase supply is used.

The plate voltage generator furnishes 1. ampere at 2,000 volts and has a mid tap for the 1,000 volt supply. It is a flat compounded machine and is excited from the double current generator located at the right of the motor. Plate voltage is controlled by means of the plate rheostat in series with the main field of the high voltage generator, which is energized by the 125 volt D. C. supply from the double current generator. The handle of this rheostat is mounted on the middle panel, lower center, as shown in Figure 3.

The power control resistance is in series with this circuit, the resistance being short-circuited when the "power" switch on the front of the transmitter panel is set at "high power." When this switch is set at "low power," the short-circuit is removed and the resistance is in series with the field and field-rheostat, thus lowering the plate voltage. The plate voltage is shown by the voltmeter at the left-hand side of the top panel which is connected between the 2,000 volt lead and ground. (See Fig. 1.) There are two protective condensers in series across the high voltage leads, the mid-point of these condensers being connected to ground, their purpose being to safeguard against high voltage surges.

The filter condensers between the plate supply leads and ground are used to smooth out the generator ripple. The double current generator will deliver 4. amperes at 125 volts D. C.

and 10 amperes at 88 volts A. C. It is a flat compounded type of machine and is self-excited. The motor is directly connected to the two generators. The 2,000 volt plate supply is connected to the 250-watt oscillator tubes and the two 250-watt modulator tubes through the common iron-core reactance coil O. P. This reactance is necessary for the application of the Heising system of modulation. Small choke coils are placed in the plate leads of both oscillator and modulator tubes to prevent the production of ultra high-frequencies. These are generally known as parasitic oscillations which are likely to be generated when operating tubes in parallel. The 50-watt speech amplifier tube receives its plate voltage from the 1,000 volt tap on the plate supply generator. The 125 volt D. C. from the double current generator is not only used for energizing the field of the plate supply generator, but it also supplies the negative bias for the grids of the speech amplifier and modulator tubes.

The 88 volt A. C. is applied to a step-down transformer, the secondary of which is connected to the filaments of the tubes. The filaments of the tubes are all in parallel and the voltage applied to them is controlled by means of the filament rheostat on the primary side of the filament transformer. This rheostat and the filament voltmeter is usually located at the operator's desk enabling him to check and adjust the filament voltage.

Eleven volts are required to heat the filaments of the 250-watt tubes, but since only 10 volts are required for the 50-watt speech amplifier tube, a fixed resistance is mounted in series with the filament leads to this tube, of such a value, that with 11 volts at the terminals of the 250-watt tubes there will be 10 volts at the terminals of the 50-watt tube. Two by-pass condensers are connected in series across the secondary of the filament transformer and their mid-point is grounded. These condensers form a low resistance path for the radio-frequency in this part of the circuit and make it unnecessary for the radio-frequency currents to pass through the high reactance of the secondary winding of the filament transformer in order to get to ground as would be true if these by-pass condensers were not in the circuit.

The type of oscillatory circuit used is the "tickler" coil circuit with inductive plate coupling, the fundamentals of which have been previously discussed. The oscillator plates are connected to the positive high voltage through the plate coup-

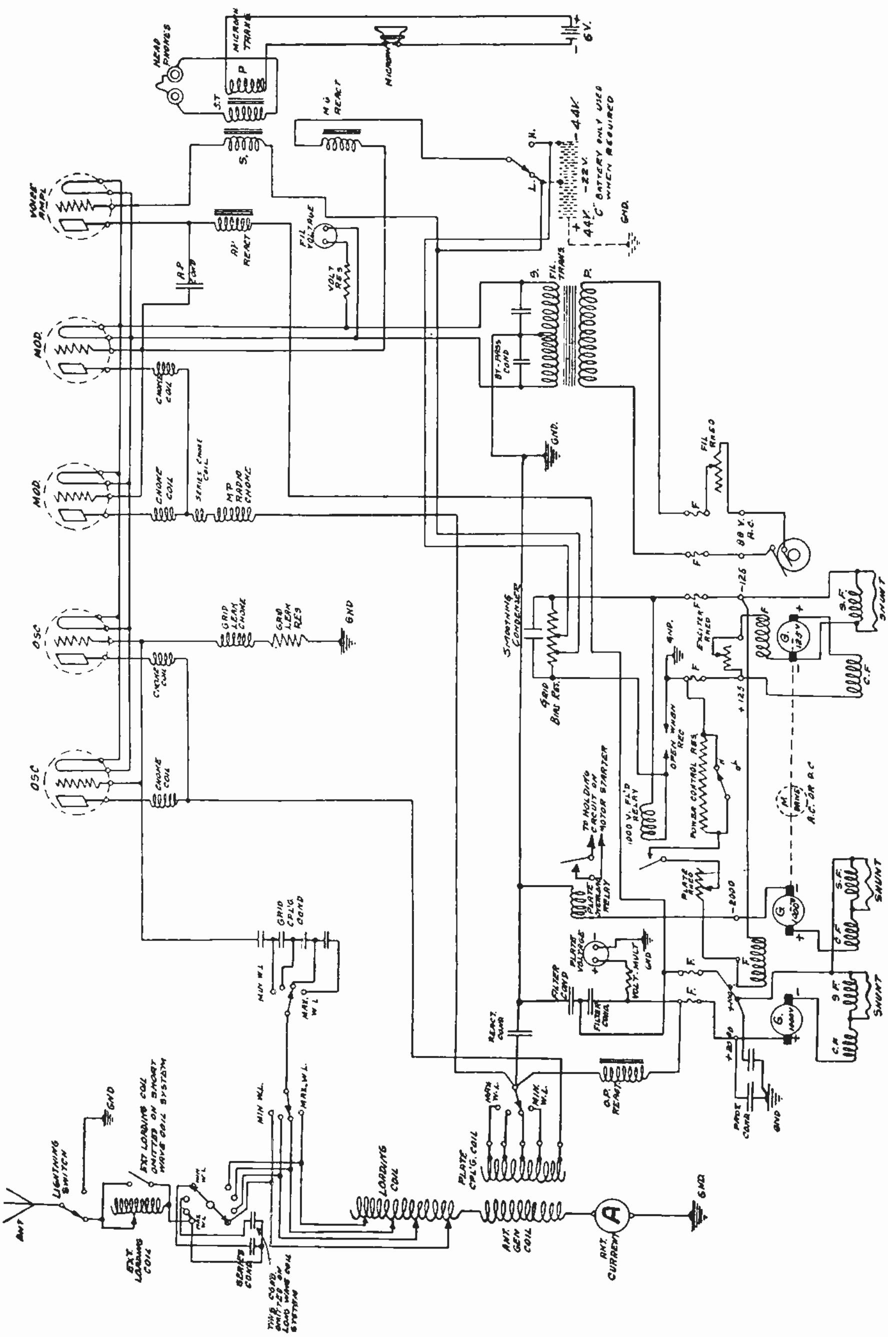


Fig. 1—Schematic Diagram of a Vacuum Tube Transmitter with Telephone Attachment (ET-3608).

ling coil and the iron-core reactance O. P. The grid excitation is supplied by means of the capacity coupling to the antenna circuit through the grid coupling condenser shown in the schematic diagram. The grid leak circuit is composed of the grid leak choke and grid leak resistance. The choke coil isolates the radio-frequency from this part of the circuit to reduce losses and the resistance, together with the D. C. flowing through it, determines the amount of negative bias on the oscillator grids. When a filament switch is closed the filaments are heated to their normal degrees, the application of the plate voltage causes an instantaneous surge in the plate circuit with the result that the antenna is forced into feeble oscillations, the frequency of which depends upon the constants of the antenna circuit. The grid circuit due to its capacitive coupling to the antenna circuit, withdraws some of this oscillating energy with the result that a radio-frequency potential is applied between the grid and the filament. This produces a

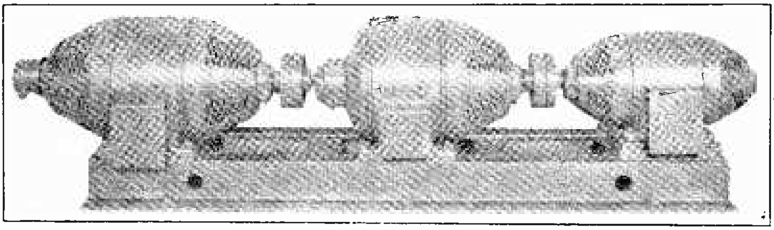


Fig. 2—Motor Generator Set

corresponding change in the plate circuit, which, if the circuits are properly arranged, adds to the effect of the original surge. This cycle of operations is then repeated with the antenna current continually increasing until limited by the antenna and tube characteristics.

