Western Electric Company

RADIO TELEPHONE BROADCASTING EQUIPMENTS

MAY, 1923 TECHNICAL BULLETIN T-670

Western Electric
Radio Telephone Broadcasting Equipments

GENERAL

Popular interest in radio telephony has brought with it a realization of new possibilities in radio telephone broadcasting for widely diversified classes of enterprises. It has been found possible to use it as a means of disseminating news, musical programs, educational and timely lectures, market reports, shipping news, stock market quotations, and political campaign speeches. The field of application is practically unlimited.

The evident need for equipment capable of supplying the highest grade of transmission finds the Western Electric Company prepared to furnish radio telephone broadcasting equipments of the best type known to the art. These equipments are the logical outcome of experimental and research work that has been carried on for a number of years by the engineers of the Bell System, that is to say, of the American Telephone and Telegraph Company and the Western Electric Company.

It will be recalled that engineers of these companies in 1915 were the first to transmit the human voice across the Atlantic Ocean by radio telephony. The development work that followed this historic event has made it possible for the Western Electric Company to manufacture for sale radio telephone broadcasting equipments that embody the best features of mechanical and electrical design.

TYPES OF EQUIPMENT

WESTERN ELECTRIC RADIO TELEPHONE BROADCASTING EQUIPMENTS are made in two sizes and operate at wave lengths of from 300 to 600 meters:

No. 101-A Radio Telephone Broadcasting Equipment consisting of:

- No. 1-A (500 Watt) Radio Transmitter
- Power Equipment
- 1A Speech Input Equipment
- No. 2-C Radio Receiver

No. 102-A Radio Telephone Broadcasting Equipment consisting of:

- No. 2-A (100 Watt) Radio Transmitter
- Power Equipment
- 1A Speech Input Equipment
- No. 2-C Radio Receiver

The No. 2-C radio receiver is supplied in order to comply with the United States

Government regulations, which provide that at certain intervals the operator shall "listen" to determine whether distress signals are being sent or the transmitting operations of the broadcasting station are causing interference with other radio communications.

An antenna relay which is electrically operated by means of a push button at the talking station is provided to change connections from "Transmit" to "Receive" or vice versa.

TRANSMITTING RANGES

No. 101-A RADIO TELEPHONE BROADCASTING EQUIPMENTS are designed to deliver 500 watts of radio frequency power to the antenna system.

They are conservatively rated as 100-mile equipments. This means that when listening with a receiving set comprising a detecting tube and two stages of audio frequency amplification, associated with a suitable antenna, located at a distance not greater than 100 miles from the transmitting station, the summer reception in the latitude of New York will in general be satisfactory.

When the conditions are favorable, as for example during the winter months and at night, the No. 101-A radio telephone broadcasting equipment, used in connection with a suitable antenna, may frequently be heard with suitable receiving equipment at very much greater distances.

No. 102-A RADIO TELEPHONE BROADCASTING EQUIPMENTS are designed to deliver 100 watts of radio frequency power to the antenna system.

They are rated as 50-mile equipments under the same conditions that govern the use of No. 101-A RADIO TELEPHONE BROADCASTING EQUIPMENTS.

It should be borne in mind that it is impossible to state with accuracy the transmitting range of any radio telephone broadcasting equipment unless all of the conditions under which it is to operate are known.

The transmitting range is determined not only by the radio transmitting apparatus and dimensions of the antenna, but also by the type and efficiency of the distant receiving equipment.

Conditions which affect both the transmitting and receiving stations are the character and location of the antennae, and their relation to surrounding objects, ground conditions, climatic conditions, the character of the country separating the transmitting and receiving stations, the season of the year, the time of day, and so on.

In general, therefore, WESTERN ELECTRIC RADIO TELEPHONE BROADCASTING EQUIPMENTS are rated in accordance with the amount of power which the apparatus is capable of delivering to the antenna system.

DESCRIPTION OF UNITS

RADIO TRANSMITTER

The No. 1-A radio transmitter (figures 1 and 2) and No. 2-A radio transmitter (figures 3 and 4) are essentially the same in regard to circuit arrangements and operating details.

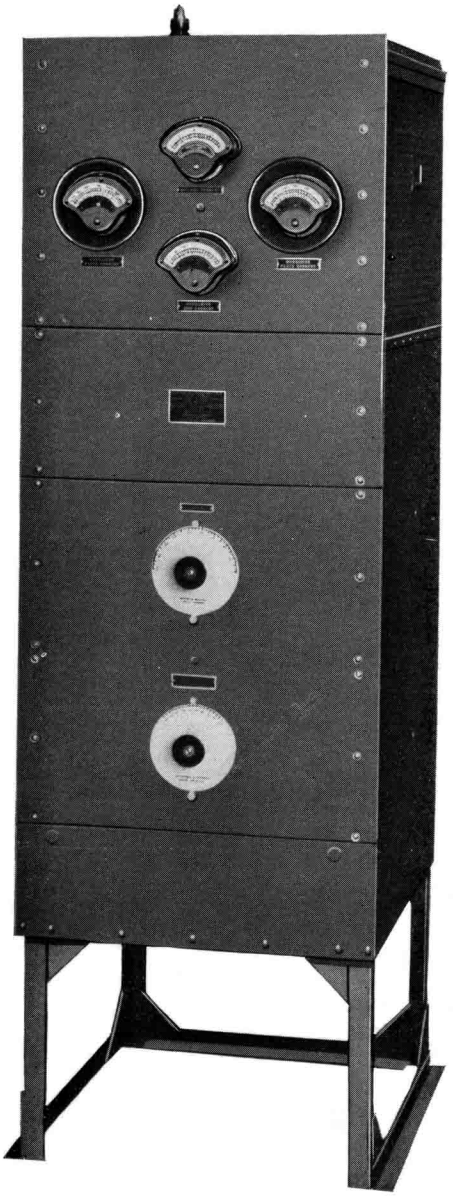

Figure 1
No. 1-A RADIO TRANSMITTER
(Front View)

