March 10, 1936. M. C. GODDARD 2,033,282

COMPOSITE SIGNALING SYSTEM

Filed July 14, 1933 2 Sheets-Sheet 1

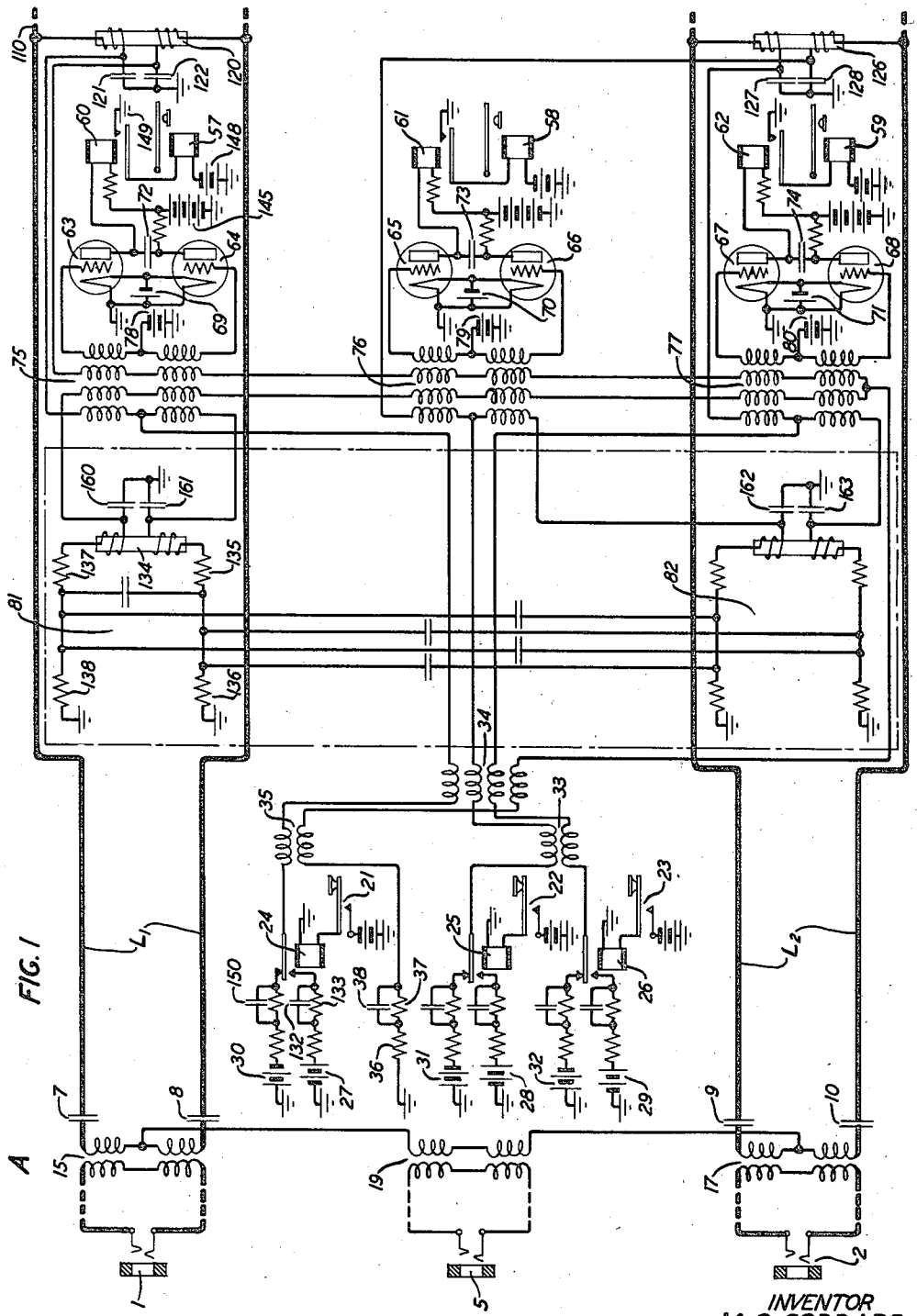

FIG. 1

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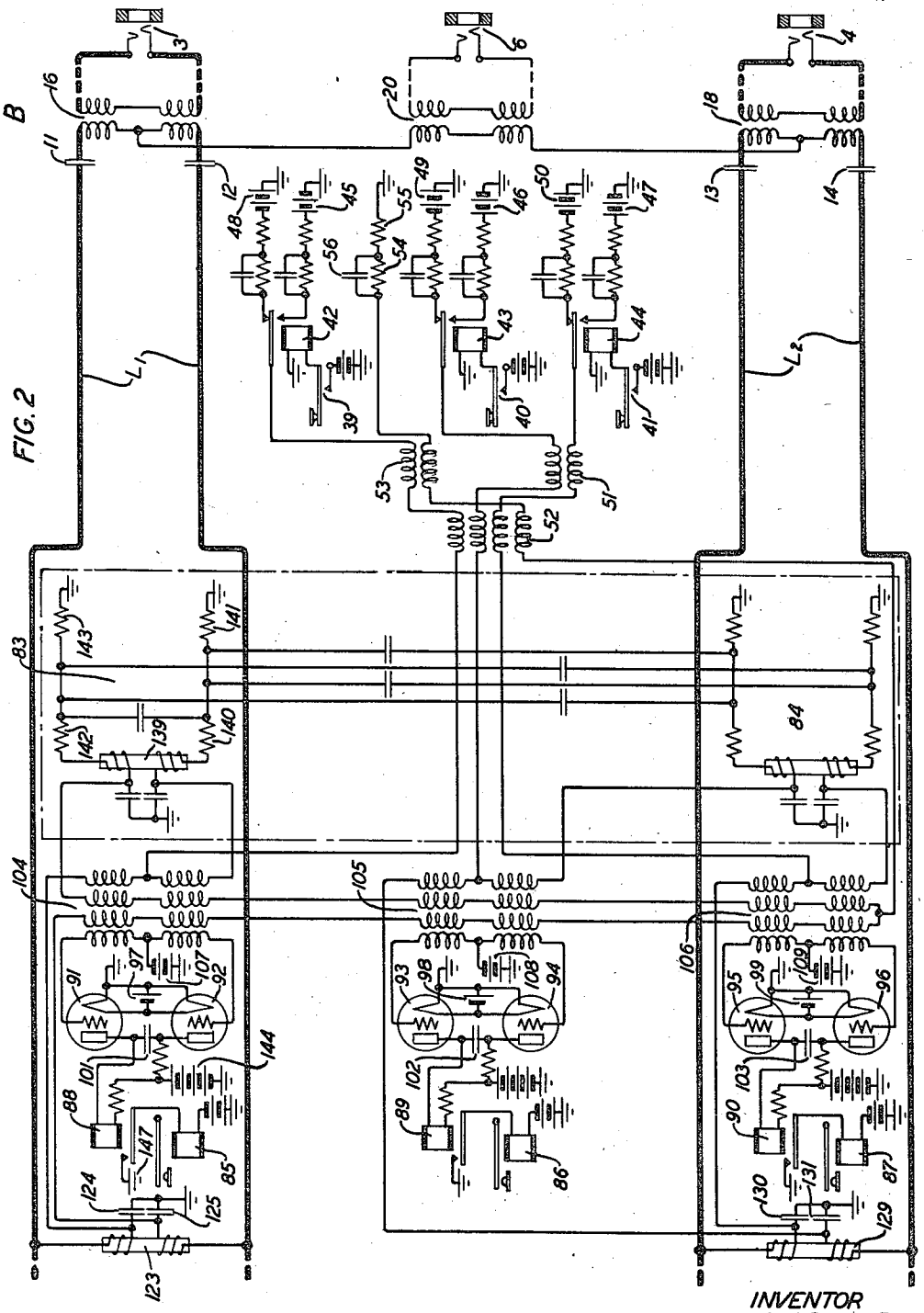

FIG. 2

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COMPOSITE SIGNALING SYSTEM

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Application July 14, 1933, Serial No. 680,422

1 Claim. (Cl. 179—3)

This invention relates to signaling systems and more particularly to systems for transmitting signals over long lines.

In systems heretofore used, particularly composite signaling circuits employing electromagnetic relays, either of the neutral or polar type, for receiving the signal impulses, a certain definite current strength is required to operate the relay and the movement of the armature lags behind the signal impulse due to the mechanical inertia of the armature and the line constants such as inductance and capacity. This time lag increases in general as these constants increase in value. This situation is accentuated, and distortion in the received signals frequently occurs, when intermediate repeaters are inserted in the signal line.