MODULATOR CIRCUIT

The Heising system of modulation is used in this set, modulation being accomplished by means of the two 250-watt modulator tubes shown in the schematic diagram and their associated circuits. In addition to the two modulator tubes, a third tube is employed which functions as a speech amplifier. The plates of the two modulator tubes are connected to the positive high voltage terminal through the modulator radio-frequency choke and the iron-core reactance O. P. The filaments of the modulator and oscillator tubes being in parallel, the plate circuit is completed through the space between the plate and filament within the tubes and thence to the negative side of the high voltage generator.

The grids of the modulator tubes are connected through a biasing resistance to the negative filament lead and are also connected to the plate circuit of the speech amplifier tube by a condenser. The plate of the speech amplifier tube is connected to the high voltage source through an iron-core reactor. The

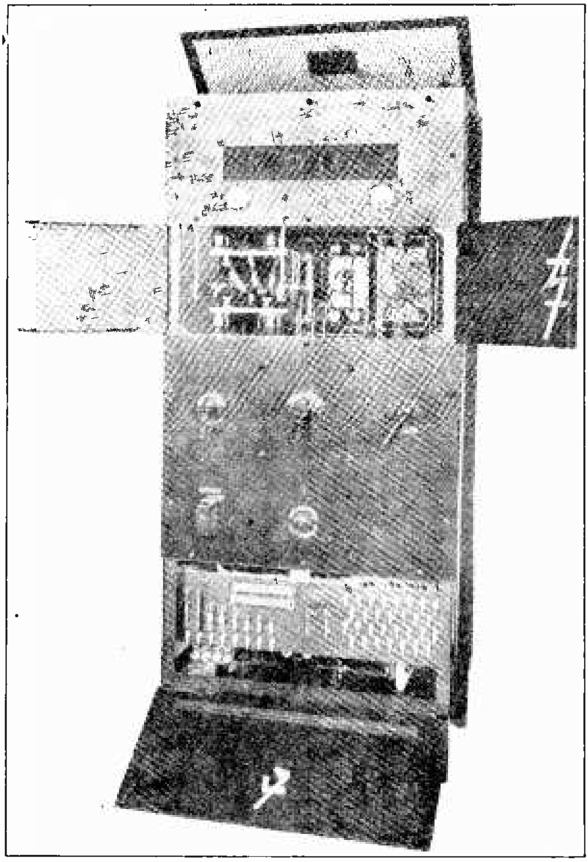


Fig. 3—Transmitter Panel

grid of the speech amplifier tube is connected through the secondary of the microphone transformer and the biasing resistance to the negative filament lead. The primary circuit consists fundamentally of a microphone in series with a 6 volt battery and the primary winding of the microphone transformer. The action that takes place is as follows:

ACTION THAT TAKES PLACE IN A TRANSMITTER

The current passing through the primary winding of the microphone transformer is varied at speech frequency due to the operator talking into the microphone, the secondary of the microphone transformer being connected between the grid and filament of the speech-amplifier tube, impresses upon the grid an alternating potential, the variations of which are in accordance with the sound waves spoken into the microphone. This variation of the speech amplifier grid potential results in a similar variation in the plate circuit. In other words, the output of the microphone is amplified to an extent determined by the circuit and tube characteristics of the speech-amplifier tube. These amplified variations are in turn impressed upon the modulator grid by means of the capacity coupling. The variation of the modulator grid potential produces a corresponding change in the plate current and tube impedance. These variations in the modulator plate circuit result in a corresponding increase or decrease of power available for the plate circuit of the oscillator tube, due to the fact that there is practically a constant current supply for both the plate circuit of the oscillator and modulator tubes which is due to the iron-core reactor in the positive side of the plate generator.

Therefore, if there is a constant supply of plate current for the combined oscillator and modulator tubes and the supply to the modulator tubes is decreased by negative grid, then the supply to the oscillator tubes must be increased and *vice versa*. Thus, the radio-frequency output of the set is modulated. It might be well to note here that the transmitter is supplied with a resistance connected across the 125 volt D. C. supply from the double current generator, this resistance being shunted with a smoothing condenser so that the generator ripple will not be applied to the grids. By means of suitable taps taken from this resistance the correct biasing voltage is maintained on the speech amplifier and modulator grids.

If for any reason, the commutation of the 125 volt generator becomes poor and causes interference, "C" batteries may be used for grid biasing, connected in the circuit as shown by the dotted lines in the diagram, Fig. 1. If this is done, the grid biasing resistance should be removed from the circuit. The speech amplifier grid is maintained at the same negative potential, both when the power switch is set for "high power" and when it is set for "low power," but the negative bias on the modulator tubes is doubled automatically when the power switch is thrown from "low power" to "high power."

The control unit on the operator's desk is shown in Fig. 4. When the operator presses the "start" button on the control unit on his desk, the automatic starter for the motor of the motor-generator set, functions, and the motor is brought up to full speed automatically. Then the "send-receive button is

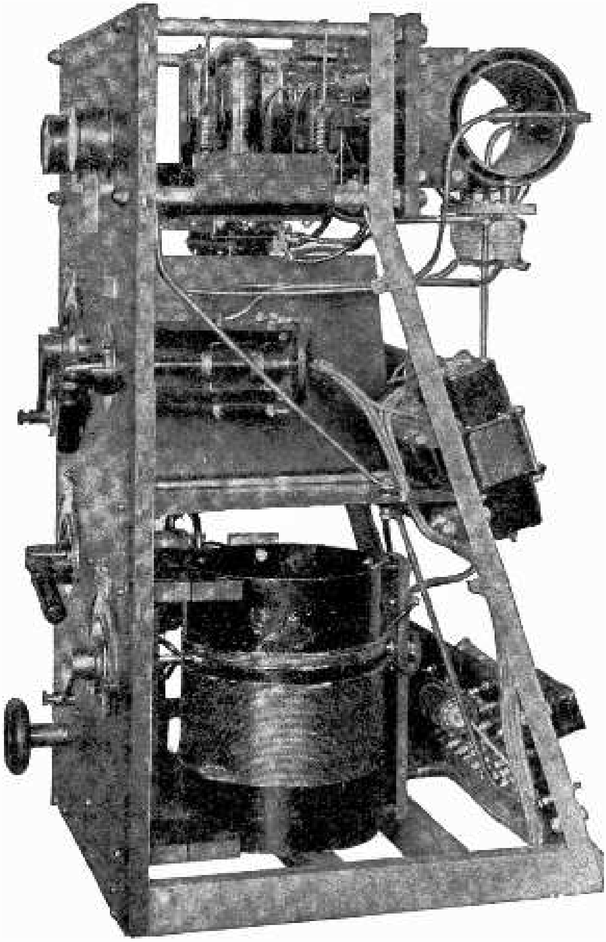
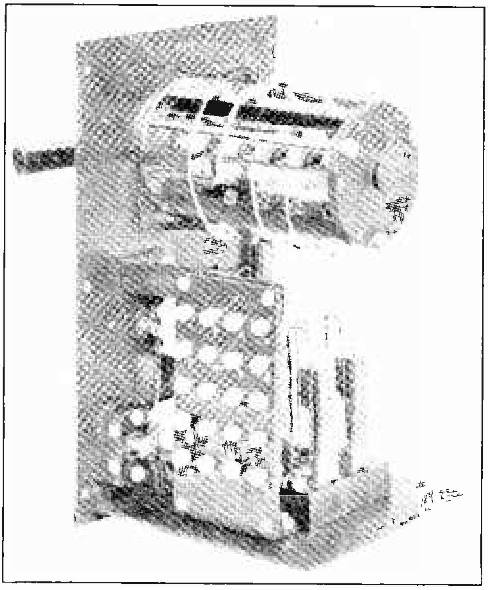
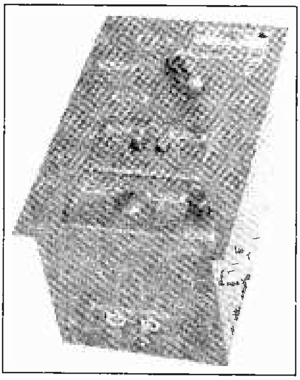