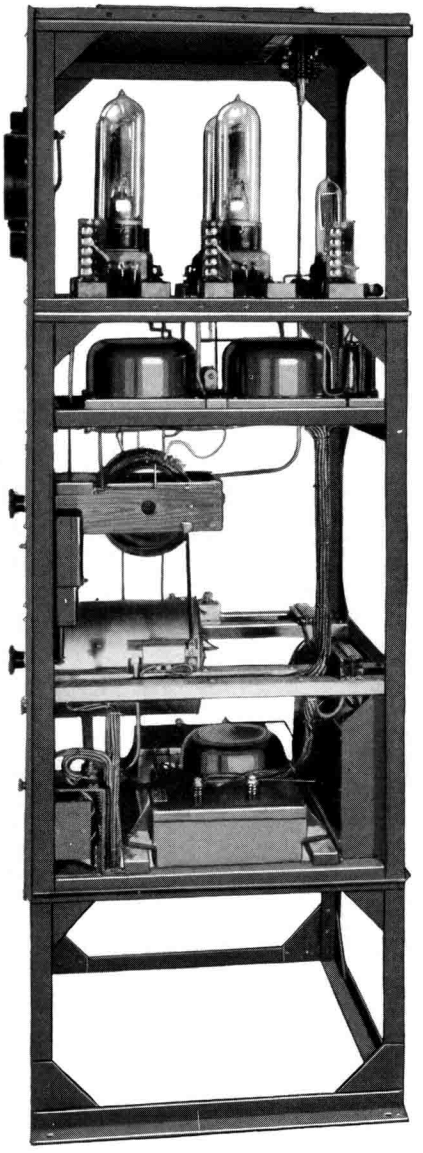

Figure 2
No. 1-A RADIO TRANSMITTER
(Side View—guards removed)

The various pieces of apparatus that make up each unit are mounted on a black finished angle iron frame work, rectangular in shape, in order to provide a rigid and

compact structure so arranged to make readily accessible every part of the equipment.

On one side of the frame work are mounted insulating panels on which are located meters and controls for the adjustable features of the equipment. The bottom panel is hinged to permit access to the terminal strip which is located behind it.

The vacuum tubes, coils, filters, relays, resistances, and other auxiliary apparatus

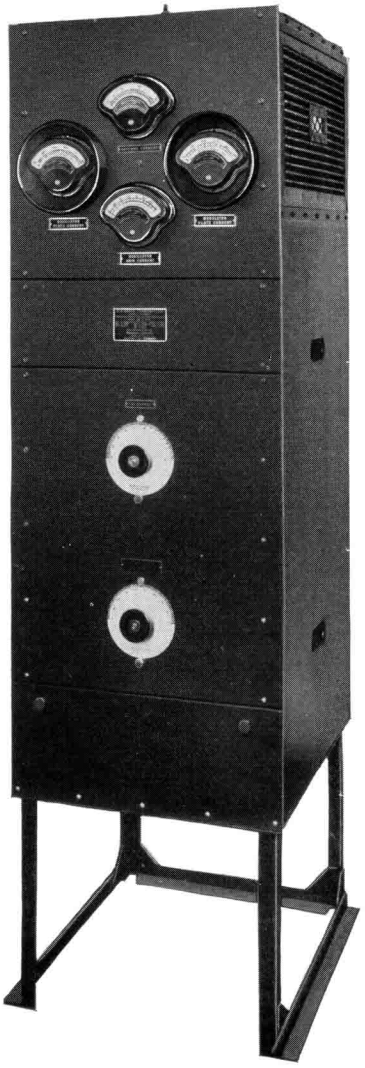

Figure 3
NO. 2-A RADIO TRANSMITTER
(Front View)

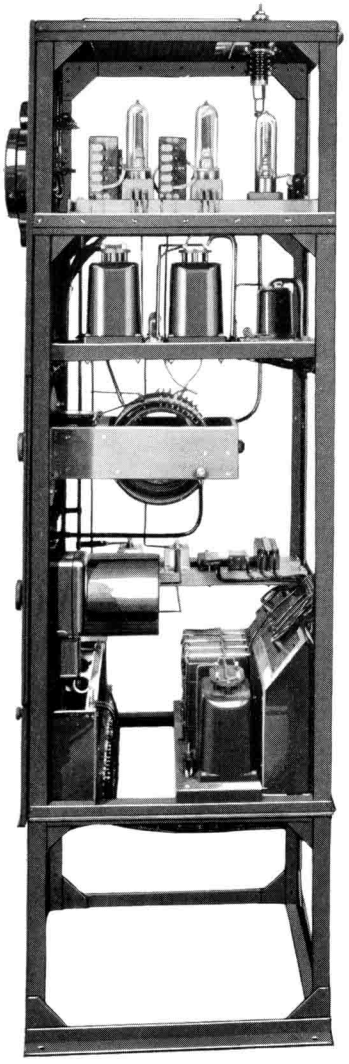

Figure 4
No. 2-A RADIO TRANSMITTER
(Side View—guards removed)

which ordinarily do not require observation or manipulation, are mounted inside of the frame work.

The sides of the framework other than that side used for the insulating panels are enclosed by expanded metal guards, which serve both to protect the apparatus from injury and to prevent accidental contact with those parts subject to high potential.

These guards may be removed without the use of tools and give access to the equipment mounted within the framework.

The four ammeters which serve to indicate respectively the antenna current, the oscillator plate current, the oscillator grid current, and the modulator plate current, are mounted on the insulating panel, at the top front of the radio transmitter.

