Jan. 1, 1946. L. J. BOWNE 2,391,941

SIGNALING SYSTEM

Filed Dec. 1, 1944 3 Sheets-Sheet 1

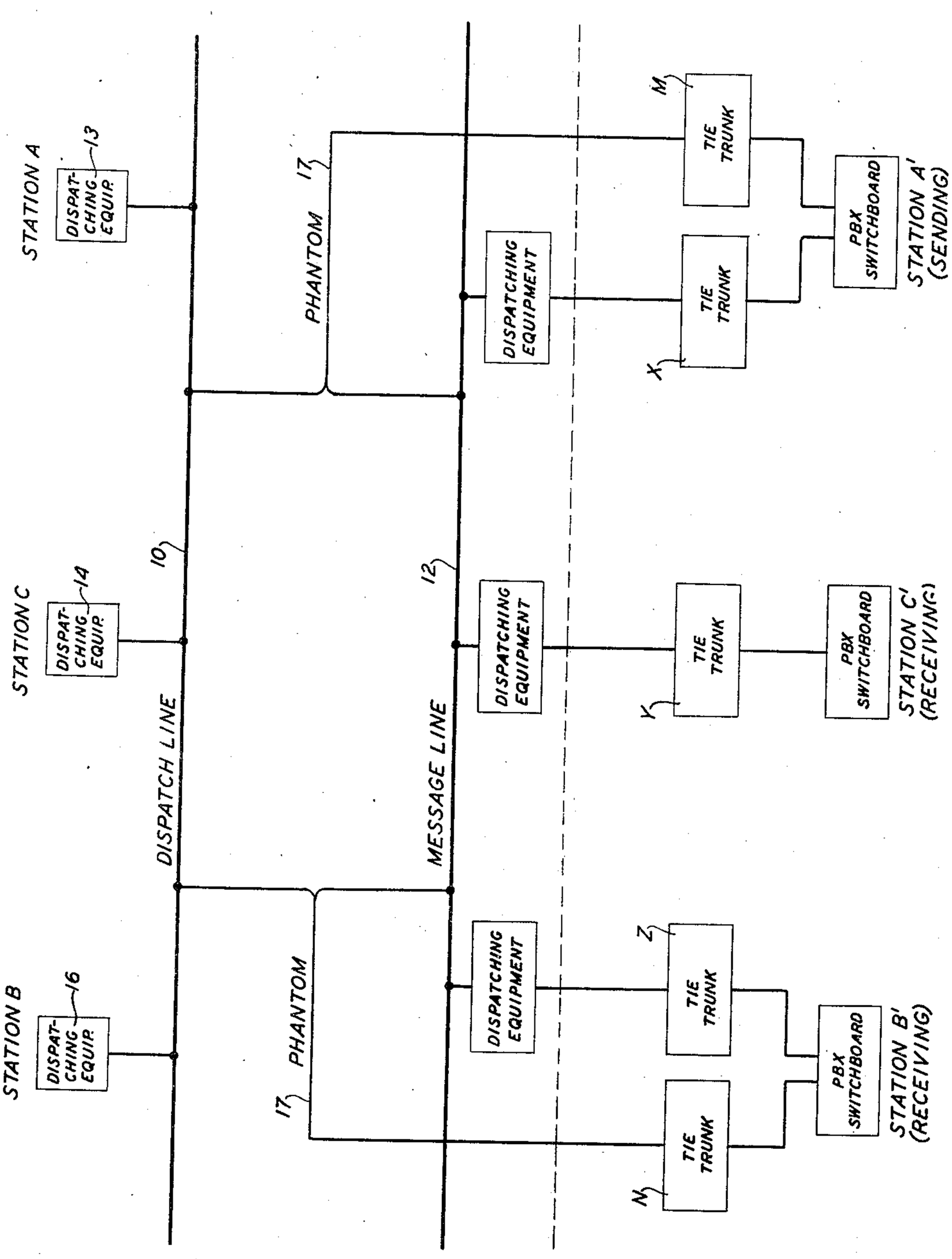


