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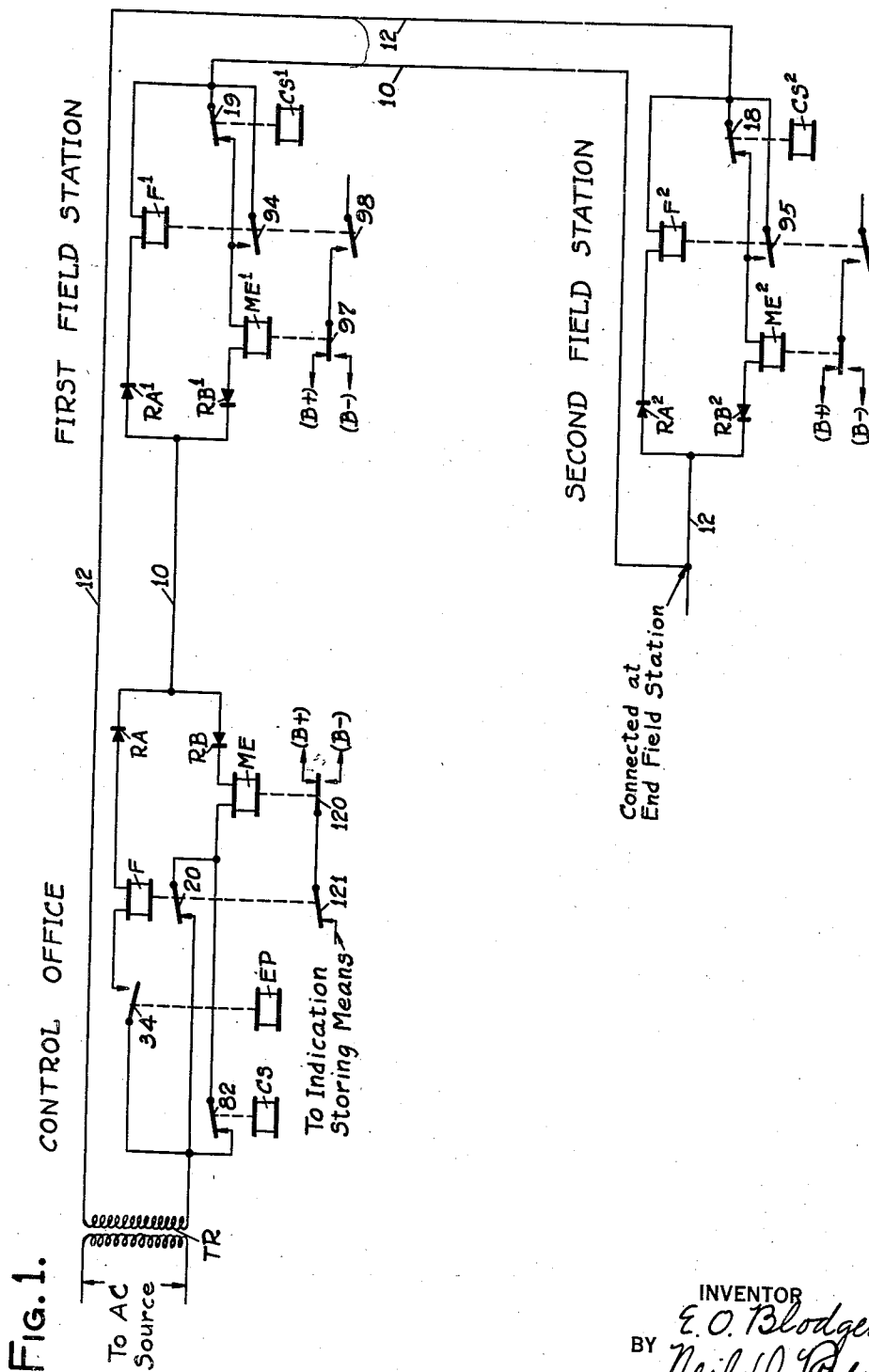
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2,113,368

CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

Filed Nov. 26, 1932

3 Sheets-Sheet 1



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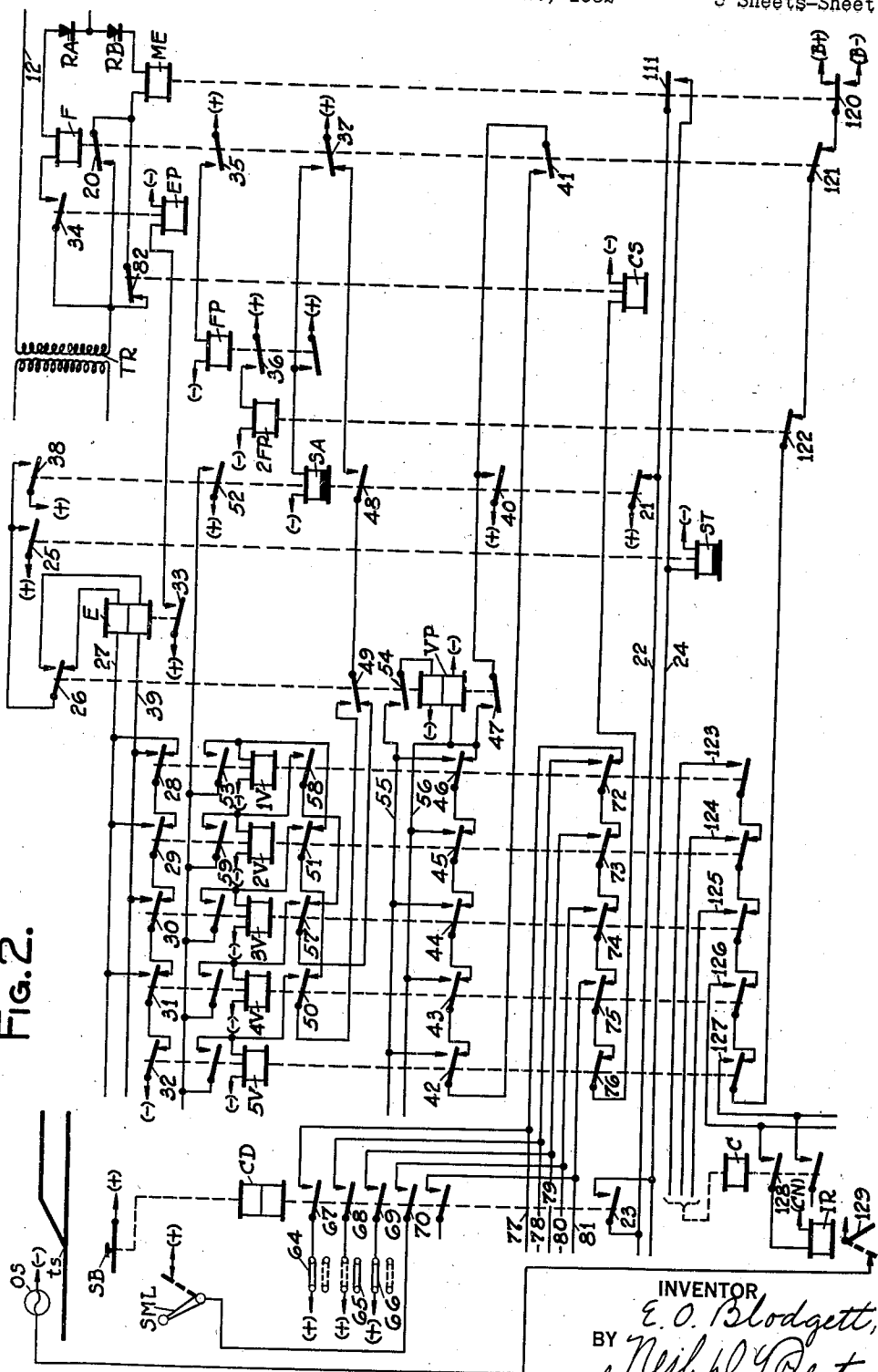
2,113,368

CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

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3 Sheets-Sheet 2

Fig. 2.



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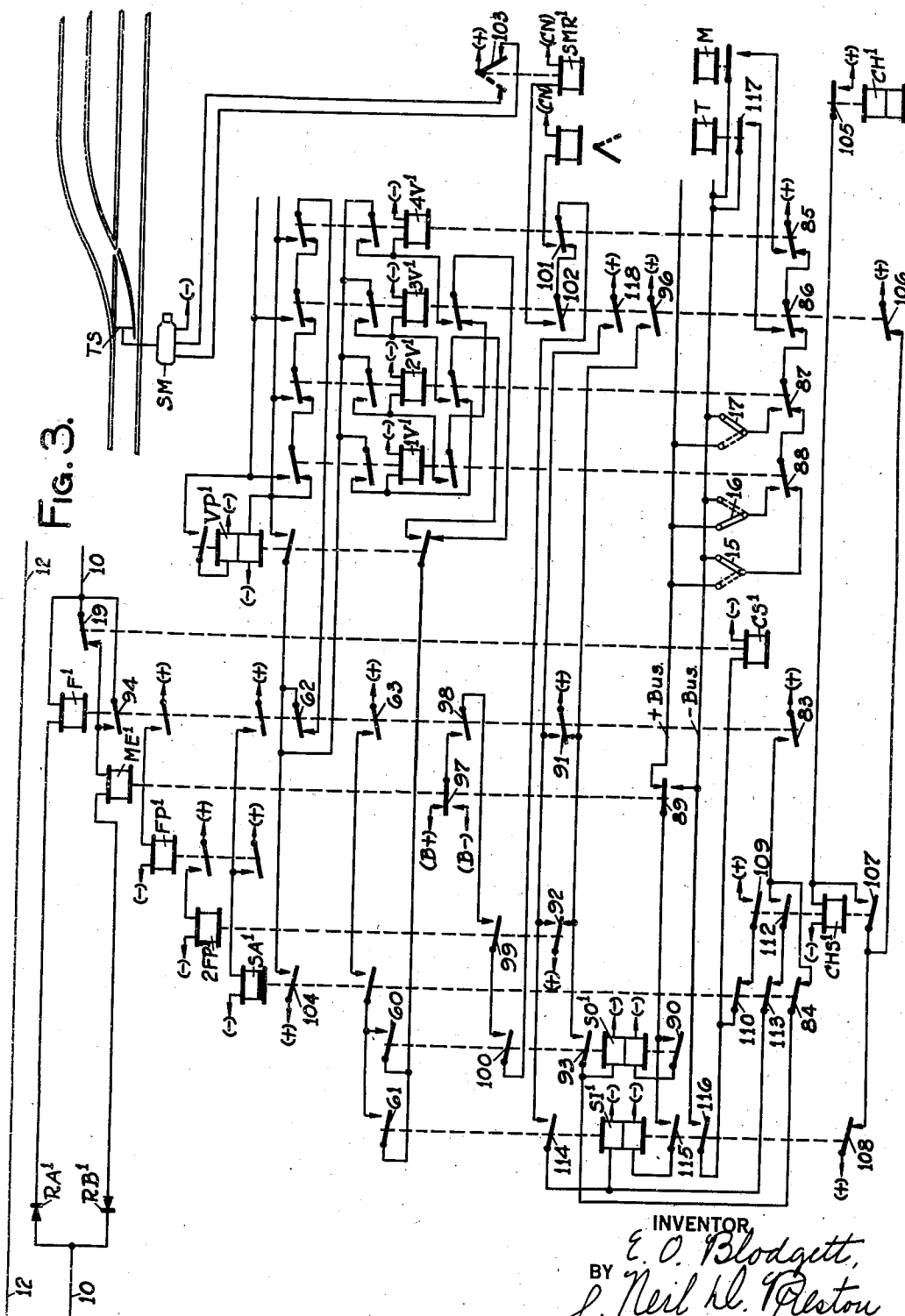
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CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

Filed Nov. 26, 1932

3 Sheets-Sheet 3



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2,113,368

CENTRALIZED TRAFFIC CONTROLLING
SYSTEM FOR RAILROADSEdwin O. Blodgett, Rochester, N. Y., assignor to
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14 Claims. (Cl. 177—353)

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

The present invention contemplates a centralized traffic control system of the type wherein the switches and signals at various points along a railroad system are placed under the control of an operator in a central office, in such a way that the operator may at will change the positions of the switches, subject to automatic approach and detector locking circuits which prevent unsafe operation of any switch, and in such a way that the operator may at will hold at stop any of the signals, or allow them to clear dependent upon the position of the associated switches and also provided the location of trains makes it safe for such signals to indicate proceed. Such a system further provides means whereby indications are displayed in the central control office to inform the operator of the presence or absence of trains on the various track sections throughout the territory under his supervision, and to indicate the operated positions and conditions of the various switches, signals and the like.

