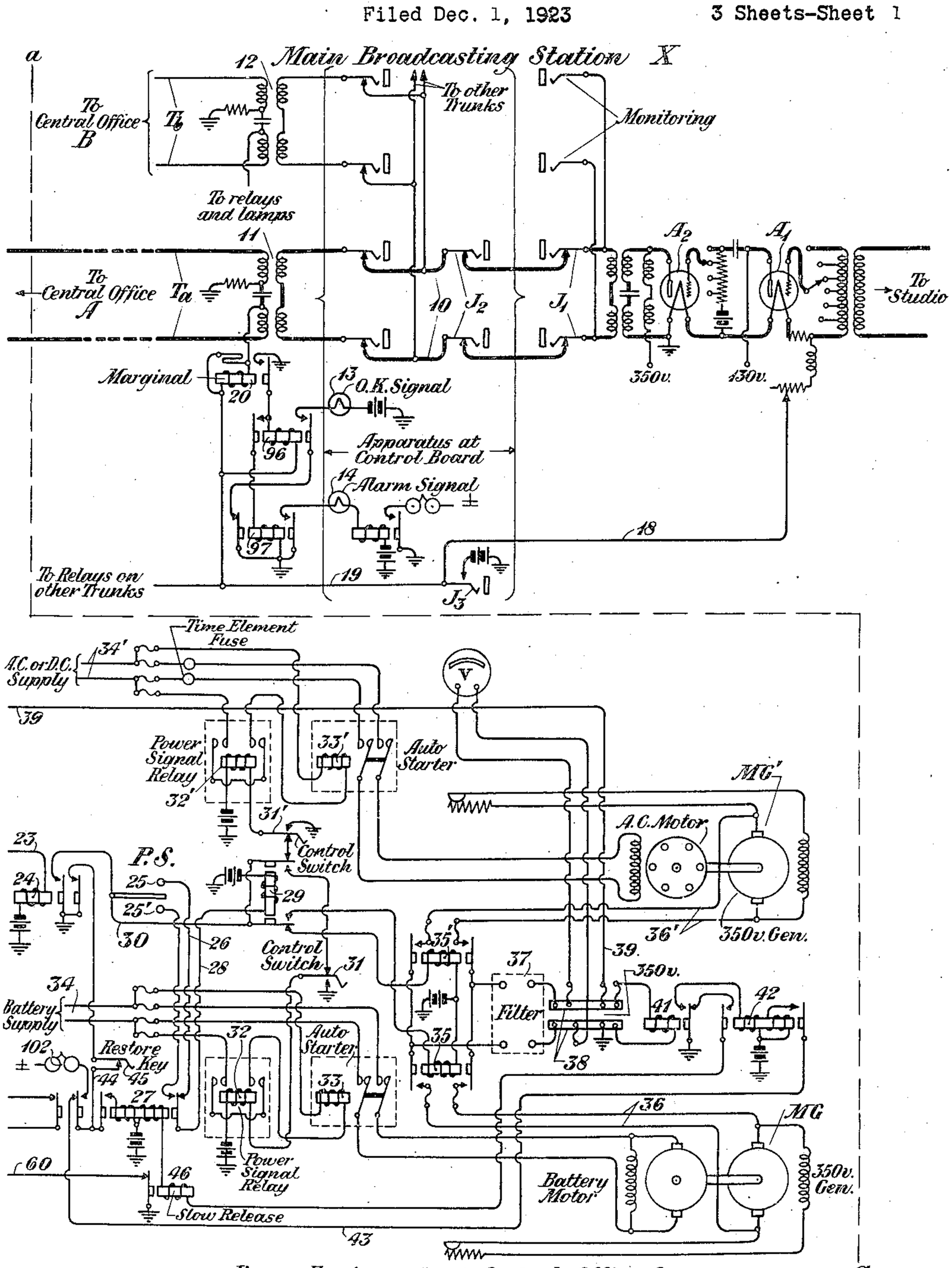
Feb. 3, 1925. 1,525,054

J. F. TOOMEY

POWER AND AMPLIFYING EQUIPMENT FOR DISTRIBUTION OF INTELLIGENCE OVER WIRES

Filed Dec. 1, 1923 3 Sheets-Sheet 1



Power Equipment at Central Office A

Fig. 1

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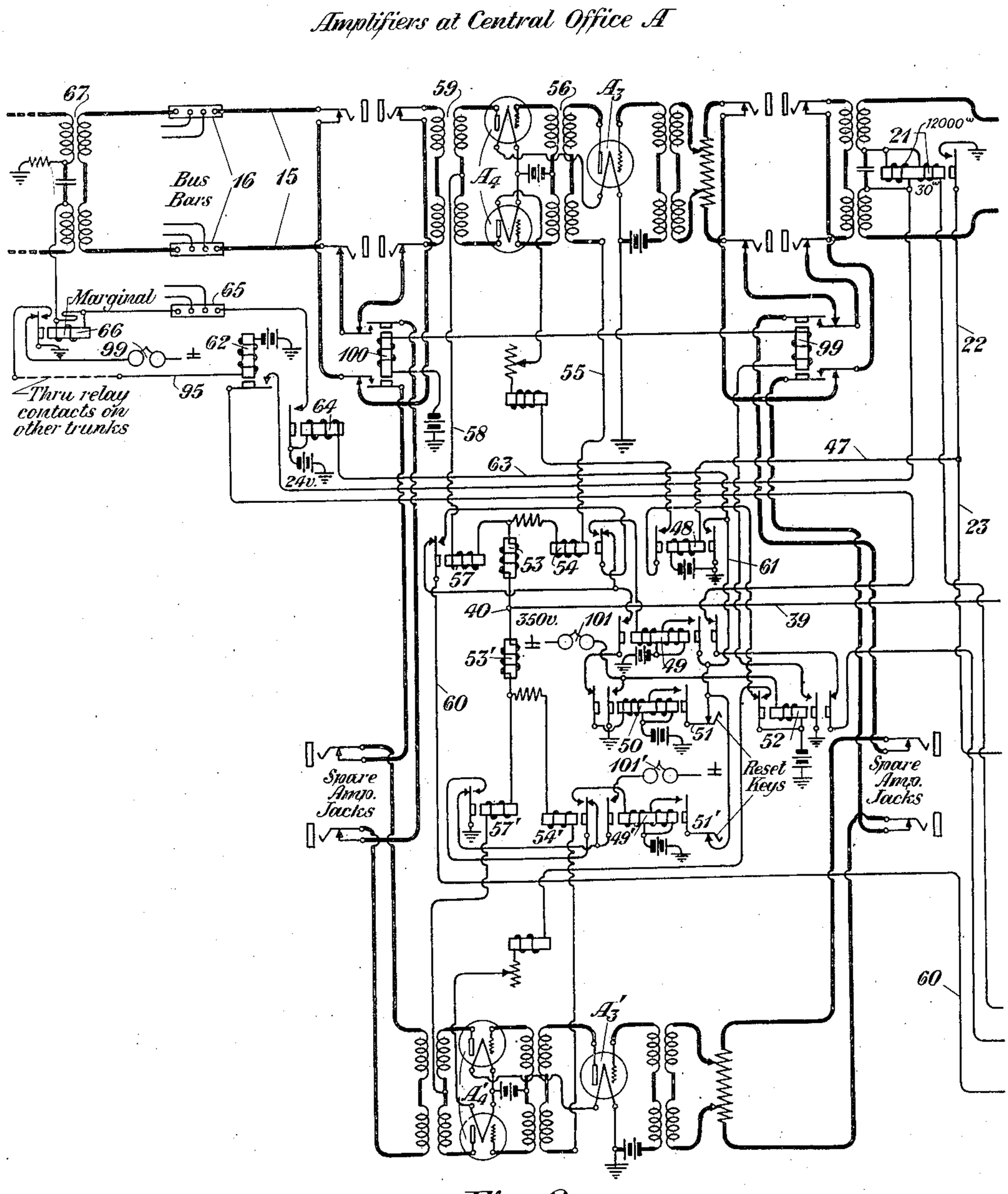