FIG. 1

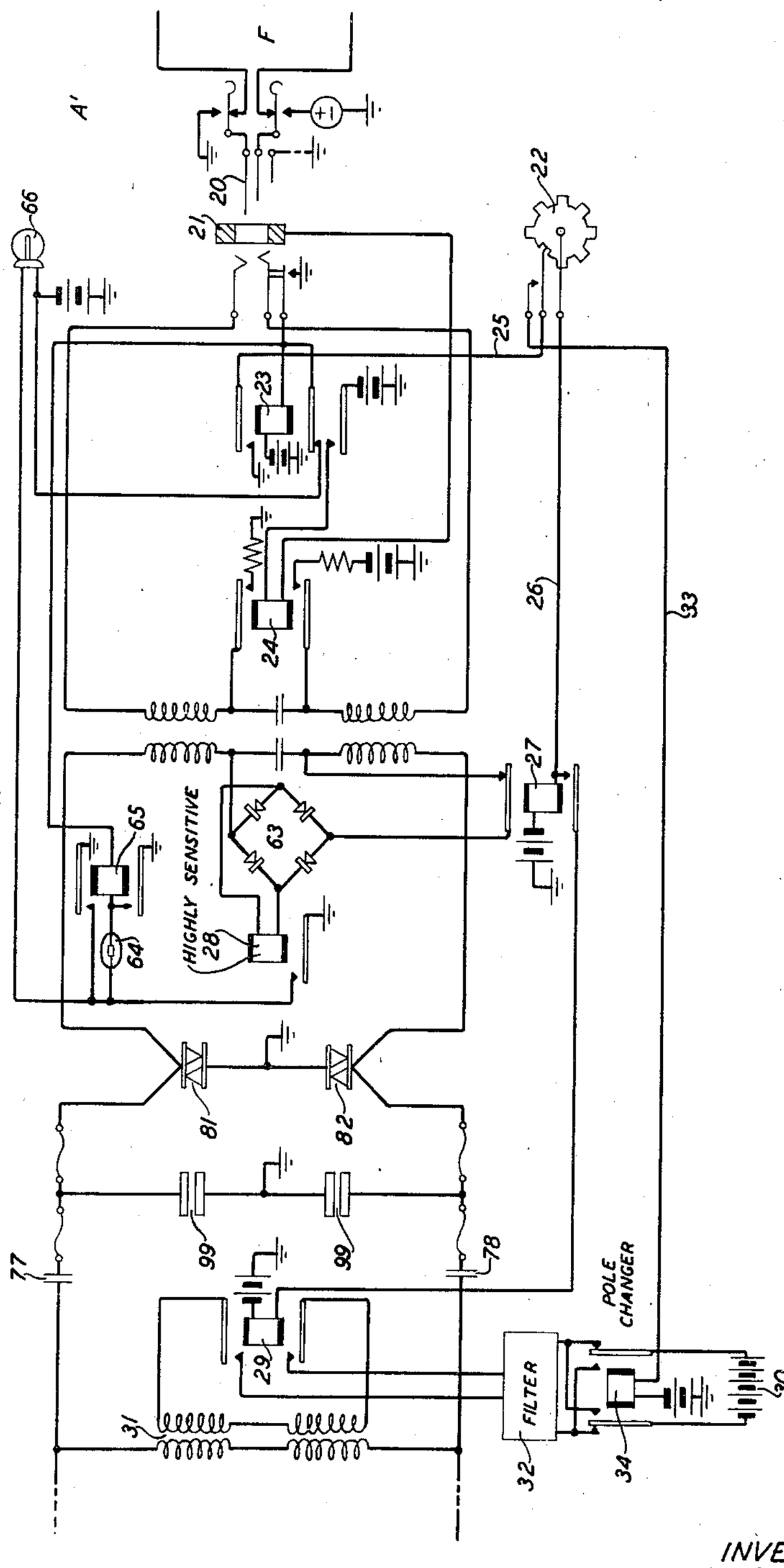
INVENTOR
L. J. BOWNE
BY G. F. Kane
ATTORNEY

