

C. S. DEMAREST.
 REPEATER CONTROLLING SYSTEM FOR FOUR-WIRE CIRCUITS.
 APPLICATION FILED FEB. 24, 1919.

1,394,189.

Patented Oct. 18, 1921.
 6 SHEETS—SHEET 1.

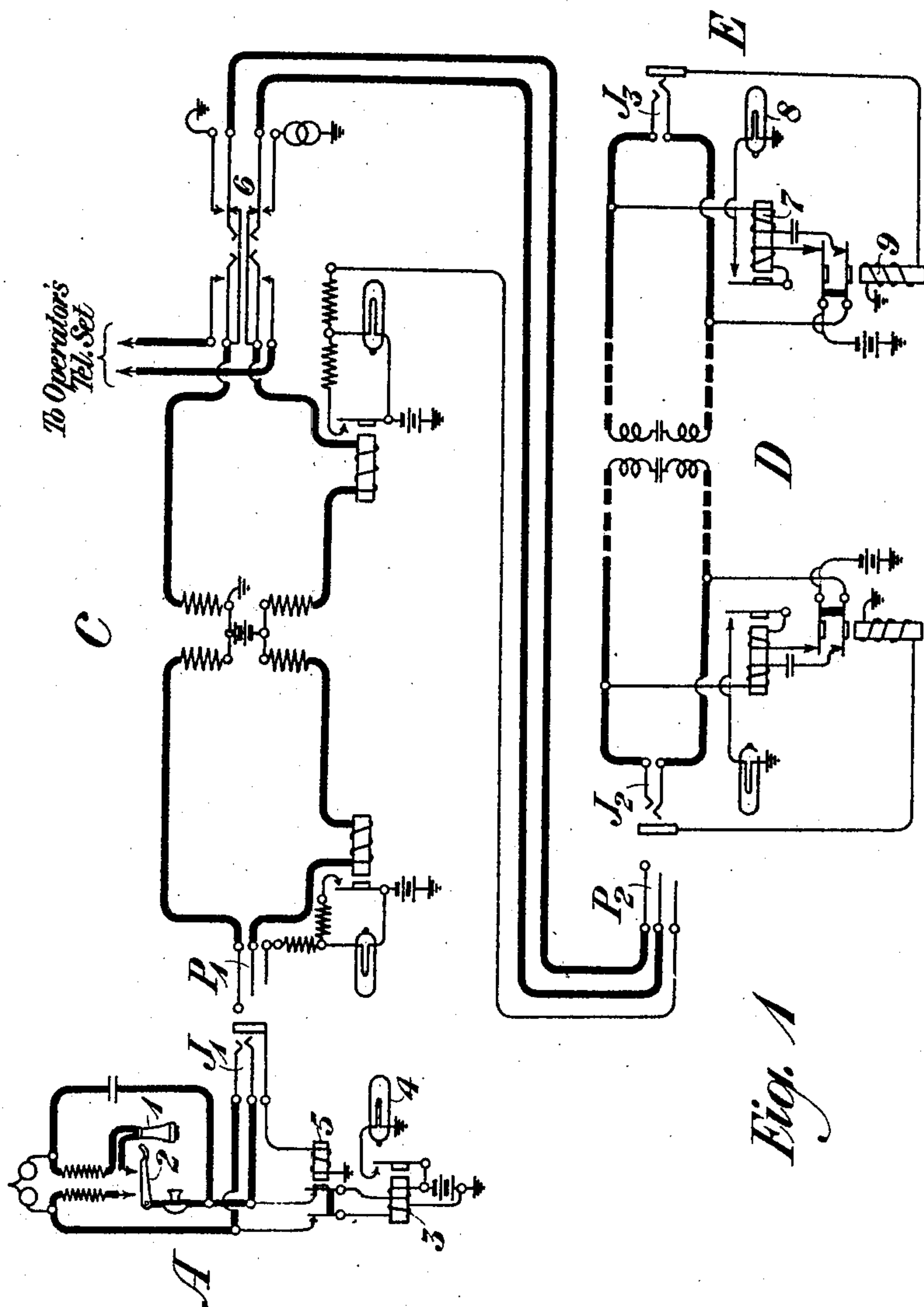


Fig. 1

INVENTOR.
C. S. Demarest
 BY *G. V. Folsom*
 ATTORNEY

C. S. DEMAREST.
 REPEATER CONTROLLING SYSTEM FOR FOUR-WIRE CIRCUITS.
 APPLICATION FILED FEB. 24, 1919.

1,394,189.

Patented Oct. 18, 1921.