Fig. 3-A—Marine Type of Tube Transmitter

pressed to the "send" position, thereby applying plate and filament voltage to the tubes. The filament voltage is adjusted to 11 volts by means of the filament rheostat and the plate voltage to 2,000 volts by means of the plate rheostat. The transmitter is now ready for operation and if the operator plugs his microphone into the "microphone" jack of the control unit, with the signal switch on the "local" position, he can modulate the set by talking into the microphone. If there is another microphone located at a distance from the transmitter, the local operator presses the "ring" button which rings a bell at the distant position and with the signal switch on "interphone" the local operator can converse with the distant operator without modulating the set. Then if the remote control operator is ready, the local operator sets the signal switch at the "remote" position and the remote control operator can modulate the set. When the conversation has been completed and it is desired to shut down the set, the send-receive switch is pressed



Operator's Control Unit.
(Interior View).



Operator's Control Unit.
(Exterior View).

Fig. 4

to the "receive" position and the "stop" button also pressed, thus opening the circuit to the motor and the motor-generator set comes to a stop.

SIMULTANEOUS TRANSMISSION AND RECEPTION

So far we have considered the radiotelephone transmitter by itself now we are going to discuss the circuit arrangement and apparatus necessary to carry on simultaneous transmission and reception. By simultaneous transmission and reception is meant the same thing as talking over the wire telephone, where it is possible to talk and listen at the same time, except of course that in radio transmission of this type, the air takes the place of the wires between stations. This method of operation is sometimes referred to as duplex radio communication. Figure 5 shows the ideal arrangement for duplex communication. The transmitting and receiving stations at point (A) are located five miles apart with all the controls installed in the receiving station. The microphone and transmitter controls are wired over to the receiving station making

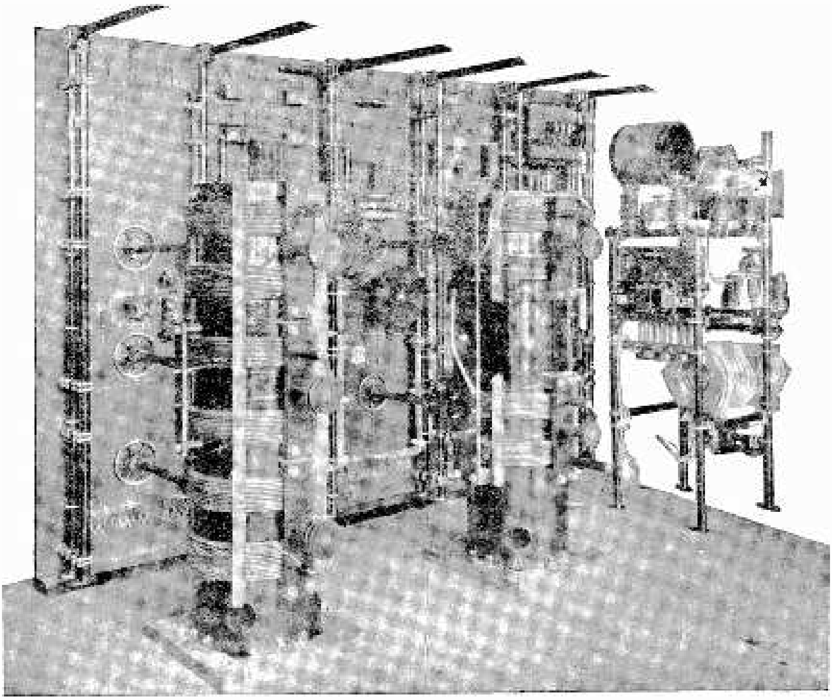


Fig. 4-A—Commercial Trans-Atlantic Tube Transmitter

it possible to start the transmitter and control or modulate its output from the receiving station.

Let us assume that the transmitter at station (A) is tuned to 400 meters and the receiver to 350 meters. The receiver must be of a selective type, either a Super-Heterodyne or a tuned radio-frequency receiver. Station (B) is 100 miles from station (A) and the transmitter and receiver here are also located five miles apart. At this point, however, the transmitter is tuned to 350 meters and the receiver to 400 meters. When the operator at station (A) talks into the microphone, a 400 meter voice-modulated wave is radiated from his transmitting antenna. His receiver being tuned to 350 meters does not pick up the 400 meter wave, but the operator at station (B) who has tuned his receiver to this wave-length hears the voice from the distant station and answers, speaking into the microphone at station (B). Thus a voice modulated wave is radiated from the transmitting antenna at station (B) but in this case the wave-length of the radiated energy is 350 meters so it does not interfere with the local receiver which is set at 400 meters, but is heard by the operator at station (A) who has his receiver tuned to this wave-length. Thus, the two operators can converse as though they were talking over the land line telephone.

It is possible, although not feasible, to locate the transmitter and the receiver at one of the above stations, five miles

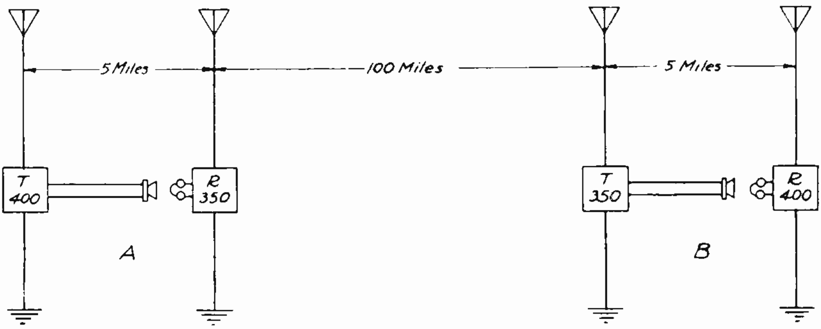


Fig. 5

apart, or they may be located only a mile apart, see Fig. 5-A. In this case it would probably only be necessary to use a loop for reception instead of the overhead antenna to eliminate the interference from the transmitter. In this case it would not be necessary to use any interference elimination circuits in conjunction with the loop, provided of course, a selective type of receiver were used.

The above requirements cannot always be fulfilled. On land it is usually practical and possible to locate the transmitter and the receiver a few miles apart, but on a ship at sea, for instance, this would be impossible. Therefore, if duplex communication is to be carried on from ship to shore it will be necessary, on shipboard, to use some method of eliminating the interference from the local transmitter. Obviously, the best arrangement is to have the transmitting and receiving antennas located as far apart and as loosely coupled as possible. When the transmitting antenna is radiating energy, a considerable amount is picked up by the receiving antenna due to the

