

March 19, 1929.

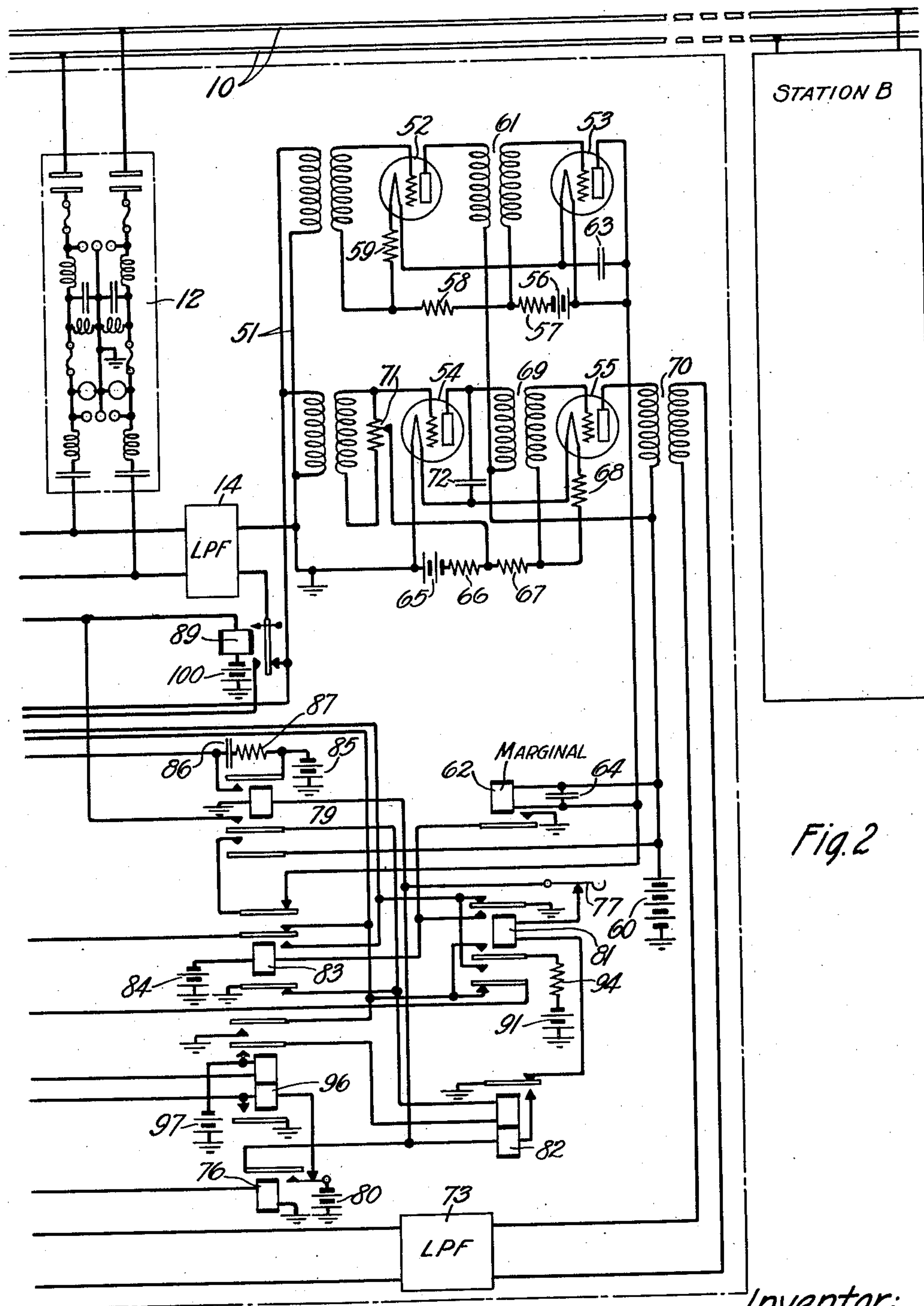
L. W. DAVEE

1,705,903

POWER LINE SIGNALING

Filed Feb. 9, 1927

5 Sheets-Sheet 2



Inventor:
Lawrence W. Davee
by W. Griggs Attorney

March 19, 1929.

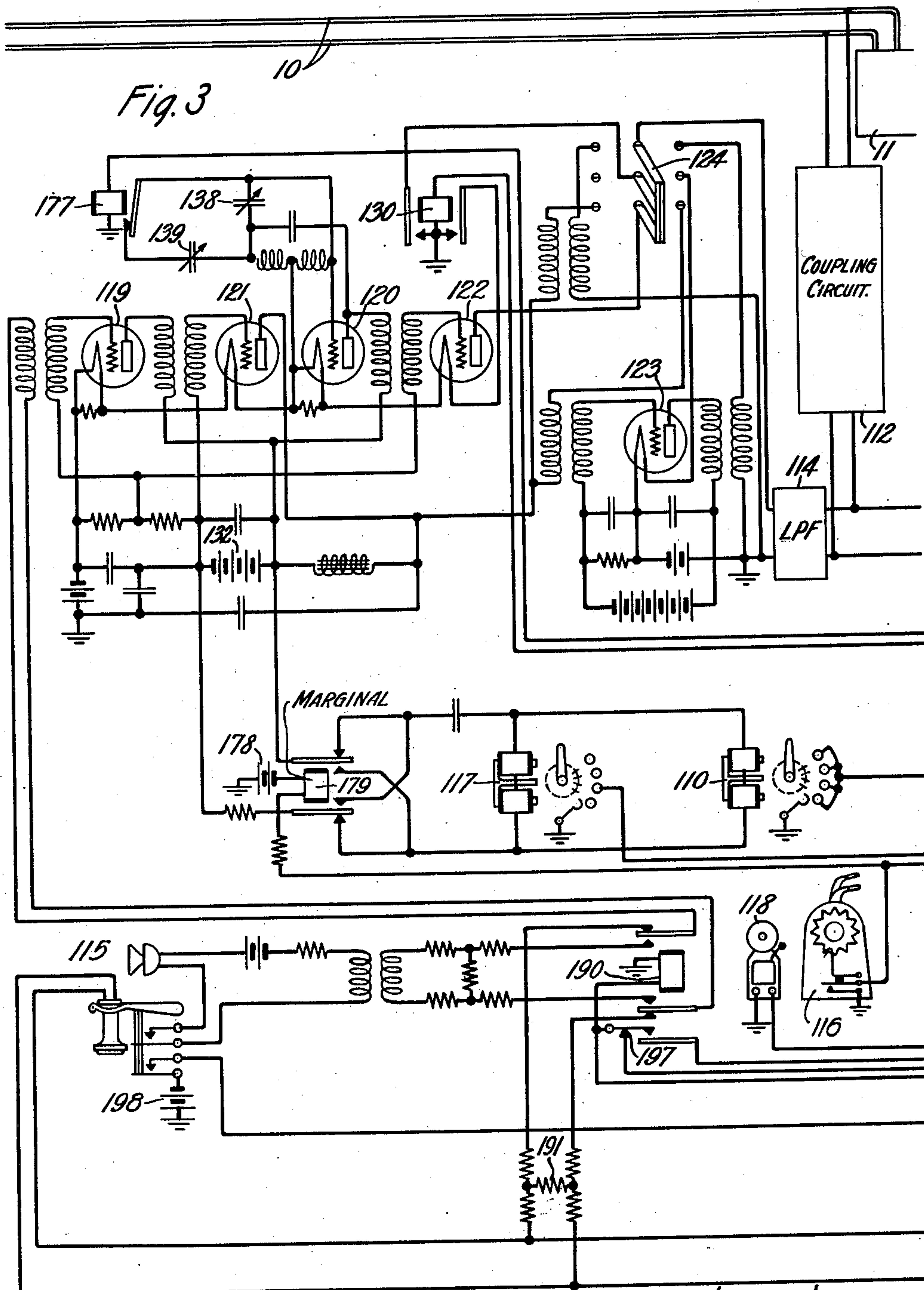
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Inventor:
Lawrence W. Davee
by W. Griggs Attorney