Fig. 2

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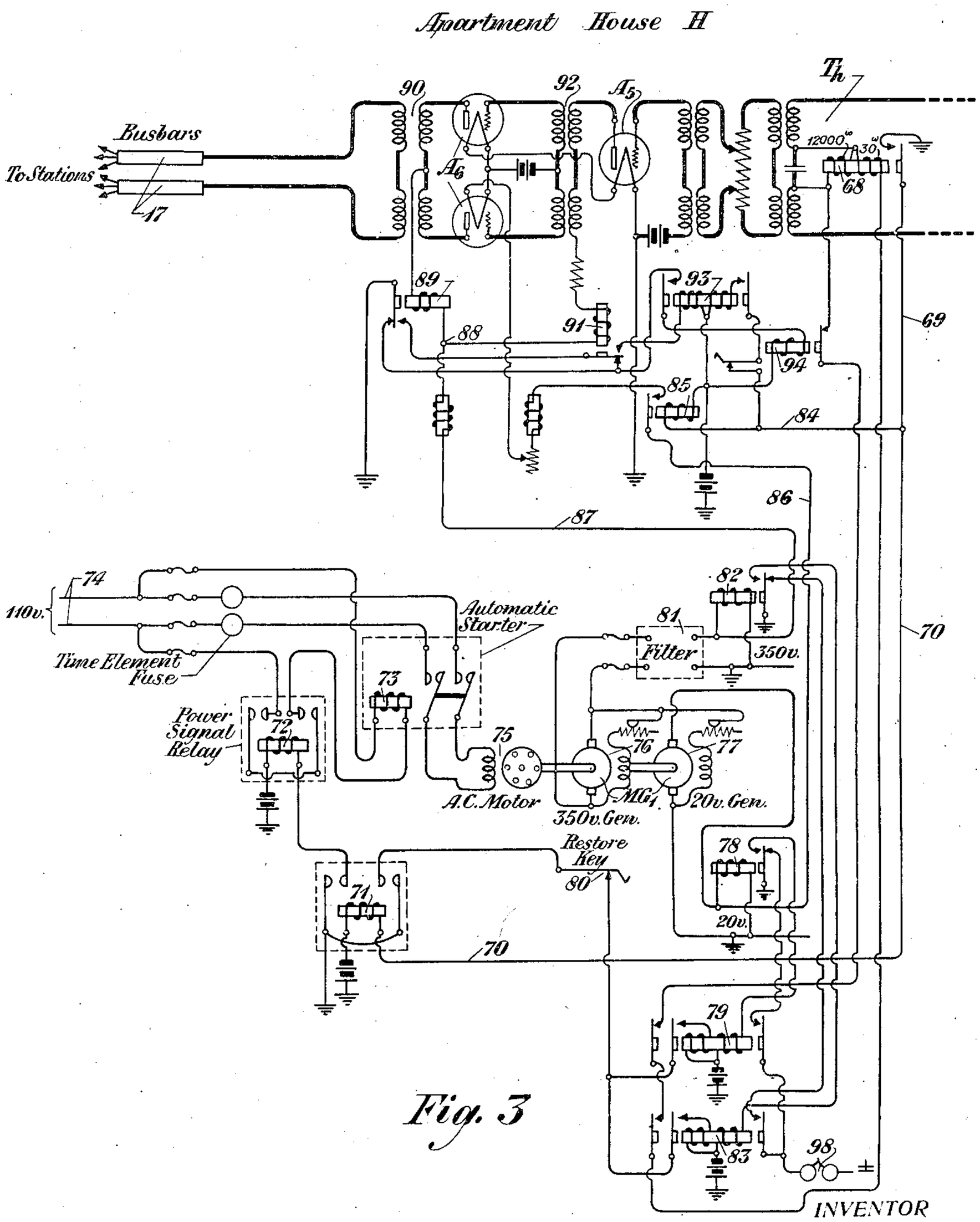

Fig. 3

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Patented Feb. 3, 1925. 1,525,054

UNITED STATES PATENT OFFICE.

JOHN F. TOOMEY, OF NEW YORK, N. Y., ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

POWER AND AMPLIFYING EQUIPMENT FOR DISTRIBUTION OF INTELLIGENCE OVER WIRES.

Application filed December 1, 1923. Serial No. 677,991.

To all whom it may concern:

Be it known that I, JOHN F. TOOMEY, residing at New York, in the county of New York and State of New York, have invented certain Improvements in Power and Amplifying Equipment for Distribution of Intelligence over Wires, of which the following is a specification.

This invention relates to electrical systems for distributing music, news, information and the like, and more particularly to arrangements for such distribution over wires.

In accordance with the present invention, it is proposed to arrange a wire distribution system so that trunks will extend from a main program station to a number of outlying central offices at which suitable amplifying arrangements may be provided. From each central office trunks or local lines will be extended to points in the vicinity of groups of subscribers, such points being, for example, apartment houses or the like. Additional amplifying means may be arranged at these outlying points, and circuits may be extended from such points to the subscribers of the group as, for example, to the various tenants in the apartment house. Suitable sources of power must necessarily be associated with the amplifying arrangements both at the central stations and at the outlying stations, such as the apartment houses.

For the most economical working of such a system, the amplifying arrangements at the central stations and at the local distributing points, such as the apartment houses, should be so arranged that it is unnecessary to provide attendants at either the central offices or the distributing points for maintaining the apparatus in operative condition. Accordingly, one of the objects of the invention is to provide means for enabling the attendant at the main broadcasting station to control, over the trunks used for distribution, the operation of the power and amplifier equipment at the distant central offices and at the distributing points, such as apartment houses, that are involved in the system.

Another object of the invention is to provide means for automatically switching a reserve generator into the circuit at a central office in case of failure of the regular generator which supplies the power for the amplifiers, etc., at that office.

Another object of the invention is to provide means for automatically switching a spare amplifier in the circuit at a central office in case the regular amplifier in use on the circuit is rendered inoperative on account of trouble, such, for example, as the burning out of one of the tube filaments.

Another object of the invention is to provide arrangements such that the reserve generator can be automatically switched in the circuit in case of power failure without switching the spare amplifier.

Still another object of the invention is to provide remote control circuits which include a signaling arrangement for indicating to the attendant at the main station when all of the power apparatus and amplifiers that are associated with a particular circuit are functioning in the proper manner. A further object of the invention is to provide an arrangement such that if any of the amplifying or power equipment or other associated apparatus fails to function the failure is indicated to the attendant at the main station by means of a signal which may preferably be associated with an alarm circuit. The operation of this signal may also be supplemented by local alarm circuits at each central office which indicate to the trouble man (or to the attendant, where one is provided at these places) the particular piece of equipment that has failed.