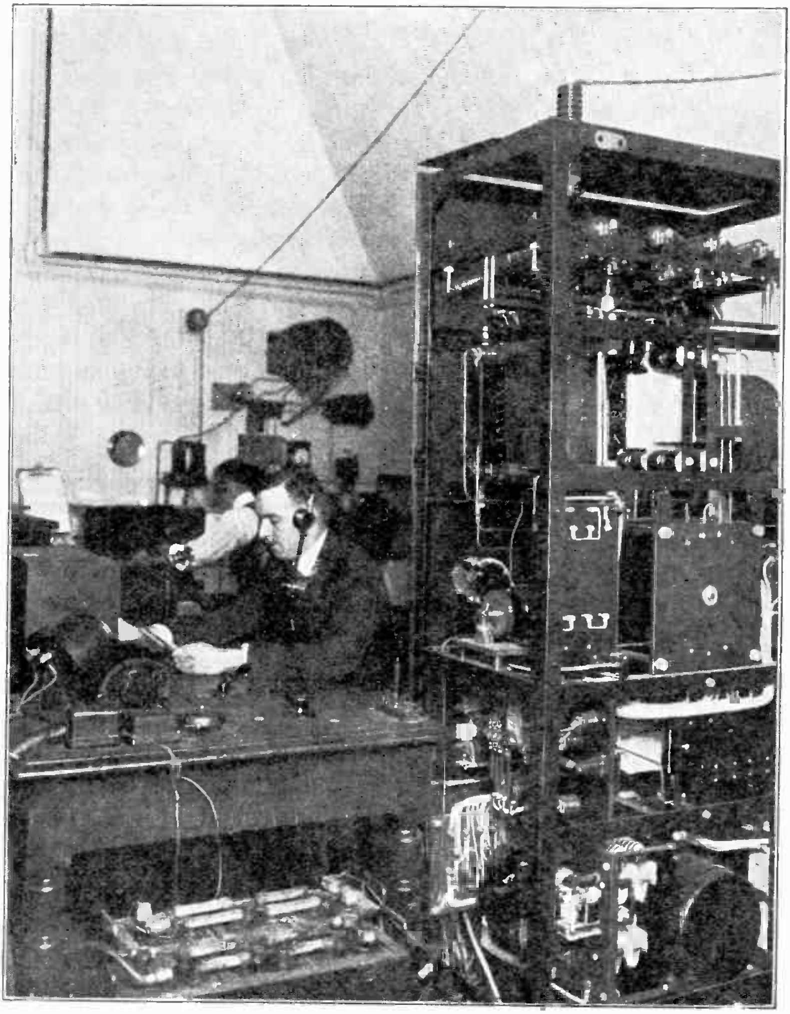


Fig. 5-A—Typical Inside View of a Broadcast Station.

proximity of the two, and even though the receiver is detuned 50 meters from the transmitter wave-length (assuming the same figures as in the previous case) a large amount of interference is experienced due to the strength of the voltage induced in the receiving antenna.

One way of eliminating this local interference and make it possible to work duplex is shown by the schematic diagram in Fig. 6. Here the transmitting and receiving antennas are only 100 feet apart and the interference is eliminated by means of the "anti-resonant" circuit in series with the antenna lead to the receiver. The inductance (L) and the capacity (C) are so chosen that they tune to 400 meters (the wave-length of the transmitter.) An inductance and capacity in parallel, when connected in series in a given circuit, offers extremely high impedance to the flow of any current of the frequency to which the parallel circuit is tuned. The circuit in this case is tuned to 400 meters and the impedance curve is shown in Fig. 7. It can be seen from this figure that the impedance is very high for the wave-length the local transmitter is tuned to, but is very low for the wave-length of the distant transmitter. Thus, the weak signals from the distant transmitter can come through with very little impedance on their path and the answer sent back from the local transmitter without interfering with reception.

Another circuit to eliminate local interference in an installation of this type is shown in Fig. 8. The same values of inductance and capacity as in the previous case are used here, but instead of connecting them in parallel and then in series with the antenna circuit, they are connected in series and the combination in parallel with the antenna circuit. They function just the opposite in this case, due to the fact that when an inductance and a capacity are connected in series and the combination connected in parallel with a given circuit, a very low resistance is offered to the flow of any current of the frequency to which they are tuned. Hence, they tend to shunt the given circuit.

This is called a "series resonant" circuit or a "zero impedance" circuit and in this case is tuned to 400 meters while the receiving circuit is tuned to 350 meters. Thus, the zero impedance circuit will practically short-circuit all 400 meter energy picked up by the receiving antenna, to ground, but will offer a very large impedance at the 350 wave-length. Then, the weak 350 meter energy from the distant station follows the path of least resistance and will flow through the primary coil of the receiver rather than through the high impedance path of the zero-impedance circuit. Fig. 9 shows the impedance curve for the zero-impedance circuit of Fig. 8. The lowest value is reached at the point (x.) Here the inductive reactance and the capacity reactance balance out and the amount of impedance (xy) is due to the ohmic resistance of the circuit. At 350 meters, the impedance of the circuit is very high.

Another type of circuit that can be used in duplex communication under the conditions cited in the previous case is shown in Fig. 10. Here, two or three turns of heavy wire are shunted across the antenna-ground binding posts of the receiving set and this coil is closely coupled to the tuned circuit (C_rLr). The few turns composing the coil (LR) should be wound directly over the coil (Lr). The parallel circuit is so closely coupled to the coil which is shunted across the input to the receiver that if it is tuned to 350 meters it produces the effect of an infinitely high impedance to the flow of all current of that frequency, through the coil (LR.)

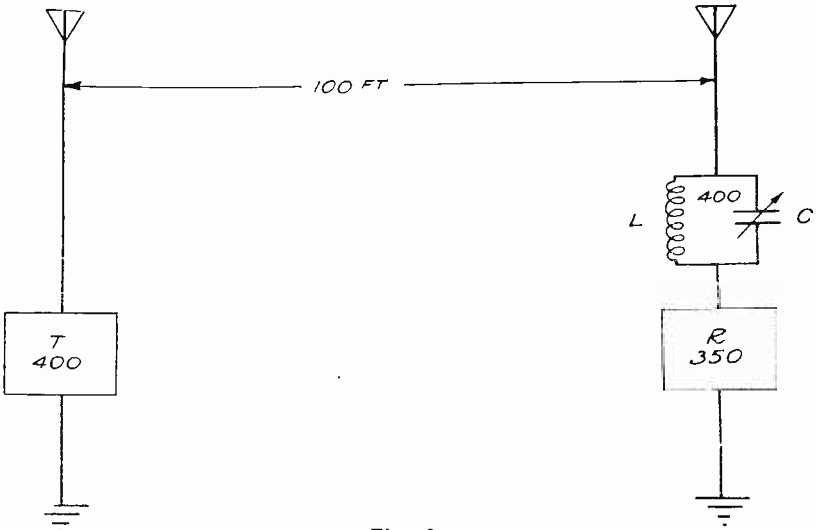


Fig. 6

The impedance of coil (LR) is as shown in Fig. 11. It has a very high impedance at 350 meters, but only practically its own ohmic resistance at all other wave-lengths. Thus, energy picked up by the receiving antenna from the local transmitter is short-circuited to ground while the 350 meter energy from the distant station follows the path of least resistance and passes through the primary coil of the receiver. Any wave-length in the immediate vicinity of 350 meters is received efficiently, but all others are short-circuited to ground. It is important to note here that while the preceding two types of trap circuits eliminated one particular frequency and accepted all others

5+

this last type accepts one particular frequency and eliminates all others.

It is often desirable in an installation aboard ship for duplex communication to use the same antenna for transmitting and receiving. This means that it is necessary for the receiver to detect the weak signals picked up from the distant transmitter, amplify them and produce good quality and volume, free from interference, while there are, say 15 amps, of modulated radio-frequency current flowing in the same antenna. These conditions, of course, make duplex communication much more difficult, but it can be done efficiently and practically. The circuit arrangement is shown in Fig. 12. The receiver used in this case is of the Super-Heterodyne type. The trans-

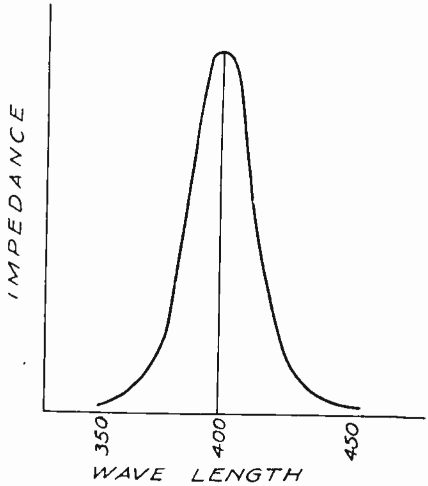


Fig. 7

mitter is tuned to 370 meters, say, and the receiver is tuned to receive 400 meter signals from the distant station. The trap circuit used here is of the anti-resonant type and since it is tuned to the same wave-length as the transmitter, offers a very high impedance to the passage of any current of that frequency. However, since there is so much energy in the antenna circuit of that frequency, a little is bound to get through to the primary circuit of the Super-Heterodyne receiver. This energy is used instead of using a separate oscillator to beat with the incoming signal in the receiver circuit. Obviously no local oscillator is necessary in a Super-Heterodyne receiver under these conditions.

