

May 9, 1944.

H. A. WALLACE

2,348,666

APPARATUS FOR TRANSMITTING ELECTRICAL SIGNALS

Filed Feb. 26, 1942

4 Sheets-Sheet 1

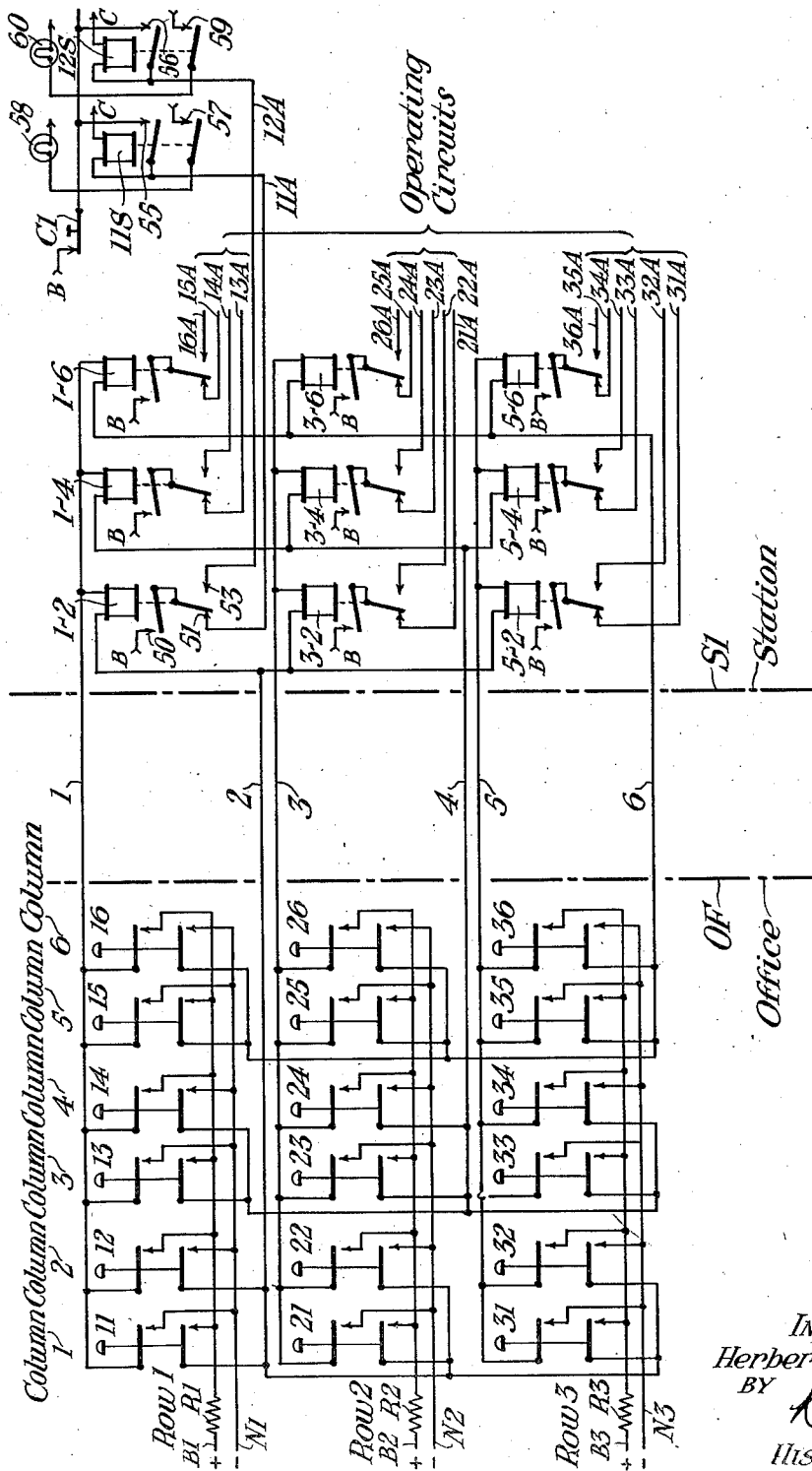


Fig. 1.