Although the switches and signals are distributed throughout the territory under the supervision of the operator in accordance with the track layout required to facilitate traffic movements, those switches and signals which are located near or adjacent to each other are controlled through communication apparatus located at a convenient point near such associated switches and signals. This communication apparatus together with the switches and signals is conveniently considered as comprising a field station. The communication system interconnects these outlying field stations with the control office in such a way as to provide for the transmission of controls to the field stations and for the transmission of indications from the field stations.

The system chosen as one embodiment of the present invention provides that the control office and the field stations are connected in series by a line circuit comprising two line wires. These two line wires are supplied with energy from an alternating current source preferably located in the control office, although such source might be located anywhere else along the communication system. The alternating current energy, thus supplied to the line wires, is divided into two circuits, namely "A" and "B" branch circuits. This division of circuits is accomplished by the use of suitable asymmetric units, such for example, as

the common copper oxide rectifier, so that the "A" branch circuit may have current flowing in one direction when it is closed, and so that the "B" branch circuit may have current flowing in the opposite direction when it is closed.

In other words, the present invention employs alternating current for energizing the equivalent of two line circuits which are created over two line wires, and which are organized in such a way that one line circuit employs one half of the alternating current cycle while the other line circuit employs the opposite half of the alternating current cycle.

In the present embodiment, the "A" branch of the line circuit is employed for governing the step-by-step operation required in a selector type system both at the control office and at the several field stations. This "A" branch also serves to determine the direction in which messages are to be transmitted over the "B" branch of the line circuit. The "B" branch is then free to have messages transmitted thereover either from the control office or from the field station as determined by the "A" branch. For example, when the "A" branch is deenergized, the "B" branch is normally energized but may be deenergized or left energized at any field station; but when the "A" branch is energized, the "B" branch may be energized or left deenergized dependent upon the messages to be transmitted from the control office. Thus, for each stepping period marked off by one energization and one deenergization of the "A" branch, messages are transmitted both ways over the "B" branch thereby providing what is conventionally termed duplex transmission.

As the system is of the coded duplex type (as just mentioned), it is operable through cycles of operation for the transmission of controls and/or for the transmission of indications. When controls are transmitted, a particular field station selecting code is first transmitted to select that station with which communication is desired, which code is then followed by the controls to be transmitted to that selected station. Similarly, when indications are transmitted, that particular field station which is transmitting first transmits its station registering code followed by the transmission of the indications at that station.

The station selecting codes and controls are transmitted over the "B" branch of the line circuit during the energized periods of the "A" branch during an operating cycle by the open or closed condition of the "B" branch during such energized periods; and similarly, the sta-

tion registering codes and indications are transmitted over the "B" branch during the deenergized periods of the "A" branch during an operating cycle by the open or closed condition of the "B" branch during such periods.

Although it is to be understood that the system of the present invention could be readily adapted for the use of a selective lock-out between field stations, such as disclosed, for example, in the pending application of T. J. Judge, Ser. No. 613,353, filed May 25, 1932, the present embodiment has been shown as employing the so-called principle of superiority of code between the field stations. This arrangement provides that all field stations having new indications to transmit at the beginning of an operating cycle, endeavor to transmit their station registering code call, but only one field station, namely, that one having the most superior code call, is successful in transmitting its complete code while all of the other stations drop out for the remainder of that cycle and again endeavor to transmit their codes on the next cycle. In this way, the field stations are allowed to transmit their indications, one station at a time, in a sequence or order determined by the relative characteristics of their station registering code calls.

These characteristic features of the present invention thus briefly stated, will be explained more in detail in the following description of one embodiment of the invention, and various other characteristic features, functions and advantages of a system embodying this invention will be in part pointed out and in part apparent as the description thereof progresses.

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

Fig. 1 illustrates the line circuit arrangement for a control office and two field stations in a system embodying the present invention together with the apparatus most closely associated with these circuits;

Fig. 2 illustrates the apparatus and circuit arrangements employed at a typical control office for providing means whereby an operator may govern the switches and signals throughout an extensive territory, and for providing means whereby indications may be received from the various field locations throughout such territory; and

Fig. 3 illustrates the apparatus and circuit arrangements employed at a typical field station for providing control of a single railroad track switch and for transmitting indications to the control office, all in accordance with the present invention.

For the purpose of simplifying the illustrations and facilitating in the explanation, various parts and circuits constituting the embodiment of the invention have been shown diagrammatically and certain conventional illustrations have been employed, the drawings having been made more with the purpose of making it easy to understand the principles and mode of operation than with the idea of illustrating the specific construction and arrangement of parts that would be preferably employed in practice. Thus, the various

relays and their contacts are illustrated in a conventional manner, and symbols are used to indicate the connections to the terminals of batteries or other sources of electric current instead of showing all of the wiring connections to these terminals.

The symbols (+) and (−) are employed to indicate the positive and negative terminals respectively of suitable batteries or other sources of electrical energy; and the circuits with which these symbols are used always have current flowing in the same direction. The symbols (B+) and (B−) are employed to indicate the positive and negative terminals, respectively, of suitable batteries or other sources of current having mid-taps designated (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 the central tap (CN).

It should be noted, that the present embodiment employs direct current at the control office and at the field stations for energizing the local circuits, while alternating current is employed for the line circuits. However, it might be expedient to employ alternating current for the local circuits and in such cases the usual engineering expedients may be employed in adapting the operation of the system to such a source of energy. When alternating current is used in place of direct current, the particular symbols employed as representing local sources of energy should be considered as indicative of the relative instantaneous polarities of the alternating current sources substituted for the direct current sources.

Communication system generally.—The general plan of organization of the system may be best understood by referring to Fig. 1 of the drawings which discloses the line circuits of the system with the most closely associated apparatus. It is to be understood, of course, that the system may be extended to include as many field stations as necessary for the proper supervision of the territory allotted to a particular control office, but for convenience in disclosing the present invention only a first and a second field station have been illustrated.

Two line wires 10 and 12 serve to connect the control office with the first field station, and similarly the same line wires serve to connect the first and second field station, and so on, to the end of the system where they are connected together to thereby provide a series line circuit. Although the control office has been shown as being located at one end of the system, it is to be understood that it may be located at any intermediate point or at the opposite end of the system, as the present system is of the coded type employing a superiority of code preference between field stations.

As alternating current is provided to energize the line circuits, the apparatus included in the line wires 10 and 12 should be alternately included in these two line wires at successive stations so as to provide the proper transposition of the wires in accordance with the usual engineering practices. Also, various other engineering expedients may be applied to the line circuit arrangement to obtain the desired characteristics for alternating current, and still be within the scope of the present invention.

The line circuit is energized in the control office from a suitable alternating current source of energy. The source is indicated as being connected to the primary of a transformer TR, while

the secondary of this transformer is included in series in the line circuit. The alternating current is contemplated as preferably having the usual sine wave form and may have a frequency distinctive from the usual power lines in order to avoid interference. However, any wave form or frequency may be employed and still be within the scope of the invention.

The "A" branch of the line circuit includes at the control office and at each field station a neutral line relay F (with suitable exponent), and a rectifier unit RA (with suitable exponent). The "A" branch at the control office also includes a contact 34 of a pulsing relay EP. The "B" branch of the line circuit includes at the control office and at each field station a message line relay ME (with suitable exponent), a rectifier unit RB (with suitable exponent), a contact of the respective line relay F (with suitable exponent) in multiple with a contact of a code sending relay CS (with suitable exponent). It may be well to note here that the letter reference characters have no exponents in the control office; while the exponent (1) is provided at the first field station, and the exponent (2) is provided at the second field station.

As previously mentioned, the rectifier units RA and RB (with suitable exponents) may be of any suitable type of asymmetric unit, such as the usual copper oxide unit, the electrolytic rectifying unit, the vacuum tube rectifier unit more commonly known by the trade name "Tunger Rectifier", or any other type of rectifier which may be readily adapted to the rectification of the low current values used in such a communication system.

It should also be understood, that the line relays F and ME (with suitable exponents), provided in the line circuits to be controlled by half cycles of alternating current, or in other words pulsating current, should for greatest efficiency be particularly designed for current having such characteristics although the conventional direct current telephone type relay will operate satisfactorily. In other words, the most desirable relay to employ will probably have neither true direct current relay characteristics nor true alternating current characteristics but will be made especially efficient for pulsating current. Some of the expedients employed for such purposes include the shunting of the relay windings by suitable resistors, by rectifier units, or by a resistor and a condenser in series. Also, a special design of the magnetic circuits may be provided in the relays so as to provide for the "hold over" of the relay armature between successive energizations of its windings on successive half waves of the alternating current.

Control office equipment.—The control office (see Fig. 2) includes a control machine having a group of control levers for each of the field stations, a miniature track layout corresponding in every way to the actual track layout in the field, and various indicating lamps or equivalent devices together with apparatus and circuits to accomplish the desired functioning of the system.

That part of the control office illustrated shows more particularly those devices of a control machine which are typical of the apparatus associated with a single field station having a track switch, a crossover, or the like, together with the general transmitting apparatus employed in common with all such field station units of apparatus.

This apparatus for one track switch includes a switch machine control lever SML, a self-restoring starting button SB, a miniature track switch point ts, and a track occupancy indicating lamp OS. Similarly, a signal control lever or levers (not shown) would also be associated therewith but have been omitted for convenience in the description, as the control of a track switch may be considered as typical of the control of other traffic controlling devices.

The movement of the switch machine control lever SML to one extreme position or the other followed by the actuation of the starting button SB results in the normal or reverse operation of the corresponding track switch at the corresponding field station controlled through the medium of the communication system of the present invention. The momentary actuation of the starting button SB is preferably stored by a suitable storing relay (not shown) which in turn picks up the corresponding code determining relay CD for the associated station. Such control has been merely indicated in order to simplify the present disclosure.

The storing relays for each starting button and their respective code determining relays are so interlocked that irrespective of the number of storing relays that are energized simultaneously or in rapid succession for the transmission of controls to their respective field stations, only one code determining relay for a particular field station may be energized or picked up during any one particular cycle of operation. This interlocked bank of relays is so arranged that if several storing relays are energized at the same time, their corresponding code determining relays will be energized successively during successive operating cycles in a predetermined order or sequence determined by their relative location in the code determining bank of relays, all of which has been completely disclosed in the application of N. D. Preston et al, Ser. No. 455,304 filed May 24, 1930.

The control office includes, as previously mentioned, a neutral line relay F. This line relay has associated therewith a neutral quick acting line repeating relay FP, which repeats each energization and each deenergization of the line relay F, and for the purpose of obtaining suitable margins of time, the relay FP is provided with a repeating relay 2FP also of the quick acting neutral type.

A slow acting line repeating relay SA is picked up at the beginning of each cycle of operation and is dropped at the end of each cycle of operation. This slow acting relay SA has such slow acting characteristics that its pick-up time is relatively slow compared to the pick-up time of the neutral relay FP, for example, but is relatively quick in picking up as compared with its drop-away period. The drop-away period of relay SA is sufficiently retarded, so that its contacts remain in picked up positions between successive energizations of the line relay F and its repeating relay FP, although its contacts readily drop away during the prolonged period of deenergization of the relays F and FP at the end of each cycle of operation.

Associated with the line relay F and its repeating relays, is a bank of stepping relays including relays 1V, 2V, 3V, 4V and 5V, together with a half-step relay VF, which bank of relays marks off the successive steps of each cycle of operation.

An impulsing relay E is jointly controlled by

the stepping relays V (with suitable preceding numerals) and the half-step relay VP, which impulsing relay together with its repeating relay EP, previously mentioned, governs the opening and closing of the "A" branch of the line circuit.

The "B" branch of the line circuit is in an opened or closed condition during each energized period of the "A" branch by reason of the deenergized or energized condition of the code sending relay CS. This code sending relay CS is of the neutral type and is energized or is left deenergized on each step in accordance with the station code call and the particular controls to be transmitted for that particular cycle of operation.

The message receiving relay ME is effective during each deenergized period of the "A" branch of the line circuit to position on the corresponding step a suitable pilot relay or indication storing relay in accordance with its condition (energized or deenergized) as determined at the field station by the particular code call or indication being transmitted.

