Dec. 24, 1935. H. M. BASCOM ET AL 2,025,145

TRANSMISSION SYSTEM

Filed Oct. 4, 1929 3 Sheets-Sheet 1

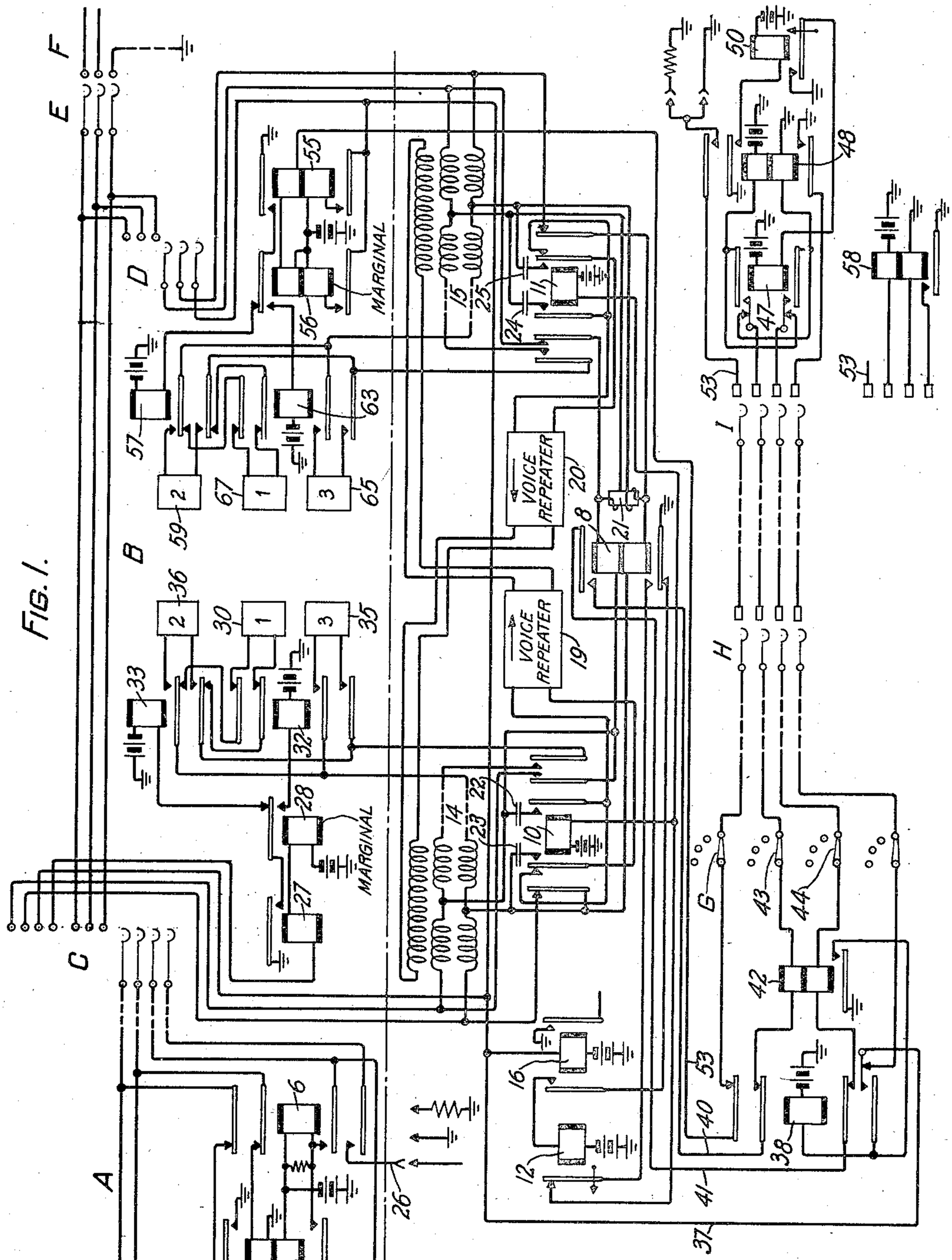

FIG. 1.