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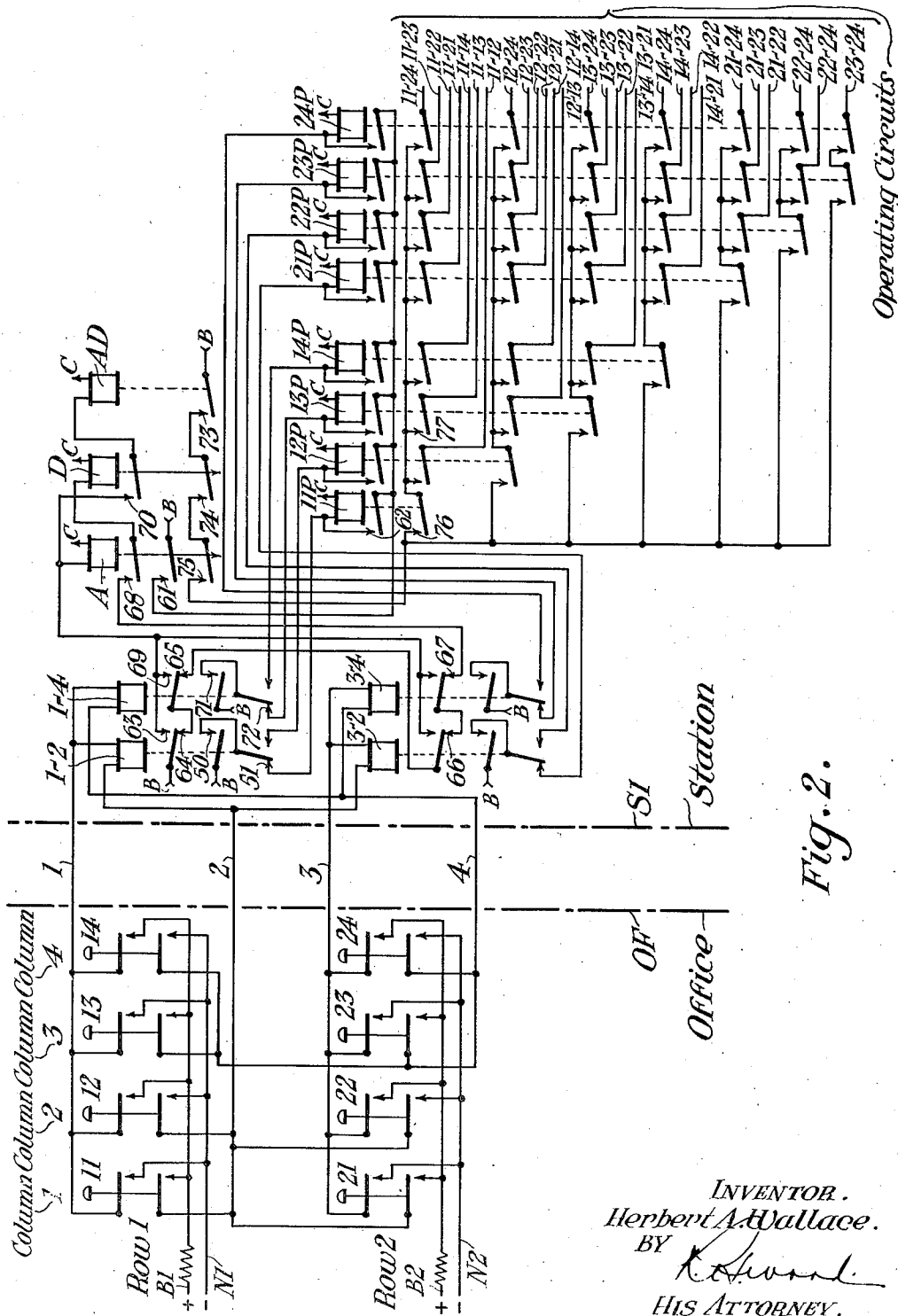


Fig. 2.

