

Feb. 6, 1945.

W. D. HAILES ET AL

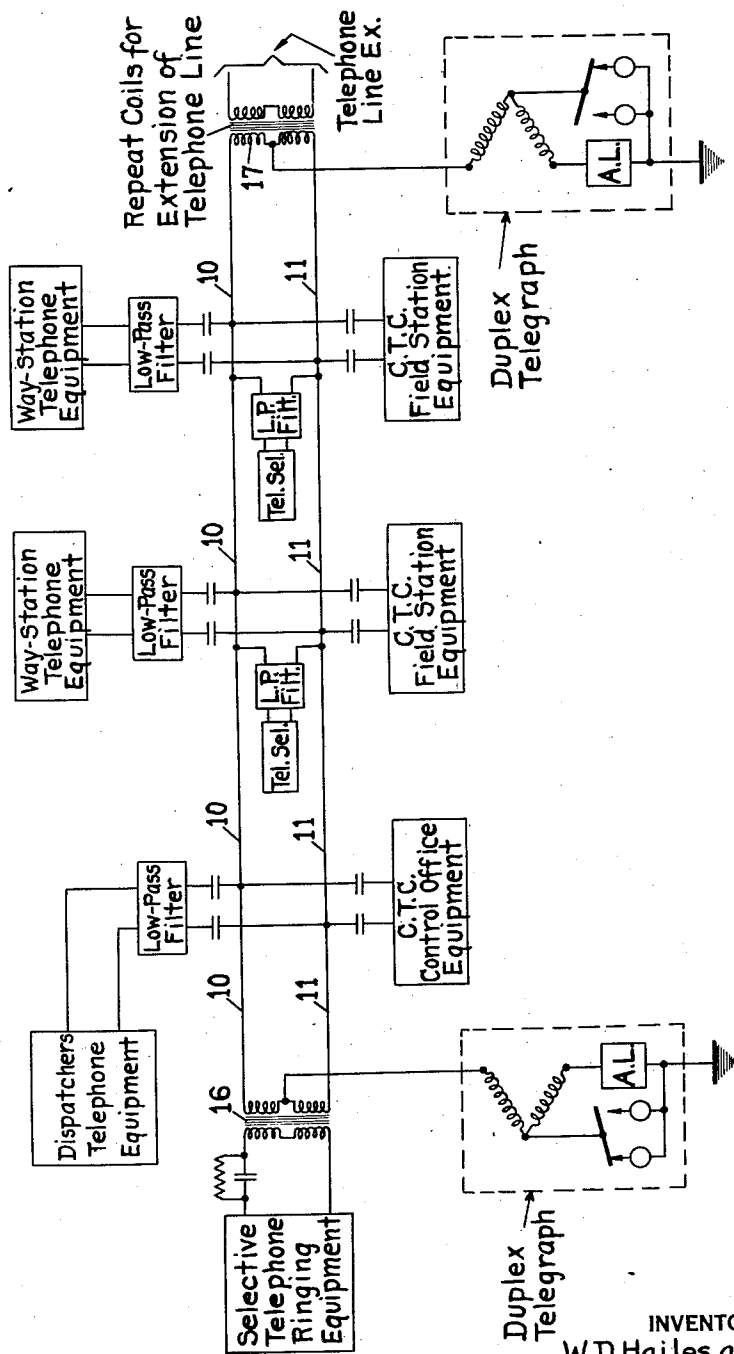
2,368,826

CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

Filed May 11, 1942

8 Sheets-Sheet 1

FIG. 1.



INVENTORS
W.D. Hailes and F.W. Brixner,
BY *Neil H. Preston,*
THEIR ATTORNEY

Feb. 6, 1945.