INVENTORS H. M. BASCOM
O. A. FRIEND
M. B. McDAVITT

BY G. V. Fok

ATTORNEY

Dec. 24, 1935. H. M. BASCOM ET AL 2,025,145

TRANSMISSION SYSTEM

Filed Oct. 4, 1929 3 Sheets-Sheet 2

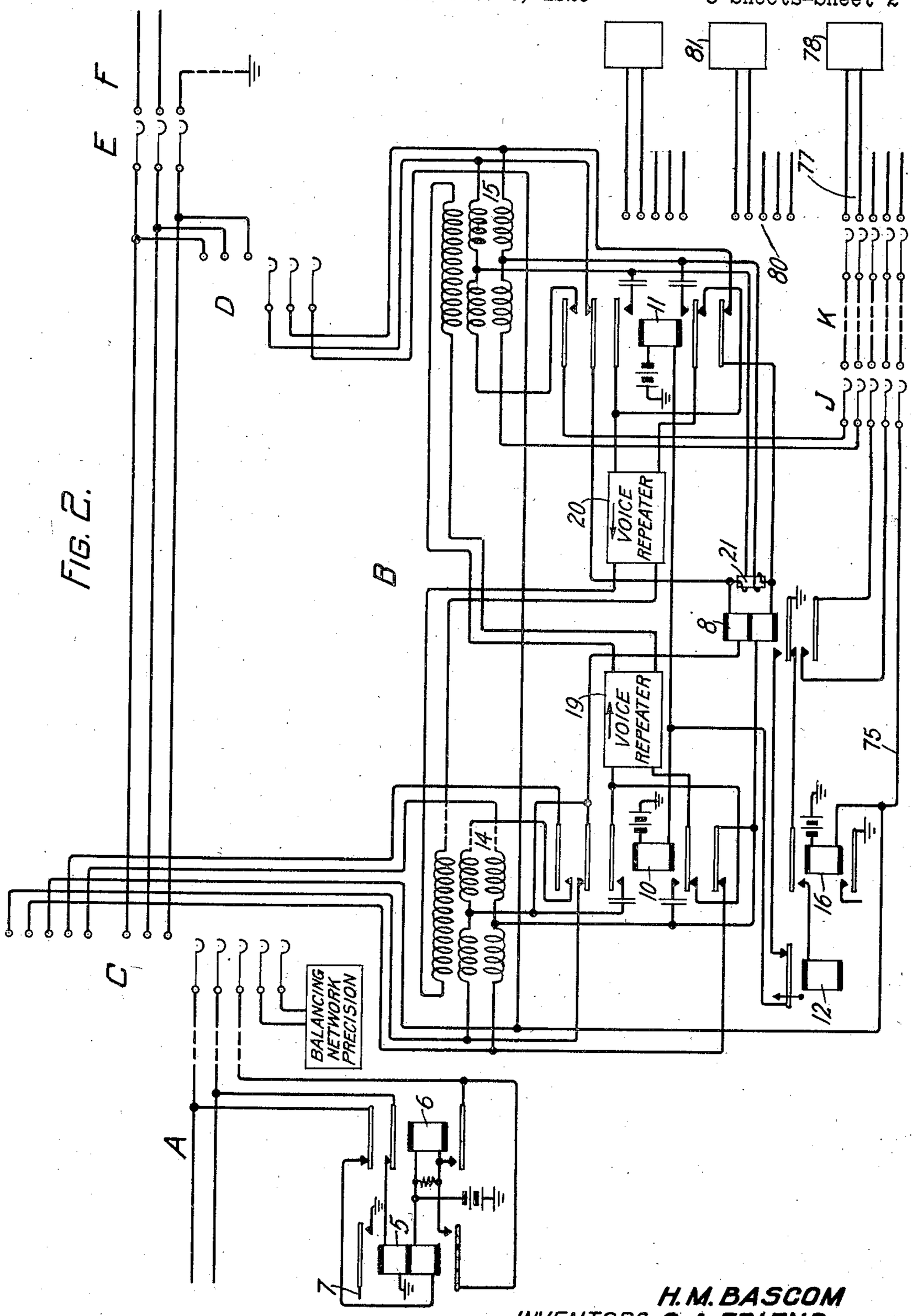

FIG. 2.