These objects, as well as other objects of the invention more fully hereinafter appearing, are attained by means of the arrangement set forth in the following description and illustrated in the accompanying drawing in which Figs. 1, 2 and 3, when placed side by side, with Fig. 1 at the right, disclose circuit arrangements of apparatus at the main broadcasting station, at a central office and at an outlying distributing point such as a power house, these circuits comprising a preferred embodiment of the invention.

The apparatus at the main program station is shown above and at the right of the dotted line *a*—*a* in Fig. 1. The power equipment for a central office is shown in the lower part of Fig. 1. The regular amplifier and spare amplifier at a central office together with the associated equipment is shown in

Fig. 2. The amplifier for an outlying distributing point such as an apartment house is illustrated in the upper part of Fig. 3, and the corresponding power equipment is illustrated in the lower part of Fig. 3.

The general features of the apparatus herein disclosed will first be described, the details of the circuits being made clear in connection with the description of the operation of the invention to be given later. It will be understood that the apparatus herein disclosed, while intended primarily for a wire distribution system employing voice frequencies is equally capable of use in connection with a similar system transmitting at carrier frequencies.

Referring to Fig. 1, an amplifying set comprising tubes A_1 and A_2 is provided at the main program station, a connection leading from the studio being associated with the input of the amplifier A_1. The output of the second-stage amplifier A_2 leads through suitable jacks J_1 and J_2 to bus-bars 10 from which branches lead through transformers such as 11, 12, etc., to trunks T_a, T_b, etc., extending to distant central offices. The trunk T_a extends to the central office A, a part of whose equipment is illustrated in Fig. 2. Associated with each trunk as, for example, T_a, is an O. K. signal 13 and an alarm signal 14. The former signal indicates when the apparatus is set into operation that all of the apparatus at the various central stations and outlying distributing points is functioning properly. The latter signal indicates trouble at some point. A switch, such as the jack J_3, common to the various trunks leading to central offices is provided at the program station X for setting the circuits into operation.

At the central office A (see Fig. 2) an amplifying set is provided comprising a first-stage amplifier A_3 and a push-pull amplifier A_4. This amplifying apparatus will normally be included in series with the trunk T_a, but in the event this amplifying arrangement is disabled a spare amplifying set is provided comprising a first-stage amplifier A_3' and a second-stage push-pull amplifier A_4'. Suitable relay arrangements are associated with the amplifiers for automatically switching in the spare amplifier when the main amplifier is disabled, as will be described later. Similar amplifying apparatus and control circuits are provided at the other central offices (not illustrated).

In order to provide the energizing currents for the amplifiers at each central office A, power equipment is provided as illustrated at the bottom of Fig. 1, the particular power apparatus illustrated being located at the central office A, for supplying the amplifiers at that office. The power equipment comprises a motor generator set MG which may be operated from a storage battery, for example, and an alternate motor generator set MG' which may be operated from the usual power mains of an electric lighting system. Both of these generators are designed to generate the desired plate voltage for the amplifying equipment which, in the case illustrated, may be 350 volts. One of these motor generator outfits may be used for regular operation, and the other set may be used as a spare. A power switch PS is provided for determining which motor generator set will be used for regular operation. When the power switch PS is thrown to its upper position, the motor generator set MG will be used in the normal operation of the circuit, and when the power switch is thrown to its lower position the motor generator set MG' will be used in the normal operation.

Suitable switching devices are provided for setting the regular motor generator equipment into operation whenever the main switching jack J_3 at the main program station X is operated. When the motor generator is set into operation, it supplies the space current to the amplifier at the central office A. Suitable switching devices are also provided for switching the alternative motor generator set into the circuit in case trouble develops upon the motor generator set which is regularly used. The details of the switching apparatus will be described more fully hereinafter.

The power amplifying equipment at the central office A is intended to supply amplified program transmission for a number of outlying distributing stations, such as apartment houses, and for this purpose conductors 15 lead from the output side of the amplifying equipment to the bus-bars 16. From these bus-bars trunks lead in multiple to the various distributing points, such, for example, as the apartment house H (see Fig. 3), the latter being connected to the bus-bar 16 through the trunk T_h.

At the distributing point, such as the apartment house H, an amplifying equipment is interposed between the trunk T_h and the bus-bar 17 to which the various extensions are connected which lead to the individual subscribers in the apartment house or elsewhere in the neighborhood. This amplifying equipment comprises a first-stage amplifier A_5 and a second-stage push-pull amplifier A_6. In order to provide the current supply for operating the amplifier, which is a power amplifier, a motor generator apparatus MG_1 is provided, and the motor of this arrangement is designed to be operated from the power mains entering the apartment house or other distributing point. Controlling circuits for starting and stopping the amplifier from the broadcasting station are provided, as will be more fully described hereinafter.

Further details of the apparatus will be clear from a description of the operation which is as follows:

When the program is about to start at the studio, the attendant at the main program station X establishes the circuits in their operating condition at the main program station, the outlying central stations and all of the distant distributing points, such as apartment houses, by inserting an idle plug in the jack J_3. This operation closes the circuit to battery over the contact of the jack and over conductor 18 to the filaments of the amplifiers A_1 and A_2 thereby rendering the amplifier at the main program station operative. A circuit is also closed from battery over the contact of the jack J_3, over the conductor 19, through the marginal relay 20, over the ring side of the trunk T_a leading to the central office A, through the high resistance winding of the relay 21 and back over the tip side of the trunk T_a to ground at the midpoint of the secondary of the transformer 11. Similar circuits are closed by the jack J_3 over all of the other trunks connected to the bus-bars 10. The relay 20, being marginal, is not energized over the circuit including the high resistance winding of the relay 21.

The relay 21, on the other hand, is energized and at its front contact completes a circuit from ground, over the conductor 22, over the conductor 23, through the winding of the relay 24 to battery. The purpose of the relay 24 is to set into operation the motor generator apparatus which is arranged to normally supply the amplifiers at the central office A. Which of the two motor generators MG and MG′ will normally be used is determined by the setting of the power switch PS.

Assuming that the power switch is thrown to its upper contact 25, a circuit is closed from ground, over the inner front contact of the relay 24, over the switch PS, contact 25, conductor 26, right-hand back contact of relay 27, conductor 28, and through the winding of relay 29 to battery. Relay 29, upon being energized, completes a circuit over its upper front contact from ground, over the inner contact of relay 24, conductor 30, upper front contact of relay 29, through the control switch 31, and through the winding of power signal relay 32 to battery. Power signal relay 32, upon being energized, connects the automatic starter magnetic switch 33 into circuit with the power mains 34 leading to the storage battery supply source for operating the motor generator MG. The automatic starter magnet 33 is accordingly energized and connects the motor generator set MG to the power mains 34, so that the motor generator now starts to operate. It will be obvious from the circuit that the motor generator MG may be started locally by an attendant upon throwing the switch 31 to its lower position thereby energizing the power signal relay 32.

Returning to relay 29, a circuit is closed over its lower front contact from ground, over the inner front contact of relay 24, conductor 30, lower front contact of relay 29 and through the winding of relay 35 to battery. Relay 35, upon being energized, connects the output conductors 36 of motor generator MG over its front contacts and through the filter 37 to the power bus-bars 38. A conductor 39 leads from the power bus-bars to point 40, so that when the motor generator MG reaches its full speed a voltage of about 350 volts will be supplied to the point 40 for energizing the plate circuits of the central office amplifiers, as will be described later. As soon as the motor generator MG reaches its full speed and generates the proper voltage for the bus-bars 38, the relay 41 is energized and completes a circuit at its front contact for the left-hand winding of the relay 42. Relay 42 is then locked up from battery, through its left-hand winding and over its right-hand front contact, over conductor 43, middle left-hand back contact of relay 27, conductor 44, restore key 45, and over the outer front contact of relay 24 to ground. Relay 42 produces no circuit translation at this time, its purpose being to control a trouble signal circuit as will be described later.