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L. W. DAVEE

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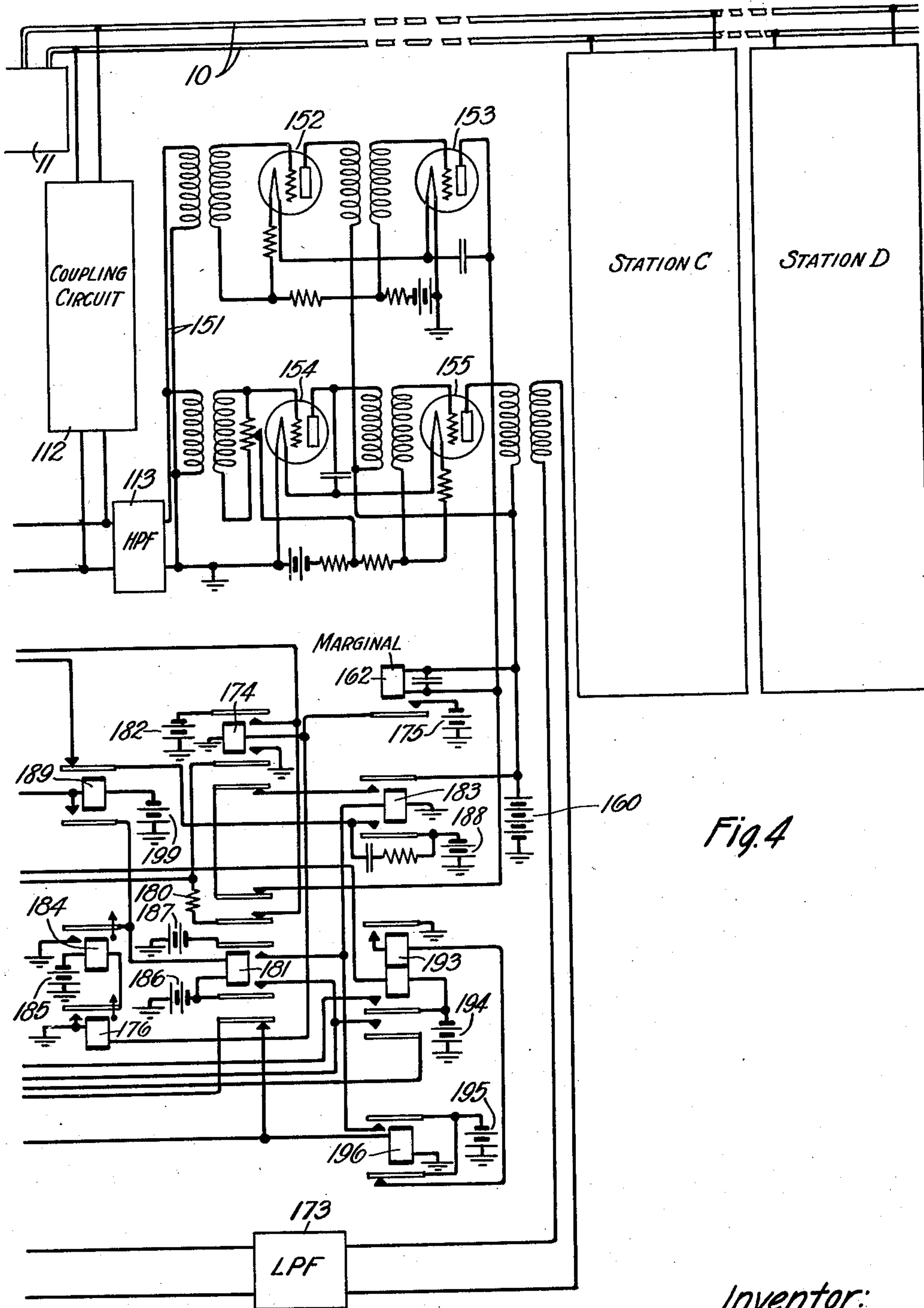


Fig. 4

Inventor:
Lawrence W. Davee
by W. Griggs
Attorney

March 19, 1929.

L. W. DAVEE

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Fig. 5a.

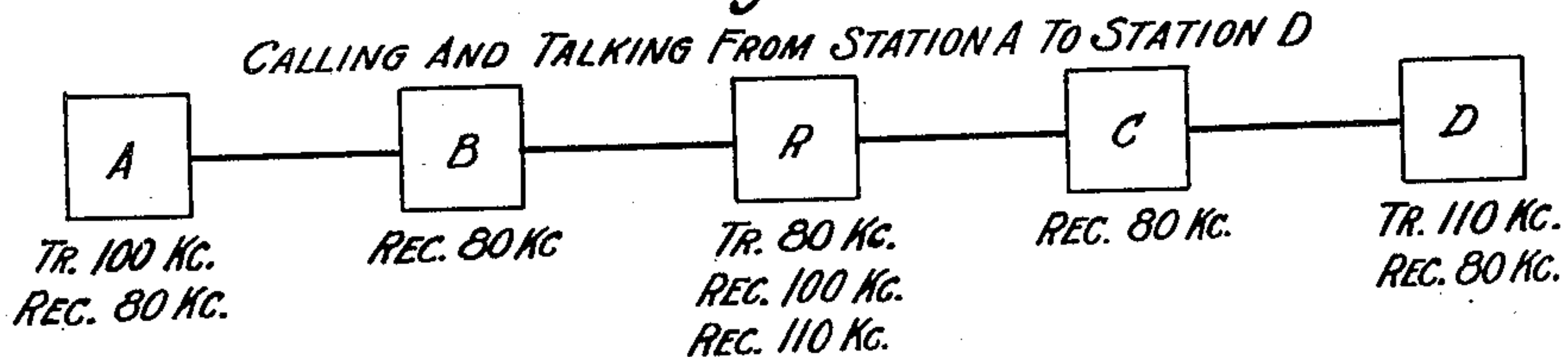


Fig. 5b.

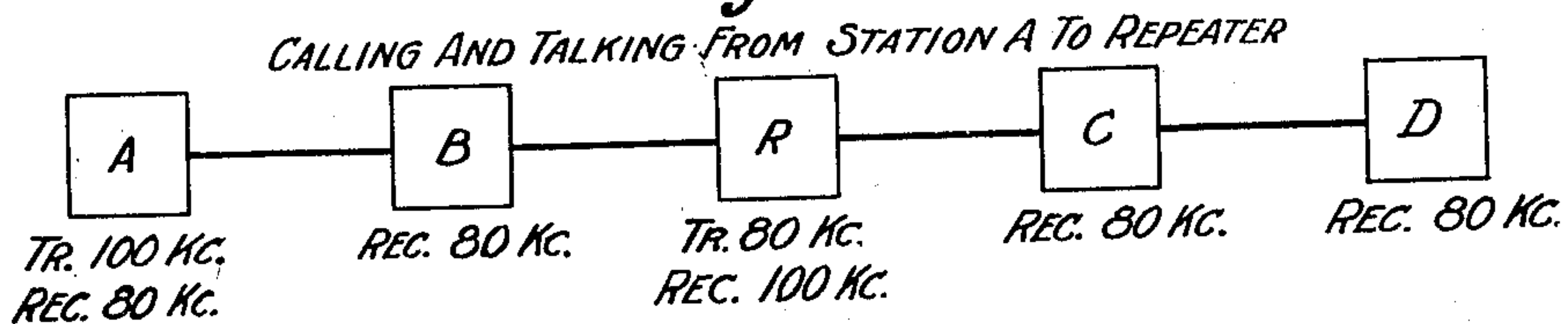


Fig. 5c.

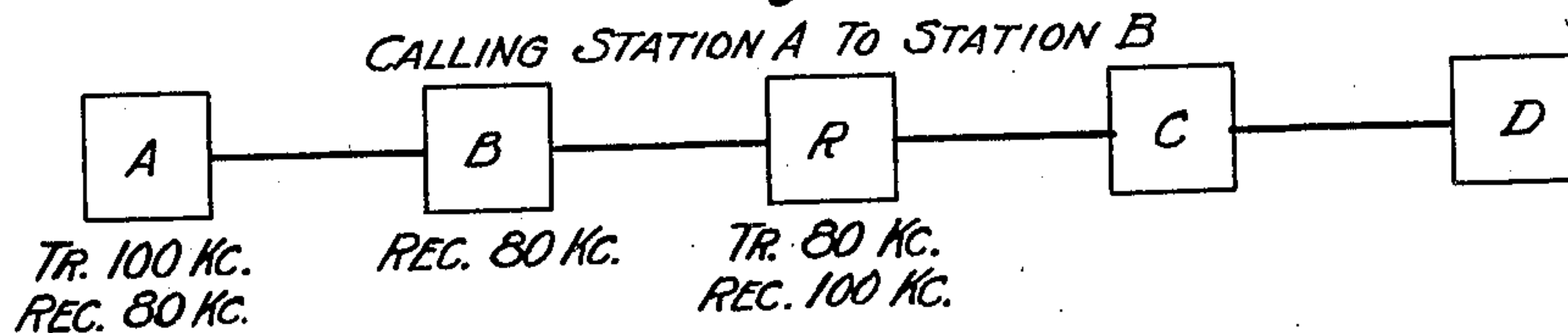


Fig. 5d.