INVENTORS H.M. BASCOM
O.A. FRIEND
M.B. McDAVITT

BY

ATTORNEY

Dec. 24, 1935. H. M. BASCOM ET AL 2,025,145

TRANSMISSION SYSTEM

Filed Oct. 4, 1929 3 Sheets-Sheet 3

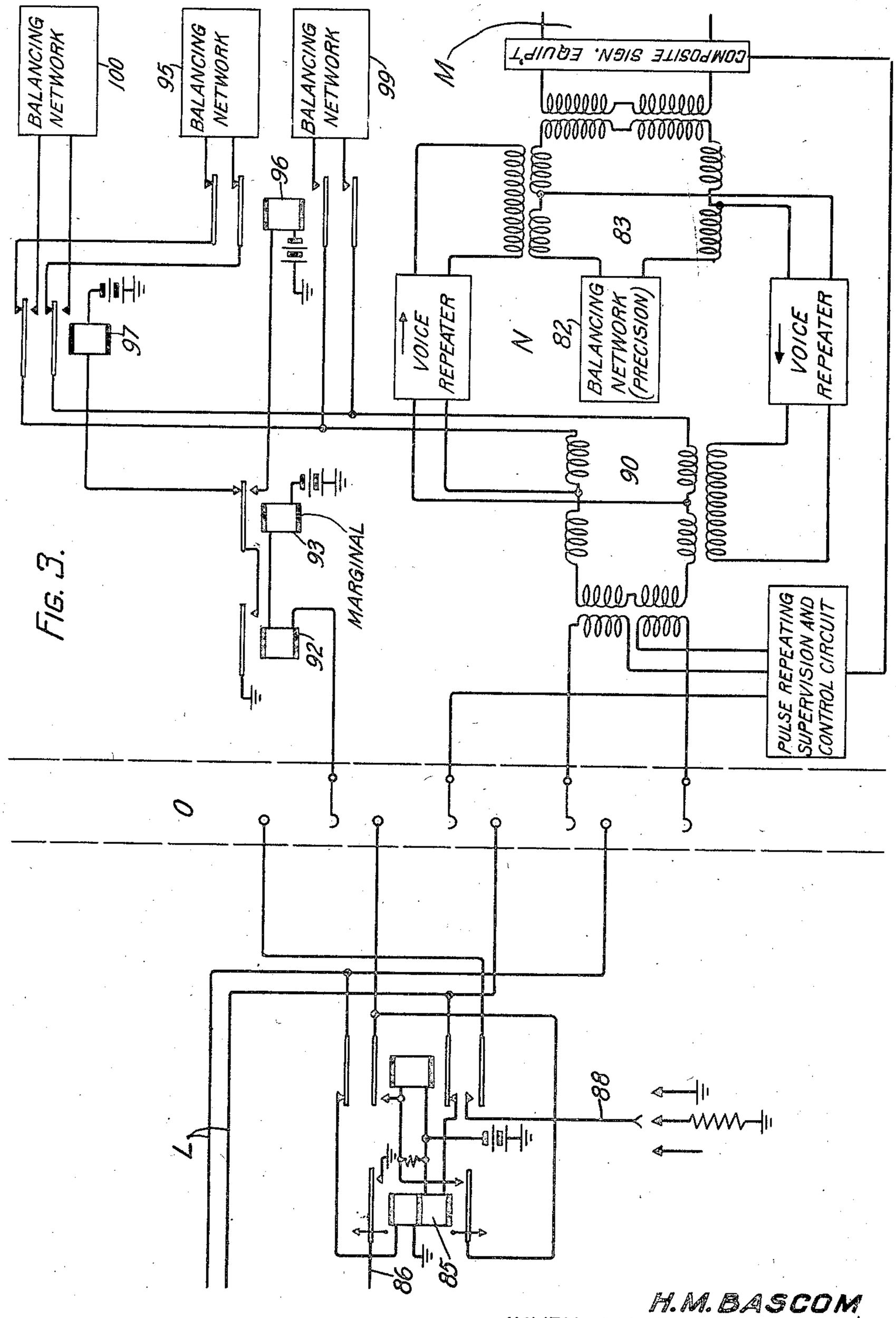

FIG. 3.

INVENTORS H. M. BASCOM
O. A. FRIEND
M. B. McDAVITT

BY

ATTORNEY

Patented Dec. 24, 1935 2,025,145

UNITED STATES PATENT OFFICE

2,025,145

TRANSMISSION SYSTEM

Henry M. Bascom, Brooklyn, and Otto A. Friend and Marcellus B. McDavitt, New York, N. Y., assignors to American Telephone and Telegraph Company, a corporation of New York

Application October 4, 1929, Serial No. 397,311

9 Claims. (Cl. 179—18)

This invention relates to transmission systems and particularly to the automatic selection and insertion of speech repeating and line balancing devices between the lines of automatically completed telephone connections.