For the purpose of illustrating the registration of a field station, only one station relay C has been shown, which relay is indicated as being selected in accordance with the character of the code element impulses for the first three steps. In other words, any suitable pilot relay bank, such as disclosed for example in the above-mentioned application of N. D. Preston, et al., Ser. No. 455,304, filed May 24, 1930, may be employed for registering the station code call and for selecting the particular station relay C associated with the station to which the received code call is assigned, to thereby render effective on the remaining steps of the cycle the respective conditions of the message receiving relay ME for positioning the magnetic stick type indication storing relays IR in accordance with the indications being transmitted from that field station which has been registered.

A starting relay ST is provided for causing the system to enter a cycle of operation whenever it is picked up while the system is at rest. This starting relay ST may be energized by reason of the presence of new controls to be transmitted from the control office or by reason of the presence of new indications ready to be transmitted from a single field station or any number of field stations.

The control office also includes various sources of current supply, bus wires and circuit connections, indicator lamps, terminal boards, overload protection, and such other devices as may be required for the proper functioning of such a system.

Field station equipment.—The field station illustrated in Fig. 3 of the accompanying drawings, is typical of all field stations of the system and may be adapted to be used at the first, the second or any other location by merely altering certain code jumpers and connections to arrange for the desired codes assigned to the various locations, but for convenience in the description of the embodiment of the present invention, the apparatus illustrated in Fig. 3 has been designated as associated with the first field station by reason of the distinctive exponent (1) employed with each of the letter reference characters.

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

The switch machine SM is governed by a switch

machine control relay SMR¹, which is of the two-position polar magnetic stick type, and which is controlled from the control office through the medium of the communication system herein disclosed. It is to be understood of course that the switch machine SM is governed by the relay SMR¹ subject to suitable approach locking, detector locking and such other signalling means as is usually employed, but which is not shown in the present disclosure.

Although the switch machine SM is remotely controlled, it may have associated therewith what is commonly termed a dual control selector to provide for the manual operation of the track switch at the field location.

Suitable signals (not shown) are associated with the track switch TS for governing traffic thereover and are provided with automatic signalling means interrelating the traffic over this track switch with such other track switches and track sections as may be associated therewith. These signals are also contemplated as being governed from the control office through the medium of the communication system in any suitable way by control relays operated from the control office, similarly, as the switch machine control relay SMR¹, all of which has been omitted for the sake of simplifying the present disclosure.

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

Whenever the signals governing the passage of trains over the track switch TS are displaying stop indications, a signal-at-stop relay M is normally energized, but when any one of these signals associated with the track switch TS is caused or allowed to give a proceed indication the relay M is deenergized.

The communication part of the system includes at the field station besides the line relays and rectifying units, above mentioned, a quick acting line repeating relay FP¹ with its repeating relay 2FP¹. These relays FP¹ and 2FP¹ are of the neutral quick acting type and follow each energization and each deenergization of the line relay F¹. A slow acting line repeating relay SA¹ is also provided with similar slow acting characteristics as the corresponding relay in the control office.

The field station includes a bank of stepping relays, including relays 1V¹, 2V¹, 3V¹ and 4V¹ together with a half-step relay VP¹, arranged and controlled in a similar manner as the stepping relay bank in the control office with a few exceptions hereinafter explained in detail.

The field station includes a selecting relay SO¹ which is responsive to the station selecting code calls transmitted from the control office so as to select its corresponding field station and render it effective to succeeding control impulses whenever the code call transmitted from the control office corresponds to the one which is assigned to its field station. Similarly, a selecting relay SI¹ is provided to be responsive to the code calls transmitted from the field stations so that when the resulting code call corresponds to the code call assigned to its station, that its station will be effective to cause the transmission of indications to the control office.

A change relay CH¹ is provided to register a change in any of the traffic controlling devices at the field station, such as the devices T and M,

so that the system will be initiated for the transmission of new indications. The specific control for this change relay has not been illustrated, but is assumed to be of any suitable type so that it is deenergized whenever a change occurs and is reenergized whenever its associated change storing relay CHS¹ has been actuated, all of which has been disclosed in detail in the patent to D. F. DeLong et. al., Patent No. 1,852,402 dated April 5, 1932. The change storing relay CHS¹ when once energized, can be deenergized only when its field station has been effective in registering its code call in the control office.

For the purpose of imposing the code call of the field station upon the "B" branch of the line circuits in accordance with the position of the station code jumpers 15, 16 and 17, a code sending relay CS¹ of the neutral type is provided. This code sending relay is subject to the selecting relay SI¹, so that it is rendered ineffective during a cycle of operation in which this field station is endeavoring to transmit, as soon as this station fails to be selected by reason of the differences between the code call actually transmitted to the control office and the code call assigned to the field station.

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

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

Operation

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

Whenever there are new controls and new indications ready for transmission at the same time, controls are transmitted to a particular field station simultaneously, that is, on the same operating cycle, with the transmission of indications from that same station or some other selected station.

Irrespective of whether a cycle of operation is to be for the transmission of controls and/or indications, a predetermined number of time spaced impulses are placed upon the "A" branch of the line circuit to accomplish the step-by-step operation of the stepping relay banks at the control office and at each field station. Each series of time spaced impulses includes a relatively long impulse at the beginning, while the remaining impulses of that series are of substantially the same duration. Also, the time spaces between the impulses of each series are of substantially equal duration.

The stepping relay bank in the control office is arranged to take one step for each of the time

spaces of any series of impulses on the "A" branch, while the stepping relay banks at the field stations are arranged to take one step for each of the impulse periods of such series.

Those periods of time during which the "A" branch of the line circuit is deenergized, the "B" branch is employed for the transmission of indications; while during the energized periods of the "A" branch, the "B" branch is employed for the transmission of controls.

Whenever a cycle of operation is initiated for the transmission of controls, the characters of the impulses placed upon the "B" branch of the line circuit during the energized periods of the "A" branch for that cycle are determined in accordance with the station to be selected and the controls to be transmitted to the selected station, as set up by the code jumpers and control levers for the corresponding field station in the control office.

On the other hand, during a cycle of operation initiated for the transmission of indications, the characters of the impulses placed upon the "B" branch of the line circuit during the deenergized periods of the "A" branch of the line circuit are determined in accordance with the code jumpers at the station to be registered in the control office and the indication contacts at that station.

If controls are being transmitted alone, then a non-registering code is impressed on the "B" branch during the indication transmitting periods; while if indications are being transmitted alone, then a non-selecting code is impressed on the "B" branch during the control transmitting periods. However, when both controls and indications are being transmitted, the characters of the impulses during the respective transmitting periods are determined in accordance with their respective code determining means.

Normal at rest conditions.—Although the system of the present invention is in a normal at rest condition, the "B" branch of the line circuit is normally energized so as to permit any field station to initiate the system into a cycle of operation. For example, the "B" branch of the line circuit is energized from the transformer TR (see Fig. 1) by a circuit closed from the upper terminal of the secondary winding of the transformer TR, through a circuit including the line wire 12 through the first field station to the second field station, back contact 18 of the code sending relay CS² at the second field station, windings of the message receiving relay ME², rectifying unit RB², through the line wire 12 to the line wire 10 (which occurs only at the last field station of the system) to the first field station, back contact 19 of the code sending relay CS¹ at the first field station, windings of the message receiving relay ME¹, rectifying unit RB¹, through the line wire 10 to the control office, rectifying unit RB, windings of the message receiving relay ME, back contact 20 of the line relay F and back contact 32 of relay CS in multiple therewith, to the lower terminal of the secondary of transformer TR.

Most of the remaining circuits of the system are normally deenergized with but a few exceptions. For example, the detector track circuit associated with the track switch TS (see Fig. 3) is preferably of the closed circuit type. Also, the signals at stop relay M are normally energized as well as the change relay CH¹. These circuits however have not been shown in detail, as this is not required for an understanding of the present invention.

Manual starting.—With the system in a condition of rest, it may be manually initiated into a cycle of operation for the transmission of controls and may also be automatically initiated into a cycle of operation for the transmission of indications. However, it is considered expedient to first consider the transmission of controls alone followed by a description of the transmission of indications alone, after which a description of duplex transmission will be given.

Whenever a cycle of operation for the transmission of controls is desired, the operator first positions the control levers for the field stations to which he desires to transmit controls and then actuates their corresponding starting buttons associated with those stations.

Whenever the starting button for a station is actuated, such actuation is then stored or registered in a suitable storing relay (not shown), and if the system is in a condition of rest, the code determining relay for that station is immediately energized. However, the code determining relays for the several stations are so interlocked that if several starting buttons are actuated successively or simultaneously, only one code determining relay may be picked up at any one time. Thus, the code determining relays for those stations having their starting buttons actuated are energized successively for successive cycles of operation. Such interlocking for a code determining bank has not been shown in detail, but may be of any suitable type such as disclosed for example in the application of N. D. Preston et al., Ser. No. 455,304, filed May 24, 1930.

For the purpose of considering the operation of the present invention, it is sufficient to know that the actuation of the starting button SB (see Fig. 2), for example, causes the actuation of the code determining relay CD in its proper turn, while the system is at rest. The response of the code determining relay CD, as well as the actuation of any other code determining relay (not shown), closes the energizing circuit for the starting relay ST. This energizing circuit for the relay ST is closed from (+), through a circuit including back contact 21 of relay SA, bus wire 22, front contact 23 of relay CD, bus wire 24, windings of the relay ST, to (−). It is understood of course, that the bus wires 22 and 24 extend to the remaining code determining relays in the bank.

The response of the starting relay ST closes the pick-up circuit for the impulsing relay E from (+), through a circuit including front contact 25 of relay ST, back contact 26 of relay VP, upper winding of relay E, bus wire 27, back contacts 28, 29, 30, 31, and 32 of the relays 1V, 2V, 3V, 4V and 5V respectively, to (−).

This energization of the relay E is repeated by the relay EP upon the closure of front contact 33 through a circuit obvious from the drawings. The closure of front contact 34 of the relay EP results in the energization of the "A" branch of the line circuit.

For example, the "A" branch of the line circuit is closed from the lower terminal of the secondary of the transformer TR (see Fig. 1), through a circuit including front contact 34 of the relay EP, windings of the line relay F, rectifying unit RA, through the line wire 10 to the first field station, rectifying unit RA¹, winding of the line relay F¹, through the line wire 10 to the second field station, connected to the line wire 12, rectifying unit RA², windings of the line relay F², line wire 12 through the first field sta-

tion to the control office and to the upper terminal of the secondary of the transformer TR. This energization of the "A" branch of the line circuit is repeated at the control office and at each field station by the response of the line relays F (with suitable exponents).

This response of the line relays F (with suitable exponents) is repeated by their respective repeating relays FP and 2FP (with suitable exponents). For example, the relay FP in the control office is energized upon the closure of front contact 35 of the relay F; while the response of the relay FP is repeated by the relay 2FP upon the closure of front contact 36.

The picking up of the contacts of the relays FP (with suitable exponents) at the control office and at each field station is repeated by their respective slow acting relays SA (with suitable exponents). For example, the picking up of the contact 37 of the relay F in the control office closes an obvious energizing circuit for the relay SA. The relay SA is of the slow acting type, as previously pointed out, so that its contacts respond after a predetermined period of time.

The response of the relay SA in the control office closes the pick-up circuit for the relay VP; while the response of the relays SA (with suitable exponents) at the field stations is not followed by the response of the relays VP (with suitable exponents) at their respective field stations until the following deenergized period of the "A" branch of the line circuit.

Although the station selecting relays at the field stations are initially conditioned for selection during the pick-up periods of their respective slow acting relays, together with the conditioning of various other devices, such operation will be considered separately. Attention is more particularly directed at this time to the manner in which the "A" branch of the line circuit is impulsed with time spaced impulses marking off the energized and deenergized periods of the cycle.

Impulsing operation.—As pointed out above, the actuation of the starting relay ST results in the successive operation of the relays E and EP to cause the first energized period of the "A" branch of the line circuit. The repeating of such energized condition by the line relay F results in the successive energizations of the relays FP, 2FP, SA and VP. Assuming for the time being that the relay VP suitably responds without pointing out its detailed circuit, the opening of its back contact 26 deenergizes the relay E. This deenergization of the relay E is repeated by the relay EP upon the opening of front contact 33 which in turn opens front contact 34 to deenergize the "A" branch of the line circuit.