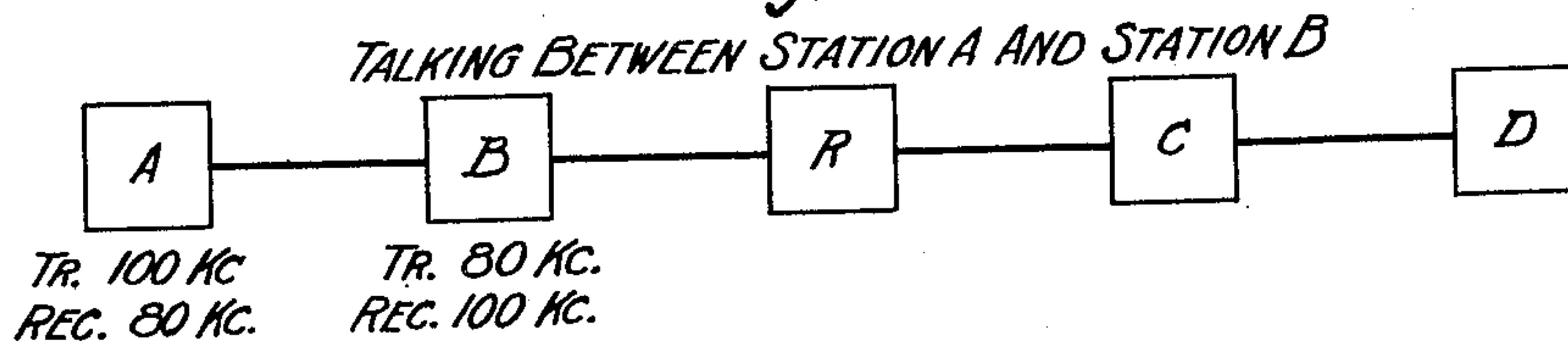
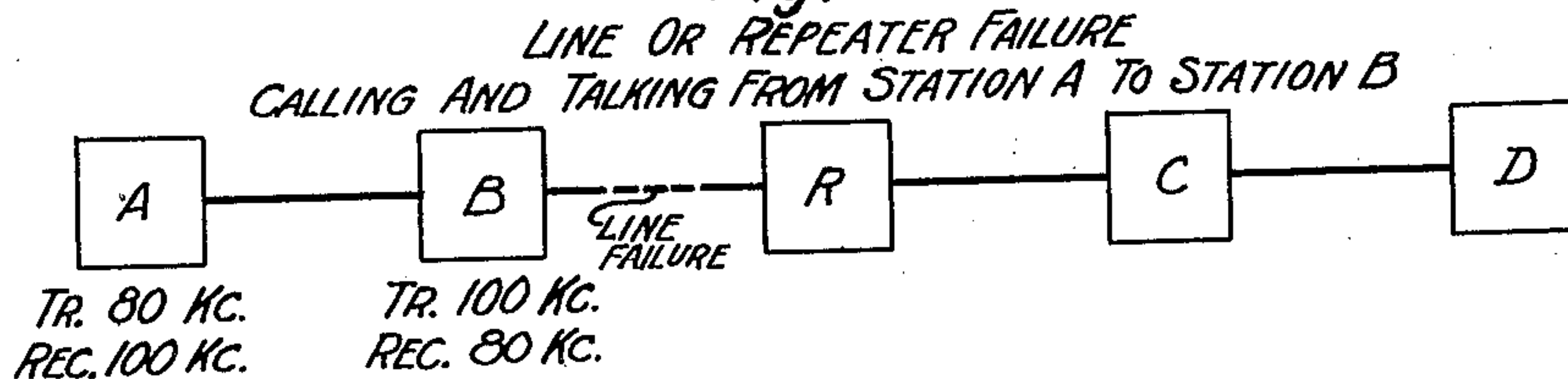


Fig. 5e.



Inventor:
Lawrence W. Davee
by *W. Griggs* Attorney

UNITED STATES PATENT OFFICE.

LAWRENCE W. DAVEE, OF BROOKLYN, NEW YORK, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

POWER LINE SIGNALING.

Application filed February 9, 1927. Serial No. 166,863.

This invention relates to communication by means of carrier frequency waves and particularly to communication over composite power current and carrier wave transmission systems employing repeaters.

An object of the invention is to increase the utility and efficiency of power line signaling systems employing repeaters.

A related object of the invention is to reduce the communication channels which may be lost to service due to the failure of a portion of the transmission circuit.

The invention is especially applicable to power line signaling systems of the type disclosed in a copending application of W. V. Wolfe, Serial No. 166,664, filed February 8, 1927, in which any of a plurality of stations may call and converse with any other station on the line. A feature of the present invention consists in effecting communication between stations located on the same side of a break occurring in the transmission circuit. In an important embodiment of the invention means are provided for communicating between stations located on the same side of a repeater when the repeater is lost to service.

In the system disclosed in the above mentioned Wolfe application, a repeater is employed to repeat calling impulses and telephone conversations between stations located on either side of a discontinuity in the power line, such as a voltage transformer or an open power switch. Three different carrier frequencies are utilized to communicate selectively between stations on the same side of the repeater, between any station and the repeater, and between stations on opposite sides of the repeater. Any station desiring to call another station transmits properly arranged groups of carrier impulses of one frequency which are received only by the repeater. The carrier impulses received by the repeater are converted into carrier impulses of another frequency which are impressed upon the power line on both sides of the repeater. These impulses operate a selector at the called station which is adjusted to respond to that particular group of impulses. Thus, even though the calling station and the called station are on the same side of the repeater, the impulses transmitted by the calling station must be converted at the repeater into impulses of a frequency receivable at the

called station. If the repeater is rendered inoperative for any reason, the entire signaling system is lost to service until the necessary repairs are made. Likewise, if a break occurs in the line on one side of the repeater, all stations on that side of the repeater are rendered inoperative.

In the system of the present invention calling is normally accomplished in the manner disclosed in the Wolfe application. That is, connection between any two stations is normally effected through the repeater. According to a feature of the invention, however, means are provided for communicating between terminals located on the same side of a break in the line, or on the same side of the repeater, if the repeater fails to operate. This is accomplished by means of a switching arrangement at each station whereby the transmitting apparatus may be converted to transmit calling impulses of a frequency which is receivable by all stations located on the same side of the repeater. This switching arrangement is operated only at the station originating the call, and is employed only when it has been determined that the repeater will not receive the calling impulses.

The various features and advantages of the invention will be described in detail in connection with the accompanying drawings, in which:

Figs. 1 to 4, inclusive, illustrate diagrammatically a power line signaling system comprising a plurality of stations and a repeater embodying the invention;

Figs. 5^a to 5^e, inclusive, are schematic views illustrating the method of utilizing three different carrier frequencies for effecting communication between the different stations; and

Fig. 6 is a diagram showing the manner in which Figs. 1 to 4 should be organized.

In the system shown in Figs. 1 to 4, inclusive, a plurality of stations and a repeater are arranged for communication over a high voltage transmission line 10. By "high voltage transmission line" is to be understood any system or network of conductors for the electrical transmission of power over which it is possible to transmit high frequency waves.

The repeater, shown in Figs. 3 and 4, serves to repeat calling signals and telephone con-

versations past a discontinuity in the power line 10, such as a voltage transformer or open power switch 11. Stations A and B are connected to the power line at the left of the repeater, and stations C and D are connected to the power line at the right of the repeater.

Each station is equipped with terminal apparatus similar in arrangement and function to that shown at station A in Figs. 1 and 2.

The following description of station A, which is also representative of the other stations, will be followed by a description of the repeater and a consideration of the method of communicating between the several stations.

Station A.

The terminal apparatus at station A comprises an outgoing channel and an incoming channel which are connected to the power line 10 by means of a coupling circuit 12. This coupling circuit may be of the type disclosed in a copending application of W. V. Wolfe, Serial No. 664,147, filed September 22, 1923, permitting the transfer of high frequency waves between the terminal apparatus and the power line without danger to the apparatus or the operator.

High pass and low pass filters 13 and 14 are connected to the coupling circuit 12 and are arranged to be included alternatively in either the outgoing channel or the incoming channel by means of apparatus hereinafter described. These filters, and the other filters employed in the system, may be designed in accordance with the principles set forth in U. S. Patent No. 1,227,113 to G. A. Campbell, issued May 22, 1917.

Telephone communication with a distant station is effected by means of an operator's telephone set 15 comprising a receiver which is connected to the incoming channel, and a transmitter which is arranged to be connected to the outgoing channel when the receiver is removed from the switchhook. A selector key 16 controls the transmission of calling signals to the distant stations in a manner hereinafter described. This key may be of any suitable type such as the master impulse transmitting device disclosed in U. S. Patent No. 1,354,814 to J. C. Field, issued October 5, 1920, which may be adjusted to transmit the proper combination of impulses for calling any station on the line. A selector 17 associated with the receiving channel responds to either of two different groups of incoming impulses for controlling the operation of a bell or other signaling device 18. One of the two groups of impulses is used by station B when the operator at station B desires to call station A. The other group of impulses is used by the repeater or by stations C and D, which are connected to the power line at the right of the repeater, when the operator at any of these stations desires to call station A. The selector 17 may be of the type disclosed

in U. S. Patent No. 1,343,256 to J. C. Field, issued June 15, 1920.