6 SHEETS—SHEET 2.

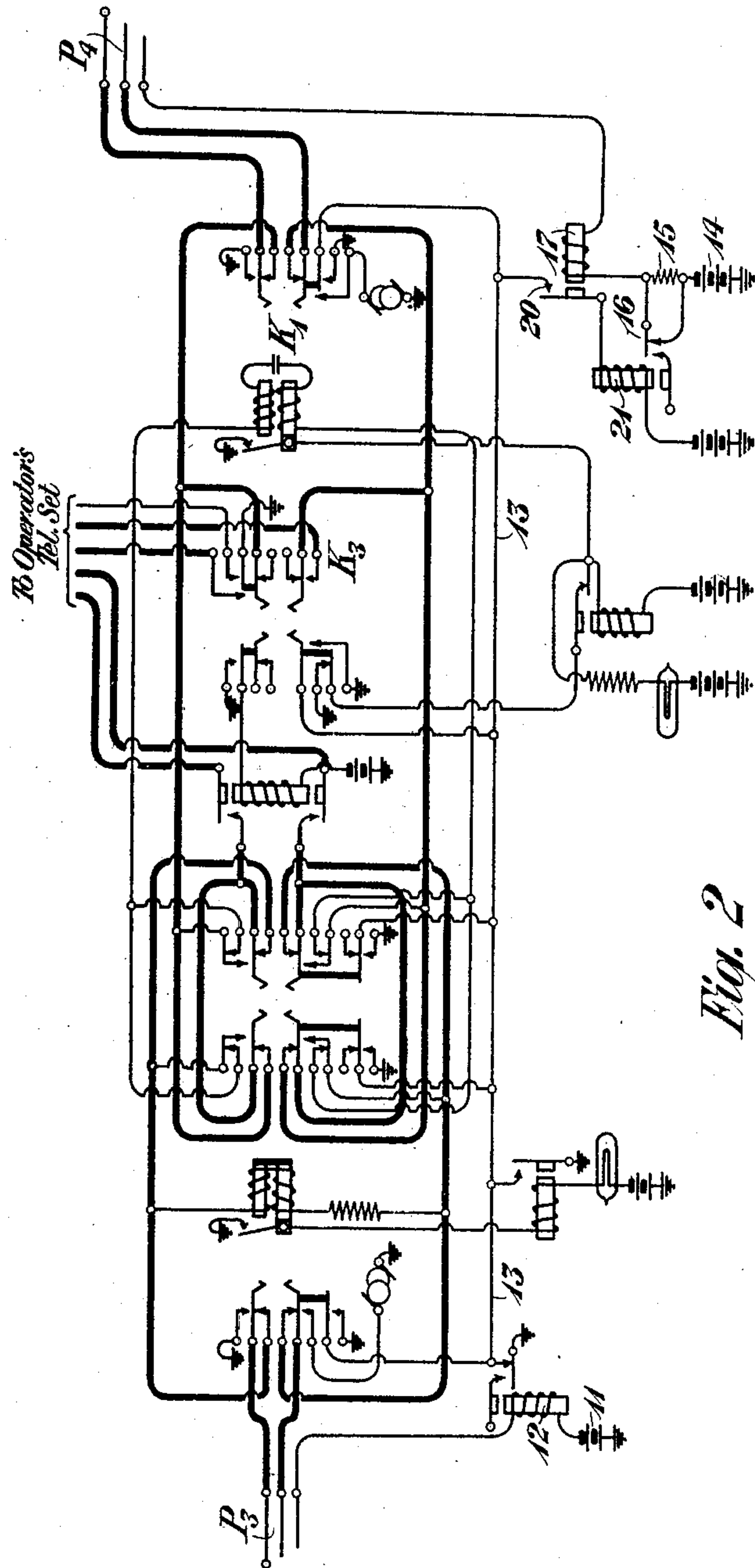


Fig. 2

INVENTOR.
C. S. Demarest
 BY *J. E. Folsom*
 ATTORNEY

1,394,189.

Patented Oct. 18, 1921.

6 SHEETS—SHEET 3.



INVENTOR.

C. S. Demarest

BY

ATTORNEY

C. S. DEMAREST.
 REPEATER CONTROLLING SYSTEM FOR FOUR-WIRE CIRCUITS.
 APPLICATION FILED FEB. 24, 1919.

1,394,189.

Patented Oct. 18, 1921.
 6 SHEETS—SHEET 4.