Jan. 1, 1946. L. J. BOWNE 2,391,941

SIGNALING SYSTEM

Filed Dec. 1, 1944 3 Sheets-Sheet 2

FIG. 2



INVENTOR
L. J. BOWNE
BY
G. F. Kane
ATTORNEY

Jan. 1, 1946. L. J. BOWNE 2,391,941

SIGNALING SYSTEM

Filed Dec. 1, 1944 3 Sheets-Sheet 3

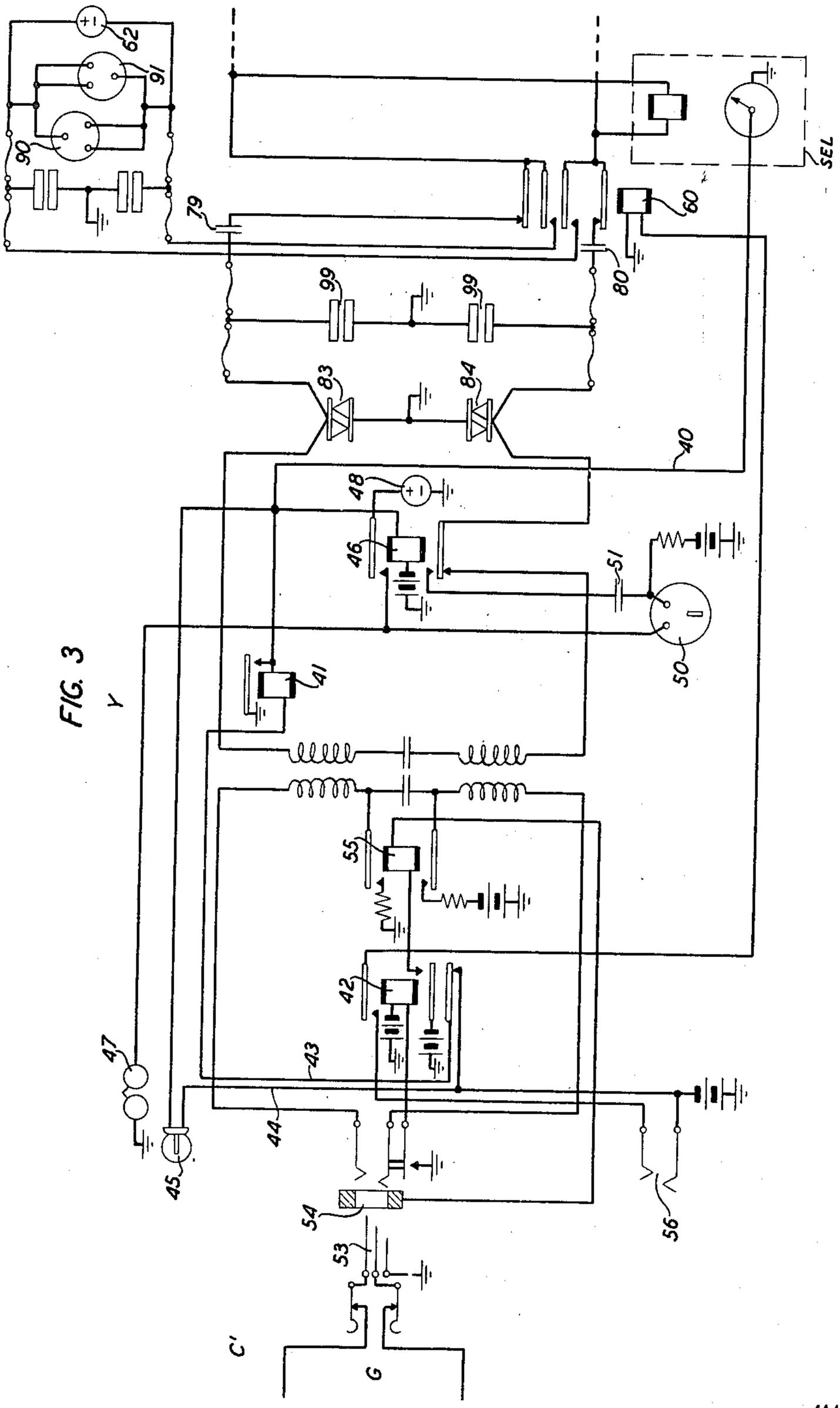


FIG. 3

INVENTOR
L. J. BOWNE

BY G. F. Kane

ATTORNEY

Patented Jan. 1, 1946 2,391,941

UNITED STATES PATENT OFFICE

2,391,941

SIGNALING SYSTEM

Langford J. Bowne, Howard Beach, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application December 1, 1944, Serial No. 566,085

6 Claims. (Cl. 179—2)

This invention relates to signaling systems and particularly to signaling over telephone tie trunks of the type employed to terminate lines, normally maintained by companies other than the telephone company, in exchanges maintained by the telephone company.

In train dispatching systems a pair of lines, commonly known as the dispatch and message lines, usually extend between a sending or control station and a receiving station located at a distance from the sending station. Intermediate such stations there are located a plurality of way stations which are normally accessible to the other stations by way of the dispatch line for the receipt of dispatch signals transmitted from the control station. In such systems, the message line is considered to be an auxiliary dispatch line in that it may be used in times of emergency, such as caused by the failure of the regular dispatch line, for the purpose of carrying dispatch signals. When the regular dispatch line is functioning properly, the message line is employed for the purpose of telephone communication between the various stations. To provide such communication facilities, provision is made at the various stations for terminating the message line at a switchboard which may be located, for example, in the freight or passenger stations located at way stations and at the control, or sending station. The link which is used to connect such switchboards to the railroad companies' lines is generally referred to as a tie trunk. To increase the number of circuits available for communication purposes it is customary to derive a phantom circuit from the conductors of the dispatch and message lines. Such phantom circuits are also terminated at the switchboards by means of tie trunks.