It may be well to note at this time that the picking up of the relay SA deenergizes the starting relay ST by opening back contact 21, but such deenergization of the relay ST and the opening of its front contact 25 is not effective to remove the control of the relay E from the relay VP and the stepping relays, as relay SA closes its front contact 38, thereby placing energy upon the control circuits of the relay E, which condition is maintained throughout the cycle of operation.

The deenergization of the relay F for the first deenergized period of the "A" branch of the line circuit is repeated by the relays FP and 2FP in succession, but the relay SA is sufficiently slow acting to maintain its contacts in picked up positions between its successive energizations during a cycle of operation. The response of the relay

F to this first deenergized period causes the first stepping relay IV to be picked up, by reasons of circuits hereinafter pointed out.

The response of the relay IV with the relay VP picked up closes an energizing circuit for the relay E from (+), through a circuit including front contact 38 of relay SA, front contact 26 of relay VP, lower winding of relay E, bus wire 39, front contact 28 of relay IV, back contacts 29, 30, 31 and 32 of relays 2V, 3V, 4V and 5V respectively, to (-).

This energization of the relay E is repeated by the relay EP which in turn energizes the "A" branch of the line circuit for the second energized period by the closure of its front contact 34.

This second energization of the "A" branch of the line circuit is repeated by the relays F, FP and 2FP. The response of the relay F causes the relay VP to be deenergized, as later explained. This opens the energizing circuit of the relay E at open front contact 26. The deenergization of the relay E is repeated by the relay EP which in turn deenergizes the "A" branch of the line circuit.

In the embodiment of this present invention, this impulsing of the "A" branch of the line circuit continues, as above explained, for five energized periods separated by deenergized periods to comprise a cycle of operation.

It will be apparent, that the impulses are time spaced as determined by the response of the stepping relay bank in the control office. In brief, each energized period causes the actuation of the contacts of the relay VP to an opposite position, while each deenergized period causes the picking up of the next stepping relay. The response of the relay VP in each case causes the deenergization of the relays E and EP, so as to deenergize the "A" branch; while the response of the stepping relay during a deenergized period causes the relays E and EP to be energized for causing the application of the next impulse.

The duration of the first energized period of the "A" branch of the line circuit is measured by the cumulative pick-up periods or times of response of the relays F, SA and VP, together with the drop-away periods of the relays E and EP, thus applying a relatively long impulse for the first impulse of the series; while each succeeding impulse of the series is measured only by the pick-up periods of the relays F and VP, together with the drop-away periods of the relays E and EP. Similarly, each deenergized period of the "A" branch of the line circuit includes the drop-away period of the relay F, the pick-up period of a stepping relay and the pick-up periods of the relays E and EP.

The stopping of the impulsing at the end of a cycle of operation by prolonging the deenergization of the "A" branch of the line circuit will be explained in detail hereinafter when considering the end of the cycle of operation.

Having pointed out in detail how a series of time spaced impulses are placed upon the "A" branch of the line circuit, the response of the step-by-step mechanisms at the control office and at the field stations may be considered.

Step-by-step operation.—The step-by-step operation will be considered with more particular reference to the stepping relay bank illustrated in the control office (see Fig. 2), but those exceptions with regard to the operation of the corresponding bank in the field station will be pointed out with reference to Fig. 3.

The application of the first impulse of the "A"

branch of the line circuit, as repeated by the line relay F, causes the half step relay VP to be picked up by reason of a pick-up circuit which is closed (following the response of the relay SA) from (+), through a circuit including front contact 40 of relay SA, front contact 41 of relay F, back contacts 42, 43, 44, 45 and 46 of relays 5V, 4V, 3V, 2V and IV, respectively, lower winding of the relay VP, to (-). The response of the relay VP closes its stick circuit from (+), through a circuit including front contact 40 of relay SA, front contact 47 of relay VP, lower winding of relay VP, to (-).

With the contacts of the relay VP in picked up positions, the pick-up circuit for the first stepping relay IV is prepared, so that when the first deenergized period is repeated by the relay F, its pick-up circuit is closed from (+), through a circuit including back contact 37 of relay F, front contact 48 of relay SA, front contact 49 of relay VP, back contacts 50 and 51 of relays 4V and 2V respectively, windings of relay IV, to (-). The response of the relay IV closes its stick circuit from (+), through a circuit including front contact 52 of relay SA, front contact 53 of relay IV, windings of relay IV, to (-).

The response of the relay IV also prepares the circuit for the differential winding of relay VP, so that upon the application of the next impulse (second), as repeated by the relay F, the relay VP is differentially energized and its contacts are caused to assume dropped-away positions. This differentially energizing circuit for the relay VP is closed from (+), through a circuit including front contact 40 of relay SA, contact 41 of relay F, back contacts 42, 43, 44 and 45 of relays 5V, 4V, 3V and 2V respectively, front contact 46 of relay IV, bus wire 55, front contact 54 of relay VP, upper winding of relay VP, to (-). This energization of the upper winding of relay VP is opposite with regard to the energization of its lower winding, so that the magnetic flux in the relay VP is reduced substantially to zero allowing its contacts to drop away. The dropping away of its contacts, simultaneously opens front contacts 47 and 54 entirely deenergizing the relay VP. Therefore, its contacts remain in released positions until its pick-up circuit is again closed.

With the relay VP in a deenergized position, the pick-up circuit for the stepping relay 2V is prepared, so that when the next deenergized period (second) of the "A" branch of the line circuit is repeated by the line relay F, the stepping relay 2V is energized by a pick-up circuit closed from (+), through a circuit including back contact 37 of relay F, front contact 48 of relay SA, back contact 49 of relay VP, back contact 57 of relay 3V, front contact 58 of relay IV, windings of relay 2V, to (-). The response of the relay 2V closes its stick circuit from (+), through a circuit including front contact 52 of relay SA, front contact 59 of relay 2V, windings of relay 2V, to (-).

This step-by-step operation continues throughout the cycle of operation until the last step has been taken, it being readily apparent that for each energized period of the "A" branch of the line circuit, the relay VP is actuated to a new position while during each deenergized period of the "A" branch of the line circuit the next stepping relay is picked up. The stepping relays are all stuck up until the end of the cycle of operation, as marked off by the relay SA.

The step-by-step operation of the stepping re-

lay banks at the several field stations is identical, so that the consideration of the stepping bank at the first field station (see Fig. 3) may be considered as typical of all field stations. At each field station, the operation of the stepping relays is made dependent upon station selection as rendered effective by the selecting relays SO^1 and SI^1 , for example. However, for the purpose of considering the stepping operation before the description of station selection, it may be assumed that one or the other or both of the selecting relays SO^1 and SI^1 are picked up, so as to close one or the other or both of the contacts 60 and 61.

The response of the relay SA^1 at the beginning of the cycle does not close a pick-up circuit for a stepping relay nor for the half step relay VP^1 , but upon the first deenergized period of the "A" branch, as repeated by the relay F^1 , the half step relay VP^1 is picked up by closure of back contact 62. This prepares the pick-up circuit for the first stepping relay IV^1 . Then upon the next energized period (second), as repeated by the relay F^1 , the closure of front contact 63 completes the pick-up circuit for the relay IV^1 . The stepping bank takes one step for each energized period, and operates the contacts of the relay VP^1 to opposite positions for each deenergized period, throughout the cycle of operation so long as the pick-up circuits for the stepping relays are closed by one or the other or both of the contacts 60 and 61. It is considered unnecessary to point out the circuits in detail for these relays, as they are substantially identical with the circuits already pointed out in connection with the stepping relay bank in the control office, with the obvious exception that the half step and stepping relays operate on opposite periods to those corresponding relays at the control office. In other words, the half step relays at the field station are actuated on the deenergized periods with the stepping relays successively picked up on the energized periods; while at the control office the half step relay is actuated on the energized periods with the stepping relays successively picked up on the deenergized periods.

Station selection for controls.—The application of impulses to the "A" branch of the line circuit has been explained in detail. In brief, a series of impulses is placed upon the "A" branch, each of which impulses includes a plurality of half cycles of an alternating current. This current flows in a direction permitted by the rectifying units RA (with suitable exponents) at the control office and at each field station. The application and removal of impulses upon the "A" branch of the line circuit causes the step-by-step operation, so that the condition of the "B" branch of the line circuit for each period marked off on the "A" branch may be employed for the transmission of control and indication impulses.

The energy selectively applied to the "B" branch includes a plurality of half cycles of the alternating current of a polarity opposite to that on the "A" branch by reason of the opposite arrangement of the rectifying units RB (with suitable exponents). The energized or deenergized condition of the "B" branch during an energized period of the "A" branch is employed for the transmission of controls, while the deenergized period of the "A" branch marks off the time during which the "B" branch is energized or deenergized for the transmission of indications.

Forgetting for the time being how the "B" branch may be conditioned for the transmission

of indications from a field station, we may consider how the "B" branch is conditioned for the transmission of controls, it being considered sufficient to know that so far as the field stations are concerned during a cycle of operation for the transmission of controls alone, the "B" branch is continuously closed, as will be explained more in detail hereinafter.

As soon as the operator has actuated a starting button, which results in the response of a code determining relay, the code sending relay CS is positioned in accordance with the first code jumper associated with that code determining relay which has responded. In this particular case, the energization of the code determining relay CD (see Fig. 2) in response to the actuation of the starting button SB, causes the energization of the code sending relay CS, as the code jumper 64 is in an upper position.

This energizing circuit is closed from (+) through a circuit including code jumper 64 in a closed position, front contact 67 of the code determining relay CD, code bus 77, back contacts 72, 73, 74, 75 and 76 of relays IV, 2V, 3V, 4V and 5V respectively, windings of the relay CS, to (—).

As previously pointed out, the "B" branch of the line circuit is normally energized, so that the energization of the relay CS opening its back contact 82 does nothing to the "B" branch of the line circuit at this time, although the relay CS is actuated simultaneously with the actuation of the starting relay ST, as back contact 20 of relay F is still closed. However, when the first impulse has been placed upon the "A" branch of the line circuit causing the relay F to open its back contact 20, it is then that the contact 82 of the relay CS controls the "B" branch.

In other words, if the code jumper 64 is in a lower non-contacting position, then the relay CS is not energized, so that upon the picking up of back contact 20 of relay F, the "B" branch will remain energized, but if the code jumper is in an upper closed position, as shown, the relay CS is picked up and the "B" branch is deenergized.

It is well to note here, that with the line relays F (with suitable exponents) deenergized, the control of the "B" branch is with the relay CS (with suitable exponents) at the field stations, but with the relays F (with suitable exponents) energized, the control of the "B" branch is with the relay CS in the control office.

For example, with relays F, F^1 and F^2 deenergized, the back contact 20 is closed shunting contact 82, but the contacts 94 and 95 are open allowing the contacts 19 and 18 to control the "B" branch. On the other hand, with the relays F, F^1 and F^2 energized, the back contact 20 is opened allowing the contact 82 to control the "B" branch, but the front contacts 94 and 95 are closed shunting the contacts 19 and 18, thereby rendering them ineffective. This means that the "B" branch may be either open or closed depending upon the position of the code jumper 64 during the first energized period marked off on the "A" branch. The condition of the code sending relay CS is maintained until the first stepping relay IV is picked up upon the first deenergized period on the "A" branch of the line circuit, at which time the back contact 20 of the relay F is closed so that the "B" branch is energized independent of the front contact 82 of the relay CS.

With the stepping relay IV picked up, the control of the relay CS is shifted to the code bus 78, so that the code jumper 65 can determine

whether the relay CS will be energized or de-energized depending upon whether it is in a closed or an open position, as it is connected to code bus 78 by front contact 68 of relay CD. Similarly, for each of the remaining steps, the control of the code sending relay is shifted from one code bus to the next, each one of which is conditioned either in accordance with a suitable code jumper or a control lever, so as to determine whether the code sending relay CS shall be energized or deenergized for that step.

In the present embodiment of the invention, the five code buses 77, 78, 79, 80 and 81 have been shown, and are contemplated as extending to all of the code determining relays, so that the particular code determining relay which is picked up for a cycle of operation will connect those buses to its respective code jumpers and control levers. Associated with the code determining relay CD are three code jumpers 64, 65 and 66 together with a control lever SML which are connected to the code buses 77, 78, 79 and 80 by contacts 67, 68, 69 and 70, the last code bus 81 being shown vacant although any type of control lever may be associated therewith.

