

June 1, 1937.

T. J. JUDGE ET AL

2,082,544

CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

Original Filed Oct. 28, 1932

8 Sheets-Sheet 1

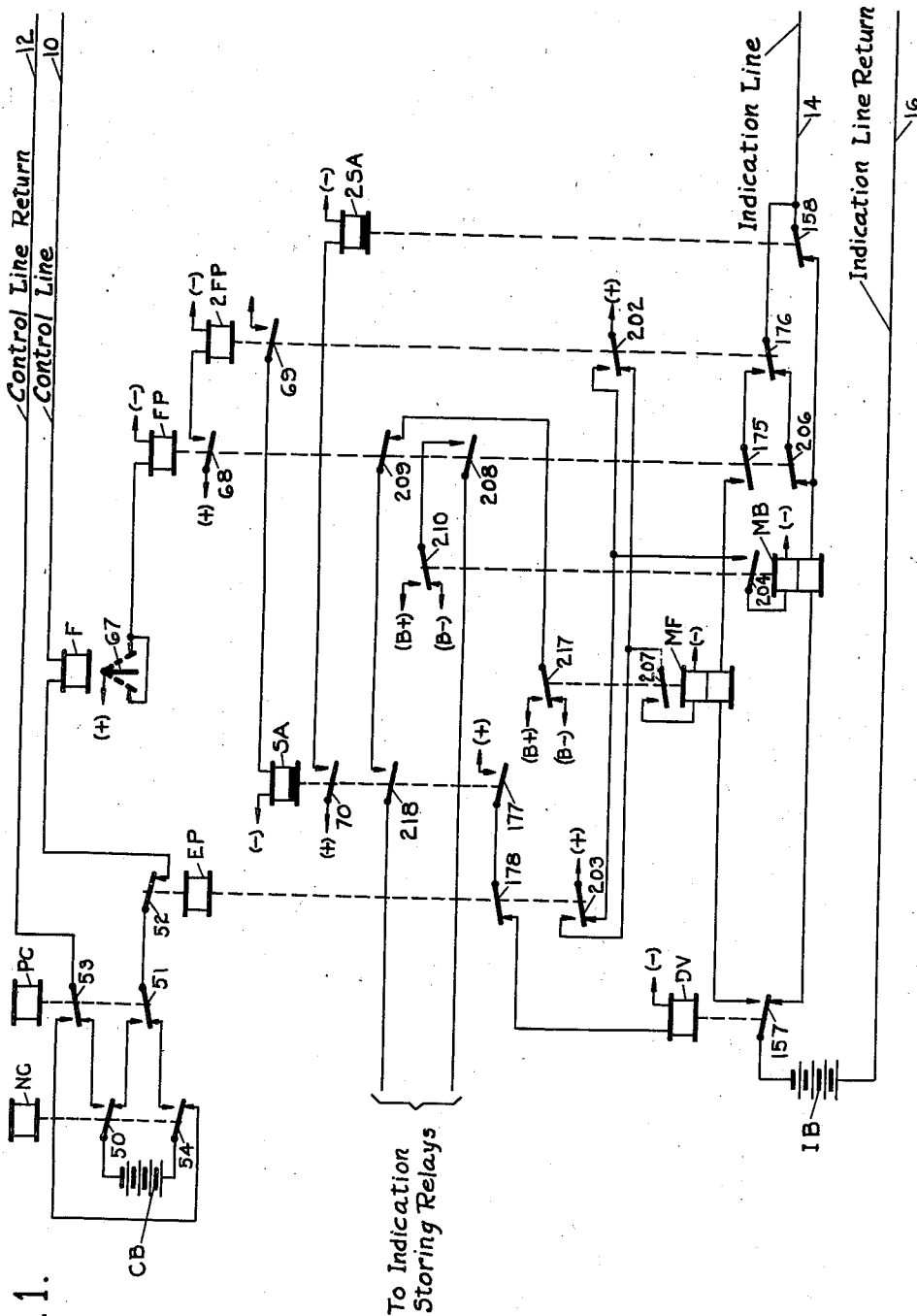


FIG. 1.

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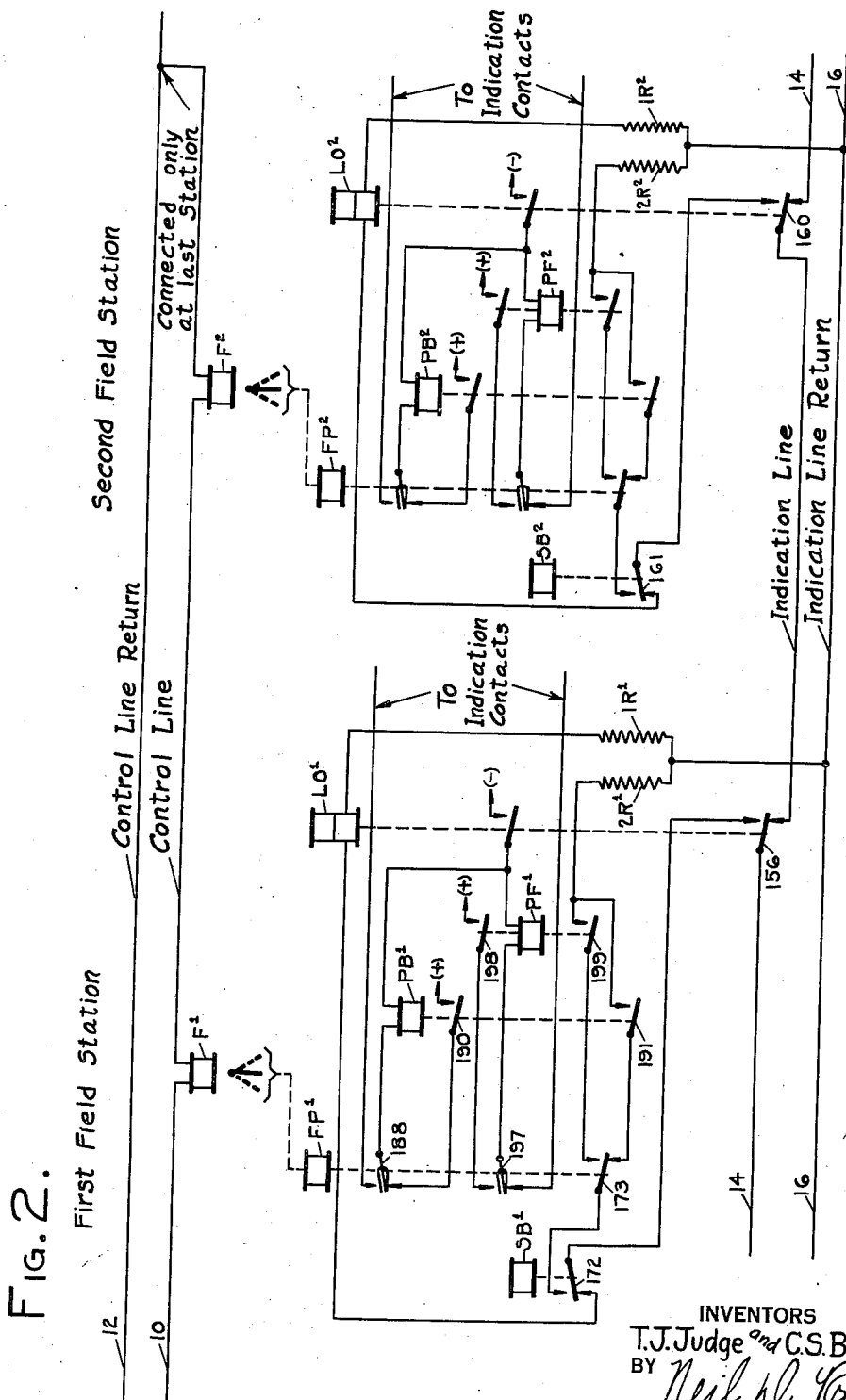
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CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

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8 Sheets-Sheet 2



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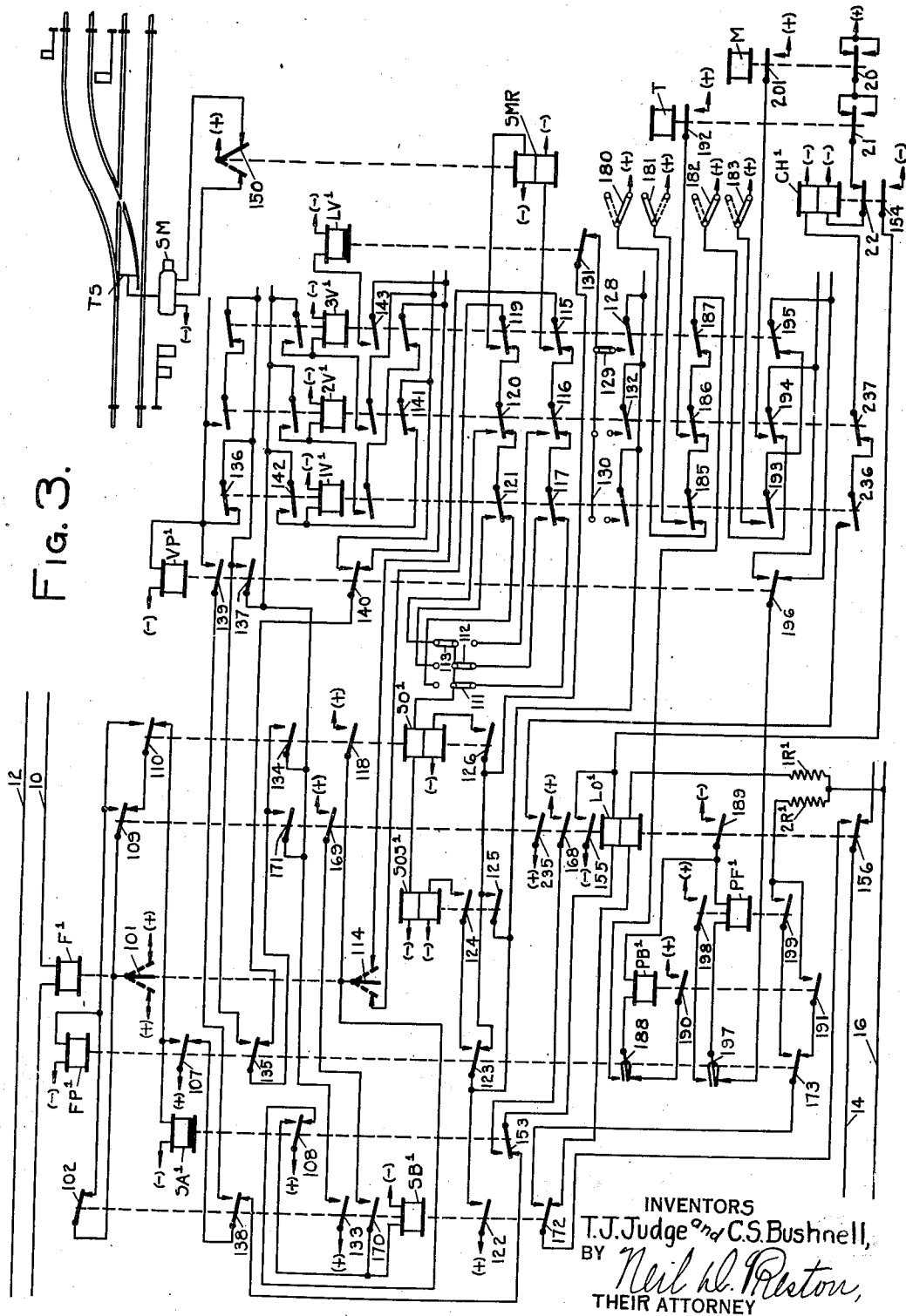
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CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

Original Filed Oct. 28, 1932

8 Sheets-Sheet 3



June 1, 1937.

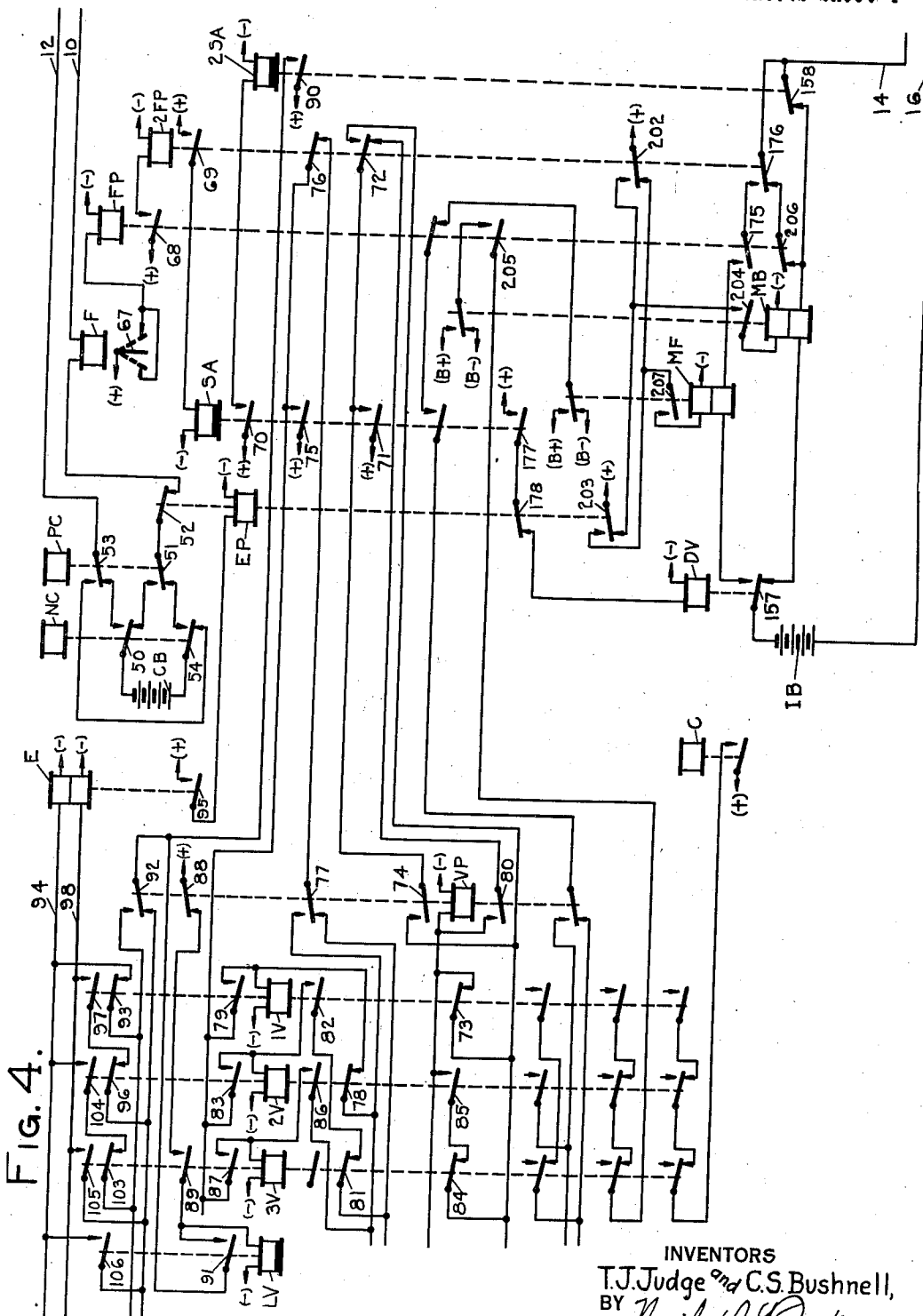
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2,082,544

CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

Original Filed Oct. 28, 1932

8 Sheets-Sheet 4



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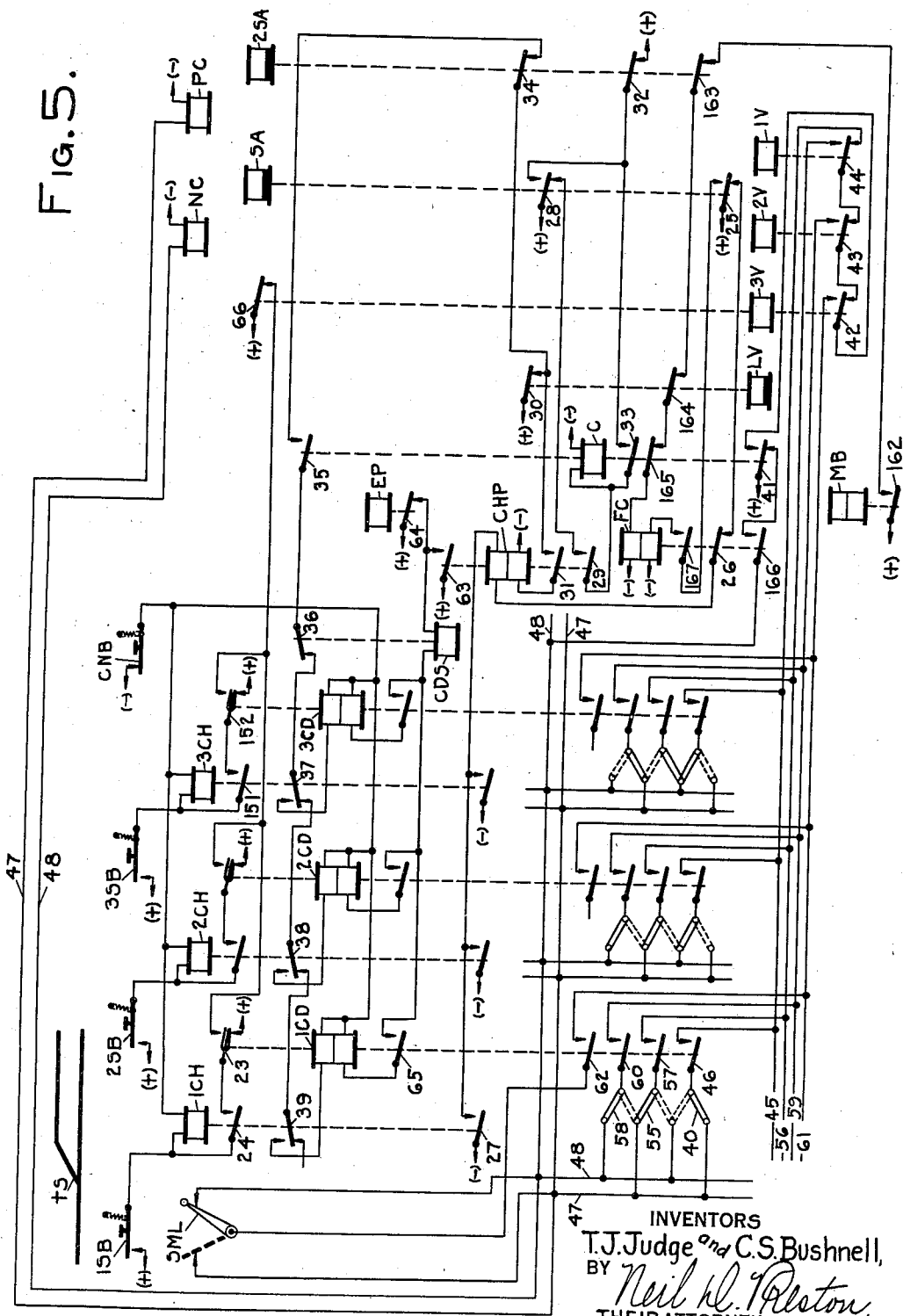
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2,082,544

CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

Original Filed Oct. 28, 1932 8 Sheets-Sheet 5

FIG. 5.



June 1, 1937.

