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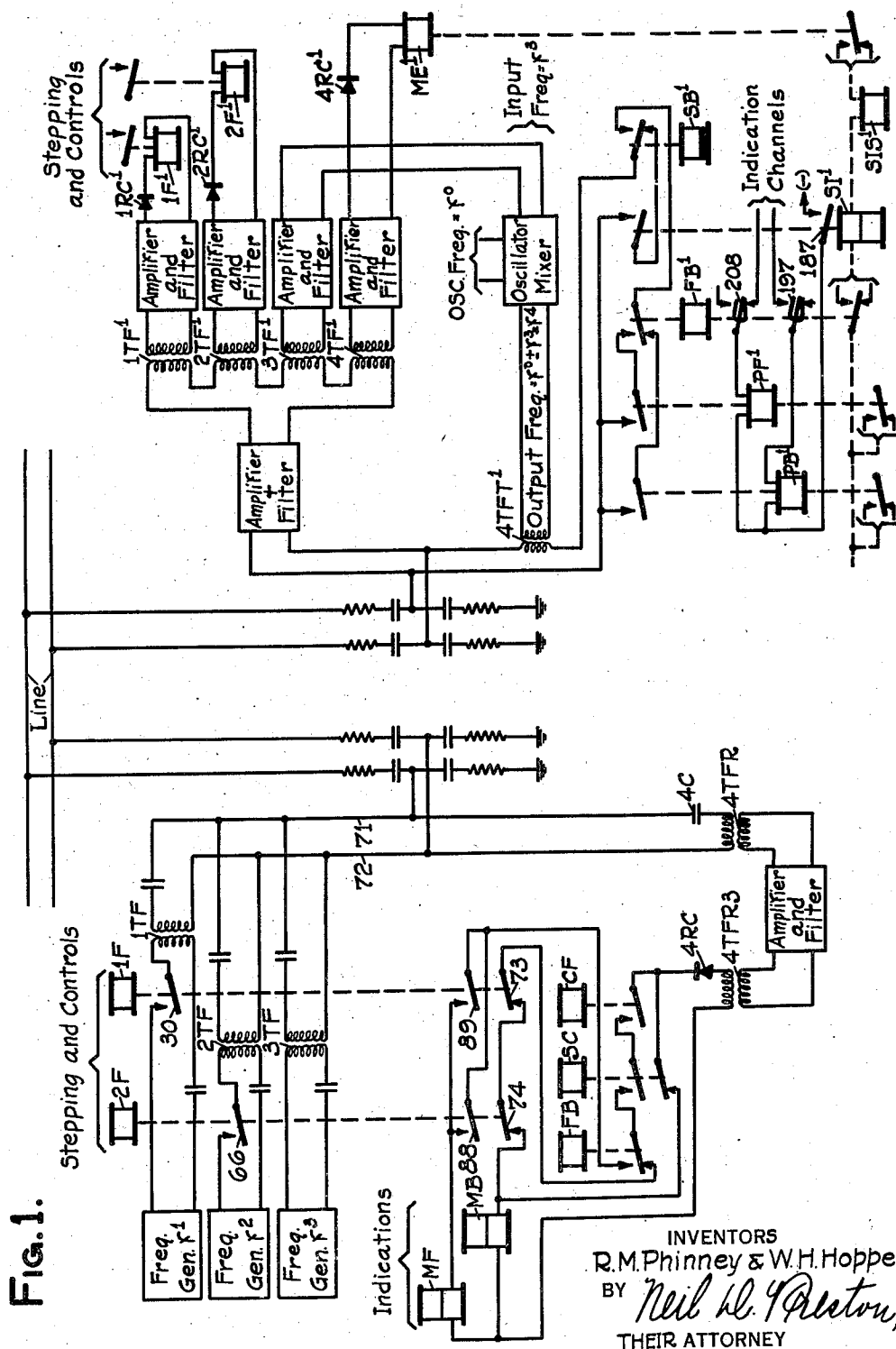
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2,141,551

CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

Filed Aug. 1, 1936

7 Sheets-Sheet 1



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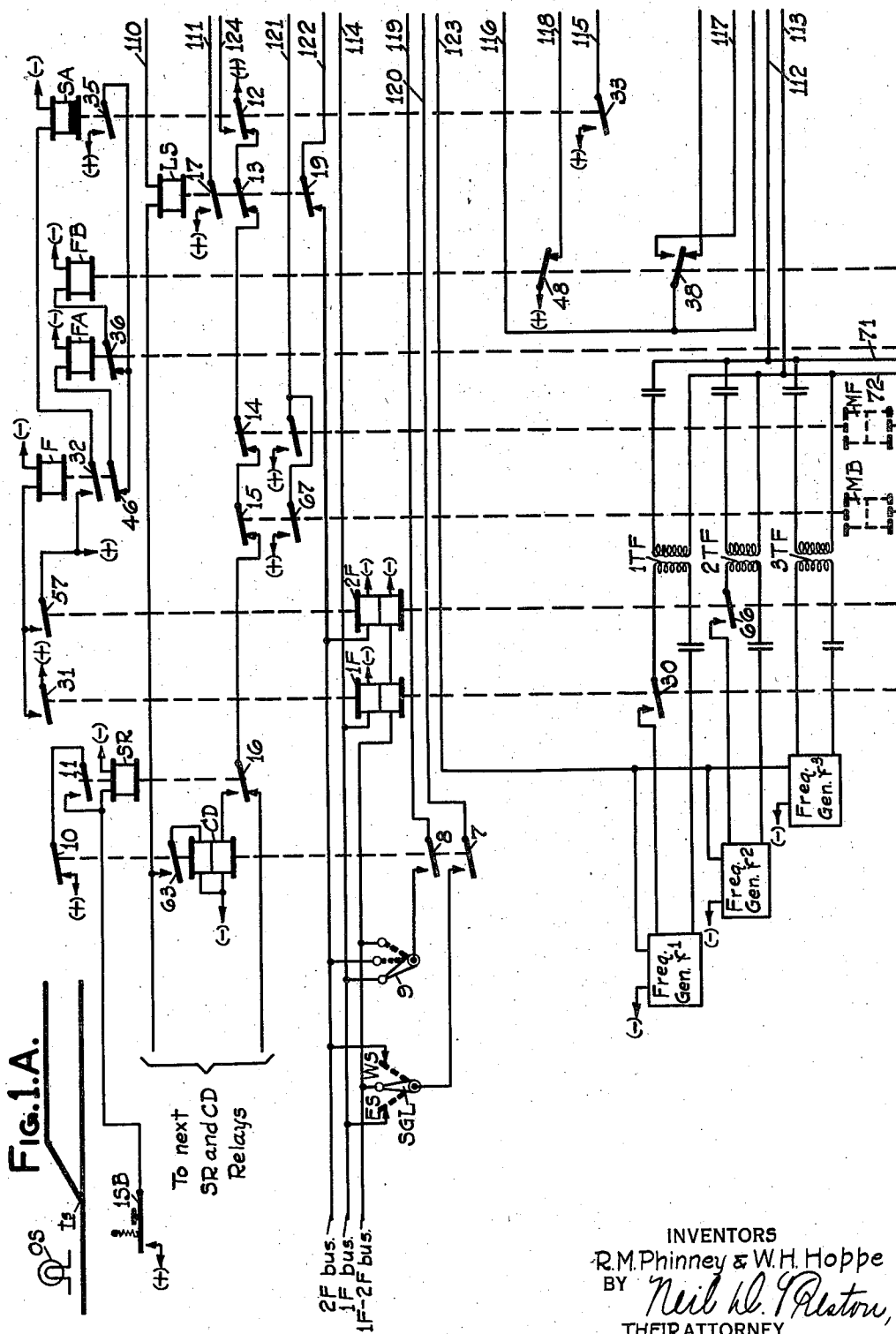
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CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

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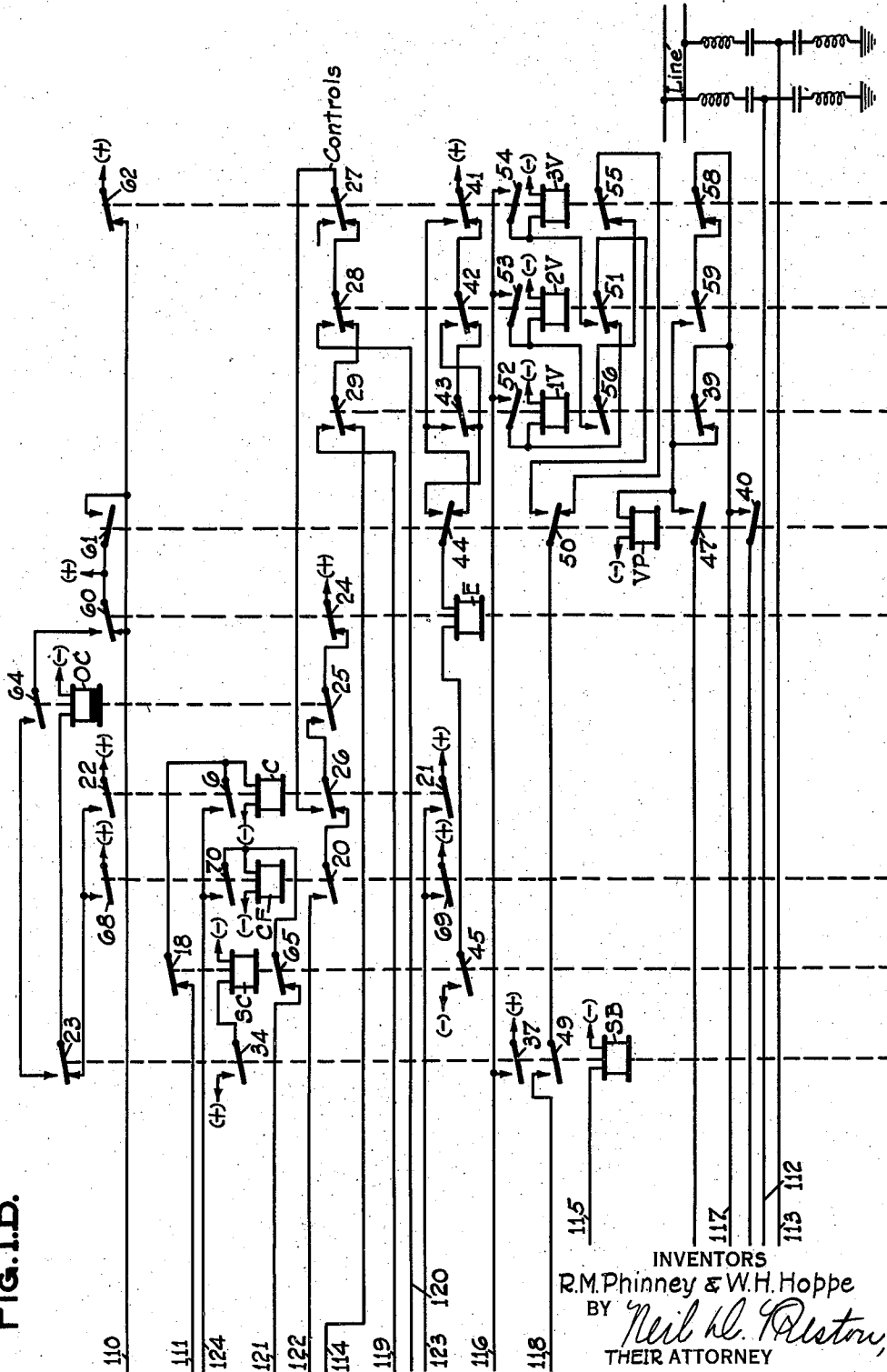
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CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

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FIG. 1B.