The frequency of the local transmitter = 300,000,000 ÷ 370 = 811,000 cycles.

The frequency of the distant transmitter = 300,000,000 ÷ 400 = 750,000 cycles.

The beat frequency = 61,000 cycles.

The wave-length of the beat note = 300,000,000 ÷ 61000 = 4,900 meters.

The above calculations are in round figures and not carried out to the last place. The distant 750,000 cycle signals beat with the 811,000 cycles which is the frequency of the local transmitter and form a 61,000 cycle beat note. In terms of wave-length we can say that the distant 400 meter signal has been changed into a 4,900 meter signal at the re-

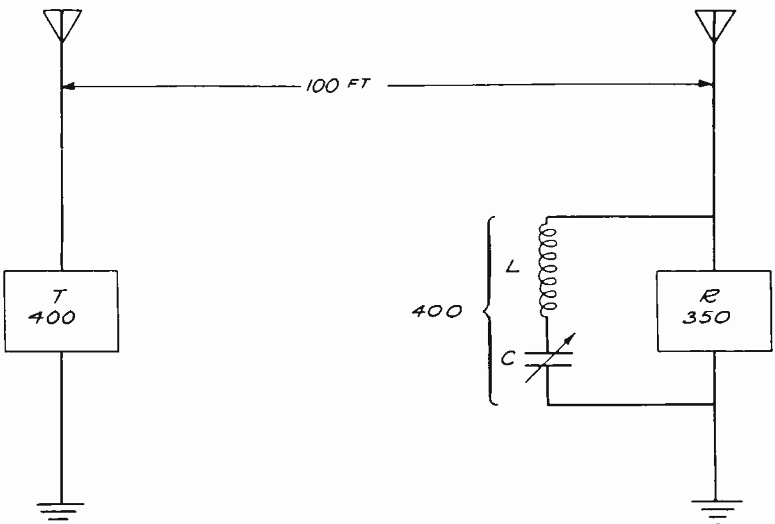


Fig. 8

ceiving station. This 4,900 meter beat note is detected by the high-frequency detector in the receiver and amplified by the intermediate frequency amplifier. The audio-frequency envelope over the 4,900 meter beat note is detected by the low-frequency detector and is amplified in the audio-frequency amplifier circuit. This system has been tried out and proved satisfactory.

BROADCASTING TRANSMITTERS

There is a marked difference between the commercial type of radiotelephone transmitter previously described and the type of transmitter used for broadcasting. The limits for both the mechanical and electrical design of the former are definitely fixed by economic and operating conditions. On the other hand, the economics of the broadcasting station are indefinite at present and the method of operation is determined by factors very different from those governing commercial traffic. The commercial radiotelephone transmitter is designed so that it can be used either for telegraph or telephone communication. Also, in the commercial type of transmitter it is possible, by means of a wave-change switch, to change to any one of half a dozen wave-lengths to which the set is tuned and by a separate gang switch select any one of the following methods of transmission:

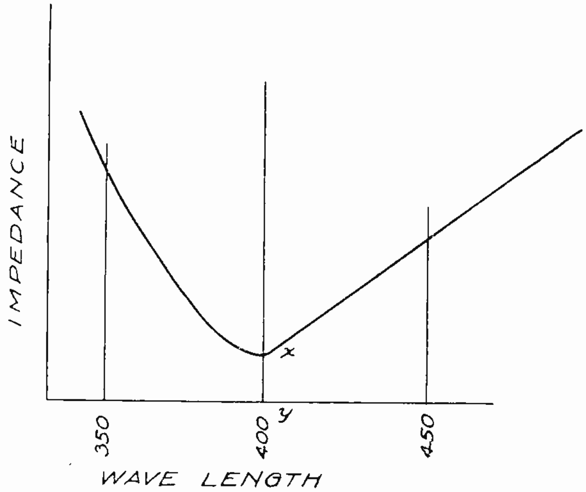


Fig. 9

continuous wave telegraphy (CW), interrupted continuous wave telegraphy (ICW) and telephone.

For transmitting with interrupted continuous waves, use is made of a motor-driven interrupter, which operates similarly to the transmitting key on the continuous wave position except that the oscillations are started and stopped at an audio-frequency.

The broadcasting transmitter, however, is assigned to one particular wave-length. The oscillatory circuits are tuned to that one wave-length and all the associated apparatus is adjusted for maximum efficiency at that particular wave-length. While the commercial transmitter is required to transmit only the band of frequencies necessary to handle commercial telephony, the broadcast transmitter must be capable of transmitting frequencies from the deepest tone of the organ to the highest note of the piccolo flute. In short, the broadcast transmitter has numerous refinements which, due to both economic and operating conditions, could not be incorporated in the commercial type of transmitter. All apparatus in a broadcasting station is in duplicate to insure continuity of service. Summarizing, the general requirements of the broadcasting station are as follows:

1. The station must be ready for operation at all times so that the director may be able to handle a special program.

2. Continuity of service is absolutely necessary. The equipment must be so designed and operated that there will be no interruptions during the program.

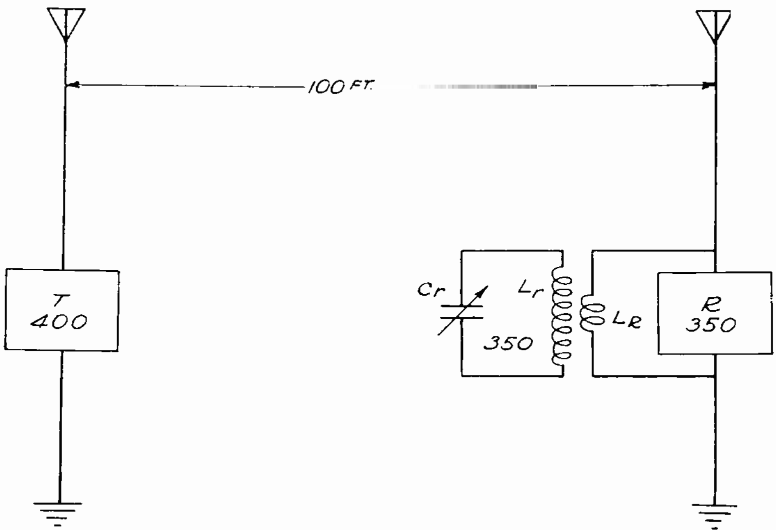


Fig. 10

3. The quality must be of the highest order.

4. The transmitter frequency must remain constant under all operating conditions.

Figure 13 shows a plan view of the layout for a broadcasting station. The power house here is situated 1,000 feet from the studio but this is not a necessity—in many instances the power house is located adjacent to the control room.

The power plant contains all the equipment necessary for the generation, modulation and radiation of radio-frequency power. The apparatus consists of the following, supplied in duplicate to insure continuity of service:

1. Kenotron rectifier unit to supply high voltage D. C.

2. Radio-frequency generator utilizing high power vacuum tubes as oscillators.

3. Modulator unit utilizing high power vacuum tubes as modulators.

The control room contains all amplifying and switching equipment. The main studio consists of a room prepared and furnished especially for broadcasting service. The walls and ceiling are covered with draperies to prevent the reflection of the sound waves. All microphone and control circuits are carried in lead covered cables placed behind the wall draperies. Connection boxes are usually located along the base-

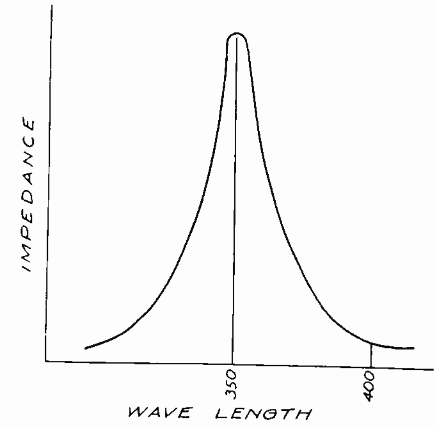


Fig. 11

board near the floor for the microphone outlets. The auxiliary studio is similar to the main studio but is generally much smaller and is used principally for readings and lectures.