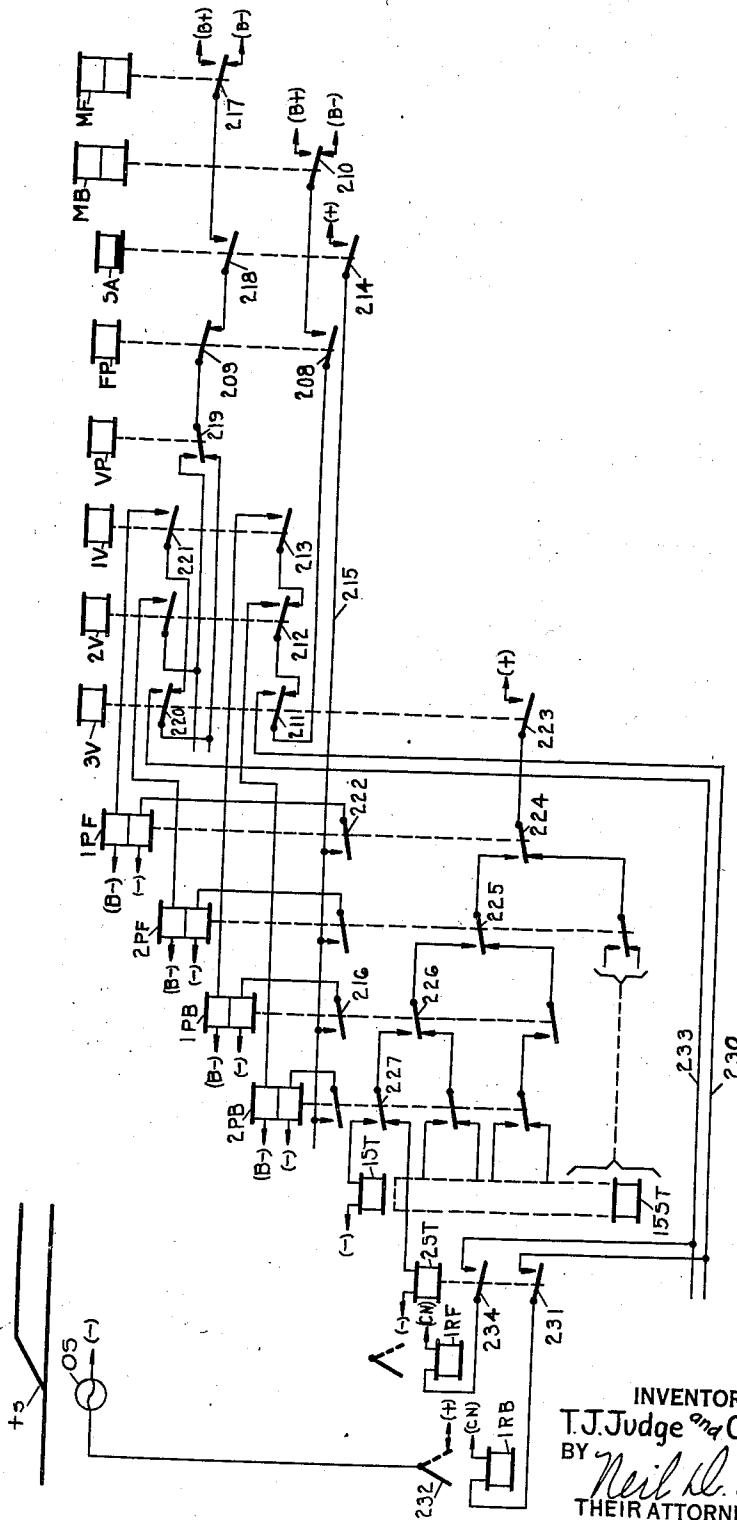
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2,082,544

CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

Original Filed Oct. 28, 1932 3 Sheets-Sheet 6

FIG. 6.



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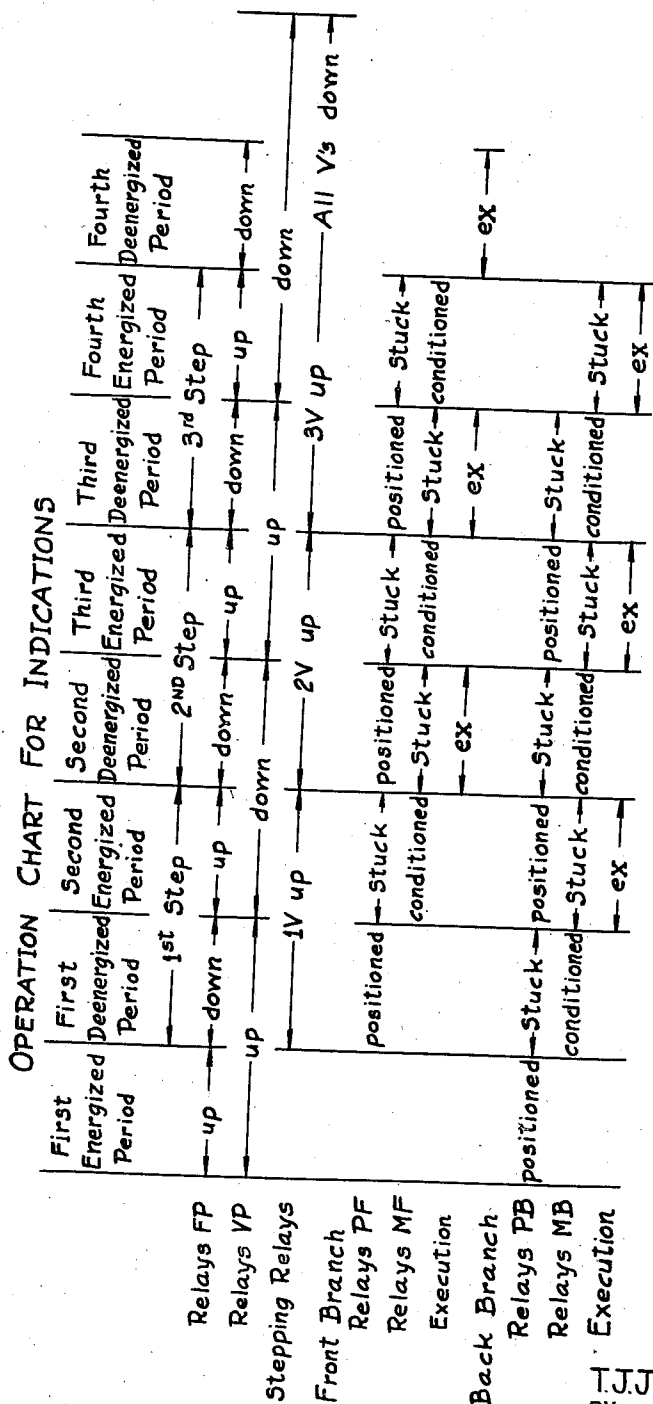
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2,082,544

CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

Original Filed Oct. 28, 1932 8 Sheets-Sheet 7

FIG. 7.



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2,082,544

CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

Original Filed Oct. 28, 1932 8 Sheets-Sheet 8

FIG. 8.

TYPICAL CODE TABLE

		First Energized Period	First Deenergized Period	Second Energized Period	Second Deenergized Period	Third Energized Period
Station Selecting Codes + Positive Impulse - Negative Impulse Code No. 8 is not assigned to any Field Station	1	+		+		+
	2	+		+		-
	3	+		-		+
	4	+		-		-
	5	-		+		+
	6	-		+		-
	7	-		-		+
	8	-		-		-
Station Registering Codes + Closed Indication Circuit - Open Indication Circuit Code No. 16 is not assigned to any Field Station	1		+	+	+	+
	2		+	+	+	-
	3		+	+	-	+
	4		+	+	-	-
	5		+	-	+	+
	6		+	-	+	-
	7		+	-	-	+
	8		+	-	-	-
	9		-	+	+	+
	10		-	+	+	-
	11		-	+	-	+
	12		-	+	-	-
	13		-	-	+	+
	14		-	-	+	-
	15		-	-	-	+
	16		-	-	-	-

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UNITED STATES PATENT OFFICE

2,082,544

CENTRALIZED TRAFFIC CONTROLLING
SYSTEM FOR RAILROADSThomas J. Judge and Charles S. Bushnell, Roch-
ester, N. Y., assignors to General Railway Sig-
nal Company, Rochester, N. Y.Application October 28, 1932, Serial No. 640,062
Renewed March 27, 1936

23 Claims. (Cl. 177—353)

This invention relates to centralized traffic controlling systems for governing traffic on railroads, and more particularly pertains to the communication part of such systems.

5 In a centralized traffic controlling system of the type contemplated by this invention, the switches and signals at various points along a railroad are placed under the control of an operator in a central control office, in such a way that the operator may at will change the position of the switches subject to automatic approach and detector locking circuits which prevent unsafe operation of any switch, and in such a way that the operator may at will hold at stop any of the signals or allow them to clear dependent upon the position of the associated switches and the location of trains within certain track sections, so that the signals will indicate proceed only when it is safe for the passage of traffic. Also, the system provides means whereby indications are displayed in the control office to inform the operator of the presence or absence of trains on various track sections throughout the territory under his supervision, and to show the operated positions and conditions of the various switches, signals and other traffic controlling devices located in the territory.

10 The switches and signals of a railroad system are not usually evenly distributed throughout the system, but some are located near or adjacent to each other while others are at considerable distances. That apparatus, located within a limited area determined by the convenience and economy with which the apparatus may be interconnected by direct control wires, is conveniently termed a field station. A code type selective communication system is then provided to interconnect the control office with the several outlying field stations for the transmission of controls and indications to and from these field stations.

15 This code selective type communication system requires only a small number of line wires to establish communication between the control office and a large number of field stations with means providing for the transmission of a large number of controls and indications for each of the field stations. The system is of the two circuit type having a control line circuit and an indication line circuit, which circuits are made up by the provision of at least three line wires, one control line wire, one indication line wire and a common return line wire. In

the illustrations, however, the control line is provided with an individual return line, and similarly, the indication line is provided with an individual return line.

Communication is established between the control office and the several field stations by the transmission of suitable codes, which cause the selector type apparatus at each location to operate step-by-step through cycles of operation. The system embodying the present invention, is of the station selective coded duplex type, wherein controls and/or indications may be transmitted during any particular operating cycle of the system.

For the transmission of controls, a series of impulses of selected polarities is placed upon the control line circuit. The apparatus at the control office and at each field station is operated through a cycle of operation (with exceptions hereinafter described) for each series, irrespective of the character of the impulses of the series, while the character of the impulses of each series determines the particular station selected for that cycle and the controls transmitted to that selected station.

For the transmission of indications, a series of impulses is placed upon the indication line circuit, which impulses set up distinctive conditions by reason of their presence or absence on the steps of each cycle, as marked off by impulses placed upon the control line circuit.

With such an arrangement, whenever a cycle of operation occurs for the transmission of indications alone, then the series of impulses placed upon the control line circuit for causing the step-by-step operation must be of such a character as not to select any field station, but to merely cause the step-by-step operation at that field station then transmitting its indications. Similarly, whenever a cycle of operation occurs for the transmission of controls alone, then there are no impulses placed upon the indication line circuit, thereby setting up distinctive conditions which form a code, and this code is not employed by any field station, so as to prevent the false registration of a station when it is not transmitting indications.

One feature of the present invention resides in the manner in which stations are selected for the reception of controls, and the manner in which stations are registered in the control office for the transmission of indications.

Another feature of the present invention more particularly resides in the manner in which impulses are placed upon the indication line cir-

cuit so as to increase the speed of operation in a system which substantially doubles the capacity of the indication line circuit over the capacity of the control line circuit. For example, one energization and one deenergization of the control line circuit has usually been designated as comprising a single step. In previous systems, the field stations have been arranged so that the indications were transmitted by the pulsing of the indication line circuit once for each step. In accordance with the present invention, the indication line circuit is preconditioned and impulsed twice during each step, namely, once during the energized period of the control line circuit and also once during the deenergized period of the control line circuit.

This double capacity pulsation of the indication line circuit is accomplished in a novel manner by the branching of the indication line circuit into two branches at the control office and at each field station, with the corresponding branches at the several locations connected in series at any one time by the use of the relays responsive to the presence or absence of impulses on the control line circuit. In this connection, special means is provided for preconditioning the respective branches of the indication line circuit at the field stations so as to more quickly transmit such conditions to the corresponding branches in the control office. This is accomplished by the elimination of certain operations previously required at a field station between the change from one condition to the other on the control line circuit.

A system arranged in this manner for the double capacity transmission of impulses over the indication line circuit is particularly desirable for centralized traffic controlling systems, as the circumstances of practice have taught that the desirable number of indications to give the best facility in train operation is now considered to be substantially double the number of controls required for the positioning of the traffic governing devices throughout the controlled territory.

Another feature of the present invention resides in the manner in which the selector type apparatus at the several field stations is so controlled that it ceases to respond to impulses impressed on the control line circuit whenever the respective field station fails to be selected. This functioning of the system of the present invention includes not only the stopping of the usual step-by-step means but also the stopping of the operations of all other controlling relays except the relay included in the control line circuit. This feature of the present invention is particularly desirable where relays are employed in that all relay operations are discontinued, thereby eliminating considerable unnecessary wear of their operating parts.

A further feature of the invention resides in the improved arrangement of code determining relays in the control office for setting up the interlock between the control levers for the several stations to thereby allow the transmission of but a single code call for any one particular cycle of operation. In connection with this code determining bank, an improved polarity selecting means is provided whereby the failure of a circuit or a short between circuits results in the stopping of the cycle of operation rather than the erroneous transmission of impulses. This is accomplished by the provision of two neutral

polarity selecting relays, one for positive impulses and one for negative impulses.

These characteristic features of the present invention, thus briefly stated, will be explained more in detail in the following description of one embodiment of the invention; and various other characteristic features, functions and advantages of a system embodying this invention will be in part pointed out and in part apparent as the description thereof progresses. This invention relates to an improvement in certain features of the prior application of T. J. Judge, Ser. No. 613,353, filed May 25, 1932, which improvements will be claimed in the present application.

In describing the invention in detail, reference will be made to the accompanying drawings, in which those parts having similar features and functions are designated throughout the several views by like letter reference characters which are generally made distinctive either by reason of distinctive exponents representative of their location or by reason of preceding numerals representative of the order of their operation, and in which:—

Figs. 1 and 2, when placed end to end, illustrate the line circuits of a system embodying the present invention, which system includes a control office and a plurality of field stations;

Fig. 3 illustrates the apparatus employed at a typical field station arranged in accordance with the present invention;

Figs. 4, 5, and 6, when considered together as hereinafter explained, illustrate the apparatus and circuit arrangements employed at a typical control office and adapted to be associated with the apparatus employed at the field stations;

Fig. 7 illustrates an operation chart for indication; and,

Fig. 8 illustrates a typical code table.

For the purpose of simplifying the illustrations and facilitating in the explanation, the various parts and circuits constituting the embodiment of the invention have been shown diagrammatically and certain conventional illustrations have been employed, the drawings having been made more with the purpose in mind of making it easy to understand the principles and mode of operation, than with the idea of illustrating the specific construction and arrangement of parts that would be employed in practice. Thus, the various relays and their contacts are illustrated in a conventional manner, and symbols are used to indicate connections to the terminals of batteries, or other sources of electric current, instead of showing all of the wiring connections to these terminals.

The symbols (+) and (−) are employed to indicate the positive and negative terminals respectively of suitable batteries, or other sources of direct current; and the circuits with which these symbols are used, always have current flowing in the same direction. The symbols (B+) and (B−) indicate connections to the opposite terminals of a suitable battery, or other direct current source which has a central or intermediate tap designated (CN); and the circuits with which these symbols are used, may have current flowing in one direction or the other depending upon the particular terminal used in combination with the intermediate tap (CN). When alternating current is used in place of direct current, the particular symbols employed represent the relative instantaneous polarities.

Communication system generally.—The gen-

eral plan of organization of a system contemplated by the present invention may be best understood by placing Figs. 1 and 2 end to end, which illustrates the line circuits of a system having a control office and two field stations. It is to be understood of course, that the system may be extended so as to provide as many field stations as necessary to govern the territory placed under the supervision of the operator in the control office, but for convenience in describing the present invention, only a first and a second field station have been shown in the present embodiment.

A control line wire 10 extends from the control office to the first field station, from the first field station to the second field station, and so on to the end of the system where it is connected to the control line return wire 12 which extends from the control office through each of the field stations. Similarly, an indication line wire 14 extends from the control office to the first field station, from the first field station to the second field station, and so on, to the end of the system where it is open ended. Associated with this indication line wire 14 is an indication line return wire 16 which extends from the control office through the several field stations and to which the indication line is connected at that particular field station selected for the transmission of indications during a cycle of operation, as more specifically explained hereinafter. Although a four wire system has been shown for convenience in illustrating one embodiment of the present invention, it is to be understood that one common return wire may be used in place of the two return wires 12 and 16. In other words, the system may be termed a two line circuit system which circuits may be combined in any suitable manner, such as by the provision of a single common return, thereby making a three line wire system, or by both line circuits superimposed upon two line wires by employing distinctive currents such as direct current and alternating current, or by the use of two frequencies which do not have common harmonics.

The control line circuit includes a three position biased-to-neutral polarized line relay F (with suitable exponent) at the control office and at each field station. Energy for the control line circuit is supplied from a control battery CB in the control office with the particular polarity selected by pole changing contacts located on code sending relays PC and NC. When the code sending relay PC is energized, a positive impulse is placed on the control line circuit, but when the code sending relay NC is energized, a negative impulse is placed upon the control line circuit. With both the code sending relays PC and NC energized or deenergized the control line circuit is maintained deenergized. Whenever energy is applied to the control line circuit by the code sending relays, such energization is broken up into time spaced impulses by the periodic operation of an impulsing contact of the relay EP.

The indication line circuit includes message relays in its two branches in the control office and includes pulsing contacts in the corresponding branches at each field station. As corresponding branches are selected at the control office and at each field station when the control line circuit is energized closing front contacts on the repeating relays for the control line circuit, and as corresponding branches are con-

nected in series during the deenergized condition of the control line circuit as repeated at the control office and at each field station by the closure of suitable back contacts, these two branches of the indication line circuit at the control office and at each field station may be conveniently termed front and back branches. In the control office, a message relay MB is included in the back branch, and similarly, a message relay MF is included in the front branch. At each field station, the front and back branches are respectively conditioned by pulsing relays PF and PB (with suitable exponents) in accordance with the code call and indications to be transmitted. The indication line circuit is supplied with energy from a suitable indication battery IB located in the control office.

Both line circuits are normally deenergized, but for the purpose of rendering the system capable of initiation by each field station, the connecting of the indication line wire at any field station to its return line wire results in the initiation of the system for the transmission of indications.

Control office equipment.—The control office (see Figs. 4, 5, and 6) includes a control machine having a group of control levers for each field station, a miniature track layout corresponding in every way to the actual track layout in the field and various indicating lamps or equivalent devices together with apparatus and circuits to accomplish the desired functioning of the system.

That part of the control office illustrated shows more particularly that part of a control machine which is typical of the apparatus associated with a single field station having a track switch, a cross-over or the like, together with the general transmitting apparatus employed in common by all the field station units of the system.

Instead of showing the apparatus and circuit arrangements of the control office in an illustration of the aggregate divided between several sheets of drawings, the apparatus has been divided into three groups, with that apparatus which is common between the groups being illustrated fragmentarily in all groups except one, where its control circuits are illustrated in detail. In other words, the control circuits for each relay will be completely found on at least one sheet, but all of the circuits controlled by that relay may not be found on the same sheet of drawings.

With this explanation of the manner of disclosure of one embodiment of a control office for a system of the present invention, it may be stated that the apparatus for a single track switch comprises a switch machine control lever SML (see Fig. 5), a self-restoring starting button SB (with suitable preceding numeral), a miniature track switch *ts*, and a track occupancy indicating lamp OS (see Fig. 6). Similarly, a signal control lever (not shown) would also be associated therewith but for convenience has been omitted, as the control of a track switch may be considered as typical of the control of other types of traffic controlling devices.

The movement of the switch machine control lever SML from one extreme position to the other followed by the actuation of its corresponding starting button ISB results in the normal or reverse operation of the track switch at the corresponding field station controlled

through the medium of the communication system of the present invention.

Associated with each group of control levers is a change storing relay CH (with suitable preceding numeral) and a code determining relay CD (with suitable preceding numeral). Although only the control lever for a single field station has been illustrated, the starting buttons, 1SB, 2SB, and 3SB for several field stations have been illustrated together with their respective relays 1CH, 2CH, and 3CH and their corresponding code determining relays 1CD, 2CD, and 3CD.

The actuation of a starting button SB (with suitable preceding numeral) causes the energization of its corresponding change relay CH which in turn energizes the corresponding code determining relay for transmitting a code for the selection of the associated field station if the system is at rest. However, in the event that the system is in operation, the change relay CH remains energized and causes the energization of its corresponding code determining relay CD the next time the system enters a condition of rest, provided of course, that no other more superior starting button has been actuated.

In the event that several starting buttons are actuated simultaneously or in rapid succession, the change relays CH and code determining relays CD together with a code determining stick relay CDS, are so interlocked that only one code determining relay may be picked up for any one particular cycle of operation with the interlock so arranged that the relays CD are picked up in a predetermined sequence dependent upon their location in the bank relays.

Associated with each code determining relay CD is a corresponding group of code jumpers. Also, a cancelling button CNB is provided to cancel the operation of the starting buttons when so desired.

The control office includes, as previously mentioned a control line relay F of the three position biased-to-neutral polarized type (see Fig. 4). This line relay F has associated therewith a neutral quick acting line repeating relay FP which repeats each energization and each deenergization of the line relay F irrespective of the polarity with which the relay F is energized. For purposes later to be explained, the quick acting neutral relay FP is provided with a neutral quick acting repeating relay 2FP.

A slow acting line repeating relay SA is picked up at the beginning of each cycle of operation and is dropped at the end of each cycle of operation. This neutral slow acting relay SA has such slow acting characteristics that its pick-up time is relatively slow compared to the pick-up time of the neutral relay FP, for example, but is relatively quick in picking up as compared with its drop-away period. The drop-away period of this relay SA is sufficiently retarded so that its contacts remain in picked up positions between successive impulses applied to the control line circuit during a cycle of operation, as repeated by the neutral relay 2FP. Also, the relay SA has associated therewith, a neutral slow acting repeating relay 2SA having similar characteristics as the relay SA which is provided for purposes hereinafter pointed out.

Associated with the line relay F and its repeating relays, is a bank of stepping relays including relays 1V, 2V, 3V and a last step relay LV together with a half-step relay VP. This bank

of stepping relays is provided to mark off the steps of each cycle of operation.