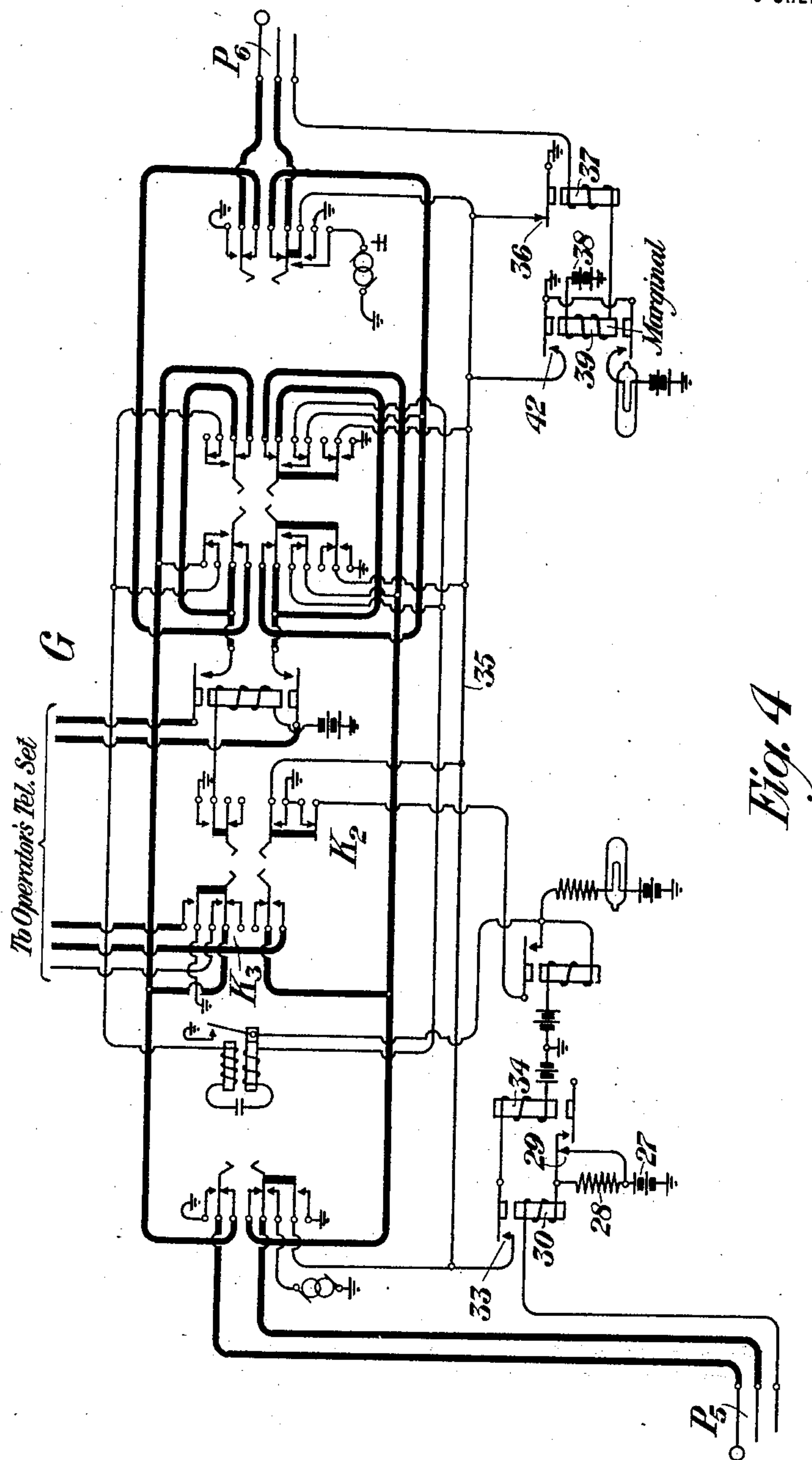


Fig. 4

INVENTOR.
C. S. Demarest
 BY *g. v. for*
 ATTORNEY

C. S. DEMAREST.
 REPEATER CONTROLLING SYSTEM FOR FOUR-WIRE CIRCUITS.
 APPLICATION FILED FEB. 24, 1919.

1,394,189.

Patented Oct. 18, 1921.