The code jumpers for the several code determining relays are arranged in different combinations, so that each is assigned a distinctive code call. For example, the symbol "+" may be assigned to represent a code jumper in an open position, and the symbol "-" may be assigned to represent a code jumper in a closed position. In the present case, three steps are provided for station selecting codes, so that eight different combinations are provided, as illustrated in the code table given below. This code table is also applicable to other features of station selection and registration besides the positioning of the code jumpers 64, 65 and 66, and will thus be referred to in various connections.

Typical code table

	First step	Second step	Third step
1----	+	+	+
2----	+	+	+
3----	+	-	+
4----	+	-	+
5----	-	+	+
6----	-	+	+
7----	-	-	+
8----	-	-	-

For the purpose of illustration, the code jumpers 64, 65, and 66 are arranged to transmit a code call of (-)(+)(-).

It is thus seen how the "B" branch of the line circuit is conditioned in accordance with the position of the code sending relay CS during the energized condition of the "A" branch. These conditions of the "B" branch are rendered effective at the several field stations, so as to select a particular field station in accordance with the code transmitted and to actuate suitable control storing relays in accordance with the controls transmitted.

Before considering how these conditions on the "B" branch of the line circuit are effective to select a field station, it is necessary to know that the station selecting relays are picked up at all of the stations during the first long impulse applied to the "A" branch at the beginning of the cycle. For example, the relay SO¹ at the first field station is picked up as soon as the relay F¹ is actuated in response to the first impulse on the "A" branch by reason of a pick-up circuit closed

from (+), through front contact 83 of relay F¹, back contact 84 of relay SA¹, upper winding of relay SO¹, to (-).

With all of the station selecting relays SO (with suitable exponents) picked up at the several stations before their respective slow acting relays SA (with suitable exponents) respond, all of the field stations are then in readiness to be selected or to be dropped out. The system of the present invention employs the usual Baudot code wherein the number of selections with a given number of code impulses, when a choice of either of two characters may be had for each impulse, is equal to two raised to the power of the number of impulses, all of which has been shown and described in the above mentioned pending application of N. D. Preston, et al., 455,304, filed May 24, 1930. However, it may be well to note that half of the stations are selected on the first code impulse and the other half are dropped out. Half of those selected on the first impulse are selected on the second impulse and the other half are dropped out. This subdivision continues until only one field station remains, as will be apparent by referring to the "Typical code table" given above. In other words, the code jumpers in the control office cause the code sending relay CS to transmit a code call to which all selecting relays SO (with suitable exponents) are subjected, but at the end of the code only one relay SO (with suitable exponent) remains picked up.

For example, assuming that the code sending relay CS in the control office is picked up so as to open the "B" branch of the line circuit when the back contact 20 of the relay F is opened, then the relays ME (with suitable exponents) at the field stations will be deenergized, so that the relays SO (with suitable exponents) at those field stations where the code jumpers are connected to the "-" bus will be maintained energized through their selecting stick circuits, while at the other stations where the code jumpers are connected to the "+" bus the relays SO (with suitable exponents) will be dropped out.

More specifically, as soon as the relay SA¹ at the first field station is picked up opening up its back contact 84, both the pick-up and holding circuits for the relay SO¹ are open, so that the relay SO¹ is then dependent upon its selecting stick circuit. With the relay ME¹ in a deenergized position because of the energized condition of the code sending relay CS in the control office, the relay SO¹ is maintained energized by reason of a selecting stick circuit closed from (+), through a circuit including back contacts 85, 86, 87 and 88 of relays 4V¹, 3V¹, 2V¹ and 1V¹ respectively, code jumper 15 connected to the "-" bus back contact 89 of the relay ME¹, front contact 90 of the relay SO¹, lower windings of relay SO¹, to (-). It will be apparent that at all other field stations where the code jumpers corresponding to code jumper 15 are connected to the "+" bus, the selecting stick circuits for the selecting relays SO (with suitable exponents) at those field stations will be opened.

On the other hand, if the code sending relay CS in the control office were left deenergized by reason of the code jumper 64 being in an open position, then the relay SO¹ at the first field station, for example, would not be selected as the contact 89 of relay ME¹ would be in an energized position out of correspondence with the code jumper 15, thereby allowing the relay SO¹ to drop away; while at those field stations where the code jumpers corresponding to code jumper 15 are con-

connected to the "+ bus", the relays SO (with suitable exponents) at those stations would be selected.

Upon the removal of the first impulse from the "A" branch of the line circuit, such condition is repeated by the relays F (with suitable exponents) at the several stations. This completes a holding stick circuit for the relay SO¹ from (+), through a circuit including back contact 91 of relay F¹, front contact 93 of relay SO¹, upper winding of relay SO¹, to (-). Also, as soon as such deenergized period (first) is repeated by the relay 2FP¹, the back contact 92 connects positive energy (+) to the holding stick circuit of the relay SO¹ in multiple with the back contact 91 of relay F¹. In other words, at the beginning of a deenergized period the back contact 91 of relay F¹ initially closes the holding stick circuit of relay SO¹; while at the end of the deenergized period, the back contact 92 of relay 2FP¹ finally opens the holding stick circuit of the relay SO¹.

It is to be understood, of course, that similar holding circuits are present at all of the field stations, but that they are effective only at those stations where the relays SO (with suitable exponents) have been selectively maintained energized during the preceding energized period on the "A" branch.

The application of the second impulse to the "A" branch of the line circuit is repeated by the relays F (with suitable exponents) at the control office and at the field stations. As soon as the contact 20 of the relay F in the control office opens, the condition of the relay CS is impressed upon the "B" branch of the line circuit, so as to energize the relays ME (with suitable exponents) at the field stations if contact 82 of relay CS is closed, or to leave the relays ME (with suitable exponents) at the field stations deenergized if the contact 82 of the relay CS is opened. The relays ME (with suitable exponents) assume their positions immediately after the energization of the relays F (with suitable exponents) at the control office and at the field stations, which is effected prior to the response of the relays 2FP (with suitable exponents), at the field stations thereby positioning the contacts of the ME relays prior to the time that the holding stick circuits for the relays SO (with suitable exponents) are opened.

For example, if the "B" branch of the line circuit is deenergized during the second energized period of the "A" branch, then the contact 89 of relay ME¹ is in a dropped away position and the relay SO¹ is deenergized as soon as the back contact 92 of relay 2FP¹ is opened in response to the second impulse on the "A" branch. This is because the code jumper 16, selected by the picked up condition of the stepping relay IV¹ during the first deenergized period on the "A" branch, is in a left hand position requiring a (+) code or an energized condition of the "B" branch for this second energized period in order to maintain the relay SO¹ energized.

The relays SO (with suitable exponents) at all of those field stations having their code jumpers 16 connected to the "- bus" are dropped out when the "B" branch is energized during this period; while all of the field stations having their code jumpers connected to the "+ bus" are selected. On the other hand, if the "B" branch is deenergized, the opposite is true.

In this case, the "B" branch is energized during this period so that the contact 89 of relay

ME¹ is energized and the relay SO¹ is maintained energized by reason of a selecting stick circuit closed from (+), through a circuit including back contacts 85, 86, and 87 of relays 4V¹, 3V¹ and 2V¹ respectively, front contact 88 of stepping relay IV¹, code jumper 16 in a left hand position, "+ bus", front contact 89 of relay ME¹, front contact 90 of relay SO¹, lower winding of relay SO¹, to (-).

The end of the second energized period is marked off by the second deenergization of the "A" branch of the line circuit which is repeated by the relays F (with suitable exponents) at the control office and at the several field stations. The closure of back contact 91 of relay F¹, for example, completes a holding stick circuit for the relay SO¹, as it has been maintained selected during the preceding energized period. The deenergization of the relay 2FP¹ of course follows in proper time so as to close its back contact 92 for further energizing the holding stick circuit of the relay SO¹ for reasons previously explained. During this second deenergized period, the second stepping relay at each field station is picked up (providing its relay SO is up), so as to render the next code jumper effective to select the relays SO (with suitable exponents) on the next energized period (third).

The third energized period allows the "B" branch to be conditioned in accordance with the code call being transmitted from the control office and selects between those relays SO (with suitable exponents) still remaining energized. In the case where only three steps are provided for station selection, there is a possibility of eight selections so that on the last code impulse, a selection is made between only two relays SO, all of which will be understood with reference to the above description. It is, of course, understood that any number of station selecting steps may be employed by the addition of stepping relays at the control office and at each field station, together with the duplication of various other code sending and code receiving equipment.

The end of the third energized period of the cycle is marked off by the deenergization of the "A" branch of the line circuit which is repeated by the relays F (with suitable exponents) at the control office and at each field station. This results in the picking up of the third stepping relay at that particular station still having its relay SO (with suitable exponent) selected, it being understood that the relays SO (with suitable exponents) at all other field stations have been deenergized during the station selecting steps so that the stepping relay banks have discontinued their operations as soon as their selecting relays SO (with suitable exponents) have been dropped out and have opened their front contacts 60. The picking up of the third stepping relay at the selected station completes a holding stick circuit for the relay SO (with suitable exponent) at that station which is maintained throughout the remainder of the cycle of operation so as to allow the stepping relay bank to operate and receive the controls for that selected station.

For example, assuming that the code transmitted over the "B" branch of the line circuit during the energized periods marked off by the "A" branch of the line circuit has agreed with the positions of code jumpers 15, 16 and 17, then relay SO¹ is held energized through its holding stick circuits including back contacts 91 and 92 of relays F¹ and 2FP¹ during the third deenergized period marked off on the "A" branch of

the line circuit. The picking up of the stepping relay 3V¹ during this period closes a holding stick circuit from (+), through a circuit including front contact 96 of relay 3V¹, front contact 93 of relay SO¹, upper winding of relay SO¹, to (-). This holding stick circuit is completed for the relay SO¹ until the relay 3V¹ is deenergized at the end of a cycle of operation.

Transmission of controls.—From the above description, we have seen how a station may be selected whenever the code call of that station agrees with the code call transmitted over the "B" branch of the line circuit during the energized periods marked off on the "A" branch.

Assuming that the field station illustrated in Fig. 3 of the accompanying drawings has been selected by the maintenance of its relay SO¹ in an energized position, the application of the fourth impulse to the "A" branch of the line circuit is repeated by the relays F (with suitable exponents) at the control office and at each field station. The code impulse impressed during this fourth energized period on the "B" branch is in accordance with the position of control level SML, for example, and the relay ME¹ at the field station assumes its position prior to the closure of the front contacts of the relay 2FP¹. Thus, if the "B" branch is energized during this fourth energized period, then upon the picking up of the contacts of the relay 2FP¹, positive potential (B+) is executed to the switch machine control relay SMR¹; while if the "B" branch is deenergized during this period, negative potential (B-) is executed to this switch machine control relay.

More specifically, upon the closure of front contact 99 of relay 2FP¹ following the closure of the front contact 98 of relay F¹, an executing circuit is closed from either (B+) or (B-), through either front or back contact 97 of relay ME¹ respectively, front contact 98 of relay F¹, front contact 99 of relay 2FP¹, front contact 100 of relay SO¹, back contact 101 of stepping relay 4V¹, front contact 102 of relay 3V¹, windings of relay SMR¹, to (CN). The application of positive potential (B+) causes the contact 103 of the relay SMR¹ to be actuated to a right hand position, while the application of negative potential (B-) causes the contact 103 of relay SMR¹ to be actuated to a left hand position. Contact 103 in a right hand position causes the switch machine to operate the track switch TS to a normal position, while the contact 103 in a left hand position causes the switch machine to operate the track switch to a reverse position.

The end of the fourth energized period is marked off by the deenergization of the "A" branch of the line circuit which is repeated by the relays F at the control office and at the field station. This initially opens the executing circuit for the relay SMR¹ at front contact 98. During this deenergized period (fourth), the fourth stepping relay 4V¹ is picked up connecting the next relay to be controlled to the executing circuit, so that upon the next energized period (fifth), it will be energized with positive or negative energy in accordance with the control transmitted, all of which will be readily understood by analogy to the above description.