The outgoing channel includes (1) an amplifying tube 19 for amplifying the outgoing speech currents; (2) an oscillator 20 designed to produce waves at two different high frequencies, for example, 80 and 100 kilocycles per second; (3) a constant current modulator including the tube 21 and associated circuits whereby the outgoing high frequency waves are modulated in accordance with speech; (4) an amplifying tube 22 whereby the waves produced by the oscillator 20 are amplified to sufficiently high power for transmission under normal conditions; (5) an auxiliary amplifier 23 and its associated circuit connections which may be connected into circuit to increase the power amplification for transmission under abnormal conditions as, for example, when a section of the line is down; and (6) a switch 24 which when thrown to the left connects the output circuit of amplifier 22 to filter 13 or 14 through transformer 25, and when thrown to the right connects the output circuit of amplifier 22 to the input circuit of auxiliary amplifier 23 through transformer 26, and connects the output circuit of auxiliary amplifier 23 to filter 13 or 14 through transformer 27.

It will first be assumed that line conditions are normal and that the auxiliary amplifier 23 is not to be used, in which case the switch 24 is closed in the left position. Filament heating current is supplied to the tubes 19, 20, 21 and 22 under the control of a heavy duty relay 30 having a high inductance winding which is adapted to be energized in a manner hereinafter described. The filament heating circuit extends from grounded battery 31, through the filaments of the tubes, right hand armature and contact of relay 30 to ground. Space current is supplied to the tube 19 through a circuit extending from the positive side of battery 32, through the primary winding of transformer 33, the plate, discharge path and filament of tube 19, resistances 34 and 35, to the negative side of battery 32. The current flowing in this circuit produces a drop in potential across the resistance 34 which causes a negative biasing potential to be impressed upon the grid of tube 19. The oscillator tube 20 is supplied with space current through a circuit extending from the positive side of battery 32, through the primary winding of transformer 36, the plate, discharge path and filament of tube 20, filaments of tubes 21 and 19, resistances 34, and 35, to the negative side of battery 32. A blocking condenser 37 prevents the plate potential from being applied to the grid of the oscillator tube 20. A condenser 38 which is permanently connected in the oscillator circuit determines the higher carrier frequency of 100 kilocycles per second, and the addition of condenser 39 in parallel as shown in the

drawing, determines the lower carrier frequency of 80 kilocycles per second. The transformer 36 couples the output circuit of oscillator 20 to the amplifier 22 whereby the carrier waves are amplified before being impressed upon the power line.

The carrier waves in the anode-cathode circuit of the amplifying tube 22 are modulated according to the "constant current" method of modulation disclosed in a copending application of R. A. Heising, Serial No. 525,906, filed December 30, 1921. The modulating tube 21 has its plate connected to the plate of the amplifying tube 22 through the primary winding of transformer 25. Space current is supplied to these tubes from the battery 32 through a retard coil 40. The drop in potential across the resistances 34 and 35 due to the current flowing therein causes a negative biasing potential to be impressed upon the grid of the tube 21. The drop in potential across the resistance 34, which is connected between the filament and grid of the amplifying tube 22, causes a negative biasing potential to be impressed upon the grid of this tube. The retard coil 40 offers a high impedance to the speech and carrier currents and hence there will be no change in current through this coil. Speech variations which are impressed upon the grid of the modulating tube 21, however, produce variations in the impedance of the anode-cathode circuit of this tube. The condenser 41 serves to by-pass the carrier current around the retard coil 40, but offers an impedance such that changes in the impedance of the anode-cathode circuit of the modulating tube 21 produce corresponding changes in the carrier current flowing in the anode-cathode circuit of the amplifying tube 22. As a result of this action the carrier waves flowing in the output circuit of the amplifying tube 22 are modulated in accordance with the speech variations which are impressed upon the grid of the modulating tube 21. Both the upper and lower side bands produced by modulation are impressed upon the power line along with a component of carrier frequency. The condenser 42 serves to by-pass speech frequency currents in the output circuit of tube 19 around resistances 34 and 35. Condenser 43 by-passes alternating currents around the plate battery 32, and condenser 44 by-passes alternating currents around the filament battery 31.

If line conditions are bad owing, for example, to a section of the line being down, the switch 24 is moved from the normal left position to the right position. The plates of the modulating and amplifying tubes 21 and 22 are then connected together through the primary winding of transformer 26 instead of through the primary winding of transformer 25. The production and modulation of the carrier waves, however, is accom-

plished in the manner described above. Filament heating current is supplied to the auxiliary amplifying tube 23 over a circuit extending from grounded battery 45, through the filament of tube 23, switch 24, left hand armature and contact of relay 30, to ground. Space current is supplied to the tube 23 over a circuit extending from the positive side of battery 46, through the primary winding of transformer 27, the plate, discharge path and filament of tube 23, resistance 47 to the negative side of battery 46. The current flowing in this circuit produces a drop in potential across the resistance 47 which causes a negative biasing potential to be impressed upon the grid of the tube 23. The condensers 48 and 49 serve to by-pass alternating currents around battery 46 and resistance 47, respectively. When the auxiliary amplifier 23 is connected in circuit, the amplified carrier and side band waves are transmitted through the transformer 27, filter 13 or 14, as the case may be, and coupling circuit 12 to the power line 10.

The incoming channel extends from the power line 10, through the coupling circuit 12, to the high pass or low pass filter 13 or 14, and includes in addition to these elements, (1) a common collecting circuit 51 for receiving unmodulated carrier waves, carrier waves interrupted in accordance with the calling impulses, and the side bands representing the carrier waves modulated in accordance with speech; (2) an amplifier 52 for amplifying the received calling impulses; (3) a rectifier 53 for rectifying the amplified calling impulses; (4) a demodulator 54 for combining the received carrier and side bands to reproduce the speech currents; and (5) an amplifier 55 for amplifying the speech currents.

The amplifying and rectifying tubes 52 and 53 are supplied with filament heating current through a circuit extending from the negative side of battery 56, through resistances 57, 58 and 59, the filaments of the tubes, to the positive side of battery 56. Space current is supplied to the amplifying tube 52 through a circuit extending from grounded battery 60, through the primary winding of transformer 61, the plate, discharge path and grounded filament of tube 52. Space current is supplied to the rectifying tube 53 through a circuit extending from grounded battery 60, through the winding of relay 62, the plate, discharge path and grounded filament of tube 53. The grid of the amplifying tube 52 is made negative with respect to the negative end of its filament due to the drop in potential produced by the filament current in resistance 59. The grid of the rectifying tube 53 is made negative with respect to the negative end of its filament due to the drop in potential produced by the filament current in resistances 58 and 59 and the filament of the amplifying tube 52. The relay 62 is a mar-

ginal relay and is not operated by the small current normally flowing in the anode-cathode circuit of the rectifying tube 53 when no calling impulses are received. The characteristics of the tube 53 and its associated circuits are such that the received calling impulses of carrier frequency are rectified and caused to operate the relay 62. The operation of this relay causes the stepping up of the selector 17, as hereinafter more fully described. The condenser 63 by-passes the alternating current in the output circuit of the tube 53. The condenser 64 by-passes alternating currents around the winding of relay 62.

The demodulating and amplifying tubes 54 and 55 are supplied with filament heating current through a circuit extending from the negative side of battery 65, through resistances 66, 67 and 68, the filaments of the tubes, to the positive side of battery 65. Space current is supplied to the tube 54 over a circuit extending from grounded battery 60, through the primary winding of transformer 69, the plate, discharge path and grounded filament of tube 54. Space current is supplied to the tube 55 over a circuit extending from grounded battery 60, through the primary winding of transformer 70, the plate, discharge path and grounded filament of tube 55. The grid of the tube 54 is made negative with respect to the negative end of its filament due to the drop in potential produced by the filament current in resistances 67 and 68 and the filament of tube 55. The grid of the tube 55 is made negative with respect to the negative end of its filament due to the drop in potential produced by the filament current in resistance 68. Again control potentiometer 71 is included in the input circuit of the demodulator tube 54. A condenser 72 in the output circuit of tube 54 serves to by-pass the high frequency carrier waves. The speech frequency waves in the output circuit of the demodulator 54 are amplified by the amplifier 55 and transmitted through transformer 70, low pass filter 73, resistance network 74, and transformer 75 to the receiver of the operator's telephone set 15. The low pass filter 73 is designed to pass waves comprised within the speech frequency range and to suppress waves of other frequencies.

Repeater.

The repeater, shown in Figs. 3 and 4, comprises an outgoing channel and an incoming channel which are connected to the power line 10 on both sides of the voltage transformer or upon power switch 11 by means of coupling circuits 112. These coupling circuits are similar to the coupling circuit 12 employed at station A. The repeater is arranged to receive only waves of 100 and 110 kilocycles frequency and to transmit only waves of 80 kilocycles frequency, the high

pass filter 113 being permanently connected to the incoming channel and the low pass filter 114 being permanently connected to the outgoing channel.