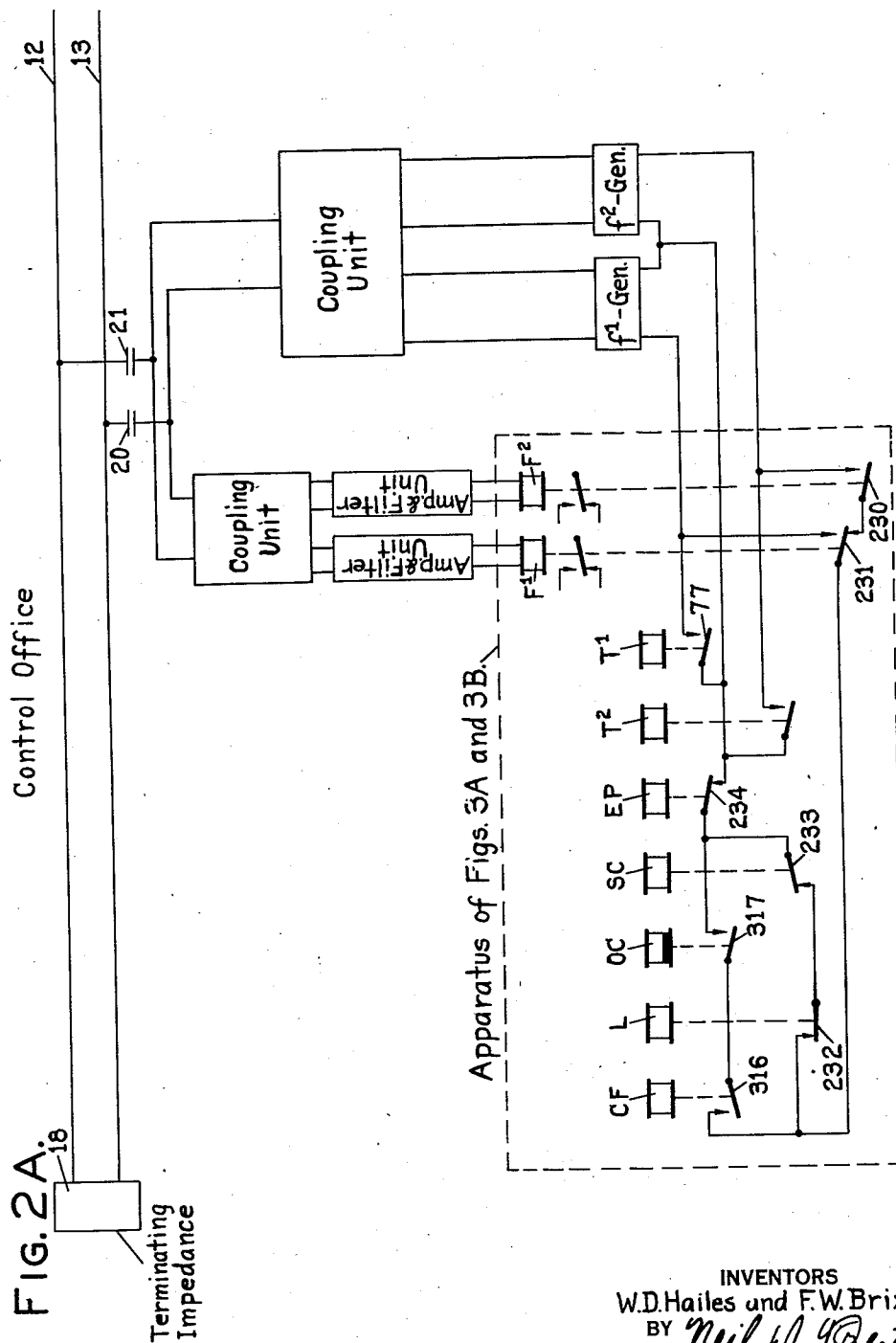
W. D. HAILES ET AL

2,368,826

CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

Filed May 11, 1942

8 Sheets-Sheet 2



INVENTORS
W.D. Hailes and F.W. Brixner,
BY *Neil H. Preston,*
THEIR ATTORNEY

Feb. 6, 1945.

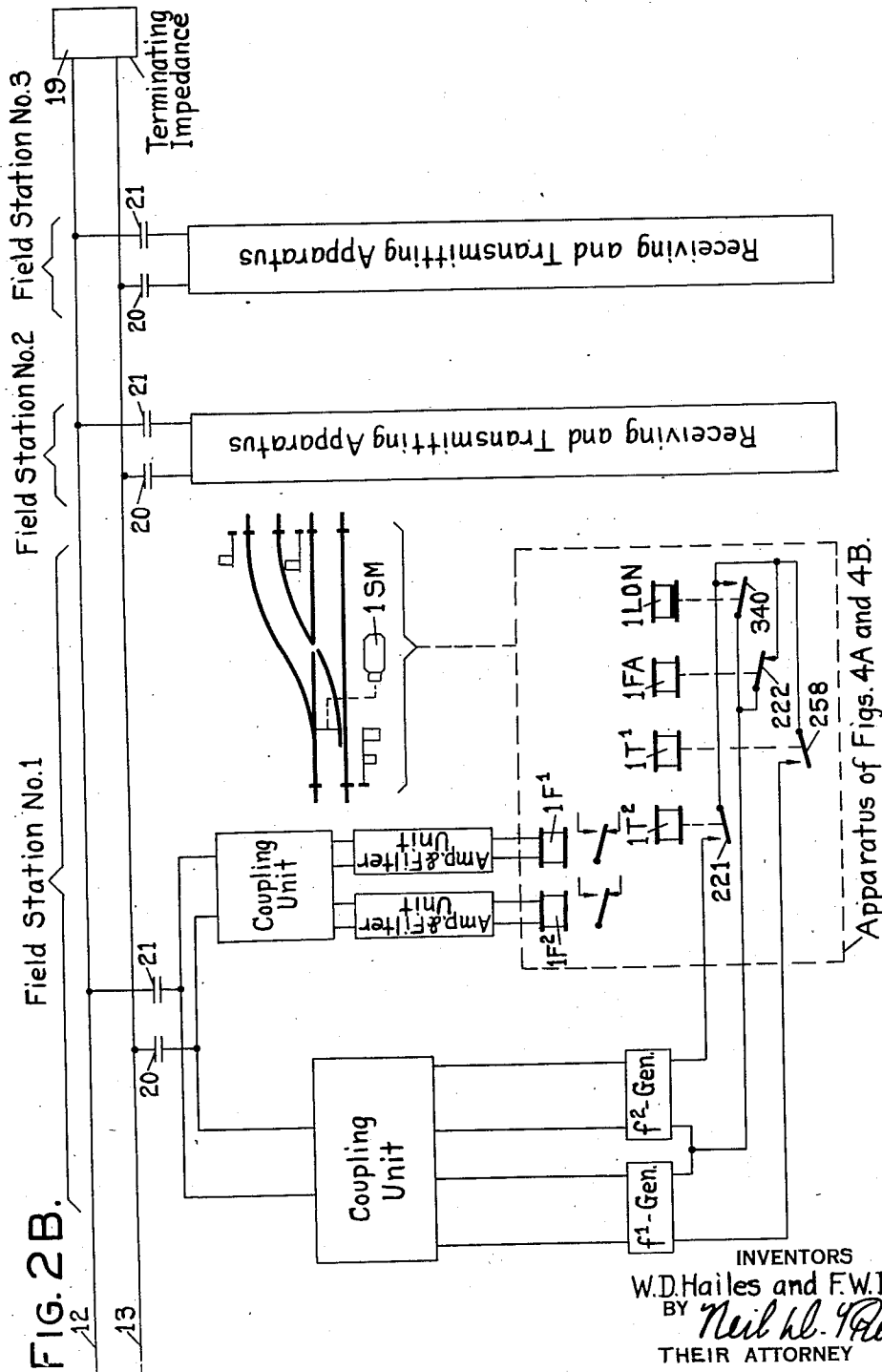
W. D. HAILES ET AL

2,368,826

CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

Filed May 11, 1942

8 Sheets-Sheet. 3



Feb. 6, 1945.