It is the object of this invention to improve the design of tie trunks generally, and particularly of tie trunks used to terminate the lines of a railway dispatch system at telephone exchanges, such as private branch exchanges located on a railroad company's premises at the various stations of the system.

As is commonly known, relatively high potentials are employed in transmitting dispatch signals in a train dispatching system as compared to the potentials encountered in a telephone communication system. In accordance with a feature of the invention protective devices are interposed between the railway lines and the terminating tie trunks and between such lines and the telephone signaling equipment for insulating the telephone exchange equipment from such high voltages and for thus guarding such equipment from damage which would otherwise ensue.

It has been found in practice that the range of signaling in such systems may be substantially extended by utilizing, in the tie trunk circuits, a particularly sensitive ring-up relay which responds to the transmission of signaling current over the trunk to control the operation of call indicating signal devices. It has been found also that the use of such a sensitive relay introduces the possibility of false signaling due to line surges irrespective of their cause. A particular feature of the present invention contemplates the provision of means which functions to preclude the possibility of false signaling caused by current surges and which, at the same time, permits signaling over long ranges. More particularly, this feature of the invention is embodied in a delay circuit controlled by a highly sensitive ring-up relay which functions to delay the permanent appearance of a call signal for a predetermined interval of time following the operation of the ring-up relay. In this manner, any operation of the ring-up relay which is caused by a transitory voltage condition on the line will not result in the actuation of the call signal device to give a false call signal. Upon cessation of the transitory voltage or surge, the ring-up relay restores to normal. The receipt of a call signal will, of course, actuate the ring-up relay for a sufficiently long interval of time to produce the desired actuation of the signal device.

These and other features of the invention will be best understood from the following detailed description when read in connection with the accompanying drawings, in which:

Fig. 1 is a circuit schematic illustrating a particular application of the tie trunk of this invention to the message and phantom circuits of a train dispatching system;

Fig. 2 is a circuit diagram of the tie trunk of this invention employed at a sending or control station; and

Fig. 3 is a circuit diagram of the tie trunk employed at a receiving station.

Referring to Fig. 1, the dispatch and message lines are indicated by the numerals 10 and 12, respectively, and are shown extending from a control or sending station A which may be a terminal station of the railroad line, to a plurality of stations such as stations B and C which may be way stations on the line terminating at station A. Each of the stations A, B and C is furnished with the usual dispatching equipment

indicated at 13, 14 and 16 by means of which dispatch signals are transmitted and received by way of the dispatch line 10. In the general vicinity of each of the dispatching stations A, B and C, such as at the freight station located at these stations, there will be found duplicate dispatching equipment and private branch exchanges such as indicated in Fig. 1 as stations A', B' and C'. A tie trunk is indicated at X which serves to terminate the message line 12 at the switchboard located at the sending station A', whereas the tie trunks Y and Z serve to terminate the message line 12 at the switchboards located at stations C' and B', respectively. The tie trunk indicated by the letter X in Fig. 1 is shown in detail in Fig. 2, whereas the tie trunks designated Y and Z in Fig. 1 are identical and are shown in detail in Fig. 3.

The phantom circuit is indicated by the numeral 17 in Fig. 1 and is derived in the well-known manner from the dispatch and message lines 10 and 12, respectively. The phantom circuit 17 is illustrated terminating in a tie trunk M at the station A' and in the tie trunk N at a way station B'. The tie trunks M and N distinguish particularly from the tie trunks employed to terminate the message line 12 at stations A' and B' in that the signal control equipment of the former functions when signaling current is applied to the phantom by means of a ringing key associated with the attendant's telephone cord at either station A' or B' whereas, as will appear from a later description, signaling over the message line is accomplished by means of a ringing key associated with the tie trunks Y and Z at receiving stations C' and B' and by means of a selecting key associated with the tie trunk X at the sending station A'. The tie trunk circuits M and N would be similar circuits and may take any suitable form, such for example, as is shown in Fig. 4 of L. J. Bowne Patent 1,987,430.

Description will now be made of the operation of the tie trunk circuits X and Y when used to extend a connection from a sending station A' to a receiving station C'. To initiate a call to the receiving station C', the calling operator at station A' inserts plug 20 (Fig. 2) of her cord circuit F into jack 21 associated with the tie trunk X whereupon relay 23 operates in an obvious circuit to ground at the jack contacts. Relay 23 at its upper armature and front contact connects ground potential to the middle spring of the train dispatching key 22 by way of conductor 25. The operator now proceeds to signal the desired station C' by operating the key 22 to send the code to which the selector SEL at the called station C' will respond. The operation of the key 22 is such that the connections between the contacts associated with the leads 25 and 33 are established on the return of the key to normal. The key 22 is of well-known design and its structural details need not be described in this application.