The pick-up device or microphone, see Fig. 13-A, is one of the most important units associated with a broadcasting station, its function being to transform the sound vibrations imposed upon it into electrical oscillations that can be handled efficiently by the rest of the apparatus. In the studio, a separate microphone is sometimes used for a particular instrument such as a piano and the soloist also, usually has an individual microphone. A great portion of the success of any broadcasting station depends upon the operation of the studio. The proper placing of the artists and the relation of the various instruments of the orchestra, band or chorus, affect the transmission very materially.

The problem of broadcasting from churches and other places outside of the regular studio has received considerable

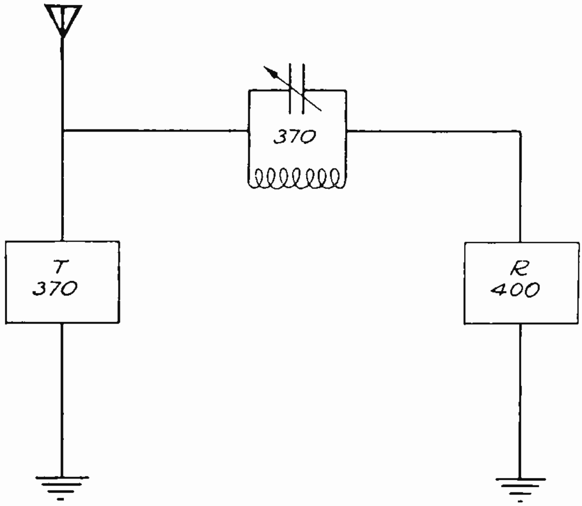


Fig. 12

attention. A typical arrangement of the microphones necessary to broadcast a church service is shown in Fig. 14. Eight microphones are used in this case besides the operator's microphone which is not shown in the figure. By means of a control unit

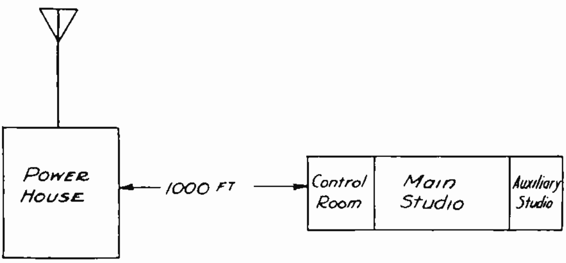


Fig. 13

at the operator's position, any combination of the nine microphones may be switched into service. Figure 15 is a schematic diagram showing an operator's control position with the four incoming microphone circuits and the two outgoing circuits to the control room at the studio. The second circuit to the control room is available for use in case the first circuit becomes noisy or otherwise inoperative.

In the commercial type of radiotelephone transmitter previously described, there was a 50 watt tube which was used as a speech amplifier. In the modern type of the broadcasting transmitter, the speech which actuates the microphone diaphragm passes through an elaborate system of speech amplifiers before it reaches the speech amplifier tube in the transmitter unit, as shown schematically in Fig. 16.

Figure 17 is a plan view showing the layout of the first second and third stage amplifiers with the coupling units and the lines to the power house. In this case, there are 10 first

Fig. 13-A—The Microphone Which Changes the Sound Vibrations Into Electrical Oscillations

stage amplifiers. Numbers 1 and 2 are for the announcer's microphones in the main and the auxiliary studios. Number 3 is for time signals. Numbers 4 and 5 are on church circuits and Nos. 6 to 10, inclusive, are on concert circuits. Four different types of first stage amplifiers are provided and one selected according to the pick-up device used. Certain amplifiers are assigned to certain classes of service. For example, each studio has its own announcer's amplifier which may be of the type shown in Figs. 18 or 19. The former is a first stage amplifier used in conjunction with a single button type of microphone. The latter is the type of circuit used with the double type of pick-up device.

Certain amplifiers are used for broadcasting from the places other than the studio. For example, Fig. 20 shows a circuit arrangement where the condenser type of microphone is used. In this case the output of the microphone circuit is put through two stages of resistance coupled amplification be-

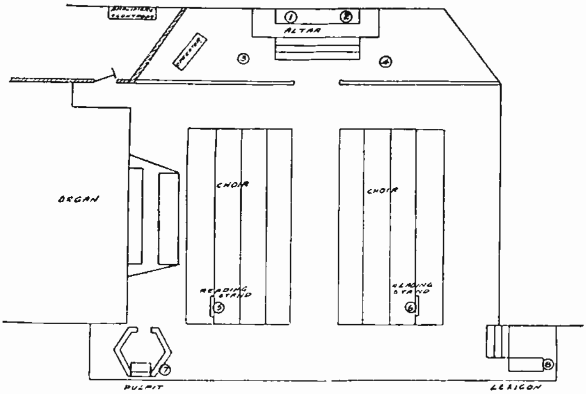


Fig. 14—Typical Arrangement of Microphones in a Church

fore being put on the line to the control room at the studio. When it reaches the studio, this energy passes through another stage of amplification before being passed to the 50 watt second stage amplifier. All the stages ahead of the 50 watt tube or second stage amplifier are referred to as first stage amplifiers. In other words, they are the stages of amplification using the lowest capacity tubes.

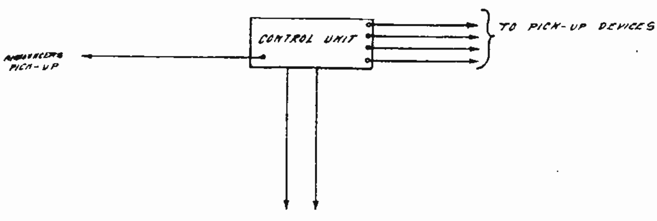


Fig. 15

Another type of amplifier which is used a great deal for broadcasting concerts, etc., is shown in Fig. 21. The push-pull amplifier shown here is located at the concert hall and the output from this amplifier is put on the line to the studio. At the studio, the incoming energy is amplified by a 5 watt tube and the output of this tube is applied to the grid of the second stage amplifier tube.

Each first stage amplifier has its own output control, filament control and listening-in jack. The output circuits of any-

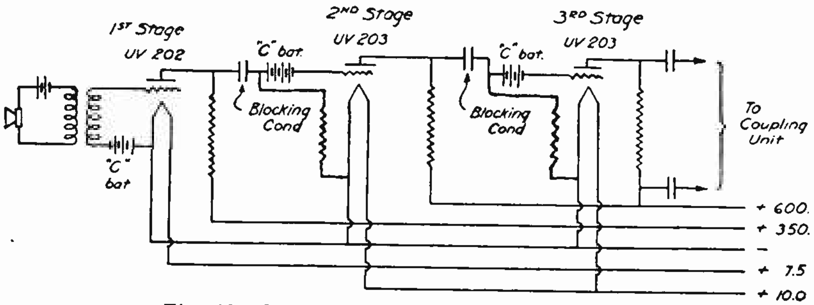


Fig. 16—Circuit diagram of speech amplifier

one of the 10 first stage amplifiers shown in Fig. 17, may be plugged into either one of two second stage amplifiers. The input circuits of the second stage units include several jacks connected in parallel, thus permitting a number of first stage