In the event the motor generator set MG′ is to be used as the normal source of power supply, the power switch PS will be thrown into its lower contact 25′ in which case no circuit would be completed for the relay 29 upon the energization of relay 24, since the circuit of the relay 29 would now be open at the right-hand back contact of relay 27. Consequently when the relay 24 is energized, a circuit is completed for the power signal relay 32′ from ground, over the inner front contact of relay 24, conductor 30, upper back contact of relay 29, over the control switch 31′, and through the winding of the power signal relay 32′ to battery. The power signal relay, upon being energized, connects the automatic starter switch 33′ to the power mains 34′. The automatic starter switch 33′ is thereby closed and connects the power mains to the motor of the motor generator apparatus MG′ thereby setting the apparatus into operation.

A circuit is also completed for the relay 35′ from ground, inner front contact of relay 24, conductor 30, lower back contact of relay 29, and through the winding of relay 35′ to battery. Relay 35′ connects the output conductors 36′ of the motor generator set MG′ to the bus-bars 38, and through the filter 37. Consequently the current for supplying the plate circuit to the amplifiers will be generated by the motor generator

MG'. As soon as the motor generator MG' reaches its full speed and generates the desired voltage, the relay 41 will be operated with the results previously set forth.

Returning now to the relay 21, which it will be recalled was energized at the time the plug was inserted in the jack J_3 at the main program station, it will be observed that the relay 21 closed a circuit from ground, over its front contact, over the conductors 22 and 47, and through the winding of relay 48 to battery. Relay 48, upon being energized, closes the filament circuit of the normal amplifying set as follows: from the 24 volt battery, over the left-hand back contact of relay 52, left-hand front contact of relay 48, through the impedance coil and resistance and thence through the filaments of the amplifying arrangements A_4 and A_3 in series to ground.

The filaments of the normal amplifiers A_3 and A_4 are now caused to glow, thereby permitting the space current to flow. The space current for the amplifier A_3 will flow from the point 40 (which is connected to the bus-bars 38 of the motor generator set), through impedance coil 53, relay 54, over the conductor 55, and through the primary winding of the transformer 56 to the plate of the amplifier. Similarly, the space current for the amplifier A_4 flows from the point 40, through the impedance coil 53, winding of the relay 57, over conductor 58 to the midpoint of the primary windings of the transformer 59, and thence to the plates of the two tubes of the amplifier A_4.

Relays 54 and 57 are energized by the plate currents and complete a circuit for the right-hand winding of the relay 49 as follows: from ground, over the back contact of relay 46 of the power equipment (this relay is deenergized when the power equipment is normal), over conductor 60, front contact of relay 57, front contact of relay 54, and through the winding of relay 49 to battery. Relay 49 is energized and is locked up through its right-hand winding and inner right-hand front contact, and over the conductor 61 and right-hand front contact of relay 48 to ground. At its right-hand front contact relay 49 prepares the circuit through the low resistance winding of the relay 21 of the trunk T_a, this low resistance path being actually completed when the relay 62 is energized in response to the establishment of the circuits at all of the apartment house distributing points as will be described later. When the low resistance shunt path of the relay 21 is completed, a signal will be given at the main program station as will be hereinafter set forth.

Returning again to the relay 48, a circuit is completed by the actuation of this relay from ground, over its right-hand front contact and over conductor 63, through winding of relay 64 to battery. The relay 64 is thereupon energized and connects battery to the bus-bar 65. Associated with each trunk leading from the bus-bars 16 is a relay such as 66, and one terminal of each relay of this type is connected to the bus-bar 65. Consequently when the relay 64 pulls up, a circuit will be completed for each of the relays such as 66. The circuit of this particular relay is from battery, over the front contact of relay 64, bus-bar 65, winding of relay 66 to the midpoint of transformer 67, over the ring conductor of trunk T_b, through the high resistance winding of relay 68, over the tip conductor of the trunk T_b, and through the upper half of the secondary winding of transformer 67 to ground.

Relay 66 is marginal and is not energized in series with the high resistance winding of the relay 68. Relay 68 attracts its armature, however, and completes a circuit from ground, over said armature, over conductor 69, conductor 70, through the winding of relay 71 to battery. Relay 71 completes a circuit over its left-hand front contact from ground, through the winding of the power signal relay 72 to battery. Power signal relay 72 in turn connects the winding of the automatic starter magnetic switch 73 to the power mains 74, thereby energizing the automatic starter switch. This switch, when closed by its magnet coil connects the power mains 74 to the motor element of the motor generator set MG_1.

The motor generator set MG_1 comprises a motor and two generators 76 and 77 respectively. The generator 76 generates a voltage of 350 volts for supplying the space current of the amplifying set at the apartment house or other distributing point. The generator 77, on the other hand, generates approximately 20 volts for supplying the filament current of the tubes of the amplifier. As soon as the motor generator set attains its full speed, 20 volts will be applied to the terminals of the relay 78 which is bridged across the generator terminals, and this relay will accordingly be energized to complete a circuit for the right-hand winding of relay 79. Relay 79 locks up over a circuit from battery, through its left-hand winding, and over its inner left-hand contact, through the restore key 80 and over the right-hand front contact of relay 71 to ground. At its outer left-hand contact relay 79 prepares the circuit of the low resistance shunt winding of the relay 68 as will be described later.

The 350 volt generator 76 of the motor generator set MG_1 is connected through a filter 81 to the terminals of the winding of relay 82. This relay is energized when the full voltage of the generator 76 is reached

and at its front contact closes a circuit through the right-hand winding of relay 83. Relay 83, upon being energized, completes a locking circuit from battery, over its left-hand front contact, and over the key 80 and right-hand front contact of relay 71 to ground. At its outer left-hand front contact relay 83 closes the circuit of the low resistance shunt winding of the relay 68 at another point.

Returning again to relay 68, a circuit is completed from ground, over its front contact, over conductor 69, conductor 84 and through the winding of relay 85 to battery. Relay 85, upon being energized, closes the filament circuit of the amplifying apparatus A_5—A_6 from the 20 volt terminal of the generator 77 over the conductor 86, front contact of relay 85, through a choke coil and resistance and thence through the filaments of the amplifiers A_6 and A_5 in series to ground. The filaments are thereby caused to glow so that the space current flows through the tubes. The space current is supplied to the plates of the amplifying tubes, over a circuit from the 350 volt terminal of the generator 76, over conductor 87 to the point 88. From this point a circuit extends through the winding of the relay 89 to the midpoint of the primary windings of the transformer 90 and thence to the plates of the two tubes of the amplifier 86. A circuit also extends from the point 88, through the winding of the relay 91, through the primary winding of the transformer 92 to the plate of the amplifier A_5.

As soon as the plate current flows through the amplifying tubes, the relays 89 and 91 are energized, completing a circuit from ground, over the front contacts of said relays in series and through the left-hand winding of relay 93 to battery. Relay 93, upon being energized, completes a locking circuit from battery, through its right-hand winding and right-hand front contact and thence over conductors 84 and 69 to ground over the contact of relay 68. The relay 93 at its left-hand front contact prepares a circuit for the relay 94 so that if either the relay 89 or 91 should be deenergized the circuit for the relay 94 will be completed.