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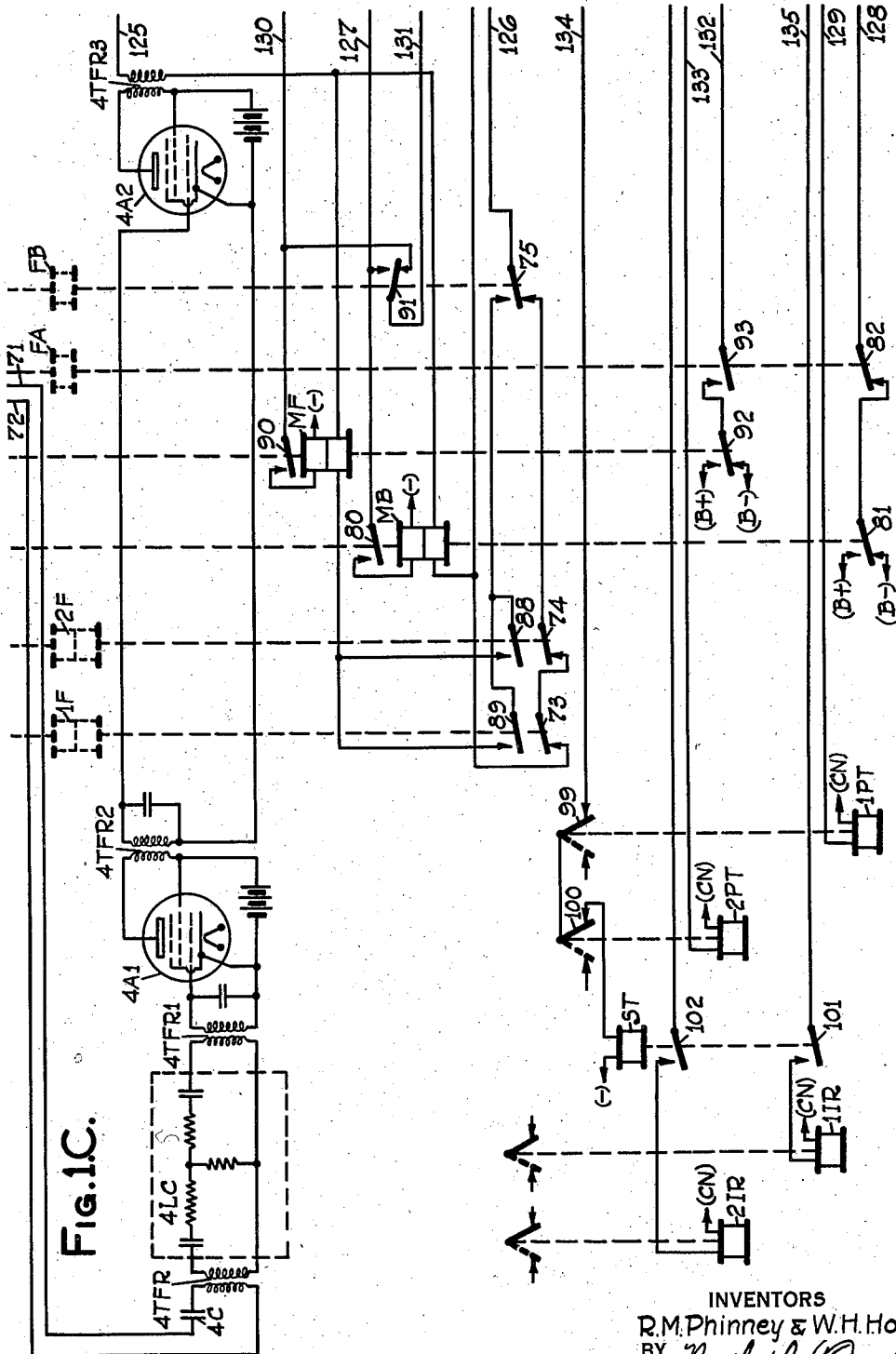
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CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

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FIG. 1C.



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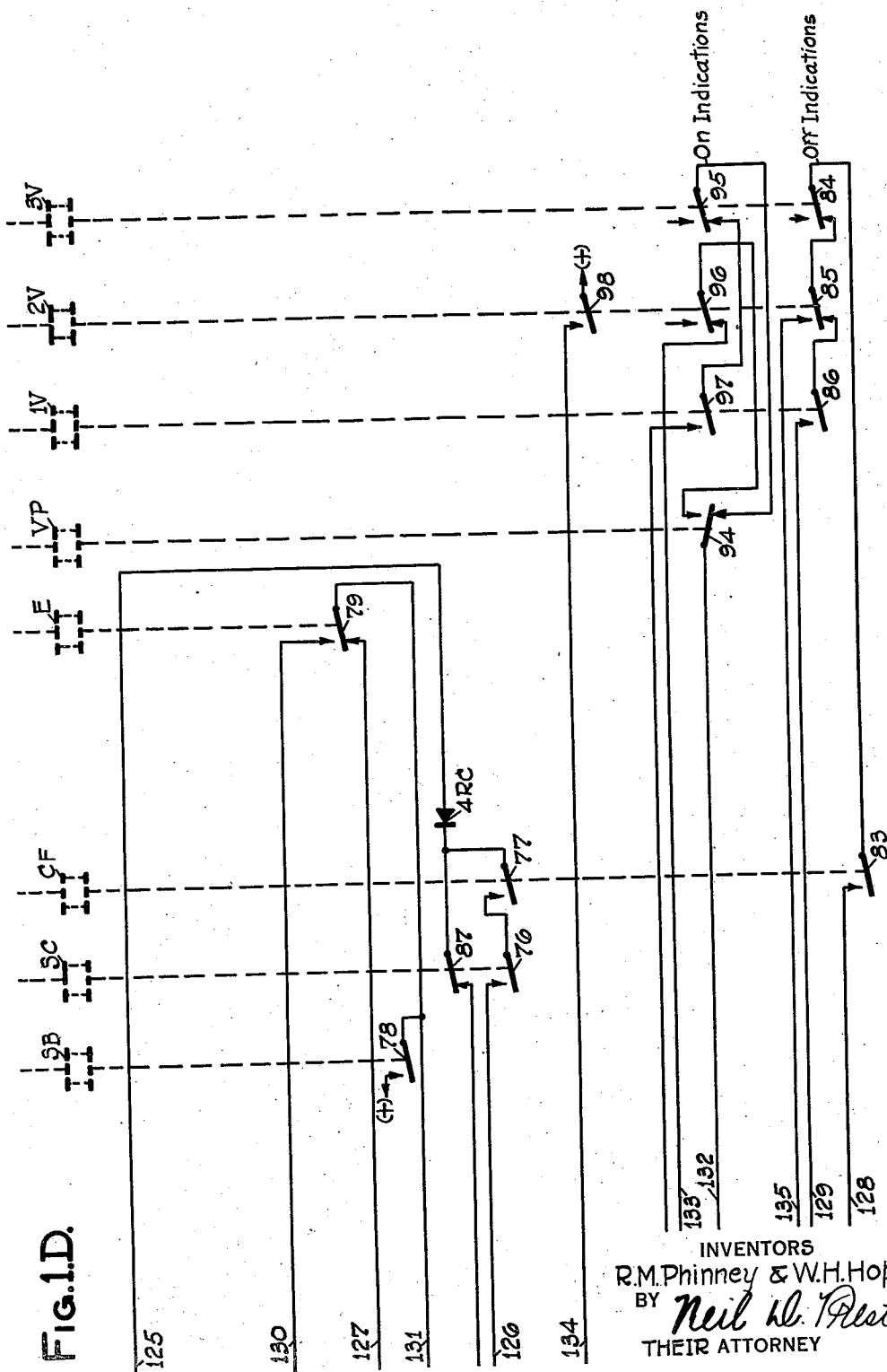
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CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

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FIG. 1.D.



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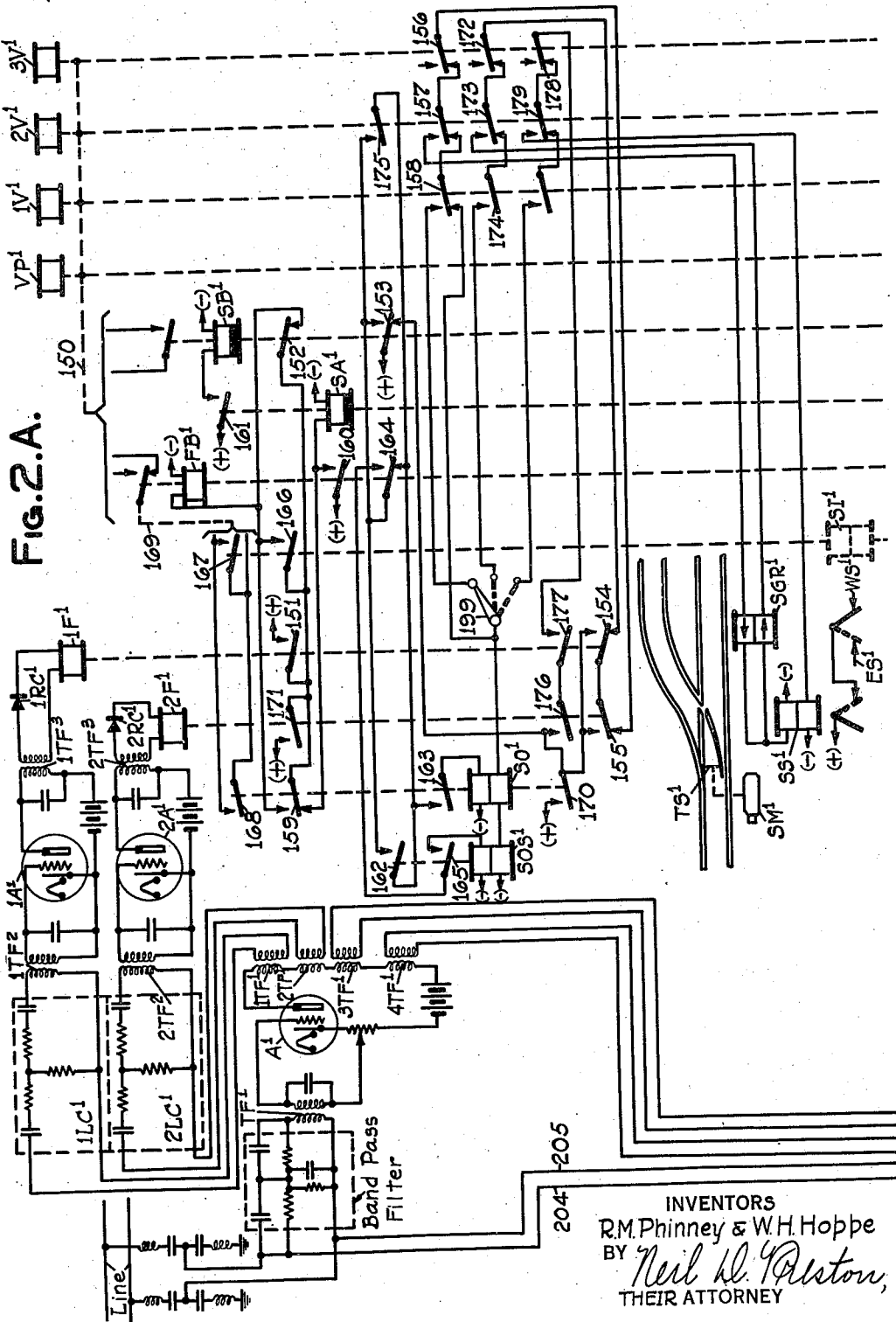
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CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

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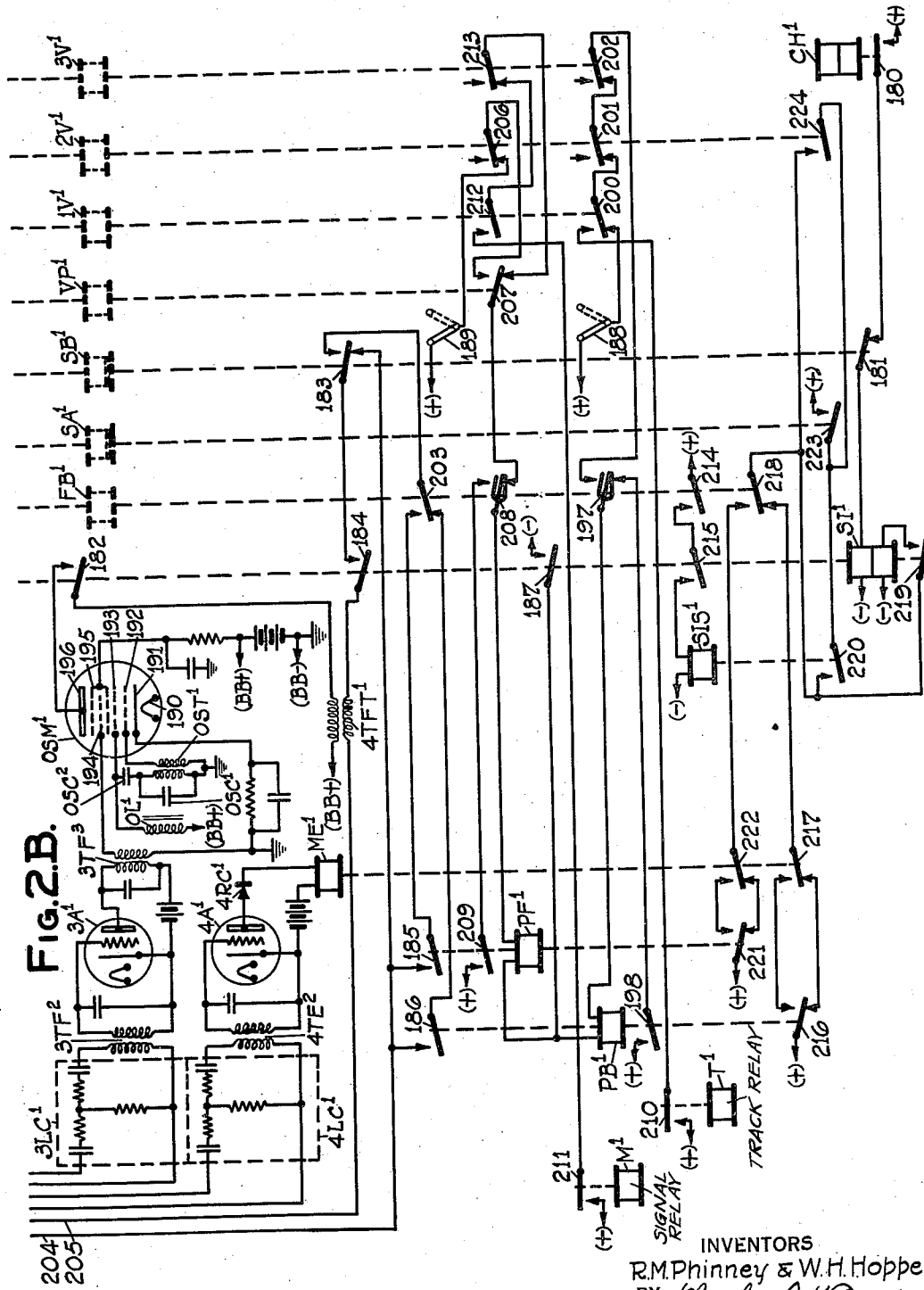
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CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

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7 Sheets-Sheet 7



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UNITED STATES PATENT OFFICE

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CENTRALIZED TRAFFIC CONTROLLING
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7 Claims. (Cl. 177—353)

This invention relates to centralized traffic controlling systems for railroads and it more particularly pertains to means for transmitting, receiving, storing and executing controls and indications in a communication system of the multiple impulse or coded type.