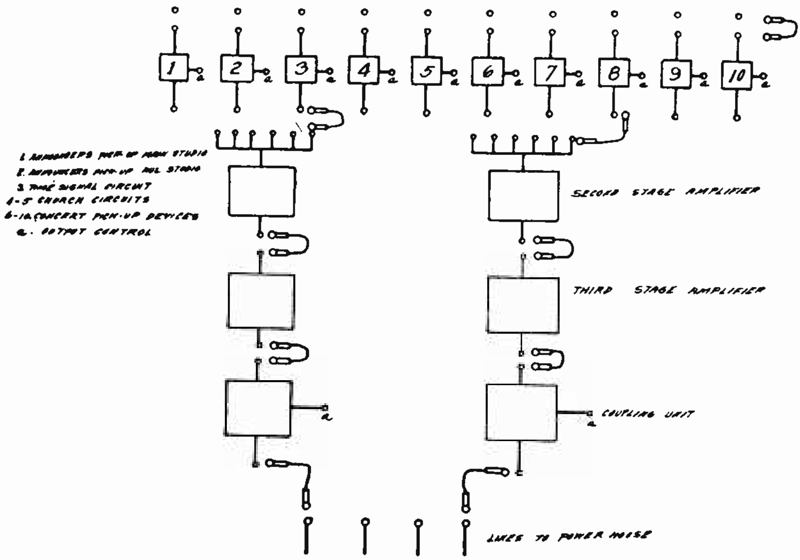


Fig. 17—Layout of Amplifiers, Coupling Units and Lines to Power House

amplifiers to be plugged into one second stage amplifier. For instance, if the first stage amplifiers, Nos. 1, 3 and 6 were all plugged into the second stage amplifier, it would be possible for the local control operator (assuming that a concert was coming in on No. 6) to cut out the concert and cut in the announcer's microphone at the studio by the single throw of a switch. The announcer at the studio might then broadcast the following: "The concert from the Waldorf-Astoria will be in-

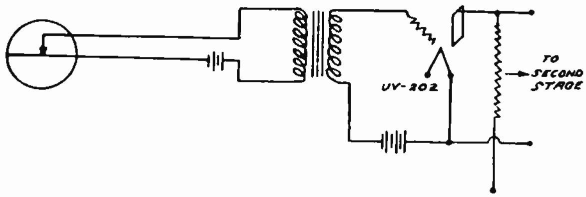


Fig. 18—Schematic Diagram Showing Single Button Microphone Connected to Amplifier

terrupted for a few minutes for the re-transmission of the Arlington time signals." Then with another throw of the control switch, the announcer's microphone at the studio could be cut

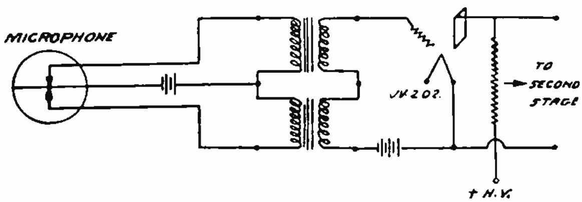


Fig. 19—Schematic Diagram Showing Double Button Microphone Connected to Amplifier

out and the time signals cut in. At the end of the re-transmission of time signals the concert could again be thrown on the air.

The output of the second stage amplifier may be plugged into either of the two third stage amplifiers. Both the second and third stage amplifiers use a 50 watt tube operated at a plate

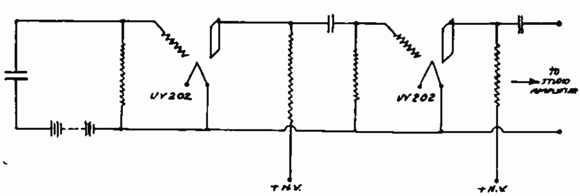


Fig. 20—Schematic Diagram Showing Condenser Microphone Connected to Amplifiers

potential of 600 volts. The output of the third stage amplifier may be plugged into either of two filter units, designated as coupling units in Fig. 17. The output of either filter unit can be plugged into any one of four lines to the power house, where the oscillator and modulator units are located.

The layout of the apparatus in the power house is shown in Fig. 22. This is the transmitter which consists of an oscilla-

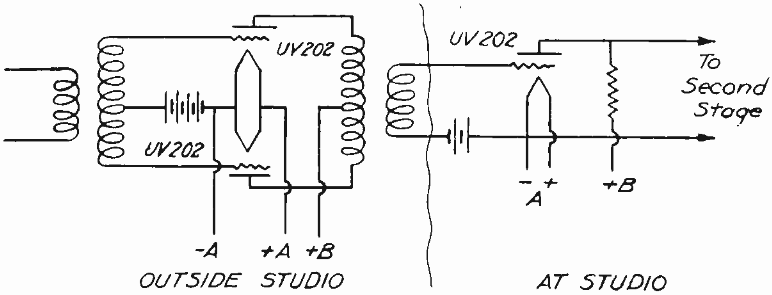


Fig. 21—Push Pull Amplifier

tor, modulator and speech amplifier unit corresponding to the commercial telephone transmitter described previously.

In the commercial transmitter the speech amplifier in the transmitter unit is the first and only stage of amplification, whereas, in this broadcasting layout, the speech-amplifier in the transmitter unit constitutes the fourth stage of amplification.

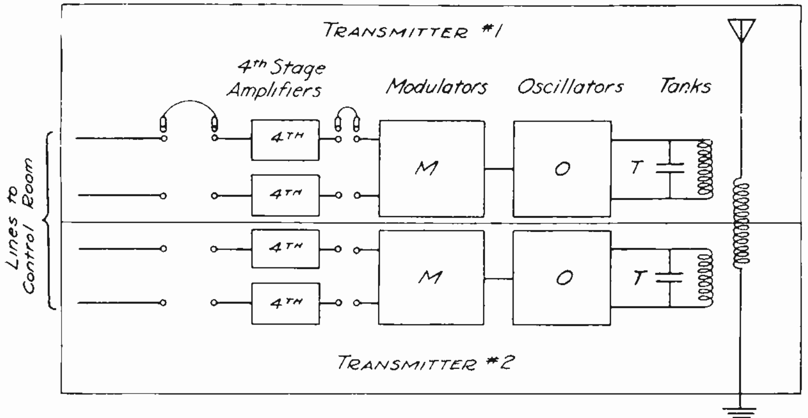


Fig. 22—Layout of Apparatus in the Power House

Any of the lines from the control room may be plugged into any one of the four fourth stage amplifiers. There are two amplifiers for transmitter No. 1 and two for transmitter No. 2. One is a push-pull amplifier and the other a reactance coupled amplifier. Either may be used depending upon operating conditions. Two hundred and fifty watt tubes (UV-204) at a plate