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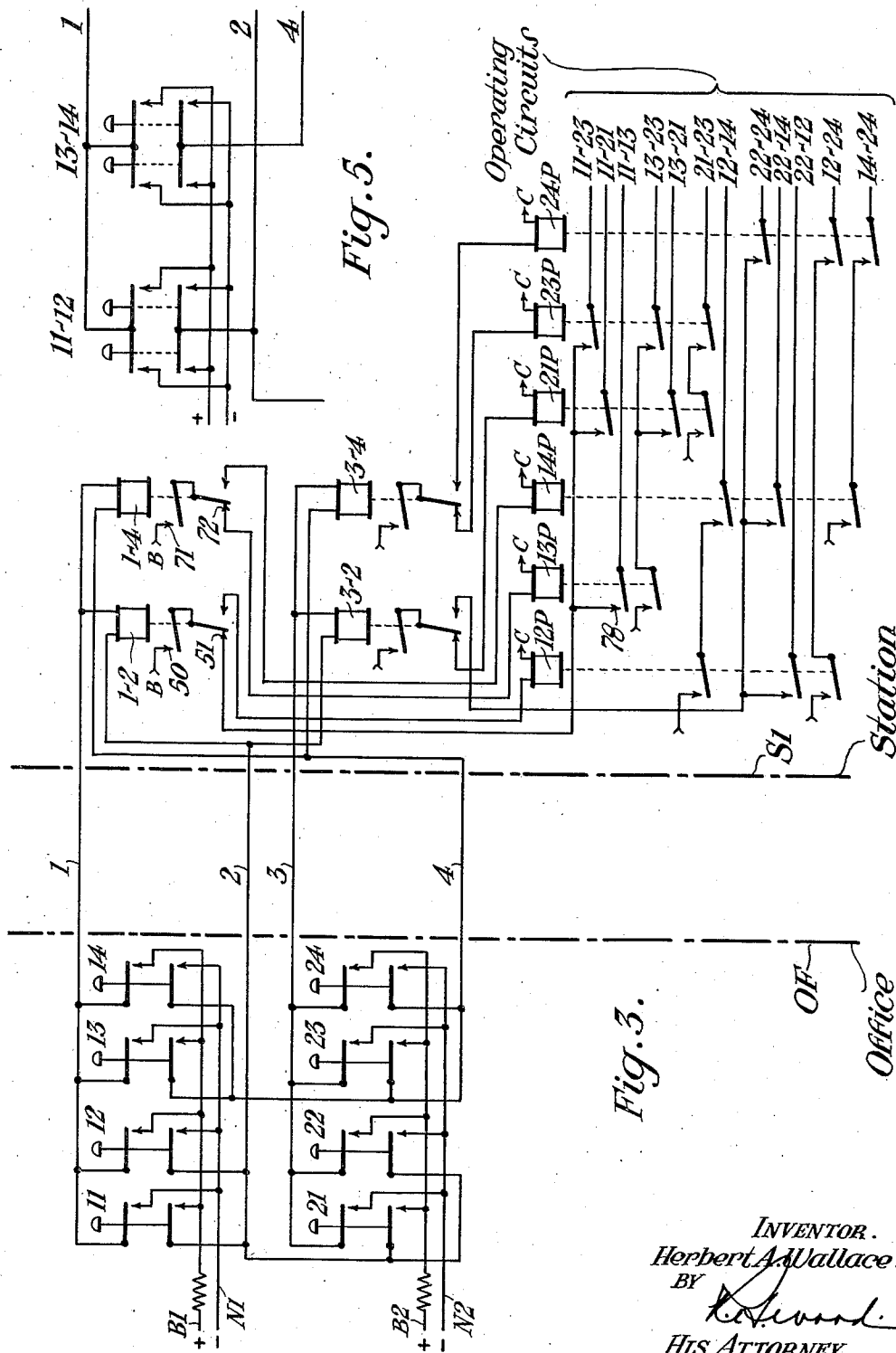
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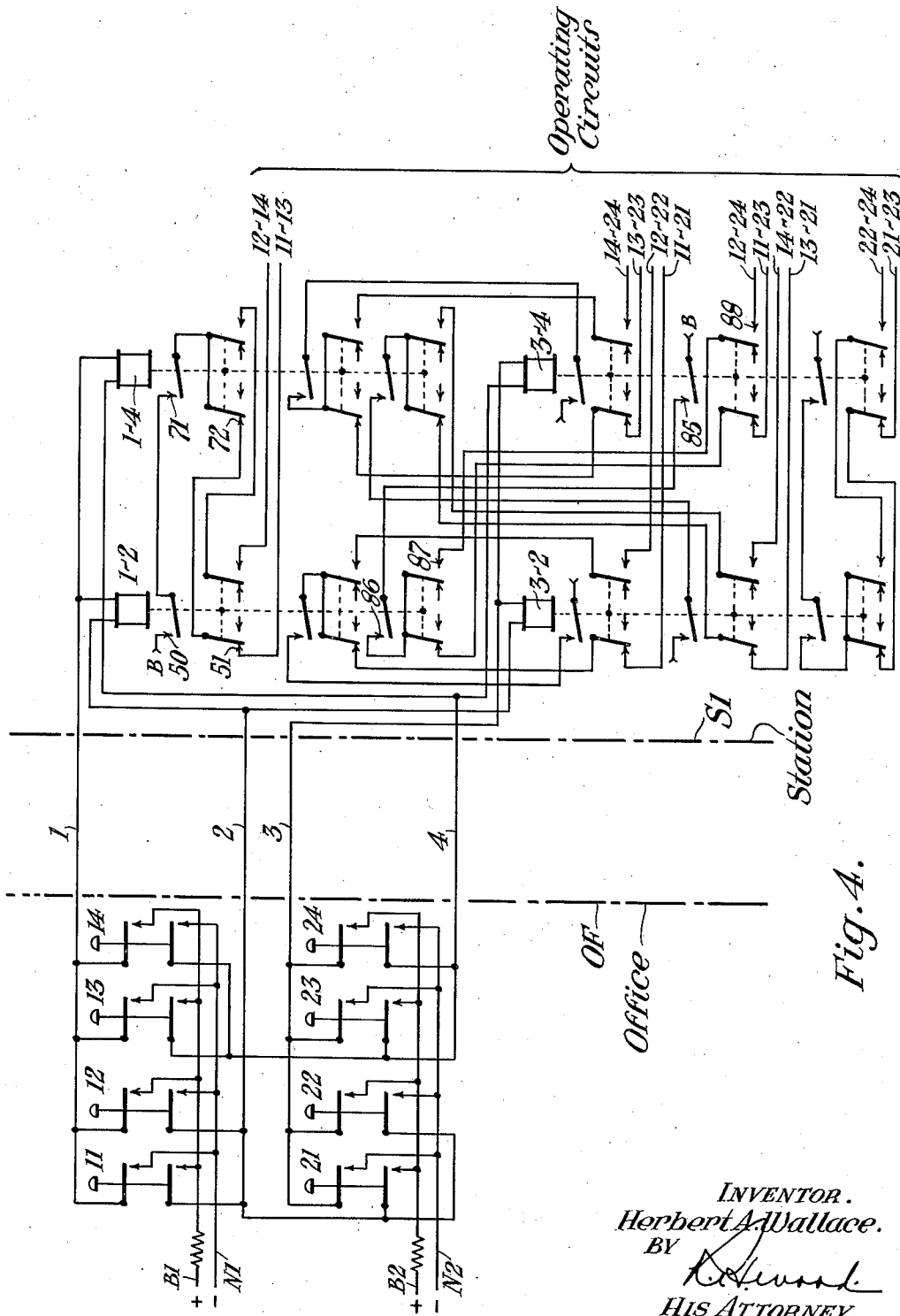
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Filed Feb. 26, 1942

4 Sheets-Sheet 4



UNITED STATES PATENT OFFICE

2,348,666

APPARATUS FOR TRANSMITTING
ELECTRICAL SIGNALS

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Application February 26, 1942, Serial No. 432,441

3 Claims. (Cl. 177-353)

My invention relates to apparatus for transmitting electrical signals, and more particularly to apparatus for selectively transmitting a relatively large number of different electrical signals.

Signal systems are frequently required to transmit any one of a relatively large number of different electrical signals between two locations spaced apart. For example, railway signal systems are required to transmit different controls and indications between an office or tower and a track layout for controlling and indicating the positions of track switches, signals and other devices of the layout. Furthermore, it is often necessary in such systems that each one of a relatively large number of electrical signals be transmitted over a separate and independent circuit which includes conductors extending between the sending and receiving locations.

Accordingly, a feature of my invention is the provision of novel and improved apparatus for transmitting a relatively large number of different electrical signals over a relatively small number of conductors.