Telephone communication with a distant terminal station is effected by means of an operator's telephone set 115 comprising a receiver which is connected to the incoming channel, and a transmitter which is arranged to be connected to the outgoing channel in a manner hereinafter described. A selector key 116 is employed to transmit calling signals when the operator at the repeater desires to communicate with the operator at any station. A selector 117 associated with the receiving channel is operated according to a predetermined code of impulses when any station calls the repeater. This selector controls the operation of the bell or other signaling device 118. An auxiliary selector 110, having its windings connected in parallel with the windings of selector 117, is arranged to close a contact whenever one station calls another station located on the same side of the repeater. The closure of such contact serves to disconnect the repeater from the talking circuit, as hereinafter described, so that thereafter the calling and called stations on the same side of the repeater may converse directly without using the repeater. The selector 110 is therefore provided with four contacts, one for each station in the system, each of these contacts corresponding in its code setting to one of the selector contacts at a station. As pointed out above, one group of impulses is used when any station is being called by another station on the same side of the repeater, and another group of impulses is used when the same station is being called by the repeater or any other station located on the opposite side of the repeater. Station B, in calling station A, for example, transmits a predetermined group of impulses which not only causes the selector 17 at station A to close one of its contacts, but also causes the selector 110 at the repeater to close its corresponding contact, whereby the repeater is subsequently disconnected from the talking circuit. Either of stations C or D, in calling station A, however, transmits a different group of impulses which causes the selector 17 at station A to close its second contact but does cause the selector 110 at the repeater to close a contact, and hence the repeater remains in service to repeat the two-way conversation between station A and station C or D, as the case may be. It will thus be seen that the selector 110 at the repeater is selectively operated only when the calling and the called stations are located on the same side of the repeater.

The outgoing and incoming channels at the repeater are similar to the corresponding channels at station A and, therefore, will not be described in detail except so far as it

is considered necessary to understand the operation of the system. The outgoing channel includes a speech frequency amplifier 119, an oscillator 120, a modulator 121, an amplifier 122, and an auxiliary amplifier 123 which may be connected to or disconnected from the circuit by means of switch 124. The condensers 138 and 139, which are normally connected in parallel in the oscillator circuit, determine the carrier frequency of 80 kilocycles per second assigned to the outgoing channel. The disconnection of condenser 139 from the circuit in accordance with groups of impulses permits corresponding groups of impulses of 80 kilocycles frequency to be transmitted through the low pass filter 114 to the line.

The incoming channel includes an amplifier 152 for amplifying the received calling impulses, a rectifier 153 for rectifying these impulses, a demodulator 154 for demodulating the received speech modulated carrier waves, and an amplifier 155 for amplifying the speech currents. It will be noted that space current from the source 160 is supplied to the rectifier tube 153 through the winding of relay 162. This relay is marginal, like the relay 62 at station A, and is operated only in response to the rectified current flowing in the anode-cathode circuit of the rectifier tube 153.

Calling and talking through repeater.

In describing the operation of the system, the method of calling and talking through the repeater from station A to station D will first be considered. The arrangement of the carrier frequencies transmitted and received by the different stations in this situation is illustrated in Fig. 5^a. Stations A and B, as pointed out above, are capable of transmitting or receiving carrier waves of 80 and 100 kilocycles frequency, depending upon the arrangement of the terminal filters. Stations C and D, on the opposite side of the repeater, are capable of transmitting or receiving carrier waves of 80 and 110 kilocycles frequency, depending upon the arrangement of the filters at these stations. In the operation of the system first to be considered, it is to be understood that the system is functioning in its normal condition, that is, there is no line failure, and the repeater will function to repeat signals between the several stations. Under such condition the key 77 at station A and all the other stations is closed. The key 77 is never opened until it has been definitely determined that the repeater will not receive a call.

The operator at station A, in initiating a call to station D, removes his receiver from the switchhook, thereby operating relay 76 over a circuit extending from grounded battery 78, through the lower contact of the switchhook, winding of relay 76, to ground.

Relay 79 is thereupon energized over a circuit extending from grounded battery 80, through the front contact and armature of relay 76, winding of relay 79, to ground. Relay 81 is energized over a circuit extending from grounded battery 80, through the front contact and armature 76, key 77, winding of relay 81, back contact and armature of relay 82, to ground. The operation of relay 81 causes the energization of relay 83 over a circuit extending from grounded battery 84, through the winding of relay 83, uppermost front contact and armature of relay 81, to ground. The operation of relay 79 causes the operation of relay 30 over a circuit which extends from grounded battery 85, through the uppermost armature and contact of relay 79, winding of relay 30, to ground. The condenser 86 and resistance 87 serve to protect the upper contact of relay 79 against sparking due to the high inductance of the winding of relay 30. The energization of relay 30 causes filament heating current to be supplied to all the space discharge tubes in the outgoing channel, including the auxiliary amplifying tube 23, if this tube is in service. The filament circuits were traced above in the description of the terminal apparatus.

Relay 83, in operating, opens its lowermost contact, thereby preventing relays 88 and 89 from being energized through this contact and the first lower contact and armature of relay 79. The relays 88 and 89 control the connections of the high pass filter 13 and the low pass filter 14, and by maintaining these relays deenergized, the high pass filter 13 remains connected to the outgoing channel and the low pass filter 14 remains connected to the incoming channel, as shown in the drawings. Relay 90 is normally energized over a circuit extending from grounded battery 92, through the winding of relay 93, resistance 95, second upper armature and back contact of relay 83, winding of relay 90, uppermost back contact and armature of relay 81 to ground, the current flowing in this circuit, however, being insufficient to operate the relay 93. The operation of relay 81 opens the energizing circuit of relay 90. Furthermore, the relay 81, in operating, attracts its first lower armature, thereby preparing a circuit to be closed through the relay 90, grounded battery 91 and selector key 16 when the selector key 16 is subsequently operated. At the same time, relay 81 attracts its lowermost armature, thereby preparing a circuit to be closed through grounded battery 92, pole changing relay 93 and selector key 16 when the selector key 16 is subsequently operated. As a result of the sequence of operations described above, and before the selector key 16 is operated, condenser 39 is disconnected from the circuit of oscillator 20 and carrier waves of 100 kilocycles frequency generated by oscillator 20 are transmitted through the high pass filter

13 and coupling circuit 12 to the power line 10.

The repeater is arranged to receive carrier waves of either 100 or 110 kilocycles frequency, and to transmit carrier waves of 80 kilocycles frequency. Accordingly, the carrier waves of 100 kilocycles frequency transmitted from station A pass through the left hand coupling circuit 112 at the repeater, and are selectively passed by the high pass filter 113 to the common collecting circuit 151. Carrier waves of this frequency, however, will not pass into the receiving channel at station B which, like the receiving channel at station A, is normally arranged to receive only waves of 80 kilocycles frequency. The carrier waves received in the circuit 151 at the repeater are amplified by the amplifier 152 and rectified by the rectifier 153, the rectified waves causing the operation of relay 162. The operation of relay 162 causes the operation of relay 174 over a circuit extending from grounded battery 175, through the contact and armature of relay 162, winding of relay 174, to ground. Slow releasing relay 176 is also operated over a circuit extending from grounded battery 175, through the contact and armature of relay 162, winding of relay 176, to ground. The relay 177 which controls the connection of the condenser 139 to the circuit of the oscillator 120 is normally energized over a circuit extending from grounded battery 178, through the winding of pole changing relay 179, resistance 180, upper middle armature and contact of relay 181, winding of relay 177, to ground, the current flowing in this circuit, however, being insufficient to operate the relay 179. The operation of relay 174 completes another energizing circuit for the relay 177, which extends from grounded battery 182, through the uppermost armature and contact of relay 174, winding of relay 177, to ground. The operation of relay 174 also causes the operation of relay 179 over a circuit extending from grounded battery 178, through the winding of relay 179, middle armature and contact of relay 174, to ground.

The operation of relay 179 causes an impulse of current from the source 132 to be supplied to the electromagnets of selectors 110 and 117. The selectors will thereupon advance one step but will immediately fall back to the starting position. If either of these selectors happens accidentally to be held in an advanced position before the call is initiated, this single impulse will cause it to advance another step to a position from which it will promptly fall back to the normal starting position before the operator at station A actuates his calling key 16. The relay 174 in attracting its lowermost armature opens a shunt path around the relay 162 which would otherwise be closed upon the operation of relay 183, and would extend from grounded battery 160, through the upper armature and contact of

relay 183, lowermost contact and armature of relay 174, and uppermost armature and contact of relay 181. The opening of this shunt path allows the relay 162 to remain in the anode-cathode circuit of the rectifier tube 153, responsive to impulse subsequently received from the power line.