An impulsing relay E is jointly controlled by the stepping relays and the half-step relay VP, which impulsing relay E together with a repeating relay EP governs the time spacing of the impulses on the control line circuit. Associated with the relay EP is a branch dividing relay DV which repeats the condition of the relay EP for the purpose of selecting the front and back branches of the indication line circuit in the control office.

The polarity of the impulses applied to the control line circuit from the control battery CB, is determined by the code sending relays PC and NC, as previously mentioned. These relays are controlled in accordance with the position of those code jumpers and control levers which are rendered effective for a particular cycle of operation by the corresponding code determining relay CD.

As previously mentioned, the two neutral message receiving relays MB and MF are provided to repeat the condition of the indication line circuit for each step. The conditions of these relays are stored in suitable pilot relays and indication storing relays for registering that station having indications to transmit and for registering the indications transmitted (see Fig. 6).

For the purpose of illustrating the feature of station registration, the pilot relays 1PB and 2PB are controlled on the first and second steps in accordance with the conditions received by the message receiving relay MB; while pilot relays 1PF and 2PF are controlled on the first and second steps in accordance with the conditions received by the message receiving relay MF. If a larger number of field stations are employed than may be registered by this pilot relay bank, more steps may be employed and additional pilot relays provided. These pilot relays are of the neutral type provided with stick circuits which maintain those relays energized, which are once picked up during a cycle, until the end of that cycle of operation. Following the positioning of the pilot relays, a station relay ST (with suitable numeral) is selected in accordance with the station registered.

It is well understood that with four two-position relays sixteen different selections may be made, thus fifteen station relays are provided, and the sixteenth combination is employed as the phantom station code call for purposes well understood in connection with a duplex system of the type contemplated by the present invention.

Following the registration of a station by the picking up of a station relay, suitable indication storing relays, such as relays 1RF and 1RB, for example, which are of the two-position polarized magnetic stick type, are positioned on the remaining steps of the cycle of operation for storing the indications transmitted from that field station which has been registered in.

For the purpose of initiating the system and determining whether such operation occurs at a field station or at the control office, the relays CHP, C, and FC are provided. The functions of these relays will be more readily apparent from the description given hereinafter, it being sufficient for the present to know that the relay C is always picked up for a control cycle and the relay FC is always picked up for an indication cycle.

The control office equipment also includes vari-

ous sources of current supply, bus wires and circuit connections, indicator lamps, overload protection and such other devices as may be needed for the proper functioning of such a system.

5 *Field station equipment.*—The field station illustrated in Fig. 3 of the accompanying drawings is typical of all field stations of the system and may be adapted for use at the first, second, or any other location by merely altering certain
10 code jumpers and selections to arrange for the proper code. But for convenience in the description, it is assumed that this field station is at the first location along the line circuits extending from the control office, and is so designated by reason of the distinctive exponents
15 employed.

With reference to Fig. 3, a turn-out track is illustrated as connected to a main track by a track switch TS. This track switch TS is operated from one extreme locked position to the other by a suitable switch machine SM.

This switch machine SM is governed by a switch machine control relay SMR which is of the two-position polar magnetic stick type and
25 which is governed from the control office through the medium of the communication system herein disclosed. The relay SMR controls the operation of the switch machine SM by energizing its normal or reverse operating wires from a source
30 local to the field station in any suitable well-known manner, which control of course preferably includes suitable approach and detector locking so as to prevent the unsafe operation of the track switch TS.

35 Although only the remote control of the switch machine SM has been indicated, it is to be understood that a dual control selector may be associated therewith for the purpose of local manual operation of the track switch TS.

40 Suitable signals are associated with the track switch TS for governing traffic thereover and are provided with automatic block signalling means with selections made in accordance with the position of the track switch TS and condition of the detector track section and such other
45 sections of track and traffic controlling devices as may be associated therewith.

These signals are also contemplated as governed from the control office through the medium of the communication system by positioning
50 suitable control relays, which are governed similarly as the switch machine control relay SMR. All such control has been omitted for the sake of simplifying the present disclosure.

55 Associated with the signals governing traffic over the track switch TS is a suitable signal indicating relay M which is normally energized but is deenergized whenever any one of the signals is actuated or caused to give a proceed indication.
60

A detector track section having a normally closed track circuit is provided with a track relay T and a suitable track battery for indicating the passage of trains over the track switch TS.

65 The communication part of the system includes at the field station a three position biased-to-neutral polar line relay F, as previously mentioned, together with its quick acting line repeating relay FP¹. These relays FP¹ and SA¹ have similar characteristics as the corresponding relays in the control office, the only difference being in the control of these relays which is subject to certain conditions explained
75 in detail hereinafter.

The field station includes a bank of stepping relays 1V¹, 2V¹, 3V¹, and LV¹ together with a half step relay VP¹ arranged in a similar manner as the stepping relay bank in the control office. However, the operation of the stepping relay
5 bank at the field station is dependent upon station selection both during the transmission of controls and during the transmission of indications.

For the selection of the station for the reception of controls, a station selecting outbound relay SO¹ together with a stick relay SOS¹ is provided to determine when the code call placed upon the control line circuit corresponds to the code call assigned to the field station.
15

The selection of a station for the transmission of indications is rendered available at the field station by the continued energization of the lock-out relay LO¹. When the lock-out relay LO¹ is picked up for a cycle of operation, the pulsing
20 relays PB¹ and PF¹ are effective to transmit the code call of the station followed by a transmission of the indications.

A stick relay SB¹ is provided to determine the restoration of the station in a positive manner at the end of each cycle of operation, as herein-
25 after explained.

A change relay CH¹ is provided to register a change in any of the traffic controlling devices at the station, so that the system will be initiated for the transmission of new indications.
30

At each field station, suitable compensating resistance 1R¹ and 2R¹ are provided to compensate for the difference in distance between the field station at which they are located and the control office. In other words, the field station at the end of the system requires no resistances, but for each station nearer the control office, higher resistances are employed so that the same current from the indication battery IB always
35 flows through the indication line circuit irrespective of which particular station is transmitting. The resistance 2R¹ is employed during the transmission of indications; while the resistance 1R¹ is employed during the lock-out period at the beginning of a cycle of operation. The resistance 1R¹ is of a lower value than the resistance 2R¹, as the lower winding of the lock-out relay LO¹ is included in series therewith.
40

The field station also includes suitable bus wires, circuit connections, code jumpers, overload devices, and other devices and apparatus necessary for a centralized traffic controlling system as contemplated in accordance with the present invention.
45

It is believed that the nature of the invention, its advantages and characteristic features can be best understood with further description being set forth from the standpoint of operation.
50

Operation

The system of the present invention is normally in a condition of rest, but may be initiated into a cycle of operation either from the control office or from any of the field stations whenever there are new controls or new indications ready to be transmitted. If new controls for several different field stations are ready for transmission at substantially the same time, the controls for the several stations are transmitted on separate cycles of operation. Similarly, if several field stations have indications ready for transmission at the same time, the indications are transmitted from such field stations
55
60
65
70
75

to the control office, one station at a time on separate operating cycles.

It may happen, that there are new controls and new indications ready to be transmitted at the same time and in such instances controls are to be transmitted to a selected field station and simultaneously therewith indications are transmitted from that field station or some other field station during the same cycle of operation.

Although the embodiment of the present invention is capable of duplex transmission, that is, the simultaneous transmission of controls and indications, it is convenient to first consider the transmission of controls and indications separately and then point out the operation during a duplex cycle.

Normal at rest conditions.—The line circuits of the system are arranged to be normally deenergized, and similarly the remaining circuits of the system are arranged to be normally deenergized with a few exceptions.

For example, the detector track circuit associated with the track switch TS (see Fig. 3) is preferably of the closed circuit type, as previously mentioned. Also, the change relay CH¹ is normally energized by a stick circuit closed from (+), through a circuit including front contact 20 of the relay M, front contact 21 of track relay T, front contact 22 of change relay CH¹, lower winding of change relay CH¹, to (—).

Manual starting.—With the system in a condition of rest or a period of blank, it may be manually initiated into a cycle of operation for the transmission of controls to any desired station. Whenever such a cycle of operation is desired, the operator first positions the control levers of that particular station with which he desires to communicate and then actuates the corresponding starting button.

Although the operator may position the levers and actuate the starting buttons simultaneously or in rapid succession, suitable means is provided so that the code call of only one station is transmitted during any one particular cycle of operation. This feature is provided by an interlocked relay bank in the control office associated with the control levers and starting buttons for the several stations. The sequence between control operations following the actuation of a large number of starting buttons is more conveniently discussed, after a description of the transmission of controls to a single field station has been given.

Let us assume that the operator desires to transmit controls to a field station, such as, for example, the first field station (see Figs. 2 and 3). To do this, he first positions the control levers associated therewith, such as the control lever SML, and then actuates the starting button ISB (see Fig. 5). The actuation of the starting button closes a pick-up circuit for the change relay ICH from (+), through a circuit including the back point of the starting button ISB, windings of the relay ICH, front point of the cancelling button CNB, to (—).

As soon as the contacts of the relay ICH respond to such energization, a stick circuit is closed from (+), through a circuit including back contact 23 of code determining relay ICD, front contact 24 of change relay ICH, windings of relay ICH, front point of the cancelling button CNB, to (—).

The picking up of the contacts of the relay ICH also closes a pick-up circuit for the change

repeating relay CHP which is common to all of the change relays in the interlocked bank. This pick-up circuit is closed, providing the system is at rest, from (+), through a circuit including back contact 25 of relay SA, back contact 26 of starting and cycle controlling relay FC, upper winding of the change repeating relay CHP, front contact 27 of the change relay ICH, to (—).

The energization of the change repeating relay CHP is in turn repeated by the control office starting and cycle controlling relay C by reason of a circuit closed from (+), through a circuit including back contact 28 of slow acting relay SA, front contact 29 of relay CHP, windings of relay C, to (—). The picking up of the contacts of the relay CHP closes its stick circuit from (+), through a circuit including back contact 30 of the last stepping relay LV, front contact 31 of relay CHP, lower winding of the relay CHP, to (—). Similarly, the relay C closes its stick circuit from (+), through back contact 32 of relay 2SA, front contact 33 of relay C, windings of relay C, to (—).

It is noted that the stick circuit for the relay CHP is closed through the back contact 30 of the last stepping relay, and hence the relay CHP will remain energized throughout the cycle of operation, until the last step has been taken. Also, the relay C is temporarily stuck up through back contact 32 of relay 2SA which is opened as soon as the cycle is initiated, but the front contact 28 of relay SA is closed prior to the picking up of the contacts of the relay 2SA, so that the relay C is maintained energized during the cycle of operation. However, at the end of the cycle of operation, later to be pointed out, the relays SA and 2SA are deenergized successively, so that contact 28 of relay SA is opened before back contact 32 of relay 2SA is closed, thus allowing the relay C sufficient time to drop away at the end of such cycle of operation.

The energization of the relay ICH also accomplishes the energization of its corresponding code determining relay ICD as soon as the control office starting and cycle controlling relay C is picked up, providing of course that the system is at rest, that there are no other code determining relays CD (with suitable preceding numerals) already picked up, and that there is no preceding change relay CH energized. This pick-up circuit for the relay ICD is closed from (+), through a circuit including back contact 30 of the last step relay LV, back contact 34 of the slow acting repeating relay 2SA, front contact 35 of the starting and cycle controlling relay C, back contact 36 of the relay CDS, back contact 37 of the relay 3CH, back contact 38 of the relay 2CH, front contact 39 of relay ICH, upper winding of relay ICD, front contact of the cancelling button CNB, to (—).

As soon as the contacts of the relay ICD have responded to such energization, a stick circuit is completed from (+), through a circuit including front contact 63 of relay CHP in multiple with back contact 64 of relay EP, windings of relay CDS, front contact 65 of relay ICD, lower winding of relay ICD, front contact of cancelling button CNB, to (—).

It is apparent that this stick circuit will be prepared by the front contact 63 of relay CHP prior to the picking up of the contacts of relay ICD, as it is necessary that the relay CHP be picked up to pick up the relay C before the relay ICD can respond. Thus, the back contact 64 of relay EP, included in multiple with front

contact 63 of relay CHP, is unnecessary at the beginning of a cycle of operation, but this combination of contacts is essential at the end of the cycle of operation so as to maintain the relay ICD energized until after the removal of the last impulse applied to the control line circuit, all of which will be pointed out hereinafter in connection with the end of the operating cycle. During the cycle, the relay CHP is maintained steadily energized through its stick circuit including back contact 30 of relay LV, so that the front contact 63 included in the stick circuit ICD is closed continuously during the cycle. However, the back contact 64 of relay EP is periodically opened and closed during the cycle, as the relay EP is the one which impulses the control line circuit.

The energization of the relay CDS, which is quick acting as compared to the relays CD (with suitable preceding numerals), opens its back contact 36 immediately upon its energization, thereby preventing the energization of some other code determining relay. This function will be described more in detail under a consideration of the sequence of station selection for controls.

The energization of the relay ICD opens its back contact 23 and closes its front contact 23, thereby transferring the stick circuit of the relay ICH to the control of back contact 66 of relay 3V. In other words, with the relay ICD picked up, a stick circuit for the relay ICH is closed from (+), through a circuit including back contact 66 of stepping relay 3V, front contact 23 of relay ICD, front contact 24 of relay ICH, windings of relay ICH, front contact of the cancelling button CNB, to (-). It will be apparent that the contact 23 must be of the make-before-break type of contact in order to insure that the relay ICH is not momentarily deenergized during this transfer of its stick circuit. It will also be understood in this connection that the back contact 66 is always on the stepping relay last in the bank and immediately preceding the last step relay LV.

From the above description, the manner in which the relays C and ICD are conditioned as a result of the manual actuation of the starting button ISB will be apparent, and such conditioning of these relays prepares the system for the transmission of a series of code impulses of selected polarities, as presently to be explained.

Polarity selection of stepping impulses.—Whenever the system is initiated from the control office resulting in the energization of the starting relay C (see Fig. 5) and the energization of a code determining relay, such as relay ICD, the impulses placed upon the line circuit for the succeeding cycle of operation are of polarities in accordance with the positions of the code jumpers and the control levers rendered effective by the picking up of that particular code determining relay.

As soon as the code determining relay ICD is picked up following the energization of the relay C, one or the other of the code sending relays PC and NC is energized depending on the position of the first code jumper.

More specifically, if the code jumper 40 is in a lower position, as illustrated, the relay PC is energized, but if the code jumper 40 is in an upper position the relay NC is energized. For example, assuming the code jumper 40 to be in a lower position, the relay PC is energized from (+), through front contact 41 of the relay C,

back contacts 42, 43 and 44 of relays 3V, 2V and IV respectively, code bus 45, front contact 46 of relay ICD, code jumper 40 in a lower position, positive bus 47, winding of the relay PC, to (-). The energization of the relay PC results in the application of a positive impulse on the control line circuit, as will be more readily seen by considering the line circuits illustrated in Figs. 1 and 2. It is apparent that with the code jumper 40 in the opposite position, the negative bus 48 will be energized, resulting in the energization of NC instead of relay PC.

Referring to Figs. 1 and 2 and assuming, for example, that the relay PC is energized, the control line circuit is energized from the positive terminal of the control battery CB, through a circuit including back contact 50 of the negative code sending relay NC, front contact 51 of the positive code sending relay PC, back contact 52 of the impulsing repeating relay EP, windings of the line relay F¹, through the control line wire 10 to the first field station, windings of the line relay F¹ at the first field station, through the control line wire 10 to the second field station, windings of the line relay F² at the second field station, and similarly through the remaining field stations to the control line return wire 12 at the last field station, and thence to the control office through the several field stations, front contact 53 of the positive code sending relay PC, back contact 54 of the negative code sending relay NC, to the negative terminal of the control battery CB.

This energization of the control line circuit is of course repeated by the three position biased-to-neutral polarized line relays F (with suitable exponents) at the control office and at the several field stations by actuating their contacts to right hand positions. It is apparent that the energization of the relay NC instead of the relay PC reverses the direction of current flow in the control line circuit and causes the contacts of the relays F (with suitable exponents) to be actuated to left hand positions instead of right hand positions.

Assuming that the application of the first impulse to the control line circuit results in the subsequent deenergization of the control line circuit by the relay EP, and the picking up of the stepping relay IV, all in a manner hereinafter explained, it will be seen that one or the other of the code sending relays PC and NC will be energized depending upon the position of the code jumper 55.

For example, with the code jumper 55 in the position illustrated, the energization of the positive code sending relay PC is continued by a circuit from (+), through a circuit including front contact 41 of the relay C, back contacts 42 and 43 of the relays 3V and 2V respectively, front contact 44 of the relay IV, code bus 56, front contact 57 of the relay ICD, code jumper 55 in an upper position, positive bus 47, windings of the relay PC, to (-).

It will be apparent, that with the code jumper 55 in a lower dotted line position, the negative code bus 48 will receive potential, thereby resulting in the energization of the relay NC instead of the relay PC.

Assuming that the application of the second impulse to the control line circuit results in the subsequent deenergization of the control line circuit by the impulsing relay EP and in the picking up of the stepping relay 2V, all in a manner hereinafter explained, it will be seen that one

or the other of the code sending relays PC and NC will be energized depending upon the position of the code jumper 58.

For example, with the code jumper 58 in the position illustrated, the energization of the negative code sending relay NC is accomplished by a circuit closed from (+), through a circuit including front contact 41 of relay C, back contact 42 of relay 3V, front contact 43 of relay 2V, code bus 59, front contact 60 of relay ICD, code jumper 58 in an upper position, negative bus 48, windings of relay NC, to (-).

It will be apparent that with the code jumper 58 in its lower dotted line position, that the positive bus 47 will receive potential instead of the negative bus 48, thereby energizing the relay PC instead of the relay NC.

Assuming that the application of the third impulse to the control line circuit results in the subsequent deenergization of the control line circuit by the impulsing relay EP and also the picking up of the stepping relay 3V, all in a manner hereinafter explained, it will be seen that one or the other of the code sending relays PC and NC will be energized depending upon the position of the switch machine control lever SML.

For example, with the switch machine control lever in the position illustrated, the code sending relay NC is energized by a circuit closed from (+), through a circuit including front contact 41 of relay C, front contact 42 of stepping relay 3V, code bus 61, front contact 62 of relay ICD, switch machine control lever SML in a right hand position, negative code bus 48, windings of relay NC, to (-).

It will be apparent that if the lever SML is in a left hand position instead of a right hand position, that the positive code bus 47 will receive potential instead of the negative code bus 48, thereby resulting in the energization of the positive code sending relay PC instead of the negative code sending relay NC.

From the above description it will be seen that the control line circuit is initially energized, as the relay EP is deenergized (see Figs. 1 and 4), upon the energization of one or the other of the code sending relays PC and NC following the energization of the cycle controlling relay C and the code determining relay ICD. As presently to be explained, the application of the first impulse to the control line circuit results, after a predetermined time in the deenergization of the control line circuit by the picking up of the relay EP opening back contact 52. During such deenergization of the control line circuit, the next step is taken which transfers the energy supplied through front contact 41 of the relay C to the next code bus in succession, thereby selectively energizing one or the other of the code sending relays PC and NC so that upon the dropping of the relay EP and the closure of back contact 52, an impulse of selected polarity is applied to the control line circuit.

In other words, the operation of the stepping relays causes energy to be applied to the several code buses 45, 56, 59, and 61, in succession, and such energization is applied to the positive or negative code buses in accordance with the positions of the code jumpers and control levers selected by that particular code determining relay which is energized.

It should be particularly noted, that the operation of the step-by-step relays shifts the

energization from one code bus to another during that time when the control line circuit is deenergized by the open condition of back contact 52 of relay EP (see Figs. 1 and 4), so that the change in position of the relays PC and NC is immaterial insofar as the then existing condition of the line circuit is concerned.

It is now considered expedient to explain how the impulses applied to the control line circuit operate the stepping relay bank followed by a description of how these impulses are suitably time spaced by the response of the stepping relay bank in the control office.

Operation of stepping relay bank.—The control line circuit is initially energized at the beginning of a cycle of operation, as pointed out above. Such energization is terminated upon the picking up of the back contact 52 of the relay EP (see Figs. 1 and 4), during which time the code sending relays PC and NC are positioned for the application of the next impulse. In other words, time spaced impulses are placed upon the control line circuit by the periodic operation of the contact 52 of the relay EP; while the particular polarities of these impulses are determined by the contacts 50, 51, 53, and 54 of the code sending relays PC and NC.

Assuming for the time being that time spaced impulses are suitably placed upon the control line circuit, each impulse being of a selected polarity, we may consider the step-by-step operation of the stepping relay bank.

Each impulse on the control line circuit is repeated by the polarized line relays F' (with suitable exponents), but irrespective of the particular polarity of such impulse, the line repeating relays FP (with suitable exponents) repeat each energization and each deenergization. For example, the actuation of polar contact 67 of relay F' (see Figs. 1 and 4) to either of its positions connects positive energy (+), to one terminal of the relay FP, while negative energy (-) is permanently connected to the opposite terminal of this relay. The relay FP is sufficiently quick acting to respond to each energization and each deenergization of the relay F' which completes an energizing circuit through front contact 68 for its repeater relay 2FP upon each energization.