6 SHEETS—SHEET 5.

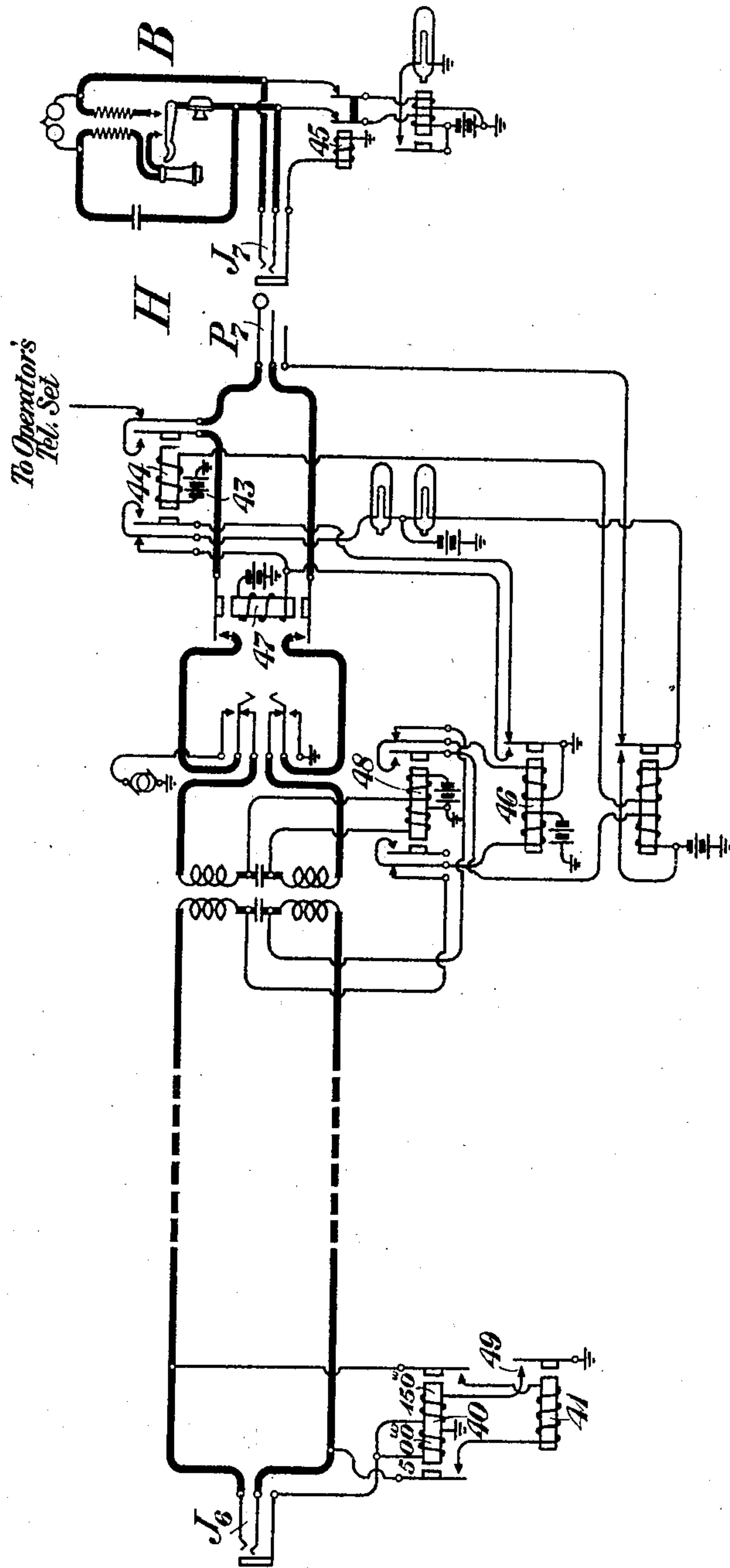


Fig. 5

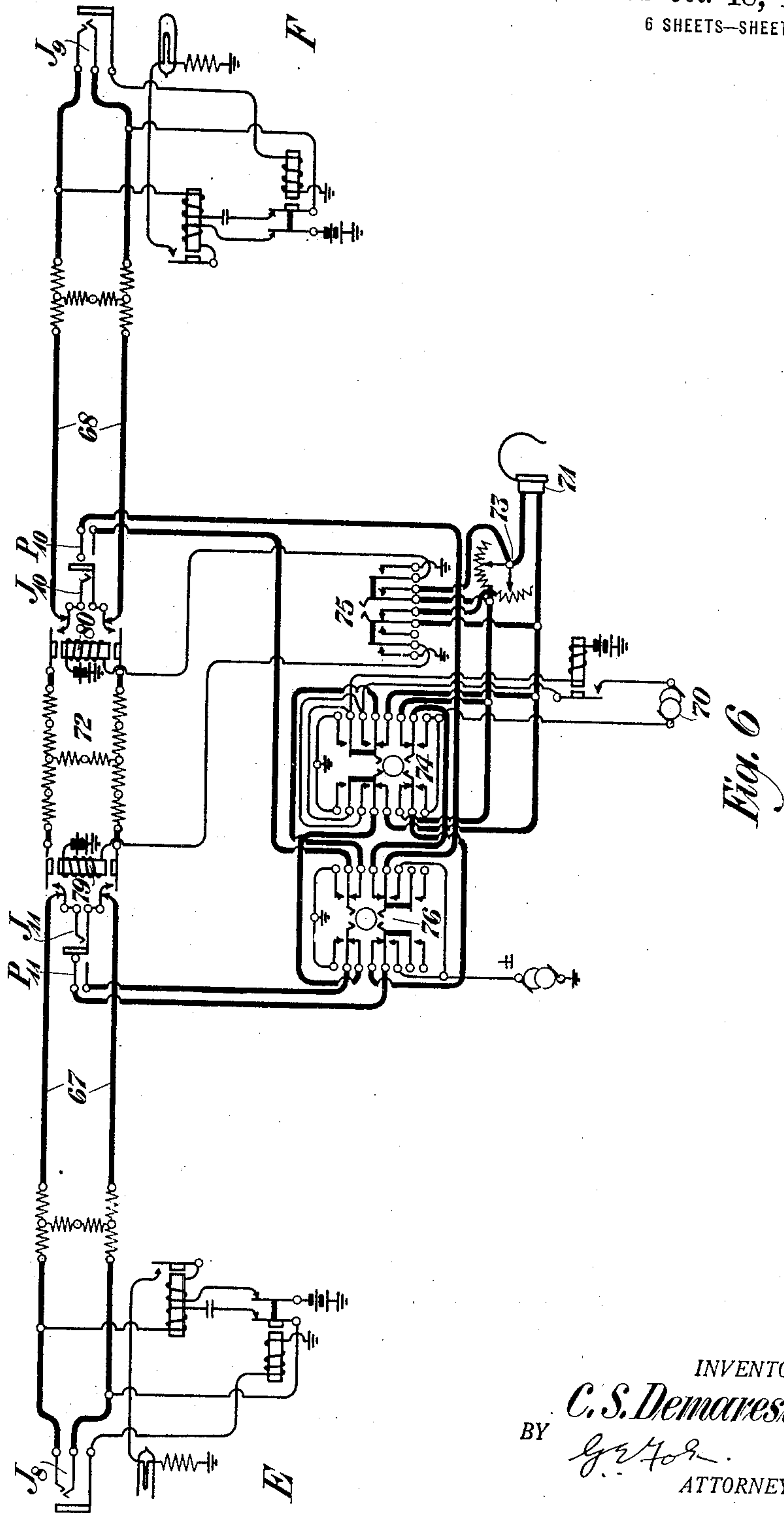
INVENTOR.
C. S. Demarest
 BY *g. e. for*
 ATTORNEY

C. S. DEMAREST.
 REPEATER CONTROLLING SYSTEM FOR FOUR-WIRE CIRCUITS.
 APPLICATION FILED FEB. 24, 1919.

1,394,189.

Patented Oct. 18, 1921.

6 SHEETS—SHEET 6.



INVENTOR.
C. S. Demarest
 BY *g. v. 402*
 ATTORNEY

UNITED STATES PATENT OFFICE.

CHARLES S. DEMAREST, OF NEW YORK, N. Y., ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

REPEATER-CONTROLLING SYSTEM FOR FOUR-WIRE CIRCUITS.

1,394,189.

Specification of Letters Patent.

Patented Oct. 18, 1921.

Application filed February 24, 1919. Serial No. 278,945.

To all whom it may concern:

Be it known that I, CHARLES S. DEMAREST, residing at New York, in the county of New York and State of New York, have invented certain Improvements in Repeater-Controlling Systems for Four-Wire Circuits, of which the following is a specification.

This invention relates to telephone transmission systems and more particularly to means for controlling the connection of telephone repeaters to a four-wire telephone transmission circuit, and for testing the efficiency of such type of circuit.

Heretofore it has been customary to connect the repeaters into the four-wire repeater circuit, and to maintain such connection permanently, regardless of the nature of the circuit that may be connected with each end of the said four-wire circuit. The telephone repeaters connected with a four-wire circuit are usually designed and operated to give an amplification that will compensate not only for the loss in the four-wire circuit itself, but also for the losses in the telephone trunk lines that may ordinarily be connected with the said four-wire circuit. When such a circuit is completely connected from subscriber to subscriber, the repeater is balanced and will operate satisfactorily, that is, without "singing". It has been found that whenever an operator connects her telephone set with such circuit for the purpose of supervising such connection, an unbalanced condition is created and the repeaters begin to "sing", thereby impairing the transmission over the circuit.

One of the objects of this invention is to provide means, whereby the repeater which is normally effectively disconnected from a repeater trunk circuit may be effectively connected to the said circuit only when the repeater trunk circuit is connected in both directions to telephone circuits of the type with which it is intended that it should be associated, and when the keys of all associated cord circuits are in their normal, non-operated positions.

A further object of this invention is to provide means for controlling the connections between the filament heater batteries and the filaments of thermionic repeaters whereby the said batteries will be connected with the filaments only when the repeaters are effectively connected into the repeater trunk circuit.