In such a system the switches and signals are distributed throughout the territory, with those located relatively near or adjacent to each other, together with the apparatus provided to govern these switches and signals, conveniently referred to as comprising a field station.

The communication system interconnects the control office and the several field stations and is so organized that complete control and supervision of the various switch and signal devices at the remote locations are obtained by the operator in the control office. Such a traffic controlling system is supplemented by the usual automatic block signal system and other local means ordinarily provided to guard against unsafe train movements, improper operation of track switches and the like.

In accordance with the present invention the communication system comprises an existing telegraph, telephone or power line which extends between the control office and field stations upon which coded impulses are superimposed for the transmission of controls and indications. The coded impulses are made up from carrier currents of various frequencies and it is contemplated that sufficiently high frequencies may be used in the event that it is desired to operate the centralized traffic controlling system by radio by substituting antenna and ground systems for the illustrated line circuit at the office and at the stations. From the following description it will be obvious that the system of the present invention may be applied to a separate line circuit used for centralized traffic controlling operation only, although the particular advantages of the present embodiment reside in the provision of a centralized traffic controlling system operating over an existing line circuit which is used for other purposes.

For convenience in describing the operation of the present invention it has been shown as applied to an existing telegraph line by means of a composite set at each location. Although the circuits are shown connected to a telegraph line circuit and ground connections, it will be understood that it is also possible to operate the centralized traffic controlling system over a phantom circuit superimposed on two physical circuits. It will also be understood that the carrier fre-

quencies chosen for operating the centralized traffic controlling system will be such as to cause no interference with the regular currents in the lines and to be free from interference by such currents. As will be explained in detail, five separate carrier frequencies are used and referred to as frequency f^0 , f^1 , f^2 , f^3 and f^4 .

The circuits are so arranged that any field station in the series may initiate the communication system into a cycle of operations by applying a momentary impulse of frequency f^0 , followed by an impulse of frequency f^4 for conditioning the various circuits and during such a cycle indications are transmitted from the initiating field station to the control office. These indications are made up of combinations of the presence and absence of frequency f^4 during the step-by-step operations of the stepping relay banks provided at the control office and at the various field stations. These combinations make up codes which register the transmitting station in the control office and transmit indications from the registered station in accordance with the track, switch and signal conditions at the transmitting station.

The circuits are so arranged that the control office may initiate the operation of the communication system by applying an impulse of frequency f^1 to the line circuit for conditioning the various circuits. During such a cycle control codes are transmitted which are effective to select a desired station and to transmit controls thereto.

The system is of the duplex type, that is, it is operated through separate cycles of operation during each of which transmission of controls and/or transmission of indications may occur. When controls are transmitted a station selective code is first applied to the line circuit for selecting the particular station with which communication is desired and then the controls are transmitted to that station. When indications are transmitted the particular field station transmitting such indications first transmits a station registering code for identifying this station in the office and then the indications are transmitted from this station to the office.

For the transmission of controls a predetermined number of impulses of selected frequencies are applied to the line circuit, each impulse operating step-by-step apparatus in the control office and at the field stations in synchronism through a cycle of operations irrespective of the frequency of the impulses. The lengths of the impulse and time space periods are all substantially equal.

For the transmission of indications a predetermined number of impulses are applied to the line circuit for operating the step-by-step apparatus in the office and at the transmitting station in synchronism through a cycle of operations. During such a cycle an impulse of the indication carrier frequency is or is not superimposed on the line circuit during the impulse and time space periods for making up the indication code combinations.

For convenience in describing the operation of this system the periods during which stepping impulses are superimposed on the line circuit in the control office will be referred to as the "on" periods and the time spaces between these impulses will be referred to as the "off" periods.

At the start of a cycle of operations for the transmission of controls a conditioning impulse of one frequency is applied to the line circuit for conditioning the apparatus at the office and at the field stations, followed by a number of "off" and "on" periods, the number of which is determined by the number of stepping relays, which in turn is determined by the size of the system.

At the start of a cycle for the transmission of indications, a first impulse of one frequency is momentarily applied to the line circuit for starting the system, followed by an impulse of another frequency for conditioning the apparatus at the office and at the field stations. A number of "off" and "on" periods then follow, the number of which is determined, as above mentioned, by the size of the system.

Other objects and advantages of the present invention will be hereinafter set forth in the specification and claims and further details will be better understood by referring to the accompanying drawings which illustrate one method of carrying out the invention by way of example.

The drawings illustrate in a diagrammatic manner the apparatus and circuits employed. For convenience in describing the invention in detail those parts having similar features and functions are designated in the different figures by like reference characters, generally made distinctive either by the use of distinctive exponents representative of their location in the system or by the use of preceding numerals representative of the order of their operation. It has been found convenient to illustrate contacts of certain relays on two different sheets of drawings and in this case the circuits which control these relays have been shown connected to full line blocks, with these same relays indicated on an adjacent drawing by dotted line blocks. For this reason certain reference characters have been repeated on some of the drawings but only where they refer to the same relay on another drawing.

Fig. 1 illustrates the line circuit and the arrangement whereby stepping and control impulses are applied to the line circuit in the control office by way of a composite set and whereby these stepping and control impulses are taken off of the line circuit at a field station by way of a composite set. This figure also illustrates in brief form how the indication impulses are applied to the line circuit at a field station by way of the composite set and taken off of the line circuit in the control office by way of the composite set. Fig. 1 includes only the apparatus most closely associated with the line circuit and it will be understood that other stations are connected to the line circuit in the same manner as that illustrated in this figure.

Figs. 1A, 1B, 1C and 1D illustrate the apparatus

and circuit arrangement employed in the control office for providing means whereby the operator may govern the switches and signals throughout an extensive territory and whereby indications may be received from various field stations throughout such territory. For convenience in considering the control office circuits, Fig. 1B should be placed to the right of Fig. 1A, Fig. 1D should be placed to the right of Fig. 1C and Fig. 1C should be placed below Fig. 1A with correspondingly numbered lines in alignment.

Figs. 2A and 2B illustrate the apparatus and circuit arrangement employed at a typical field station for providing control of a track switch and associated signals and for transmitting indications to the control office in accordance with the present invention. For convenience in following the circuit operation of the system, Fig. 2A should be placed to the right of Fig. 1B and Fig. 2B should be placed below Fig. 2A with correspondingly numbered lines in alignment.

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, that is from (+) to (−). The symbols (B+) and (B−) are employed to indicate the positive and negative terminals respectively of a suitable battery or other source of direct current having an intermediate tap (CN) and the circuits with which these symbols are used may have current flowing in one direction or the other depending upon whether the terminal (B+) or (B−) is used in combination with tap (CN).

Plate batteries have been illustrated in connection with the various vacuum tubes used in the present system and although these batteries have been separately indicated, it will be understood that a single source of plate current may ordinarily be used at a single location for supplying all of the tubes. Although the filament energizing circuits for the various vacuum tubes have not been illustrated, it will be obvious that these circuits may be energized from any desired source of supply, such as a battery, alternating current or rectified alternating current. It will also be understood that rectified alternating current may be used in place of the plate batteries illustrated. Furthermore, no grid potential sources are illustrated but it is well within the scope of the present invention to apply such bias potentials when needed.

Control office equipment.—The control office (Figs. 1A, 1B, 1C and 1D) includes a control machine having a group of control levers for each field station, a miniature track layout corresponding to the track layout in the field and various indicating lamps or equivalent devices, together with apparatus and circuits to accomplish the desired operation of the system.

That part of the control office illustrated shows more particularly the portion of the control machine which is typical of the apparatus for selecting any one of a plurality of field stations, for transmitting controls to a selected station, for registering the identity of a transmitting field station in the office and for receiving indications from a transmitting station.

The illustrated apparatus includes a starting button SB associated with a particular station, which button controls the operation of a storing relay SR and a code determining relay CD, both associated with the station corresponding to but-

ton ISB. It will be understood that there will be a starting button and associated SR and CD relays for each station in the system which is to be selected from the control office. Typical apparatus for controlling the operation of traffic signals has been illustrated and comprises signal lever SGL. It will be understood that other signal levers may be provided and that levers for controlling the track switches may likewise be provided, but for convenience only lever SGL is illustrated since the control of one or more track switches and other signals may be understood by analogy to the control by lever SGL, which will be explained in detail.

Code jumpers are selected by the circuits controlled by the CD relays, only one of which has been illustrated and which is for the purpose of applying a station selecting code to the line circuit in response to the initiation of the system when the associated starting button is actuated. One code jumper indicates that the desired station is selected on a single step of the cycle and when the number of stations is larger, then of course additional code jumpers will be provided and selected on additional steps of the cycle.

Code sending relays 1F and 2F are for the purpose of applying the proper frequency to the line circuit during the transmission of controls. With relay 1F picked up, frequency f^1 is applied to the line circuit, with relay 2F picked up, frequency f^2 is applied to the line circuit and with both relays 1F and 2F picked up, both frequencies f^1 and f^2 are simultaneously applied to the line circuit.

Relays F, FA and FB are the impulse repeating relays operated in various combinations (as will be fully described) in response to the impulses of either or both frequencies applied to the line circuit. Slow acting relay SA is for the purpose of defining the bounds of an operating cycle, that is it is picked up at the beginning of each cycle, is held up throughout the cycle and is dropped out during the "clearing out" period at the end of the cycle. Relays SB and SC repeat the SA relay operations and are likewise maintained in their picked up positions throughout each cycle.

Relay C is a control cycle controlling relay, being picked up at the start of a control cycle and dropped out at the end of such a cycle. Relay CF is an indication cycle controlling relay, being picked up in response to a field start at the beginning of a cycle and dropped out at the end of such a cycle. During a duplex cycle, relays C and CF may both be picked up. Impulse controlling relay E is for the purpose of timing the "off" and "on" periods during a cycle of operations in response to the operation of the stepping relays which respond to these "off" and "on" periods.

Associated with the line and line repeating relays is a bank of stepping relays including relays IV, 2V, 3V, together with half-step relay VP. This bank of stepping relays is for the purpose of marking off the successive steps of each cycle, the stepping relays being successively picked up during the "off" periods and relay VP being shifted in position during each "on" period. Relay OC is a cycle controlling relay, being picked up at the start of a cycle of any class and maintained picked up until the end of such cycle. Relay LS is included in the stick circuit of any CD relay which is picked up and is primarily for the purpose of opening the chain circuit leading to other SR relay contacts, so that only one CD relay can be picked up at any one time.

Three frequency generators are illustrated in Fig. 1A which generate frequencies f^1 , f^2 , f^3 , and it will be obvious that these generators may comprise vacuum tube oscillators, tone generators or the like for providing the required frequencies. The three carrier frequencies provided by these frequency generators are applied to the line circuit through transformers and condensers of such characteristics that the required frequency will be passed through these respective circuits with minimum attenuation, while frequencies above and below those required to be transmitted will be sharply cut off.

A level control unit 4LC is illustrated in Fig. 1C, through which frequency f^4 is transmitted by way of transformers 4TFR and 4TFR¹ to amplifier 4A1. Currents of this frequency appearing in the output of amplifier 4A1 are applied to the input of amplifier 4A2 by means of transformer 4TFR2 and the amplified currents in the output of amplifier 4A2 are rectified by rectifier 4RC and applied to the windings of message receiving relays MB and MF. It will be noted that amplifiers 4A1 and 4A2 are of a different type from the amplifiers at the field station for amplifying frequencies f^1 , f^2 , f^3 . The reason for this is that higher gain amplifiers are proposed for amplifying the indication frequencies, because it is assumed that these frequencies applied at the field stations will be of considerably lower level than the frequencies applied in the control office.

Pilot relays 1PT and 2PT are of the polar magnetic stick type and are positioned in accordance with a station identifying code received in the control office during a duplex cycle or a cycle during which indications alone are transmitted. Station relay ST is assumed to be associated with the station illustrated in Figs. 2A and 2B, it being picked up in response to the station identifying code transmitted by this station. It will be understood that there is a separate ST relay for each station to be registered in the control office, these relays being selected by the different positions of the pilot relay contacts. Indication receiving relays 1IR and 2IR are also of the polar magnetic stick type and are positioned in accordance with the indications received from a transmitting station during a cycle in which indications are transmitted.

Field station equipment.—The field station illustrated in Figs. 2A and 2B is typical of all stations of the system and may be adapted for use at the first, second or any other location by merely altering certain code jumpers to provide for the desired codes. For convenience in the descriptions, this field station has been specifically illustrated as being the first of the series by reason of the distinctive exponents employed and it will be understood that other stations may be connected to the line circuit between the illustrated station and the control office or at points more distant from the control office than the illustrated station.

A track section is illustrated, with track switch TS¹ which is operated from one extreme locked position to the other by means of switch machine SM¹. Suitable signals are associated with the illustrated track section for governing traffic thereover and these signals, as well as the switch machine, are governed from the control office through the medium of the communication system. Signal relay SGR¹ is shown to illustrate how east and west signals are selectively controlled and relay SS¹ is illustrated to show how these signals may be put to stop, all in response

to a choice of three codes transmitted at a single step of the cycle. The control of the switch machine by a switch machine relay in response to controls has been omitted, since such control may be clearly understood by analogy to the control of the signal relays which will be described in detail.