End of operating cycle.—The operation of the system during a cycle has been explained in detail, and it is now necessary to understand the manner in which the system is returned to its normal at rest conditions. As previously mentioned, the stepping relay bank in the control

office takes one step for each deenergized period marked off on the "A" branch of the line circuit beginning with the first deenergized period. Thus, the picking up of the fourth stepping relay 4V for the fourth deenergized period causes the fifth energization of the "A" branch, which in turn causes the actuation of the relay VP, to allow the fifth deenergization of the "A" branch. This fifth deenergized period causes the relay 5V to be picked up, but the response of the contact 32 does not again energize relay E so that the "A" branch is maintained deenergized. This prolonged deenergization of the "A" branch of the line circuit is sufficiently long to allow the relay SA in the control office to become deenergized opening its front contact 38, which prevents further energization of the relay E. It also opens its front contact 52 which deenergizes all of the stepping relays as well as front contact 40 which causes the half step relay VP to be restored to normal. The closing of its back contact 21 allows the starting relay ST to be conditioned in readiness for the initiation of another cycle of operation. The picking up of the fifth stepping relay 5V in the control office prior to the dropping of the relay SA, causes the code determining relay then effective, such as relay CD, for example, to be deenergized conditioning the next code determining relay in order for the initiation of another cycle of operation.

At the field station, the system is similarly restored to normal by the prolonged deenergization of the "A" branch, by the dropping of the stepping relays upon the opening of front contact 104 of relay SA¹.

The relay SO¹ at the selected station remains picked up through the following period of rest by reason of the fact that relays F¹ and FP¹ are deenergized prior to the dropping of relay 3V¹, so that the holding stick circuit for the relay SO¹ is maintained closed at back contacts 91 and 92. However, this is immaterial as the last selected relay SO has no controlling function while the system is at rest. Also, such maintaining of the relay SO at the last selected station is permissible as the relay SO at every field station is picked up at the beginning of each cycle of operation and is thereafter selectively maintained picked up in accordance with the code transmitted for that cycle.

The system is now in a condition for the initiation of another cycle of operations either from the control office or from a field station.

Indications.—As previously mentioned, indications may be ready for transmission at a field station at the same time that controls are ready for transmission from the central office and the system is arranged so that the simultaneous two-way or duplex transmission of controls and indications may occur during each cycle of operations. However, for convenience, the transmission of controls has been considered separately, so that the transmission of indications will also be considered separately with the features of duplex transmission being considered under a separate heading.

It also may happen that there are several field stations which may have indications ready for transmission at the same time and they are registered in the control office, one at a time, in a sequence or order determined by the relative characteristics of their code calls, but this feature of determining the sequence of station registration by the superiority of code will also be considered separately with the transmission of 75

indications from a single station being considered at this time.

Automatic starting.—The change in the position of a controlled device or the automatic change of a traffic indicating device such as the track relay T, may cause the system to be initiated by the deenergization of the change relay CH¹. The change relay CH¹, thus deenergized by a change in the indication conditions at a field station is restored upon the registering of the changed condition in the change storing relay CHS¹, all of which is disclosed in the above mentioned Patent No. 1,852,402, dated April 5, 1932, granted to D. F. DeLong et al., so the details of this operation need not be pointed out herein.

It is sufficient for an understanding of this part of the invention to know that the deenergization of the relay CH¹ causes the change storing relay CHS¹ to be energized by a circuit closed from (+), through a circuit including back contact 105 of relay CH¹, windings of relay CHS¹, to (—). As soon as the contacts of the relay CHS¹ respond, a stick circuit is closed from (+), through a circuit including back contact 108 of relay SI¹ and back contact 106 of relay 3V¹ in multiple, front contact 107 of relay CHS¹, windings of relay CHS¹, to (—).

The relay CHS¹, thus picked up, causes the code sending relay CS¹ to be energized by reason of a circuit closed from (+), through a circuit including front contact 109 of relay CHS¹, back contact 110 of relay SA¹, windings of relay CS¹, to (—). This energization of the code sending relay CS¹ causes the normally energized "B" branch of the line circuit to be opened at back contact 19, so that the relays ME (with suitable exponents) at the control office and at the several field stations are deenergized.

The deenergization of the relay ME in the control office causes the starting relay ST to be energized by reason of a circuit closed from (+), through a circuit including back contact 21 of relay SA, bus wire 22, back contact 111 of relay ME, bus wire 24, windings of starting relay ST, to (—).

The response of the contact 25 of the starting relay ST causes the system to be initiated and the application of a series of impulses to the "A" branch of the line circuit, as previously described, marking off the cycle of operations. During such a cycle of operations, assuming that no controls are being transmitted, the code sending relay CS at the control office remains deenergized, so that during each energized period marked off on the "A" branch of the line circuit, the "B" branch is left energized. Such a code of (+)(+)(+) impressed upon the "B" branch results in the dropping out of all of the relays SO (with suitable exponents) at the field stations during the cycle of operations, as there is no field station which has all positive code call impulses assigned to it (see Typical Code Table). This occurs in spite of the fact that the relays SO (with suitable exponents) are picked up at the beginning of a cycle of operations in the usual manner. The step-by-step operation occurs in the manner previously described so that a description of the registration of that particular field station which is transmitting may be immediately considered.

Station registration for indications.—The application of the first impulse to the "A" branch of the line circuit is repeated by the relays F (with suitable exponents) at the control office and at each field station. The closure of the

front contacts of the relay F (with suitable exponents) at the field station which has initiated the system causes the relay SI (with suitable exponent) at that station to be picked up.

For example, with the relay CHS¹ picked up, the closure of front contact 83 of relay F¹ completes a pick-up circuit for the relay SI¹ from (+), through a circuit including front contact 83 of relay F¹, front contact 112 of relay CHS¹, back contact 113 of relay SA¹, upper winding of relay SI¹, to (—). As soon as the relay SI¹ responds to such energization, a holding stick circuit is closed from (+), through a circuit including front contact 91 of relay F¹, front contact 114 of relay SI¹, upper winding of relay SI¹, to (—).

The energization of the relay F¹ is of course repeated by the sequential energizations of the relays FP¹ and 2FP¹. The closure of front contact 92 of relay 2FP¹ connects energy from (+) in multiple with the front contact 91 of the relay F¹. In other words, the front contact 91 of relay F¹ initially closes the holding circuit for the relay SI¹, while the front contact 92 of relay 2FP¹ finally opens this holding circuit of the relay SI¹. This operation is analogous to the operations associated with the relay SO¹ except that the holding circuits for the relay SO¹ are closed during deenergized periods, while the circuits for the relays SI¹ are closed during energized periods.

After the predetermined time measured off by the picking up of the relay SA¹, the code sending relay CS¹ at the first field station is deenergized, so far as its initial energizing circuit is concerned, by reason of the opening of back contact 110 of relay SA¹. However, with the relay SI¹ picked up, the closure of front contact 116 of this relay prepares the code sending relay CS¹ for the transmission of the station code call and the indications associated therewith.

Assuming for the time being that the relay SI¹ is maintained energized by reason of the fact that the code call impressed on the "B" branch of the line circuit during the deenergized periods of the "A" branch of the line circuit corresponds to the code call of the station, as this is the only station transmitting, we may consider how the code call is impressed on the "B" branch.

As soon as the relay SI¹ closes its front contact 116 and relay SA¹ opens its back contact 110, the relay CS¹ is conditioned in accordance with the code jumper 15. If the code jumper 15 is connected to the "+ bus", the code sending relay CS¹ is left deenergized; but if the code jumper is connected to the "— bus", the code sending relay CS¹ is energized from (+), through a circuit including back contacts 85, 86, 87 and 88 of relays 4V¹, 3V¹, 2V¹ and 1V¹ respectively, code jumper 15 in a right hand position, "—bus", front contact 116 of relay SI¹, windings of relay CS¹, to (—).

This conditioning of the code sending relay CS¹ is not effective to condition the "B" branch of the line circuit until the first deenergized period of the "A" branch at which time the front contact 94 of relay F¹ is open and unshunts back contact 19 of relay CS¹. Under such circumstances, if the relay CS¹ is left deenergized with the code jumper 15 connected to the "+ bus", the "B" branch of the line circuit is energized by a circuit completed from the upper terminal of the secondary of the transformer TR (see Fig. 1), through the line wire 12 to the second field station, back contact 18 of relay CS², windings of relay ME², recti-

5 fying unit RB², line wire 12, to the line wire 10 at the end field station, line wire 10 to the first field station, back contact 19 of relay CS¹, windings of relay ME¹, rectifying unit RB¹, line wire 10 to the control office, rectifying unit RB, windings of relay ME, back contact 20 of relay F, to the lower terminal of the transformer TR. This, of course, assumes that no other field station is transmitting and back contact 18 of relay CS² at the second field station is closed, as well as the back contacts of the corresponding code sending relays of any other field station in the system, as such back contacts are closed when their respective stations are not transmitting.

10 On the other hand, if the code jumper 15 is connected to the "— bus" and the relay CS¹ is energized, as previously pointed out, the back contact 19 is opened so that the "B" branch of the line circuit is deenergized. It is, of course, apparent that the opening of the corresponding back contact of the code sending relay CS (with suitable exponent) of any other station would likewise deenergize the "B" branch under similar circumstances which will be considered herein-

25 after.

The relay CS¹ is maintained in this condition as set up by the code jumper 15 until the first stepping relay 1V¹ is picked up on the second energized period, as previously explained, at which time the code sending relay CS¹ is ineffective to condition the "B" branch of the line circuit, as the front contact 94 of relay F¹ is closed, shunting this contact out.

30 During the time that the code sending relay CS¹ is ineffective to condition the "B" branch of the line circuit, the next stepping relay 1V¹ is picked up so that the code sending relay CS¹ is conditioned in accordance with the code jumper 16.

40 If the code jumper 16 is connected to the "— bus", then the relay CS¹ is energized by a circuit closed from (+), through a circuit including back contacts 85, 86 and 87 of relays 4V¹, 3V¹ and 2V¹ respectively, front contact 88 of relay 1V¹, code jumper 16 in a right hand position, "— bus", front contact 116 of relay SI¹, windings of relay CS¹, to (—).

45 On the other hand, if the code jumper 16 is connected to the "+ bus", the code sending relay CS¹ is left deenergized.

This positioning of the contact 19 of the code sending relay CS¹ occurs while the contact 94 of relay F¹ is still closed, but upon the occurrence of the next deenergized period (second) opening front contact 94, the contact 19 is then rendered effective to condition the "B" branch of the line circuit in accordance with the position of the code jumper 16.

50 It is readily apparent, that as the successive steps of the cycle are taken in response to the impulses on the "A" branch, the code jumpers 15, 16 and 17 are successively rendered effective to condition the "B" branch of the line circuit during the deenergized periods marked off on the "A" branch.

55 Similarly, after the station registering steps have been taken, the indication contacts are rendered effective to condition the code sending relay. For example, with the third stepping relay 3V¹ picked up, the contact 117 of the track relay T is effective to condition the code sending relay CS¹. If the contact 117 of the track relay T is picked up, then the code sending relay CS¹ is left deenergized; but, if the contact 117 of the track relay T is closed, then the code sending re-

lay CS¹ is energized by reason of a circuit closed from (+), through a circuit including back contact 85 of stepping relay 4V¹, front contact 86 of relay 3V¹, back contact 117 of track relay T, "— bus", front contact 116 of relay SI¹, windings of relay CS¹, to (—).

Succeeding indication contacts control the code sending relay in a similar manner.

The code sending relay CS (with suitable exponent) at the sending station conditions the "B" branch during the deenergized periods of the "A" branch by controlling its energization. If the conditions, thus impressed upon the "B" branch, correspond to the code call of the station, the relay SI (with suitable exponents) remains selected throughout the cycle of operations, which is the case when only one field station is transmitting.

For example, with the code jumper 15 connected to the "— bus", the code sending relay CS¹ is energized during the first deenergized period marked off by the "A" branch, which causes the relay ME¹ to be deenergized. With the back contact 89 of relay ME¹ closed, the relay SI¹ is maintained energized, although its holding stick circuits are opened at front contacts 91 and 92 of relays F¹ and FP¹ respectively, by reason of a selecting stick circuit closed from (+), through a circuit including back contacts 85, 86, 87 and 88 of relays 4V¹, 3V¹, 2V¹ and 1V¹, code jumper 15 in a right hand position, "— bus", back contact 89 of relay ME¹, front contact 115 of relay SI¹, lower winding of relay SI¹, to (—).