W. D. HAILES ET AL

2,368,826

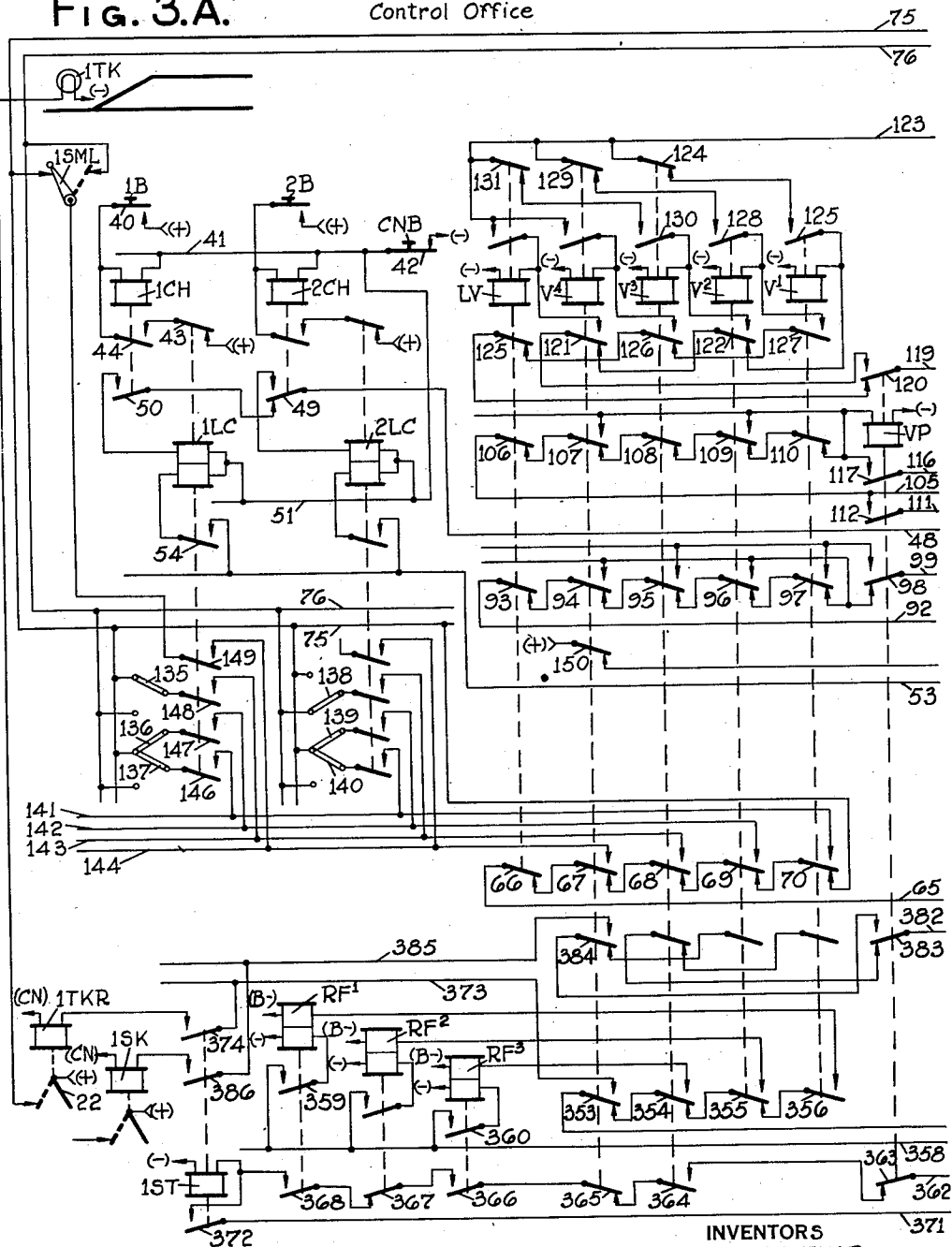
CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

Filed May 11, 1942

8 Sheets-Sheet 4

FIG. 3.A.

Control Office



INVENTORS
W.D. Hailes and F.W. Brixner
BY *Neil W. Preston*
THEIR ATTORNEY

Feb. 6, 1945.