The communication part of the system includes line relays $1F^1$ and $2F^1$ which respond to frequencies f^1 and f^2 respectively, these frequencies being received in the output of amplifier A^1 and applied through level control units $1LC^1$ and $2LC^1$ by way of transformers $1TF^1$ and $2TF^1$ to the input circuits of amplifiers $1A^1$ and $2A^1$ through transformers $1TF^2$ and $2TF^2$. The amplified carrier frequencies in the output circuits of these amplifiers are supplied to relays $1F^1$ and $2F^1$ by way of transformers $1TF^3$ and $2TF^3$ and rectifiers $1RC^1$ and $2RC^1$. A band pass filter is illustrated in Fig. 2A which is designed to pass frequencies f^1 , f^2 , f^3 and f^4 , with these frequencies being applied to the input of amplifier A^1 by way of transformer TF^1 .

For the purpose of illustrating the selection of a station for the transmission of controls, relays SO^1 and SOS^1 are shown and it will be explained in detail how these relays are picked up at all stations at the beginning of a cycle and selectively dropped out until only the one to which controls are to be transmitted remains picked up throughout the cycle of operations. Relay FB^1 repeats the operations of the $1F^1$ and $2F^1$ relays and controls the operation of the associated stepping relay bank in a manner which has not been illustrated in detail, but which is the same as the control of the stepping relay bank in the control office by relay FB . This control is merely indicated by dotted line connection 150. Relays SA^1 and SB^1 , of the slow-acting type, operate in a manner similar to and are for a purpose similar to corresponding relays in the control office.

A field change relay CH^1 is illustrated in Fig. 2B to show how a cycle of operations is initiated from a field station. For the purpose of illustrating the manner of determining when a field station is to transmit its indications, relays SI^1 and SIS^1 are employed. As will be explained in detail, these relays provide the superiority of code type of lock-out so that only one field station can transmit its indications during a cycle when several field stations have indications ready to transmit at substantially the same time.

Relays PB^1 and PF^1 are for the purpose of superimposing the indication carrier current on the line circuit during the "off" and "on" periods of a cycle for making up the indication codes. For the purpose of indicating how indications are transmitted from a station after such station identifies itself in the control office, track relay T^1 and signal indicating relay M^1 are illustrated. Although the control circuits for these relays are not shown it will be understood that relay T^1 , in its picked up position, indicates that the associated track section is unoccupied and when this section becomes occupied relay T^1 is dropped. Furthermore, it is assumed that relay M^1 , when in its picked up position, indicates that all signals associated with the illustrated track section are at stop and when any one of these signals is clear relay M^1 is dropped.

Carrier frequencies f^3 and f^4 received in the output of amplifier A^1 are applied to the input circuits of amplifiers $3A^1$ and $4A^1$ by way of transformers $3TF^2$ and $4TF^2$ and by way of level

control networks $3LC^1$ and $4LC^1$ respectively. These carrier frequencies are amplified by amplifiers $3A^1$ and $4A^1$, with frequency f^4 being rectified by rectifier $4RC^1$ for operating message relay ME^1 . Relay ME^1 is for the purpose of co-operating with indication code transmitting relays PB^1 and PF^1 for ruling inferior stations off the line, by dropping out their associated SI relays and for maintaining the SI relay energized at a superior station, in response to a station identifying code being transmitted over the line circuit to the office.

The level control units illustrated in the control office and at the field station are for the purpose of maintaining the signal level applied to the amplifier, to which each level control unit is connected, at the desired value for the various frequencies, which value might otherwise be improper due to line attenuation.

An oscillator mixer tube OSM^1 is illustrated in Fig. 2B for the purpose of mixing oscillating frequency f^0 with the received monitoring or synchronizing frequency f^3 for providing indication frequency f^4 , which preferably has a definite frequency relation to the monitoring frequency f^4 and has the same frequency as similar frequencies f^4 generated at other field stations. In other words the oscillating circuits associated with vacuum tube OSM^1 preferably provide an oscillating frequency f^0 which is dominated by synchronizing frequency f^3 to provide a resultant indication, transmitting frequency f^4 . The purpose of such an arrangement will be explained in detail later in the specification. The indication carrier frequency currents are applied to the line circuit by way of transformer $4TF^1$.

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

Operation

Manual start.—For the purpose of explaining the operation of the present system it will be assumed that lever SGL is actuated to its right hand (west) position for clearing a signal for governing west bound traffic at the station illustrated in Fig. 2A. Starting button $1SB$ is actuated to start the system into operation and this closes an obvious pick-up circuit for starting relay SR . Relay SR closes a stick circuit for itself extending from (+), back contact 10 of relay CD , front contact 11 and winding of relay SR to (—). A circuit is now closed for picking up relay CD which extends from (+), back contacts 12, 13, 14 and 15 of relays SA , LS , MF and MB respectively, front contact 16 of relay SR and lower winding of relay CD to (—). Relay CD closes a stick circuit for itself which extends from (+), back contacts 60 and 62 in multiple of relays E and $3V$ respectively, conductor 110, winding of relay LS , front contact 63 and upper winding of relay CD to (—). Since the winding of relay LS is included in this stick circuit, relay LS picks up and opens back contact 13 for preventing the picking up of any other CD relay, in the event that another office start is stored by the picking up of another SR relay in response to the actuation of another SB button. The opening of back contact 10 of relay CD deenergizes relay SR .

A circuit is now closed for picking up relay C Fig. 1B which extends from (+), front contact 17 of relay LS , conductor 111, back contact 18 of relay SC and winding of relay C to (—). The

picking up of relay LS also opens the circuit extending to the upper winding of relay 2F at back contact 19, so that the energization of relay 2F during the following cycle is dependent upon the code jumper and control lever connections instead of directly through front contact 20 of relay CF, which direct circuit will be explained in connection with an indication cycle. The closure of front contact 21 of relay C starts the three frequency generators into operation for generating frequencies f^1 , f^2 and f^3 . Frequency f^3 is immediately applied to the line circuit by way of transformer 3TF and the multiple circuit leading to the composite set connected to the line circuit in the control office, including conductors 112 and 113. It will be pointed out at this time that the condensers in the primary and secondary windings of transformers 1TF, 2TF, and 3TF are of the proper value to sharply tune these circuits to the frequencies which they are to pass.

Relay OC is now picked up over a circuit extending from (+), front contact 22 of relay C, back contact 23 of relay SB and winding of relay OC to (-). Relay 1F is picked up over a circuit extending from (+), back contact 24 of relay E, front contact 25 of relay OC, front contact 26 of relay C, back contacts 27, 28 and 29 of relays 3V, 2V and 1V respectively, conductor 114, and upper winding of relay 1F to (-). Relay 1F completes the circuit from generated frequency f^1 to the primary of transformer 1TF by way of front contact 30, so that frequency f^1 is applied to the line circuit by way of the secondary of this transformer.

The above explanation relates to the initiation of the system from the control office and it will now be explained how the circuits are conditioned in the control office and at the field stations for receiving the code which is applied to the line circuit. The picking up of relay 1F closes an obvious circuit at its front contact 31 for picking up relay F and relay F closes an obvious circuit at its front contact 32 for picking up relay SA. Relay SA closes an obvious circuit at its front contact 33 for picking up relay SB by way of conductor 115 and relay SB closes an obvious circuit at its front contact 34 for picking up relay SC. Relay SA closes a circuit for picking up relay FB which extends from (+), front contact 35 of relay SA, back contact 36 of relay FA and winding of relay FB to (-).

Because of the slow-acting characteristics of relay SA, this relay will be maintained in its picked up position throughout the operating cycle until the "clearing out" period at the end of the cycle and its repeating relays SB and SC will likewise remain picked up until the clearing out period. Relay SA maintains relay C energized during the cycle by means of a stick circuit extending from (+), front contact 12 of relay SA, conductor 124, front contact 6 and winding of relay C to (-).

Frequency f^1 applied to the line circuit is received through the composite set at the field station illustrated in Fig. 2A (and at all other field stations), is transmitted through the band pass filter illustrated in Fig. 2A and applied to the input of amplifier A¹ by way of transformer 70 TF¹. Frequency f^1 appears in the output of amplifier A¹ and is applied to the input of amplifier 1A¹ by way of transformers 1TF¹, 1TF² and level control network 1LC¹. This frequency is again amplified by amplifier 1A¹ and appears in the output circuit of this tube, where it is repeated

by transformer 1TF³ and rectified by rectifier 1RC¹ for operating relay 1F¹. It will be understood that, by means of similar circuits at the other stations, the 1F relays at these other stations will also be picked up.

Relay 1F¹ closes a circuit for picking up relay FB¹ which extends from (+), front contact 151 of relay 1F¹, back contact 152 of relay SB¹ and winding of relay FB¹ to (-). Relays SO¹ and SOS¹ are picked up over a circuit extending from (+), back contact 153 of relay SB¹, front contact 154 of relay 1F¹, back contact 155 of relay 2F¹, back contacts 156, 157 and 158 of relays 3V¹, 2V¹, and 1V¹ respectively and lower windings of relays SO¹ and SOS¹ in series to (-).

Relay SA¹ is picked up over a circuit extending from (+), front contact 151 of relay 1F¹, back contact 159 of relay SO¹ and winding of relay SA¹ to (-). A substitute circuit for intermittently energizing relay SA¹ during the following cycle is closed at front contact 160 of relay FB¹. Relay SA¹ closes an obvious pick-up circuit for relay SB¹ at front contact 161.

A stick circuit is closed for relay SO¹ extending from (+), front contact 153 of relay SB¹, front contacts 162 and 163 of relays SOS¹ and SO¹ respectively and upper winding of relay SO¹ to (-). A stick circuit is closed for relay SOS¹ which extends from (+) front contact 153 of relay SB¹, front contact 164 of relay FB¹, front contact 165 and upper winding of relay SOS¹ to (-). It will be understood that the FB, SA, SB, SO and SOS relays at all other stations are picked up during this conditioning period and it will be later explained how the SO and SOS relays are dropped out at non-selected stations.

Impulsing and stepping operations.—It will first be assumed (and later explained) that the 1F and 2F code sending relays are positioned in accordance with the control code to be applied to the line circuit, for energizing the line circuit with frequency f^1 , frequency f^2 or both of these frequencies simultaneously. For the present it will be assumed that relay 1F (which was picked up as previously described to apply frequency f^1 to the line circuit) is dropped to remove this frequency from the line to mark the end of the conditioning "on" period. It will be assumed that relay 1F is picked up to apply frequency f^1 to the line circuit for the first coded impulse and dropped to mark the end of this impulse or "on" period. It will be assumed that both relays 1F and 2F are picked up to apply frequencies f^1 and f^2 to the line circuit during the second "on" period and that these relays are dropped to mark the end of this "on" period. It will then be assumed that relay 2F is picked up to apply frequency f^2 to the line circuit for the third "on" period and that this relay is dropped to mark the end of this "on" period and the beginning of the "clearing out" period. It will be later explained how relays 1F and 2F are selectively energized in accordance with the code to be transmitted.

The picking up of relay SB (above described) closes a pick-up circuit for relay VP which extends from (+), front contact 37 of relay SB, conductor 116, front contact 38 of relay FB, conductor 117, back contact 39 of relay 1V and winding of relay VP to (-). Relay VP closes a first stick circuit for itself at its front contact 40 which is independent of front contact 38 of relay FB. Relay E is now picked up over a circuit extending from (+), back contacts 41, 42 and 43 of relays 3V, 2V and 1V respectively, front

contact 44 of relay VP, winding of relay E and front contact 45 of relay SC to (-). The picking up of relay E opens the above described pick-up circuit for relay 1F at back contact 24 and relay 1F drops to remove frequency f^1 from the line to mark the end of the conditioning "on" period and the beginning of the first "off" period.

The dropping of relay 1F opens the energizing circuit of relay F at front contact 31, relay F drops and closes a pick-up circuit for relay FA which extends from (+), front contact 35 of relay SA, back contact 46 of relay F and winding of relay FA to (-). Relay FA opens the above described circuit for relay FB at back contact 36 and relay FB is dropped. A second stick circuit is now closed for relay VP which extends from (+), front contact 37 of relay SB, back contact 38 of relay FB, front contact 47 and winding of relay VP to (-).

Relay IV is now picked up over a circuit extending from (+), back contact 48 of relay FB, conductor 118, front contact 49 of relay SB, front contact 50 of relay VP, back contact 51 of relay 2V and winding of relay IV to (-). Relay IV closes a stick circuit for itself extending from (+), front contact 37 of relay SB, front contact 52 and winding of relay IV to (-). It will be mentioned at this point that similar stick circuits are closed by relays 2V and 3V at their front contacts 53 and 54 when they are picked up later in the cycle. The picking up of relay IV opens the above described energizing circuit for relay E at back contact 43, relay E drops and closes a pick-up circuit for relay 1F (later described) and the picking up of relay 1F applies frequency f^1 to the line to mark the end of the first "off" period and the beginning of the first "on" period.

Relay F is now picked up over the previously described circuit including front contact 31 of relay 1F and relay FA is dropped because of open back contact 46. The dropping of relay FA again closes the pick-up circuit for relay FB at back contact 36. The picking up of relay FB effects the dropping of relay VP because its first stick circuit is open at back contact 39 of relay IV and its second stick circuit is open at back contact 38 of relay FB. Relay E is now picked up over the previously described circuit but which now extends through front contact 43 of relay IV and back contact 44 of relay VP and relay 1F is dropped because of open back contact 24 of relay E. The dropping of relay 1F removes frequency f^1 from the line to mark the end of the first "on" period and the beginning of the second "off" period.