The relay SI¹, thus held energized in accordance with the correspondence between the condition of the "B" branch of the line circuit and its code jumper, is maintained energized during the following energized period (second) on the "A" branch by reason of the closure of the front contact 91 of relay F¹ prior to the opening of its selecting stick circuit by the transfer from code jumper 15 to the code jumper 16 upon the picking up of the stepping relay 1V¹ during this period. Similarly, during each of the deenergized periods marked off on the "A" branch of the line circuit, the relay SI¹ is selected, so long as the code call impressed on the "B" branch of the line circuit corresponds to the code call of the station.

55 With reference to the drawings, it will be seen that the code jumper 17 is effective during the third deenergized period marked off on the "A" branch, and at the end of this period marked off by the fourth energized period on the "A" branch, the relay 3V¹ is picked up, at which time a holding circuit is closed for the relay SI¹, assuming of course, that it has been selected or maintained which circuit is closed throughout the remainder of the cycle of operation. This holding circuit is closed from (+), through a circuit including front contact 118 of relay 3V¹, front contact 114 of relay SI¹, upper winding of relay SI¹, to (—).

The code call, which is imposed upon the "B" branch, is registered in the control office on suitable pilot relays, which, for convenience, have not been illustrated, but may be of any suitable type such as disclosed in the pending application of N. D. Preston et al., Ser. No. 455,304, filed May 24, 1930. It is sufficient for an understanding of the present invention to know that the condition of the "B" branch of the line circuit during each deenergized period marked off on the "A" branch is made available in the control office by the relay ME which is allowed to execute its condition for each period to a suitable pilot relay when the relays F and 2FP are deenergized. During each

executing period, a circuit is closed either from positive or negative potential (B+) or (B-) through front or back contact 120 of relay ME respectively, back contact 121 of relay F, back contact 122 of relay 2FP, back contacts of those stepping relays which have not yet been picked up and the front contact of that stepping relay which is picked up just prior to the closure of the executing circuit by the closure of back contact 122 of relay 2FP, and thence to the particular pilot relay, all of which will be readily understood and need not be explained in detail.

Following the registration of the code call impressed upon the "B" branch, the station relay C is picked up through selection by the pilot relays, which relay C corresponds to the particular station which has been effective to impress its code call upon the "B" branch and connects the indication storing relays IR for that station to the buses which are sequentially energized in accordance with the indications received after the station is registered.

More specifically, the pilot relays in the present embodiment are positioned on the first three steps in accordance with the polarities applied to the buses 123, 124 and 125; while the buses 126 and 127 are energized in accordance with the indications received on the last two steps. This means that two indications may be transmitted on the last two steps and those particular indication storing relays which receive such indications are determined in accordance with the particular station relay C which is picked up.

Assuming that the energization of the relay C corresponds to the station illustrated in Fig. 3, then upon the fourth deenergized period, the indication bus 126 is energized with positive or negative energy in accordance with the condition of the "B" branch as reflected in the ME relay. At this time relay IR is connected by front contact 128 of relay C to the bus 126, so that its contact is actuated to a right or a left hand position dependent upon the particular polarity applied. With the track relay T in the field energized, the code sending relay CS¹ is left deenergized which energizes the relay ME, thereby applying positive potential from (B+), so that contact 129 of the relay IR remains in a right hand position. On the other hand, if the track relay T is deenergized closing back contact 117, the relay CS¹ is energized and the "B" branch is deenergized, which is reflected by the relay ME so that negative potential is applied, and the contact 129 of relay IR is actuated to a left hand position.

With the contact 129 of relay IR in a right hand position, the OS lamp is deenergized; but with the contact 129 of relay IR in a left hand position, the OS lamp is energized by an obvious circuit, thereby informing the operator of the occupancy of the detector track section associated with the track switch TS.

After the registration of a station and the transmission of its indications, the system returns to normal, as previously described.

Selection between a plurality of stations ready to transmit new indications.—As previously stated, it may happen that two or more stations may have new indications to transmit to the control office at substantially the same time, as for example, when two trains enter or leave track circuits simultaneously; and in a communication system adaptable for centralized traffic control it is necessary to provide means whereby priority between two or more stations that may be ready to send in indications, can be established.

In accordance with this invention, only one station registers itself in the control office during an operating cycle regardless of the number of stations which may have new indications ready to transmit. The sequence or order in which the stations communicate their indications, one station at a time, is determined by the characteristics of the code calls of these stations.

With reference to the code table given above, which is applicable to both station selection and station registration, a (+) code element or digit is assigned to represent the energized condition of the "B" branch of the line circuit; while the (−) code element or digit is assigned to represent the open or deenergized condition of the "B" branch. The code calls Nos. 2 to 8 inclusive are assigned to the different stations of the system, while the code call No. 1 is assigned to a phantom or non-existent station. As the "B" branch of the line circuit is a series circuit, it may be opened at any field station by the code sending contact at that station, irrespective of the closed condition of the code sending contact at any other field station. In other words, the open condition represented by the (−) symbol is the most superior condition, and any field station having such a code element in its code call is superior to all other stations having a (+) code symbol or element in its code call for the corresponding period of the cycle.

This feature may be more readily seen by consideration of the field station illustrated in Fig. 3 which has been assigned the code call No. 3 comprising code elements (−)(+)(−). Let us assume that this station illustrated in Fig. 3 is transmitting so as to register itself in the control office. As its code jumper 15 is connected to the "− bus" in accordance with the (−) code element assigned for the first registering period, which is the first deenergized period of the "A" branch of the line circuit, those stations having code calls Nos. 2, 3 and 4 assigned thereto which include (+) code elements for the corresponding period, are the most inferior and can not impress their code call element upon the "B" branch when the station illustrated in Fig. 3 is transmitting, thereby causing the relays SI (with suitable exponents) at those stations to be dropped out. In other words, during the first deenergized period, the contact 19 of the relay CS¹ is open and the "B" branch can not be energized by any other station, and a (−) code element is registered in the control office.

As the condition of the "B" branch corresponds to the code element assigned to the first station, then the relay SI¹ at that station is maintained energized; while the relay SI (with suitable exponent) at any other field station having a (+) code element is dropped out because the contact 89 of relay ME (with suitable exponent) at such station is in a deenergized position while the code jumper 15 at that station is connected to the "+ bus".

Thus, it is apparent that any station having a (−) code element or digit on the first step is one of the more superior stations and is selected so far as that step is concerned.

On the second step, the station illustrated in Fig. 3 is assigned a (+) code element. Now, if there is another station transmitting which has a (−) code element for both the first and second steps it will be the more superior and the first station will be dropped out. Similar selection occurs on each of the station registering steps.

Irrespective of the number of stations trans-

mitting at the same time, the most superior station maintains its relay SI picked up and the SI relays at the other stations are dropped out in groups. The code No. 8 is the most superior and the code No. 1 the most inferior. In other words, they rank each other in the reverse order of that given in the code table.

It is believed unnecessary to explain in further detail the manner in which the stations are given preference over one another in accordance with their code characteristics, as the feature of superiority of code has been disclosed in detail in the above mentioned application of N. D. Preston et al., Ser. No. 455,304, filed May 24, 1930, it being understood that the use of the superiority of code is adaptable to a system arranged in accordance with the present invention, but that the invention is not necessarily limited to use with a system employing this specific type of preference between field stations.

Two-way or duplex transmission.—From the above description it is apparent that the "B" branch of the line circuit is employed for the transmission of control during the energized periods of the cycle as marked off on the "A" branch; while indications are transmitted over the "B" branch during the deenergized periods of the cycle as marked off on the "A" branch. This is accomplished in accordance with the present invention by providing that the line relays F (with suitable exponents) at the field stations shunt the code sending contacts at the field station during the energized periods of the "A" branch and unshunt them during the deenergized periods; while the contacts of the relay F in the control office shunt the code sending contact in the control office during the deenergized periods and unshunt it during the energized periods. In other words, the energized and deenergized condition of the "A" branch for each step is employed successively for the transmission of controls and indications for that step so that it is readily apparent that the "B" branch of the line circuit accommodates the transmission of both controls and indications during the same cycle of operation.

In brief, the selecting relays SO (with suitable exponents) are picked up at the beginning of every cycle of operation, but the selecting relays SI (with suitable exponents) are picked up at their respective stations only upon such cycles as their stations have indications to transmit. For a cycle of operation for the transmission of controls alone, a code call is placed upon the "B" branch of the line circuit during the energized periods of each step for the selection of a station; but as the relays SI (with suitable exponents) are not picked up, their code sending relays CS (with suitable exponents) are rendered ineffective, so that the code placed upon the "B" branch during the deenergized periods of each step corresponds to the code call No. 1 which is not assigned to any station and which provides that there is no field station registered in the control office.

On the other hand, if the cycle of operation is for the transmission of both controls and indications, then the "B" branch is conditioned with a particular station selecting code during the energized periods and a particular station registering code during the deenergized periods of the cycle to provide for both the selection of a field station and the registration of that field station or some other field station having indications to transmit and being the most superior

field station among those having such indications to transmit. This is termed two-way or duplex transmission.

If the cycle of operation is for the transmission of indications alone, then the code sending relay CS in the control office is effective to condition the "B" branch during the energized periods with the code No. 1 which is not assigned to any field station, so that although the cycle of operation continues for the transmission of indications, no field station is selected for the reception of controls. However, that particular field station or those particular field stations having indications to transmit are impressing their station registering codes upon the "B" branch during the deenergized periods of the cycle, and the most superior station registers itself in the control office and is selected at its station by the maintenance of its selecting relay SI (with suitable exponent).

As previously mentioned, the stepping relay banks at the field station are dependent for their operation upon the energized or picked up condition of one of their selecting relays. Thus, if one field station is being selected for controls and another field station is being selected for registering indications, the step-by-step operation occurs at both such field stations, but at the remaining field stations of the system the step-by-step operation discontinues as soon as such field stations fail to be selected.

Thus, duplex transmission is provided by allotting the "B" branch of the line circuit to the transmission of controls and indications during separate parts of each step, by the provision of separate station selecting means at each field station for both controls and indications, and by making the step-by-step operation at each field station dependent upon both of its station selecting means.

In other words, the selecting relays SO (with suitable exponents) are picked up at the beginning of every cycle of operations, but when there are no controls to be transmitted, the code call No. 1 is impressed upon the "B" branch, which code call is not assigned to any station so that no station is selected if the cycle of operation is for the transmission of indications alone. On the other hand, if the cycle of operation is for the transmission of indications and controls, then the "B" branch is conditioned with a particular station selecting code during the energized periods and a particular station registering code during the deenergized periods of the cycle to provide for the duplex transmission feature.

If the cycle of operation is for the transmission of controls alone, then the code call No. 1 which is not assigned to any field station is the one which is impressed upon the "B" branch during the deenergized period, as the code sending relays CS (with suitable exponents) are normally deenergized so that no field station is registered in the control office.

It is believed unnecessary to point out in detail the operations involved for the simultaneous two-way transmission of controls and indications, as such operation is merely the simultaneous occurrence of the control and indication cycles described separately.

Summary

The present invention contemplates a communication system for centralized traffic control in which a small number of line wires is employed to transmit a large number of distinctive con-

ditions during a short operating cycle. In the particular embodiment chosen, two line wires are employed to form a line circuit having two branches, one branch of which is employed for causing the synchronous step-by-step operation at the control office and at the field stations and for determining the direction of transmission of messages over the other branch of the line circuit. With this arrangement, one of two conditions is set up on the message transmitting branch for the transmission of controls during one period of each step; while one of two conditions is set up on the message transmitting branch for the transmission of indications during the other period of each step. These selected conditions are set up alternately throughout the cycle of operations so that when a cycle of operation has been completed, both controls and/or indications may have been transmitted.

A further feature of the invention resides in the novel manner in which the line circuit is divided into branches by the use of asymmetric units, which may be of any suitable type, such for example, as the usual copper oxide rectifier.

Attention should also be directed to the manner in which the step-by-step operation at the field station is one-half step behind the step-by-step operation in the control office, to thereby obviate the necessity for suitable storing means to store controls and indications until a proper executing period can be set up. The advantages of this arrangement may more specifically be seen by considering that the relays at both the control office and at the field stations employed to select the condition of the message branch are preconditioned on the particular period of each step which precedes the period allotted to the transmission of messages in that direction. Inasmuch as the condition of these code selecting relays is selected by each of their associated stepping relays as they are successively picked up, the energizing circuits for the code selecting relays at both the control office and the field stations are controlled directly from contacts of their associated bank of stepping relays because the stepping relays are arranged at both the control office and field stations to pick up during the same period that the associated code selecting relay is conditioned.