To overcome these difficulties and secure more satisfactory operation especially under these extreme conditions, it is proposed to substitute for the electromagnetic receiving relay an arrangement comprising a pair of gas-filled discharge tubes coupled to the line by means of a transformer whereby a change in potential in one direction in the line will start a space discharge in one of the tubes which will persist until a potential change in the line occurs in the opposite direction which will start a discharge in the other tube which will stop the discharge in the first tube. By inserting a conventional relay in the plate circuit of the first tube any desired signal device can be controlled.

An object of the invention therefore is to improve the signal receiving means in systems of the character described.

Another object is to reduce distortion in the received signals.

Still another object is to permit satisfactory signal reception over longer lines than has been possible heretofore.

A further object is to reduce the current necessary for the operation of systems of the character described.

A still further object is to eliminate interference with the signals by steady state earth potential at either the transmitting or receiving station.

A feature of the invention whereby the foregoing objects are attained resides in substituting, for the electromagnetic relays heretofore used in systems of the character described, a pair of gas-filled discharge tubes and a transformer having an extra winding in addition to the windings employed in connection with the electromagnetic relays. To the midpoint of the extra transformer winding a source of negative grid potential is connected and the two winding terminals are connected to the respective grid electrodes of the pair of discharge tubes. In the plate circuit of the first tube is connected a conventional type neutral relay and the two anodes of the tubes are connected together by a circuit including a condenser. By means of this arrangement a change in the line current potential in a certain direction and flowing in a winding of the transformer causes a momentary current impulse to flow in the extra winding of the transformer which causes the normally negative condition of the grid of one tube to be changed to positive long enough to start a discharge between its space electrodes thereby causing the operation of the plate circuit relay in series therewith. Due to the characteristics of this tube the discharge continues until the plate current is interrupted.

The grid polarity of the second tube is not changed by this first line potential change.

During the period the first tube is discharging each plate of the condenser is positively charged to the polarity of its associated tube anode. When the potential of the line again changes, in a reverse direction, a momentary current impulse in an opposite direction to the first impulse is induced in the extra winding of the transformer thereby changing the grid potential of the second tube from negative to positive whereupon a discharge starts therein. This discharge causes the condenser plate connected to the anode of the second tube to change its potential sufficiently to cause the opposite plate of the condenser to change from positive to negative thereby stopping the discharge of the first tube and releasing the relay.

A complete understanding of the operation of the system contemplated by the invention as well as an appreciation of its various features may be gained from a consideration of the following detailed description and the annexed drawings.

Referring now to the drawings, there is shown a two-way composite phantom trunk system providing simultaneous telephone and telegraph transmission.

Fig. 1 shows the equipment located in office A while

Fig. 2 shows the equipment of a distant office B.

Two physical telephone circuits are provided by lines L_1 and L_2 terminating respectively in jacks 1 and 2 at office A and jacks 3 and 4 at office B while a third telephone circuit is provided by "phantoming", this circuit terminating at office A in jack 5 and at office B in jack 6.

Condensers 7, 8, 9 and 10 at office A and 11, 12, 13 and 14 at office B are connected in series with the lines and furnish a low impedance path to the telephone currents at the same time preventing the passage of the direct current telegraph signals. Repeating coils 15 and 16 are connected across line L_1, 17 and 18 are connected across line L_2 while 19 and 20 are associated with the phantom circuit.

For initiation of the telegraph or other signals, three telegraph sending sets are shown at each station, the sets at station A including keys 21, 22 and 23 which control respectively the operation of relays 24, 25 and 26. Associated with the armature circuits of these relays are sources of positive potential 27, 28 and 29 and sources of negative potential 30, 31 and 32. The armatures of relays 25 and 26 are associated with the respective windings of repeating coil 33 and with two windings of repeating coil 34 while the armature of relay 24 is associated with one winding of repeating coil 35 and a third winding of repeating coil 34. A path to ground including resistances 36 and 37 and condenser 38 is associated with the second winding of repeating coil 35 and the fourth winding of repeating coil 34 for purposes of line balance.

The telegraph sending sets associated with station B are similar to those of station A, including keys 39, 40 and 41, relays 42, 43 and 44, sources of positive potential 45, 46 and 47 and sources of negative potential 48, 49 and 50.