Relay F is now dropped because of open front contact 31, relay FA is picked up because of closed back contact 46 and relay FB is dropped because of open back contact 36. Relay 2V is now picked up over a circuit extending from (+), back contact 48 of relay FB, conductor 118, front contact 49 of relay SB, back contact 50 of relay VP, back contact 55 of relay 3V, front contact 56 of relay IV and winding of relay 2V to (-). Relay E is now dropped because of open back contact 42 of relay 2V and relays 1F and 2F are picked up over circuits later to be described. The picking up of relays 1F and 2F applies frequencies f^1 and f^2 to the line circuit which marks the end of the second "off" period and the beginning of the second "on" period.

Relay F is now picked up because of closed front contact 31 and it will be understood that in the event that only relay 2F is picked up, relay F would be energized because of front contact 57.

Relay FA is dropped because of open back contact 46 and relay FB is picked up because of closed back contact 36. A circuit is now closed for picking up relay VP which extends from (+), front contact 37 of relay SB, conductor 116, front contact 38 of relay FB, conductor 117, back contact 58 of relay 3V, front contact 59 of relay 2V and winding of relay VP to (-). Relay VP again closes its first stick circuit at front contact 40, which includes the above described circuit independent of front contact 38 of relay FB. The picking up of relay VP picks up relay E because of closed front contacts 42 and 44 of relays 2V and VP respectively. The picking up of relay E drops relays 1F and 2F because of open back contact 24 and the dropping of relays 1F and 2F removes frequencies f^1 and f^2 from the line to mark the end of the second "on" period and the beginning of the third "off" period.

Relay F is now dropped because of open front contacts 31 and 57, relay FA is picked up because of closed back contact 46 and relay FB is dropped because of open back contact 36. The second stick circuit for relay VP is again closed as previously described and relay 3V is picked up over a circuit extending from (+), back contact 48 of relay FB, conductor 118, front contact 49 of relay SB, front contact 50 of relay VP, front contact 51 of relay 2V and winding of relay 3V to (-). Relay E is dropped because of open back contact 41 and relay 1F, or 2F or both will be picked up (as later described) to mark the end of the third "off" period and the beginning of the third "on" period.

The picking up of relay 1F, or relay 2F, closes the obvious pick-up circuit for relay F, relay F drops relay FA because of open back contact 46 and relay FB is picked up because of closed back contact 36. Relay VP is now dropped because its first stick circuit is open at back contact 58 of relay 3V and its second stick circuit is open at back contact 38 of relay FB. Relay E is now picked up over the above described circuit, but now includes front contact 41 of relay 3V and back contact 44 of relay VP. The picking up of relay E drops relay 1F, or 2F or both because of open back contact 24 to mark the end of the third "on" period and the beginning of the "clearing out" period.

Relay F is now dropped because of open front contacts 31 and 57, relay FA is picked up because of closed back contact 46 and relay FB is dropped because of open back contact 36. Since there are no other stepping relays to be picked up, the condition of the E relay (picked up) is not changed and relays 1F, 2F and F remain down for a sufficiently long interval of time to drop relay SA because of open front contact 32 of relay F. Relay FA is now dropped because of open front contact 35 of relay SA and relay SB is dropped because of open front contact 33 of relay SA. Relay C is dropped because of open front contact 12 of relay SA and relay C stops the operation of the frequency generators because of open front contact 21. Relay SC is dropped because of open front contact 34 of relay SB and the stepping relays are dropped because their stick circuits are de-energized at open front contact 37 of relay SB. The dropping of the stepping relays and the dropping of relay SC drops relay E because of open front contacts 41 and 45 of relays 3V and SC respectively.

During the operation of the cycle just described, relay OC is maintained energized during the intermittent operation of contact 60 of re-

lay E by means of a stick circuit extending through front contact 60 of relay E, front contact 64 of relay OC, front contact 23 of relay SB and winding of relay OC to (-). At the end of the third "on" period, relays LS and CD are dropped when relay 3V picks up and opens its back contact 62. When relay SA drops and closes its back contact 12, any CD relay in the bank can be picked up in the event that a stored start has been effected by operating the associated starting button. When relay SC drops, a field start can be received in the office because of closed back contact 65 of relay SC and at this same time an office start can be effective to pick up relay C because of closed back contact 18 of relay SC. This condition, which permits the picking up of relays C and CF at the start of a cycle, will be more clearly understood in connection with the description of a duplex cycle of operations.

From the above description it will be apparent that frequency f^3 is applied to the line circuit during the initiating period, remains on the line circuit throughout the cycle and is removed when relay C drops to stop the operation of the frequency generators. This application of frequency f^3 to the line circuit is of no effect during a control cycle and its purpose will be explained in connection with an indication cycle. Relay FB¹ at the illustrated field station is dropped at the beginning of the "clearing out" period to effect the dropping of relay SA¹ because of open front contact 160 and relay SB¹ is dropped because of open front contact 161. The particular SO relay at the selected field station will be dropped out during the "clearing out" period when relay SB¹ drops and opens its front contact 153.

As previously mentioned, the stepping relays at the station illustrated in Fig. 2A will operate in synchronism with the stepping relays in the office by circuits not shown but which are indicated by dotted line 150. At those stations which are dropped out during the station selection portion of the control cycle, the FB relays are not operated because of open front contact 150 of the SO relays. Since the FB relays do not operate at these dropped out stations the associated stepping relays stop operating at such stations.

Although a station may be dropped out for control selection during a cycle, this station may continue to step in the event that indications are being transmitted during this cycle and in this event the FB relays will be intermittently operated to operate the associated stepping relays because of the closed front contact 166 of relay SI¹. Front contacts 167 and 168 of relays SI¹ and SO¹, leading to dotted line 169, indicate that stepping is dependent upon a station being selected by its SO relay being picked up or by its SI relay being picked up. The stepping relays which are picked up during the cycle are dropped out during the "clearing out" period at the end of the cycle in the same manner explained in connection with those in the control office.

Selection of control code.—Jumper 9 (see Fig. 1A) connected in its full line position as illustrated determines that the first "on" period (first coded impulse) is to be frequency f^1 . This is effected by picking up relay 1F at the end of the first "off" period over a circuit extending from (+), back contact 24 of relay E, front contact 25 of relay OC, front contact 26 of relay C, back contacts 27 and 28 of relays 3V and 2V respectively, front contact 29 of relay 1V, conductor 119, front contact 8 of relay CD, jumper 9, 1F bus and

upper winding of relay 1F to (-). With relay 1F picked up, frequency f^1 is applied to the line circuit during the first "on" period because of closed front contact 30.

In the event that jumper 9 is in its center dotted line position, then the above described circuit extends by way of the 2F bus and the upper winding of relay 2F to (-). This effects the picking up of relay 2F and frequency f^2 is applied to the line circuit because of closed front contact 66. In the event that jumper 9 is in its right hand dotted position then the above described pick-up circuit extends through the lower windings of relays 1F and 2F in series to (-). This effects the picking up of both of these relays to simultaneously apply frequencies f^1 and f^2 to the line circuit because of closed front contacts 30 and 66.

This choice of three codes applied to the line circuit during the first "on" period is illustrated to indicate how station selection is accomplished on a single step of the system. It will be obvious that, in systems of larger capacity, additional code jumpers will be provided and selected on one or more additional steps of the stepping bank to provide a selection of nine different codes on two steps, twenty-seven on three steps, etc.

The code which is selected for the second "on" period is determined by the position of lever SGL. With this lever in its right hand position as assumed, frequency f^2 is applied to the line because the code selecting circuit extending through front contact 23 of relay 2V, conductor 120, and front contact 7 of relay CD, picks up relay 2F by way of lever SGL in its right hand dotted position. In the event that lever SGL is in its left hand dotted position, then the second code will be frequency f^1 because relay 1F will be picked up over the above described circuit and now including lever SGL in its left hand dotted position. In the event that lever SGL is in its mid (stop) position, then the above described selecting circuit includes both windings of relays 1F and 2F so that both frequencies f^1 and f^2 are applied to the line circuit.

Although the circuit extending through front contact 27 of relay 3V is not shown completed, it will be understood that this circuit may be connected to an additional lever, such as a switch machine control lever, for determining the frequency of the third impulse.

Station selection for controls.—For convenience in describing the operation of station selection, reference will be made to Fig. 2A which illustrates a typical field station somewhat in detail and which is considered to be the first station of the series and selected by station selecting code f^1 applied to the line circuit during the first "on" period, as previously explained. The illustrated field station is rendered responsive to this particular code because of the connection of jumper 199 in its full line position. It will be understood that a jumper similar to 199 at the station responding to code f^2 during the first "on" period, is connected in its center dotted line position and that a station responsive to code f^1, f^2 during the first "on" period has its code jumper connected in its lower dotted line position. It will also be understood that the FB relay will be impulsed in response to the operation of relay 2F¹ at selected stations because of front contact 171 which energizes the same circuit as contact 151 of relay 1F¹.

It was previously explained that relays SO¹ and SOS¹ were picked up during the condition-

ing "on" period and their stick circuits were pointed out. When relay FB¹ is dropped at the beginning of the first "off" period by the dropping of relay IF¹, relay SO¹ is stuck up over a circuit extending from (+), front contact 153 of relay SB¹, back contact 164 of relay FB¹, front contact 163 and upper winding of relay SO¹ to (-). During the first "off" period the circuit including the lower windings of relays SO¹ and SOS¹ is de-energized at open front contacts 154 and 155 because both relays IF¹ and 2F¹ are down. Relays SOS¹ is dropped during the first "off" period because its stick circuit is open at front contact 164 of relay FB¹.

When relay IF¹ is picked up at the beginning of the first "on" period in response to code frequency f¹, the selection is made for picking up relay SOS¹ and maintaining relay SO¹ picked up. This selection is made over the circuit extending from (+), front contact 170 of relay SO¹, front contact 154 of relay IF¹, back contact 155 of relay 2F¹, back contacts 156 and 157 of relays 3V¹ and 2V¹, respectively, front contact 158 of relay IV¹, jumper 199 in its full line position and lower windings of relays SO¹ and SOS¹ to (-). This selective circuit is completed by relay IF¹ before relay FB¹ picks up to open the above described stick circuit for relay SO¹ at back contact 164. Relay SO¹ is therefore prevented from dropping out and relay SOS¹ is picked up, so that the above described stick circuit for relay SO¹ is completed by way of front contacts 162 and 163 and the above described stick circuit for relay SOS¹ is completed at front contacts 164 and 165.

By means of this selective circuit the energization of relay SO¹ is made dependent upon the first code element applied to the line circuit as repeated by relay IF¹ closing its front contact 154. In the event that this code element comprises frequency f², then the above described selecting circuit extends through front contact 155 of relay 2F¹, back contact 154 of relay IF¹, back contacts 172 and 173 of relays 3V¹ and 2V¹ respectively, front contact 174 of relay IV¹ to the center point of jumper connection 199. This would effect the dropping out of relay SO¹ because of the open jumper connection at this point, but in this case the SO relay at the station having its code jumper in the center position would be maintained energized.

When relay FB¹ is dropped in response to the dropping of relay IF¹ at the beginning of the second "off" period, relay SOS¹ is dropped because of open front contact 164. Relay SO¹ is stuck up at this time because of the previously described stick circuit by way of its front contact 163 which is completed at back contact 164 before it is opened at front contact 162. The picking up of relay 2V during the second "off" period establishes a permanent stick circuit (permanent during the rest of the cycle) for relay SO¹, which circuit extends from (+), front contact 153 of relay SB¹, front contact 175 of relay 2V¹, front contact 163 and upper winding of relay SO¹ to (-).

From the above it will be apparent that a code jumper similar to 199 of Fig. 2A is provided at other field stations, but connected in different positions for making these field stations selectively responsive to different codes applied to the line circuit. With the provision of a single code jumper 9 in the office and its associated code jumper 199 at the illustrated field station (and similar jumpers at other stations), three dif-

ferent code combinations are possible during the single impulse period which is used for station selection. Two of these may be employed for station selection with the third being used for the control phantom code. This is because the system will inherently transmit a series of f² impulses during the station selecting step of the cycle if no CD relay is picked up because of closed back contact 19 of relay LS, due to the system being initiated from a field station. It will be understood that when two steps are used for station selection for controls, either combinations may be used for selecting stations with the ninth corresponding to the control phantom code.

Transmission of controls.—It will be recalled that the code combination applied to the line circuit during the second "on" period consisted of frequency f² as determined by signal lever SGL being in its right hand dotted position and this code is received at the selected field station by the picking up of relay 2F¹. A circuit is closed for actuating the polar contact of signal relay SGR¹ to the right which extends from (+), front contact 170 of relay SO¹, front contact 155 of relay 2F¹, back contact 154 of relay IF¹, back contact 172 of relay 3V¹, front contact 173 of relay 2V¹, lower winding of relay SGR¹ and upper winding of relay SS¹ to (-). The polar contact of relay SS¹ is likewise positioned to the right and a circuit is completed (not shown) for clearing signal WS¹.