The relay 94, by means of its contact, exercises control over the circuit of the low resistance winding of the relay 68 previously referred to. If the amplifiers are in proper working order when the motor generator set is started in operation, the relay 94 will not be energized, and hence the low resistance shunt winding of the relay 68 will have its circuit completed as soon as the relays 79 and 83 are energized, the low resistance shunt circuit extending over the back contact of the relay 94 and over the front contacts of the relays 79 and 83 in series. Consequently when the motor generator set is started into operation and the amplifying equipment is functioning normally, the resistance of the relay 68 will be reduced, thereby causing the marginal relay 66 to be energized.

Similar operations take place in connection with other trunks leading to apartment houses and other distributing points, and if the apparatus associated with the various trunks is functioning normally, relays corresponding to 66 will be energized for each trunk. A circuit will then be completed from ground, over the front contact of the relay 66 and over contacts of other relays such as 66 (not shown), and then over the conductor 95 and through the winding of the relay 62 to battery. It will be recalled that when the motor generator set at the central office A was started into operation and the amplifying apparatus at said central office supplied with its operating currents, the relay 49 was energized, preparing the circuit of the low resistance shunt winding of the relay 21 at its outer right-hand contact. The contact of the relay 62 is in series with the outer right-hand contact of the relay 49, and consequently when both of these relays have been energized (which can only take place when all of the apparatus is functioning normally), the circuit of the low resistance shunt winding will be completed, thereby reducing the resistance in series with the marginal relay 20. Marginal relay 20 is thereupon energized, and at its front contact completes a circuit from ground through the winding of relay 96, conductor 19 and the contact of the jack J_3 to battery. The relay 96 upon being energized completes a circuit for the O. K. signal lamp 13 from battery, through said lamp, over the right-hand front contact of relay 96, over the left-hand back contact of the relay 97 to ground. This indicates to the attendant at the main program station X that all of the equipment is in proper order and functioning normally.

We will now consider what takes place in the event trouble develops in the equipment at the local distributing point such as an apartment house. If the 20 volt generator 77 should not function properly, the relay 78 will be deenergized and a circuit will be completed from ground over its back contact and over the front contact of relay 79 to actuate a local signal 98. The current supply for the filaments of the amplifiers A_6 and A_5 will also be interrupted or reduced if the generator 77 is not functioning properly, thereby either interrupting or reducing the plate current of these tubes. This will cause the relays 89 and 91 to fall off and complete a circuit from ground, over the back contacts of relay 89, over the left-hand front contact of relay 93, through the winding of relay 94 to battery. Relay 94

will therefore be energized and open the low resistance shunt of the relay 68 with results that will be described hereinafter.

If the 350 volt generator is not functioning properly, the relay 82 will fall off and complete a circuit over its back contact and the right-hand front contact of the relay 83 for the signal 98. The space current of the tubes of the amplifiers A_6 or A_5 will also be interrupted or reduced by trouble on the generator 76 so that the relays 89 and 91 will fall off, completing the circuit of the relay 94 and thereby opening the low resistance shunt of relay 68 as above described.

Similarly, if the motor 75 should develop trouble, or if the conductors of the power mains should be interrupted, relays 78 and 82 would both be deenergized to actuate the signal 98, and the filament space current of the amplifiers A_5 and A_6 would cease flowing so that the relay 94 would be energized over the back contact of relay 89 to open the low resistance shunt of the relay 68.

If a filament of one of the tubes of the amplifying apparatus A_5 and A_6 should burn out, the filaments of all of the tubes would cease to glow, as they are connected in series. Accordingly, the space currents would be interrupted and the relays 89 and 91 be deenergized, thereby completing the circuit of the relay 94 to open the low resistance shunt of relay 68. If, for any reason, the space current should cease to flow through the amplifier A_5, the relay 91 would be deenergized, thereby completing the circuit from ground, over the front contact of relay 85, over the back contact of relay 91 and over the left-hand front contact of relay 93, through the winding of the relay 94 to battery. The relay 94 would therefore open the low resistance shunt of the relay 68 as before. Similarly, if the space current of the amplifier 86 should cease flowing for any reason, the relay 89 will be deenergized to complete the circuit of the relay 94 and interrupt the shunt of the relay 68.

Obviously any trouble in the motor generator set or in the amplifying equipment at the apartment house H will result in the energization of the relay 94 and the opening of the low resistance shunt of the relay 68. When this shunt is open, the resistance in series with the relay 66 individual to the trunk T_h at the central office A will be increased, and the relay 66 will be caused to fall off, thereby completing an alarm signal circuit 99 at the central office and at the same time deenergizing the relay 62. Relay 62 opens the low resistance shunt for the relay 21 of the trunk T_a, thereby increasing the resistance of the circuit of the marginal relay 20 at the main program station. The relay 20 thereupon releases its armature, opening the short circuit to the winding of the relay 97 whose circuit is now completed from ground, through its winding, over the front contact and through the winding of the relay 96, over the conductor 19, over the contact of jack J_a to battery. Relay 97, upon being energized, opens the circuit of the O. K. signal 13 at its left-hand contact and completes the circuit of the alarm or trouble signal 14 at its right-hand front contact.

The attendant at the main program station is thus informed that trouble has developed somewhere upon the circuit supplied by the trunk T_a. If there is no trouble man at the central office A the attendant may then go to the central office A, and by determining which relay, such as 66, is deenergized will at once know that the trouble is local to the apartment house H. The attendant may then go to the apartment house H and make the necessary repairs or adjustments.

At the central office A the equipment is so arranged that if one amplifying set becomes disabled by reason of the filament burning out or the plate circuit being interrupted, a spare amplifier is switched into its place automatically. It will be seen that since the filaments of the amplifiers A_3 and A_4 are connected in series, if one filament burns out the plate current ceases to flow in all three tubes, thereby causing relays 54 and 57 to be deenergized. A circuit is thereby completed for the relay 50 from ground, over the back contact of the relay 46 of the power equipment, over conductor 60, back contact of relay 57, front left-hand contact of relay 49, through the winding of relay 50 to battery. If the plate circuit of the amplifier A_4 is interrupted the relay 57 only will be deenergized, but the circuit of the relay 50 will be completed in the same manner as just described. In case the plate circuit of amplifier A_3 is interrupted, relay 54 only is deenergized in which case the relay 50 is energized over a circuit previously traced to conductor 60 and thence over the front contact of relay 57, back contact of relay 54, front left-hand contact of relay 49, and through the winding of the relay 50 to battery.

In any one of these cases the relay 50 is energized and is locked up over a circuit from battery, over its right-hand winding and over its right-hand front contact, over the key 51, over the conductor 61 and over the right-hand front contact of relay 48 to ground. At its inner left-hand front contact relay 50 closes the circuit of relay 52. Relay 52, upon being energized, at its left-hand contact shifts the connection of the filament battery from the filament circuits of the amplifiers A_3 and A_4 to the filament circuit of the spare amplifying equipment A_3'—A_4'. The new circuit is as follows: from 24 volt battery, left-hand front contact

of relay 52, through the choke coil and resistance, and thence through the filaments of amplifiers A_4' and A_3' in series to ground. As soon as the filaments glow and the electron emisson starts, the space current in the tubes passes through the choke coil 53′ and thence in parallel through the relays 57′ and 54′ to the plates of the tubes of the amplifiers A_4' and A_3' respectively.