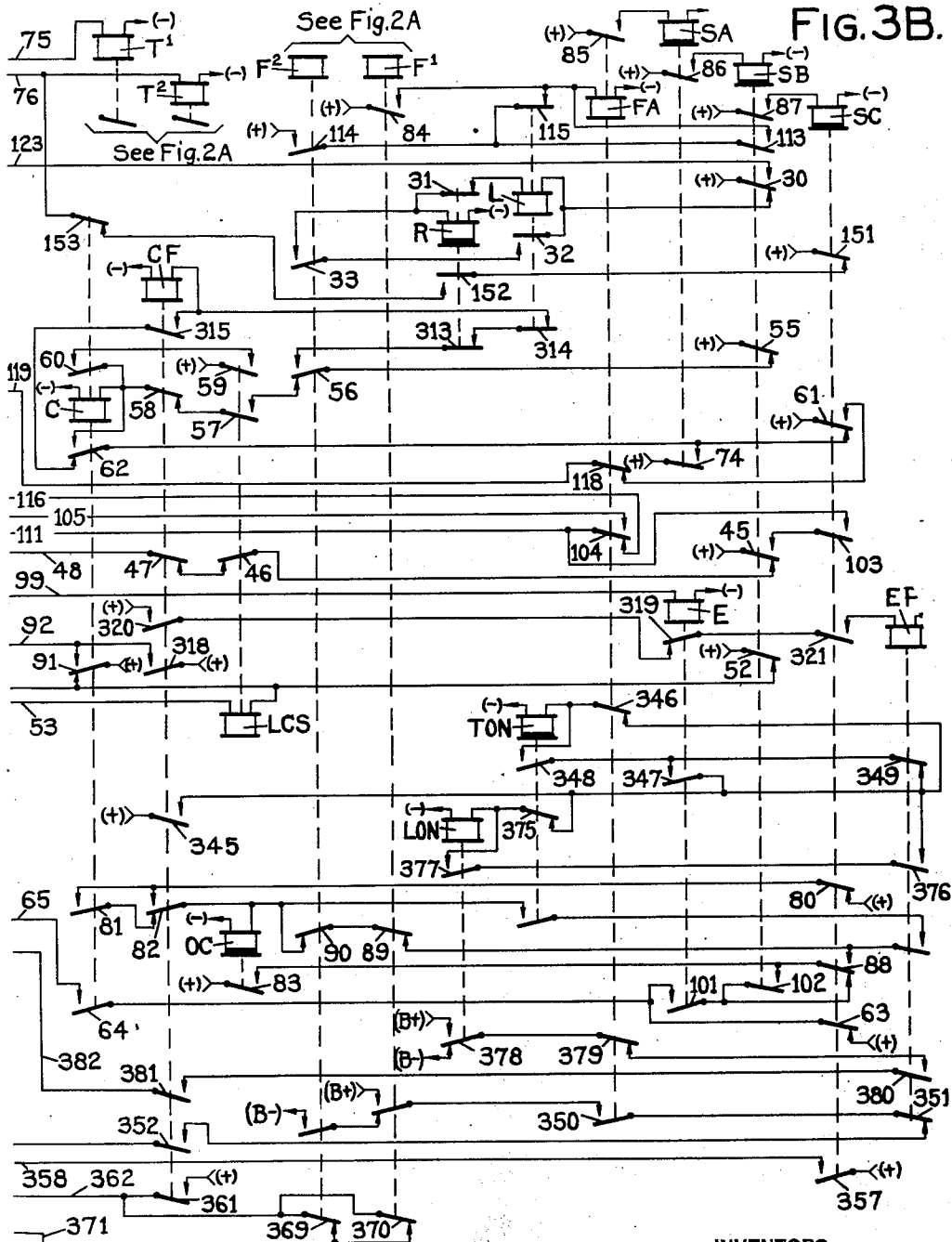
W. D. HAILES ET AL

2,368,826

CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

Filed May 11, 1942

8 Sheets-Sheet 5



INVENTORS
W.D. Hailes and F.W. Brixner
BY *Neil W. Ranton*
THEIR ATTORNEY

Feb. 6, 1945.