Associated with station A are three telegraph receiving sets including sounders 57, 58 and 59 controlled respectively by relays 60, 61 and 62. These relays are in turn each associated with the plate circuits of a pair of gas-filled vacuum tubes. These vacuum tubes 63, 64, 65, 66, 67 and 68 are of the type frequently referred to as "trigger" tubes and may, for example, be constructed as described in the copending application of A. L. Samuel filed July 1, 1930, Serial No. 465,083. Each tube is provided with a filament heating battery 69, 70 and 71 while the plates of each pair of tubes are connected through a path including respectively condensers 72, 73 and 74.

A four winding transformer 75, 76 and 77 is associated with each receiving set, the fourth winding of each transformer (in describing these transformers as well as the similar transformers associated with station B, the windings will be termed, "first", "second", "third" and "fourth", starting in each instance with the winding most remote from the associated pair of tubes) being connected to the grids of the associated tubes. By virtue of a source of negative potential 78, 79 and 80, associated with the fourth winding of each transformer, the grids of the tubes normally are negatively biased.

The telegraph receiving sets located at station B are similar to those at station A and include sounders 85, 86 and 87 controlled, respectively, by relays 88, 89 and 90, "trigger" tubes 91, 92, 93, 94, 95 and 96 and transformers 104, 105 and 106.

For purposes of line balance networks 81 and 83 are associated with line L_1 and networks 82 and 84 are associated with line L_2.

Impedance coil 120 is bridged across line L_1 at station A and serves as a means for preventing the flow of alternating current telephone signals in the telegraph receiving circuit of station A and yet presents a low impedance path to the direct current telegraph signals. For the slight alternating current that may possibly traverse the impedance coil, a low impedance path to ground is presented through condensers 121 and 122.

A similar network including impedance 123 and condensers 124 and 125 is bridged across line L_1 at station B while impedance 126 with condensers 127 and 128 and impedance 129 with condensers 130 and 131 are bridged across line L_2 at stations A and B respectively.

Let it now be assumed for purposes of illustration that one of the telegraph keys, say 21, at station A is operated in order that a signal may be produced on the associated sounder 85 at station B. Normally, i. e., when key 21 is in unoperated position a negative potential is applied to line conductor 110 from battery 30. As key 21 is operated, however, relay 24 operates and substitutes battery 27 for battery 30 thus applying a positive potential on the line and causing a reversal of the line current. As battery 27 is connected to the line, a momentary positive pulse of current of greater magnitude than the steady state current results from the charging of condenser 132. This positive pulse of current passes through repeating coils 35 and 34 to the midpoint of the first winding of transformer 75 where the current divides, a part passing through the lower half of the winding, through impedance 134 and resistances 135 and 136 of the balancing network to ground and the remainder passing through the upper half of the winding, through the upper winding of impedance 120, line conductor 110 and upper winding of impedance 123, upper half of first or right hand winding of transformer 104 where it divides, a part passing through repeating coils 52 and 53, armature of relay 42, negative battery 48 to ground and the remainder passing through the lower half of the first winding of transformer 104, through impedance 139 and resistances 140 and 141 of balancing network 83 to ground. Condenser 11 prevents this pulse of direct current from passing into the telephone repeating coil 16. Now this momentary positive pulse of current flowing through the first winding of transformer 75 has no inductive effect on the other windings thereof in view of the fact that an equal amount of the current passes through each half of the winding, the direction of current flow through each half being opposite. The flux set up about one half of the winding is therefore cancelled by that set up about the second half. The current, however, passes through each half of the first or right hand winding of transformer 104 in the same direction thus inducing a momentary voltage in the fourth or left hand winding of the transformer. This induced voltage momentarily reduces the normal negative grid bias of tube 91 towards a positive grid bias which, in accordance with the characteristics of the tube, and its associated circuit, starts a discharge between the space electrodes of the tube which will persist until the positive plate current be interrupted. The normal negative grid bias of tube 92 is not changed in a positive direction at this time, however, in view of the direction of flow of the induced current.

The completion of the space current path in tube 91 now completes a path for the operation of relay 88 by battery 144. The operation of relay 88, in turn completes the energizing path for sounder 85, from battery 146 through the winding of the sounder 85, armature and make contact of relay 88 to ground 147.