When relay 23 operated incident to the insertion of plug 20 into jack 21, relay 24 operated in a circuit extending from grounded battery, outer lower armature and front contact of relay 23, winding of relay 24, sleeve contacts of jack 21 and plug 20 to ground. Relay 24 operated, connects battery and ground to the jack end of the trunk X to supply talking battery to the attendant's telephone set associated with the cord F, but not illustrated. The attendant listens on the line to determine whether or not it is idle and upon finding it idle actuates the key 22. The key 22 functions to close the leads 25 and 26 whereupon relay 27 operates in a circuit extending from grounded battery, winding of relay 27, conductor 26, contacts of key 22, conductor 25 to ground by way of the upper armature and front contact of relay 23.

Relay 27 at its upper armature opens one of the input leads to the full-wave rectifier 63 thereby disabling the highly sensitive relay 28 whose operating winding is connected across the output terminals of the rectifier. In this manner the false operation of the relay 28 on surges produced on the line by the operation of key 22 is precluded. It will be observed that when relay 23 operated it opened, at its inner lower armature, the operating circuit for relay 65 which, as will be pointed out hereinafter, controls the operation and locking of the call signal 66 on a call incoming to station A'.

At its lower armature, relay 27 extends the conductor 26 to the winding of "stick" relay 29 causing this relay to operate, it being understood that the conductor 26 is grounded at the upper armature and front contact of relay 23 as described above. Relay 29 in operating, connects the primary coil of transformer 31 to the armature contacts of pole changer relay 34 by way of the filter 32. The high voltage battery 30 is connected to the armatures of pole changer relay 34. Further operation of the key 22 causes the pole changer relay 34 to alternately reverse the train dispatching battery 30 on the line by way of transformer 31. This potential on the line may be heard by the attendant at station A' as dull thumps in the receiver of the telephone set associated with her cord F. The attendant's headset will, at this time, be associated with the cord F in order to receive the answer-back signal, as described hereinafter. The relay 29 remains operated during the transmission of the signals caused by the operation of key 22.

The current reversals transmitted over the message line 12 through transformer 31 operate all selectors on the line, but only selector SEL (Fig. 3) will close its signal contact on the particular code transmitted by key 22. When the selector SEL closes its contact, in the well-known manner, in response to the operation of key 22, relays 41 and 46 and the lamp signal 45 at station C' are operated. Relay 41 operates in a circuit extending from the grounded contact of selector SEL, conductor 40, winding of relay 41, outer lower armature and back contact of relay 42, conductors 43 and 44 to battery and ground associated with key 56. Relay 46 and the lamp signal 45 operate in parallel with relay 41.

Relay 46, at its upper armature and front contact establishes an obvious operating circuit for the audible signal 47 from the alternating current source 48. Thus the arrival of a call at station C' is indicated by the lighting of lamp 45 and by the actuation of the ringer 47.

Relay 46, at its lower armature, opens the ring conductor of the line and connects an audible ring-back circuit to that portion of the ring conductor which extends towards the calling station A' for the purpose of indicating to the calling operator that the proper selector SEL has closed its ringing contact. While in some cases the ringing current, such as that furnished by the source 48 at the private branch exchange, has a sufficiently audible tone to pass the signal to the calling station, in other cases the audible tone may not be loud enough. The ringing voltage of the source 48 accordingly is impressed on the cold cathode tube 50 causing the tube to flash

over and change the wave shape of the ringing current. This occurs both at the rise and decline of each half cycle and simulates the audible ring, in intensified form, which is normally associated with the ringing current. This tone signal is applied to the ring conductor of the line by way of condenser 51 and the front contact and lower armature of relay 46 and is heard by the attendant at station A' in her receiver.

When relay 41 operated, it completed a locking circuit for itself to battery, associated with key 56, by way of the outer lower armature and back contact of relay 42. The ground associated with the armature of relay 41 also serves as a substitute ground for the ground connected to conductor 40 by selector SEL so that relay 46 and lamp 45 remain operated after the selector ground is removed and until the incoming call is answered by the attendant at station C'. The visual and audible call indicating signals and also the audible answer-back signal therefor persist until the call is answered.