The cases of the oscillator plate current milliammeter and the modulator plate current milliammeter are covered with a grounded guard, in view of the fact that these instruments are subjected to the full voltage of the plate circuit generator, whose voltage may be either 1600 or 800.

The other two ammeters are not subjected to high potentials, and are therefore not specially protected.

The over-all dimensions and electrical characteristics of Nos. 1A and 2A radio transmitters are approximately as follows:

	Height	Width	Depth
1-A Radio Transmitter (500 watt)	78 in.	25 in.	27 in.
2-A Radio Transmitter (100 watt)	69¼ in.	20 in.	21½ in.

	1-A Radio Transmitter	2-A Radio Transmitter
Plate Potential	1,600 volts	800 volts
Total Plate Current	1.25 amperes	0.7 amperes
Filament Potential	14 volts	11 volts
Total Filament Current	28.4 amperes	17 amperes

VACUUM TUBES USED FOR TRANSMITTING

Western Electric Vacuum Tubes have an oxide coated filament which insures maximum electron emission with minimum expenditure of filament circuit power.

No. 1-A radio transmitter (500 watt) makes use of four No. 212-A (250 watt) tubes and one No. 211-A (50 watt) tube (figures 5 and 6 respectively).

No. 2-A radio transmitter (100 watt) makes use of five No. 211-A tubes.

These tubes are mounted in the upper part of the framework of the transmitters where they can be readily seen, and in addition, provided with adequate ventilation.

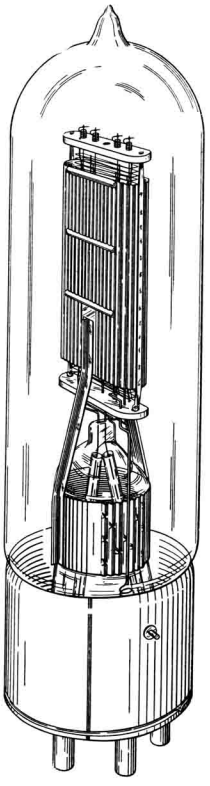

Figure 5
NO. 212-A VACUUM TUBE

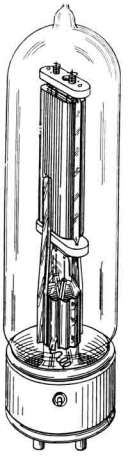

Figure 6
NO. 211-A VACUUM TUBE

Both the No. 212-A and 211-A vacuum tubes operate with the filaments at a dull red heat.

Each No. 212-A vacuum tube requires a filament current of 6.25 amperes; each No. 211-A, 3.4 amperes.

Current for heating the filaments is supplied from a constant potential generator. The filament current is adjusted and held constant by means of the generator field rheostat.

The No. 212-A and No. 211-A vacuum tubes are rated in accordance with their filament resistance, each tube being marked with a designating letter A, B, C, D, or E. A separate adjustable resistance with stages correspondingly marked is placed in circuit with the filament of each tube. When a new tube is placed in circuit, the

resistance should be set to the required value so as to insure that the correct amount of current is supplied to the filament when the generator voltage is held at the value designated.

Oscillator and Modulator—The radio transmitter is essentially a generator of radio frequency energy (an oscillation generator), with means for modulating this energy in accordance with current variations produced by a microphone operating in conjunction with an amplifier and certain other auxiliary equipment.

The oscillator comprises vacuum tubes and a tuned circuit which includes the antenna system. This tuned circuit determines the frequency and wave length of the radiated energy.

The modulating system provides means whereby the alternating currents corresponding to speech or music are supplied in amplified form direct to the oscillator circuit. The operation of this system may be understood by considering that the plate circuit of the oscillator is supplied with speech currents directly from the modulator. The combined circuits provide a sort of mixing chamber in which the speech currents are combined with the steady carrier wave supplied by the oscillator to produce the modulated wave required.

The system of modulation used in these equipments, in connection with Western Electric vacuum tubes, insures the highest efficiency in clearly reproducing speech and music; in other words, complete and perfect modulation.

Transmitter Frequency Adjustment—The frequency of the transmitted energy (wave length) is controlled by the value of the inductance in the oscillatory circuit which includes the antenna. The inductance is adjusted by means of a variometer. To provide this feature a portion of the oscillator coil included in the antenna circuit is arranged to turn on an axis at right angles to its normal axis so that the inductance of the movable coil either aids or opposes the inductance of the remainder of the coil.

The movable coil also serves to vary the coupling between the antenna circuit and that portion of the coil system which is connected to the plates and grids of the oscillator tubes in a manner to insure satisfactory operating conditions throughout the frequency range for which the transmitter is designed.

Oscillator Adjustment—A variable condenser connected across the plate coil controls the plate current through the oscillator tubes, and to a large extent the output of these tubes. This condenser consists of a variable unit in parallel with two fixed units which may be switched in or out of the circuit as required. The variable unit is controlled by a knob on the front of the set and is designated "Oscillator Adjustment."

Both the adjustable inductance and the adjustable condenser are provided with graduated dials so that after the transmitting set has once been calibrated in connection with its associated antenna, wave length adjustments can be made without a wave meter.

The following special circuit features are embodied in the No. 1-A and 2-A radio transmitters:

Antenna Relay—The antenna relay is operated by means of push buttons and is used while the equipment is in operation to change connections from "send" to "receive" and vice versa. When the relay is in "receive" position an auxiliary contact is opened which renders the transmitter inactive and prevents it from interfering with local reception.

Negative Grid Potential—In order that the vacuum tubes used for modulating and speech amplifying purposes may operate under the most favorable conditions to prevent distortion, the grid circuits of these tubes are given a negative bias by means of a resistance connected between the negative terminal of the high potential generator and the filaments of the tubes.