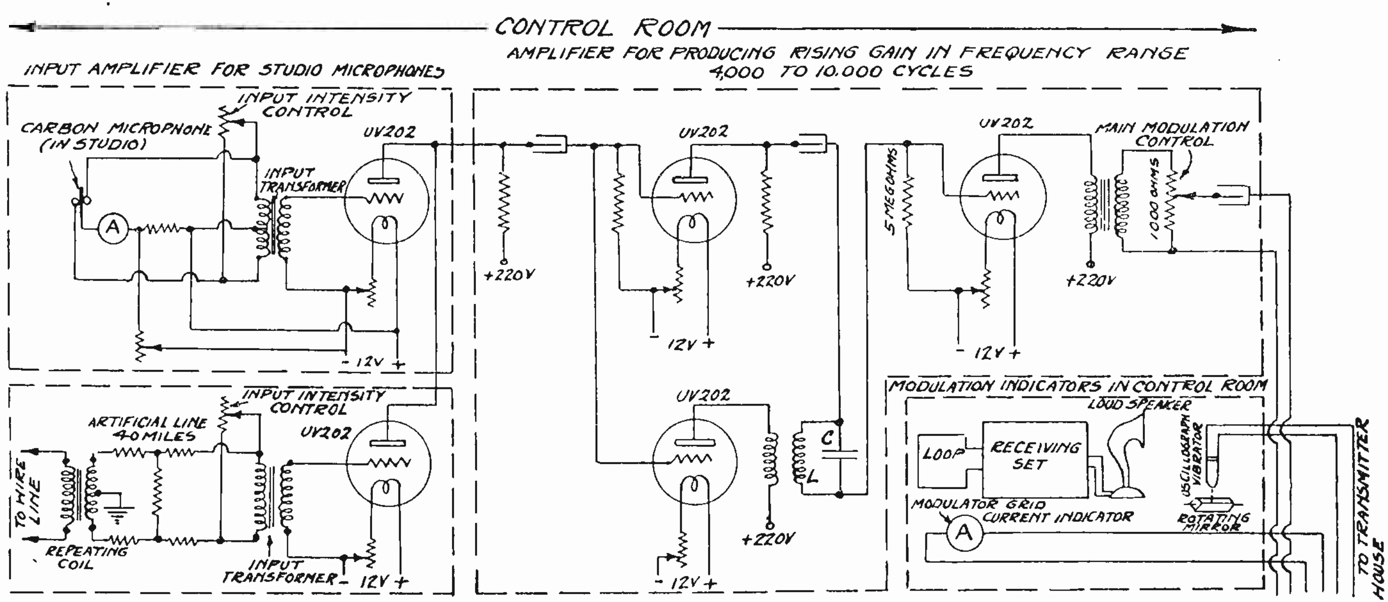


Fig. 23—Wiring Diagram of Control Apparatus

potential of 2,000 volts are used in these amplifiers. The output of the fourth stage amplifier is plugged into the modulator unit which consists of five 1.K.W. tubes (UV-206.) The oscillator utilizes a "tank" circuit, loosely coupled to the antenna circuit to maintain constant frequency. A "tank" circuit is simply a tuned intermediate circuit which transfers the power output of the oscillator to the antenna circuit, the frequency of the radiated energy being determined chiefly by the constants of the tank or dummy circuit.

STATION APPARATUS AND DIAGRAMS OF CONNECTIONS

Schematic wiring diagrams of a station apparatus involved in broadcasting is shown in Figs. 23 and 24. Starting at the upper left-hand corner of Fig. 23, we have a single stage amplifier which is arranged for inputs from a studio microphone or a wire line (in case of broadcasting from points outside the studio.) The microphone is connected directly to the input transformer, while in the case of wire lines a 40-mile resistance artificial line is connected between the line and input transformer to lower the input energy to a level of the same order of magnitude as that obtained from a microphone. The voltage produced by a microphone across the terminals of the input transformer is about two millivolts, while at the end of a line, a signal of about two-tenths of a volt is usually available.

The first stage is resistance coupled to the input side of a special amplifier designed to give uniform amplification over the frequency band from 100 to 4,000 cycles. From 4,000 to 10,000 cycles, it is arranged to produce gradually increasing amplification. The reason for this is that all present loudspeakers, head-telephones, and many audio-frequency transformers (as used in receiving sets) give a decreasing output in this range, and a rising frequency at the transmitting station will tend to compensate for this. As a result, such sounds as the consonant "s," the characteristic frequency of which is of the order of 10,000 cycles, are reproduced very clearly on the average receiving set, while music is also given greater clearness because of the better reproduction of harmonics.

The output of the microphone amplifier is fed to the grids of two tubes, in parallel. The upper tube has a resistance in its plate circuit and the lower one a resonance transformer composed of air-core coils and a condenser with its resonance peak

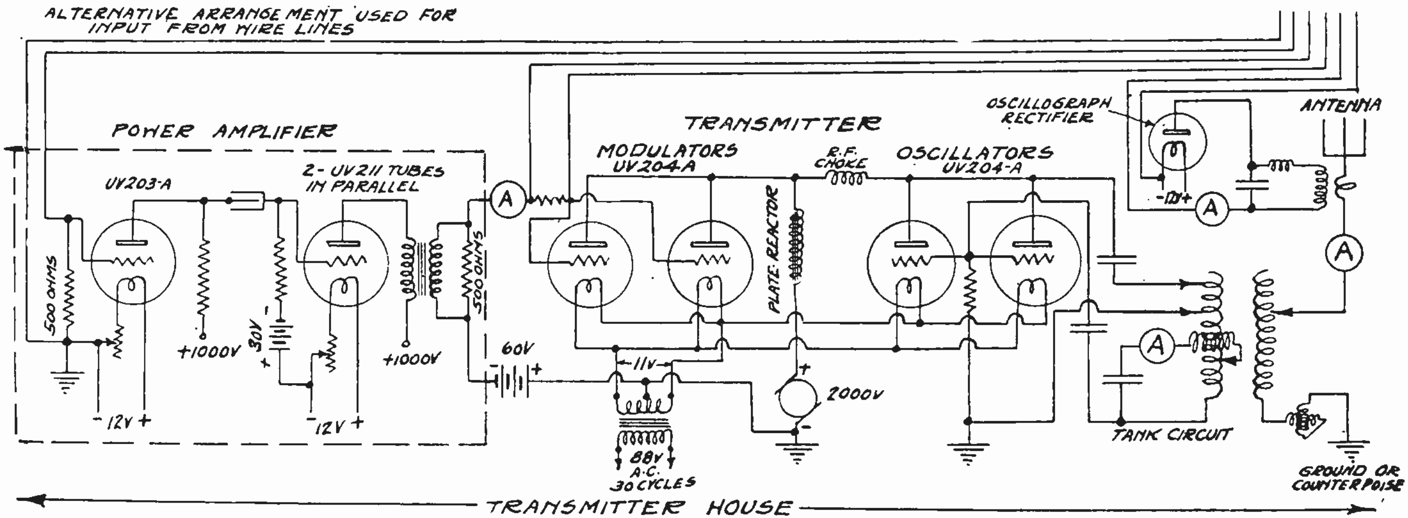


Fig. 24—Wiring Diagram of Transmitting Apparatus

10

at 10,000 cycles. The voltage delivered by the upper (resistance) coupled tube is uniform with respect to frequency, while that delivered by the lower tube is a resonance curve having a maximum at 10,000 cycles. The voltages delivered by these two tubes are added in series and applied to the grid of a third tube, the magnitudes being so chosen that the sum of the two gives the proper frequency characteristic. The third tube serves as an output tube, and its output is stepped down in order to feed the input side of the power amplifier, Fig. 24, in the transmitter house through a cable which is about 600 feet (185 meters) long. On the low voltage side of the output transformer is placed the main modulation control, a 500-ohm potentiometer, by means of which the voltage supplied to the power amplifier may be regulated. The cable in the transmitter house is terminated by a 500-ohm resistance, from which the grid of the first power amplifier tube is fed. It may appear uneconomical not to place a step-up transformer at this point, but it is preferable to avoid transformers whenever sufficient amplification is already available, since each transformer cuts off transmission of low and high frequencies to some extent.

The power amplifier has two stages, the first being resistance coupled and the second transformer coupled to the grids of the modulator tubes. A step-down transformer with 500 ohms across the secondary is used so that with positive potentials applied to the modulator grids no distortion will occur, due to the grid current drawn. The customary "constant current" modulation system is used. The oscillators work into a local circuit (called the "tank circuit") which is inductively coupled to the antenna. Variometers are provided for wavelength control in both local and antenna circuit. The antenna power, unmodulated, is normally 500 watts, antenna current about 7 amperes on 455 meters and 6 amperes on 405 meters.

TEST QUESTIONS

Number Your Answer Sheet 35 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. How is the high voltage plate current obtained from the 110 volt power lines?
2. Why are the two condensers joined in series (mid-point grounded) and connected across the secondary coil of the filament transformer in Fig. 1?
3. What provision is made to correct interference to the grid bias in case the commutation of the 125 volt generator becomes bad?
4. Represent by a drawing the arrangement of transmitter and receiver (100 feet apart) for simultaneous operation.
5. What is the advantage of the arrangement in Fig. 10 over the other methods?
6. Explain by use of a drawing the method of reception by the transmitting aerial on shipboard for Duplex operation.
7. Illustrate the system of speech amplifiers before it reaches the broadcast transmitter.
8. Show the layout of the apparatus in the power house of a broadcasting station.
9. Draw a wiring diagram for the control room apparatus.
10. Show the method of wiring for the transmitting apparatus.

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