To answer the call incoming on tie trunk Y at station C', the attendant at station C' inserts plug 53 of her cord G into jack 54 corresponding to the lighted lamp 45. In response to the insertion of plug 53 into jack 54, relay 42 operates in an obvious circuit to ground at the jack contacts. At its outer lower armature and back contact relay 42 opens the locking circuit for relay 41 causing this relay to restore its armature. The release of the armature of relay 41 causes relay 46 to be deenergized and the lamp signal 45 to be extinguished. Relay 46 silences the audible signal 47, disconnects the audible answer-back tone from the calling end of the connection, and reestablishes the continuity of the ring conductor of the tie trunk Y.

When the plug 53 was inserted into jack 54 and relay 42 operated, relay 55 operated in an obvious sleeve circuit to ground associated with the sleeve contact of plug 53. In operating, relay 55 connects battery and ground to the jack end of the trunk Y to supply talking battery to the telephone circuit which is subsequently connected. Conversation between the attendants at stations A' and C' may now be carried on.

If it is found necessary for the attendant at station A' to recall the attendant at station C' while the plug 53 is in the jack 54 she may do so by reactuating the key 22 to cause the transmission of the proper code to cause the reoperation of selector SEL. Under this condition relay 41 will not operate since its circuit is now open at the outer lower armature and back contact of relay 42 but the lamp signal 45 will operate in a circuit from ground at the ringing contact of the selector SEL, conductor 40, filament of lamp 45, conductor 44 to battery and ground associated with key 56. Relay 46 also operates on a recall to perform the functions ascribed to it in connection with the receipt of a call signal at station C'.

At the termination of conversation, withdrawal of plugs 20 and 53 from jacks 21 and 54, respectively, restores the circuit to normal.

On a call from station C' to station A' the plug 53 is inserted into the jack 54 of the trunk Y and the ringing key 56 is actuated. Relay 42 operates in an obvious circuit to ground at the jack contacts when the plug 53 is inserted into jack 54. At its inner lower armature and front contact, relay 42 completes an obvious operating circuit for relay 55 to ground at the sleeve contact of plug 53. Relay 55, operated, connects battery and ground to the jack end of the tie trunk Y to supply talking battery to the attendant's cord at station C'. At its outer lower armature and back contact, relay 42 opens the circuit to relay 41.

When the ringing key 56 is actuated, relay 60 operates in a circuit traced from grounded battery, contacts of ringing key 56, front contact and inner upper armature of relay 42, winding of relay 60 to ground. Relay 60, at its innermost and outermost armatures, opens the message line to the trunk Y and, at its two middle armatures and front contacts, connects the alternating current source 62 to the tip and ring conductors of the line. The ringing current source 62 is shunted by two oppositely poled parallelly connected vacuum tubes 90 and 91 whose function will be described in detail hereinafter.

Ringing current from the source 62 traverses the line conductors and is rectified at 63, the rectified current traversing the winding of highly sensitive relay 28 which is connected to the output terminals of rectifier 63. Relay 28 operates immediately and connects the thermistor 64 in series with the winding of relay 65 and completes an obvious energizing circuit for the signal lamp 66. Relay 65 is not operated therefore immediately upon the operation of relay 28 since the resistance of the thermistor is so high in its cool state as to allow insufficient current to traverse the circuit which includes the winding of relay 65. However, as the current continues to flow, the thermistor 64 is heated and as its temperature increases its resistance decreases so that eventually the resistance of the circuit is reduced sufficiently to allow adequate current to flow and operate relay 65. Relay 65 operates in a circuit extending from grounded battery, back contact and inner lower armature of relay 23, winding of relay 65, thermistor 64, front contact and armature of relay 28 to ground. When relay 65 operates it completes at its upper armature and front contacts a locking circuit for the lamp 66 and, at its lower armature and front contact, a locking circuit for itself, both of which circuits are independent of the thermistor 64. In fact, when relay 65 operates, its lower armature effectively shunts the thermistor. Thus the call indicating signal 66 remains lighted after the ringing key 56 has been restored and until the call is answered at station A'.

In answering the incoming call at station A' the attendant thereat inserts the plug 20 of her cord F into jack 21 associated with the lighted lamp signal 66.

When the call is answered in the manner indicated, relay 23 operates in an obvious circuit to ground at the contacts of jack 21. Relay 23, at its outer lower armature and front contact establishes an obvious sleeve circuit in which relay 24 operates to ground at the sleeve contact of plug 20. Relay 24 connects talking battery to the jack end of trunk X thereby furnishing the operator's telephone circuit at station A' with talking battery.

When relay 23 operated as described it opened, at its inner lower armature and back contact, the holding circuit for relay 65 whereupon this relay restores its armature to deenergize the lamp 66. The attendants at stations C' and A' may now converse and if required, either attendant may further extend the connection in a well-known manner.