The object of this invention is to improve and simplify the establishing of automatic telephone connections requiring such devices in the transmission circuits.

Heretofore telephone repeaters have been automatically selected and inserted between two telephone lines in response to the manual connection of two lines or simultaneously with the automatic connection of two lines. In the case of systems where the connections are established manually a network is provided for each line suitable for the balancing of the corresponding line. This network is usually automatically selected simultaneously with the selection of a repeater and connected thereto to balance the connected line. In the case of systems where the connections are established automatically, compromise networks are permanently connected in the repeater to balance the connected lines although the balancing characteristics of these networks will not be ideal for lines connected together having varying electrical transmission characteristics.

A feature of this invention is a system of the above type in which networks for accurately balancing the individual lines are automatically selected simultaneously with and in response to the automatic selection and connection of the repeater between the calling line and the called line.

Another feature is a system of this kind in which the selection of the network for the calling line is accomplished through means controlled by electrical conditions individual to the calling line and in which the selection of the network for the called line is accomplished through means controlled by impulses received over the calling line for the selection of the called line.

This invention has been illustrated in the accompanying drawings in which Fig. 1 shows the invention applied to an arrangement whereby balancing networks may be selected for two trunk lines connected through a repeater; Fig. 2 shows a similar system with a modified arrangement for selecting the balancing networks; while Fig. 3 shows the invention applied to a system in which balancing networks are only selected for insertion at the incoming end of a repeater for balancing the characteristics of an incoming trunk which may be connected to an outgoing trunk to which the repeater is permanently connected.

Referring now to the preferred form of the invention as illustrated in Fig. 1, the incoming end of a trunk A has been shown having access to a repeater equipment B through a first selector C. A second selector D and a third selector E have been shown for connecting the incoming trunk to an outgoing trunk F through the repeater B, or for connecting these trunks directly without the repeater B as desired. Equipment for selecting balancing networks for these trunks has also been shown including switches G, H and I.

It should be understood that the above mentioned switches C, D, E, H and I may be of any well known step-by-step types responsive to dial impulses, and switch G may be of the well known step-by-step type having no normal position and operative to preselect an idle equipment including switches such as H and I.

If a connection is desired with a repeater inserted between the trunks A and F, the operation of the system is as follows: When a call is incoming over trunk A line relay **5** operates from battery and ground, through the windings of this relay, through the upper armatures and back contacts of the cut-off relay **6** and tip and ring conductors of the trunk A, through a loop closed between these conductors of trunk A at a distant office. Relay **5** in operating closes a connection at its upper armature and front contact to ground for a start wire **7** which connects the trunk A through a line finder, not shown, to an idle first selector C in any manner well known in the art. The operator or subscriber at the distant end of trunk A will now dial the first digit of the number of the desired outgoing trunk group and thereby cause the selector C to advance its brushes to connect with a set of terminals through which a repeater may be inserted between the trunks. The arrangement of the terminal banks in the selector may be such that, for example, the terminals in the uppermost level may be assigned to connections in which repeaters are included. When the connection to a set of terminals through which a repeater may be inserted, has been established by selector C, a circuit is completed through the tip and ring conductors of trunk A for the operation of relay **8**. This circuit extends through the middle right hand and outer left hand armatures of relay **10** and middle left hand and outer right hand armatures of relay **11** to the tip and ring conductors and the usual pulsing relay in selector D. Relay **8** in operating closes a circuit for the operation of relays **10** and **11** from battery through the windings of these relays, armature and back contact of relay **12**, lower

armature and front contact of relay 8 to ground. Relay 10 in operating removes the short circuit for the left hand windings of transformer 14 and relay 11 in operating removes the short circuit for the right hand windings of transformer 15 and the windings of retardation coil 21 so that the connection to the selector D will now extend through their windings. At the time relay 8 operates ground is also connected through the sleeve circuit of the selector D for the operation of relay 16. This ground connection extends to battery through the winding of relay 16. It also extends through the selector C to control the line finder and cut-off relay 6 through the usual circuit arrangement of this type. It should be understood that it is well known in the art that this ground connection has already caused the operation of the cut-off relay 6 over a circuit from battery, winding of relay 6, lower armature and front contact of line relay 5 to said ground. Relay 6 when operated opened the connection for the line relay 5 to cause it to release while relay 6 established a locking circuit for itself from battery to ground through its winding and lower contact. Relay 16 in operating prepares a portion of a circuit at its armature and front contact for the subsequent operation of relay 12 and also serves to close a circuit to ground through its right hand armature and front contact for the purpose of lighting the filaments of the vacuum tubes used in the usual voice frequency repeaters indicated by boxes 19 and 20 respectively. The details of these voice frequency repeaters have not been shown as their construction is well known in the art.