W. D. HAILES ET AL

2,368,826

CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

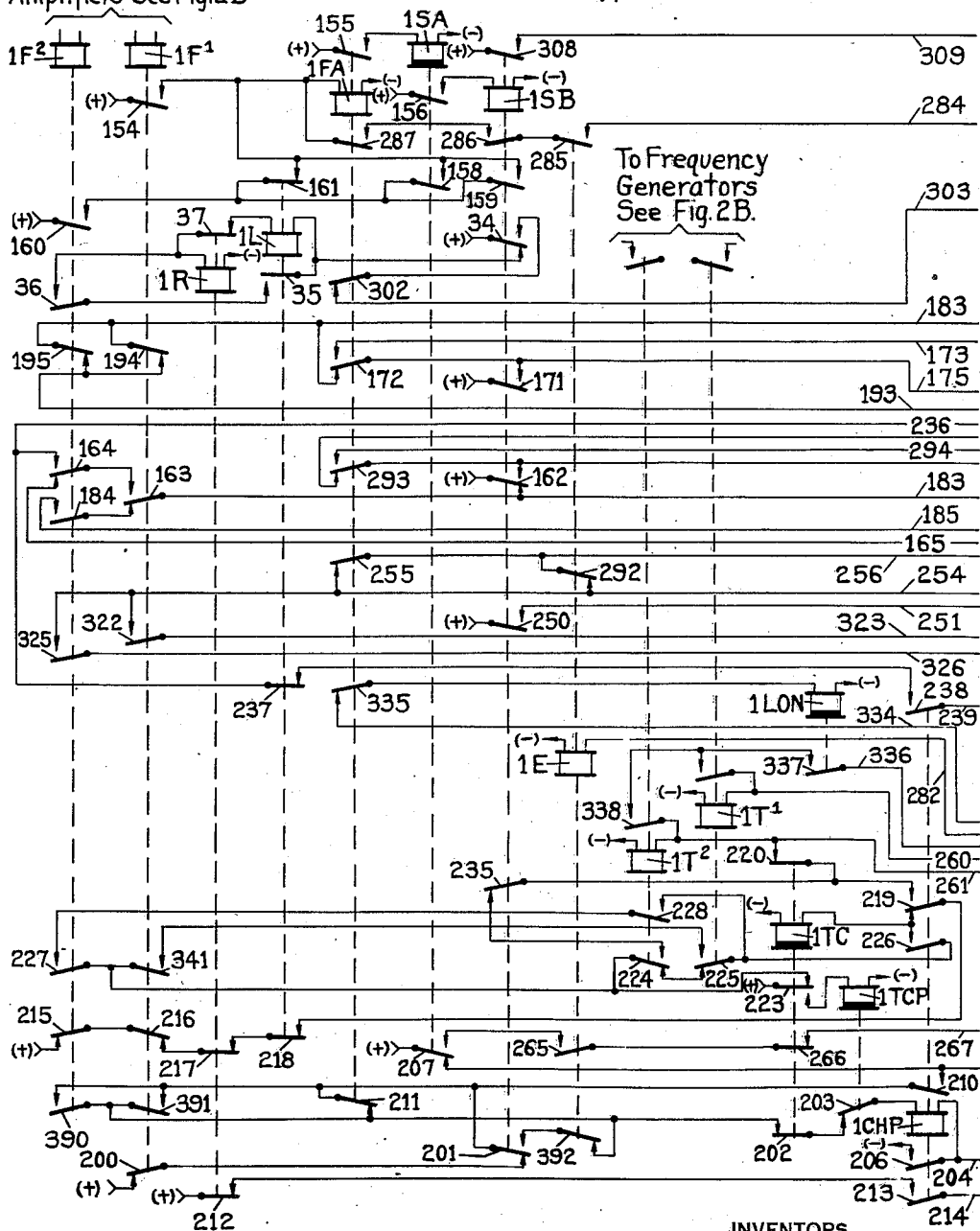
Filed May 11, 1942

8 Sheets-Sheet 6

From Filters and
Amplifiers-See Fig. 2B

FIG 4A.

Typical Field Station



INVENTORS
W.D. Hailes and F.W. Brixner
BY *Neil W. Reston*
THEIR ATTORNEY

Feb. 6, 1945.

W. D. HAILES ET AL

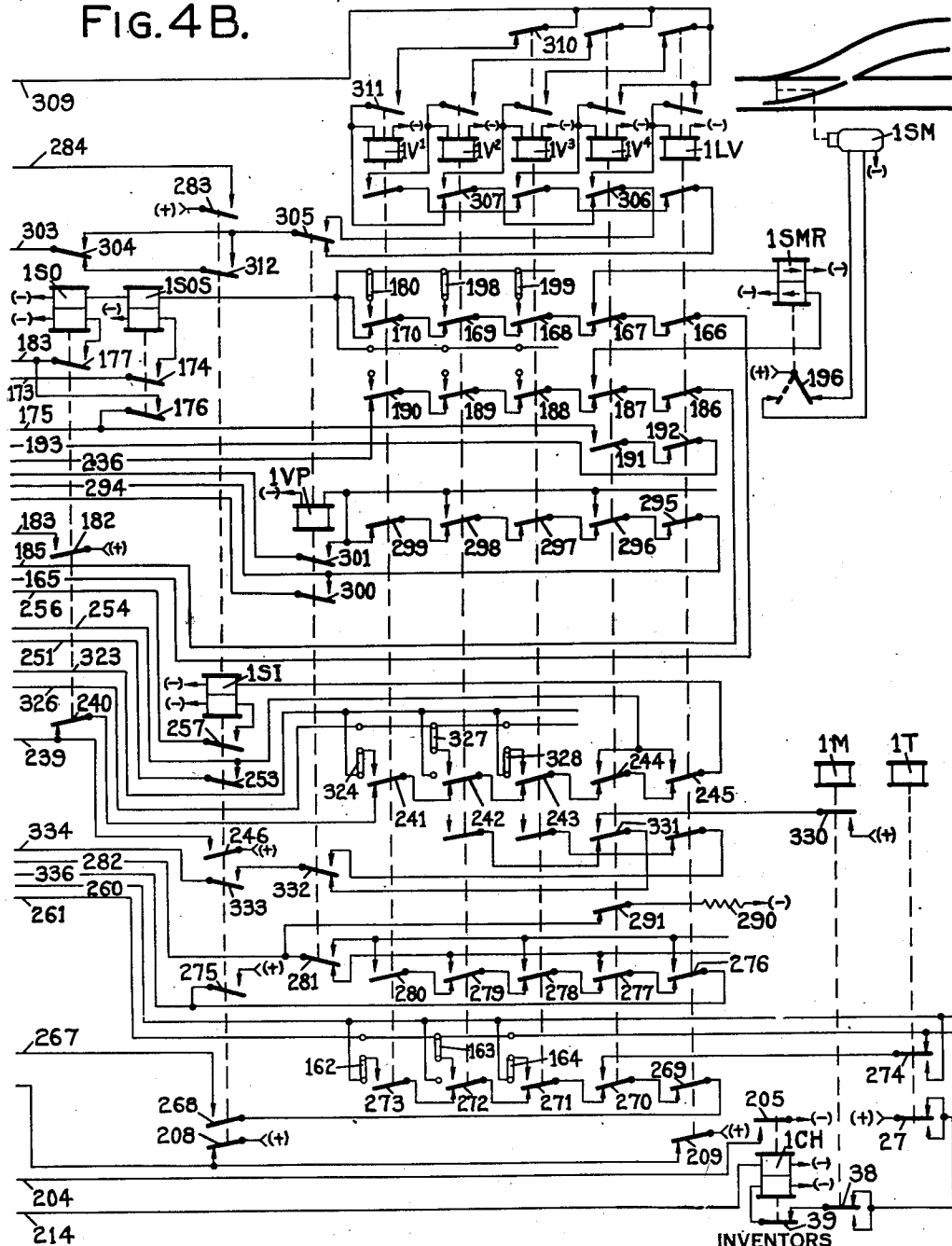
2,368,826

CENTRALIZED TRAFFIC CONTROLLING SYSTEM FOR RAILROADS

Filed May 11, 1942

8 Sheets-Sheet 7

FIG. 4B.