Elimination of Commutator Noises—The plate circuits of the vacuum tubes are supplied with direct current from a high potential generator. A noise filter is used to eliminate commutator noises and is mounted on the framework of the radio transmitter.

Delayed Action Relay—Under certain conditions, if the plate circuit is closed before the filament circuit, a destructive rush of current through the tubes may occur. To prevent damage due to this cause, a delayed action relay is provided. This relay which is operated by the filament current requires approximately 20 seconds to operate and its contacts are so arranged that the full plate potential is not applied to the tubes until the filaments have been lighted for this period of time.

POWER EQUIPMENT

MOTOR GENERATOR SETS

Power supply for the radio transmitters is obtained from a three-unit motor generator set consisting of one high voltage and one low voltage D. C. generator, both direct connected to a driving motor. The three units are mounted on a common base plate (Figure 7).

Driving Motor—The motor will be furnished for either alternating or direct current depending upon the character of the commercial current supply. Alternating current motors are of the induction type. For the No. 101-A RADIO TELEPHONE BROADCASTING EQUIPMENT a five and one-half horsepower motor is required; for the No. 102-A equipment a two horsepower motor.

During the operation of the radio telephone broadcasting equipment the load on the high voltage generator varies considerably, due to the operation

of the antenna relay. The motors are designed so that these normal fluctuations of load will not appreciably affect the speed of the motor and the normal voltage of the generators.

The motors operate at a normal speed of approximately 1750 R. P. M.

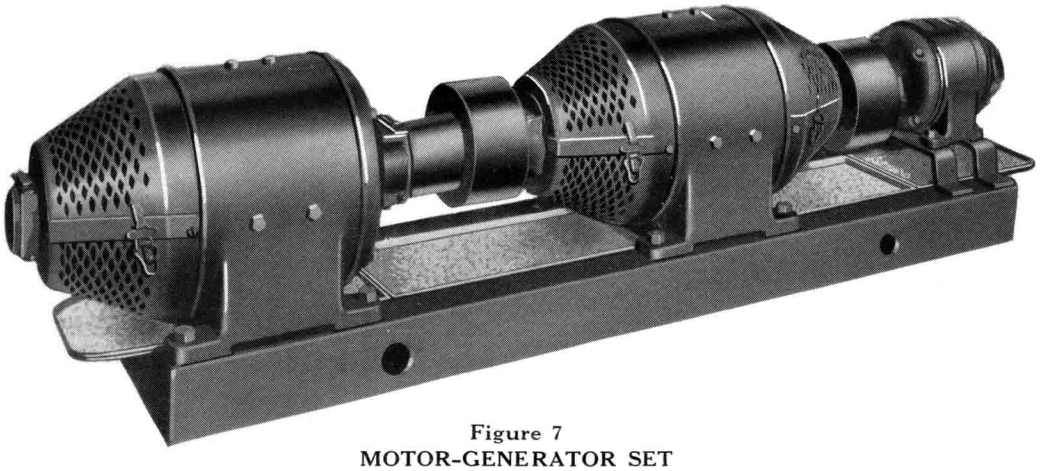

Figure 7
MOTOR-GENERATOR SET

High Voltage Generator—The high voltage generator which supplies direct current to the oscillator and modulator circuits is shunt wound.

The normal rating of the high voltage generator for the No. 101-A equipment is 1600 volts, at 1.25 amperes; for the No. 102-A equipment, 800 volts at 0.7 ampere.

The field excitation current for these generators is obtained from the low voltage generator with which each is associated.

Low Voltage Generator—The low voltage generator provides current for the filaments of the vacuum tubes, plus the necessary field excitation current for the high voltage generator. It is shunt wound. Its potential is regulated by means of a field rheostat mounted on the power switchboard. The resistance per step regulates the voltage in steps of approximately 0.2 volts under all normal conditions of load, speed and machine temperature. The high and low voltage generators are so designed as to reduce to a minimum commutator ripples which might introduce disturbance in the circuits of the radio equipment.

POWER SWITCHBOARD

The power switchboard is the same for both the No. 101-A and No. 102-A radio telephone broadcasting equipments. The voltmeters, however, have different ranges.

The power switchboard (figures 8 and 9) consists of two slate panels mounted on a black finished angle iron framework approximately 69¼ inches high by 24½ inches wide by 10 inches deep. Upon the slate panels are mounted the various starting and control devices, voltmeters, etc.

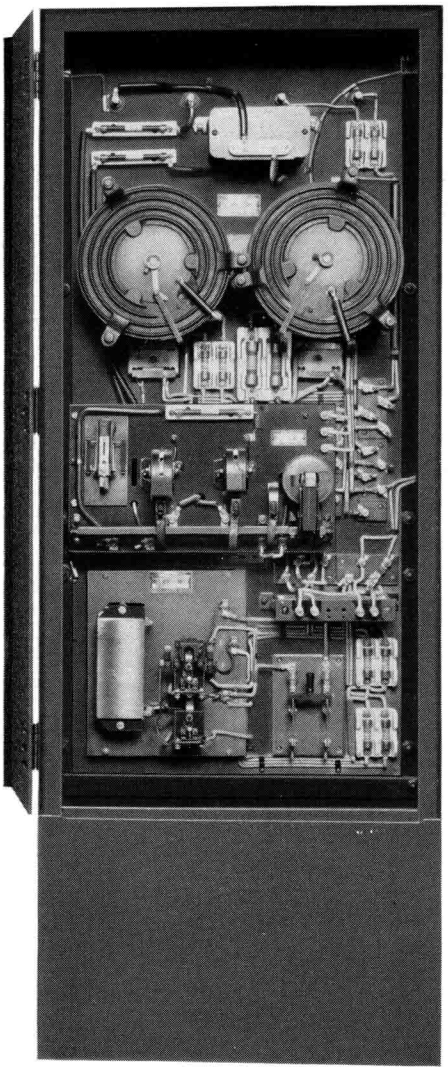

Figure 8
POWER SWITCHBOARD
(Rear View—Door Open)