The operator or subscriber connected at the distant end of trunk A will now dial the second digit of the desired number. Relay 8 will therefore respond to the dial pulses of this digit and on the first release of relay 8, relay 12 is operated over a circuit from battery, winding of relay 12, left hand armature and front contact of relay 16 to ground at the lower armature and back contact of relay 8. Relay 12 is slow to release so that it will remain operated during the succeeding pulsing operations of relay 8. On this first release of relay 8, relays 10 and 11 are released and will not operate again during the sending of the second digit due to the opening of the circuits therefor at the armature and back contact of relay 12. The release of relays 10 and 11 reestablishes the short circuit for the left hand windings of transformer 14, the right hand windings of transformer 15 and retardation coil 21 to provide a better pulsing circuit; the input circuits to the voice repeater are also opened to prevent so-called "singing" of the repeater during the pulsing. It should be noted that the retardation coil 21 is in series with the tip and ring conductor during the talking condition, to provide a high impedance in the return path provided through the signaling by-pass circuit, to prevent repeater "singing". After the pulses of the second digit have been completed and the second selector D thereby controlled to extend the connection to the third selector E, relay 12 is released and thereby causes the reoperation of relays 10 and 11 to reestablish the circuit through transformer 14, retardation coil 21 and transformer 15.

The third digit is now sent and during the sending of this digit relays 8 and 12 and 10 and 11 are operated in the same manner, while the third selector E is controlled to extend the connection to trunk F. The talking circuit is then established between trunks A and F for talking conditions through the windings of the transformers 14 and 15, the condensers 22, 23, 24 and 25 and the voice frequency repeaters 19 and 20; at the same time the signaling circuit, which presents a high impedance to voice frequency currents, is established through the left hand windings of transformer 14, relay 8, retardation coil 21 and the right hand windings of transformer 15.

It should, however, be observed that in order to establish proper transmission characteristics for trunks A and F, balancing networks must be inserted in this connection. The insertion of the balancing network for trunk A is accomplished as follows: Trunk A and others may be connected at the conductor 26 and corresponding conductors in different manners depending on the particular type of balancing network required in each case. Conductor 26 may be open or connected as shown directly to ground or through a resistance to ground. If trunk A has its conductor 26 open it will be noted that relays 27 and 28 will remain in a non-operated condition as there is no ground connection for the circuit from battery through the winding of these relays the fourth terminal and brush of selector C, lower outer armature and front contact of relay 6 to conductor 26. Hence a balancing network indicated by means of a box at 30 will remain connected to the transformer 14 as follows: From this network through the upper armatures and back contacts of relay 32, lower armatures and back contacts of relay 33, to the upper right hand winding of transformer 14 through the right hand outer armature and front contact of relay 10 and to the lower winding of transformer 14 directly.

If conductor 26 had been connected directly to ground both relays 27 and 28 would have operated and in this case the balancing network indicated at 35 would have been connected to the transformer 14 through the lower armatures and front contact of relay 32, as this relay would have operated over a circuit from battery, winding of relay 32, the armatures and front contacts of relays 27 and 28 to ground.

On the other hand, if conductor 26 had been connected through a resistance to ground, only relay 27 would have operated as relay 28 is of such marginal characteristics as not to operate when this resistance is inserted in the circuit. In this case the operation of relay 27 would have closed a circuit for the operation of relay 33 and the balancing network 36 would have been connected to the transformer 14 through the lower armatures and front contacts of relay 33. In this manner the various trunks incoming from distant offices may be divided into groups having the same or similar transmission characteristics, one group requiring, for example, a balancing network such as 30, another group a balancing network such as 35, and a third group a balancing network such as 36. It is obvious that other arrangements of this circuit may be made to provide other groups of incoming trunks with suitable balancing networks. For example, other different electrical characteristics may be established for the circuit through conductor 26 to operate various other arrangements of relays to connect different balancing networks for corresponding groups of trunks.