Another feature of my invention is the provision of a novel arrangement of a plurality of control wires to provide a greater number of independent non-interfering two-wire circuits than the number of wires.

Still another feature of my invention is the provision of novel means to multiply the number of different electrical signals that can be transmitted over a given number of control wires which are formed into individual circuits of two wires each.

Again, a feature of my invention is the provision of a novel arrangement of a relatively large number of different control devices for reversibly connecting a current source to each of a relatively large number of different non-interfering two-wire circuits.

Other objects and advantages of apparatus embodying my invention will appear as the specification progresses.

The above features, objects and advantages of my invention are obtained by providing a plurality of conductors or wires between a sending point and a receiving point, together with a current source and a plurality of different control devices at the sending point and a plurality of receiving or control relays at the receiving point. The conductors consist of a plurality of odd numbered wires and a plurality of even numbered wires. For example, six wires would be

numbered 1 to 6, inclusive, there being three odd numbered wires 1, 3 and 5, and three even numbered wires 2, 4 and 6. I combine these wires in combinations of two wires each, by each odd numbered wire being used with each of the even numbered wires. For example, when six wires are used, wire 1 is used with each of the wires 2, 4 and 6 to form three separate combinations 1-2, 1-4 and 1-6; wire 3 is used with each wire 2, 4 and 6 to form three combinations 3-2, 3-4 and 3-6; and wire 5 is used with each wire 2, 4 and 6 to form three combinations 5-2, 5-4 and 5-6. Thus six wires are arranged in nine separate combinations of which the two wires of each combination can be used to form a control circuit that does not interfere with the circuit formed by the wires of any other one of the combinations. Similarly, four wires would form four combinations 1-2, 1-4, 3-2 and 3-4; eight wires would form sixteen combinations and ten wires would form twenty-five combinations, and of course a larger number of wires would form a still larger number of such combinations.

At the sending point I provide a separate control device for each combination of the wires. That is, there is provided a control device for each separate control circuit. Each control device is operable to different positions for governing circuit controlling contacts, and the control devices may be either manually operated or operated in response to different conditions of some suitable machine. One form of manually operable control device that may be used is that of the spring return type of push button. When manually operable control devices are used I prefer to arrange the several control devices in horizontal rows and vertical columns, there being a row of devices for each odd numbered wire and a column or pair of associated columns for each even numbered wire. For example, in the case of six wires formed in nine combinations as explained above, there would be nine control devices arranged in three rows with at least three columns.

The contacts governed by each control device are used for reversibly connecting the current source to the wires of the respective combination or circuit. Each control device is preferably biased to a normal position at which the contacts governed thereby are open and the current source is disconnected from the associated circuit. In one operated position of a control device the current source is connected to the associated circuit to supply current of normal

polarity, and at another operated position to supply current of reverse polarity.

The control relays at the receiving point or station are polarized relays and I provide a control relay for each control circuit. Again, using the case of six wires for an example, nine control relays would be provided, one for each of the nine control circuits. Each control relay is connected across the two wires of the associated circuit with the result that the relay is normally deenergized, and is energized at normal or reverse polarity according to the polarity of the current supplied to the associated circuit as predetermined by the position of the associated control device. For convenience the control relays may be arranged in groups with a group for each odd numbered wire, and each relay group consisting of as many relays as there are even numbered wires. Each control relay governs two operating circuits, one completed at a normal polar contact and the other completed at a reverse polar contact. Each such operating circuit would be used to govern a distinctive operating unit or mechanism. It follows that in the case of six wires there are provided nine different control circuits to transmit eighteen different signals for governing eighteen different operating circuits. In the case of four wires, there are provided four different control circuits to transmit eight different signals for governing eight different operating circuits; and eight wires would provide sixteen different circuits to transmit thirty-two different signals for governing thirty-two different operating circuits.

Each polarized relay is energized only as long as the respective control device is operated and thus each operating circuit would be closed only while the associated control device is held in an operated position. To retain a transmitted signal indefinitely, I provide stick relays at the receiving stations, each stick relay being picked up over a respective polar contact of a corresponding control relay and then retained energized over a stick circuit that would be under the control of some circuit controller at the receiving station operated either manually or by some mechanism of the receiving station. With this arrangement each stick relay would be used to govern the circuit of the associated operating unit or mechanism.

If further multiplying of the number of the transmitted signals is desired, I provide the receiving station with a group of repeater relays, there being a repeater relay for each of the normal and reverse positions of each of the polarized control relays. In this form of the invention, an electrical signal is transmitted by the operation of two control devices successively within a predetermined period of time to thereby energize two polarized relays successively within such predetermined period of time. In this way a particular combination of two repeater relays is selected in response to each transmitted signal. Each such combination of two repeater relays governs a corresponding operating circuit. For example, four polarized control relays each operable to a normal and a reverse position would govern eight respective repeater relays which eight relays would provide twenty-eight different combinations of two relays each, with the result that twenty-eight different electrical signals can be transmitted over four control wires. In place of requiring operation of two control devices successively within a predetermined period of time to transmit a signal the

same results can be accomplished by operating two control devices simultaneously.

In one form of the invention, the number of different electrical signals that can be provided is multiplied by providing each polarized control relay with a plurality of different polar contacts which are used in various combinations to govern the operating circuits. In this form of the invention the repeater relays would be eliminated.

For a more complete understanding of my invention, reference may be had to the accompanying drawings in which several different forms of the invention are disclosed and after a description of which I shall point out the novel features thereof in claims.