Another object of this invention is to provide a testing circuit the function of which is to determine whether the repeaters are operating properly so as to produce the desired transmission gain.

In order to show more effectively the nature of the invention a telephone transmission circuit is shown complete from one subscriber's station to another. Figure 1 shows a subscriber's line connected at its exchange with a trunk extending to one toll office. Fig. 2 shows a cord circuit at the aforementioned toll office to connect the incoming trunk circuit with the four-wire repeater trunk shown in Fig. 3, which for purpose of description, is assumed to extend between two toll offices. Fig. 4 shows a cord circuit at the other of said toll offices to connect said repeater trunk with the trunk circuit shown on Fig. 5, which terminates in the office in which the other of said subscribers' lines also terminates. The complete circuit may be clearly seen by arranging all the figures subsequent to Fig. 1 so that the bottom edge of each figure coincides with the top edge of the preceding figure. Fig. 6 shows a testing circuit by means of which the repeaters shown in Fig. 3 may be tested. The circuit arrangements shown on these figures will be better understood from the following detailed description of the figures.

In Fig. 1 is shown a standard subscriber's line A terminating at its exchange in the jack J_1 . C is a cord circuit of the usual subscriber's type, having a plug P_1 adapted to be inserted in the jack J_1 and a plug P_2 , adapted to be inserted in jack J_2 of a ring-down trunk D which extends from the said exchange to a toll board at the toll office E terminating therein in a jack J_3 .

Fig. 2 shows the cord circuit at the toll board E terminating in a plug P_3 adapted to be inserted in the jack J_3 of the ring-down trunk shown in Fig. 1 and also in a plug P_4 adapted for insertion in either jack J_4 or jack J_4' of the toll board E shown in Fig. 3.

Fig. 3 shows a four-wire repeater trunk circuit extending between two toll offices, designated W and F, and terminating at each of these offices in two jacks. The four-wire circuit is of the usual type, having two two-wire branches which are electrically related by means of the hybrid repeating coils X

and Y. Associated with coil X are two networks N_1 and N_3 , the former being adapted to balance the circuit connected with jack J_4' and the combined networks being adapted to balance the circuit connected with jack J_4 . In a similar manner coil Y has associated with it two networks N_2 and N_4 ; N_2 being adapted to balance the circuit connected with jack J_5' and the combined networks to balance the circuit connected with jack J_5 . Each group of jacks at either end of the four-wire circuit has associated with it a group of relays controlled by the circuits connected with said jacks and adapted to control relays 25 and 26 of the repeater circuit which, in turn control the connection of the repeaters to the branches of the four-wire circuit, and the connection of the heater batteries with the filaments.

Fig. 4 shows a cord circuit located at the toll office F terminating in two plugs P_5 and P_6 , P_5 being adapted for insertion in jacks J_5 and J_5' of the four-wire trunk circuit and plug P_6 being adapted for insertion in jack J_6 of the circuit trunk shown in Fig. 5.

Fig. 5 shows a circuit trunk terminating in the jack J_6 at the toll office F and in the plug P_7 at the exchange H in which the subscriber's line B also terminates, the said plug being adapted for insertion in the jack J_7 of the said subscriber's line.

Fig. 6 shows the repeater testing equipment which is preferably located in the same office in which the repeater shown in Fig. 3 is located and is connected by means of ring-down trunks with the switchboards at the toll offices E and F terminating therein in jacks J_8 and J_9 , respectively. This circuit and the method of its operation will be described more fully hereafter.

If the subscriber at substation A, which is located in a territory in which toll line service is furnished by the toll office E, desires to communicate with the subscriber at B, which is in a territory in which toll line service is furnished by the toll office F, the method of establishing the line of communication is as follows:—

When the subscriber at A removes his receiver 1 from the switch hook 2, causing the operation of relay 3 and the lighting of the lamp 4 the operator at the exchange C inserts plug P_1 of the cord circuit in the jack J_1 , thereby operating relay 5 and extinguishing the lamp 4. When the operator at C ascertains from the subscriber at A that the subscriber desires to communicate with a subscriber B in the territory controlled by the toll office F, the operator inserts the other plug P_2 of the cord circuit in jack J_2 of the ring-down trunk connecting exchange C with the toll office E. The operator at C applies ringing current to the trunk by operating key 6 which causes relay 7 to operate,

thereby lighting the lamp 8 which is associated with jack J_3 . The operator at the toll office E answers this call by inserting plug P_3 of the cord circuit in jack J_3 which operates relay 9, thereby opening the circuit of relay 7 which is normally bridged across the trunk. When the operator at toll office E ascertains that communication is desired with subscriber B whose line is in the territory served by toll board F, she inserts plug P_4 of the cord circuit in either jack J_4 or J_4' and depresses the ringing key K_1 of the cord circuit which causes the lamp 10 at the toll office F to light. The operator at toll office F inserts the plug P_5 of the cord circuit in the jack J_5 or J_5' and operates the talking key K_2 of the cord circuit. The selection of the proper jack at office E or F in which the plugs P_4 and P_5 , respectively, are to be inserted depends upon the characteristics of the trunk circuit with which the four-wire trunk circuit is to be connected. The basis of selection will be fully explained hereafter.