The energization of relays 54′ and 57′ causes a circuit to be completed from ground, over the front contact of relay 57′, front contact of relay 54′, and through the right-hand winding of relay 49′ to battery. Relay 49′ is locked up from battery, through its right-hand winding and over its right-hand front contact, over the reset key 51′, and thence to ground over the right-hand front contact of relay 48. At its left-hand front contact relay 49′ prepares a circuit for a trouble signal, which circuit will be completed in case either or both of the relays 54′ or 57′ are deenergized. Consequently if any failure occurs either in the filament circuit or in the plate circuits of the amplifiers A_3' and A_4', the local trouble signal controlled by the relay 49′ will be operated.

Returning again to relay 52, a circuit is completed from ground, over its inner right-hand front contact, and through the windings of relays 99 and 100 to battery. The relays 99 and 100, upon being energized, disconnect the terminals of the amplifying equipment A_3 and A_4 from the trunk T_a and the conductors 15 and substitute the now operating amplifying equipment A_3'—A_4' instead. Returning to relay 50 the left-hand contact of said relay 50 completes a circuit for the local trouble signal 101, so that if an attendant is on duty at the central office he may locate the trouble and repair it.

At the same time it is desirable to give a signal at the main program station X. This is accomplished by having the circuit so arranged that when the relay 52 is energized to shift the amplifier connections its outer right-hand contact opens the low resistance shunt of the relay 21, this low resistance shunt circuit being under the joint control of relays 49 and 52 of the amplifying equipment, relay 27 of the power equipment, and relay 62 individual to the outgoing trunk T_h. Accordingly, the resistance in series with the marginal relay 20 is increased when the amplifier connections are shifted, and the alarm signal 14 at the main program station will be actuated in a manner already described.

Since the amplifying equipment and power apparatus at the central office A will, in general, be located at a central office of a telephone system where maintenance men are usually on duty, the local signals at the central office will apprise such maintenance men of the trouble so that it may be taken care of without sending an attendant out from the main program station. Consequently the attendants at the main program station may disregard the alarm signal given at that station unless it continues for an unreasonable length of time. In the latter case the attendant at the main program station may communicate with a maintenance man at the central office, requesting him to look after the difficulty, or if for some reason it cannot be taken care of at the central office someone may be sent from the main program station to locate the trouble.

Where the amplifying apparatus A_3 and A_4 has failed and the amplifying apparatus A_3' and A_4' have been substituted therefor, the trouble may be located and overcome by well known methods. Usually the difficulty will be that the filament of one of the vacuum tubes has failed, and merely by inserting a new tube in the socket the amplifier circuit will again be in good condition. When it has been tested the trouble man will open the key 51, thereby opening the locking circuit of the relay 50. The initial energizing circuit of the relay 50 is held open over its outer left-hand front contact, and consequently the relay 50 is deenergized when the key 51 is open. The deenergization of this relay opens the circuit of the relay 52 at the inner left-hand contact of the relay 50, so that the relay 52 releases its armature. Accordingly the low resistance shunt of the realy 21 is again closed at the outer right-hand contact of the relay 52. The left-hand contact of the relay 52 now opens the filament circuit of the amplifying equipment A_3'—A_4' and closes the filament circuit for the amplifying equipment A_3—A_4 as previously described. Relay 52 also releases relays 99 and 100 to cut in the amplifying equipment A_3—A_4. The apparatus will now be in normal condition.

If, while the amplifying equipment A_3—A_4 was out of service, the amplifying equipment A_3'—A_4' had also failed so that the signal 101′ was actuated, the trouble man would, after repairing the trouble in both amplifiers, actuate the reset key 51′ as well as the reset key 51, thereby restoring the relay 49′ to normal.

The manner in which the power equipment at the central office A functions when trouble develops will now be considered. Assuming that the switch PS is thrown to its upper contact 25 so that the motor generator set MG is running to supply the space current to the amplifiers as already described, it will be remembered that under these conditions the relay 41 is energized and the relay 42 locked up. If the generator MG should fail, the relay 41 would be released, thereby closing a circuit over

its back contact and over the front contact of relay 42, through the winding of relay 46 and right-hand winding of relay 27 to battery. Relay 46 disconnects ground from conductor 60 thereby preventing the relays 54 and 47 (which will be released when the power fails) from closing the circuit of the relay 50. Consequently the relay 52 of the amplifying equipment will not be energized to shift the connection from one amplifier to the other merely because the power fails.

Relay 27, upon being energized, is locked up over a circuit from ground, over the outer front contact of the relay 24, through the restore key 45, and over the inner left-hand front contact, and through the left-hand winding of relay 27 to battery. The middle left-hand contact of relay 27 opens the locking circuit of the relay 42, permitting the latter relay to become deenergized, and closes a local signal circuit through the bell 102, through the restore key 105, and over the outer right-hand contact of relay 24 to ground. At its outer left-hand contact relay 27 opens the low resistance shunt of the relay 21 in the trunk circuit T^a, thereby causing the alarm signal 14 at the main program station to be actuated as already described.

At its right-hand contact relay 27 opens the circuit of the relay 29 (which it will be remembered was energized when the circuit was set into operation with the switch PS on its upper contact 25). The deenergization of relay 29 opens the circuit previously traced for relays 32 and 35, thereby causing the autostarter switch 33 to be released and the generator MG to be disconnected from the bus-bars 38. At the same time a circuit is closed for the power signal relay 32′ from ground, over the inner front contact of relay 24, upper back contact of relay 29, control switch 31′, and through the winding of relay 32′ to battery. Relay 32′ connects the electromagnet 33′ of the autostarter switch to the power mains 34′, thereby causing the switch to be actuated to connect the operating circuit of the motor generator set MG′ to the power mains 34′. The motor generator set MG′ is accordingly set into operation. A circuit is also closed through the relay 35′ from ground, over the inner front contact of relay 34, conductor 30, lower back contact of relay 29 and through the winding of relay 35′ to battery. Relay 35′ connects the output circuit of the motor generator set MG′ through the filter 37 to the bus-bars 38.

When this occurs and the motor generator set is in full operation, a generated voltage of 350 volts will be supplied to the amplifier apparatus over the conductor 39, and the relay 41 will be energized. This will cause the relay 42 to again be energized and locked up over circuits previously traced. The relay 42, upon releasing its left-hand armature, has previously opened the circuit recently traced for the relay 46 through the right-hand winding of the relay 27. Relay 46, which is sufficiently slow in releasing to permit the spare generator to be cut in, will accordingly be deenergized and will again connect ground to the conductor 60, so that if the amplifying apparatus A_3—A_4 fails, the spare amplifier will be connected into the circuit. The relay 27, however, will remain locked up so that the signal 102 at the central office will continue to be actuated, and the signal 14 at the main program station will also remain actuated.

A trouble man at the central office A, if one is available, may, upon observing the signal 102, run down the trouble. If no trouble man is available at the central office A, the attendant at the main program station may, upon observing the signal 14, go to the central office A to determine the cause of the difficulty. Upon determining that it is the generator MG which has developed trouble, the trouble man may open the switch PS, then actuate the restore key 45 to open the locking circuit of the relay 27 and thereafter connect the switch PS to the contact 25. The relay 27, upon being deenergized, will open the circuit of the local signal 102 and will close the low resistance shunt of the relay 21, so that the alarm signal 14 at the main program station will be restored to normal.