In the accompanying drawings, Fig. 1 is a diagrammatic view showing one form of apparatus embodying my invention when used with six wires extending between an office and a station. Fig. 2 is a diagrammatic view showing another form of apparatus embodying my invention wherewith the number of electrical signals transmitted over four control wires is multiplied by means of repeater relays which are grouped in different combinations of two relays each and controlled in response to operation of two control devices successively within a predetermined interval of time. Fig. 3 is a diagrammatic view showing still another form of apparatus embodying my invention for multiplying the number of different electrical signals by operation of two control devices simultaneously. Fig. 4 is a diagrammatic view showing a modification of the apparatus of Fig. 3 for multiplying the number of signals by means of additional polar contacts of the polarized relays. Fig. 5 is a diagrammatic view showing a modification that may be used with Figs. 1, 2, 3 and 4.

In each of the several views like reference characters are used to designate similar parts.

Referring to Fig. 1, the reference character OF designates a sending point or office, and the reference character SI designates a receiving station. For example, in a remote control system for railways, the office OF would be the location of the operator, and the station SI would be located adjacent the track layout whose switches and signals are to be governed from the office. As shown in Fig. 1, six conductors or control wires designated by the numerals 1, 2, 3, 4, 5 and 6 extend between the office OF and the station SI. These six wires are grouped in nine different combinations of two wires each to form nine separate control circuits. This grouping is accomplished by each odd numbered wire being used with each one of the even numbered wires. That is, wire 1 is used with each of the wires 2, 4 and 6 to form three separate circuits, wire 3 is used with each of the wires 2, 4 and 6 to form three separate circuits, and wire 5 is used with each of the wires 2, 4 and 6 to form three separate circuits.

It is to be understood, of course, that my invention is not limited to the use of six wires, and the number of wires would be selected according to the number of different electrical signals required. Six wires are shown in Fig. 1 since six wires with the apparatus associated therewith are sufficient to provide a full understanding of my invention. Furthermore, it is to be understood that my invention is not limited to use with railway signal systems, but reference is made to such use as an aid to clarifying the description

and as an illustration of the utility of such apparatus.

The office OF is provided with a plurality of control devices. These control devices may take any one of several different forms of circuit controlling means and are shown as spring return type of push button, each of which push buttons is provided with a top and a lower contact member biased to one position and operable in unison to a second position when the push button is depressed. There is provided a control device for each of the nine combinations of the wires, that is, for each of the nine separate control circuits. In Fig. 1 each such control device consists of two separate push buttons which are preferably located adjacent each other. For convenience these push buttons are shown arranged in horizontal rows and vertical columns, there being three rows of six push buttons each. I shall identify each push button by a compound number which corresponds to the position of the push button with respect to the rows and columns. For example, push button 11 is in row 1 and column 1, and push button 23 is in row 2 and column 3.

The current source provided at the office OF may be any convenient source, such as a battery, whose positive and negative terminals are identified by the plus and minus signs. Three bus wires B1, B2 and B3 are connected to the positive terminal of the current source and three negative bus wires N1, N2 and N3 are connected to the negative terminal of the source. Resistors R1, R2 and R3 are preferably interposed in bus wires B1, B2 and B3, respectively.

Each control device reversibly connects the current source across the corresponding combination of wires. Looking at push buttons 11 and 12 which together form a control device, the top contact member of each is connected to wire 1 and the lower contact member of each is connected to wire 2, while bus wire B1 is connected to the second position contact of the lower contact member of push button 11 and to the second position contact of the top contact member of push button 12, and the bus wire N1 is connected to the second position contact of the top contact member of push button 11 and to the second position contact of the lower contact member of push button 12. It is clear, therefore, that when push button 11 is depressed, control wires 1 and 2 are supplied with current of one polarity, which I shall call normal polarity, and when push button 12 is depressed, control wires 1 and 2 are supplied with current of the opposite polarity and which I shall call reverse polarity. In like manner, push buttons 13 and 14 form a control device to reversibly connect the current source to the circuit comprising wires 1 and 4, and push buttons 15 and 16 form a control device to reversibly connect the current source to the circuit comprising wires 1 and 6. In the second row of push buttons, the push buttons 21 and 22 form a control device which reversibly connects the current source to the circuit comprising control wires 3 and 2, push buttons 23 and 24 form a control device which reversibly connects the current source to the circuit comprising wires 3 and 4, and push buttons 25 and 26 form a control device which reversibly connects the current source to the circuit comprising wires 3 and 6. In the third row the current source is reversibly connected to the circuit comprising wires 5 and 2 by push buttons 31 and 32, to the circuit comprising wires 5 and 4 by

push buttons 33 and 34, and to the circuit comprising wires 5 and 6 by the push buttons 35 and 36.

Nine polarized relays are provided at station S1, one such relay being connected to each of the nine different circuits into which the six wires are arranged. I shall identify each polarized relay by the two numbers of the wires of the associated circuit separated by a hyphen. For convenience these nine polarized relays are shown arranged in three groups, one group associated with each odd numbered wire and each group of relays comprising as many relays as there are even numbered wires.

Each of the polarized relays of station S1 governs two local operating circuits, one completed over a normal polar contact of the relay, and the other completed over a reverse polar contact of the relay. Hence the nine polarized relays govern a total of eighteen operating circuits which are identified at the right hand portion of Fig. 1 by a reference character A with a distinctive prefix and any one of which eighteen operating circuits can be selected by operation of the proper push button at the office OF. For example, operation of push button 11 supplies current of normal polarity to wires 1 and 2 to energize relay 1-2 at normal polarity to close front contact 50 and normal polar contact 51 of relay 1-2, and select operating circuit 11A. It is apparent from an inspection of Fig. 1 that each one of the eighteen operating circuits can be selected by operation of the proper push button at the office to energize the corresponding control relay at normal or reverse polarity.