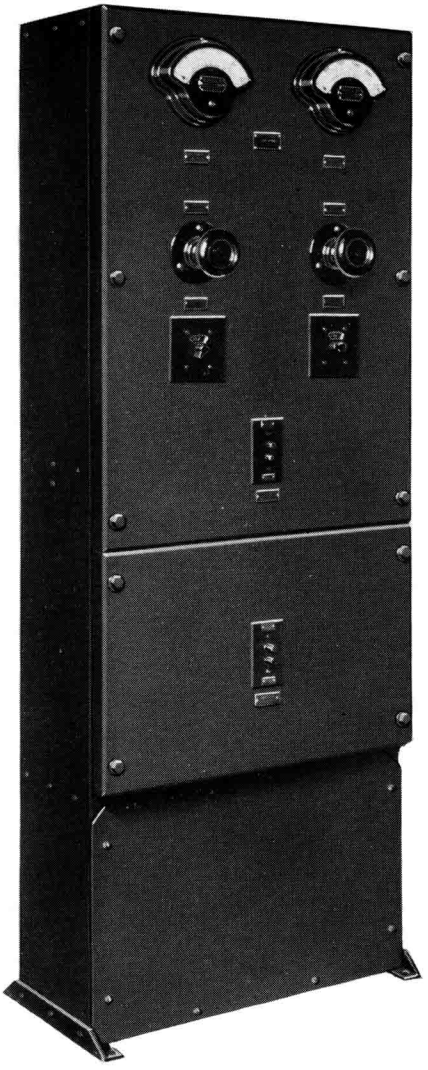

Figure 9
POWER SWITCHBOARD
(Front View)

The power switchboard is described as "dead front," which means that although the handles of the switches, rheostats, circuit breakers, etc., appear on the face of the switchboard, all of the current carrying portions are mounted at the rear of the slate panel to protect the operator from accidental contacts.

The rear of the switchboard is completely enclosed by a metal cabinet. An automatic safety switch shuts down the motor generator when the door of the cabinet is open.

Motor Starting Device—The motor of the motor generator set is started or stopped by means of momentary contact push buttons. The main push buttons are located on the power switchboard, but similar push buttons connected in parallel are located at the operator's desk.

The starting mechanism used in connection with both D. C. and A. C. motors represents the best commercial equipment obtainable. The particular type used in each case depends upon the character of the commercial current supply and varies in detail for each different type.

Measuring Instruments—Two voltmeters are provided on the power switchboard. One of these is used to indicate the potential delivered to the filament circuit of the vacuum tubes; the other the potential of the high voltage generator.

The case of the high potential voltmeter is connected to ground, and it is not necessary, therefore, to use an insulated guard to protect the operator. The low potential voltmeter mounted on the power switchboard is not connected direct to the terminals of the low voltage machine, but is wired to the filament circuit on the radio transmitter. Under these conditions, the reading of the voltmeter indicates the actual voltage across the terminals of the tubes, and it is not necessary to make allowance for voltage drop in the wiring, etc.

Circuit Breaker—A circuit breaker mounted on the power switchboard is provided for the plate current supply circuit. It is usually adjusted to open under an over-load of about 25 per cent.

Field Rheostats—Field rheostats are included in the field circuits of both generators, but only the low voltage generator rheostat may be adjusted from the front of the panel. The rheostat of the high voltage generator is adjusted from the rear. This rheostat requires infrequent settings since when properly set and the potential of the low voltage machine is correctly adjusted, the potential of the high voltage machine is established at the correct operating value.

Note—The potential of the low voltage machine should be held constant by the operator at 14 volts in the case of the No. 1-A radio transmitter and at 11 volts in the case of the No. 2-A radio transmitter. With the potential of the low voltage machine set at one or the other of these values, the plate voltage for the respective transmitter should be adjusted initially to 1600 volts and 800 volts when the set is operating at full load.

Switches—In addition to the voltmeters, the circuit breaker, field rheostat, etc., the face of the power switchboard has mounted upon it a total of four switches (figure 8). These switches control—

(1) Field Circuit of High Voltage Generator.
(2) Plate Current Supply Circuit.
(3) Filament Current Supply.
(4) Motor Circuit.

INPUT EQUIPMENT

The 1-A speech input equipment consists of microphones, input amplifier, control apparatus, batteries and a loud speaking receiver for monitoring purposes.

Depending only upon the class of transmission involved this equipment is identical for both the No. 101-A and No. 102-A radio telephone broadcasting equipments.

MICROPHONE

The microphone (figure 10) used in connection with WESTERN ELECTRIC RADIO TELEPHONE BROADCASTING EQUIPMENTS, may be operated by talking close up or from a distance of several feet. Its design is such as to insure

Figure 10
MICROPHONE

faithful reproduction of every gradation of tone of speech or music which is to be transmitted.

The microphone is mounted in a casing which minimizes the effect of mechanical vibration that might affect the clarity of the reproduced sounds.

INPUT AMPLIFIER

To obtain the best results the magnitude of the feeble currents produced by the microphone must be increased many thousand times before they are impressed on

the radio transmitter. For this purpose an input amplifier (figure 11) provides the necessary amplification.

This consists of a three stage amplifier mounted upon a black finished angle iron framework so that all items of the apparatus are accessible. The dimensions of the framework are approximately five feet high by two feet wide by ten inches deep.