The operation of key 21 at station A has there-

fore, in the manner described above, resulted in a corresponding operation of associated sounder **85** at station B. It is also desirable of course that the return of key **21** to normal position will at the same time result in sounder **85** restoring to normal. Such action is brought about in the following manner:

Assuming that key **21** be restored to normal, the energizing circuit of relay **24** is interrupted and the relay therefore restores to normal which in turn removes the positive source of potential **27** from the line and replaces the negative source **30**. Now when battery **30** is reconnected to the line, condenser **150** again charges and a momentary pulse of current of greater magnitude than the steady state current value is impressed on the line. This action is similar to that resulting when relay **24** was operated through the operation of key **21**, the pulse of current in this instance however being in the opposite direction. In the manner previously described in tracing the action of the positive pulse, the negative pulse of current passes through the first winding of transformer **75**, having no inductive effect on the other windings, but, in passing through the first winding of transformer **104**, induces a momentary potential in the fourth or "grid" winding of the transformer. Now due to the opposite direction of the pulse, the induced current is, in this instance, of a direction to reduce the normal negative grid bias of tube **92** towards a positive bias. As the characteristics of tube **92** are similar to those of tube **91** previously referred to, a discharge is now set up between the space electrodes of tube **92**.

During the discharge of tube **91**, each plate of condenser **101** was positively charged to the polarity of its associated tube anode. As tube **92** starts to discharge the associated plate of condenser **101** changes its potential sufficiently to cause the opposite plate to change from positive potential to a negative potential. Due to the characteristics of tube **91**, its discharge is stopped as the positive potential of its anode is interrupted.

The interruption of the space current path in tube **91** removes the energizing circuit of relay **88** which therefore restores to normal. As the energizing circuit for sounder **85** is now interrupted, the sounder also drops back to normal.

In the manner described therefore, restoring key **21** to normal has resulted in the corresponding sounder **85** also restoring to normal. From the previous description of the result of operating key **21** and the description just given of the result of restoring the key to normal, it will be apparent that the sounder is operated in step with the key. As the operation of the other sending sets and associated receiving sets is similar to that described above they will not be described in detail.

When a signal impulse passes over a conductor to the distant station, there is a momentary current flow of smaller magnitude in the other conductors of the quad due to capacity between the conductors. This current flows in the same direction as the signal at the receiving end and in the opposite direction at the sending end and, if uncorrected, gives rise to "cross-fire", i. e., the fault of one telegraph sounder responding when a signal is being received by another.

In order to remedy this objectionable feature at the receiving end, the current pulses are led through a winding of either transformer **35** or **33** and a winding of transformer **34** at the sending end thereby inducing an opposing and neutralizing current flow in the other conductors of the quad at the receiving end. The line capacity currents received at the sending end over the other conductors of the quad pass through the upper half of the first windings and through the third windings of the transformers but their effect is neutralized by current flowing through the lower half of the first windings and through the second windings of the transformers due to the discharge of condensers **160**, **161**, **162** and **163** associated with the balancing networks.

In view of the fact that the only telegraph signals effective are those received through inductive transformer action it will be apparent that steady state earth potentials can cause no interfering signals in the receiving circuits. Earth potential surges or alternating earth potentials cause currents of equal magnitude in the upper halves of the first windings of the transformers and in the third windings which currents neutralize one another and thus cause no inductive effect in the "grid" windings.

No detailed description of the method of telephone signal transmission has been given, as the transmission of such signals over phantomed circuits is well understood.

While a phantom telephone system composited for telegraph transmission has been selected for detailed description the invention is not limited in its application to such a system. For example, circuit controlling members other than telegraph keys such as means for transmitting supervisory signals or the like may be utilized at the sending end while the responsive devices at the receiving end may be other than telegraph sounders. The invention is, as a matter of fact, intended to be limited only as indicated by the attached claim.

What is claimed is:

In a composite signaling system, in combination, a pair of line circuits arranged in phantom relation, a plurality of signaling stations at each end of said lines, direct current signal transmitting means at each station including a source of positive and a source of negative potential, composite circuit means connecting each transmitting means to a different conductor of said lines, switching means for controlling the connection of either the positive or negative source to the composite circuit, receiving means at each station connected to the same composite circuit as the transmitting means, said receiving means including a pair of gas-filled discharge devices and a relay, one device being responsive to a signal impulse of one polarity transmitted from the distant station over the respective conductor to operate the relay and the other device being responsive to a pulse of the opposite polarity to restore the relay to normal, a transformer at each station having a portion of one winding in series between the respective composite circuit and the transmitting means and another portion connected between the transmitting means and a balancing network to ground, a second winding connected to the control electrodes of the associated discharge devices and means including a third winding of all said transformers in series for preventing currents induced in the other conductors of the lines due to impulses transmitted by one station from affecting the receiving means of the other stations at the transmitting end.

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