In the event that lever SGL is in its left hand dotted (east) position for applying frequency f¹ to the line during the second "on" period, then relay IF¹ is picked up and a circuit is completed for actuating the polar contact of relay SGR¹ to the left and the polar contact of relay SS¹ to the right for completing a signal clearing circuit for signal ES¹. This circuit extends from (+), front contact 170 of relay SO¹, front contact 154 of relay IF¹, back contact 155 of relay 2F¹, back contact 156 of relay 3V¹, front contact 157 of relay 2V¹, upper winding of relay SGR¹ and upper winding of relay SS¹ to (-). It will be understood that the windings of relay SGR¹ are oppositely related as indicated by the arrows associated with these windings to obtain the polar operation of this relay.

In the event that lever SGL is in its center (stop) position for applying both frequencies f¹ and f² to the line circuit during the second "on" period, then relays IF¹ and 2F¹ will both be picked up so that neither of the above described circuits for relay SGR¹ will be completed, but a circuit will be completed for the lower winding of relay SS¹ which extends from (+), front contacts 170, 176 and 177 of relays SO¹, 2F¹ and IF¹ respectively, back contact 178 of relay 3V¹, front contact 179 of relay 2V¹ and lower winding of relay SS¹ to (-). The energization of the lower winding of relay SS¹ positions its polar contact to the left so that both signals are put to stop.

In a similar manner additional steps may be used for transmitting additional controls to the selected station for controlling the switch machine, by energizing a switch machine control relay in accordance with the frequency of the impulses applied to the line circuit as determined by the position of a switch machine control lever. However, since the above typical examples illustrate the manner of such transmission it is believed unnecessary to point out in detail how this control is effected.

During the operation of a control cycle no impulses of frequency f^4 are superimposed on the line circuit at a field station, because it is assumed that no SI relay is picked up for effecting the operation of the f^4 frequency generator at any station. This results in neither relay MB nor MF (see Fig. 1C) being picked up during a control cycle and therefore (B—) is applied through the back contacts of these relays during the indication station registration step of the cycle for positioning pilot relays 1PT and 2PT to the left. Such a code must not register any field station in the control office and therefore the contacts of these two pilot relays in their left hand positions in combination do not select any station relay.

The selection and operation of a station relay for identifying a calling field station in the office will be described in connection with the transmission of indications. A series of "off" and "on" periods of a cycle during which no f^4 carrier current is received in the control office during the station selecting steps of the cycle results in an indication phantom code.

Transmission of indications.—Although the system is of the duplex type and indications may be transmitted from any station to the control office during the same cycle that controls are transmitted to the same or some other station, it is convenient to first explain the transmission of indications alone on a separate operating cycle before considering the duplex feature of the system.

The manner in which field stations are allowed to transmit only one at a time in a predetermined order will be explained in connection with the superiority of code lock-out feature, this feature being included in the description following the description relating to the transmission of indications from a single field station, assuming that such a field station is the only one having new indications to transmit at the beginning of the cycle.

Automatic start.—Referring to Fig. 2B, a change in condition of the detector track section or a change in condition of the traffic controlling devices at the station may occur for effecting the initiation of the system for the transmission of indications. Although the detailed circuits are not shown it will be assumed (and readily understood by referring to Fig. 2 of Patent No. 2,049,406) that any such change may so condition the circuits that relay CH¹ is dropped. The dropping of relay CH¹ closes a circuit for picking up relay SI¹ which extends from (+), back contact 180 of relay CH¹, back contact 181 of relay SB¹ and upper winding of relay SI¹ to (—). It will be assumed at present (and later explained) that relay SI¹ remains picked up throughout the following indication cycle. The closure of front contact 182 of relay SI¹ starts the operation of the oscillator mixer tube OSM¹ by completing the plate circuit of this tube.

Tube OSM¹ is a multi-electrode tube known in the radio art as a Pentagrid converter. Such a tube is shown and its operation is described on page 23 of the R. C. A. Cunningham Radiotron Manual Technical Series RC-12, copyright 1934. This tube comprises heater 190, cathode 191, grids 192, 193, 194 and 195 and plate 196. Although no connection is shown to heater 190, it will be understood that this element may be energized from any proper source of heater current supply. In this tube, cathode 191 and the first two grids 192 and 193 may be regarded as a composite

cathode which supplies a modulated electron stream. The modulated electron stream has its frequency determined by the characteristics of the oscillating circuit including transformer OST¹, condenser OSC¹ and inductance OL¹. The modulated electron stream is further controlled by the other grids 194 and 195 and plate 196. In other words grid 192 is the control grid for the oscillator portion of the tube, grid 193 is the anode for the oscillator and grids 195 (connected together within the tube) are used to accelerate the electron stream from the cathode, which acceleration is controlled or modulated by frequency f^3 applied to grid 194 by way of transformer 3TF³.

Grids 195 electrically shield the signal control grid 194 from the other electrodes, which increases the output impedance of the tube to provide a desirable characteristic gain. From the above brief explanation it will be understood that the oscillator grid circuit, including grid 192, is made to oscillate at frequency f^4 so that the electron stream in flowing through grid 192 is modulated at this frequency. This modulated electron stream comes under the influence of grid 195 which is operated at a positive potential with respect to the cathode and as a result the electron stream is accelerated toward plate 196 by grid 195. The incoming monitoring frequency f^3 , applied to grid 194, preferably monitors or dominates the electron stream (already modulated at the oscillator frequency), thus producing plate current, the frequency of which has a definite relation to the synchronizing or monitoring frequency f^3 . Since transformer 4TFR¹ applies the oscillator frequency f^0 and the indication signal frequency f^4 , both of which have practically the same number of cycles per unit of time, from the plate circuit to the line circuit by way of the composite set at the transmitting field station, these two frequencies will be received in the control office.

However, the control office apparatus has not yet been started into operation so that frequency f^3 is not yet applied to the line circuit. Frequency f^0 is received in the control office and passed through transformer 4TFR, level control 4LC, transformer 4TFR1, amplifier 4A1, transformer 4TFR2, amplifier 4A2, transformer 4TFR3 and rectifier 4RC through the lower winding of relay MB. It will be understood that the above described units in the control office are designed to effectively pass frequency f^0 as well as frequency f^4 , which frequencies, as above mentioned, are practically the same.

Relay MB is therefore picked up and a circuit is closed for picking up relay CF which extends from (+), front contact 67 of relay MB, conductor 121, back contact 65 of relay SC and winding of relay CF to (—). Relay CF closes a circuit at its front contact 68 for picking up relay OC and relay OC closes a circuit for picking up relay 2F which extends from (+), back contact 24 of relay E, front contact 25 of relay OC, back contact 26 of relay C, front contact 20 of relay CF, conductor 122, back contact 19 of relay LS and upper winding of relay 2F to (—). The picking up of relay 2F, applies frequency f^2 to the line circuit, since the three frequency generators are started by the closure of front contact 69 of relay CF, by way of conductor 123. It will be obvious that frequency f^3 is applied to the line circuit as soon as relay CF picks up to start the generators into operation.

The system now operates through a cycle as

previously described, except in this case relay 2F is always actuated to apply frequency f^2 to the line during the "on" periods because it is assumed that relay C is down and its back contact 26 is closed. A stick circuit is closed for relay CF, when relay SA picks up, which extends from (+), front contact 12 of relay SA, conductor 124, front contact 70 and winding of relay CF to (-).

As soon as the office applies frequency f^3 to the line circuit it monitors or dominates the frequency f^0 , which is applied to the line circuit at the transmitting station, to produce frequency f^4 preferably having a definite frequency relation to frequency f^3 . It will therefore be understood that during the following cycle of operations, frequency f^4 is selectively applied to the line for transmitting indications. Frequency f^0 is applied when the station start is initiated, from the secondary of transformer 4TFT¹, by way of back contact 183 of relay SB¹ and front contact 184 of relay SI¹. During the following cycle, frequency f^3 is received through level control network 3LC¹ and transformer 3TF² and amplified by amplifier 3A¹, from which it is applied to oscillator mixer grid 194 by way of transformer 3TF³.

During the following cycle, relay SB¹ will be picked up and since front contacts 183 and 184 are closed, indication codes are transmitted in accordance with the operations of relays FB¹, PF¹ and PB¹ as will now be described. During the conditioning "on" period, the opening of back contact 183 of relay SB¹ removes frequency f^4 from the line, since neither front contact 185 of relay PF¹ nor 186 of relay PB¹ is closed. Relay MB in the office is dropped during the first "off" period when front contact 91 of relay FB and back contact 79 of relay E are both open.

Registration of a field station.—To avoid confusion regarding the periods of selection, transmission and execution of indications, the order of occurrence of these periods will be briefly pointed out before the manner of transmitting indications is explained in detail. The first "off" indication is selected at the station during the first "off" period and is executed in the office during the first "on" period. The first "on" indication is selected at the station during the first "off" period, is transmitted and received during the first "on" period and is executed in the office during the second "off" period. The second "off" indication is selected at the station during the first "on" period, is transmitted and received during the second "off" period and is executed in the office during the second "on" period. The second "on" indication is selected at the station during the second "off" period, is transmitted and received during the second "on" period and is executed in the office during the third "off" period. The third "off" indication is selected at the station during the second "on" period, is transmitted and received during the third "off" period and is executed in the office during the third "on" period. The third "on" indication is selected at the station during the third "off" period, is transmitted and received during the third "on" period and is executed in the office during the "clearing out" period.

At the particular station having indications to transmit, relay SI¹ is up and by means of its front contact 187 the indication code transmitting relays PB¹ and PF¹ are rendered effective. It will be assumed that the transmitting station, illustrated in Figs. 2A and 2B, identifies itself in the control office by a code comprising

an impulse of indication carrier current f^4 during the first "off" and the first "on" periods as determined by jumpers 188 and 189 in their full line positions. This code combination positions the polar contacts of pilot relays 1PT and 2PT (see Fig. 1C) to their right hand positions for selecting station relay ST, which is the relay for identifying the illustrated station in the control office.

When relay FB¹ is picked up during the conditioning "on" period, the first "off" indication is selected. Relay PB¹ is picked up over a circuit extending from (+), jumper 188 in its full line position, back contacts 200, 201 and 202 of relays 1V¹, 2V¹ and 3V¹ respectively, front contact 197 of relay FB¹, winding of relay PB¹ and front contact 187 of relay SI¹ to (-). This indication is transmitted over the line circuit during the first "off" period when relay FB¹ drops, at which time a stick circuit is completed for relay PB¹ extending from (+), front contact 198 of relay PB¹, back contact 197 of relay FB¹, winding of relay PB¹ and front contact 187 of relay SI¹ to (-).

Relay PB¹ up determines that indication frequency f^4 shall be transmitted over the line circuit during the first "off" period. The circuit for transmitting this indication carrier current may be traced from the right hand terminal of the secondary winding of transformer 4TFT¹, front contact 184 of relay SI¹, front contact 183 of relay SB¹, back contact 203 of relay FB¹, front contact 186 of relay PB¹, conductor 204 to the upper line conductor by way of the composite set, from the upper line conductor in the office by way of the composite set, conductors 112 and 71, condenser 4C, primary winding of transformer 4TFR, conductors 72 and 113 to the lower line by way of the composite set in the office, from the lower line conductor by way of the composite set at the station and conductor 205 to the left hand terminal of transformer 4TFT¹.

The transmission of this first "off" indication code is terminated when relay FB¹ picks up and opens the above described circuit at back contact 203. When relay FB¹ picks up to terminate this first "off" code the above described stick circuit for relay PB¹ is opened at back contact 197 and relay PB¹ is dropped. In the event that jumper 188 is in its alternate dotted line position, then relay PB¹ will not be picked up so that no indication carrier current will be transmitted during the first "off" period.

The first "on" indication code is selected when relay FB¹ is dropped during the first "off" period. A circuit is closed for picking up relay PF¹ which extends from (+), jumper 189 in its full line position, back contact 206 of relay 2V¹, front contact 207 of relay VP¹, back contact 208 of relay FB¹, winding of relay PF¹ and front contact 187 of relay SI¹ to (-). When relay FB¹ is picked up during the first "on" period a stick circuit is closed for relay PF¹ which extends from (+), front contact 209 of relay PF¹, front contact 208 of relay FB¹, winding of relay PF¹ and front contact 187 of relay SI¹ to (-). This stick circuit is broken and relay PF¹ is dropped during the second "off" period, when relay FB¹ drops and opens the above described stick circuit at front contact 208.

Carrier current frequency f^4 is transmitted during the first "on" period (while relay FB¹ is picked up) over the above described circuit, but which now extends through front contact 183 of relay SB¹, front contact 203 of relay FB¹ and front contact 185 of relay PF¹. This carrier cur-

rent impulse is terminated when relay FB¹ drops during the second "off" period and opens the above described circuit at front contact 203. In the event that jumper 189 is in its alternate dotted line position, then relay PF¹ will not be picked up and no carrier current frequency will be transmitted over the line circuit during the first "on" period.

Referring to the control office, the indication frequency f^1 received during the first "off" period is applied to the input of amplifier 4A¹ by way of level control network 4LC and is amplified by amplifiers 4A¹ and 4A², with rectified current resulting from this carrier frequency being effective to pick up relay MB over a circuit which may be traced from the upper terminal of the secondary windings of transformer 4TFR³, conductor 125, rectifier 4RC, front contacts 77 and 76 of relays CF and SC respectively, conductor 126, back contacts 75, 74 and 73 of relays FB, 2F and 1F respectively and lower winding of relay MB to the lower terminal of the secondary winding of transformer 4TFR³. During this first "off" period, relay MB is stuck up over a circuit extending from (+), front contact 78 of relay SB, back contact 79 of relay E, conductor 127, front contact 80 and upper winding of relay MB to (-).