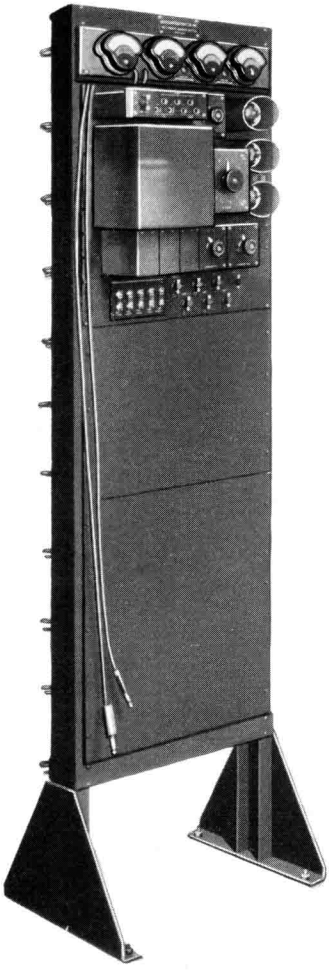

Figure 11
INPUT AMPLIFIER

In addition to the amplifier tubes, transformers, etc., the input amplifier panel has mounted upon it control apparatus to regulate the amplification.

Note—Where speech only is to be broadcasted and no music, much simpler forms and equally satisfactory speech input equipment can be supplied. The services of Western Electric engineers are available to assist in any problems which appear to involve the use of less elaborate speech input equipment than that detailed herein.

BATTERIES

Current to operate the microphone is supplied by an 18-volt storage battery, and is regulated by a rheostat on the input amplifier panel.

Filament current for the input amplifier is obtained from the same 18-volt storage battery that supplies the current to the microphone.

Suitable provision is made for charging this battery, depending upon whether the commercial current supply is alternating or direct.

Current for the plate circuit of the amplifier should be supplied from six-inch (No. 6) dry cells. A total of 130 volts is required. A special cabinet installed in the same room as the motor generator set may be provided for the dry cells. Its dimensions should be approximately 4 feet high, 30 inches wide and 10 inches deep.

MONITORING FACILITIES

To enable the operator to observe the loudness and quality of speech or music delivered to the radio transmitter without having to wear a head telephone set continually a loud speaking receiver with suitable horn and mounting is connected across the input terminals of the radio transmitter. The loud speaking receiver must not, however, be installed in the same room as the microphone.

RADIO RECEIVER

A No. 2-C radio receiver (figure 12) is supplied with both No. 101-A and No. 102-A radio telephone broadcasting equipments. This makes it possible for the broadcasting station to comply with the United States Government regulations in regard to "listening" at intervals to determine whether distress signals are being sent or the

Figure 12
NO. 2-C RADIO RECEIVER

transmitting operations of the broadcasting station are causing interference with other radio communications. The No. 2-C radio receiver provides both primary and secondary tuning so as to insure a high degree of selectivity.

CABINET

The No. 2-C radio receiver, exclusive of batteries and telephone head-set, is contained in a wooden cabinet approximately 13 inches by 9 inches by 5 inches. The face of the cabinet is of approved insulating material. In convenient positions upon the face-plate are mounted the antenna inductance switch, the coupling control, the primary and the secondary condenser controls, the vacuum tube sockets, the filament circuit switch, and the binding posts for the antenna, ground and battery connections.

VACUUM TUBES

The No. 2-C radio receiver is equipped with a total of three No. 203-B vacuum tubes, one for use as a detector, and the others for the two stages of audio frequency amplification. The total current drain is approximately 1.1 amperes at 18 volts for

the filaments and 1½ milliamperes at 18 volts and three milliamperes at 30 volts for plate circuits.

With the usual forms of antenna the No. 2-C radio receiver will receive wave lengths of from 300 to 600 meters.

BATTERIES

The filament and plate current supply for the No. 2-C radio receiver is obtained from the batteries which are used for the input amplifier.

TELEPHONE HEAD-SETS

A Western Electric No. 1002-F telephone head-set is supplied with the No. 102-C radio receiver. The cord attached to the telephone head-set is equipped with a plug at one end so that the telephone head-set can be conveniently connected to the detector tube circuit only or to the first or second amplifying tube circuit. Jacks are provided on the face of the receiver for this purpose.

GENERAL PLAN OF CONNECTIONS

A general plan of connections for Western Electric radio telephone broadcasting equipments is shown in Figure 13. A diagram of actual wiring is supplied with each equipment.