The relay 176, in operating, completes an energizing circuit for slow releasing relay 184, which extends from grounded battery 185, through the winding of relay 184, armature and contact of relay 176 to ground. The operation of slow releasing relay 184 causes the energization of relay 181 over a circuit extending from grounded battery 186, through the winding of relay 181, armature and contact of relay 184, to ground. Relay 181 in opening its uppermost contact opens the shunt path around the relay 162 which was traced above. By opening its second upper contact the relay 181 opens the energizing circuit of relay 177 which extends through resistance 180, the relay 177, however, remaining energized over the circuit previously traced from grounded battery 182 through the uppermost armature of relay 174. The relay 181 also closes its third upper contact, establishing an energizing circuit for relay 183, which extends from grounded battery 187, through the third upper armature and contact of relay 181, winding of relay 183, to ground. At its lowermost contact the relay 181 opens a circuit through the relay 190 so that this relay will remain deenergized even if the operator at the repeater removes his receiver from the switchhook. The operation of relay 183 establishes an energizing circuit for relay 130, which may be traced from grounded battery 188, through the lower armature and contact of relay 183, upper armature and contact of relay 189, winding of relay 130, to ground. The operation of relay 130 causes filament heating current to be supplied to all the space discharge tubes in the outgoing channel, including the auxiliary amplifying tube 123 if this tube is in service. Carrier waves of 80 kilocycles frequency generated by the oscillator 120 are thereupon transmitted through the low pass filter 114 and coupling circuits 112 to both sections of the power line 10. These carrier waves of 80 kilocycles frequency are received by all the stations, and are rectified at stations B, C and D and caused to operate the relay thereat which corresponds to relay 62 at station A. While the relay 62 at station A also operates in response to these 80 kilocycle waves, it performs no useful function at this time. The circuits controlled by this relay are already energized. The operation of such relay at stations B, C and D, however, causes the selector at each of these stations to advance one step from which advanced position it will fall back to the starting position.

The sequence of operations described above

took place when the operator at station A removed his receiver from the switchhook. The operator at station A now actuates the selector key 16 which is set to transmit the proper combination of impulses for calling station D. The operation of selector key 16 causes the relay 90 to operate each time a tooth of the selector key closes the key contact. The energizing circuit of the relay 90 may be traced from ground, through the closed contact of selector key 16, lowermost armature and front contact of relay 81, winding of relay 90, first lower contact and armature of relay 81, resistance 94, to grounded battery 91. The alternate energization and deenergization of relay 90 in response to these impulses causes the condenser 39 to be placed alternately into and out of the oscillator circuit. During the operation of the selector key the frequency generated by the oscillator 20 is thus changed back and forth from the high carrier frequency of 100 kilocycles per second to the low carrier frequency of 80 kilocycles per second, and vice versa. However, the low carrier frequency is not transmitted to the power line inasmuch as the high pass filter 13, which is connected between the outgoing channel and the power line, is designed to pass only the high carrier frequency and to suppress the low carrier frequency. The groups of impulses of the high carrier frequency of 100 kilocycles per second are thus transmitted to and impressed upon the power line. The operation of the selector key 16 also completes an energizing circuit for the pole changing relay 93, from grounded battery 92, through the winding of relay 93, resistance 95, second upper armature and front contact of relay 83, lowermost front contact and armature of relay 81, closed contact of selector key 16, to ground. The energization of relay 93 causes the impulse of current from the battery 32 to be supplied to the electromagnet of selector 17 which causes the selector to advance one step. When the contact of the selector key is opened, the relay 93 releases, which causes an impulse of current of opposite sign through the electromagnet of selector 17. The operation of relay 93 and the selector 17 at this time performs no useful function, but is usually provided for in systems of this general type so that relay 93 may also be used to relay calling impulses to a sub-station, not shown in the drawing, if this feature should be found desirable.

The high frequency impulses which are transmitted over the power line pass through the left hand coupling circuit 112 at the repeater, and thence through high pass filter 113 to the common collecting circuit 151, amplifier 152 and rectifier 153. The rectified impulses in the output circuit of the rectifier 153 cause the alternate deenergization and energization of relay 162, thus alternately

opening and closing the energizing circuit of relay 174 which, in turn, causes the relay 177 to release and operate, alternately placing the condenser 139 out of and into the circuit of oscillator 120. As a result of this action groups of impulses of 80 kilocycles frequency, corresponding in number and arrangement to the impulses transmitted from station A, are transmitted through low pass filter 114 and coupling circuits 112, to both sections of the power line. The relay 174, in opening and closing its first lower contact, alternately opens and closes the energizing circuit of relay 179, thereby causing selectors 110 and 117 to advance step-by-step. The relays 176 and 184 at the repeater are made slow releasing in order to maintain the relay 181 energized during the calling operation, thus maintaining the closure of the filament circuit of the tubes in the outgoing channel. The relay 190, being unoperated, maintains the closure between the incoming and the outgoing repeater channels through which the speech currents are to be transmitted.

The calling impulses of 80 kilocycles frequency which are relayed from the repeater cause the selectors at stations B, C and D to step up, but only the selector at station D closes the proper contact. The selectors at the repeater and the other stations fall back to the starting position. The operation at station D may be followed by referring to the corresponding apparatus at station A, shown in Figs. 1 and 2. The alternate energization and deenergization of relay 62 at station D in response to the received impulses causes the alternate energization and deenergization of relay 83, the circuit of relay 83 extending from grounded battery 84, through the winding of relay 83, armature and contact of relay 62, to ground. The intermittent operation of relay 83 by relay 62 causes the intermittent operation of the pole changing relay 93. The energizing circuit of relay 93 extends from grounded battery 92, through the winding of relay 93, resistance 95, second upper armature and front contact of relay 83, upper most back contact and armature of relay 81, to ground. The operation of relay 93 causes the selector 17 to step up until it closes the contact corresponding to the transmitted code of impulses. When the selector 17 at station D stops at the proper contact, the relay 96 is energized over a circuit extending from grounded battery 97, through the upper winding of relay 96, closed contact of selector 17, to ground. Relay 96 is thereupon locked up through a circuit extending from grounded battery 80, through the back contact of relay 76, lower winding and armature of relay 96, to ground. The bell 18 is energized over a circuit extending from grounded battery 98, through the electromagnet of bell 18, lower contact and armature of relay 96, to ground. It will be noted that the contact

of selector key 16 at the calling station A is opened at the conclusion of the dialing, that is, this contact is opened after the last tooth has passed the contact arm of the selector key, and as a result carrier waves of 100 kilocycles frequency continue to flow from the outgoing channel at station A to the power line. Carrier waves of 80 kilocycles frequency are therefore impressed upon the power line from the outgoing channel of the repeater at the conclusion of the dialing operation. The carrier waves of 80 kilocycles frequency which are thus received at station D maintain the relays 62 and 83 energized during the subsequent communication between stations A and D. The final operation of relay 83 causes an additional impulse through the pole changing relay 93 which causes the selector 17 to advance another step from which advanced position it falls back to the starting position.

When the operator at station D responds to the call by lifting his receiver from the switchhook, the relay 76 is operated over the circuit previously traced. Relay 76 establishes energizing circuits for relays 79 and 81, which were traced above in describing the operation at station A. Relay 79 in attracting its uppermost armature, causes the operation of relay 30 which lights the filaments of the space discharge tubes in the outgoing channel at station D, causing carrier waves of 110 kilocycles frequency to be impressed upon the power line. The operation of relay 76 also opens the locking circuit of relay 96 thereby deenergizing the bell 18. Relay 81 which, in operating, establishes an energizing circuit for relay 83, actually performs no useful function at this time since relay 83 is already energized through the closed contact of relay 62. The energization of relay 83, it will be noted, prevents relays 88 and 89 from operating since the energizing circuits of these relays are open at the lowermost contact of relay 83. Accordingly, the outgoing channel at station D is arranged to transmit carrier waves of 110 kilocycles frequency and the incoming channel at station D is arranged to receive carrier waves of 80 kilocycles frequency.

Speech modulated carrier waves of 100 kilocycles frequency impressed upon the power line at station A pass through the left hand coupling circuit 112 at the repeater, and thence through high pass filter 113 to the common collecting circuit 151. These waves are combined in the demodulator 154 with the unmodulated carrier component which is also transmitted over the line. The low frequency components of demodulation appearing in the output of the demodulator 154 are amplified by the amplifier 155 and transmitted through low pass filter 173, resistance network 191, back contacts and armatures of relay 190, to the input circuit of speech

frequency amplifier 119. The speech currents which are thus supplied to the outgoing repeater channel are caused to modulate the carrier waves of 80 kilocycles frequency produced by the oscillator 120, and the modulated carrier waves are transmitted over the power line to station D. A portion of the waves received at the repeater is rectified to maintain the relay 162 energized. Similarly, the speech modulated carrier waves of 110 kilocycles frequency impressed upon the power line at station D are transmitted to the repeater where they are converted into speech modulated carrier waves of 80 kilocycles frequency which are transmitted to station A. At station A these waves are demodulated in the demodulator 54 and the low frequency components of demodulation, after being amplified by amplifier 55, pass through low pass filter 73, resistance network 74 and transformer 75 to the receiver of the operator's telephone set 15. Upon the completion of the conversation, the operators at stations A and D will replace their receivers upon the switchhooks, causing the system to return to the normal condition shown in the drawings. On a call through the repeater, such as that described above, the receiver associated with the operator's telephone set 115 is connected to the talking circuit so that the operator at the repeater may determine when the line is busy. If, however, the operator at the repeater should dial under this condition, the dialing will be ineffective, since the circuit extending from the selector key 116 to the relay 177 is open at the second upper armature and contact of relay 181.