The repeating relay 2FP is sufficiently quick acting to follow the relay FP, and completes an energizing circuit for the slow acting relay SA each time it is picked up by reason of the closure of its front contact 69.

Upon the application of the first impulse, which is repeated by the relay 2FP, the relay SA is energized through front contact 69 and after a time, determined by the slow acting characteristics of this relay, its contacts assume energized positions. This closes a circuit for its repeater relay 2SA through front contact 70, so that the contacts of the relay 2SA assume energized positions after a time period determined by its slow acting characteristics.

In brief, the relays F, FP, 2FP, SA, and 2SA pick up in succession, each being a direct repeater of the next preceding relay. These successive relay operations serve to mark off the sequential stages in the initiation of the system at the beginning of each cycle, as well as serving to select the branches of the indication line circuit during each cycle of operation (explained hereinafter). For example, the picking up of the contacts of the relays FP

(with suitable exponents) at the control office and at each field station marks the end of the initiation period at the beginning of a cycle; while the picking up of the contacts of the relays SA (with suitable exponents) at the control office and at each field station marks the end of the lock-out period and the beginning of the transmitting part of the cycle.

Forgetting for the time the various operations which occur during the starting of the system, and assuming that a predetermined time after the picking up of the relays SA; that the control line is deenergized followed by energizations and deenergizations alternately, we may consider the operation of the stepping relay banks. It is to be understood of course, that the relays F, FP and 2FP follow each condition of the control line circuit, while the relays SA and 2SA remain picked up throughout the cycle of operation, as they are provided with such slow acting characteristics that they are maintained picked up between successive applications of energy to the control line circuit.

As the stepping relay banks at the control office and at each field station are similar, the description will be directed more particularly to the control office stepping bank (see Fig. 4), and only the distinct differences between the control office stepping bank and a typical field station stepping bank will be pointed out in connection with the field station illustrated in Fig. 3.

With reference to Fig. 4, the picking up of the contacts of the relay SA upon the first impulse (first energized period) of a cycle with the contacts of the relay 2FP already picked up, closes a pick-up circuit for the relay VP from (+), through a circuit including front contact 71 of relay SA, front contact 72 of relay 2FP, back contact 73 of relay IV, windings of relay VP, to (-). As soon as the contacts of the relay VP have picked up, a stick circuit is closed from (+), through a circuit including front contact 71 of relay SA, front contact 74 of relay VP, back contact 73 of relay IV, windings of relay VP, to (-).

Upon the following deenergization of the control line circuit (first deenergized period) the relay 2FP is deenergized, thereby closing a pick-up circuit for the relay IV from (+), through a circuit including front contact 75 of relay SA, back contact 76 of relay 2FP, front contact 77 of relay VP, back contact 78 of relay 2V, windings of relay IV, to (-). As soon as the contacts of the relay IV assume picked up positions, a stick circuit is closed from (+), through a circuit including front contact 75 of relay SA, front contact 79 of relay IV, windings of relay IV, to (-). Although the stick circuit for the relay VP including back contact 73 of stepping relay IV is opened when the relay IV is picked up, the relay VP is previously energized through its other stick circuit closed from (+), through a circuit including front contact 71 of relay SA, back contact 72 of relay 2FP, front contact 83 of relay VP, windings of relay VP, to (-).

Upon the following energization of the control line circuit (second energized period), as repeated by the relay 2FP, the relay VP is deenergized, as its stick circuit including front contact 80 is opened at back contact 72 of relay 2FP, and its stick circuit including its front contact 74 is opened at back contact 73 of relay IV.

The next deenergized condition of the control line circuit (second deenergized period), as repeated by the relay 2FP, causes the second step-

ping relay 2V to be energized through a pick-up circuit closed from (+), through a circuit including front contact 75 of relay SA, back contact 76 of relay 2FP, back contact 77 of relay VP, back contact 81 of relay 3V, front contact 82 of relay IV, windings of relay 2V, to (-). As soon as its contacts are picked up, a stick circuit is closed from (+), through a circuit including front contact 75 of relay SA, front contact 83 of relay 2V, windings of relay 2V, to (-).

The following energized condition of the control line circuit (third energized period), as repeated by the relay 2FP, closes a pick-up circuit for the relay VP from (+), through a circuit including front contact 71 of relay SA, front contact 72 of relay 2FP, back contact 84 of relay 3V, front contact 85 of relay 2V, windings of relay VP, to (-). The closure of front contact 74 of relay VP completes a stick circuit from (+), through a circuit including front contact 71 of relay SA, front contact 74 of relay VP, back contact 84 of relay 3V, front contact 85 of relay 2V, windings of relay VP, to (-).

The next deenergized condition of the control line circuit (third deenergized period), as repeated by the relay 2FP, causes the third stepping relay 3V to be energized through a pick-up circuit closed from (+), through a circuit including front contact 75 of relay SA, back contact 76 of relay 2FP, front contact 77 of relay VP, front contact 86 of relay 2V, windings of relay 3V, to (-). As soon as the contacts of the relay 3V are picked up, a stick circuit is closed from (+), through a circuit including front contact 75 of relay SA, front contact 87 of relay 3V, windings of relay 3V, to (-).

Although the stick circuit for the relay VP including back contact 84 and front contact 74 is opened when relay 3V is picked up, its other stick circuit including front contact 80 and back contact 72 is closed prior to the response of the relay 3V.

When the relay 2FP picks up in response to the next energized condition of the control line circuit (fourth energized period), the relay VP is deenergized, as its stick circuit including front contact 80 is opened at the back contact 72 of the relay 2FP, and as its stick circuit including front contact 74 is opened at back contact 84 of relay 3V.

With the stepping relay 3V picked up, the deenergization of the relay VP upon the fourth energized period closes a pick-up circuit for the slow acting last step relay LV, from (+), through a circuit including back contact 88 of relay VP, front contact 89 of relay 3V, windings of relay LV, to (-). As soon as the contacts of the relay LV are picked up, a stick circuit is closed from (+), through a circuit including front contact 90 of relay 2SA, front contact 91 of relay LV, windings of relay LV, to (-). Thus, the relay LV, when once picked up, is maintained energized until the system has returned to normal at rest conditions upon the deenergization of the relay 2SA at the end of the operating cycle.

It should also be noted in this connection, that if the stepping relay bank included an even number of stepping relays instead of the odd number, as illustrated, the relay VP would be in an energized position when the last stepping relay LV is picked up upon the fourth energization of the control line circuit, so that it would be necessary for the back contact 88 of relay VP to be replaced by a front contact.

As the fourth impulse on the control line circuit is the last in a cycle of operation for the present embodiment, the next deenergization of the control line circuit (fourth deenergized period) continues until the system returns to normal conditions of rest and is again initiated. At the end of the cycle when the relay SA drops its contacts a predetermined time after the beginning of such fourth deenergized period, the stick circuits for the stepping relays are opened at front contact 75 and all the stepping relays assume deenergized positions at substantially the same time.

Also, the opening of front contact 71 of relay SA at the end of a cycle of operation, would deenergize the relay VP if this relay VP were in a picked up position, which would be the case if a stepping relay bank having an even number of stepping relays were employed.

It should be understood, that these circuit connections for a stepping relay bank may be extended for as many steps as may be required for a system in actual practice, but for the purpose of illustrating the present invention only three stepping relays have been employed together with a last step relay LV, for purposes hereinafter explained.

The stepping relay banks at each of the field stations (see Fig. 3 for example) are substantially identical in operation, as the stepping relay bank already explained, with the exception that the stepping operation is made dependent upon certain station selections, as hereinafter pointed out in connection with the description of the station selection.

Impulsing of control line circuit.—The initial application of the first impulse to the control line circuit results in the successive energization of the relays F, FP, 2FP, SA, and VP. The energization of the relay SA is of course followed by the picking up of the contacts of the relay 2SA, which completes a pick-up circuit for the relay E prepared by the picking up of the contacts of the relay VP. This pick-up circuit is closed from (+), through a circuit including front contact 90 of relay 2SA, front contact 92 of relay VP, back contact 93 of relay IV, bus wire 94, upper winding of relay E, to (—). This energization of the relay E is repeated by the relay EP by reason of the closure of front contact 95.

Upon the picking up of the contact 52 of the relay EP, the control line circuit is deenergized which is repeated by the relays F, FP, and 2FP, but the relay SA is sufficiently slow acting to maintain its contacts in picked up positions until the succeeding application of energy to the control line circuit.

The deenergization of the relay 2FP causes the first stepping relay IV to be picked up, as previously explained, and this opens the energizing circuit of the relay E at back contact 93 thereby allowing its contact 95 to open and deenergize the relay EP. This deenergization of the relay EP closes the back contact 52 included in the control line circuit causing the next impulse (second energized period) to be applied to the control line circuit in accordance with the position of the relays PC and NC, as set up during the time in which the relay EP is energized and the contact 52 is opened.

This energization of the control line circuit (second energized period) is repeated by the relays F, FP and 2FP, and as soon as the relay 2FP is picked up, the relay VP is deenergized.

This completes a pick-up circuit for the relay E from (+), through a circuit including front contact 90 of relay 2SA, back contact 92 of relay VP, back contact 96 of relay 2V, front contact 97 of relay IV, bus wire 98, lower winding of relay E, to (—). This energization of relay E is repeated by the relay EP and again results in the deenergization of the control line circuit (second deenergized period).

This second deenergization of the control line circuit is repeated by the relays F, FP, and 2FP, but the relay SA is sufficiently slow acting to maintain its contacts in picked up positions until the next succeeding application of energy to the control line circuit. The deenergization of the relay 2FP causes the second stepping relay 2V to be picked up, as previously explained, and this opens the energizing circuit of the relay E at back contact 96, thereby allowing contact 95 of the relay E to open and deenergize the relay EP. This deenergization of the relay EP closes its back contact 52 included in the control line circuit causing the next impulse (third energized period) to be applied to the control line circuit in accordance with the positions of the relays PC and NC as set up during the time in which the relay EP is energized and the contact 52 is opened.

This energization of the control line circuit (third energized period) is repeated by the relays F, FP and 2FP, and as soon as the relay 2FP is picked up, the relay VP is energized. This completes a pick-up circuit for the relay E from (+), through a circuit including front contact 90 of relay 2SA, front contact 92 of relay VP, back contact 103 of stepping relay 3V, front contact 104 of stepping relay 2V, bus wire 94, upper winding of the relay E, to (—). This energization of the relay E is repeated by the relay EP and again results in the deenergization of the control line circuit (third deenergized period).

This third deenergization of the control line circuit is repeated by the relays F, FP, and 2FP, but the relay SA is sufficiently slow acting to maintain its contacts in picked up positions until the succeeding application of energy to the control line circuit. The deenergization of the relay 2FP causes the stepping relay 3V to be picked up, as previously explained, and this opens the energizing circuit of the relay E at back contact 103, thereby allowing its contact 95 to open and deenergize the relay EP. This deenergization of the relay EP closes the back contact 52 included in the control line circuit causing the next impulse (fourth energized period) to be applied to the control line circuit in accordance with the positions of the relays PC and NC, as set up during the time which the relay PC is energized and the contact 52 is opened.

This energization of the control line circuit (fourth energized period) is repeated by the relays F, FP, and 2FP, and as soon as the relay 2FP is picked up, the relay VP is deenergized. This completes a pick-up circuit for the relay E closed from (+), through a circuit including front contact 90 of relay 2SA, back contact 92 of relay VP, front contact 105 of relay 3V, bus wire 98, lower winding of the relay E, to (—). This energization of the relay E is repeated by the relay EP and again results in the deenergization of the control line circuit (fourth deenergized period). As the beginning of this deenergized period marks the end of the operating

cycle of the present embodiment of the invention, means is provided to prolong such deenergized condition of the control line circuit until the relays SA and 2SA assume deenergized positions, and even then the deenergized condition of the control line circuit is continued unless another cycle of operation is initiated.

As previously pointed out the last step relay LV is picked up as soon as the relay VP responds to the fourth deenergization of the control line circuit, so that in addition to the energizing circuit for the relay E including front contact 105 of relay 3V another energizing circuit is completed through front contact 106 of relay LV, which circuit is maintained until the relay 2SA has dropped away opening front contact 90. This energizing circuit for the relay E at the end of a cycle of operation is closed from (+), through a circuit including front contact 90 of relay 2SA, back contact 92 of relay VP, front contact 106 of relay LV, bus wire 94, upper winding of the relay E, to (-).

The particular operations which occur at the end of a cycle of operation will be described more particularly under a corresponding heading.

The impulsing operation may be summarized by stating that the relays F, FP, 2FP, VP, E, EP and the relays of the stepping relay bank continue during the operation of the system in what may be termed cycles of operation, irrespective of the number of steps, until the last impulse has been placed upon the control line circuit, after which the control line circuit is maintained opened by the last step relay LV to cause the system to enter a period of rest.

In brief, the initial period of the energization of the control line circuit includes the pick-up periods of the relays F, FP, 2FP, SA, 2SA, E, and EP; while the succeeding periods of energization include the pick-up periods of the relays F, FP, 2FP, VP, E, and EP. Then the deenergized periods between successive impulses applied to the control line circuit include the drop-away periods of the relays F, FP, and 2FP, the pick-up period of a stepping relay and the drop-away periods of the relays E and EP.

Station selection for controls.—The manner in which a predetermined number of impulses of selected polarities are applied to the control line circuit to comprise a cycle of operation has been explained in detail. The positive and negative characters of these impulses are arranged in accordance with the particular code jumpers and control levers which are effective for that cycle of operation.

It will be apparent from the line circuit illustrated in Figs. 1 and 2, that these impulses are received at all of the field stations, and are repeated by the line relay F (with suitable exponent) at each station, but for convenience in describing the operation of the field stations, reference will be more particularly made to Fig. 3 which illustrates a typical station in detail and which for convenience is considered to be the first field station in the system.

The application of the first impulse to the control line circuit causes the line relay F¹ to actuate its polar contacts to either right or left hand positions dependent upon the positive or negative character of the impulse. However, the actuation of polar contact 101 to either a right hand or a left hand position causes the application of energy to the pick-up circuit for the relay FP¹. This pick-up circuit for relay FP¹ is closed from (+) through a circuit in-

cluding polar contact 101 of relay F¹ in either a right or a left hand position, back contact 102 of relay SB¹, windings of relay FP¹, to (-). This energization of the relay FP¹ closes the energizing circuit for the relay SA¹, from (+), through a circuit including front contact 107 of relay FP¹, winding of relay SA¹, to (-). After a time marked off by the slow acting characteristics of the relay SA¹, its contacts pick up thereby closing a pick-up circuit for the relay SB¹ from (+), through a circuit including front contact 108 of relay SA¹, windings of relay SB¹, to (-).

From this it is apparent that the relays F¹, FP¹, SA¹, and SB¹ pick up in succession. Similar successive operations of the corresponding relays occur at all of the field stations. In other words, the relays FP (with suitable exponents) at the several field stations are all insured of being picked up by reason of a pick-up circuit including a back contact of their corresponding relays SB (with suitable exponents). However, the relays FP (with suitable exponents) are maintained energized throughout the remainder of the first impulse following the picking up of the relays SB (with suitable exponents) and are maintained operable throughout the remainder of the cycle, only at those stations still having possibilities of selection by reason of the picked up condition of the relays SO (with suitable exponents) at such stations.

If the first impulse of the code call placed upon the control line circuit is of one character, a part of the field stations will have their selecting relays SO picked up during the application of the first impulse; while if the first impulse of the code call placed upon the control line circuit is of the other character, the remaining field stations will have their selecting relays SO picked up during the application of the first impulse. In other words, depending upon the code call transmitted, only one or the other part of the field stations will have their relays SO energized at the beginning of a cycle of operation.

At those stations where the relays SO (with suitable exponents) are picked up, the relays FP (with suitable exponents) follow the impulsing of the control line circuit until the relays SO drop out. Thus, at only one station of the system will the relay FP (with suitable exponent) operate throughout the control cycle of operation, as those relays SO which are picked up at the beginning of a cycle are selectively dropped out until only one remains (presently to be explained).

For example, assuming relay SO¹ to be picked up (see Fig. 3), a controlling circuit for the relay FP¹ is closed from (+), through a circuit including polar contact 101 of relay F¹ in either a right or a left hand position, back contact 109 of relay LO¹, front contact 110 of relay SO¹, windings of relay FP¹, to (-).

At those field stations where the relays SO (with suitable exponents) do not pick up, there is an energizing circuit which is closed for the relays SA (with suitable exponents) even prior to the picking up of the relays FP (with suitable exponents). For example, assuming that the relay SO¹ (see Fig. 3) does not pick up at the beginning of a cycle, then as soon as the relay F¹ is energized, there is a circuit for the relay SA¹ closed from (+), through a circuit including polar contact 101 of relay F¹ in either a right

or a left hand position, back contact 109 of relay LO¹, back contact 110 of relay SO¹, windings of relay SA¹, to (—). In other words, at this station when the relay SO¹ is not picked up at the beginning of a cycle, the relay SA¹ is energized prior to the picking up of the relay FP¹, but as the relay SA¹ is considerably slower acting than the relay FP¹, the relays F¹, FP¹ and SA¹ pick up in succession, as previously stated. This earlier response of the relay SA¹ is immaterial insofar as the operation is concerned, but is pointed out merely for the sake of completeness.

Also, at those stations where the relays SO (with suitable exponents) are picked up at the beginning of the cycle, the energizing circuits for the relays SA (with suitable exponents) which include the back contacts of the lock-out relays and the selecting relays, such for example as back contacts 109 and 110 (see Fig. 3), are closed until the relays SO (with suitable exponents) respond. If the relays SO (with suitable exponents) pick up simultaneously with the relays FP (with suitable exponents), then the relays SA (with suitable exponents) are continuously energized subsequent to the response of the relays F (with suitable exponents). In this case, the relays F, FP and SA (with suitable exponents) pick up in succession, as pointed out above, by reason of the fact that relays SA (with suitable exponents) are slow acting as compared to the relays FP (with suitable exponents).

On the other hand, the relays SO (with suitable exponents) may respond more quickly to their energization than the relays FP (with suitable exponents), so that the energization of the relays SA (with suitable exponents) is but temporary until their respective relays FP (with suitable exponents) are picked up. In such cases, the relays SA (with suitable exponents) may be considered as being effectively energized only subsequent to the picking up of the relays FP (with suitable exponents). In such cases, the relays F, FP, and SA (with suitable exponents) pick up sequentially, as will be readily apparent. These various combinations of timing operations which occur during a control cycle are immaterial insofar as the control cycle of operation is concerned, but are pointed out for the sake of completeness.

We may now consider the manner in which the relays SO (with suitable exponents) may be selectively picked up at the beginning of a cycle of operation and selectively dropped out during such a cycle until only one remains energized at the end of the station selecting steps. As illustrative of the way in which positive and negative impulses may be combined to form a number of distinctive code calls for several field stations, there is shown a typical code table in Fig. 8 where eight different combinations or code calls may be obtained by three successive impulses for the selection of stations to receive control impulses. In this type of code, a choice of a positive or a negative impulse on each of three steps gives eight different combinations. Similarly, four impulses on each of four steps gives sixteen different code calls, and the same method of arrangement of code calls may be carried on for any number of additional impulses, each additional impulse doubling the number of possible distinctive code calls.

Upon referring to the code table shown in Fig. 8, it will be noted that in this type of code arrangement, the character of the impulse on the control line circuit for the first energized period

is positive (+) for one-half the total number of code calls and negative (—) for the other half, so that a selection is made between half of the total number of stations on the first impulse depending upon whether it is a positive or a negative impulse. Similarly, the impulse on the second energized period of the control line circuit is positive (+) for one-half of the code calls remaining after the first selection, and negative (—) for the other half, so that a selection is made between half of those stations selected by the first impulse, thereby leaving only one-quarter of the total number of stations. The impulse on the third energized period selects in a similar manner depending upon its character between those stations selected by the first two impulses, thereby carrying the selection to one-eighth of the total number. In other words, on the first impulse, half of the total number of stations may be selected and the other half discarded with the process of subdividing continuing until the desired individual station is the only one which remains.

For reasons explained hereinafter, the eighth code call is assigned to a phantom station, so that with three station selecting impulses, only seven actual stations may be employed.

For convenience in describing this station selecting feature of the present invention, reference will be made more particularly to Fig. 3 of the accompanying drawings which illustrates the relays and circuits employed at a typical field station. This typical field station has its code jumpers 111, 112, and 113 so arranged, as to make this station responsive to a code call comprising three impulses of (+) (+) (—). This arrangement corresponds with the character of the impulses transmitted over the control line circuit when the code jumpers 40, 55 and 58 are rendered effective by the code determining relay ICD in the control office (see Fig. 5) to govern the impulses placed upon the control line circuit. This code call is the station selecting code No. 2 illustrated in the typical code table of Fig. 8.