Each control relay of station S1 is picked up and the associated operating circuit closed only as long as the associated push button is depressed. That is, an operating circuit is made effective only during the interval a control device at the office is retained at an operated position. If it is desired that the transmitted signal be stored, then I provide a stick relay for each electrical signal transmitted. In Fig. 1 I have shown two stick relays 11S and 12S associated with control relay 1-2 for storing the two different signals which energize control relay 1-2 at normal and reverse polarity. Stick relay 11S is picked up over a circuit including front contact 50 and normal polar contact 51 of control relay 1-2 and relay 11S is then held energized over a stick circuit including terminal B of the current source, a circuit controller C1 and front contact 55 of relay 11S. Stick relay 12S is picked up over a circuit including front contact 50 and reverse polar contact 53 of control relay 1-2, and then is held energized over a stick circuit which includes terminal B, circuit controller C1 and front contact 56 of relay 12S. Each stick relay 11S and 12S is then used in turn to govern an operating circuit of an associated unit, relay 11S governing at its front contact 57 an operating circuit for a lamp 58 and relay 12S governing at its front contact 59 an operating circuit for a lamp 60. Transmission of an electrical signal to energize relay 1-2 at normal polarity would close the pick-up circuit for relay 11S and lamp 58 would be illuminated. Lamp 58 would continue to be illuminated subsequent to the electrical signal that energized control relay 1-2 until such time as controller C1 is opened to release stick relay 11S. Controller C1 could be a manually operable controller at station S1, or it could be controlled by some operating condition of the apparatus at the station. For example, if the apparatus of

station S1 is used to govern the track switches and other devices of a track layout, controller C1 might be governed by a track relay of a track circuit. It is obvious that the electrical signal for governing each of the remaining operating circuits shown at the right-hand portion of Fig. 1 can be stored by a stick relay connected in the manner of stick relay 11S or 12S.

It is to be seen therefore that in Fig. 1, I have disclosed apparatus wherewith eighteen separate electrical signals are transmitted over six wires arranged in nine separate non-interfering two-wire circuits, and wherewith each of these transmitted signals can be stored at the receiving station if desired.

Referring to Fig. 2, four wires 1, 2, 3 and 4 are provided between office OF and station S1, and as explained hereinbefore, these four wires provide four different combinations or circuits 1—2, 1—4, 3—2 and 3—4. At office OF of Fig. 2, eight push buttons are provided to form four control devices each of which reversibly connects the current source to an associated control circuit, the operation of the push buttons of Fig. 2 being the same as described in connection with Fig. 1. At station S1 of Fig. 2 four polarized relays are provided and each of which is associated with a different one of the control circuits in the same manner as the control relays of Fig. 1. These four polarized relays of Fig. 2 are used to govern eight different repeater relays for multiplying the number of different electrical signals that can be transmitted over the four wires. I shall identify these repeater relays by the number of the push button by which the repeater relay is selected plus the letter P. For example, repeater relay 11P is selected in response to operation of push button 11 at the office as will appear hereinafter. In addition the station S1 is provided with two slow acting relays A and D and another relay AD associated with the slow acting relays. As here shown, relays A and D are provided with slow release characteristics and the slow release period of relay A is used to determine the interval within which two control devices must be operated successively for an electrical signal to be transmitted from the office to select a desired operating circuit.

Each repeater relay of station S1 is picked up over a circuit including a respective polar contact of the associated control relay, and then is retained energized over a stick circuit governed by the slow release relay A. For example, relay 11P is picked up over a circuit including front contact 50 and normal polar contact 51 of control relay 1—2, and is retained energized over a stick circuit including terminal B, front contact 61 of relay A and front contact 62 of relay 11P. Each of the remaining repeater relays is picked up over a circuit similar to that just described for repeater relay 11P and then is retained energized over a stick circuit including front contact 61 of relay A, front contact 61 of relay A being common to the stick circuits of all the repeater relays.

The eight repeater relays are arranged in different combinations of two relays each, such combinations being effected by the relay at one end of the group, such as relay 11P, being combined with each one of the remaining relays of the group and this arrangement being repeated for each one of the successive relays. For example, repeater relay 11P is combined with each of the remaining relays 12P, 13P, 14P, 21P, 22P, 23P and 24P; repeater relay 12P is combined with each of the remaining relays 13P, 14P, 21P, 22P,

23P and 24P; and so on until the entire group is exhausted.

The two repeater relays of each combination when picked up complete an associated operating circuit. In this way the eight repeater relays provide twenty-eight combinations to govern the twenty-eight different operating circuits shown at the right-hand portion of Fig. 2, each such operating circuit being identified by the numbers of the two relays of the respective combination separated by a hyphen.

The relays A, D and AD are governed by the control relays. It is thought that the control of relays A, D and AD and of the repeater relays to govern the operating circuits can best be understood from a description of the operation of the apparatus of Fig. 2.