If desirable, the attendant at station C' may recall the attendant at station A' while the plugs

53 and 20 are in their respective jacks 54 and 21. To do so the key 56 is reoperated to cause relay 60 to reoperate and again connect the signal current source 62 to the message line 12. Relay 28 responds to the actuation of key 56 in the manner previously described and when operated, completes an obvious circuit for lamp 66. It will be observed that relay 65 does not operate at this time since its energizing circuit is opened at the inner lower armature and back contact of relay 23. It is apparent from the foregoing description, that though relay 28 will operate on transients as well as on the regular signaling current, relay 65 will not operate in the first case due to the inclusion of the thermistor 64 in series with its winding so that the visual signal 66 is never locked operated in response to a transient surge on the line. Though the lamp 66 may be instantaneously energized when relay 28 operates on a transient no perceptible signal results.

The potentials used in signaling on the train dispatching lines exceed those normally used in the telephone plant and in order to keep the voltage within the requirements of the telephone plants provision is made for coupling the two circuits by means of condensers in the tip and ring of the talking circuits. These condensers are identified in Fig. 2 by the numerals 77 and 78 and in Fig. 3 by the numerals 79 and 80. In addition to the condensers, varistors such as shown at 81 and 82 in Fig. 2 and at 83 and 84 in Fig. 3 are used. These varistors are preferably of the silicon carbide type and normally have a very high resistance and do not effect transmission or reduce incoming ringing signals. In case of a failure of a condenser, the varistor will drop in resistance to a point where the voltage applied toward the private branch exchange is below the required limit. The fuses shown on the exchange side of the condensers will operate should the voltage and the current from the line exceed their carrying capacities to disconnect the railroad company's line from the private branch exchange equipment.

In the case of the receiving circuit such as the tie trunk Y, where ringing current is used to signal the sending end of the line as hereinbefore described, the ringing current may be supplied over cable conductors from the source in a telephone exchange indicated at 62. Provision is made to prevent the high voltage of the train dispatching signaling system from being carried on through the ringing supply circuit to the source 62 by means of the cold cathode tubes 90 and 91. These tubes have a breakdown potential in the neighborhood of 200 volts which is well above the peak voltage of 175 volts normally reached on ringing current from the ringing machines employed in the telephone plant. In case the sending station A' signals on the line while a receiving station such as station B', for example, is ringing, any line potential which exceeds the breakdown potential of the tubes 90 and 91 will flash over in the tubes, and shunt the ringing leads to the exchanges, reducing the voltage below the limit permitted in the telephone plant. The fuses shown in the ringing leads to the exchange ringing equipment function to disconnect the ringing leads from the railroad company's line should the current exceed the carrying capacity of the fuses. The tubes 90 and 91 are oppositely poled and are connected in parallel across the ringing leads so as to function on either half cycle of the current.

Hereinbefore, a connection originating at receiving station C' and directed towards the sending station A' was described. When the attendant at station C', for example, withdraws the plug 53 from jack 54, a transitory surge is built up in the connection, due to the energy stored in the circuit, which traverses the tip and ring conductors towards the station A' and unless steps were taken to guard against it, the consequent operation of the highly sensitive relay 28 in response to this surge would cause the lamp 66 to be permanently lighted as a false call indication. As hereinbefore described, the thermistor 64 functions to delay the operation of relay 65 until a predetermined interval of time elapses following the operation of relay 28. In this manner the surge dissipates itself before the resistance of the thermistor 64 is reduced sufficiently to permit the operation of relay 65 which controls the locking of the signal 66.

The protector blocks designated 99 in Figs. 2 and 3 are supplementary protection devices and function to protect the telephone exchange equipment from extraneous high voltages to which the message line may be subjected.

The particular feature hereinbefore described which involves the signal delay circuit renders possible the use of a highly sensitive ring-up relay in the tie trunks and thereby substantially extends the range over which signaling is possible. It also contributes to the provision of a highly efficient and practical termination for the lines of a train dispatching system in exchanges maintained by the telephone companies by precluding the possibility of false signaling due to surges resulting from the relatively high voltages employed in signaling over the train dispatching lines.

What is claimed is:

1. The combination in a signaling system of a line interconnecting two or more stations, means at one of said stations for applying alternating current to said line, a signal device at another of said stations, a first relay, means responsive to the application of alternating current to said line for controlling the operation of said first relay comprising a rectifier bridge having its input terminals connected to said line, a highly sensitive direct current responsive relay connected to the output of said rectifier bridge, a resistor having a negative temperature coefficient of resistance, means controlled by said highly sensitive relay for completing an operating circuit for said first relay which includes said resistor, and means responsive to the operation of said first relay for completing an operating circuit for said signal device and for locking said first relay operated independent of said highly sensitive relay.