Trunks such as F leading to distant offices may also require different types of balancing networks. To this end a circuit arrangement as follows has been provided. On the operation of relay 16 at the seizure of the repeater B, the circuit from

ground at the selector D is also extended to the conductor **37** through the make-before-break contacts of relay **38** to switch G. This switch will have previously selected an idle selector H and the application of ground on conductor **37** will make selector H busy to other switches similar to G. Switch G may be of the usual step-by-step rotary line switch type which is often employed in selecting idle common equipments for various purposes in automatic telephone systems as is well known in the art. If it is assumed that switch G had selected the selector H, this selector will be actuated when relay **8** responds to the impulses of the second digit as a pulsing circuit is closed through the upper armature and front contact of relay **8** for the actuation of the usual pulsing relay in selector H over the conductors **40** and **41** that extend through the lower and upper inner armatures and back contacts of relay **38**, the windings of polar relay **42**, brushes **44** and **43** of switch G, through the pulsing relay (not shown) of selector H to battery and ground. Selector H will thereby be actuated to advance to a position in a level corresponding to that selected by selector D when responding to the impulses of the second digit. Similarly when the third digit causes the relay **8** to respond to the impulses thereof, the succeeding selector I is actuated to take a position in a level corresponding to that selected by selector E when actuated by the impulses of the third digit. Selectors H and I will consequently select a point which corresponds to trunk F and when this is accomplished a circuit is completed through the tip and ring conductors of selectors H and I, make-before-break contacts of relay **47**, windings of relay **48**, to battery and ground. Relay **48** is now operated to close at its lower armature and front contact a circuit to ground, back through selectors I and H to hold them operated as is well known in the art. An obvious circuit is also completed by the operation of relay **48** for the operation of relay **50**. This relay is slow in operating. Relay **48** in operating provides a third circuit through its upper outer armature and front contact for the conductor **53** which extends back through the selectors I, H and switch G through the upper outer armature and back contact of relay **38**, windings of relays **55** and **56** in series to battery. Depending now on the point selected by selectors H and I an electrical condition will be established on the conductor **53** for the selection of the proper balancing network for trunk F.

If the conductor **53** is connected through a resistance to ground only relay **55** will operate in this circuit as relay **56** is marginal and thus close the circuit for the operation of relay **57**. This relay in operating will connect a balancing network as indicated by box **59** through its armatures and front contacts, the left hand upper winding of transformer **15** over the connection through the left hand outer armature and front contact of relay **11** for one conductor and directly to the lower left hand winding of transformer **15** for the other conductor.

If the conductor **53** had been connected directly to ground relays **55** and **56** would have operated to close a circuit for the operation of relay **63**. This relay would then have connected the balancing network indicated by box **65** through the lower armatures and front contacts of relay **63** to the transformer **15**.

If another point had been selected, the conductor **53** would have been open as shown and in this case on the establishing of the connection through the relay **58** to battery and ground, a connection would merely have been established through the armature and front contact of this relay to ground for holding the switches I and H operated. In this case as the conductor **53** is opened, neither relay **55** nor relay **56** would have operated and consequently a balancing network such as indicated by box **67** would have been connected through the upper armatures and back contacts of relay **63** and the lower armatures and back contacts of relay **57** to the transformer **15**.

It should be noted that when either relay **55** or relay **56** is operated, or both of these relays are operated, they are locked in operated positions through their lower armatures and lower contacts to the ground connection established through the sleeve of selector D. It is therefore evident that the common equipment for selecting the balancing networks for the outgoing trunk are not required after they have been operated. The selectors H and I may therefore be released as soon as the identifying condition has been established. It should be noted in the case of the connection through relay **48** that when relay **50** is operated an obvious circuit is completed for the operation of relay **47**. This relay in operating reverses the connection from battery and ground through the windings of relay **48**, back through the tip and ring conductors of the selectors I and H and switch G and when this takes place relay **42** which is polarized operates to close an obvious circuit for the operation of relay **38**. This relay operating opens the ground connections from lead **37** to the switch G and selectors H and I so that these switches are released. Relay **38** in operating establishes a locking circuit for itself from battery, the lower outer armature and front contact to ground and lead **37** so that this relay is now maintained operated as long as the connection remains in use. The arrangement with relay **58** is provided for the class of trunks where the network **67** is to be used, and where it is not necessary, therefore, to transmit any signal over lead **53** or to operate either of relays **55** or **56**. Therefore, as soon as the connection is established to relay **58** it operates and as the connection from battery and ground is permanently reversed, relay **42** is operated immediately to release the common equipment through the operation of relay **38**.