Starting with the apparatus of Fig. 2 at its normal condition wherein all the relays are released, I shall assume that push button 11 is first depressed to apply current of normal polarity to the circuit comprising wires 1 and 2, and control relay 1—2 is energized at normal polarity. Control relay 1—2 on picking up to close front contact 63 completes a simple circuit for relay A and relay A is picked up. The energizing of relay 1—2 at normal polarity to close front contact 50 and normal polar contact 51 picks up the repeater relay 11P after which relay 11P is energized by its stick circuit including front contact 61 of relay A. When push button 11 is released, control relay 1—2 is immediately released closing back contact 64 and a circuit is completed from terminal B over back contacts 64, 65, 66 and 67 of control relays 1—2, 1—4, 3—2 and 3—4, respectively, front contact 68 of relay A since relay A is slow releasing in character, winding of relay D and terminal C, and relay D is picked up. I shall now assume that the operator depresses push button 13 to apply current of normal polarity to the wires 1 and 4, whereby the control relay 1—4 is energized at normal polarity. The closing of front contact 69 of relay 1—4 completes a circuit that can be traced from terminal B over back contact 64 of relay 1—2, front contact 69 of relay 1—4, front contact 70 of relay D and winding of relay AD to terminal C, and relay AD is picked up. Relay A is also supplied with an energizing impulse over this circuit including back contact 64 of relay 1—2 and front contact 69 of relay 1—4, and hence remains picked up. The closing of front contact 71 and normal polar contact 72 of relay 1—4 selects repeater relay 13P, after which relay 13P is energized over its stick circuit including front contact 61 of relay A. With relays A, D and AD all picked up as well as repeater relays 11P and 13P, an operating circuit can be traced from terminal B over front contacts 73, 74, 75, 76 and 77 of relays AD, D, A, 11P and 13P, respectively, and thence over wire 11—13 to an associated operating unit not shown. When push button 13 is released, the control relay 1—4 is immediately released to deenergize relays A, D and AD, with the result that relay AD is released at once and relays A and D are each released at the end of their slow release periods. The release of relay AD to open front contact 73 opens the associated operating circuit. If, however, it is desired to retain an operating circuit closed then the circuit including wire 11—13 would control a stick relay similar to the stick relay 11S of Fig. 1. When slow acting relay A is released to open front contact 61, both repeater relays 11P and 13P are deenergized and released with the result that the apparatus is then restored to its normal condition. Similarly, any

combination of the repeater relays can be selected and a corresponding operating circuit closed by the operation of two control devices successively within the predetermined slow release period of relay A as will be apparent from an inspection of Fig. 2 taken in connection with the description of the operation of the apparatus for selecting the operating circuit 11-13. It is to be seen therefore that in Fig. 2 I have disclosed apparatus by which twenty-eight different electrical signals can be transmitted by the use of four wires to govern twenty-eight operating circuits.

In Fig. 3, apparatus for multiplying the number of different electrical signals that can be transmitted for selecting different combinations of repeater relays in response to operation of two control devices simultaneously is disclosed. In Fig. 3 four wires between office OF and station S1, eight push buttons at the office and four polarized control relays at the station are provided, the same as in Fig. 2. Since transmission of an electrical signal requires simultaneous operation of the two control devices, it is clear that some combinations of two push buttons cannot be used because of the possible shunt paths created when certain ones of the push buttons are simultaneously operated. For example, if push buttons 11 and 12 are depressed at the same time, the conductors 1 and 2 will be shunted over paths created through the contacts of the push buttons. There are, however, a possible twelve different combinations of the eight push buttons that can be simultaneously operated. These twelve combinations consist of the following combinations 11-13, 11-21, 11-23, 12-14, 12-22, 12-24, 13-21, 13-23, 14-22, 14-24, 21-23 and 22-24. In Fig. 3 a group of repeater relays similar to the group of repeater relays of Fig. 2 is provided and controlled by the control relays the same as in Fig. 2, except for the fact that slow acting relays and stick circuits are not required in Fig. 3 because two control relays are energized simultaneously. The group of repeater relays of Fig. 3 includes only six relays, which six relays are used with the normal position of control relay 1-2 and the reverse position of control relay 3-2 to form twelve combinations to govern twelve different operating circuits indicated at the lower right-hand portion of Fig. 3.

In describing the operation of the apparatus of Fig. 3 I shall assume that push buttons 11 and 13 are simultaneously depressed to supply current of normal polarity to each of the circuits comprising wires 1 and 2 and wires 1 and 4. These two currents cause the two control relays 1-2 and 1-4 to be energized each at normal polarity. The closing of front contact 71 and normal polar contact 72 of control relay 1-4 selects repeater relay 13P and relay 13P is picked up. Relay 13P and the normal position of relay 1-2 form a combination that governs an operating circuit traced from terminal B over front contact 50 and normal polar contact 51 of control relay 1-2, front contact 78 of repeater relay 13P and thence over wire 11-13 to an associated operating unit. When push buttons 11 and 13 are released, the control relays 1-2 and 1-4 are immediately de-energized and the operating circuit is opened and if it is desired to retain the operating circuit closed then the wire 11-13 would extend to a stick relay similar to the stick relay 11S of Fig. 1. In a similar manner each of the remaining eleven of the twelve operating circuits can be governed by simultaneous operation of the proper two corresponding push buttons at the office as will be apparent from an inspection of Fig. 3 taken in

connection with the description of the manner whereby the operating circuit including wire 11-13 is selected. It is to be seen, therefore, that in Fig. 3 I have disclosed apparatus effective for selectively transmitting twelve electrical signals over four control wires.

Referring to Fig. 4, the electrical signals that can be transmitted over four control wires by operation of two control devices simultaneously are multiplied by providing extra polar contacts on the control relays at the receiving station. Four control wires extend from office OF to station S1 of Fig. 4 and are associated with eight push buttons at the office and four control relays at the station in the same manner as described in connection with Fig. 3, except for the fact that the control relays are provided with additional contacts. Since transmission of an electrical signal by simultaneous operation of two control devices is contemplated in Fig. 4, the eight push buttons can be arranged to provide the twelve different combinations of two each that do not create shunt paths, the same as set forth in connection with Fig. 3. The polar contacts of the different control relays are combined in combinations corresponding to the twelve selected combinations for the push buttons and are used to govern the twelve different operating circuits indicated at the right-hand portion of Fig. 4.