When the operator at office E takes up the call over trunk D by inserting the plug P_3 in jack J_3 , a circuit is established over the sleeve contacts of the plug and the jack from the grounded battery 11 of the cord circuit, windings of relays 12 and 9 thereby operating both of said relays. The result of the operation of relay 9 has been heretofore described. By the opening of the normal contact of relay 12 a ground is removed from conductor 13. When plug P_4 was inserted in jack J_4 a circuit was established over the sleeve contacts of this plug and jack from the grounded battery 14, through resistance 15 in parallel with a short circuiting strap through contact 16, winding of relay 17, sleeve contacts of the plug P_4 and jack J_4 , windings of relays 18 and 19 to ground, operating relays 17, 18 and 19. The operation of relay 17 closes contact 20, thereby connecting grounded battery through winding of relay 21 to conductor 13. If conductor 13 is not grounded at any point relay 21 remains inoperative and contact 16 remains closed thereby maintaining a low resistance path around resistance 15. Relay 19, which is marginal, receives under these conditions sufficient current to effect its operation, thereby establishing a circuit from ground through conductor 22 to the midpoint of one of the windings of coil 23, over the two wires of one of the branches of the four-wire circuit to the midpoint of coil 24, thence through relay 25 to the grounded battery. The operation of relay 25 applies a ground to a part of the repeater control circuit but it does not effect the connection of the repeater to this branch of the circuit until relay 26 is operated which will now be described:—

When the operator at toll office F inserts

the plug P_5 in the jack J_5 , a circuit is established over the sleeve contacts of the plug and jack from the grounded battery 27 of the cord circuit through resistance 28 in parallel with the short circuiting strap through contact 29, thence through windings of relays 30, 31 and 32 to ground, thereby effecting the operation of relays 30 and 31. When relay 30 operates it closes contact 33, thereby establishing a circuit from grounded battery, through the winding of relay 34, over conductor 35 and contact 36 of relay 37 to ground, thereby causing relay 34 to operate which opens contact 29 of relay 34 and opens the short circuit around resistance 28. As a result of the removal of this short circuit, the amount of current that flows through relay 32 and the other relays in series therewith is limited by resistance 28 to such an extent that relay 32 which is marginal will not be operated; consequently, relay 26 remains unoperated and neither repeater will be connected into the four-wire circuit. Therefore the toll operators may use this circuit to establish the proper connections free from the annoyance caused by the "singing" of the repeaters. When the operator at toll office F has learned the number of the desired subscriber's line and has restored the talking key K_2 to its normal position she transmits the number over an order wire circuit (not shown) to a trunk operator at H and she inserts plug P_6 in jack J_6 of the proper circuit trunk extending from the toll office F to the exchange H at which the subscriber's line of the desired subscriber terminates. When the plug P_6 is inserted in jack J_6 , a circuit is established over the sleeve contacts of the plug and jack from the grounded battery 38, through relays 39 and 37 and the 500 ohm winding of relay 40, causing relay 40 to operate which bridges the winding of relay 41 across the circuit trunk. Relay 37 is operated thereby which removes the ground from conductor 35 by opening contact 36 but relay 39 is marginal and does not respond when the 500 ohm winding is in series. However, as soon as relay 41 operates and connects the 150 ohm winding in parallel with the 500 ohm winding to ground, relay 39 operates closing contact 42, thereby grounding conductor 35. This therefore maintains a closed circuit through relay 34 which keeps open the short circuit around resistance 28 and thereby prevents the operation of the marginal relay 32 which controls the connection of the repeaters.

When the operator at exchange H has been advised over the said order wire circuit by the operator at the toll office F the number of the desired subscriber, the operator at H inserts the plug P_7 into the jack J_7 of the desired subscriber's line, thereby establishing a circuit over the sleeve contacts of the

plug and jack from the grounded battery 43, relay 44 and cut off relay 45 to ground, thereby operating relays 44 and 45. When plug P_6 was inserted in jack J_6 and the winding of relay 41 was bridged across the trunk, relay 46 was thereby operated closing a contact to ground, thereby operating relay 47 which closed through the two sides of the trunk circuit to a subscriber's station B. When the subscriber at station B removes his receiver from the hook, relay 48 is thereby operated by the closing of the circuit at the hook switch and thereby disconnects relay 46 from the trunk circuit. Relay 41 which depends upon relay 46 for its energization is thereby released, opening its contact 49. This removes the ground from the 150 ohm winding of relay 40 leaving the 500 ohm winding in series with relays 37 and 39. Relay 39 which is marginal does not receive sufficient current under this condition to energize it and therefore it is released, causing the opening of contact 42 and thereby removing the ground from the conductor 35. It should be noted that relay 37 receives sufficient current to remain in its operated position thereby maintaining contact 36 in its open position and removing the ground from conductor 35. Furthermore, if all of the keys of the cord circuits at the toll stations E and F are in their normal positions, relay 34 will be unoperated, contact 29 will remain closed and the marginal relay 32 of the four-wire trunk circuit will receive sufficient current to effect its operation. When relay 32 operates a circuit is established from ground through conductor 50 to the midpoint of coil 51, thence over the two wires in parallel of one branch of the four-wire circuit to the midpoint of one of the windings of coil 52, over conductor 53, relay 26 to the grounded battery 54, thereby operating relay 26. As will be recalled relay 25 was operated when the telephone circuit was completely established from the subscriber's station at A to the jack J_4 of the four-wire trunk circuit at the toll office E, and when all of the keys of the cord circuit at the toll office E were in their normal non-operated positions. When relays 25 and 26 are simultaneously operated, relays 55, 56, 57 and 58 will operate, thereby removing the short circuit around the repeaters 59 and 60 and effectively connecting these repeaters into the two branches of the four-wire trunk circuit. Also relay 61 is operated as a result of the operation of relays 25 and 26, thereby connecting the filament heater batteries 62 and 63 in series with the filaments of the thermionic repeaters 60 and 59, respectively.

If the operator at either of the toll offices operates any of the keys except the monitoring keys K_3 of the cord circuit with which said keys are associated or if she removes

either of the plugs of either cord circuit from its associated jack, the winding of either relay 21 or relay 34 will be grounded thereby operating either of said relays and causing the marginal relays 19 or 32 to release. This will, in turn, release either relay 25 or 26 and will effect the disconnection of the repeaters 59 and 60 from the four-wire trunk circuit, thereby preventing the "singing" of the repeaters.