Calling and talking to repeater.

When the operator at station A desires to call and converse with the operator at the repeater, he proceeds in the manner employed in calling station D except that the selector key 16 must first be adjusted to transmit the particular code of impulses which will cause the selector 117 at the repeater to close its associated contact. When such a call has been initiated at station A, the operation of the apparatus at station A and the repeater is the same as that previously described up to the stepping up of the selectors in response to the calling impulses. Only the selector 117 at the repeater stops on the proper contact, the selector 110 and the selectors at the several stations falling back to the starting position. The operation of selector 117 causes the energization of relay 193 over a circuit extending from grounded battery 194, through the lower winding of relay 193, closed contact of selector 117, to ground. A holding circuit for relay 193 is established from grounded battery 195, through the lower armature and contact of relay 196, upper winding and uppermost contact and armature of relay 193, to ground. An energizing

circuit for the bell 118 is established from grounded battery 194, through the first lower armature and contact of relay 193, electro-magnet of bell 118, to ground. The carrier waves received from the power line at the conclusion of the calling impulses cause the selector 117 to advance a final step from which advanced position it falls back to the starting point. The relay 190 is energized over a circuit extending from grounded battery 186, through the first lower armature and contact of relay 181, which was energized by relay 184 in the manner previously described, lowermost contact and armature of relay 193, contact 197 of relay 190, winding of relay 190 to ground. An energizing circuit for relay 190 is thereupon established from grounded battery 186, through the first lower armature and contact of relay 181, lowermost armature and contact of relay 190, winding of relay 190, to ground, so that relay 190 will remain energized even though relay 193 becomes deenergized when the operator removes his receiver from the switchhook. The operation of relay 190 opens the connection between the incoming and outgoing channels of the repeater and connects the local transmitting circuit of the operator's telephone set 115 to the input circuit of the speech frequency amplifier 119. When the operator removes the receiver from the switchhook, the local circuit of the operator's transmitter is closed, and the relay 196 is energized over a circuit extending from grounded battery 198, through the lower contact of the switchhook, winding of relay 196, to ground. Relay 196 in opening its lower contact breaks the holding circuit of relay 193, thereby deenergizing the bell 118. A second energizing circuit is established for the relay 183 from grounded battery 195, through the upper armature and contact of relay 196, winding of relay 183 to ground, which, however, performs no useful function at this time, since the relay 183 is already energized over a circuit previously traced through the third upper armature and contact of relay 181. The circuit from grounded battery 195 through relay 183, however, is the circuit which is established for operating the relay 183 to energize the filaments of the space discharge tubes in the outgoing channel when a call is initiated at the repeater. The operators at station A and the repeater may now converse, station A transmitting at 100 kilocycles and receiving at 80 kilocycles, and the repeater transmitting at 80 kilocycles and receiving at 100 kilocycles, as indicated in Fig. 5^b.

Calling and talking to station on same side of repeater.

The operation of the system on a call under normal line conditions from station A through the repeater to station B will now be

described. In this situation, as in the situations described above, the key 77 at station A remains closed. The operator at station A proceeds to call station B in the manner employed in calling either station D or the repeater, except that the selector key 16 must first be adjusted to transmit the particular combination of impulses which will cause the selector 17 at station B to close its associated contact. When such a call has been initiated at station A, the operation of the apparatus at station A and the repeater is the same as that previously described up to the stepping up of the selectors in response to the calling impulses. The combination of impulses transmitted in this case, however, not only cause the selector at station B to close its associated contact, but also cause the selector 110 at the repeater to close one of its four contacts. This is due to the fact that, as pointed out above, one of the contacts of selector 110 corresponds to the code employed by the operator at station A to call station B.

The operation of the apparatus at station B is the same as that previously described in connection with station D up to the completion of the dialing. In other words, the calling impulses relayed to station B by the repeater, cause the operation of relays 62, 83 and 93. When the selector 17 at station B closes the proper contact, the relay 96 is operated in the manner described above, thereby energizing the bell 18. Although the selector 17 at station B falls back to its starting position, the bell 18 continues to ring until the operator at station B removes his receiver from the switchhook, since relay 96 is locked up in the manner previously described.

When the selector 110 at the repeater closes its associated contact corresponding to the code setting of the selector 17 at station B, the relay 189 is operated over a circuit extending from grounded battery 199, through the winding of relay 189, closed contact of selector 110, to ground. Although the selector 110 falls back to the starting position, the relay 189 remains energized over a holding circuit extending from grounded battery 199, through the winding, lower contact and armature of relay 189, upper armature and contact of relay 184, to ground. The relay 189, in attracting its upper armature, opens the energizing circuit of relay 130, thereby disconnecting battery from the filaments of the space discharge tubes in the outgoing channel at the repeater. The carrier waves of 80 kilocycles frequency thereupon cease to flow to the power line from the repeater, and hence relay 62 at station B is deenergized. Relay 62, in opening its contact, opens the energizing circuit of relay 83. Relay 83 in releasing, and relay 79 in operating as it does when the operator removes the receiver from the switchhook, short-circuits relay 62 through the second lower armature and contact of relay 79

and the uppermost armature and contact of relay 83, preventing the subsequent operation of relay 62 in response to incoming carrier waves.

5 When the operator at station B removes his receiver from the switchhook, the relay 76 is energized, thereby energizing relay 79 over a circuit previously traced from grounded bat-
 10 tery 80, through the front contact and armature of relay 76, winding of relay 79, to ground. The operation of relay 79 causes the energization of relay 30 which lights the filaments of the space discharge tubes in the out-
 15 going channel. Before the operator at station B removed his receiver from the switchhook, relay 82 was energized over a circuit extending from grounded battery 97, through the second upper contact and armature of re-
 20 lay 96, upper winding of relay 82, lowermost contact and armature of relay 83, to ground. Thereafter, when relay 76 was energized upon removing the receiver from the switchhook, a holding circuit was established for relay 82, from grounded battery 80, through the front
 25 contact and armature of relay 76, lower winding and the closed contact and armature of relay 82, to ground. Relay 82 thus remains energized even after relay 96 is deenergized when the receiver is removed from the switch-
 30 hook. Relay 82, in attracting its armature, opens the energizing circuit of relay 81. During the transmission of the calling impulses, station A, which originates the call, transmits at 100 kilocycles and the repeater receives at
 35 100 kilocycles and transmits at 80 kilocycles, while all of the other stations receive the interrupted 80 kilocycle waves, as illustrated in Fig. 5^c.

40 The filter controlling relays 88 and 89 are now energized, the energizing circuit of relay 88 extending from grounded battery 99, through the winding of relay 88, first lower contact and armature of relay 79, lower arma-
 45 ture and contact of relay 83, to ground, and the energizing circuit of relay 89 extending from grounded battery 100, through the winding of relay 89, first lower contact and arma-
 50 ture of relay 79, lower contact and armature of relay 83, to ground. The operation of relay 88 serves to disconnect the high pass filter 13 from the outgoing channel and connect it to the incoming channel, and the operation
 55 of relay 89 serves to disconnect the low pass filter 14 from the incoming channel and connect it to the outgoing channel. Relay 90 at station B is now energized over a circuit extending from grounded battery 92, through the
 60 winding of relay 93, resistance 95, second upper armature and back contact of relay 83, winding of relay 90, uppermost back contact and armature of relay 81, to ground. Since
 65 relay 90 is energized, the condenser 39 is connected in the circuit of the oscillator 20 and hence carrier waves of 80 kilocycles frequency are transmitted through low pass filter

14 and coupling circuit 12 to the power line 10. The speech modulated carrier waves of 100 kilocycles frequency which are impressed upon the power line at station A pass through the coupling circuit 12 at station B and are se-
 70 lectively passed by the high pass filter 13 to the common collecting circuit 51, and are then demodulated in the demodulator 54. The low frequency components of demodulation ap-
 75 pearing in the output circuit of the demodulator 54 are amplified by the amplifier 55 and passed through transformer 70, low pass filter 73, resistance network 74, and transformer 75 to the receiver of the operator's telephone set
 80 15. Although a portion of the carrier waves received at station D are rectified by the rectifier 53, the relay 62 will not operate since the winding of this relay is short-circuited in the manner described above. The operators at
 85 stations A and B may thus converse directly without using the repeater, station A transmitting at 100 kilocycles and receiving at 80 kilocycles, and station B transmitting at 80 kilocycles and receiving at 100 kilocycles, as indicated in Fig. 5^d.
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Calling and talking to station on same side of repeater upon failure of the line or the repeater.