As intimated above, the station selecting relays SO (with suitable exponents) are selectively picked up at the beginning of a cycle of operation. If the character of the first impulse is positive (+), then the relays SO are selectively picked up at one-half of the field stations and are left de-energized at the other half; while if the first impulse of the cycle is negative (—) in character the situation will be reversed. Then on the second impulse, one-half of those station selecting relays SO which have been picked up during the first impulse are selectively dropped out depending upon the correspondence between the character of the impulse and the code jumpers at the respective stations. Similarly, on the third impulse, one-half of those SO relays still remaining from the first and second impulses are dropped out, and this selection is carried on until only one station selecting relay SO remains energized. More specifically, if the character of the first impulse applied to the control line circuit for a control cycle is positive (+), then the relays SO¹ and SOS¹ (see Fig. 3) will be picked up upon such impulse, as will similarly the remaining field stations of the system which have code calls beginning with a positive (+) impulse. For example, this pick-up circuit for the relays SOS¹ and SO¹ is closed upon the response of the relay F¹ from (+), through a circuit including

back contact 108 of relay SA¹, polar contact 114 of relay F¹ in a right hand position, back contacts 115, 116 and 117 of relays 3V¹, 2V¹, and 1V¹ respectively, code jumper 111, upper windings of relays SO¹ and SOS¹ in series, to (—). As soon as the relay SO¹ responds to such energization, a stick circuit is closed from (+), through a circuit including front contact 118 of relay SO¹, polar contact 114 of relay F¹ in a right hand position, back contacts 115, 116 and 117 of relays 3V¹, 2V¹, and 1V¹ respectively, code jumper 111, upper windings of relay SO¹ and SOS¹ in series, to (—).

On the other hand, if the code call of this station remains as chosen, and the character of the first impulse on the control line circuit is negative (—) instead of positive (+), the polar contact 114 of relay F¹ would be in a left hand position and there would be no pick-up circuit for the relays SO¹ and SOS¹. But at those stations where the code jumpers corresponding to code jumper 111 are in upper positions, pick-up circuits would be closed.

For example, we may assume that the code jumper 111 of Fig. 3 is moved to its upper position, and in such a case with a negative (—) impulse on the control line circuit, a pick-up circuit for the relays SO¹ and SOS¹ would be closed from (+), through a circuit including back contact 108 of relay SA¹, polar contact 114 of relay F¹ in a left hand position, back contacts 119, 120 and 121 of relays 3V¹, 2V¹, and 1V¹ respectively, code jumper 111 in an upper position (not shown, but assumed), windings of relays SO¹ and SOS¹ in series, to (—). As soon as the contacts of relay SO¹ respond, a stick circuit including its front contact 118 and polar contact 114 of relay F¹ in a left hand position is completed.

In the present embodiment, three station selecting impulses are provided, so that the total number of combinations is eight, but one of these combinations is allotted as a code call for a phantom station, so that there may be seven field stations for receiving controls. Four of these stations may have a code call beginning with one polarity, while the remaining three stations may have the opposite character, all of which will be apparent from the table of codes in Fig. 8.

The manner in which the relays FP (with suitable exponents) follow the relays F¹ (with suitable exponents) so long as their corresponding relays SO (with suitable exponents) remain energized, has been pointed out above. Assuming for the time being that the stepping relay banks follow their respective relays FP (with suitable exponents) to take one step for each de-energized period of the control line circuit, we may continue to consider the features of station selection. Following such description, the effect of station selection on the stepping operation will then be taken up.

Returning now to the consideration of the station selection functioning of the system, the character of the first impulse applied to the control line circuit determines which station selecting relays SO (with suitable exponents) are picked up at the beginning of the cycle. These relays SO (with suitable exponents) are then maintained energized during the deenergized condition of the line circuit immediately following, while their associated stick relays SOS (with suitable exponents) are deenergized.

For example, while the first impulse is still

applied to the control line circuit, as repeated by the relay FP¹ (see Fig. 3), a stick circuit is closed for the relay SOS¹ from (+), through a circuit including front contact 122 of relay SB¹, front contact 123 of relay FP¹, front contact 124 of relay SOS¹, lower winding of relay SOS¹, to (—).

Upon the following deenergized condition of the control line circuit (first de-energized period), such condition is repeated by the line relay F¹, so that its polar contact 114 assumes a biased-to-neutral position which de-energizes the upper windings of the relays SO¹ and SOS¹. This is then followed by the repeating of this de-energized condition by the relay FP¹.

Thus, the relay SOS¹ is maintained energized through its stick circuit until after the de-energization of the relay FP¹. While the relay SOS¹ is still picked up, the relay SO¹ is maintained energized by a stick circuit closed from (+), through a circuit including front contact 122 of relay SB¹, front contact 125 of relay SOS¹, front contact 126 of relay SO¹, lower winding of relay SO¹, to (—). Then upon the dropping away of the relay SOS¹ this stick circuit is opened at front contact 125, but prior to its dropping away, the contacts of the relay FP¹ assume de-energized positions thereby closing another stick circuit from (+), through a circuit including front contact 122 of relay SB¹, back contact 123 of relay FP¹, front contact 126 of relay SO¹, lower winding of relay SO¹, to (—).

Upon the next energization of the control line circuit (second energization), a part of those relays SO (with suitable exponents), which are still picked up, are energized through their upper windings depending upon the correspondence between the polarity of the impulse and the position of their respective code jumpers.

For example, assuming that the relay SO¹ (see Fig. 3) is still picked up by reason of a positive impulse having been applied during the first energized period, the relays SO¹ and SOS¹ will be energized in series if the second impulse is positive in character, by reason of a circuit closed from (+), through a circuit including front contact 118 of relay SO¹, polar contact 114 of relay F¹ in a right hand position, back contacts 115 and 116 of relays 3V¹ and 2V¹ respectively, front contact 117 of relay 1V¹, code jumper 112, windings of relay SO¹ and SOS¹ in series to (—).

This energization of the relays SO¹ and SOS¹ occurs even prior to the response of the relay FP¹, so that upon the closure of front contact 123 of relay FP¹, the stick circuit for the relay SOS¹, as previously pointed out, is closed, as well as the stick circuit for the relay SO¹ including the front contact 125 of relay SOS¹.

At those stations where the code jumper 112 is connected in an upper position for a negative (—) impulse, the relays SO (with suitable exponents) will not be energized through their upper windings, so that upon the picking up of their corresponding relays FP (with suitable exponents) opening their stick circuits through their lower windings, they will drop away and thereby eliminate their stations from the possibility of selection for the cycle in progress.

This dropping out of an SO relay providing the character of the impulse does not correspond to the character assigned its respective code jumper for that step, may be best understood by considering the dropping out of the relay SO¹ (see Fig. 3) when the second impulse is negative in character. For example, if a negative im-

pulse is applied to the control line circuit for the second energized period, the polar contact 114 of relay F^1 is actuated to a left hand position. This applies potential to front contact 121 of relay IV^1 , but the code jumper 112 is in a lower, or positive position so that the relay SO^1 and SOS^1 are not energized in series through their upper windings. Then upon the picking up of back contact 123 of relay FP^1 the stick circuit for relay SO^1 is opened.

Then, upon the deenergization (second), the stick circuits for the relay SO^1 can not be closed. In other words, those relays SO (with suitable exponents) which are deenergized when the impulse on the control line circuit does not correspond to the position of their code jumpers, actually drop away when such impulse is repeated by their relays FP (with suitable exponents).

On the other hand, when the character of the impulse corresponds to the position of the code jumper, the relay SO^1 is held energized during the third deenergized period by its stick circuit including back contact 123 of relay FP^1 . Also, before the relay F^1 opens the selecting stick circuit including the polar contact 114, a stick circuit is completed for relay SO^1 through front contact 125 of relay SOS^1 , which circuit is closed until after back contact 123 is closed and relay SOS^1 repeats the deenergized condition of the relay FP^1 by reason of the opening of its stick circuit at front contact 123.

Assuming that the first two impulses applied to the control line circuit are positive (+) (+) in character, to correspond with the code coil assigned to this station (see Fig. 3), so that the relay SO^1 is maintained energized during the second deenergized period of the control line circuit, the application of the third impulse selects between the two remaining stations as indicated in the typical code table. In other words, if the first two impulses are (+)(+) there are two stations which are responsive to such character of impulses, namely, those stations which have assigned thereto station selecting code calls Nos. 1 and 2. The field station illustrated in Fig. 3 requires a negative (-) impulse on the third energized period, while the other remaining station requires a positive (+) impulse on the third energized period of the control line circuit.

The application of a negative (-) impulse to the control line circuit for the third energized period, is repeated by the relay F^1 , thereby completing an energizing circuit for the relay SO^1 through its upper winding in series with the upper winding of relay SOS^1 from (+), through a circuit including front contact 118 of relay SO^1 , polar contact 114 of relay F^1 in a left hand position, back contact 119 of relay $3V^1$, front contact 120 of relay $2V^1$, code jumper 113 in an upper position, upper windings of relays SO^1 and SOS^1 in series, to (-).

This circuit is completed before the relay FP^1 opens the stick circuit of relay SO^1 at back contact 123, so that the relay SO^1 is maintained energized. This circuit also picks up the relay SOS^1 to close its own stick circuit through front contacts 123 and 124, and also to close the stick circuit of relay SO^1 through front contacts 125 and 126. Thus, upon the following deenergized period the relay SO^1 is maintained energized, as previously explained for the second deenergized period.

While the relay SO^1 is thus maintained energized during the third deenergized period, the third stepping relay $3V^1$ is picked up which

closes a holding stick circuit for the relay SO^1 that is continued throughout the remainder of the cycle of operation.

For example, this holding circuit is closed from (+), through a circuit including front contact 122 of relay SB^1 , front contact 128 of relay $3V^1$, code jumper 129, bus wire 130, back contact 131 of relay LV^1 , front contact 126 of relay SO^1 , lower winding of relay SO^1 , to (-).

In the present embodiment only three stepping relays have been illustrated, so that there are no steps taken following the closure of this holding stick circuit for the relay SO^1 . However, as all stepping relays are maintained energized when once picked up, until the end of the cycle of operation, it is apparent that this holding stick circuit for the relay SO^1 will remain closed until the last stepping relay LV^1 is picked up, independently of the number of intervening steps which are taken.

In other words, that particular relay SO (with suitable exponent), which is maintained energized throughout the station selecting impulses continues to be energized throughout the remainder of the cycle of operation thereby permitting its corresponding relay FP (with suitable exponent) to be operated by the impulses applied to the control line circuit which in turn causes the step-by-step operation of its stepping relay bank, while at all other stations the stepping relay banks and their relays FP (with suitable exponents) have discontinued their operation.

On the other hand, at that station where code jumper 113 is connected in a lower position for a positive (+) impulse, the relay SO (with suitable exponent) will not be energized through its upper winding, so that upon the picking up of the relay FP (with suitable exponent) upon the application of the third impulse, the relay SO will drop away thereby eliminating that station from the possibility of selection. Thus, the field station illustrated in Fig. 3 is the only field station which has its station selecting relay picked up at the end of the third energized period, when the code call transmitted is (+) (+) (-).

If, however, the third impulse for station selection were positive instead of negative, it is apparent that the polar contact 114 would be moved to a right hand position applying potential to front contact 116 of stepping relay $2V^1$, but with code jumper 113 in an upper position, the energizing circuit for the relays SO^1 and SOS^1 is not complete so that upon the picking up of the contact 123 of relay FP^1 , the relay SO^1 would be dropped out. At the other field station still remaining the code jumper 113 would be in a lower position which would permit its selection.

It will be evident that the selection of the station selecting relays SO (with suitable exponents) may go on for as many steps as necessary until the stations have been subdivided until only one selecting relay SO (with suitable exponent) will be energized at the end of the station code call. The present embodiment illustrates only three steps for this purpose, that is, three impulses transmitted over the control line circuit are employed to distinctively select the stations. It is also to be understood that a smaller number of steps, such as two, may be employed if desired. In such a case, the code jumper 113 would be eliminated and the front contacts 116 and 120 of stepping relay $2V^1$ would be used to govern a control relay as presently pointed out in con-

nection with the relay SMR. Also, the jumper 129 would be moved to connect the front contact 132 of relay 2V¹ to the bus wire 130, so as to move the retaining or holding stick circuit for the relay SO¹ up one step.

Stepping operation at the field station.—The manner in which the relays FP (with suitable exponents) pick up at the several stations independently of the selecting relays SO (with suitable exponents) by reason of the back contacts of their respective relays SB (with suitable exponents) has been pointed out above. However, with reference to Fig. 3, it will be apparent that as soon as the relay SB¹ has been picked up opening back contact 102, the relay FP¹ is dependent upon its energizing circuit including front contact 110 of relay SO¹ in order to repeat the relay F¹. Also, it is necessary that the relay FP¹ operate in order to cause the step-by-step operation.

More specifically, at the beginning of a cycle of operation, the response of the relays FP¹ and SO¹ closes a pick-up circuit for the relay VP¹ from (+), through a circuit including front contact 133 of relay SB¹, front contact 134 of relay SO¹, front contact 135 of relay FP¹, back contact 136 of relay IV¹, windings of relay VP¹, to (—).

The response of the relay VP¹ closes its stick circuit from (+), through a circuit including front contact 133 of relay SB¹, front contact 137 of relay VP¹, back contact 136 of relay IV¹, windings of relay VP¹, to (—). This stick circuit maintains the relay VP¹ energized until the relay IV¹ responds to the first de-energized period, at which time the de-energization of the relay FP¹ to cause such picking up of the relay IV¹, previously completes a stick circuit for the relay VP¹ from (+), through a circuit including back contact 107 of relay FP¹, front contact 138 of relay SB¹, front contact 139 of relay VP¹, windings of relay VP¹, to (—).

Upon the following de-energized period of the control line circuit (first de-energized period), the first stepping relay is energized by a circuit closed from (+), through a circuit including front contact 133 of relay SB¹, front contact 134 of relay SO¹, back contact 135 of relay FP¹, front contact 140 of relay VP¹, back contact 141 of relay 2V¹, windings of relay IV¹, to (—). The response of the contacts of the relay IV¹ completes its stick circuit from (+) through a circuit including front contact 133 of relay SB¹, front contact 142 of relay IV¹, windings of relay IV¹, to (—).

It is believed unnecessary to explain further operation of the stepping relay bank, as it is apparent that the operation of the relay FP¹ is dependent for its repeating operation of the relay F¹ upon the closed condition of front contact 110 of relay SO¹, so that upon the dropping away of the relay SO¹ upon any impulse, the relay FP¹ is immediately de-energized, irrespective of the continued energizations of the relay F¹. The dropping away of the relay FP¹ at the beginning of an impulse by reason of the dropping of the relay SO¹ because of the lack of correspondence between the character of that impulse and the position of its code jumper, does not result in the picking up of the next stepping relay as the pick-up circuit for the stepping relay is opened at front contact 134 simultaneously with the opening of front contact 110. In other words, the pick-up circuits for the stepping re-

lays are opened prior to the repeating of the de-energized condition by the relay FP¹.

As the relay SO¹ can only be picked up at the beginning of a cycle of operation, it is obvious that once it is dropped out that the stepping operation ceases and that the relay FP¹ is prevented from repeating the relay F¹. However, those stepping relays that have been picked up prior to the dropping out of the relay SO¹ are maintained energized until the end of the cycle of operation.

Further operation of the stepping relay bank at this field station is similar to that above explained for the stepping relay bank in the control office. It is also believed that the operation of the bank at the other field stations of the system will be understood by analogy.

Assuming the first field station as illustrated in Fig. 3 to be selected by having its selecting relay SO¹ maintained energized, then upon the application of the fourth impulse to the control line circuit, the third stepping relay 3V¹ having been picked up on the preceding de-energized period, the two position polarized relay SMR is energized in one direction or the other dependent upon the character of this fourth impulse.

For example, if the impulse is positive in character, the lower winding of the relay SMR will be energized by a circuit closed from (+), through a circuit including front contact 118 of relay SO¹, polar contact 114 of relay F¹ in a right-hand position, front contact 115 of relay 3V¹, lower winding of relay SMR, to (—). This direction of current flow through the relay SMR causes its polar contact 150 to be actuated to a right hand position (as shown) closing the normal operating circuit of the switch machine SM.

On the other hand, if the fourth impulse applied to the control line circuit is negative in character the upper winding of the relay SMR is energized by a circuit closed from (+), through a circuit including front contact 118 of relay SO¹, polar contact 114 of relay F¹ in a left hand position, front contact 119 of relay 3V¹, upper winding of relay SMR, to (—). This direction of current flow through the upper winding of the relay SMR causes it to actuate its polar contact to a left hand dotted line position which closes the reverse operating circuit for the switch machine SM. When the polar contact 150 of relay SMR is operated to a new position, the switch machine SM operates the track switch TS to its corresponding locked position, subject to suitable approach and detector locking, all of which will be well understood by those skilled in the art.

In a similar manner, by the provision of additional steps, any number of additional control relays, such as relay SMR, may be suitably positioned for governing traffic controlling devices.

End of operating cycle.—Upon the application of the fourth impulse to the control line circuit (the last impulse of the cycle) the half step relay VP in the control office is de-energized which completes a pick-up circuit for the relay E from (+), through a circuit including front contact 90 of relay 2SA, back contact 92 of relay VP, front contact 105 of relay 3V, bus wire 98, lower winding of relay E, to (—). This energization of the relay E is repeated by the relay EP which in turn opens the control line circuit.

Such de-energization of the control line circuit is repeated by the relays F, FP, and 2FP as usual, but there are no more stepping relays to be energized, so that the relay E continues to

be energized through front contact 105 of relay 3V. When the de-energization of the control line circuit has been continued for a sufficient period of time to drop the relay SA, the stepping relays are de-energized by reason of the opening of front contact 75. However, prior to such de-energization of the stepping relays and as soon as the relay VP is de-energized, a pick-up circuit is closed for the last step relay LV from (+), through a circuit including back contact 88 of relay VP, front contact 89 of relay 3V, windings of relay LV, to (-). This relay LV is slightly slow acting so that its contacts do not assume energized positions quite as quickly as the relay E, but the front contact 106 of relay LV is closed a considerable time before the stepping relays drop away opening front contact 105 included in the energizing circuit of the lower winding of the relay E. This circuit is not opened until the relay LV is deenergized at the end of the cycle, which does not occur until a time subsequent to the dropping away of the relay 2SA to open front contact 90, as the relay LV is held energized through its stick circuit.

The picking up of the relay LV following as a result of the fourth energization of the control line circuit, causes the drop-away of the relay CHP (see Fig. 5) by the opening of back contact 30 included in its stick circuit. The deenergization of the relay CHP opens front contact 63, but the stick circuit of that particular code determining relay which is energized, is closed through back contact 64 of relay EP. Thus, the relay CD, which is picked up, does not interrupt the control of the relays PC and NC until the last deenergized period (fourth in this case).

In this case, the relay ICD was assumed to be picked up, so that the opening of front contact 63 caused it to be dropped away. Also, the stick circuit for the relay ICH is opened prior to the opening of the stick circuit for the relay ICD by reason of open back contact 66 of the stepping relay 3V. This arrangement is provided, so as to allow the relay ICH to drop away before its stick circuit is transferred to back contact 23 upon the dropping away of the relay ICD. Thus, the relays ICH and ICD assume their normally deenergized positions and another code determining relay (if its change relay is up) may be picked up as soon as the last step relay LV is deenergized following the dropping of the slow acting repeating relay 2SA, thereby closing back contacts 30 and 34.

The sequential dropping away of the relays SA and 2SA opens the stick circuit for the relay C, as previously mentioned, so that upon the dropping away of the relay 2SA, positive energy is removed from the code buses 45, 56, 59, and 61 by reason of open front contact 41 of relay C, which will not be again closed until another cycle of operation is initiated. Thus, upon the deenergization of the relays SA and 2SA after the control line circuit has been deenergized for a sufficient period of time the relay LV is deenergized by the opening of front contact 90 (see Fig. 4), and the relay E is also deenergized by the opening of the same contact. The condition of the relay E is repeated by the relay EP.

As the relays PC and NC are deenergized, and can not be energized until another code determining relay CD is picked up, or until the field starting and cycle controlling relay FC is picked up, it is apparent that the closure of back contact 52 of relay EP does not result in the energization of the control line circuit. The system

has thus been returned to a normal condition insofar as the control office is concerned.

At the field station (see Fig. 3) the fourth deenergization of the control line circuit causes the picking up of the slightly slow acting last step relay LV¹ by reason of a pick-up circuit closed from (+), through a circuit including front contact 133 of relay SB¹, front contact 134 of relay SO¹, back contact 135 of relay FP¹, back contact 140 of relay VP¹, front contact 143 of relay 3V¹, windings of relay LV¹, to (-). This energization of the relay LV¹ opens back contact 131 which deenergizes the relay SO¹ causing it to assume a deenergized position. The opening of front contact 110 of relay SO¹ deenergizes the relay FP¹. This dropping of the relay SO¹ before the cycle demarcating relay SA¹ is dropped, provides that the selecting relay SO¹ is in a normal position in readiness for being selectively governed upon the next cycle. If the contact 131 of relay LV¹ were not employed, the relay SO¹ would not drop until after the relay SA¹ dropped, which would allow less time for the restoration, and it might happen that the relay SO¹ would not get down before the next cycle, thereby causing an undesired selection.