If the subscriber at station B restores his receiver to the hook, relay 48 will be de-energized, thus reconnecting relay 46 across the trunk circuit which again energizes relay 41. This will effectively connect the two windings of relay 40 in parallel to ground and will permit sufficient current to flow through the marginal relay 39 to effect its operation. When relay 39 operates a ground is thereby placed upon conductor 35 which causes relay 34 to operate which, in turn, results in the operation of marginal relay 32, thereby disconnecting the repeaters 59 and 60 from the trunk circuit.

If the subscriber at station A restores his receiver to the hook the operator at the exchange C will receive a disconnect signal and will remove the plugs P_1 and P_2 of the cord circuit from the associated jacks. When the toll operator at the office E receives the disconnect signal she removes plug P_3 from jack J_3 of the trunk circuit thereby releasing relay 12 and grounding conductor 13. Relay 21 is thereby energized opening contact 16 in the short circuiting strap around resistance 15. Under this condition the marginal relay 19 will not receive sufficient current to maintain it in its operated position, and consequently it will release, thereby removing the ground from conductor 22 and releasing relay 25. As a result, the repeater switching relays are de-energized and the repeaters are effectively disconnected from the trunk circuit.

Mention has been made heretofore of a plurality of jacks in which the four-wire repeater trunk circuit terminates at the toll offices E and F, and of the necessity for making a selection among said jacks in order to establish the proper connection between the subscribers' stations A and B. It will be noted that in addition to the two balancing networks N_1 and N_2 associated with the hybrid repeating coils X and Y respectively of the repeater circuit, two other networks N_3 and N_4 are connected with the repeater circuit, N_3 being adapted to be associated with N_1 and N_4 with N_2 . These networks are provided to render it practicable to equalize the transmission equivalents of all through telephone connections that are completed over this four-wire repeater trunk circuit. All of the trunk circuits at offices E and F incoming from exchanges are divided into two groups, the

division depending upon whether they are above or below a certain predetermined transmission equivalent. Networks N_1 and N_2 are designed to have electrical characteristics substantially similar to those of one of said groups of trunks, and the combination of networks N_1 and N_3 , or of networks N_2 and N_4 substantially similar to those trunks of the other of said groups. The functions of the jacks J_4 and J_4' at office E and of J_5 and J_5' at office F are to connect the incoming trunks with the repeater trunk circuit and to connect the proper network with the trunk circuit.

Thus, for example, if the operator at the toll office E receives a call over a trunk, which by the marking on the jack or other suitable means is shown to be a trunk having low transmission equivalent so that when connected with the repeater it would give a better grade of transmission than was attainable on circuits of the other group, she will insert the plug P_4 in the jack J_4 , thereby connecting into the circuit the network N_3 which in addition to network N_1 will give satisfactory transmission for this type of trunk circuit. In like manner, if the operator at F finds that it is necessary in order to complete the call to use a trunk having low transmission equivalent, she will insert plug P_5 in the jack J_5 which connects the network N_4 in the circuit, in addition to network N_2 , thereby establishing the proper grade of transmission for this connection. If on the other hand, the operator at E receives a call over a trunk that has a high transmission equivalent, she will insert the plug P_4 in the jack J_4' , thereby operating relay 63. This in turn will effect the operation of relay 64, thereby disconnecting the network N_3 and will leave the network N_1 connected with the circuit which permits the desired grade of transmission for this type of circuit. Likewise, if the operator at the toll office F finds that, in order to establish the desired connection, it is necessary to use a trunk having high transmission equivalent, she inserts plug P_5 in the jack J_5' , thereby operating relay 65 and in turn relay 66. The network N_4 is disconnected from the four-wire circuit, leaving the network N_2 associated therewith, which gives the desired grade of transmission for this type of trunk.

In order to determine whether the four-wire repeater trunk circuit is in proper operating condition a testing circuit is provided as shown in Fig. 6. This consists in a central testing arrangement which preferably is located in the same office in which the repeaters 59 and 60 are located, and connected by means of the trunks 67 and 68 with the toll offices E and F, respectively, terminating therein in the jacks J_8 and J_9 , respectively.

The central testing arrangement consists of an oscillator or vibrator 70 adapted to give an electromotive force of approximately telephonic frequency. A receiver 71 with which is associated a receiver shunt 73 is adapted to be connected across the end of the repeater circuit opposite to that end with which the oscillator 70 may be connected. The artificial line 72, which is of the well known type, has the same transmission equivalent as the four-wire circuit has when the repeaters are disconnected. A switch 74 is provided for connecting the oscillator 70 with either end of the repeater circuit or of the artificial line 72. A switch 75 is provided to connect the oscillator and the receiver alternately with the transmission circuit and with the artificial line.

In order to test the repeater, plug P_{10} is inserted in jack J_{10} and plug P_{11} in jack J_{11} . Plug P_8 is inserted in jack J_8 at the toll office E, and plug P_6 is inserted in jack J_9 at toll office F. Relay 12 of the cord circuit at office E and relay 37 of the cord circuit at office F will be operated if the keys in both cord circuits are normal and if plugs P_4 and P_5 are inserted in jacks J_4 and J_5 , respectively. If key 74 of the testing circuit is operated in the left hand direction an alternating electromotive force will be applied over contacts of keys 74 and 76, tip and ring contacts of plug P_{11} and jack J_{11} , trunk 67, over the tip and ring conductors of the cord circuit at office E, through branch 77 of the four-wire repeater circuit including the repeater 59, over the conductors of the cord circuit at office F and the conductors of trunk 68, tip and ring contacts of jack J_{10} and plug P_{10} , right hand normal contacts of switches 76 and 74, through receiver shunt 73 to the receiver 71. Switch 75 is now operated, thereby causing the operation of relays 79 and 80, which disconnects the source of tone 70 from the trunk circuits 67 and 68, respectively, and connects said source of tone to one end of the artificial line 72, and the receiver 71 to the other end of said artificial line.