2. The combination in a signaling system of a line having switchboard terminations at a plurality of widely spaced stations and exposed to relatively high voltage transients, a source of relatively low voltage signaling current at one of said stations, a signal device at another of said stations, means at said one of said stations for applying current from said source to said line, and means for rendering said signal device operative as a call indicator upon the application of current from said source to said line and precluding its operation as a call indicator on the high voltage transients to which said line is exposed comprising a first relay, means controlled by said first relay when operated for operating said signal device and for locking said signal device operated as a call indicator, means con-

trolling the operation of said first relay responsive to current from said source and to said high voltage transients comprising a rectifier having input terminals connected across said line, a highly sensitive relay connected to the output terminals of said rectifier, a resistor having a negative temperature coefficient of resistance, and means controlled by said highly sensitive relay when operated for connecting said resistor in series with said first relay whereby said first relay operates under control of said highly sensitive relay in response to the application of current from said source to said line and is rendered inoperative when said highly sensitive relay operates in response to the said high voltage transients.

3. The combination in a signaling system of a line having switchboard terminations at a plurality of widely spaced stations and being exposed to relatively high voltage transients, a source of relatively low voltage signaling current at one of said stations, a signal device at another of said stations adapted to function as a call indicator when lock operated, means at said first station for applying current from said source to said line for an interval which exceeds in time the normal time duration of a transient to which said line is exposed, and means for precluding the operation of said signal device as a call indicator on transients to which said line is exposed while permitting its operation as a call indicator upon the operation of said current applying means comprising a first relay, means controlled by said first relay for operating said signal device, a resistor having a negative temperature coefficient of resistance, a relay of high sensitivity operable on transients and on current from said source to connect said resistor in series with said first relay, and means comprising a rectifier connecting said second relay to the termination of said line at said second station.

4. In combination in a signaling system, a train dispatching line having terminations at a plurality of widely spaced telephone exchanges and over which signals of relatively high voltage are transmitted, a source of relatively low voltage signaling current at one of said exchanges and capable of withstanding without injury thereto impressed voltages of predetermined magnitude, a protective circuit bridging said source of signaling current and embodying a pair of oppositely polarized space discharge devices having characteristics such that they break down at voltages of the said predetermined magnitude to effectively shunt said source of signaling current, means at one of said stations for connecting said source of low frequency current to said line, a source of relatively high voltage signaling current, means at the other of said stations for connecting said source of relatively high voltage signaling current to said line, both said connecting means being capable of concurrent operations whereby a voltage in excess of the said predetermined magnitude is impressed on said line, signaling devices at each of said stations responsive respectively to the applications of current from said sources to said line, and means for delaying the operation of one of said signaling devices for a predetermined interval of time after the application of current from its corresponding source to said line.

5. In combination in a signaling system, a calling station, a called station, a line interconnecting said stations, a source of signaling current at said calling station, a signaling device at said called station, means responsive to the application of current from said source to said line comprising a rectifier having its input terminals connected to said line, a highly sensitive direct current relay connected to the output terminals of said rectifier, means controlled by said direct current relay for completing an energizing circuit for said signaling device, a second relay controlled by said direct current relay, means controlled by said second relay for completing a second energizing circuit for said signaling device and for locking itself operated, and means for delaying the operation of said second relay for a predetermined interval of time following the operation of said direct current relay comprising a resistor having a negative temperature coefficient of resistance, means controlled by said direct current relay for connecting said resistor in series with said second relay, and means controlled by said second relay when operated for short-circuiting said resistor.

6. In a signaling system, a line interconnecting a plurality of stations, a source of signaling current at one of said stations, a signal device at another of said stations, and means responsive to the application of current from said source to said line for controlling the operations of said signal device comprising a rectifier bridge having input terminals connected to said line, a highly sensitive direct current relay connected to the output terminals of said rectifier bridge, a second relay, a resistor having a negative temperature coefficient of resistance, means controlled by said highly sensitive relay for completing an energizing circuit for said signal device and for simultaneously completing an energizing circuit for said second relay which includes said resistor, whereby said second relay operates a predetermined interval of time after the operation of said highly sensitive relay, means controlled by said second relay when operated for completing an operating circuit for said signal device independent of said highly sensitive relay, and other means controlled by said second relay for locking itself operated independent of said highly sensitive relay and for simultaneously short-circuiting said resistor.

LANGFORD J. BOWNE.