INVENTORS
W.D. Hailes and F.W. Brixner
BY *Neil W. Preston*
THEIR ATTORNEY

2,368,826

8. Sheets-Sheet 8

Control Cycle

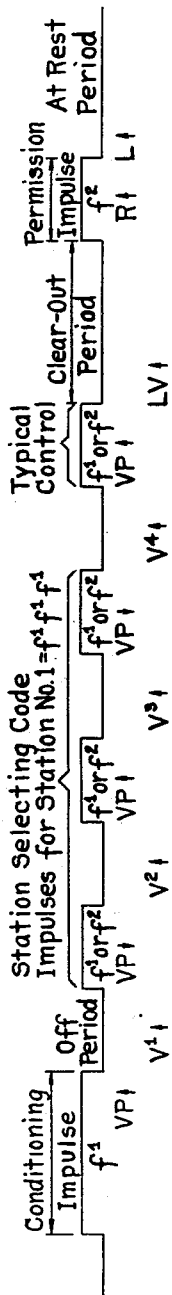


Fig. 5B.

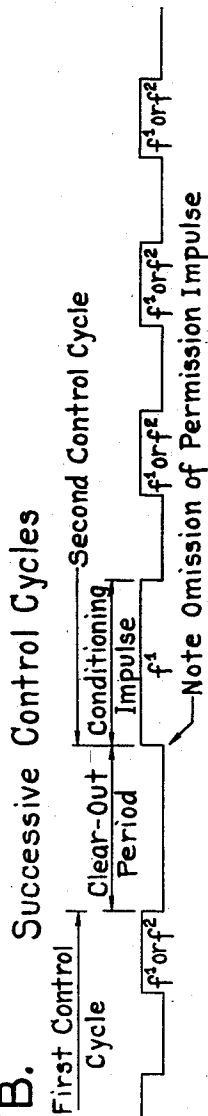


Fig. 5C.

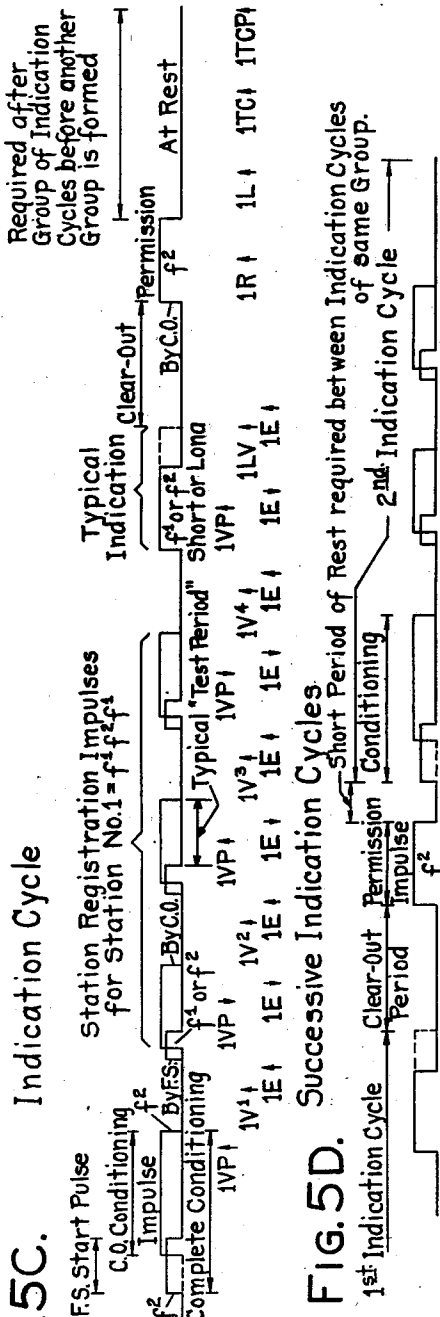


Fig. 5D.

INVENTORS
W.D. Hailes and F.W. Brixner
BY *Neil W. Platon,*
THEIR ATTORNEY

UNITED STATES PATENT OFFICE

2,368,826

CENTRALIZED TRAFFIC CONTROLLING
SYSTEM FOR RAILROADS

William D. Hailes, Brighton, and Frederick W. Brixner, Gates, N. Y., assignors to General Railway Signal Company, Rochester, N. Y.

Application May 11, 1942, Serial No. 442,508

17 Claims. (Cl. 177-353)

This invention relates to the communication part of a centralized traffic controlling system used for governing traffic on railroads, and more particularly pertains to a communication system of the carrier current coded type.

In a centralized traffic control system for railroads, often conveniently termed C. T. C. system, the switches and signals at various points along the railroad are placed under the control of an operator in a central office so that he may change the position of the switches, subject to automatic approach and detector locking circuits, which prevent unsafe operation of any switch, and may hold at stop any of the signals or allow them to clear dependent upon the position of their associated switches and in accordance with traffic conditions. Also, such a system provides means whereby indications are displayed in the control office to inform the operator of the location of trains on the various track sections throughout the territory under his supervision, and to indicate the position and condition of the various switches and signals.