The receiver shunt 73 is gradually varied until the volume of tone received in the receiver 71 when the receiver is connected across the artificial line is the same as when it is connected across the trunk leading to one end of the four-wire repeater circuit.

If the switch 74 is thrown in the right hand direction the source of alternating electromotive force 70 will be applied to the trunk 68 and the receiver 71 will be connected across the end of trunk 67, thus establishing the circuit from vibrator 70, right hand contacts of switch 74, tip and ring contacts of plug P_{10} and jack J_{10} , trunk 68, conductors of the cord circuit at office F, conductors 78 and repeater 60, forming one side of the four-wire circuit, conductors of

the cord circuit at office E, trunk 67, contacts of jack J_{11} and plug P_{11} , left hand contacts of switches 76 and 74, receiver shunt 73 to receiver 71. By operating switch 75 in the manner heretofore described the vibrator 70 and the receiver and receiver shunt are alternately connected with the four-wire circuit and with the artificial line, and shunt 73 is varied until the volume of tone in the receiver 71 when the receiver is connected with the artificial line is the same as when connected with the four-wire repeater circuit. The reading upon the scale of the receiver shunt represents the transmission gain due to the presence of repeater 60 in the circuit.

From the foregoing description of the apparatus in which this invention is embodied and of its mode of operation, it will be seen that this invention provides simple and effective means for controlling automatically the connection of the telephone repeaters with the trunk circuit, so that the said repeaters will be connected into the circuit only when it is necessary to have such repeaters connected thereto in order to produce the desired grade of transmission. This invention furthermore provides a simple and efficient method for determining the improvement in transmission due to the connection of the repeaters in the four-wire transmission circuit. Although this invention is shown as embodied in the single form, it is apparent that it is capable of embodiment in other and varied forms without departing from the spirit and scope of the appended claims.

What is claimed is:

1. In a telephone system the combination of two subscribers' circuits, trunk circuits adapted to connect each subscriber's circuit to a toll office, a four-wire repeater trunk circuit extending between said toll offices, telephonic repeaters adapted to be connected with said four-wire circuit, link circuits adapted to connect said subscribers' circuits with said trunk circuits and said trunk circuits with said repeater trunk circuit, and means associated with said repeater trunk circuit whereby the said telephonic repeaters may be effectively connected into said repeater trunk circuit when a talking connection is established between the two subscribers' circuits.

2. In a telephone system the combination of two telephone lines, each consisting of a subscriber's line connected with a trunk line, a four-wire repeater trunk circuit, telephonic repeaters adapted to be connected therewith, link circuits adapted to connect said telephone lines to the opposite ends of the said repeater trunk circuit and controlling means associated with said link circuits and said repeater trunk circuit whereby the said telephonic repeaters may be effectively con-

nected with said repeater trunk circuit only when the normal conditions for a through telephone conversation exist.

3. In a telephone system the combination
5 of two telephone lines, each consisting of a subscriber's line connected with a trunk line, a four-wire repeater trunk circuit having telephonic repeaters associated therewith, link circuits adapted to connect said tele-
10 phone lines with said repeater trunk circuit and means associated with said link circuits and said repeater trunk circuit whereby the said repeaters will be disconnected from said transmission circuit whenever any switch
15 other than the monitoring switch associated with said link circuits remains in its operated position.

4. In a telephone system the combination
of two telephone lines, each consisting of a
20 subscriber's line connected with a trunk line, a toll line having telephone repeaters adapted to be connected therewith, link circuits adapted to connect each of said telephone lines to the opposite ends of said toll line,
25 and a switching mechanism associated with said repeaters and controlled by said link circuits whereby said repeaters will remain effectively disconnected from said toll line so long as either of said link circuits remains
30 disconnected from its associated telephone line.

5. In a telephone system a combination of
two telephone lines, each consisting of a sub-
35 scriber's line connected with a trunk line, a toll line having thermionic repeaters associated therewith, link circuits adapted to connect each of said telephone lines to the opposite ends of said toll line and means
associated with the said toll line and controlled by said link circuits whereby the said
40 repeaters may be effectively disconnected from the said toll line and the filament heating batteries disconnected from the filaments of said repeaters when ever either of
45 said link circuits is disconnected from the line.

6. In a telephone system a combination of
two telephone lines, each consisting of a sub-
scriber's line connected with a trunk line, a

toll line having thermionic repeaters asso- 50
ciated therewith, link circuits adapted to connect each of said telephone lines to the opposite ends of said toll line and means associated with the said toll line and controlled by said link circuit whereby the said repeat- 55
ers may be effectively disconnected from the said toll line and the filament heating batteries disconnected from the filaments of said repeaters whenever any switch other than the monitoring switch associated with 60
either of said link circuits remains in its operated position.

7. In a telephone system, the combination
of a four-wire repeater trunk circuit, tele-
phone circuits adapted to be connected with 65
each end of said four-wire circuit, thermionic repeaters adapted for connection with either branch of said four-wire circuit, a plurality of filament heating batteries and means controlled by the connection of said 70
telephone circuits with said four-wire circuits whereby the filaments of said thermionic repeaters will be energized by said batteries simultaneously with the effective connection of said repeaters with the four-wire 75
circuit.

8. In a telephone system, the combination
of a four-wire repeater trunk circuit terminating at each end in a plurality of jacks, a plurality of groups of telephone lines adapted 80
for connection with said four-wire circuit, each of said groups having electrical characteristics differing from the others, a plurality of electrical networks adapted to be associated so as to have the same char- 85
acteristics as said groups and to be connected with said four-wire circuit to balance electrically the telephone circuit connected thereto and a plurality of telephone repeaters adapted to be connected effectively with said 90
four-wire circuit whenever said telephone lines are properly connected with the four-wire circuit.

In testimony whereof, I have signed my name to this specification this 21st day of 95
February, 1919.

CHARLES S. DEMAREST.