At those field stations that are not selected, the relays LV (with suitable exponents) are not picked up on the fourth deenergized period, as their relays SO (with suitable exponents) are already deenergized.

As soon as the fourth impulse is removed from the control line circuit, the relay SA¹ is deenergized which deenergizes the stepping relays and also relay SB¹, so that the field station has returned to normal at rest position. As there are fewer relays to be restored in succession at the field station, all such restoration is accomplished prior to the dropping away of the relay 2SA in the control office with sufficient margins to insure proper operation.

Sequence of station selection for controls.—As previously mentioned, it may happen that the operator positions the control levers for several stations and then actuates the starting buttons for such stations simultaneously or in rapid succession. In such a case, the code determining interlocked relay bank, including the relays CH and CD (with suitable preceding numerals), provides that the code calls of the several stations having their starting buttons actuated together with the associated control for each station will be transmitted on separate operating cycles in an order or sequence determined by the location of the corresponding code determining relays in the relay bank.

Only the pick-up circuit closed by the starting button 1SB for the relay ICH (see Fig. 5) has been pointed out in detail above, but it is apparent that each of the change relays, such as relays 2CH and 3CH, have similar pick-up circuits, so that irrespective of the number of starting buttons which are actuated simultaneously or in rapid succession, all of the corresponding change relays will be picked up in the order that their starting buttons are actuated. Also, each of these change relays have stick circuits which include back contacts on their corresponding code determining relays similarly as explained for the relay ICH. Thus, each of these change relays will remain picked up until the end of that cycle of operation during which its corresponding code determining relay has been effective to transmit the corresponding station code call and the controls associated therewith.

The order in which the code determining relays are picked up is dependent upon the interlock circuits.

Assuming for example, that the relays 1CH and 2CH are picked up simultaneously, it is apparent that the relay 2CD will be picked up in preference to the relay 1CD by reason of the chain circuit arrangement of their pick-up circuits, which closes the pick-up circuit of the relay 2CD at front contact 38 of relay 2CH thereby opening the pick-up circuit of relay 1CD at back contact 38. In other words, when contacts 38 and 39 are picked up at the same time, the contact 38 is the most superior or is in the preferred position to close the circuit for relay 2CD.

Assuming that all change relays CH (with suitable preceding numerals) are picked up, and that the code determining relay 3CD is picked up for an ensuing cycle of operation, then at the end of such cycle of operation, the relays 3CH and 3CD are deenergized. It is noted that the relay 3CH is deenergized before the relay 3CD by reason of the opening of back contact 66 of relay 3V, so that the front contact 151 of relay 3CH will be open upon the closure of back contact 152 of relay 3CD.

Although the deenergization of a change relay near the end of a cycle of operation passes on the change circuit for the picking up of the next code determining relay in order, the circuit is not completed until the next cycle of operation is initiated following the return of the system to at rest conditions. This is accomplished by reason of the open contacts 36, 35, and 34 of relays CDS, C and 2SA respectively. In other words, the conditions set up at the beginning of each cycle of operation, even when there are a plurality of change relays picked up at the same time, are the same as those conditions set up by the actuation of a single starting button.

It will perhaps be expedient to point out the circumstances in which the relay CDS is particularly useful in preventing a succession of different code determining relays CD from being picked up when several starting buttons are actuated while the system is at rest.

More specifically, the actuation of the starting button 1SB, for example, results in the successive energizations of the relays 1CH, CHP, C, 1CD, and CDS. Thus, the relay 1CD picks up subsequent to the picking up of the relay C and necessarily prior to the picking up of the relay CDS, as the relay CDS is controlled thereby. If the starting button 2SB is actuated at such a time subsequent to the actuation of the starting button 1SB that the relay 2CH is picked up opening back contact 38 before the relay 1CD has picked up, then the relay 1CD will not be picked up and the relay 2CD will be the code determining relay which is rendered effective.

However, if the relay 2CH picks up its contacts closing front contact 38 at exactly the same instant that the contacts of the relay 1CD assume picked up positions, then the relay 1CD will be the one which is rendered effective and is maintained energized through its stick circuit, as previously pointed out. This is true because the relay 2CD can not pick up during the same time period that is required for the picking up of the contact 38 of the relay CDS. In other words, the relay CDS is provided with particularly quick acting characteristics as compared to the characteristics of the code deter-

mining relays CD (with suitable preceding numerals). It is to be understood, that the usual engineering methods may be employed to give the relay CDS a shorter pick-up period than the pick-up periods of the code determining relays, such as relays 1CD, 2CD, and 3CD.

It is believed that any combinations of circumstances which may occur in practice and which are not explained in detail will be readily understood from that description already given, and thus no effort is made to explain every possible combination.

In the event that the operator finds that he has actuated the wrong starting button, or that the system fails to operate subsequent to the actuation of a starting button, he may actuate the cancelling button CNB which opens the stick circuits for all of the change relays and all of the code determining relays included in the interlocked bank. This will be apparent as the pick-up and stick circuits previously pointed out include the front point of the button CNB.

Indications.—The selection of field stations for outgoing controls and the transmission of these controls is all accomplished, as above explained, over the control line circuit; while the indication line circuit is employed in accordance with the present invention for the transmission of indications to the control office after the proper registration of the code call of that particular field station which has the new indications ready to transmit.

Although this system is of the coded duplex type wherein controls and/or indications may be transmitted simultaneously during the same operating cycle, it is convenient to explain the transmission of indications alone on an operating cycle before pointing out the duplex features.

Where an extended territory is placed under the supervision of an operator, there may be trains at various points in the territory and these trains may enter or leave track circuits at two or more points at substantially the same time, and likewise the switches and signals at the various controlled locations may be operated in such a way from time to time that several of these traffic controlling devices may assume new conditions or positions at substantially the same time. Thus, it will be evident that when two or more field stations have new indications to communicate to the control office at the same time or in rapid succession, some other means must be provided to prevent more than one station from transmitting a code call at the same time to thereby avoid the transmission of an erroneous code call by the combination of several code calls being applied to the indication line circuit at the same time.

The manner in which the field stations are allowed to transmit, only one station at a time, in a predetermined order or sequence is more conveniently explained following a description of the operation of the system with respect to the transmission of indications from a single field station, assuming that such station is the only one having new indications to transmit at the beginning of the operating cycle.

Automatic starting from a field station.—A change in the indication conditions at a field station may include a change in the condition of the detector track section, a change in the condition of the track switch, a change in the condition of the signals, or any one of several other changes may occur, such as approach track

sections or the like, but as illustrative of such conditions, only the change in the condition of the detector track section or signals have been shown as being effective to transmit indications in the typical field station embodying the present invention (see Fig. 3).

For example, the movement of either the track relay contact 21 or the signal-at-stop relay contact 20 from a front point to a back point or vice versa, or the simultaneous change in the position of these contacts, momentarily opens the stick circuit of the relay CH¹ so that its contacts assume deenergized positions prior to the reclosure of its stick circuit insofar as the contacts 21 and 20 of the relays T and M respectively are concerned, all of which will be readily understood as it is at this time well known in the art, that a quick acting relay, such as relay CH¹, will accomplish this feature when employed with the relatively slow acting signaling relays T and M.

With the system in a normal at rest condition, the deenergization of the change relay CH¹ closes a pick-up circuit for the lock-out relay LO¹ from (+), through a circuit including back contact 107 of relay FP¹, back contact 132 of relay SB¹, back contact 153 of relay SA¹, upper winding of the lock-out relay LO¹, back contact 154 of the change relay CH¹, to (—). As soon as the contacts of the lock-out relay LO¹ have responded to such energization, a stick circuit is closed for the relay LO¹ from (+), through a circuit including back contact 107 of relay FP¹, back contact 132 of relay SB¹, back contact 153 of relay SA¹, upper winding of lock-out relay LO¹, front contact 155 of relay LO¹, to (—).

The closure of front contact 156 of the lock-out relay LO¹ completes the indication line circuit through this field station (see Figs. 1 and 2). For example, the indication line circuit is closed from the positive terminal of the indication battery IB in the control office (see Fig. 1), through a circuit including back contact 157 of relay DV, lower winding of the relay MB, back contact 158 of relay 2SA, through the indication line wire 14 to the first field station (see Fig. 2), front contact 156 of the relay LO¹ at the first field station, back contact 172 of relay SB¹, lower winding of the lock-out relay LO¹, compensating resistance IR¹, to the indication line return wire 16, and thence to the control office to the negative terminal of the indication battery IB.

From consideration of the line circuits, it will be readily apparent that should the change have occurred at some other field station, such as the second field station, the indication line circuit would have been closed at that station through the front contact 160 of relay LO², back contact 161 of relay SB², lower winding of relay LO², compensating resistance IR² to the indication line return, as the back contact 156 of relay LO¹ at the first field station would be closed under such circumstances.

The energization of the indication line circuit including the lower winding of the message receiving relay MB results in the initiation of the system.

For example, the picking up of the contacts of the relay MB closes a pick-up circuit for the field starting and cycle controlling relay FC (see Fig. 5) from (+), through a circuit including front contact 162 of the relay MB, back contact 163 of the relay 2SA, back contact 164 of the relay LV, back contact 165 of the relay C, upper winding of relay FC, to (—).

The picking up of the contacts of the relay FC causes the application of a negative impulse to the control line circuit by energizing the negative code sending relay NC from (+), through a circuit including back contact 41 of relay C, front contact 166 of relay FC, negative bus 48, windings of negative code sending relay NC, to (—).

This application of a negative impulse to the control line circuit is repeated by the relays F and FP (with suitable exponents) at the control office and at each of the field stations. The repeating of this impulse by the relays FP (with suitable exponents), at each of the field stations, opens the pick-up circuits of all of the lock-out relays LO (with suitable exponents) so that no other lock-out relay may thereafter be picked up, but the lock-out relay at that station which is already picked up will remain energized by reason of its energizing circuit including its lower winding in the indication line circuit.

For example, the picking up of the relay FP¹, at the field station (see Fig. 3) opens the pick-up circuit of relay LO¹ at back contact 107, but the relay LO¹ remains energized by reason of the closure of the indication line circuit including its lower winding.

The application of this negative impulse to the control line circuit continues until the system is initiated, as previously described, at which time the energization of the control line circuit is broken up into time spaced impulses by the periodic operation of the impulsing relay EP previously pointed out. Each impulse applied to the control line circuit is negative in character, as the relay FC in the control office is continuously held up throughout the cycle of operation by reason of a stick circuit which is closed following the picking up of the relay SA (see Fig. 5) when the first impulse has been applied to the control line circuit for a sufficient period of time. This stick circuit is closed from (+), through a circuit including front contact 25 of relay SA, front contact 167 of relay FC, lower winding of relay FC, to (—).

The series of negative impulses thus impressed upon the control line circuit do not result in the selection of any field station for the reception of controls, for as previously pointed out, the station code call of all negative impulses, namely (—) (—) (—), is assigned as the code call for the phantom station.

The continued application of the first impulse results in the picking up of the contacts of the relays SA (with suitable exponents) at the several field stations, which marks the end of the lock-out period during which all lock-out relays except the lock-out relay nearest the control office, are dropped out.

At that field station which maintains its lock-out relay LO (with suitable exponent) energized until the end of the lock-out period, a stick circuit is closed which is maintained until the end of that cycle of operation. For example, this stick circuit for the lock-out relay LO¹ at the first field station (see Fig. 3) is closed from (+), through a circuit including front contact 168 of relay LO¹, front contact 153 of relay SA¹, upper winding of relay LO¹, front contact 155 of relay LO¹, to (—).

Following the picking up of the relays SA (with suitable exponents), the relays SB (with suitable exponents) immediately respond, as previously pointed out. At that field station

which has its lock-out relay energized, a stick circuit is closed for the relay SB (with suitable exponent) which is maintained until the lock-out-relay LO (with suitable exponent) has been returned to its normal deenergized condition. For example, assuming that the lock-out relay LO¹ at the field station (see Fig. 3) is picked up at the end of the lock-out period, the relay SB¹ has a stick circuit closed from (+), through a circuit including front contact 169 of relay LO¹, front contact 170 of relay SB¹, windings of relay SB¹, to (-).

The picking up of the contacts of the relays SB (with suitable exponents) at the field stations open the pick-up circuits for the relays FP (with suitable exponents) at the corresponding stations. Thus, the step-by-step operation at all field stations will occur only at such stations as the relays SO (with suitable exponents) are picked up, as previously pointed out in connection with the transmission of controls. However, in this case, the relays SO (with suitable exponents) will all be dropped out at the end of the station selecting impulses as code No. 8 for the phantom station is the one which is transmitted. But the step-by-step operation at that field station which has its lock-out relay LO (with suitable exponent) picked up is insured of operation by reason of the closure of its front contacts which close a circuit for the relay FP (with suitable exponent) and similarly for the stepping relay bank independently of the relay SO (with suitable exponent) at that station.

For example, at the first field station (see Fig. 3) with the relay LO¹ stuck up, the relay FP¹ is energized any time that an impulse on the control line circuit is repeated by the relay F¹ by reason of a circuit closed from (+), through polar contact 101 of relay F¹ in either a right or a left hand position, front contact 109 of LO¹, windings of FP¹, to (-). It will also be apparent that front contact 171 of relay LO¹ is in multiple with the closed contact 134 of relay SO¹, and as this contact 171 is closed, the operation of the stepping relay bank will occur as explained for the control cycle of operation.

The picking up of the contact 172 of the relay SB¹ together with the closure of front contact 156 of relay LO¹ places the control of the indication line circuit on the pulsing relays PF¹ and PB¹ which precondition the front and back branches of the indication line circuit for the transmission of the station code call and the indications, as presently described.

During the application of the first impulse to the control line circuit, the indication line circuit is routed through the front branch at the field station and at the control office by reason of front contact 173 of relay FP¹ (see Figs. 2 and 3) and front contacts 157, 175, and 176 of relays DV, FP, and 2FP respectively (see Figs. 1 and 4). The relay DV repeats the deenergized and energized condition of the relay EP in the control office subsequent to the picking up of the contacts of the relay SA. When the relay EP is deenergized, the relay DV is energized through a circuit closed from (+), through a circuit including front contact 177 of relay SA, back contact 178 of relay EP, windings of relay DV, to (-). But whenever the relay EP is energized this circuit is opened at back contact 178, so that the relay DV is deenergized.

It is considered expedient to first explain how

the relays PB¹ and PF¹ are controlled on the several steps of an indication cycle and then describe the transmission of the indications or indication impulses over the indication line circuit with respect to Figs. 1 and 2.

Transmission of station registering code call.—The control of the pulsing relays PF¹ and PB¹ with respect to the conditions of the control line circuit as repeated by the relay FP¹ can be best understood with reference to Fig. 7 of the accompanying drawings, which illustrates in a rather general way a chart of operation for the transmission of indications. This chart does not attempt to indicate the times of operation of the relays but merely illustrates the relative sequence with respect to their major functions and is merely intended to assist in an understanding of the operation rather than an illustration of the specific operation.

The relays FP, VP and the stepping relays are indicated in the chart of Fig. 7 as being energized or deenergized by the words up and down respectively; while the relays PF and PB are considered as being "positioned", that is, either energized or deenergized, during one period and maintained or "stuck" in that position during the following period. In the case of the relays MF and MB, they are considered as being "conditioned" in accordance with the energized or deenergized condition of the indication line circuit during one period, and such condition is maintained or "stuck" during the following period.

Those periods, during which the condition of a message receiving relay, such as relays MF and MB, are effective in the control office to store such conditions, are termed execution periods and are indicated in the chart by "ex."

As previously pointed out, the relays FP, (with suitable exponents) at the control office and at each field station serve to select the front and back branches of the indication line circuit and are repeaters of the control line circuit.

With reference to Figs. 3 and 7, it will be seen that the first energization of the control line circuit during which the initiation and lock-out period exists, results in the picking up of the relay FP¹ as well as the relay VP¹, but the first stepping relay IV¹ is not picked up until the first deenergized period of the control line circuit. However, during the first energized period of the control line circuit, the pulsing relay PB¹ is positioned in accordance with the first code jumper 180 for that station, and on the following deenergized period (first) of the control line circuit is maintained in such condition, as previously established. Similarly, on each succeeding energized period of the control line circuit this pulsing relay PB¹ is positioned in accordance with its code jumpers and indication contacts, and each condition thus established is maintained during the immediately following deenergized period of the control line circuit.

Also, the pulsing relay PF¹ at that field station is positioned during each deenergized condition of the control line circuit in accordance with its respective code jumper 182 and is maintained in such condition during the second energized period of the control line circuit. Similarly, the pulsing relay PF¹ is positioned on each succeeding deenergized condition of the control line circuit in accordance with its respective code jumpers and indication contacts, and each condition thus established is maintained during its

respective energized period immediately following.

More specifically, at the beginning of the cycle of operation, as soon as the relay FP^1 is picked up, the relay PB^1 is energized or left deenergized in accordance with the position of the first code jumper 180. If the code jumper 180 is in an upper position, the relay PB^1 remains deenergized; but if the code jumper 180 is in a lower position, the relay PB^1 is energized by a circuit closed from (+), through a circuit including code jumper 180 in a lower position, back contacts 185, 186 and 187 of relays IV^1 , $2V^1$, and $3V^1$ respectively, front contact 188 of relay FP^1 , windings of relay PB^1 , front contact 189 of relay LO^1 , to (-).

This governing of the pulsing relay PB^1 of course positions its contacts in accordance therewith, but irrespective of whether the contact 191 of relay PB^1 , which is included in the back branch of the indication circuit, is closed or open, it can not effect the indication line circuit during this first energized condition of the control line circuit, as the front branch is routed through front contact 173 of relay FP^1 . But the condition of this relay PB^1 is maintained for the following deenergized condition of the control line circuit (first deenergized period) at which time the back branch of the indication line circuit is completed through back contact 173 of relay FP^1 .

For example, if the relay PB^1 is deenergized, it will remain in such deenergized condition as its pick-up circuit is opened at front contact 188 and its stick circuit can not be closed by reason of open front contact 190; while if the relay PB^1 is picked up, its stick circuit is closed from (+), through a circuit including front contact 190 of relay PB^1 , back contact 188 of relay FP^1 , windings of relay PB^1 , front contact 189 of relay LO^1 , to (-). This stick circuit is effective to maintain the relay PB^1 continuously energized, as the contact 188 of relay FP^1 is a make-before-break contact completing the stick circuit before its pick-up circuit is opened.

At the end of the first deenergized period, the relay FP^1 is again picked up and the governing circuit for the relay PB^1 is connected to the second code jumper 181, as the first stepping relay IV^1 picks up during the first deenergized condition of the control line circuit. Then, dependent upon the position of the code jumper 181, the relay PB^1 is left deenergized, and remains in such deenergized condition throughout the following deenergized period of the control line circuit. If, however, the code jumper 181 is moved to a lower position, an energizing circuit for the relay PB^1 is closed from (+), through a circuit including code jumper 181 in a lower position, front contact 185 of relay IV^1 , back contacts 186 and 187 of relays $2V^1$ and $3V^1$ respectively, front contact 188 of relay FP^1 , windings of relay PB^1 , front contact 189 of relay LO^1 , to (-).

During the second deenergized period of the control line circuit, the relay PB^1 is maintained deenergized or energized in a similar manner as explained for the first deenergized period of the control line circuit.

During such second deenergized period, the second stepping relay $2V^1$ is picked up, so that upon the following energized period (third) of the control line circuit the relay PB^1 is positioned in accordance with the position of contact 192 of the track relay T.

For example, if the track relay T is in its normally energized condition, the relay PB^1 remains deenergized; but if the track relay T is deenergized, then back contact 192 is closed and a circuit is closed for the relay PB^1 from (+), through a circuit including back contact 192 of relay T, front contact 186 of relay $2V^1$, back contact 187 of relay $3V^1$, front contact 188 of relay FP^1 , windings of relay PB^1 , front contact 189 of relay LO^1 , to (-).

On the following deenergized period (third) of the control line circuit the relay PB^1 is maintained deenergized or energized in a manner previously pointed out.

During the third deenergization of the control line circuit the third stepping relay $3V^1$ is picked up, but the relay PB^1 is not conditioned on the fourth energized period, as such a conditioning on this period would be impossible to be executed in the control office for the end of the operating cycle is reached before such execution can be accomplished. In other words, the pulsing relay PB^1 is positioned on each energized condition of the control line circuit except the last of the operating cycle and each such condition of this relay is maintained during each respective deenergized period of the control line circuit immediately following.

The control of the pulsing relay PF^1 is similar to the control of the relay PB^1 with the exception that its control periods and stick periods are begun a half step later in the cycle of operation and its control circuits are selected both by the stepping relays and the half step relay associated therewith.

For example, the relay PF^1 is not conditioned or positioned until the first deenergized period of the control line circuit, at which time the relay VP^1 is picked up and the first stepping relay IV^1 is also picked up. As soon as the relay FP^1 is deenergized for marking off the first deenergized period of the control line circuit, the relay PF^1 is positioned in accordance with the code jumper 182. If the code jumper 182 is in an upper position, the relay PF^1 remains deenergized, but if the code jumper 182 is in a lower position, an energizing circuit for the relay PF^1 is closed from (+), through a circuit including code jumper 182 in a lower position, back contact 194 of relay $2V^1$, front contact 196 of relay VP^1 , back contact 197 of relay FP^1 , windings of relay PF^1 , front contact 189 of relay LO^1 , to (-).