Attention is further directed to the means by which the various transmitted conditions of the message branch are executed in the reception of messages at both the control office and field stations to insure that when the condition of the message responsive relay is executed, that condition is associated with the particular direction of transmission rather than the lagging or leading condition of the message circuit associated with the opposite direction of transmission.

More specifically, it is understood that one function of the series line relays F^1 (with suitable exponents at the field station) is to determine by its position the direction of message transmission on each step, and consequently any change in condition of the message branch in the shifting from one transmitting direction to the other is reflected by the message responsive relay ME (with suitable exponents at the field station) directly after the actuation of the F^1 relays which theoretically will then make the operation of the message responsive relay ME simultaneous with the operation of the first line repeating relay FP (with suitable exponents at the field station) and previous to the operation of the second line repeating relays 2FP (with

suitable exponents at the field stations). Obviously, with the execution of a message being dependent upon the actuation of the line relays F^1 which leads the actuation of the message responsive relays and also upon the actuation of the second line repeating relays 2FP, which lags the actuation of the message responsive relays, a time interval is provided to allow the message responsive relays to assume their proper position before such position is executed as received messages.

This may be still more specifically pointed out by considering the execution of incoming messages at the control office, which messages are transmitted on the deenergized period of the "A" branch of the series line circuit and are reflected by the position of contact 120 of relay ME, but the position of this contact 120 is executed as an incoming message only when both relays F^1 and 2FP are deenergized as enforced by the respective series back contacts 121 and 122 thereby allowing a tolerable conditioning time of the relay ME equal to the cumulative drop-away times of relays F^1 , FP and 2FP. In a similar manner at the field stations, such as the typical station shown in Fig. 3, the incoming messages are transmitted on the energized period of the "A" branch and are reflected by the position of contact 97 of relay ME¹, but the position of this contact 97 is executed as an incoming message only when both relays F^1 and 2FP¹ are energized as enforced by the respective series front contacts 98 and 99. Also at the field stations the same idea is carried out in the selection of the relays SO¹ and SI¹, but in this case the relays F^1 and 2FP¹ do not have series contacts preventing the execution of messages during the time allotted to the conditioning of the message responsive relay but rather have multiple contacts 91 and 92 functioning to hold up these relays SO¹ and SI¹ except during the period in which they are to be selected by the condition of contact 89 of relay ME, but obviously the effectiveness of the position of this contact 89 is cancelled during the same period of time as that of contact 97 of the same relay.

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

What I claim is:—

1. In a remote control system, a control office, a plurality of field stations, a series line circuit comprising two line wires connecting said control office with said field stations, an alternating current source of energy located in said control office for energizing said line circuit, means at said control office and at each of said field stations for dividing said line circuit into two branches at said control office and at each of said field stations, means at said control office and at each of said field stations permitting current to flow only in one direction in one of said branches at said control office and at each of said field stations, means at said control office and at each of said field stations permitting current to flow

only in the opposite direction in the other of said branches at said control office and at each of said field stations, means in said control office for controlling the energization of said one branch, means in said control office for controlling the energization of said other branch only when said one branch is energized, means at each of said field stations for controlling the energization of said other branch only when said one branch is deenergized, and means responsive to the energization of said other branch for transmitting messages to and from said control office and said field stations.

2. In a remote control system, a control office, a plurality of field stations, a series line circuit connecting said control office and said field stations, code sending contacts at said control office and at each of said field stations included in said series line circuit, means alternately shunting said code sending contact in said control office and said code sending contacts at said field stations, means selectively controlling said code sending contact in said control office in accordance with a code when said code sending contacts at said field stations are shunted, means selectively controlling said code sending contacts at certain of said field stations in accordance with a code when said code sending contact at said control office is shunted, and means responsive to the selective control of said code sending contacts for alternately transmitting messages from said control office and said field stations.

3. In a remote control system, a control office; a plurality of field stations; means constituting two independently energizable line circuits connecting said control office and said field stations; step-by-step means at said control office and at each of said field stations; means in said control office for impulsing one of said line circuits for a plurality of impulse periods, each impulse period including an "on" period and an "off" period, means responsive to said impulsing for operating said step-by-step means through a plurality of steps, one for each of said impulse periods to comprise a cycle of operation; code sending means at said control office and at each of said field stations; means controlled by said code sending means for transmitting messages both ways between said control office and said stations; and means allotting said other line circuit to the control of said code sending means at said control office during each "on" period of the cycle of operation and to the control of said code sending means at said field station during each "off" period of the cycle of operation.

4. In a remote control system, a control office, a field station, a series line circuit connecting said control office and said field station, an alternating current source of energy located in said control office, means at said control office and at said field station for dividing said line circuit into two branches, a line relay and a rectifier poled in one direction included in one of said branches both at said control office and at said field station, an impulsing contact included in said one branch in said control office, means responsive to the operation of said impulsing contact for applying series of impulses to said line circuit from said source of energy, means responsive to said impulses for operating said line relays, a message relay and a rectifier poled in the opposite direction included in the other of said branches both at said control office and at said field station, a back contact on said line relay in said control office included in series in said other

branch in said control office, a code sending contact included in multiple with said back contact on said line relay in said control office, a front contact on said line relay at said field station included in series in said other branch at said field station, another code sending contact included in multiple with said front contact on said line relay at said field station, step-by-step means at said control office and at said field station governed in response to the operation of said line relays, means controlling said code sending contact at said control office and at said field station on each step taken by said step-by-step means in accordance with messages to be transmitted, and means responsive to said message line relays at said control office and at said field station during each of said steps for storing said messages.

5. In a remote control system, a control office, a plurality of field stations, a series line circuit connecting the control office and the field stations, an alternating current source of energy, means for applying time-spaced energy impulses to said series line circuit made up of half cycles of one direction of current from said alternating current source, step-by-step means at said control office operating in response to the time between the energy impulses of said series line circuit, step-by-step means at said field stations operating in response to the energy impulses of said series line circuit, means including the step-by-step means at the control office for selectively applying half cycles of the opposite direction of current from said alternating current source to said series line circuit during the application of each energy impulse thereto, means including the step-by-step means at the field stations for selectively permitting the flow of half cycles of the said opposite direction of current from said alternating current source to said series line circuit during the times between the application of energy impulses thereto, and means responsive to said selective application of current for transmitting messages between said stations and said office alternately.

6. In a communicating system; a line circuit interconnecting spaced locations; means energizing said line circuit during a plurality of impulse periods, said means energizing said line circuit during one part of each impulse period with a series of spaced pulses of one polarity and removing said pulses from said line circuit during the other part of each impulse period; means controlled in response to pulses of said one polarity for selectively applying to said line circuit series of spaced pulses of the opposite polarity during the energized part of each of said impulse periods, means responsive to said pulses of opposite polarity for receiving codes transmitted in one direction over said line circuit, said pulses of said opposite polarity occurring during the spaces between the pulses of said one polarity; means for selectively applying to said line circuit series of spaced pulses of said opposite polarity during the other part of each of said impulse periods, and means responsive to the pulses of opposite polarity during the other part of each of said impulse periods for receiving codes transmitted in the opposite direction over said line circuit.

7. In a remote control system; a control office; a plurality of field stations; two lines wires connecting said control office and said field stations; rectifier means at said control office and at each of said field stations for forming two branch circuits in one of said line wires, said rectifier means

allowing only the flow of currents of opposite polarities in said branch circuits respectively; impulsing means at said control office for applying a series of time spaced impulses of one polarity to flow in the first of said two branch circuits, said impulses being of a polarity corresponding to the polarity required for that particular branch circuit; step-by-step means at said control office and at each of said field stations responsive to said series of impulses to take one step for each step period comprising an impulse and a time space; means including said impulsing means for energizing the second of said two branch circuits with a current of its corresponding opposite polarity; means at said control office for selectively opening or closing said second branch circuit during the impulse of each step period in accordance with a code, means at each of said field stations for selectively opening or closing said second branch circuit at that station during the time space of each step period in accordance with a code, means at each field station responsive to said code impulses transmitted from said control office over said second branch circuit, and means at said control office responsive to said code impulses transmitted from said field stations over said second branch circuit.

8. In a remote control system; a control office; a plurality of field stations; two line wires connecting said control office and said field stations; means at said control office and at each field station for forming two line circuits from said two line wires, each circuit of which connects said control office with said field stations and is capable of carrying current only of a particular character; a line relay included in one of said two circuits at said control office and at each of said field stations; an impulsing contact included in one of said two circuits at said control office; a message line relay included in the other of said two circuits at the control office and at each of said field stations; a back contact on said line relay in said control office included in series in the other of said two circuits; a code sending contact included in multiple with said back contact on said line relay in said control office; a front contact on said line relay at each of said field stations included in series in said other of said two line circuits; another code sending contact included in multiple with said front contact on said line relay at each of said field stations, step-by-step means at said control office and at each of said field stations governed by said line relays; means controlling said code sending contacts at said control office and at said field stations on each step taken by said step-by-step means in accordance with messages to be transmitted; and means responsive to said message line relays at said control office and at said field station during each of said steps for storing said messages.

9. In a remote control system; a control office; a plurality of field stations; means constituting two line circuits connecting said control office with said field stations; a line relay included in one of said two circuits at said control office and at each of said field stations; an impulsing contact included in said one of said two circuits at said control office; a message line relay included in the other of said two circuits at said control office and at each of said field stations; a back contact on said line relay in said control office included in series in said other of said two circuits; a code sending contact included in multiple with said back contact on said line relay in

said control office; a front contact on said line relay at each of said field stations included in series in said other of said two line circuits; another code sending contact included in multiple with said front contact on said line relay at each of said field stations; step-by-step means at said control office and at each of said field stations governed by said line relays; means controlling said code sending contacts at said control office and at said field stations on each step taken by said step-by-step means in accordance with messages to be transmitted; and means responsive to said message line relays at said control office and at said field station alternately during each of said steps for storing said messages.

10. In a signaling system of the character described, in combination a normally closed signal circuit, means for supplying said circuit with current impulses flowing alternately in opposite directions therein, code signal transmitting means serially connected in said circuit operable by the current impulses flowing in a certain one of said directions for interrupting the flow of certain ones of the current impulses in the opposite direction in accordance with a predetermined code, and code signal manifesting means operative in response to interruption of impulses flowing in said opposite direction.

11. In a signaling system of the character described, in combination a normally closed signal circuit, means for supplying said circuit with current impulses flowing alternately in opposite directions therein, and in series in said circuit signal transmitting means comprising means for separating current impulses of opposite direction, signal forming means for interrupting the flow of certain impulses of one direction in accordance with a signal code and means actuated by the impulses in the other direction for actuating said signal forming means, and code signal manifesting means operative in response to interruption of impulses flowing in said one direction.

12. In a signaling system of the character described, in combination a normally closed signal circuit, means for supplying said circuit with current impulses flowing alternately in opposite directions therein, and in series in said circuit signal transmitting means comprising means for separating in two branch circuits current impulses of opposite direction, signal forming means in one branch circuit for interrupting the flow therein of certain impulses of one direction in accordance with a signal code and means in the other branch circuit actuated by the impulses in the other direction for actuating said signal forming means, and code signal manifesting means serially connected in said normally closed circuit and operative in response to interruption of impulses flowing in said one direction.

13. In a signalling system of the character described, the combination with two spaced stations, a source of alternating current, a normally closed circuit connecting said stations and including two branches in multiple at one station and also including said source of alternating current, asymmetric units included in said branches so polarized that one wave of a cycle of alternating current from said source will flow in one branch and that the other wave will flow in the other branch, stepping means at said one station controlled by the energization of one of said branches, circuit interrupting means in said other branch at said one station controlled by said stepping means and interrupting such other

branch intermittently to characterize a code, and means at said other station for manifesting the character of said code.

5 14. In a signalling system of the character described, the combination with two spaced stations, a source of alternating current, a circuit connecting said stations and including two branches in multiple at one station and also including said source, asymmetric units included
10 in said branches in multiple so polarized that one wave of a cycle of alternating current from said source will flow in one branch and that the other wave of said current will flow in the other branch,

electro-responsive means in one of said branches, stepping means at said one station controlled by said electro-responsive means, circuit interrupting means in said other branch controlled
5 by said stepping means and interrupting said other branch intermittently to characterize a multiple element code each element of which includes a plurality of waves of current flowing in a particular direction, and means at said other
10 station for manifesting the character of said code.

EDWIN O. BLODGETT.