Those switches and signals which are located adjacent each other comprise what is conveniently termed a field station, and a communication system is then provided to interconnect the central control office with the several field stations for the transmission of controls to the field stations, and for the reception of indications from the field stations.

In accordance with the present invention, it is proposed that the communication system be of that type which is adapted to transmit its controls and indications over a single line circuit that may already carry the transmission of telegraph signals, telephone conversation and selective telephone ringing impulses. The communication system is also adapted to transmit its controls and indications over a pair of wires used for commercial alternating current distribution. This is accomplished in accordance with the present invention by superimposing a distinctive series of code impulses of alternating current of selected frequencies on the line circuit at the control office for the selection of any desired field station and the transmission of controls to that field station. Although the system of the present invention accomplishes this by the manner in which the apparatus at the control office and field stations is inductively coupled to the line circuit and also by reason of the use of the proper frequencies which may be superimposed upon the line circuit without interfering with the transmission of the other services already employed

on the line circuit, it is to be understood that the invention may just as well be used in connection with a line circuit free from all other types of services.

- 5 The field stations must, of course, be able to transmit indications to the control office, and in accordance with the present invention these field stations are also provided with frequency generators. Each station is then provided with
- 10 means for superimposing a distinctive series of code impulses of alternating current on the line circuit for its own selection and also for its registration in the control office as well as for the transmission of its indications after it has been
- 15 selected and registered. For the purpose of the present disclosure, the frequency generators at the field stations are assumed to produce the same frequencies as the frequency generators at the control office, and the description is based on this organization. But it is to be understood
- 20 that different frequencies might be employed at the field stations (assuming, of course, proper receiving apparatus is employed at the control office) and still come within the scope of the present invention.

- 25 When a station is ready to transmit indications to the control office, it applies an initiating or starting impulse of alternating current of a particular frequency to the line circuit which
- 30 initiating impulse prevents all other stations not ready to begin at that instant from thereafter interfering with the series of impulses which that station is about to transmit. Although this start impulse from the field is of relatively short
- 35 duration, the control office apparatus immediately responds by placing conditioning impulse current of the same frequency on the line circuit, which current is maintained by the office for the time required to condition the office and
- 40 all field stations for an indication cycle of operation.

- 45 After the conditioning period, that station which is ready to transmit indications to the control office, applies to the line circuit a series of code impulses of alternating current, each impulse being of a selected frequency, and which series of impulses forms a code characteristic of that station and includes impulses characteristic of the indications for that station. When the
- 50 field station applies an impulse of any series to the line circuit, such impulse is received at the control office and an impulse of the same characteristic frequency is contemporaneously applied to the line circuit at the control office.

- 55 After a very short interval of time, the field sta-

tion impulse ceases, but the control office applied persists or continues for a certain additional time during which it is effectively received at all field stations and forms what may be conveniently termed a "test period." This is done on each succeeding impulse belonging to the station selection impulses until that station has been selected.

When a plurality of field stations are ready to transmit indications at the same time, each station applies impulses to the line circuit during the station selecting portion of the cycle in accordance with its station code until it no longer has a chance of being selected. At the control office, means is provided in accordance with the present invention whereby one frequency has superiority or preference over the other, so that those stations which apply an impulse of this superior frequency to the line circuit have an impulse of this superior frequency returned to them by the control office while the others do not have their inferior frequency returned to them. Thus, those stations applying or calling for the superior frequency on any given impulse have their station selecting means conditioned, while those stations which apply or call for the inferior frequency drop out and cease transmission until some subsequent cycle of operation. This automatic selection by giving one of the frequencies a relative superiority continues throughout those impulses of the series required for station selection and registration until only one station remains on the line circuit which station then proceeds to transmit impulses characteristic of its indications.

In brief, the station selection for the transmission of indications is accomplished on a code superiority basis with the relative superiority between the different code elements being selectively determined at the control office. This principle of selection is employed so as to increase the integrity or reliability of such a system, and particularly for the purpose of solving certain problems inherent in a system employing different frequencies superimposed on a line circuit. For example, if the system were of the type where it is necessary that an inferior field station receive the superior frequency as transmitted from the superior field station, it is entirely possible that the inferior field station might fail to detect the presence of the superior frequency because of phase cancellation due to conflict between the transmitters of two superior field stations. Under such conditions, the inferior station which failed to receive the superior frequency would not be cancelled or drop out, and would continue to transmit although its code might be inferior to the codes transmitted from the other two stations and which would thus cause erroneous indications to be registered in the control office. This particular problem is solved by the present invention inasmuch as the field stations can always "hear" the control office, so to speak, although they may not always be able to "hear" each other.

In other words, the retransmission of each impulse from the control office in response to a corresponding impulse received from the field stations, makes it possible to organize a system in which the problem of phase cancellation is avoided by providing a short interval of time near the close of each impulse of the code during which the control office transmitter is the only transmitter on the line circuit, together with a field

station selecting equipment which requires that the retransmitted impulse must be received by the field station during this short interval of time at the close of such impulse (conveniently termed "test period") in order for that station to be selected.

Another object of the present invention is to provide a coded type system which will minimize the effects of the cross-fire between the different frequencies on the line responsive relay means. In a carrier current type of communication system, filters and amplifiers must be provided to respond to certain frequency bands, but, with these frequencies reasonably close together, the application of one frequency may cause a transient condition which simulates the other frequency thereby interfering with the line responsive relay means for such other frequency. The present invention minimizes this possibility by providing suitable selecting circuits which need function only during test periods when the control office transmitter is the only transmitter on the line and transients have subsided.