In describing the operation of the apparatus of Fig. 4, I shall assume that at the start the apparatus is at its normal condition wherein all the relays are released, and I shall assume that push buttons 11 and 13 are simultaneously depressed to apply current of normal polarity to each of the circuits including wires 1 and 2 and 1 and 4, and thereby cause the control relays 1-2 and 1-4 to be simultaneously energized at normal polarity. Under this condition of the control relays, an operating circuit extends from terminal B over front contact 50 of relay 1-2, front contact 71 of relay 1-4, normal polar contact 72 of relay 1-4, normal polar contact 51 of relay 1-2, and thence over wire 11-13 to a corresponding operating unit. Again, if push buttons 12 and 24 are simultaneously depressed to apply currents of reverse polarity to the circuits including wires 1 and 2 and wires 3 and 4, the two control relays 1-2 and 3-4 are simultaneously energized at reverse polarity. This combination of the control relays completes an operating circuit extending from terminal B over front contact 85 of relay 3-4, front contact 86 of relay 1-2, reverse polar contact 87 of relay 1-2, reverse polar contact 88 of relay 3-4, and thence over wire 12-24 to an associated operating unit. Similarly, simultaneous operation of the two push buttons of any one of the twelve combinations set forth hereinbefore would energize two control relays simultaneously to close proper polar contacts to select a corresponding operating circuit, as will be apparent from an inspection of Fig. 4 taken in connection with the description of the manner of selecting the operating circuits 11-13 and 12-24.

It is to be seen, therefore, that in Fig. 4 I have provided apparatus for multiplying the possible number of electrical signals that can be transmitted over four control wires by the use of additional contacts of the control relays and the repeater relays disclosed in Fig. 3 can be omitted.

It is to be understood that the forms of the invention disclosed in Figs. 2, 3 and 4 are in no manner limited to the use of four wires and additional wires may be used with each of these forms

of the invention if additional electrical signals are required, but four wires together with the associated apparatus are sufficient to illustrate the principle of the invention. Furthermore, it is to be understood that my invention is not limited to the use of an equal number of odd numbered and even numbered wires, and that an odd number of wires, such as 5, 7, 9, etc., can be used if desired. It is to be noted, however, that the most advantageous condition exists when an equal number of odd numbered and even numbered wires are used.

In Fig. 5 there is illustrated another form of push buttons that can be used as control devices. Control device 11—12 of Fig. 5 would, for example, correspond to the control device comprising push buttons 11 and 12 of Fig. 3. The two contact members of control device 11—12 are pivoted at the center and can be depressed to close either the left-hand pair of contacts or to close the right-hand pair of contacts but cannot be operated to close both pairs of contacts at the same time. Thus in Fig. 5, a push button cannot inadvertently be operated to place a short circuit on the current source. It is clear that other arrangements of interlocking the different positions of the control devices can be used, such as, for example, that provided for levers of an interlocking machine.

From the foregoing description it is apparent that apparatus embodying my invention has the advantages that a relatively large number of different electrical signals can be transmitted over a relatively small number of wires and that the number of such signals that can be transmitted over a given number of wires can be multiplied by relatively simple and inexpensive apparatus.

Although I have herein shown and described several forms of apparatus embodying my invention for transmitting electrical signals, it is understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. In combination, a plurality of normally de-energized polarized control relays, remote control means including control circuits one connected to each of said control relays and each of which control circuits is operative to apply at times current of either normal or reverse polarity to the respective control relay, a group of repeater relays comprising two repeater relays controlled by each control relay one over a normal polar contact of the respective control relay and the other over a reverse polar contact of the respective control relay, a slow acting relay controlled by a circuit completed over a

front neutral contact of any one of said control relays, a stick circuit for each of said repeater relays and including a contact of said slow acting relay, another relay controlled through a circuit including in series a back neutral contact of each of said control relays, and a plurality of different operating circuits each of which operating circuits includes in series a front contact of each of two preselected repeater relays and a front contact of said other relay.

2. In combination, a plurality of control relays, remote control means including control circuits one connected to each said control relays and each of which control circuits is adaptable of energizing the respective control relay, a group of repeater relays one controlled by each of said control relays, a first and a second slow release relay, another relay, a first circuit completed at a front contact of any one of said control relays to energize said first slow release relay, a second circuit including in series a back contact of each of said control relays and a front contact of said first slow release relay to energize said second slow release relay, a third circuit including a front contact of any one of said control relays and a front contact of said second slow release relay to energize said other relay, a stick circuit for each said repeater relay and including a front contact of said first slow release relay; and a plurality of operating circuits each of which includes in series a front contact of said other relay, a front contact of said second slow release relay, a front contact of said first slow release relay and a front contact of each of a preselected pair of said repeater relays whereby an operating circuit is energized only when said control means energizes a preselected pair of said control relays successively within the slow release period of said first slow release relay.

3. In combination, a plurality of normally de-energized control relays, remote control means including control circuits one connected to each of said control relays to energize the respective control relay in response to an electric signal transmitted over the respective control circuit, timing means controlled by each control relay when energized to initiate a time interval, another relay controlled through a circuit including in series a back neutral contact of each of said control relays to check the normal position of said control relays; and a plurality of operating circuits each of which operating circuits is governed by said timing means, said other relay and a preselected combination of two of said control relays when energized within said time interval.

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