The generator may then be repaired, and after it has been repaired the spare generator MG′ may be permitted to continue supplying the current so long as the switch PS is on its lower contact 25′. If, under these conditions, the motor generator MG′ should develop trouble, the relay 41 will be released, closing the circuits of relays 46 and 27. The latter opens the locking circuit of the relay 42 and restores it to normal, as already described, and at the same time shifts its right-hand contact so that the circuit for the relay 29 is closed from ground, over the inner front contact of relay 24, over the switch PS, contact 25′, right-hand front contact of relay 27, conductor 28, through the winding of relay 29 to battery. Relay 29, by shifting its upper and lower contacts to their front positions, thereby deenergizes power signal relay 32′ and relay 35′. Accordingly the autostarter switch 33′ is opened to disconnect the power from the motor generator MG′, and the output of the generator is disconnected from the bus-bars. At the same time the circuits of the power signal relay 32 and the switching relay 35 are closed to set the motor generator MG into operation and connect its output circuit to the bus-bars. Relay 41 then again pulls up its armature and the relay 42 is energized and locked up in the man-

ner already described. Relay 46 in the meantime is deenergized to permit the automatic switching of the amplifiers in case one should fail. Relay 27 remains locked up so that the signal at the local central office and also the signal at the main program station will be given as before. The trouble may now be run down in the manner already described in connection with the other motor generator.

If while the switch PS remained on its lower contact 25′, with the motor generator MG′ supplying the amplifiers while the motor generator MG was repaired, it is desired to again cut in the motor generator MG after the repairs have been made, it is only necessary to shift the switch PS to its upper contact 25, the relay 27 having been restored by the restore key as already described. A circuit will at once be closed from ground, over the inner front contact of relay 24, switch PS, contact 25, conductor 26, back right-hand contact of relay 27, conductor 28, through the winding of relay 29 to battery. Relay 29 attracts its armature, thereby stopping and disconnecting the motor generator MG′ and at the same time starting the motor generator MG and connecting its output circuit to the bus-bars as already described.

When the transmission from the studio ceases, the attendant at the program station may withdraw the idle plug from the jack J_3 and restore all of the apparatus to normal. The opening of the contact of the jack J_3 disconnects battery from the conductor 18 and thereby opens the filament circuit of the amplifiers A_1 and A_2 at the program station. At the same time the circuit of the relay 96 is opened so that the O. K. signal 13 is restored to normal. The circuit through the marginal relay 20 and the distant trunk relay 21 is opened, restoring both relays to normal. Relay 21, upon being released, disconnects ground from conductor 22 thereby restoring relay 24 to normal. Relay 24, upon releasing its armature, opens the circuit of the relay 29 if the switch PS is on its upper contact 25 and disconnects ground from the circuits of power signal relay 32 and from relay 35. The magnetic switch 33 is accordingly thus restored to normal thereby stopping the motor generator, and at the same time relay 35 disconnects the motor generator from the bus-bars.

Returning again to relay 21, the disconnection of ground from conductor 22 releases relay 48, which in turn opens the filament circuit previously described for the amplifiers A_3 and A_4 and at the same time disconnects the ground from conductor 61 to restore relay 49 to normal. Relay 48, upon being released, also disconnects ground from conductor 63, thereby releasing the relay 64. Relay 64 in turn opens the circuits of the relays, such as 66, of all of the trunks connected to the bus-bars 16, thereby releasing the relay 62. The relays, such as 68, of all of the trunks are also released. Relay 68 disconnects ground from conductors 69 and 70 thereby opening the circuit of the relay 71, which in turn opens the circuit of the power signal relay 72. The latter releases the automatic starter switch 73 so that the motor generator MG′ is stopped and the relays 78 and 82 released. The locking circuits of relays 79 and 83 were opened when the relay 71 was released, and the initial energizing circuits of these relays are opened by the relays 78 and 82, so that both relays are restored to normal.

Disconnection of ground from conductor 69 by the relay 68 opens the circuit of relay 85, which in turn breaks the filament circuit of the amplifiers A_5 and A_6. The space current now ceases to flow so that relays 89 and 91 are restored to normal, thereby opening the circuit of the left-hand winding of relay 93. The circuit of the right-hand locking winding of said relay is opened by the disconnection of ground from conductor 84, so that this relay is restored to normal and the apparatus at the local distributing point is in its original condition.

It will be obvious that the general principles herein disclosed may be embodied in many other and widely varied forms without departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. In a distribution system, a main program station, trunks extending from said main station to outlying stations, amplifying equipment associated with each trunk at the outlying station, and signaling means operated upon failure of the amplifying equipment.

2. In a distribution system, a main program station, trunks extending from said main station to outlying stations, amplifying equipment associated with each trunk at the outlying station, and signaling means at the main station operated upon failure of the amplifying equipment at an outlying station.

3. In a distribution system, a main program station, trunks extending from said main station to outlying stations, amplifying equipment associated with each trunk at the outlying station, and signaling means at the main station corresponding to each trunk and means to operate the signal which corresponds to a given trunk at the main station upon failure of the amplifying equipment associated with that trunk.

4. In a distribution system, a main program station, trunks extending from said main program station to a plurality of outlying stations, two sets of amplifying equipment at each outlying station, one set being normally associated with the trunk, and

means to automatically connect the other amplifying equipment to the trunk upon failure of said first mentioned equipment.

5. In a distribution system, a main program station, trunks extending from said main program station to a plurality of outlying stations, two sets of amplifying equipment at each outlying station, one set being normally associated with the trunk, means to automatically connect the other amplifying equipment to the trunk upon failure of said first mentioned equipment, and means to actuate a signal when said first mentioned set of amplifying equipment fails.

6. In a distribution system, a main program station, trunks extending from said main program station to a plurality of outlying stations, two sets of amplifying equipment at each outlying station, one set being normally associated with the trunk, means tc automatically connect the other amplifying equipment to the trunk upon failure of said first mentioned equipment, and means to actuate a signal at the main station when said first mentioned set of amplifying equipment fails.

7. In a distribution system, a main program station, trunks extending from said main program station to outlying stations, translating apparatus associated with each trunk at the outlying station, power equipment at each outlying station for energizing said translating apparatus, and means to indicate failure of the power equipment.

8. In a distribution system, a main program station, trunks extending from said main program station to outlying stations, translating apparatus associated with each trunk at the outlying station, power equipment at each outlying station for energizing said translating apparatus, and means at the main station for indicating failure of the power equipment at an outlying station.

9. In a distribution system, a main program station, trunks extending from said main program station to outlying stations, translating apparatus associated with each trunk at the outlying station, power equipment at each outlying station for energizing said translating apparatus, indicating means at the main station corresponding to each trunk, and means to actuate the indicating means of a given trunk upon failure of the power equipment at the outlying office of said trunk.

10. In a distribution system, a main program station, trunks extending from said main station to outlying stations, translating apparatus associated with each trunk, a source of energy for normally energizing said translating apparatus, a spare source of energy, and means for automatically associating the spare source with said translating apparatus upon failure of the normal source.

11. In a distribution system, a main program station, trunks extending from said main station to outlying stations, translating apparatus associated with each trunk, a source of energy for normally energizing said translating apparatus, a spare source of energy, means for automatically associating the spare source with said translating apparatus upon failure of the normal source, and means to indicate failure of the normal soiurce.

12. In a distribution system, a main program station, trunks extending from said main station to outlying stations, translating apparatus associated with each trunk, a source of energy for normally energizing said translating apparatus, a spare source of energy, means for automatically associating the spare source with said translating apparatus upon failure of the normal source, and means at the central station to indicate failure of the normal source at an outlying station.