According to this invention, calling signals 95 and speech modulated carrier waves may be transmitted between two stations which are located on the same side of a break in the power line, or on the same side of the repeater, if the repeater fails to operate. For the pur-
 100 pose of illustration it will be assumed that a break has occurred in the power line at some point between station B and the repeater, or it may be assumed that the repeater has for some reason been rendered inoperative.
 105 When this condition prevails, the operator at station A, for example, may nevertheless call and converse with the operator at station B by first operating the key 77. This key is operated only at the station which
 110 originates the call, in this case station A, and is employed only when it has been determined that the repeater, for either of the reasons mentioned above, will not receive the calling impulses.
 115

The operator at station A, after opening the key 77, removes his receiver from the switchhook. The relay 76 is thereupon en-
 120 ergized through the circuit previously traced. Relay 76, in operating, causes the energization of relay 79 in the manner previously described. The operation of relay 79 causes the operation of relay 30 which causes filament
 125 heating current to be supplied to the space discharge tubes in the outgoing channel. Since the key 77 is open, relay 81 will not be energized, and consequently relay 83 is not energized. The filter controlling relays
 88 and 89 are therefore energized over the circuits previously traced through the first
 130

lower contact and armature of relay 79 and the lower contact and armature of relay 83. The operation of relay 88 disconnects the high pass filter 13 from the outgoing channel and connects it to the incoming channel, and the operation of relay 89 disconnects the low pass filter 14 from the incoming channel and connects it to the outgoing channel. Relay 90 remains energized through the circuit previously traced from grounded battery 92, to ground at the upper back contact and armature of relay 81. Carrier waves of 80 kilocycles frequency generated by the oscillator 20 are thereupon transmitted to and impressed upon the power line at station A.

The operator at station A now actuates the selector key 16 which, of course, is adjusted to transmit the proper code of impulses for calling station B. The operation of the selector 16 causes relay 90 to release and operate alternately, this relay being short-circuited from ground at the contact of the selector key to ground at the upper back contact and armature of relay 81 each time a tooth of the selector key actuates the associated contact arm. The operation of relay 90 in alternately placing the condenser 39 out of and into the oscillator circuit causes impulses of 80 kilocycles frequency to pass through the low pass filter 14 and coupling circuit 12 to the power line. Relay 93 and selector 17 at station A also operate, but perform no useful function at this time.

The operation of the apparatus at station B in response to the calling impulses is similar to that previously described in connection with station D. Thereafter the speech modulated carrier waves of 80 kilocycles frequency which are impressed upon the power line at station A pass through the coupling circuit 12 at station B and are selectively passed by the low pass filter 14 to the common collecting circuit 51, and are then demodulated in the demodulator 54. The low frequency components of demodulation are transmitted to the receiver of the operator's telephone set 15 in the manner described above. The operators at stations A and B may thus converse directly without having used the repeater at all, station A transmitting at 80 kilocycles and receiving at 100 kilocycles, and station B transmitting at 100 kilocycles and receiving at 80 kilocycles, as indicated in Fig. 5^e. Although a portion of the carrier waves which are now received at station A is rectified by the rectifier 53 thereat, the relay 62 will not operate since the winding of this relay is short-circuited through the second lower contact and armature of relay 79 and the uppermost armature and contact of relay 83. Stations C and D, located on the opposite side of the repeater, may likewise communicate with each other in this

manner while another portion of the system is out of service.

The invention is capable of other modifications and adaptations not specifically described but included within the scope of the appended claims.

What is claimed is:

1. A transmission system comprising a transmission line, a plurality of stations and a repeater connected to said line, means at each of said stations for transmitting calling signals over said line receivable only by said repeater, means at said repeater responsive to said received signals for transmitting over said line signals receivable by said stations, and means at one or more of said stations for transmitting calling signals over said line receivable by other of said stations.

2. A transmission system comprising a transmission line, a plurality of stations and a repeater connected to said line, means at each of said stations for transmitting carrier waves of a frequency receivable only by said repeater, means at said repeater responsive to said received carrier waves for transmitting waves of a frequency receivable by said stations, and means at one or more of said stations for transmitting carrier waves over said line of a different frequency receivable by other of said stations.

3. A transmission system comprising a transmission line, a plurality of stations and a repeater connected to said line, outgoing and incoming circuits at each of said stations including apparatus for transmitting waves of one frequency and receiving waves of another frequency, means at said repeater responsive to waves of said first mentioned frequency for transmitting waves of said second mentioned frequency, and means operative upon initiating a call at one or more of said stations to interchange the transmitting and receiving apparatus thereat with respect to the outgoing and incoming circuits.

4. A transmission system comprising two line sections, a plurality of stations connected to each line section, a repeater connecting said line sections, means at each of said stations for transmitting calling signals receivable only by said repeater, means at said repeater responsive to received signals for transmitting waves receivable by the stations connected to each line section, and means at one or more of said stations for transmitting calling signals receivable by other of said stations connected to the same line section.

5. A transmission system comprising two line sections, a plurality of stations connected to each line section, a repeater connecting said line sections, means at each of said stations for transmitting calling signals of a frequency receivable only by said repeater, means at said repeater responsive to received signals for transmitting signals of a fre-

quency receivable by the stations connected to each line section, and means at each of said stations for transmitting calling signals of a frequency receivable by other of said stations
5 connected to the same line section.

6. A transmission system comprising two line sections, a plurality of stations connected to each line section, a repeater connecting said line sections, means at the stations connected to one of said line sections for transmitting carrier waves modulated in accordance with signals, means at the stations connected to the other of said line sections for transmitting carrier waves of different frequency modulated in accordance with signals,
15 means at said repeater for retransmitting said signals as modulations of carrier waves of a third frequency receivable by said stations, and switching means operative upon initiating a call at one or more of said stations to condition the transmitting means thereat to transmit signals as modulations of carrier waves of said third frequency.

7. A transmission system comprising two
25 line sections, a plurality of stations connected to each line section, a repeater connecting said line sections, means at the stations connected to one of said line sections for transmitting waves comprised within one band of frequencies and receiving waves comprised within a second band of frequencies, means at the stations connected to the other of said line sections for transmitting waves comprised within a third band of frequencies and
35 receiving waves comprised within said second band of frequencies, means at said repeater for transmitting waves comprised within said second band of frequencies and receiving waves comprised within said first and third bands of frequencies, and means at
40 one or more of said stations for transmitting waves comprised within the band of frequencies receivable by other stations connected to the same line section.

45 8. A transmission system comprising two line sections, a plurality of stations connected to each line section, a repeater connecting said line sections, outgoing and incoming circuits at the stations connected to one of said line sections including apparatus for transmitting waves comprised within one band of frequencies and receiving waves comprised within a second band of frequencies, outgoing and incoming circuits at the stations connected to the other of said line sections including
55 apparatus for transmitting waves comprised within a third band of frequencies and receiving waves comprised within said second band of frequencies, outgoing and incoming circuits at said repeater including apparatus for transmitting waves comprised within said second band of frequencies and receiving waves comprised within said first and third bands of frequencies, and means
65 operative upon initiating a call at one or more

of said stations to interchange the transmitting and receiving apparatus thereat with respect to the outgoing and incoming circuits.

9. A transmission system comprising two line sections adapted for the simultaneous
70 transmission of power currents and signaling waves, a plurality of stations associated with at least one of said sections, a repeater connecting said sections, means at one of said stations for transmitting waves of a frequency receivable only by said repeater, means
75 at said repeater responsive to received waves for transmitting waves of a frequency receivable by said stations, and means at one or more of said stations for transmitting waves
80 of a different frequency receivable by other of said stations.

10. A transmission system comprising two line sections adapted for the simultaneous
85 transmission of power currents and signaling waves, a plurality of stations connected to each line section, a repeater connecting said line sections, means for selectively calling any of said stations from any other of said stations through said repeater over said line
90 sections, and means at each of said stations for directly calling the stations connected to the same line section over said line.

11. A transmission system comprising two line sections adapted for the simultaneous
95 transmission of power currents and signaling waves, a plurality of signaling stations connected to each of said line sections, a signal repeater station connecting said line sections, means for selectively calling and communicating with any of said stations from any other of said stations through said repeater,
100 and means at each of said stations for directly calling and communicating with the stations connected to the same line section.

12. A transmission system comprising two line sections adapted for the simultaneous
110 transmission of power currents and signaling waves, a plurality of signaling stations connected to each of said line sections, a signal repeater station connecting said line sections, means for selectively calling and communicating with any of said stations from any other of said stations through said repeater over said line sections, and means at
115 each of said stations for directly calling and communicating with the stations connected to the same line section independently of the repeater.

13. A carrier wave transmission system
120 comprising a transmission line, a plurality of stations and a repeater connected to said line, means at each of said stations for communicating with any other station through said repeater over said line by carrier waves,
125 and means for one of said stations to communicate with any other station by carrier waves over said line independently of said repeater.

14. A carrier wave transmission system 130

comprising two line sections, a plurality of signal stations connected to each of said line sections, a repeater connecting said line sections, means for selectively communicating 5 with any of said stations from any other of said stations, through said repeater over the line sections by means of carrier waves, and means at each of said stations for directly communicating with any other station connected to the same line section by carrier 10 waves independently of the repeater.

In witness whereof, I hereunto subscribe my name this 3rd day of February, A. D. 1927.

LAWRENCE W. DAVEE.