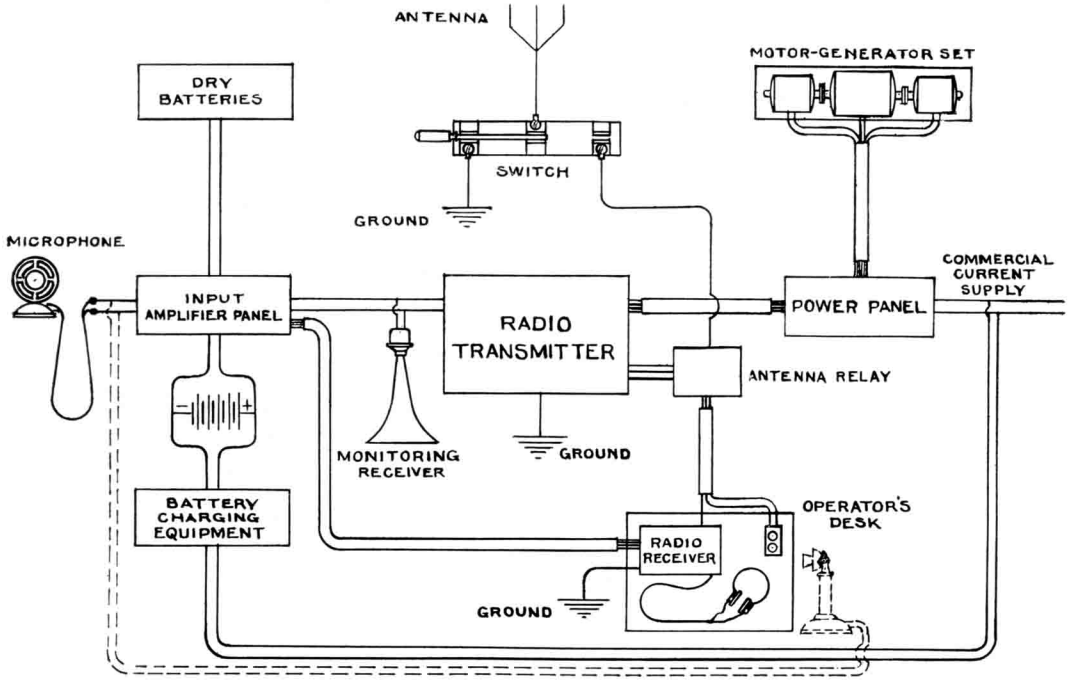

Figure 13
GENERAL PLAN OF CONNECTIONS

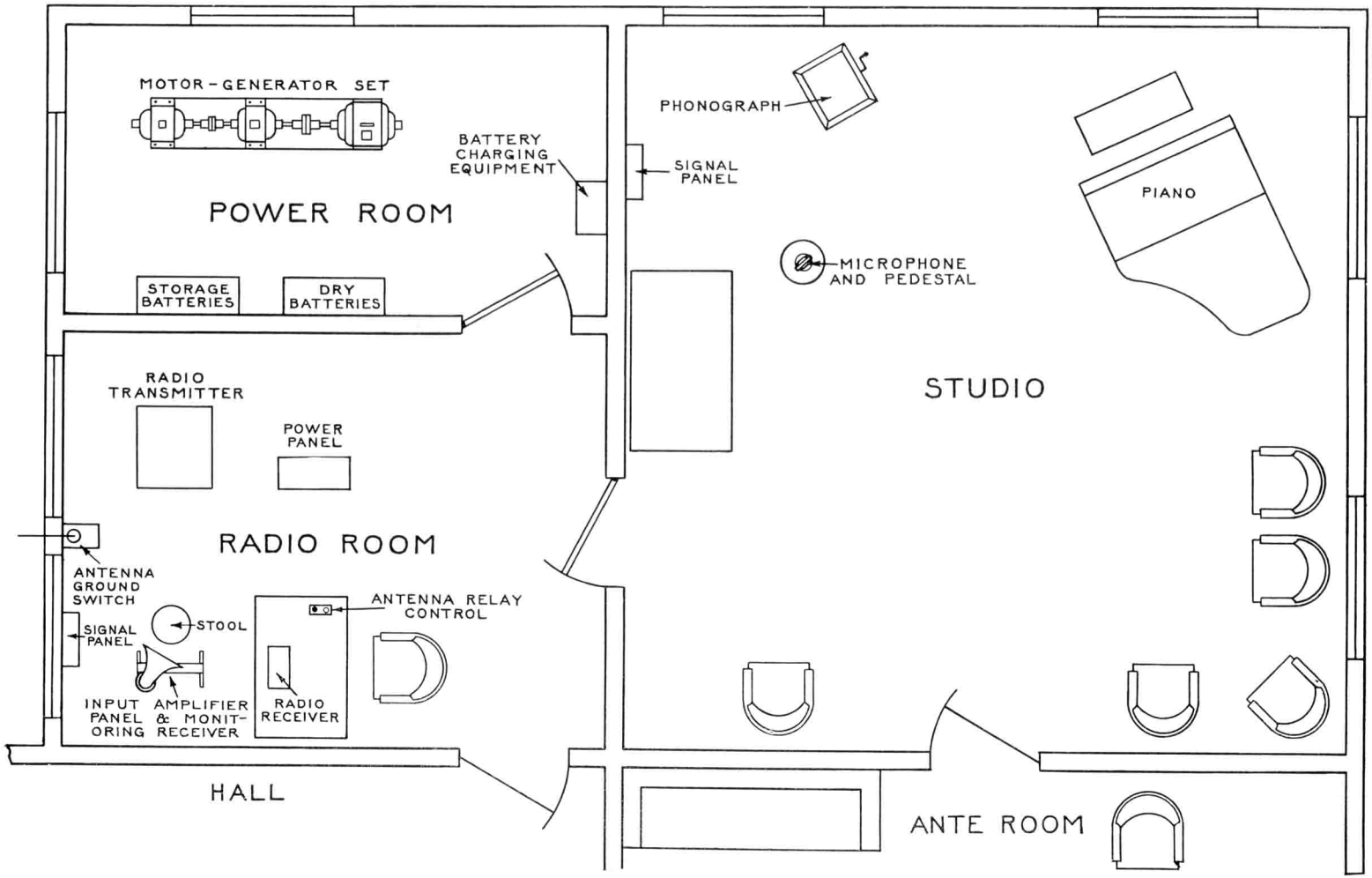

Figure 14
TYPICAL FLOOR PLAN—WESTERN ELECTRIC RADIO TELEPHONE BROADCASTING EQUIPMENT

TYPICAL FLOOR PLAN

A typical layout of a radio telephone broadcasting station making use of either the 1-A or 2-A radio transmitter is shown by figure 14.