13. In a distribution system, a main program station, trunks extending from said main station to outlying stations, amplifying apparatus at each outlying station, means to indicate failure of the amplifying apparatus, power equipment for energizing said amplifying apparatus, and means to indicate failure of the power equipment.

14. In a distribution system, a main program station, trunks extending from said main station to outlying stations, amplifying apparatus associated with each trunk at the outlying station, means at the central office to indicate failure of the amplifying apparatus at an outlying station, power equipment at each outlying station to energize the amplifying apparatus thereat, and means at the main station to indicate failure of the power equipment at an outlying station.

15. In a distribution system, a main program station, a plurality of trunks extending from said main station to outlying stations, a regular amplifying apparatus at each outlying station for the trunk extending thereto, a spare amplifying apparatus at each outlying station, means to disconnect the regular amplifying apparatus from the trunk on the failure thereof and to connect to the trunk the spare amplifying apparatus, regular power equipment at each outlying office for energizing the amplifiers thereat, spare power equipment at each outlying station, and means to substitute the spare power equipment for the regular power equipment upon failure of the latter.

16. In a distribution system, a main program station, a plurality of trunks extending from said main station to outlying sta-

tions, a regular amplifying apparatus at each outlying station for the trunk extending thereto, a spare amplifying apparatus at each outlying station, means to disconnect the regular amplifying apparatus from the trunk on the failure thereof and to connect to the trunk the spare amplifying apparatus, regular power equipment at each outlying office for energizing the amplifiers thereat, spare power equipment at each outlying station, means to substitute the spare power equipment for the regular power equipment upon failure of the latter, and means at the main station to indicate failure of the regular amplifying apparatus at an outlying station.

17. In a distribution system, a main program station, a plurality of trunks extending from said main station to outlying stations, a regular amplifying apparatus at each outlying station for the trunk extending thereto, a spare amplifying apparatus at each outlying station, means to disconnect the regular amplifying apparatus from the trunk on the failure thereof and to connect to the trunk the spare amplifying apparatus, regular power equipment at each outlying office for energizing the amplifiers thereat, spare power equipment at each outlying station, means to substitute the spare power equipment for the regular power equipment upon failure of the latter, and means at the main station for indicating failure of the regular power equipment at an outlying station.

18. In a distribution system, a main program station, a plurality of trunks extending from said main station to outlying stations, a regular amplifying apparatus at each outlying station for the trunk extending thereto, a spare amplifying apparatus at each outlying station, means to disconnect the regular amplifying apparatus from the trunk on the failure thereof and to connect to the trunk the spare amplifying apparatus, regular power equipment at each outlying office for energizing the amplifiers thereat, spare power equipment at each outlying station, means to substitute the spare power equipment for the regular power equipment upon failure of the latter, and means to prevent the substitution of the spare amplifying equipment for the regular amplifying equipment upon failure of the regular power equipment.

19. In a distribution system, a main program station, trunks extending from said main station to outlying stations, a normally inoperative amplifier associated with each trunk at the corresponding outlying station, and means to render said amplifiers operative from the main station.

20. In a distribution system, a main program station, trunks extending from said main station to outlying stations, a normally inoperative amplifier associated with each trunk at the corresponding outlying station, means to render said amplifiers operative from the main station, and means at the central office to indicate that the amplifiers at the outlying stations are operative.

21. In a distribution system, a main program station, trunks extending from said main station to outlying stations, translating apparatus at each outlying station, a normally inactive source of energy at each outlying station for energizing the translating apparatus thereat, and means to render said sources operative from the main station.

22. In a distribution system, a main program station, trunks extending from said main station to outlying stations, translating apparatus at each outlying station, a normally inactive source of energy at each outlying station for energizing the translating apparatus thereat, means to render said sources operative from the main station, and means at the main station for indicating that the sources are operating.

23. In a distribution system, a main program station, trunks extending from said main station to outlying stations, a normally inoperative amplifier associated with each trunk at the corresponding outlying station, a normally inactive source of energy at each station for energizing the amplifier thereat, means for rendering the amplifiers at said outlying stations operative from said main station, and means to render said sources of energy active from said main station.

24. In a distribution system, a main program station, trunks extending from said main station to outlying stations, a normally inoperative amplifier associated with each trunk at the corresponding outlying station, a normally inactive source of energy at each station for energizing the amplifier thereat, means for rendering the amplifiers at said outlying stations operative from said main station, means to render said sources of energy active from said main station, and means at the main station to indicate that all of the equipment at the outlying stations is operating.

25. In a distribution system, a main program station, trunks extending from said main station to central offices, amplifiers for each trunk at each central office, trunks extending from each amplifier to distributing stations, amplifiers associated with each trunk at each distributing station, and means to indicate failure of any amplifier.

26. In a distribution system, a main program station, trunks extending from said main station to central offices, amplifiers for each trunk at each central office, trunks extending from each amplifier to distributing stations, amplifiers associated with each

trunk at each distributing station, and means at the main program station for indicating failure of any outlying amplifier.

27. In a distribution system, a main program station, trunks extending from said main station to central offices, translating apparatus for each trunk at each central office, power equipment at each central office for energizing the translating apparatus thereat, trunks extending from each central office to outlying distributing stations, translating apparatus for each trunk at each distributing station, power equipment at each distributing station for energizing the translating apparatus thereat, and means to indicate failure of the power equipment at any outlying point.

28. In a distribution system, a main program station, trunks extending from said main station to central offices, translating apparatus for each trunk at each central office, power equipment at each central office for energizing the translating apparatus thereat, trunks extending from each central office to outlying distributing stations, translating apparatus for each trunk at each distributing station, power equipment at each distributing station for energizing the translating apparatus thereat, and means at the main program station to indicate failure of the power equipment at any outlying point.

29. In a distribution system, a main program station, trunks extending from said main station to central offices, normally inoperative, amplifiers associated with each trunk at the corresponding central office, means to render said amplifiers operative from the main program station, trunks extending from each central office to distributing stations, normally inoperative amplifiers for each trunk at each distributing station, and means to render the amplifiers at the distributing stations operative from the main program station.

30. In a distribution system, a main program station, trunks extending from said main station to central offices, normally inoperative amplifiers associated with each trunk at the corresponding central office, means to render said amplifiers operative from the main program station, trunks extending from each central office to distributing stations, normally inoperative amplifiers for each trunk at each distributing station, and means to render the amplifiers at the distributing stations operative from the main program station, and means at the main program station to indicate that each of the amplifiers is operating.

31. In a distribution system, a main program station, trunks extending from said main station to central offices, translating apparatus for each trunk at each central office, a normally inactive source of energy at each central office to energize the translating apparatus thereat, means to render said sources active from the main program station, trunks extending from each central office to outlying distributing stations, translating apparatus associated with each trunk at each distributing station, a normally inactive source of energy at each distributing station for energizing the translating apparatus thereat, and means to render said sources active from the main program station.

32. In a distribution system, a main program station, trunks extending from said main station to central offices, translating apparatus for each trunk at each central office, a normally inactive source of energy at each central office to energize the transmitting apparatus thereat, means to render said sources active from the main program station, trunks extending from each central office to outlying distributing stations, translating apparatus associated with each trunk at each distributing station, a normally inactive source of energy at each distributing station for energizing the translating apparatus thereat, means to render said sources active from the main program station, and means at the main program station for indicating that all of the outlying sources of energy are operative.

In testimony whereof I have signed my name to this specification this 30th day of November, 1923.

JOHN F. TOOMEY.