As mentioned above, a talking circuit through the repeater is now completed and the proper balancing networks selected for trunks A and F, respectively, so that talking over this connection may now begin. When the connection is to be released, the holding loop over the tip and ring conductor is opened, releasing relay **8**, which in turn releases relays **10** and **11**, and after an interval the ground is removed from the sleeve conductor at the outgoing trunk F and relays **16** and **38** are released and also such relays as were operated during the selection of the balancing network, namely **27**, **28**, **33**, **32**, **55**, **56**, **63** and **57**, so that the circuit arrangement of the repeater B is returned to normal condition.

Referring now to Fig. 2 in which the invention has been applied to a modified circuit arrangement for connecting the two trunks A and F through the repeater B. In this case the arrangement may be such that selectors such as C will have associated with them balancing networks suitable for balancing the incoming trunks. These balancing networks may be connected through the brushes and terminals of the

selectors to the transformers of the repeaters selected.

The operations of the circuits in this figure for establishing a connection through a repeater are identical with the operations of the circuit shown in Fig. 1, except for the means for associating the balancing networks with the trunks A and F. The same numerals and identifying letters have been applied to the corresponding elements. The connection through the sleeve circuit from selector D for the operation of relay 16 is also extended to conductor 75 for control of selectors J and K, which are similar to selectors H and I, except that five wipers and banks are provided. When relay 3 responds to the pulses of the second digit, selector J is operated through the circuit connecting the tip and ring conductors and when relay 8 responds to the impulses of the third digit selector K is similarly actuated. These selectors therefore are actuated in the same manner and at the same time as selectors D and E respectively, to select the point corresponding to trunk F. The points selectable by selector K may be associated with balancing networks of the proper characteristics. For example, if selector K connects with the set of terminals shown at 77 the balancing network indicated by box 78 will be associated with the transformer 15. If the set of terminals 80 had been selected, the balancing network indicated by box 81 would have been connected and similarly other points may be selected to connect other balancing networks to the transformer 15 for properly balancing the corresponding outgoing trunk connected at the selector E.

When the connection between trunks A and F is released, the selectors J and K are released on removal of the ground on the sleeve at outgoing trunk F, through E and D. It will thus be seen that in this case the selectors J and K remain operated and the connection from the balancing network to transformer 15 is kept established as long as the connection remains.

Referring now to Fig. 3, the invention has been applied to a circuit arrangement in which an incoming trunk L may be associated with a trunk M. In this case a proper balancing network may be selected for trunk L whereas the trunk M has a balancing network 82 permanently connected through the transformer 83 of the repeater N. Calls incoming over trunks such as L may be extended over line finders such as O to trunks such as M. It should be understood that different groups of incoming trunks may terminate in such line finders and have access to a number of outgoing trunks, each one of which is associated permanently with a repeater and a proper balancing network.

When a call is incoming over trunk L line relay 85 is operated over the tip and ring conductors and this relay establishes the starting circuit through conductor 86 to start a line finder such as O to find the trunk L in a manner well known in the art. When the connection is established to the trunk M, dialing over trunk L may take place in a manner similar to that shown in Fig. 1 and passed by the repeater N to trunk M. No details of these pulse repeating and control circuits have been shown in this case, as receiving dial pulses from the incoming trunk on a loop signaling basis and repeating them on a composite signaling basis on the outgoing trunk is a circuit arrangement well known in the art.

Depending now on the electrical characteristics of the conductor 88 the proper balancing network will be associated with the transformer 90 of repeater N to balance against the trunk L. If conductor 88 is open, neither relay 92 nor relay 93 would be operated and the balancing network indicated by box 95 will be connected through the upper armatures and back contacts of relays 96 and 97 to the transformer 90. If conductor 80 is connected directly to ground, relays 92 and 93 will operate and close the circuit for the operation of relay 96 and the balancing network indicated by box 99 will be connected to the transformer 90, whereas if conductor 88 is connected through a resistance to ground only relay 92 will operate as relay 93 is marginal and thus cause the operation of relay 97 to connect the balancing network indicated by box 100 to the transformer 90.