It will be obvious that relay SC is up during the transmission of indications, so that the circuit for relay MB is through contacts 77 and 76 instead of through back contact 87.

The first "off" indication code is executed in the control office when relay FA drops at the beginning of the first "on" period by closing a circuit which extends from (B+), front contact 81 of relay MB, back contact 82 of relay FA, conductor 128, front contact 83 of relay CF, back contacts 84 and 85 of relays 3V and 2V respectively, front contact 86 of relay 1V, conductor 129, and winding of relay 1PT to (CN). The polar contacts of relay 1PT are positioned to the right in response to the closure of this executing circuit. The execution of the first "off" code is terminated when relay FA is picked up at the beginning of the second "off" period, by the opening of back contact 82.

The first "on" code received in the control office during the first "on" period is effective to pick up relay MF over a circuit which may be traced from the upper secondary winding of transformer 4TFR³, conductor 125, rectifier 4RC, front contacts 77 and 76 of relays CF and SC respectively, conductor 126, front contact 75 of relay FB, either front contact 88 of relay 2F or front contact 89 of relay 1F (whichever is up) and lower winding of relay MF to the lower terminal of the secondary winding of transformer 4TFR³. Relay MF is stuck up throughout the second "off" period by means of a first stick circuit which is closed when relay E picks up and which extends from (+), front contact 78 of relay SB, front contact 79 of relay E, conductor 130, front contact 90, and upper winding of relay MF to (-). Before relay E drops during the second "off" period a second stick circuit is closed for relay MF which extends from (+), front contact 78 of relay SB, conductor 131, back contact 91 of relay FB, front contact 90 and upper winding of relay MF to (-).

The executing circuit for the first "on" code is completed when relay FA picks up at the beginning of the second "off" period and extends from (B+), front contact 92 of relay MF, front contact 93 of relay FA, conductor 132, front con-

tact 94 of relay VP, back contact 96 of relay 2V, conductor 133, and winding of relay 2PT to (CN). This results in positioning the polar contacts of relay 2PT to the right. The execution of the first "on" indication code is terminated when relay FA is dropped at the beginning of the second "on" period and opens its front contact 93. When relay 2V is picked up during the second "off" period relay ST is picked up over a circuit extending from (+), front contact 98 of relay 2V, conductor 134, polar contacts 99 and 100 of relays 1PT and 2PT in their right hand positions and winding of relay ST to (-).

It will be obvious that other transmitting stations will position pilot relays 1PT and 2PT in other combinations of positions for identifying these other stations in a manner which will be obvious from the above example, considering that a field station may apply a pulse (impulse of carrier frequency f^1) or a non-pulse (no impulse of carrier frequency f^1) during the "off" and "on" periods of the station selecting steps of the cycle. It will be understood that additional steps of the cycle may be allotted for transmitting similar codes in systems of larger size, the number of codes provided being equal to four for one step (an "off" and "on" period) sixteen for two steps, sixty-four for three steps, etc.

Transmission of indications.—After thus having registered or identified the transmitting field station in the control office the remaining steps of the cycle are employed for the transmission of indications from the registered station. For the purpose of illustrating indication transmission, track relay T¹ and signal repeating relay M¹ are illustrated in Fig. 2B. It is assumed that both of these relays are energized to repeat the condition that the associated track section is unoccupied and that all signals associated therewith are at stop.

The second "off" indication is selected during the first "on" period when relay FB¹ picks up and with relay T¹ picked up, relay PB¹ is dropped. This results in a non-pulse for the second "off" indication so that relay MB will be dropped during the second "off" period, when relay FB drops and opens its front contact 91. This is because at this time relay E will be up with its back contact 79 open so that the stick circuit for relay MB will be deenergized and, since no indication pulse is received, relay MB is dropped.

The second "off" indication is executed during the second "on" period when relay FA drops for closing a circuit which extends from (B-), back contact 81 of relay MB, back contact 82 of relay FA, conductor 128, front contact 83 of relay CF, back contact 84 of relay 3V, front contact 85 of relay 2V, conductor 135, front contact 101 of relay ST and winding of relay 1IR to (CN). Current flowing in this direction over this circuit positions the polar contacts of relay 1IR to the left for closing an indication circuit in the control office (not shown) which indicates that relay T¹ at the field station is picked up. The second "off" execution period is terminated at the beginning of the third "off" period, when relay FA picks up and opens the above described circuit at back contact 82.

In the event that track relay T¹ is down, then the second "off" indicating code will be a pulse because relay PB will be energized when the second "off" selection is made, over a circuit extending from (+), back contact 210 of relay T¹, front contact 200 of relay 1V¹, back contacts 201 and 202 of relays 2V¹ and 3V¹ respectively, front con-

tact 197 of relay FB¹, winding of relay PB¹ and front contact 187 of relay SI¹ to (-). From the above example it will be understood that relay PB¹ is stuck up (when picked up during the first "on" period) throughout the second "off" period in a manner which will be obvious from the above explanation relating to the sticking of relay PB¹ throughout the first "off" period. With a pulse received in the control office during the second "off" period, relay MB will be energized over the previously described circuit and the executing circuit will extend from (B+) at front contact 81 of relay MB, for positioning the polar contacts of relay 1IR to the right to close an indication circuit (not shown) repeating the condition that track relay T¹ is down.

From the above example it is believed unnecessary to point out in detail how the second "on" indication code is selected during the second "off" period, but it will merely be mentioned that a pulse is transmitted during the second "on" period if relay M¹ is down for picking up relay PF¹ over a circuit including back contact 211 of relay M¹, front contact 212 of relay IV¹, back contact 213 of relay 3V¹, back contact 207 of relay VP¹, back contact 208 of relay FB¹, winding of relay PF¹ and front contact 187 of relay SI¹ to (-). With relay PF¹ picked up the second "on" code is a pulse for picking up relay MF in the control office, which will be stuck up throughout the third "off" period. The executing circuit for the second "on" pulse code will be completed while relay FA is picked up, which is effective to position the polar contacts of relay 2IR to the right by way of a circuit extending through front contact 102 of relay ST. Obviously if relay M¹ is up, then a non-pulse for the second "on" code is transmitted and relay MF will be down, when the execution of the second "on" code takes place, for applying (B-) over the above described circuit to relay 2IR.

It will be obvious from the above examples that a choice of four indications from the transmitting field station is provided to indicate any one of four conditions at each step ("off" and "on" period) of the cycle. It will furthermore be obvious that front contacts of stepping relays 2V¹ and 3V¹ may connect to additional selecting circuits for applying additional indication codes from the transmitting field station.

Lock-out between stations.—It may happen that changes occur at a plurality of field stations at the same time, or in rapid succession, so that more than one station will have new indications to transmit at the beginning of a cycle. In order to prevent more than one station remaining in active association with the line after the station selection steps of a cycle, lock out means are provided at each station which are effective to give preference to that station having a superior code and to rule off or lock out another station or stations (having inferior codes) having indications to transmit during this cycle.

It will be assumed that changes occur at substantially the same time at the first field station illustrated in Figs. 2A and 2B and at the second field station from the control office. In this event relay CH¹ will be dropped and a similar change relay at the second station will be down at the same time. The dropping of relay CH¹ picks up relay SI¹ as previously described and a similar circuit is completed at the second station for picking up its SI relay.

It will be recalled that the illustrated (first) station registered itself in the office by transmitting code "pulse, pulse" during the first "off" and

the first "on" periods. The second station will have another code such as "pulse, non-pulse". A "pulse" is superior to a "non-pulse". Since all the stations are connected to the line and receive the indication carrier frequency f , the associated ME relays will pick up in response to a "pulse" code and remain down in response to a "non-pulse" code.

The first "off" code transmitted by both the first and second stations is "pulse". Therefore the SI relays at both stations will remain up in response to this code, due to the code selecting circuits. Relay SI¹ is held up by means of its pick-up circuit until relay SB¹ picks up during the conditioning "on" period to open this pick-up circuit at back contact 181. Before relay SB¹ picks up, relay SIS¹ is picked up (during the conditioning "on" period) over a circuit extending from (+), front contacts 214 and 215 of relays FB¹ and SI¹ and winding of relay SIS¹ to (-). A stick circuit is closed for relay SI¹ which extends from (+), back contacts 221 and 222 of relays PF¹ and ME¹ respectively, front contact 218 of relay FB¹, front contact 219 and lower winding of relay SI¹ to (-). With relay SA¹ picked up this stick circuit extends from (+), front contact 223 of relay SA¹, front contact 220 of relay SIS¹, front contact 219 and lower winding of relay SI¹ to (-). This stick circuit is opened by relay SIS¹ dropping in the first "off" period because of open front contact 214 of relay FB¹. The above discussion also applies to the manner in which the SI relay at the second station is maintained picked up until the associated FB relay drops in the first "off" period.

When relay ME¹ picks up at the first and second stations in response to the first "off" code "pulse" (pulse because the PB relays at both stations are up), the selecting stick circuits for the SE relays at these stations are completed for maintaining them energized. This circuit for relay SI¹ extends from (+), front contacts 216 and 217 of relays PB¹ and ME¹ respectively, back contact 218 of relay FB¹, front contact 219 and lower winding of relay SI¹ to (-). A similar circuit is completed at the second station.

With the SI relays up, the associated SIS relays pick up when the associated FB relays pick up and close their front contacts (such as contact 214 in Fig. 2B) in the first "on" period. With relay SIS¹ up, relay SI¹ is stuck up over the previously described circuit including front contact 220 until relay SIS¹ drops in the second "off" period. Before the dropping of relay SIS¹, relay 2V¹ picks up and completes the permanent stick circuit for relay SI¹ which extends from (+), front contact 223 of relay SA¹, front contact 224 of relay 2V¹, front contact 219 and lower winding of relay SI¹ to (-).

Relay SI¹ is not dropped when the first "on" code selection is made because relay ME¹ is up and relay PF¹ is up to complete the selecting stick circuit for relay SI¹ which extends from (+), front contacts 221 and 222 of relays PF¹ and ME¹ respectively, front contact 218 of relay FB¹, front contact 219 and lower winding of relay SI¹ to (-). Relay PF¹ is up because the first station transmits a "pulse" code for the first "on" and relay ME¹ is up because it registers the reception of the "pulse" first "on" code.

The SI relay at the second station is dropped in response to a "pulse" for the first "on" code because the ME and PF relays are out of correspondence at that station so that the selecting stick circuit cannot be completed. This is be-

cause the ME relay at the second station picks up to register the reception of the "pulse" code, but the PF relay at the second station is down because this station transmits a "non-pulse" for the first "on" code. With the SI relay down at the second station, it cannot be again picked up during this cycle because of an open back contact similar to 181 of relay SB¹. The second station is thus ruled off or locked out and is prevented from transmitting its indications because of open front contact similar to 187 of relay SI¹. Relay SI¹ at the first station however remains up and its indications are transmitted.

In the above example only two stations are considered as being ready to send in indications and one of these stations was dropped out during the first "on" code. The same plan of operation occurs irrespective of the number of stations ready at the same time to send in indications, such stations being dropped out one or more at a time during each code transmission, until only one station is left with its SI relay energized after the full number of station selecting steps has been taken.

This scheme of station selection for incoming indications is on the basis of superiority of code calls. From the example above given, it will be seen that a station having a code call with a "pulse" for the first code will drop out all other stations having a code call with a "non-pulse" for the first code. This is because the first (superior) of these stations has its code transmitting relay and its code receiving relay in corresponding positions, while the code transmitting relays and the code receiving relays at the other stations are in non-corresponding positions, so that the SI relays at these other stations have no selecting stick circuits completed and consequently they are dropped out.

Although not illustrated in the drawings, it will be understood that the CH relay at the superior station, which is effective to transmit its indications during a cycle, is picked up or resensitized after the station selecting codes have been transmitted, as illustrated in Fig. 2 of Patent No. 2,049,406. At those stations which are ruled off, the CH relays remain down so that the associated SI relays are again picked up at the beginning of the next operating cycle and the most superior station of those still having indications to transmit registers itself in the control office in the manner previously described, while the others take their turn in registering themselves in the control office in accordance with the superiority of their code calls.

Duplex operation.—It has been pointed out that control and indication cycles may occur separately or simultaneously. The operations for separate control and indication cycles have been described and it will now be pointed out how the system functions when controls and indications are transmitted during the same cycle. An actuation of the starting button in the office results in picking up of the associated CD relay. This relay may be picked up at the beginning of a cycle any time up to the end of the period marked off by the picking up of relay SA and the consequent opening of its back contact 12. If a field station has initiated the system, which results in the picking up of relay CF in the control office as previously described, this relay CF may be picked up over the previously described circuit any time up to the period marked off by the picking up of relay SC and the consequent opening of its back contact 65. When relay CF is picked up it is

stuck up over the previously described circuit extending through front contact 12 of relay SA and when relay CD is picked up it is stuck up over the previously described circuit including back contact 62 of relay 3V.

With relays CD and CF picked up due to office and field starts the system runs through a cycle of operations as before, but since back contact 19 of relay LS is open and front contacts 7, 8, etc. of relay CD are closed the carrier frequency f^2 is not invariably applied to the line circuit by relay 2F remaining up, as was the case during the transmission of indications alone, but carrier frequencies f^1 , f^2 are selectively applied in accordance with the code jumper and control lever connections.

The stepping and impulsing operations will be effected as previously described, with the station being selected for controls by the selective energization of the associated SO relay in a manner which has already been explained. Since the SI relay at the station having indications to transmit is also picked up, the associated PB and PF relays will be selectively actuated to apply the indication code, this because of closed front contact such as 187 of relay SI¹.