The positioning of the contacts of the relay PF^1 does not effect the front branch of the indication line circuit at this time, as the back branch is closed during this first deenergized period by reason of closed back contact 173 of relay FP^1 . Thus, the condition of relay PF^1 is stored or maintained until the following energized period of the control line circuit as marked off by the relay FP^1 .

For example, if the relay PF^1 is deenergized during the first deenergized period of the control line circuit, then during the following energized period (second) the relay PF^1 remains deenergized, while if the relay PF^1 is energized during the first deenergized period of the control line circuit, it is maintained energized through the following energized period (second) of the control line circuit by reason of a stick circuit closed from (+), through a circuit including front contact 198 of relay PF^1 , front contact 197 of relay FP^1 , windings of relay PF^1 , front contact 189 of relay LO^1 , to (-).

The pick-up and stick circuits for the relay

PF¹ include the make-before-break contact 197, which provides that, if the relay PF¹ is energized, its stick circuit will be completed before its pick-up circuit is opened, as explained for relay PB¹.

During the second energized period of the control line circuit, while the relay PF¹ is maintained in its condition as established during the preceding deenergized condition of the control line circuit, the half step relay is deenergized, so that upon the following deenergized period (second) of the control line circuit, the relay PF¹ is conditioned in accordance with the position of the next code jumper 183. If this code jumper 183 is in an upper position, the relay PF¹ is left deenergized; but if this code jumper 183 is in a lower position, the relay PF¹ is energized by a circuit closed from (+), through a circuit including code jumper 183 in a lower position, front contact 193 of relay IV¹, back contact 195 of relay 3V¹, back contact 196 of relay VP¹, back contact 197 of relay FP¹, windings of relay PF¹, front contact 189 of relay LO¹, to (-).

During the following energized period (third) of the control line circuit, the relay PF¹ is maintained in its condition established during the preceding condition of the control line circuit, as previously explained.

Upon the following deenergized condition of the control line circuit (third deenergized period) the relay PF¹ is positioned in accordance with the position of the relay M. If the relay M is energized, the relay PF¹ is left deenergized, but if the relay M is deenergized, the relay PF¹ is energized through a pick-up circuit closed from (+), through a circuit including back contact 201 of relay M, front contact 194 of relay 2V¹, front contact 196 of relay VP¹, back contact 197 of relay FP¹, windings of relay PF¹, front contact 189 of relay LO¹, to (-).

The condition established during this period of the control line circuit is maintained during the fourth energized period of the control line circuit, as previously explained.

In brief, the pulsing relay PF¹ is positioned during each deenergized period of the control line circuit and such condition is maintained through the energized period of the control line circuit immediately following.

In considering this operation of the pulsing relays PB¹ and PF¹, the description is given with respect to the alternative positions of their respective code jumpers and indication contacts, so that the operations for all conditions will be readily understood. However, the field station (see Fig. 3) connected as shown, gives a station registering code call of (+) (+) (-) (+). This is the station registering code call No. 3 illustrated in the typical code table of Fig. 8. The positive and negative symbols (+) and (-) represent the closed and open condition of the indication line circuit respectively.

With reference to the operation chart for indications (see Fig. 7), it will be apparent that relays PB¹ and PF¹ are positioned alternately on the successive periods of the cycle and similarly are rendered effective on alternate periods of the cycle. Thus, the station registering code characters are given in the order in which those characters or conditions are imposed upon the indication line circuit. Thus, the code jumpers 180, 182, 181, and 183 are effective in the order named to determine that the impulses will be (+) (+) (-) (+).

Although the operation of the pulsing relays

has been explained with rather specific reference to Fig. 3 of the accompanying drawings, it is to be understood that similar control of the pulsing relays is accomplished at other stations of the system when they are rendered effective by the continued energization of their respective lock-out relays LO (with suitable exponents). Also, in considering the manner in which the indication line circuit is governed by the pulsing relays and the manner in which the code calls are registered, it is to be understood that the description applies to these other stations of the system, although specific consideration is given to the field station illustrated in Fig. 3.

Consideration will now be given to the manner in which the positioning of the impulsing relays is impressed upon the front and back branches of the indication line circuit, so as to properly condition the message receiving relays MF and MB in the control office.

During the first energized period of the control line circuit, the indication line circuit is completed through the lower winding of the lock-out relay LO¹ until the relay SB¹ is picked up and transfers the indication line circuit to the control of the contact 173 of relay FP¹ and to contacts 191 and 199 of relays PB¹ and PF¹ respectively (see Figs. 2 and 3). However, during this first energized period, front contact 173 of relay FP¹ is closed, but the relay PF¹ is not positioned at this time and therefore will always remain deenergized with its front contact 199 open. In other words, the front branch of the indication line circuit is open during the first energized period of the control line circuit, but during this period the pulsing relay PB¹ is being positioned so as to be in readiness for effecting the control of the back branch of the indication line circuit as soon as the back contact 173 of relay FP¹ is closed.

Although the continued closure of the indication line circuit during the first energized period of the control line circuit may energize the message receiving relay MF (see Fig. 4) until the back contact 172 of relay SB¹ is opened (see Fig. 3), the stick circuit for the relay MF is open at the time that the relay SB¹ picks up, so that the relay MF will assume a deenergized position immediately. This is because the relay 2FP is picked up opening back contact 202, while the front contact 203 of relay EP is not closed until the end of the first impulse. The relay SB¹ picks up following the relay SA¹, but assumes its position much more quickly than the relay 2SA in the control office, so that the relay MF has the pick-up periods of the relays E and EP in addition to the remaining part of the pick-up period of the relay 2SA in which to drop out should it become energized over the temporary circuit including the back contact 172 of relay SB¹ and the lower winding of lock-out relay LO¹.

Also, the starting circuit for energizing the relay MB (see Fig. 4), is maintained until the relay SB¹ picks up opening back contact 172 (see Fig. 3), but at the time this occurs, the relay 2FP in the control office is picked up, which closes a stick circuit for the relay MB from (+), through a circuit including front contact 202 of relay 2FP, front contact 204 of relay MB, upper winding of relay MB, to (-). Such energization of the relay MB during the first energized period of the control line circuit is ineffective to register on any pilot

relay inasmuch as the first stepping relay IV is not picked up. Also, upon the first deenergized period of the control line circuit, the contact 205 of the relay FP is opened before the first stepping relay is picked up in response to the deenergization of the relay 2FP.

During the first deenergized period of the control line circuit, the back branch of the indication line circuit is closed and is conditioned in accordance with the pulsing relay PB¹ as established on the preceding energized period (first), already explained.

For example, if the relay PB¹ is deenergized during this deenergized period (first) of the control line circuit, then the relay MB remains deenergized; but, if the relay PB¹ is energized during this period, the relay MB is energized by reason of a circuit closed from the positive terminal of the indication battery IB, through a circuit including back contact 157 of relay DV, lower winding of relay MB, back contact 206 of relay FP, back contact 176 of relay 2FP, through the indication line wire 14 to the first field station, front contact 156 of relay LO¹, front contact 172 of relay SB¹, back contact 173 of relay FP¹, front contact 191 of relay PB¹, compensating resistance 2R¹, through the indication line return wire 16, to the negative terminal of the indication battery IB. Such energization of the relay MB causes its contacts to be picked up, and a stick circuit is closed upon a change to the next condition of the control line circuit before the back branch of the indication line circuit is opened at the field station.

For example, the next condition of the control line circuit is an energized period (second) which is caused by the closure of back contact 52 of relay EP. Thus, a stick circuit for relay MB is closed from (+), through a circuit including back contact 203 of relay EP, front contact 204 and upper winding of relay MB, to (-). As soon as such energization of the control line circuit is repeated by the relays FP (with suitable exponents), the indication line circuit including the back branches made up through back contact 206 of relay FP in the control office and back contact 173 of relay FP¹ at the first field station, is opened, but the stick circuit for the relay MB has been made up prior to such opening.

As soon as the relay 2FP responds to such energization (second energized period) of the control line circuit another stick circuit for the relay MB is closed from (+), through a circuit including front contact 202 of the relay 2FP, front contact 204 of the relay MB, upper windings of the relay MB, to (-). In other words, the stick circuit for the relay MB is initially closed by the relay EP and is opened by the relay 2FP, as EP picks up before the relay 2FP and drops away before the relay 2FP throughout the cycle, which is explained in connection with the impulsing operation.

With the control line circuit energized for the second energized period, thereby making up the front branches of the indication line circuit, the message receiving relay MF is positioned in accordance with the position of the pulsing relay PF¹ at the first field station. If the relay PF¹ is deenergized, the relay MF remains deenergized; but, if the relay PF¹ is energized, the relay MF is energized over the indication line circuit from the positive terminal of the battery IB through a circuit including front contact 157 of relay DV, lower windings of the relay MF,

front contact 175 of the relay FP, front contact 176 of the relay 2FP, over the indication line wire 14 to the first field station, front contact 156 of relay LO¹, front contact 172 of the relay SB¹, front contact 173 of relay FP¹, front contact 199 of relay PF¹, compensating resistance 2R¹, over the indication line return wire 16, to the negative terminal of the indication battery IB.

Upon the change of the control line circuit from the second energized period to the second deenergized period, prior to the opening of the front branch of the indication line circuit at the control office and at the field station, a stick circuit for the relay MF is closed, providing of course that it has been energized during such second energized period of the control line circuit, from (+), through front contact 203 of relay EP, front contact 207 of relay MF, upper windings of relay MF, to (-). As soon as the second deenergized period is repeated by the relay 2FP, another stick circuit is closed from (+), through a circuit including back contact 202 of relay 2FP, front contact 207 of relay MF, upper winding of relay MF, to (-).

With reference to Fig. 7, it will be apparent that the message receiving relays are alternately conditioned and then maintained in such condition on the successive periods marked off by the control line circuit.

The indication line circuit is divided into its front and back branches in the control office by the relays DV, FP and 2FP for the purpose of providing an interval of time between the opening of one branch and the closing of the other branch to give sufficient time for the corresponding branch in the field to be closed.

For example, assuming that the back branch is made up at the field station and at the control office, then the relay EP is picked up so that the control line circuit is deenergized. Upon the change to the next condition on the control line circuit (energized), the relay EP is deenergized. This energizes the relay DV immediately before the relay FP at the control office and FP¹ at the field station have responded so that the back branch is opened at back contact 157 and the front branch is closed at front contact 157 which disconnects the battery IB from the indication line circuit before the pulsing contact 191 of the pulsing relay PB¹ loses the power to control the indication line circuit upon the picking up of the contact 173 of the relay FP¹. Then upon the picking up of the relays FP and 2FP in succession, the front branch in the control office is closed at front contacts 175 and 176. Upon the picking up of the contact 173 of relay FP¹ at the field station, the front branch is closed giving the contact 199 of relay PF¹ the power to govern the indication line circuit. It is noted that, the front branch is not closed in the control office until the relay 2FP has responded, while the front branch at the field station is closed by relay FP¹. This provides additional time to compensate for the lag in the response of the relay FP¹ with respect to the response of the relay FP in the control office. It is apparent that the lag of the relays FP (with suitable exponents) at the field stations is dependent upon the length of the line circuit involved. Thus, the time period between the successive response of the relays 2FP and FP may be regulated according to the particular needs of the particular case.

During each time period marked off on the control line circuit, in which the message re-

ceiving relays MF and MB are storing their respective conditions received over the indication line circuit, such conditions are executed or stored in suitable pilot relays and indication

5 storing relays in the control office.

More specifically, the condition of the message relay MB as established during the first deenergized period and as maintained during the second energized period, is executed or stored

10 during such second energized period upon the closure of the front contact 203 of the relay FP (see Fig. 6). If the relay MB is in a deenergized position, then negative potential is placed upon the executing circuit; while, if the relay

15 MB is energized during such period, positive potential is placed upon this circuit.

Also, the condition of the message relay MF, as established during the second energized period and as maintained during the second deenergized period, is executed or stored during such

20 second deenergized period upon the closure of the back contact 209 of relay FP (see Fig. 6). If the relay MF is in a deenergized position, then negative potential is placed upon the executing circuit; while, if the relay MF is energized during such period, positive potential is

25 placed upon this circuit.

For example, upon the second energized period of the control line circuit with the first stepping relay picked up, the first pilot relay IPB remains deenergized if the relay MB is deenergized because the same potentials are placed on both sides of its upper winding. But if the relay MB is picked up, the relay IPB is energized by

35 a circuit closed from (B+), through a circuit including front contact 210 of relay MB, front contact 203 of relay FP, back contact 211 of relay 3V, back contact 212 of relay 2V, front contact 213 of relay 1V, upper winding of relay

40 IPB to (B-). If the relay IPB is deenergized it will remain so, but if it is energized, it will be maintained energized by reason of a stick circuit closed from (+), through a circuit including front contact 214 of relay SA, bus wire

45 215, front contact 216 of relay IPB, lower winding of relay IPB, to (-).

Similarly, on each succeeding energized period of the cycle marked off on the control line circuit, the succeeding executing circuits are energized in accordance with the position of the relay MB for the corresponding period. The first two

50 executing circuits are provided for station registration to position the pilot relays IPB and 2PB in accordance with the position of the code jumpers at the field station which is transmitting (in this case, code jumpers 180 and 181), while the last executing circuit is employed for registering the indication transmitted in accordance with the condition of the track relay T at that

55 field station.

In a similar manner, on each deenergized period of the control line circuit beginning with the second, the condition of message receiving relay MF is executed to its respective pilot relays IPF and 2PF and its indication storing relay IRF. For example, on the second deenergized

60 period, the relay IPF is left deenergized or is energized dependent upon the deenergized or energized condition of the relay MF by reason of a circuit from (B-) or (B+) dependent upon the back or front position of the contact 217 of relay MF, through a circuit including front

65 contact 218 of relay SA, back contact 209 of relay FP, back contact 219 of relay VP, back contact

70 220 of relay 3V, front contact 221 of relay 1V,

upper winding of relay IPF, to (B-). If the relay IPF is energized, and its contacts pick up, a stick circuit is closed through its front contact

222 to receive energy over bus wire 215 through front contact 214 of relay SA, as explained for

5 the relay IPB.

Similarly, on the next deenergized period (third) of the control line circuit, the relay 2PF is positioned in accordance with the condition then stored in the message receiving relay MF.

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As soon as the pilot relays IPF, 2PF, IPB, and 2PB are all positioned, which is accomplished during the first part of the third deenergized period of the control line circuit, a station relay

15 ST (with suitable preceding numeral) is energized. This station relay, selected by the pilot relays, connects the executing circuits for the remaining parts of the cycle to the proper indication storing relays for that station which is

20 registered.

With four pilot relays, sixteen different code combinations can be registered, which station registering codes are shown in Fig. 8. As the code call No. 16 is used for the phantom station, only fifteen station relays are required, which

25 have been merely indicated in Fig. 6 to save the space required to show all such relays.

In the typical code table for station registering codes, the symbols are given in the order in which they are effective. However, their relation

30 to the periods marked off on the control line circuit are given with respect to the time that the indication line circuit branches are effective to position the message receiving relays. In other words, the closed condition of the indication line circuit represented by a symbol (+)

35 during the first deenergized period of the control line circuit positions the message receiving relay MB which in turn positions the pilot relay IPB on the following energized period (second). In

40 brief, the pilot relays IPB, IPF, 2PB, and 2PF are positioned in the order named.

As illustrated in the present embodiment, the code call No. 3 comprising (+) (+) (-) (+) has been assigned to the first field station. The

45 registration of this code in the control office results in the energization of the relays IPB, IPF, and 2PF, so that the station relay 2ST is energized through a circuit closed from (+), through a circuit including front contact 223 of relay 3V,

50 front contacts 224, 225 and 226 of relays IPF, 2PF and IPB, back contact 227 of relay 2PB, windings of relay 2ST, to (-). Although the code call assigned to the first field station selects the relay 2ST, any other code call may be assigned to that station, so as to select any other

55 station relay desired.

It is to be noted that the stepping relay 3V picks up in response to the relay 2FP, so that the last pilot relay (relay 2PF in this case) to be positioned has the operating time of relays

60 2FP and 3V in which to assume such position, before the circuit for the station relay, then selected, is energized. Also, the particular station relay selected, is maintained energized as

65 the pilot relays and stepping relays are maintained energized until the end of the cycle.

Reception of indications.—Following the positioning of the pilot relays and the selection of a particular station relay to select or register that

70 field station which is transmitting, the indications are stored in suitable two-position indication storing relays, such as magnetic stick type relays. In other words, the indications are

75 transmitted, as has been described, so that the

message relays govern the indication storing relays in a manner similar to the governing of the pilot relays.

For example, if the track relay T is energized, the relay PB¹ will remain deenergized and the relay MB will remain deenergized, so that during the execution period marked off by the fourth energized period of the control line circuit, negative potential is applied to the indication storing relay IRB. But, if the track relay T is deenergized, it will be apparent that the relay MB will be in the opposite position resulting in the application of positive potential to the relay IRB. More specifically, a circuit for relay IRB is closed from (B+) or (B-) depending upon the position of the contact 210 of relay MB, through a circuit including front contact 208 of relay FP, front contact 211 of relay 3V, bus wire 230, front contact 231 of station relay 2ST, windings of relay IRB, to (CN). This application of negative potential positions the contact 232 of relay IRB in a left hand position, while the application of positive potential actuates its contacts to a right hand position applying energy to the indicating lamp OS which indicates to the operator that a train is on the detector track section.

Similarly, the relay IRF is positioned in accordance with the condition of the message receiving relay MF during the first part of the fourth deenergized period of the control line circuit which in this case is the entrance of the system into the period of rest. For example, the circuit for relay IRF is closed either from (B+) or (B-) through front contact 217 of relay MF in front or back positions respectively, through a circuit including front contact 218 of relay SA, back contact 209 of relay FP, back contact 219 of relay VP, front contact 220 of relay 3V, bus wire 233, front contact 234 of station relay 2ST, windings of relay IRF, to (CN).

In a similar manner, any number of stations may be registered in the control office, one at a time, any number of indications may be received, which may be accomplished by the addition of extra steps both for station registration and for indication transmission, it being assumed sufficient for the present disclosure to employ two steps for station registration and one step for the transmission of indications.

End of operating cycle.—The system returns to a normal at-rest condition similarly as explained for the transmission of controls. The relay FC is dropped out at the end of the cycle when the relay SA is deenergized by reason of the opening of front contact 25 (see Fig. 5). The control line circuit is maintained deenergized at the end of a cycle of operation for the transmission of indications to drop out the relays SA (with suitable exponents), and the relay 2SA, as previously explained. With relay 2SA deenergized, the relay E is deenergized, but the relay FC has assumed its deenergized condition while the relay 2SA is dropping away and the control line circuit will not be again energized until another cycle of operation is initiated.

At the field station (see Fig. 3), the dropping away of the relay SA¹ opens a stick circuit for the relay LO¹ at front contact 153 allowing its contacts to drop away. As soon as the relay LO¹ is deenergized the relay SB¹ is deenergized at front contact 169, so that its contacts may also assume normal deenergized positions. The remainder of the relays of the field station return to normal conditions, as previously explained, with the exception of the relay CH¹.

This relay is restored to a normally energized condition during the cycle of operation between the time in which the relays IV¹ and 2V¹ pick up successively. This is by reason of a pick-up circuit closed from (+), through a circuit including front contact 235 of relay LO¹, front contact 236 of relay IV¹, back contact 237 of relay 2V¹, upper winding of relay CH¹, to (-).

It is of course understood, that the field station which has been registered in the control office is the only one which has operated throughout the cycle of operation, and hence is the only one where all of the relays are in such operated positions so as to be returned to normal at the end of the cycle. However, there are some field stations which have operated part way through the cycle, and those relays at such stations which have been operated will of course be returned to their normal positions upon the dropping away of the relays SA (with suitable exponents) at such stations.

Duplex operation.—It is apparent from the above description that the step-by-step operation at each field station is dependent upon the station selection for outgoing controls and upon the selection of a field station during the lock-out period for incoming indications. Thus, considering that a control cycle of operation is in progress, the step-by-step mechanisms will operate at all of those stations necessary to accomplish the selection of a field station. Then, if some other field station, at which the step-by-step operation is not accomplished by reason of the selection for controls by the relays SO (with suitable exponents), has indications to transmit, the step-by-step operation at such a station is set up by reason of the energization of the lock-out relay LO (with suitable exponents) at that station during the initiating and lock-out period of the cycle. Thus, regardless of whether a cycle of operation is initiated for the transmission of controls alone or indications alone or both the transmission of controls and indications, the step-by-step mechanisms will operate at all of the necessary field stations.

The only difference between a duplex cycle of operation and a cycle of operation for the transmission of indications alone is that the step-by-step operation at the field station transmitting is accomplished by a code call, which is characteristic of a particular station being called instead of by the code call of a phantom station which is employed when there is no station being called for the reception of controls. This is because the relay C in the control office is made superior to the relay FC, so that front contact 41 of relay C, when closed at the beginning of a cycle of operation, allows the character of the succeeding impulses on the control line circuit to be determined in accordance with code jumpers and control levers rendered effective in spite of the fact that the relay FC may be picked up.