While the invention has only been applied to three different types of systems it is obvious that it may readily be applied to a plurality of other systems without departing from the spirit thereof.

What is claimed is:

1. In a telephone system, incoming lines of different transmission characteristics, an outgoing line, a switch, a voice frequency repeater having its outgoing side connected to the outgoing line and its incoming side connected with said switch, line compensating networks individual to said repeater and suitable for use with the incoming side of said repeater, a line compensating network connected in the outgoing side of said repeater, means responsive to the seizure of an incoming line for actuating said switch to connect said incoming line with the incoming side of said repeater and means including marginally responsive relays actuated in response to said connection for associating a corresponding one of said first mentioned line compensating networks with the incoming side of said repeater.

2. In a telephone system, lines, repeaters, balancing networks common to said repeaters, and automatic means for connecting two lines through a repeater and for selecting balancing networks for said lines, said means including switches controlled by directive impulses over one of said lines.

3. In a telephone system, a calling line, a called line, repeaters, networks, and means including switches responsive to current impulses incoming over the calling line for selecting a repeater, selecting the called line, selecting a network for balancing said called line and connecting said repeater between said lines.

4. In a telephone system, incoming lines, outgoing lines, repeaters, means responsive to directive impulses incoming over an incoming line for connecting said incoming line to an outgoing line through a repeater, balancing networks, means responsive to the connection of said lines for associating with said interpolated repeater a network suitable for balancing said incoming line and means responsive to said impulses for associating a network with said interpolated repeater suitable for balancing said outgoing line.

5. In a telephone system, incoming lines, outgoing lines, repeaters, switching means associated with the incoming lines for selecting the incoming side of a repeater, switching means associated with the outgoing side of the repeater for selecting outgoing lines, a separate group of balancing networks individual to each repeater, means responsive to the selection of a repeater by an incoming line for connecting to said re-

peater a suitable network from the associated group for balancing said incoming line, and means responsive to the selection of an outgoing line through a repeater for connecting to said repeater a suitable network from the associated group for balancing said outgoing line.

6. In a telephone system, incoming lines, outgoing lines, repeaters, switching means associated with the incoming lines for selecting the incoming side of a repeater, switching means associated with the outgoing sides of the repeaters for selecting outgoing lines, a separate group of balancing networks for each repeater, means responsive to the selection of a repeater by an incoming line for connecting a suitable network to said repeater from the associated group for balancing said line, and auxiliary switching means responsive to the selection of an outgoing line through a repeater for selecting and connecting to said repeater a suitable network from the associated group for balancing said outgoing line.

7. In a telephone system, incoming lines, outgoing lines, repeaters, means for connecting the incoming line with an outgoing line either directly or through a repeater, a balancing network associated with each incoming line, a group of balancing networks for outgoing lines associated with said repeaters, means responsive to the connection of an incoming line to an outgoing line through a repeater for connecting the network individual to said incoming line through said repeater for the balancing of the incoming line and for selecting and connecting a suitable network of the group associated with said repeaters to said interpolated repeater for balancing said outgoing line.

8. In a telephone system, incoming lines of different characteristics, means individual to each of said incoming lines for indicating the character of each incoming line, outgoing lines of different characteristics, repeaters, means responsive to directive impulses incoming over an incoming line for connecting said incoming line to an outgoing line through a repeater, balancing networks, means controlled by the character indicating means individual to said incoming line and responsive to the interconnection of said incoming and outgoing lines for associating with said repeater a network suitable for balancing said incoming line, and means responsive to said impulses for associating a network with said interpolated repeater suitable for balancing said outgoing line.

9. In a telephone system, incoming lines of different characteristics, means individual to each of said lines for indicating the character of said line, outgoing lines of different characteristics, a repeater, switching means controlled by directive impulses incoming over one of said incoming lines for connecting said incoming line through said repeater to a desired one of said outgoing lines, line balancing networks of different characteristics for use in balancing interconnected lines, marginal relay means controlled by the character indicating means of said incoming line for selecting a suitable one of said networks for balancing said incoming line, and switching means controlled by said impulses for selecting a suitable one of said networks for balancing said outgoing line.

HENRY M. BASCOM.
OTTO A. FRIEND.
MARCELLUS B. McDAVITT.