The floor space dimensions of the various units are approximately as follows:

No. 1-A Radio Transmitter	**2 ft. by 2½ ft. Aisle space should be left on all sides to permit access to the apparatus.**
No. 2-A Radio Transmitter	
Power board for either No. 1-A or No. 2-A Radio Transmitter	**2 ft. by 1 ft. Aisle space must be left at front and back of equipment.**
Input Amplifier Panel	**22 in. wide, 12 in. deep. Aisle space must be left at front and back of equipment.**
Motor Generator set for No. 1-A Transmitter	**7 ft. 4 in. by 2 ft.**
Motor Generator set for No. 2-A Transmitter	**6 ft. 6 in. by 2 ft.**
No. 2-C Radio Receiver used in connection with both No. 1-A and 2-A Radio Transmitter	**Small cabinet to be mounted on convenient desk or table. Dimensions of table approximately 4 ft. by 3 ft.**

All of this apparatus, with the exception of the motor generator set, may be installed in a room 20 ft. by 15 ft.

The motor generator set should preferably be installed in another room on account of noise tending to increase the difficulty of hearing when receiving.

LOCATION OF MICROPHONE USED FOR BROADCASTING

Except when operating a microphone by speaking close up, it is necessary that this device be operated in a room which has suitable acoustic properties. Particularly when broadcasting vocal and instrumental music the microphone should be installed in a room which is free from resonance effects and echoes which would tend to impair the quality of the sounds to be transmitted.

It is generally necessary that the floor of the room be covered with a heavy carpet and the walls provided with draperies to prevent the reflection of sound.

The proper arrangement of the room in which the microphone is located can as a rule be determined only by experiment. Western Electric engineers are available at all times to assist in making proper lay-outs.

ANTENNA SYSTEM

It is difficult to formulate rules in regard to the best form of antenna system to use in connection with a radio broadcasting station. It generally happens that the locality, building, etc., where the set is to be installed impose the limiting conditions.

Antennae should preferably be installed in the clear. Trees and metal structures, particularly those which would be located directly under the aerial, should be avoided. This statement does not, of course, refer to the metal network used for a counterpoise. This feature is referred to later. If lattice steel towers are necessary for the support of the aerial, a mast structure on top of the framework is desirable in order to remove the aerial as far as possible from the metal work.

The erection of an antenna involving masts or similar structural supports, should not be undertaken without the advice of construction engineers who are familiar with such work. If supporting structures are to be erected on a building, the architect should, of course, also be consulted to make sure that the building supports are adequate.

In the design of the antenna structure and supports, proper consideration should be given to high winds, sleet, etc., which necessitate the provision of adequate safety factors.

Generally speaking, the antenna used with either the No. 101-A or No. 102-A radio telephone broadcasting equipments should have an electrostatic capacity of approximately 1000 micro-farads, and an effective resistance of from 5 to 15 ohms.

Under most conditions these values will be realized with a flat topped antenna from 150 to 200 feet long composed of from 4 to 6 wires with from 4 to 6 feet separation between wires. These wires should preferably be of stranded silicon bronze.

In general, it may be said that the supports for the antenna should be at least 100 feet high. There is no objection to using a greater height, provided the electrical constants are approximately the same as already referred to.

Since the antenna system is a part of the oscillatory circuit, it is essential that the antenna supports be properly guyed to prevent swaying, which, by causing a variation in the capacity of the antenna to ground, might cause a variation in the wave length transmitted.

If the ground conditions in the vicinity of the antenna are not favorable due to soil formation, it may be necessary to use a counterpoise. This in effect is a network of wires installed in or above the ground so as to cover an area two or three times as large as the area of the flat topped antenna. In cases where the antenna is erected on a steel frame building, the steel structure generally provides an excellent counterpoise ground.

PRICES AND DELIVERY

For further information, consult the nearest Western Electric house listed on the back of this bulletin.

Western Electric Company

New York	Atlanta	Chicago	Kansas City	San Francisco
Brooklyn	Savannah	Indianapolis	Oklahoma City	Oakland
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Syracuse	Birmingham	Milwaukee	Memphis	Seattle
Buffalo	Jacksonville	Grand Rapids	Omaha	Portland
New Haven	Richmond	Cleveland	Cincinnati	Spokane
Boston	Norfolk	Minneapolis	Columbus	Tacoma
Providence	Charlotte	St. Paul	Nashville	Denver
Pittsburgh	Youngstown	Duluth	Dallas	Salt Lake City
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A NATIONAL ELECTRICAL SERVICE

International Western Electric Company

195 Broadway **New York, U. S. A.**

Foreign Offices

AFRICA, SOUTH—
Western Electric Company, Ltd., Johannesburg

ARGENTINE—
Cia Western Electric Argentina, Buenos Aires

AUSTRALIA—
Western Electric Company (Australia), Ltd., Sydney

AUSTRIA—
Vereinigte Telephon und Telegraphen Fabriks A. G., Vienna

BELGIUM—
Bell Telephone Manufacturing Co., Antwerp

BRAZIL—
International Western Electric Co., Inc., Rio de Janeiro (Rua dos Ourives 91-1)

CANADA—
Northern Electric Company, Ltd., Montreal

CHINA—
China Electric Company, Ltd., Peking and Shanghai

FRANCE—
Le Materiel Telephonique, Paris

GREAT BRITAIN—
Western Electric Company, Ltd., London, W. C. 2

HOLLAND—
Bell Telephone Manufacturing Co., The Hague

HUNGARY—
United Incandescent Lamps and Electrical Co., Ltd., Ujpest 4 near Budapest

INDIA—
Western Electric Company, Ltd., Simla

ITALY—
Western Electric Italiana, Milan

JAPAN—
Nippon Electric Company, Ltd., Tokyo

NORWAY—
Western Electric Norsk Aktieselskap, Christiania

SPAIN—
Telephonos Bell, S. A. Barcelona (Granvia Layetana 17)

STRAITS SETTLEMENTS—
Western Electric Company, Ltd., Singapore

SWITZERLAND—
Bell Telephone Manufacturing Co., Berne

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