The resulting cycle of operations is thus the same, in so far as the transmission of control codes (made up of frequencies f^1 and/or f^2) over the line circuit is concerned, as was previously described in connection with a control cycle alone. Similarly the resulting operations during the cycle, insofar as transmitting the indication carrier frequency f^4 over the line circuit during the "off" and "on" periods is concerned, is the same as described for a cycle during which indications alone were transmitted. It is believed that the above brief explanation is sufficient to indicate that, since the transmission of controls and the transmission of indications are effected by the separate and distinct conditioning of the line circuit, these transmissions may be combined and brought about during a single cycle of operations in the manner previously pointed out.

Synchronizing carrier frequency f^4 .—The above explanation pointed out that the indication code transmitting frequency f^4 is obtained from the oscillator mixer tube at the transmitting station by modulating the oscillator frequency f^0 generated by this tube with the incoming synchronizing frequency f^3 generated in the control office with a force to cause the frequency f^4 to follow the frequency f^3 so as to have a definite frequency relation thereto. The purpose of making frequency f^4 definitely relative to frequency f^3 is to prevent interference and possible neutralization of the f^4 frequencies when superimposed on the line circuit at two or more transmitting stations. If frequency f^4 were to be generated locally at each station or were to follow frequency f^0 rather than frequency f^3 , then when two or more stations picked up their SI relays in an attempt to transmit indications during the same cycle, it will be obvious that the phase angle between two or more of these frequencies applied to the line might be such that they would cancel each other and not be received in the control office and at the transmitting stations. By dominating the local oscillator frequencies f^0 generated at each transmitting station, by a common fixed synchronizing frequency f^3 generated in the control office, it will be apparent that the resultant indication code transmitting frequencies f^4 applied to the line at

two or more of these simultaneously transmitting stations will all be of the same frequency and in the same phase relation because they are all dependent upon and are controlled by common synchronizing frequency f^3 .

Having thus described a centralized traffic controlling system, it is desired to be understood that this form of the present invention has been selected to facilitate in the disclosure rather than to limit the number of forms which the invention may assume and it is further to be 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 of the invention as limited by the appended claims.

What we claim is:—

1. A communication system for transmitting multiple impulse codes, one at a time, from a central office to one of a plurality of remote stations over a continuously closed line circuit the continuity of which must not be and is not broken comprising; a central office; a plurality of field stations; a continuously closed line circuit connecting said office and field stations; a plurality of sources of alternating current of distinctive frequencies at said office; a plurality of distinctive frequency responsive relays at each of said field stations each responsive to only one of the distinctive frequency sources at said office; a step-by-step means at said office to define a cycle of impulse periods and time spaces between impulse periods and for applying a potential impulse from one or more of the sources of alternating current at said office across said line circuit during each of a plurality of impulse periods of such cycle to characterize a code transmitted to said field stations; step-by-step means at each field station each operated in synchronism with the step-by-step means at said office by said potential impulses irrespective of the particular frequency or frequencies of each of said plurality of impulses; a stick relay at each of said field stations assuming an energized condition at the beginning of each cycle of impulses; a stick circuit for each stick relay maintained closed throughout an entire cycle of impulses only if each potential impulse of such cycle is of such frequency or combination of frequencies as to characterize the complete code for that station; and means at each station controlled or not controlled in accordance with whether the stick relay for such station is energized during the last impulse period of a cycle of impulses.

2. A communication system for transmitting indications, one at a time, from one of a plurality of field stations to a central office over a continuously closed line circuit the continuity of which must not be and is not broken comprising; a central office; a plurality of field stations; a continuously closed line circuit connecting said office and field stations; a source of alternating current of a particular frequency at said office; step-by-step means at said office for defining the impulse periods and time spaces between impulse periods of a code cycle and for applying an impulse potential from said source to said line circuit during each impulse period of a code cycle; step-by-step means at each of said field stations operated in synchronism with the step-by-step means at said office and in response to said impulse potentials; a source of alternating current at each of said field stations of a frequency distinctive from the alternating current source at said office; a stick relay at each

of said field stations assuming an energized condition at the beginning of each code cycle when an indication is attempted to be transmitted from that station; an impulse responsive relay at each of said field stations responsive only to an alternating current impulse of the frequency of the alternating current source at such or any other field station; means at each field station effective only when such field station is attempting to transmit a code to said office and the stick relay for that station is energized for applying or not applying a potential from the source of alternating current at such field station to said line circuit during each impulse period of a code cycle to energize or not energize the impulse relay at that and every other field station to characterize a code; a stick circuit for each of said stick relays broken when the impulse responsive relay at that station is energized for an impulse period when no potential was applied to said line circuit at that station; and means at said office responsive only to alternating current of the frequency of the alternating current sources at said field stations for registering the impulses applied to said line circuit at said stations for a complete code cycle; whereby the indication code received at said office is that code of a plurality of codes which are being attempted to be transmitted which is superior and has held its corresponding stick relay energized to the end of the code cycle.

3. A communication system for transmitting indications, one at a time, from one of a plurality of field stations to a central office over a continuously closed line circuit the continuity of which must not be and is not broken comprising; a central office; a plurality of field stations; a continuously closed line circuit connecting said office and field stations; two sources of alternating current of distinctive frequencies at said office; step-by-step means at said office for defining the impulse periods and time spaces between impulse periods of a code cycle and for applying an impulse potential from one of said sources to said line circuit one during each impulse period of a code cycle; step-by-step means at each of said field stations operated in synchronism with the step-by-step means at said office in response to said impulse potentials; generating means for generating alternating current at each of said field stations of a frequency distinctive from the alternating current sources at said office but controlled by the other of said sources of alternating current at said office so that the frequencies and phase relation of the potentials generated by the generating means at each of a plurality of field stations are substantially the same; a stick relay at each of said field stations assuming an energized condition at the beginning of each code cycle when an indication is attempted to be transmitted from that station; an impulse responsive relay at each of said field stations responsive only to an alternating current impulse of the frequency of the alternating current generated at such or any other field station; means at each field station including the stick relay at such station effective only when the stick relay for that station is energized for applying or not applying a potential from the generating means at such field station to said line circuit during each impulse period of a code cycle to form a code and to energize or not energize the impulse relay at that and every other field station; and a stick circuit for each of said stick relays broken when the impulse

responsive relay at that station is energized for an impulse period when no potential was applied to said line circuit at that station; means at said office for registering the impulses applied to said line circuit at said stations for a complete code cycle; whereby the potentials generated by the generating means at a plurality of field stations will not be in phase opposition to neutralize each other and whereby the indication code received at said office is that code of a plurality of codes which are being attempted to be transmitted which is superior and has held its corresponding stick relay energized to the end of the code cycle.

4. A communication system for transmitting controls, one at a time, from a control office and transmitting indications, one at a time, from one of a plurality of field stations to a central office over a continuously closed line circuit the continuity of which must not be and is not broken comprising; a central office; a plurality of field stations; a continuously closed line circuit connecting said office and field stations; sources of alternating current of distinctive frequencies at said office; step-by-step means at said office for defining the impulse periods and time spaces between impulse periods of a code cycle and for applying an impulse potential from one or more of said sources to said line circuit during each impulse period of a code cycle to characterize a control code; step-by-step means at each of said field stations operated in synchronism with the step-by-step means at said office and in response to said impulse potentials irrespective of their frequencies; a source of alternating current at each of said field stations of a frequency distinctive from the alternating current sources at said office; a control stick relay and an indication stick relay at each of said field stations both assuming an energized condition at the beginning of each code cycle when an indication is attempted to be transmitted from that station and a control code is to be transmitted from said office; an impulse responsive relay at each of said field stations responsive only to an alternating current impulse of the frequency of the alternating current source at such or any other field station; means at each field station effective only when such field station is attempting to transmit a code to said office and the indication stick relay for that station is energized for applying or not applying a potential from the source of alternating current at such field station to said line circuit during each impulse period of a code cycle to energize or not energize the impulse relay at that and every other field station to characterize a code; a stick circuit for each of said indication stick relays broken when the impulse responsive relay at that station is energized for an impulse period when no potential was applied to said line circuit at that station; means at said office responsive only to alternating current of the frequency of the alternating current sources at said field stations for registering the impulses applied to said line circuit at said stations for a complete code cycle; whereby the indication code received at said office is that code of a plurality of codes which are being attempted to be transmitted which is superior and has held its corresponding stick relay energized to the end of the code cycle; a stick circuit for the control stick relay at each field station broken if the code of impulse potentials transmitted from said office disagree with the code characterizing that field station;

and means at each field station controlled by its associated control stick relay only if such control stick relay has its stick circuit retained closed to the end of a code cycle.

5. A communication system for transmitting controls one at a time to any one of a plurality of field stations and transmitting indications, one at a time, from one of said plurality of field stations to a central office over a continuously closed line circuit the continuity of which must not be and is not broken comprising; a central office; a plurality of field stations; a continuously closed line circuit connecting said office and field stations; a plurality of sources of alternating current of distinctive frequencies at said office; step-by-step means at said office for defining the impulse periods and time spaces between impulse periods of a code cycle and for applying an impulse potential from one or more of said sources to said line circuit one during each impulse period of a code cycle to characterize a control code; step-by-step means at each of said field stations operated in synchronism with the step-by-step means at said office in response to said impulse potentials irrespective of their frequencies; generating means for generating alternating current at each of said field stations of a frequency distinctive from the alternating current sources at said office but controlled by a third source of alternating current at said office so that the frequencies and phase relation of the potentials generated by the generating means at each of a plurality of field stations are substantially the same; a control stick relay and an indication stick relay at each of said field stations assuming an energized condition at the beginning of each code cycle when a control code is transmitted from said office and an indication is attempted to be transmitted from that station; an impulse responsive relay at each of said field stations responsive only to an alternating current impulse of the frequency of the alternating current generated at such or any other field station; means at each field station including the indication stick relay at such station effective only when such stick relay for that station is energized for applying or not applying a potential from the generating means at such field station to said line circuit during each impulse period of a code cycle to form an indication code and to energize or not energize the impulse relay at that and every other field station; a stick circuit for each of said indication stick relays broken when the impulse responsive relay at that station is energized for an impulse period when no potential was applied to said line circuit at that station; means at said office for registering the indication impulses applied to said line circuit at said stations for a complete code cycle; a stick circuit for the control stick relay at each field station broken if the code of impulse potentials transmitted from said office disagree with the code characterizing that field station; and means at each field station controlled by its associated control stick relay only if such control stick relay has its stick circuit retained closed to the end of the code cycle; whereby a control code and an indication code are transmitted simultaneously and whereby the potentials generated by the generating means at a plurality of field stations will not be in phase opposition to neutralize each other and whereby the indication code received at said office is that code of a plurality of codes which are being attempted to be transmitted which is superior and

has held its corresponding stick relay energized to the end of the code cycle.

6. A communication system for transmitting multiple impulse codes, one at a time, from a central office to one of a plurality of remote stations over a continuously closed line circuit the continuity of which must not be and is not broken comprising; a central office; a plurality of field stations; a continuously closed line circuit connecting said office and field stations; a plurality of sources of alternating current of distinctive frequencies at said office; a plurality of distinctive frequency responsive relays at each of said field stations each responsive to only one of the distinctive frequency sources at said office; a step-by-step means at said office to define a cycle of impulse periods and time spaces between impulse periods and for applying a potential impulse from one or more of the sources of alternating current at said office across said line circuit during each of a plurality of impulse periods of such cycle to characterize a code transmitted to said field stations; step-by-step means at each field station each operated in response to said plurality of potential impulses irrespective of the particular frequency or frequencies of each impulse and each step-by-step means taking one step for each deenergization of all of the distinctive frequency responsive relays at such field station; station selecting means at each of said field stations rendered active in response to a first series of the plurality of potential impulses constituting said cycle if each of the impulses of this series conforms with the frequency or frequencies of the code call for that station; and a control relay for each field station controlled distinctively in accordance with the frequency or frequencies of the remaining impulse or impulses of said cycle only if the station selecting means for that station has been rendered active.

7. In a code communication system for transmitting controls from a control office to any one of a plurality of field stations, the combination

with a control office and a plurality of field stations, a continuous and uninterrupted line circuit connecting said control office with said field stations, a plurality of sources of alternating current of distinctive frequencies in the control office, a bank of neutral stepping relays in the control office and at each field station, means for successively energizing the neutral relays of the bank of stepping relays at the control office one at a time, cycle marking means at the control office and at each field station each including a slow-release relay, a plurality of line relays at each of said field stations connected to said line circuit and each energized only in response to the energization of said line circuit with an alternating current of a particular frequency, said bank of stepping relays at each field station being controlled by said line relays at such field station and being energized sequentially one at a time and one only in response to each simultaneous deenergization of all of said line relays at such field station while said slow-release relay for that field station is energized, manually controlled means at the control office co-operating with the bank of stepping relays at the control office for selectively energizing said line circuit after the energization of each stepping relay with one or more of said distinctive frequency alternating currents in accordance with a distinctive code call belonging to a particular field station and the character of the controls to be transmitted to that station, station selecting means at each field station responsive to a particular combination of successive impulses each comprising particular frequency or frequencies applied to said line circuit during some of said steps, and a control relay at each field station selectively energized only if the station selecting means at that station is effective and in accordance with the distinctive character of the frequency or combinations of frequencies applied to said line circuit for the remaining step or steps.

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