Lock-out between field stations.—It may happen that a change in the indication conditions may occur at several field stations at the same time, but, in order to prevent more than one field station from actually transmitting indications during any particular cycle of operation, lock-out means is provided at each field station which is effective to select that station nearest the control office that has new indications to transmit at the beginning of a cycle of operation.

The system has what may be termed an ini-

tiating period and a lock-out period at the beginning of each cycle of operation. The initiating period may be said to include the time which elapses between the occurrence of a change in conditions either at the control office or at a field station up to the instant that the quick acting line repeating relays FP (with suitable exponents) at the control office and at each field station pick up their contacts in response to the first impulse applied to the control line circuit; while the lock-out period may be considered as that time which elapses between the actual picking up of the contacts of the relays FP (with suitable exponents) and the picking up of their respective slow acting relays SA (with suitable exponents).

With reference to Fig. 2 of the accompanying drawings, it will be apparent that the simultaneous energization of the two lock-out relays LO¹ and LO² will result in the selection of that lock-out relay nearest the control office, as that lock-out relay opens the indication line circuit extending to the farther or succeeding field stations.

More specifically, assuming that relays LO¹ and LO² are picked up simultaneously, it is apparent that the indication line wire 14 is connected to the indication line return wire 16 at the first field station by reason of closed front contact 156 of relay LO¹, and that the relay LO² cannot close an initiating circuit by reason of open back contact 156 of relay LO¹. During the lock-out period, the relay LO¹ will be selected as it will be maintained energized subsequent to the picking up of the relay FP¹ by reason of its circuit including the indication line circuit, as previously pointed out, until its stick circuits are closed at the end of the lock-out period by the picking up of the contacts of the relays SA¹. On the other hand, the relay LO² will drop away during the lock-out period, as it has no selecting circuit made up over the indication line circuit.

These two stations in Fig. 2 may have changes in indication conditions occur in succession instead of simultaneously. In such cases, where the last change occurs at a station closer to the control office prior to the picking up of the relays FP (with suitable exponents), then the lock-out relays at the stations farther away will be dropped out during the lock-out period, or their pick-up circuits are opened by their respective FP relays and their selecting circuits are opened by reason of that picked up lock-out relay which is closest to the control office. It is of course apparent that when the first change occurs closer to the control office, that the lock-out relay at such station will be selected.

On the other hand, no lock-out relay irrespective of its location, can be picked up subsequent to the picking up of the relays FP (with suitable exponents) at the beginning of a cycle of operation, as their pick-up circuits are initially opened by the relays FP and are maintained opened throughout a cycle of operation by the relays SB.

In this connection it will be well to note, that the end of the initiating period is marked off at all field stations by the picking up of the relays FP (with suitable exponents) at all stations. Also, during an indication cycle of operation alone, the relays FP would be picked up at only those stations where the lock-out relays were picked up, if it were not for the back contact corresponding to the back contact 102 of relay SB¹ for example, but this back contact at each

field station energizes the relays FP at every station, regardless of whether such stations are initiating the cycle for the transmission of indications, or whether they are to receive controls, as indicated by the picking up of the relays SO at such stations. At all such stations where the selection is not continued, the FP relays return to normal deenergized conditions subsequent to the picking up of the relays SB.

Further control of step-by-step operation.—It was pointed out in connection with station selection for controls, that the relays SO (with suitable exponents) at the beginning of a cycle of operation are picked up at substantially half of the stations dependent upon the character of the first impulse. In other words, only a part of the stations start stepping for each cycle of operation. Then, during a cycle of operation for indications alone, the relays SO are similarly picked up at a part of the stations and continue the stepping operations at such stations until the relays SO are all dropped out by reason of the phantom code call. In other words, for the indication cycle alone, the step-by-step operation at the field stations is not entirely dependent upon the lock-out relays LO (with suitable exponents) at those stations having indications to transmit.

In accordance with the present invention, the code calls may be so arranged that for an indication cycle alone, the stepping will be entirely dependent upon the lock-out relays LO. This is accomplished by first positioning the code jumpers III at all of the field stations in lower positions so that the relays SO at all field stations will not pick up when the first impulse on the control line circuit is negative (—) in character, and then by positioning the first code jumpers 40 of all stations in the control office so that the first code impulse of a control cycle or a duplex cycle is always positive (+) in character. Thus, when an indication cycle alone is initiated, all negative impulses will be placed upon the control line circuit and the relays SO at all field stations will remain deenergized. Thus, the stepping operation will occur at only that station where the lock-out relay LO is relatively energized during the lock-out period. The relays FP at all other stations return to normally deenergized positions at the end of the lock-out period upon the picking up of the relays SB. On the other hand, for a control cycle or a duplex cycle, the first impulse will always be positive and the SO relays at all field stations are picked up and the step-by-step operations at such stations would depend upon the further selection of their stations.

Such an arrangement of course reduces the number of station selections for controls possible with a given number of steps. In the present case, it would reduce the number of station code calls from eight to four.

Summary

One embodiment of the present invention has thus been described with regard to one embodiment of a system arranged particularly to disclose the features and functions of the invention rather than the particular arrangement employed in practice. Typical operations of this embodiment have also been pointed out, it being understood of course, that all possible combinations of circumstances cannot be described in detail.

The system of the present invention is of the

two circuit type with provisions made for duplex operation, that is, for the transmission of controls and/or indications. Priority is established between field stations for the transmission of indications by reason of a lock-out arrangement which sets up geographic preference between the stations. A field station, when once selected for the transmission of indications, governs two branches of the indication line circuit so as to register in the control office substantially double the number of indications as compared to the number of controls transmitted for the same cycle of operation. The system also provides means for preconditioning the several branches of the indication line circuit at a field station thus transmitting, so that no time is lost in the transmission of these conditions to the control office.

Having thus described a centralized traffic controlling system as one specific embodiment of the present invention, it is desired to be understood that this form is selected to facilitate in the disclosure of the invention rather than to limit the number of forms which it may assume; and, it is to be further understood that various modifications, adaptations and alterations may be applied to the specific form shown to meet the requirements of practice, without in any manner departing from the spirit or scope of the present invention except as limited by the appended claims.

What we claim is:—

1. In a remote control system, a plurality of locations including a control office and a field station, a control line circuit connecting said control office and said field station, an indication line circuit connecting said control office, and field station, means in the control office for impressing a series of time spaced impulses on said control line circuit, means responsive to said impulses for transmitting messages between said locations, two code transmitting means at said field station for transmitting over said indication line circuit, means rendering one of said code transmitting means effective during each impulse on said control line circuit, and means rendering the other of said code transmitting means effective during each time space on said control line circuit.

2. In a remote control system, a plurality of locations including a control office and a field station, a control line circuit connecting said control office and said field station, an indication line circuit connecting said control office and field station, means in the control office for impressing a series of time spaced impulses on said control line circuit, means responsive to said impulses for transmitting messages between said locations, two pulsing relays at said field station for conditioning said indication line circuit when rendered effective, means rendering one of said pulsing relays effective to condition said indication line circuit during each impulse on said control line circuit, and means rendering the other of said pulsing relays effective to condition said indication line circuit during each time space between the successive impulses of said series of impulses on said control circuit.

3. In a remote control system, a plurality of locations including a control office and a field station, a control line circuit connecting said control office and said field station, an indication line circuit connecting said control office and said field station, impulsing means in the control office for impressing a series of time spaced

impulses on said control line circuit, means responsive to said impulses for transmitting messages between said locations, two pulsing relays at said field station, means including said control line circuit for rendering one of said pulsing relays effective to condition said indication line circuit during each impulse on said control line circuit, means including said control line circuit for rendering the other of said pulsing relays effective to condition said indication line circuit during each time space between the successive impulses of said series of impulses, two message receiving relays in said control office, means including said control line circuit for inserting said message receiving relays into said indication line circuit alternately upon the successive impulses and time spaces marked off on said control line circuit by said series of impulses.

4. In a remote control system, a control office, a field station, means for synchronously marking off a series of successive time periods at said control office and at said field station, an indication line circuit connecting said control office and said field station, two pulsing relays at said field station, two message receiving relays at said control office, means causing said indication line circuit to be conditioned by one of said pulsing relays during the odd time periods, means causing said indication line circuit to be conditioned by the other of said pulsing relays during the even time periods, means inserting one of said message receiving relays in said indication line circuit during the odd time periods, means inserting the other of said message receiving relays in said indication line circuit during the even time periods, and means for establishing the condition of each of said pulsing relays during the time period immediately preceding the time period during which it is effective to condition said indication line circuit.

5. In a remote control system, a control office, a field station, means for synchronously marking off a series of successive time periods at said control office and at said field station, an indication line circuit connecting said control office and said field station, a first pulsing relay, a second pulsing relay, two message receiving relays at said control office, means causing said indication line circuit to be conditioned by said first pulsing relay during the odd time periods, means causing said indication line circuit to be conditioned by said second pulsing relay during the even time periods, means inserting one of said message receiving relays in said indication line circuit during the odd time periods, means inserting the other of said message receiving relays in said indication line circuit during the even time periods, means for establishing the conditions of said first pulsing relay during the even time periods and maintaining such conditions during the odd time periods, and means for establishing the conditions of said second pulsing relay during the odd time periods and maintaining such conditions during the even time periods.

6. In a remote control system, a control office, a field station, means for synchronously marking off a series of successive time periods at said control office and at said field station, an indication line circuit connecting said control office and said field station, a first and a second pulsing relay at said field station, a first and a second message receiving relay at said control office, means causing said indication line circuit to

be conditioned by said first pulsing relay during the odd time periods, means causing said indication line circuit to be conditioned by said second pulsing relay during the even time periods, means inserting said first message receiving relay into said indication line circuit during the odd time periods, means inserting said second message receiving relay into said indication line circuit during the even time periods, a plurality of indication contacts, means controlling said first pulsing relay during each even time period in accordance with a particular one of said indication contacts and maintaining such preconditioned first pulsing relay during the following odd time period, means controlling said second pulsing relay during each odd time period in accordance with a particular one of said indication contacts and maintaining such preconditioned second pulsing relay during the following even time period, means maintaining said message receiving relays in the same condition, as established when they are inserted in said indication line circuit during the immediately succeeding period, and a plurality of indication storing relays each being controlled by the conditions set up in either said first or said second message receiving relays.

7. In a remote control system, a control line circuit, means for applying a series of time spaced distinctive impulses on said control line circuit, a line relay means for distinctively repeating said distinctive impulses of said series, a line relay repeating means for repeating said impulses of said series of impulses irrespective of their distinctiveness, a step-by-step means controlled by said line relay repeating means to take one step for each time space in said series of impulses, a selecting relay, a pick-up circuit for said selecting relay closed by said line relay during the first impulse of said series if that impulse is of a particular character, a code jumper for each step having a plurality of positions, a stick circuit for said selecting relay closed during each impulse if the character of the impulse corresponds to the position of the code jumper for that step, a stick circuit for said selecting relay closed during each time space of the series if the selecting relay remained stuck up during the preceding impulse, said stick circuit being closed by said line relay repeating means, a selecting impulse repeating relay, a pick-up circuit for said selecting impulse repeating relay closed during each impulse of said series if said selecting relay is picked up, a stick circuit for said selecting impulse repeating relay closed whenever it is picked up so long as said line relay repeating means is picked up, and a stick circuit for said selecting relay closed by said selecting impulse repeating relay whenever it is picked up at the same time that said selecting relay is picked up.

8. In a remote control system, a control office, a field station, a control line circuit connecting said control office and said field station, impulsing means in the control office for impressing a series of distinctive time spaced impulses on said control line circuit to comprise a code call, a selecting relay at said field station, a pick-up circuit for said selecting relay closed during the first impulse of said series dependent upon its character, selecting stick circuits for said selecting relay closed during each impulse dependent upon the correspondence of the character of that impulse with the code call assigned to said field station, a holding stick circuit for said selecting relay closed during each

time space of said series if said selecting relay is maintained picked up during the preceding impulse of said series, and means closing a temporary holding stick circuit for said selecting relay, said temporary holding stick circuit being closed during the later part of an impulse upon which said selecting relay is maintained picked up and being maintained closed during the first part of the following time space in said series.

9. In a remote control system, a control office, a field station having a code call assigned thereto, a control line circuit connecting said control office and field station, impulsing means in the control office for impressing a series of distinctive impulses on said control line circuit to comprise a code call, a control line relay for repeating the distinctiveness of each impulse on said control line circuit, a station selecting relay, means controlled by said control line relay for selectively operating said station selecting relay in response to a series of impulses which forms a code call corresponding to the code call assigned to said station, a line repeating relay operative to repeat each impulse irrespective of its character only when said station selecting relay is selectively controlled, and means controlled by said line repeating relay for controlling the selective operation of said station selecting relay.

10. In a remote control system, a control office, a field station having a code call assigned thereto, a control line circuit connecting said control office and said field station, impulsing means in the control office for impressing a series of distinctive impulses on said control line circuit to comprise a code call, a control line relay for repeating the distinctiveness of each impulse on said control line circuit, a step-by-step means, a station selecting relay, means controlled by said line relay and said step-by-step means when said series of impulses forms a code call corresponding to the code call assigned to said field station for selectively operating said station selecting relay, a line repeating relay operative to repeat each impulse of said series irrespective of its distinctiveness only when said station selecting relay is selectively controlled, and means including said line repeating relay for controlling said step-by-step means through a cycle of operation in response to said series of impulses when the code call formed by said series corresponds to the code call assigned to said field station.

11. In a remote control system, a control office, a field station, a control line circuit connecting said control office and said field station, impulsing means in the control office for impressing a series of impulses on said control line circuit, a line relay for repeating said impulses, a line repeating relay for repeating said line relay only when rendered effective, an indication line circuit, a step-by-step means operated by said line repeating relay, a code transmitting means for governing said indication line circuit when rendered effective, and means for rendering said code transmitting means effective, said means simultaneously rendering said line repeating relay effective, whereby said step-by-step means can be operated through a cycle of operation only when said code transmitting means is rendered effective.

12. In combination; a series of stepping relays; a series of impulses; means responsive to said series of impulses for operating said stepping relays through cycles of operation; a plurality of buses; means always applying the same

potential to said buses sequentially, said means including said stepping relays; two impulse transmitting relays, each transmitting impulses of a distinctive character; and means selectively determining the particular one of said impulse transmitting relays to be energized by the application of potential to each of said buses successively whereby codes are formed by said impulses.

13. In a remote control system, a control line circuit, a control battery, a positive code sending relay and a negative code sending relay, whereby said control line circuit is energized in one direction from said battery when said positive code sending relay is picked up and whereby said control line circuit is energized in the opposite direction when said negative code sending relay is picked up, a positive and a negative code bus, a step-by-step means operable through cycles of operation, a plurality of buses sequentially receiving potential when said step-by-step means is operated through a cycle of operation, a plurality of groups of code jumpers, means including said code jumpers of any group for connecting each of said plurality of buses to one or the other of said positive or negative buses when a particular group of code jumpers is rendered effective, and means permitting only one of said groups of code jumpers to be rendered effective at any one time.

14. In combination a plurality of code determining relays, a control means for each of said relays having front and back contacts; a stick repeater relay for repeating the energized condition of said code determining relays; a pick-up circuit for each of said code determining relays including a front contact of its corresponding control means, a back contact of all succeeding control means, and a back contact of said stick repeater relay; a code repeater relay for repeating the position of said code determining relays; and a stick circuit for each code determining relay closed when it is picked up only after said code repeater relay has been picked up by that particular code determining relay, said stick circuit including said stick repeater relay, whereby only one of said code determining relays can be picked up at any one time.

15. In combination, a series of stepping relays, a series of impulses, means responsive to said series of impulses for operating said stepping relays through cycles of operation, a plurality of buses, means always applying the same potential to said buses sequentially said means including said stepping relays, two impulse transmitting relays each transmitting characteristic impulses, and means selectively connecting each of said buses to one or the other of said impulse transmitting relays during a cycle of operation whereby codes are formed by said impulses.

16. In a remote control system, a control office connected to a stepping line circuit and an indication line circuit, impulsing means for impressing a series of impulses on said stepping line circuit, a line repeating relay for repeating said impulses, step-by-step means operated by said line repeating relay, two code transmitting relays selectively conditioned by said step-by-step means, means controlled by said impulsing means and said code transmitting relays for dividing said indication line circuit into two branches, and means for selectively energizing said branches.

17. In a remote control system, a control office connected to a stepping line circuit and an indi-

cation line circuit, impulsing means for impressing a series of impulses on said stepping line circuit, a line repeating relay for repeating said impulses, step-by-step means operated by said line repeating relay, two code transmitting relays selectively conditioned by said step-by-step means, means controlled by said impulsing means and said code transmitting relays for dividing said indication line circuit into two branches, and means for selectively energizing said branches during separate conditions of said stepping line circuit.

18. In a remote control system, a control line circuit having a series of time spaced impulses impressed thereon, an indication line circuit, step-by-step means for preparing a plurality of channel circuits for each step, a first preconditioning device selectively operated during the impression of an impulse on said control line circuit, means controlled by said first preconditioning device for distinctively conditioning said indication line circuit during the time space following its selective operation, a second preconditioning device selectively operated during the time space period following said impulse, means controlled by said second preconditioning device for distinctively conditioning said indication line circuit during the impulse period following its selective operation, and means controlled by said preconditioning devices for characteristically energizing said channel circuits.

19. In a remote control system, a control line circuit having a series of time spaced impulses impressed thereon, an indication line circuit, step-by-step means for preparing a plurality of channel circuits for each step, a first preconditioning device selectively operated during the impression of said impulses on said control line circuit, means controlled by said first preconditioning device for distinctively conditioning said indication line circuit during the time spaces following its selective operation, a second preconditioning device selectively operated during each time space period following said impulses, means controlled by said second preconditioning device for distinctively conditioning said indication line circuit during the impulse periods following its selective operation, and means controlled by said preconditioning devices for characteristically energizing said channel circuits.

20. In a remote control system, a control line circuit having a series of time spaced impulses impressed thereon, an indication line circuit, step-by-step means for preparing a plurality of channel circuits for each step, a first preconditioning device selectively operated during the impression of said impulses on said control line circuit, means controlled by said first preconditioning device for distinctively conditioning said indication line circuit during the time spaces following its selective operation, a second preconditioning device selectively operated during each time space period following said impulses, means controlled by said second preconditioning device for distinctively conditioning said indication line circuit during the impulse periods following its selective operation, storing means for storing the condition of said indication line circuit from one impulse and time spaced period into the next time space and impulse period respectively, and means controlled by said storing means for characteristically energizing said channel circuits during said next time space and said next impulse periods.

21. In a remote control system, a plurality of

locations including a control office and a plurality of field stations, a control line circuit connecting said office with said stations, an indication line circuit connecting said office with said stations, means in said office for impressing a series of time spaced impulses on said control line circuit, means responsive to said impulses for transmitting messages between said locations, two transmitters at each of said stations for transmitting over said indication line circuit, lock-out means at each of said stations for rendering the associated transmitters at a preferred station effective and the associated transmitters at any other station ineffective to transmit during the impression of said series of impulses on said control line circuit, means rendering one of said transmitters at said preferred station effective during each impulse on said control line circuit, and means rendering the other of said transmitters at said preferred station effective during each time space on said control line circuit.

22. In a remote control system, a plurality of locations including a control office and a plurality of field stations, a control line circuit connecting said office with said stations, an indication line circuit connecting said office with said stations, means in said office for impressing a series of time spaced impulses on said control line circuit, means responsive to said impulses for transmitting messages between said locations, two pulsing relays at each of said stations for conditioning said indication line circuit when rendered effective, lock-out means at each of said stations for rendering the associated pulsing relays at a preferred station effective and the associated pulsing relays at any other station ineffective to condition said indication line circuit

during the impression of said series of impulses on said control line circuit, means rendering one of said pulsing relays at said preferred station effective to condition said indication line circuit during each impulse on said control line circuit, and means rendering the other of said pulsing relays at said preferred station effective to condition said indication line circuit during each time space on said control line circuit.

23. In a remote control system, a line circuit, a battery, a positive code sending relay and a negative code sending relay, means controlled by said positive code sending relay for energizing said line circuit in one direction from said battery, means controlled by said negative code sending relay for energizing said line circuit in the opposite direction from said battery, a positive and a negative bus, step-by-step means operable through a cycle of operations, a plurality of code buses sequentially receiving energy when said step-by-step means is operated through a cycle of operations, a plurality of groups of code jumpers, means including the jumpers of any of said groups for connecting each of said code buses to either said positive bus or said negative bus when a particular group of jumpers is rendered effective, means permitting only one of said groups of jumpers to be rendered effective at any one time, an impulse relay for intermittently interrupting the energization of said line circuit, means controlled by said impulse relay for controlling the operation of said step-by-step means through a cycle of operations, and means responsive to the operation of said step-by-step means for controlling the operation of said impulse relay.

THOMAS J. JUDGE.
CHARLES S. BUSHNELL.