In a system of this character, it is necessary to have the transmitters and receivers at the field stations set with the proper gains to insure that each field station will transmit at an energy level sufficiently high to be received at the control office and to insure that the impulses transmitted by the control office will be properly received at the field stations. For example, this means that a distant field station receiver must be set at a high gain in order to properly receive the impulses transmitted from the control office at the other end of the line, and it also means that the output energy level of the transmitter at such distant field station must be high in order to be received by the control office. This combination of a receiver of high gain at the same or an adjoining location with a transmitter of a high output level increases the tendency of one frequency to cross-fire into the other frequency at that receiver. This source of potential difficulty due to cross-fire between frequencies, is overcome by the feature of the present invention employing retransmission of each impulse by the control office, the latter part of which forms a "test period" during which the control office transmitter is the only transmitter on the line circuit, because it is obvious that with but a single frequency on the line circuit, there is no possibility of cross-fire conditions.

Another advantage of a system organized in accordance with this invention is the manner in which the output levels of field transmitters may be adjusted in accordance with their geographic relationship to the control office so that code impulses received from the various field stations are received with substantially the same intensity or energy level at the control office. This is particularly advantageous when it is remembered that the control office receiver must be adjusted with sufficient amplifying gain to properly receive impulses transmitted from the most distant field location of the system as well as from those field stations very close to the control office. If, however, as might be required in another or different organization of a system, each transmitter had to be adjusted to transmit at a sufficiently high energy level to be received at all field locations as well as at the control office, there would be present a problem of cross-fire at the control office tending to cause an erroneous registration of the frequency characteristic of any impulse

since the control office receiver must be set at such a gain as to most profitably receive the most distant transmitter on the line circuit. However, by employing the feature of retransmission in a system organized in accordance with the present invention, this difficulty from cross-fire at the control office is eliminated without additional cost and complication.

Another object of the present invention is to provide a system in which a field station is retired (or fails to be selected) when it has a defective transmitter or receiver. Such transmitter or receiver might be defective as a result of a broken wire, a burned-out vacuum tube, or the like.

Another object of the present invention is to provide a code type communication system which is operative with various different types of generators and code receivers. For example, it is possible to have generators at each of the field stations which do not lock into synchronism with the generators of other field stations when all are endeavoring to transmit at the same time. On the other hand, the generators can be of the self-synchronizing or locking-in type so that if two field stations start transmission at the same time these generators will operate in phase for each of the impulses transmitted from such stations. Each of these arrangements of generators provides distinctive problems and characteristics in connection with the line circuits, but the object of the present invention is to provide local control circuits for the control office and the field stations which will be operative with either arrangement.

Another object of this invention is to provide a simplex type of communication system, that is, a system in which only controls or indications can be transmitted on any particular cycle of operation even though the control office and field stations have separate sources of energy and can initiate a cycle of operation at any time while the system is at rest. This feature is accomplished by arranging that the initiating or conditioning impulse applied at the control office, as above mentioned, is of one frequency if a control office start occurs to initiate a cycle of operation for the transmission of controls, but such initiating or conditioning impulse is of a different frequency if a field station initiates a cycle of operation for the transmission of indications. At the end of a cycle of operation, the control office applies a permission impulse on the line which is of the same frequency as applied for a field station start impulse, and this permission impulse places the field station in condition to initiate an indication cycle of operation, but when the control office has new controls to transmit to a field station, this permission impulse is not applied to the line by the control office, so that the following cycle of operation is for the transmission of controls. The field stations, although ready to transmit, cannot effect a field station start until the control office has completed the transmission of the new controls and places the temporary permission impulse on the line.

Another object of the invention is to provide a system in which the indication cycles will be distributed between the different field stations having indications to transmit so that if any particular station has a large number of indications to transmit because of frequent changes in indication conditions at that station it cannot dominate the system. In other words, the system provides what is conveniently termed cycle distribution for the transmission of indi-

cations, and is arranged so that if there is a group of field stations ready to transmit at the same time, each of these stations has an opportunity to transmit only one cycle of operation until all of the stations in that group have transmitted. At the end of the transmission of the successive cycles of operation by this group of stations, a prolonged period of rest occurs during which all stations then having indications ready to transmit form another group, so as to speak, and indications are then transmitted on successive cycles of operation from such another group of stations.

Other objects, purposes, and characteristic features of the present invention will be in part obvious from the accompanying drawings and in part pointed out as the description of the invention 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 figures by like letter reference characters which are generally made distinctive either by reason of preceding numerals representative of their location or by reason of succeeding numerals or exponents representative of the order of their operation, and in which—

Fig. 1 illustrates in a diagrammatic manner the relationship of the C. T. C. system of the present invention to the various other services which may be associated with a line circuit upon which the system of the present invention may be superimposed;

Figs. 2A and 2B when placed end to end illustrate diagrammatically the line circuit arrangement of the present invention when applied to a line circuit having no other services thereon as well as showing the interconnections between the line circuit and the control apparatus in the control office and at a typical one of the field stations;

Figs. 3A and 3B when placed side by side illustrate the apparatus and circuit arrangement employed at the control office;

Figs. 4A and 4B when placed side by side illustrate the apparatus and circuits employed at a typical field station arranged and controlled in accordance with the present invention; and

Figs. 5A, 5B, 5C, and 5D illustrate typical charts of operation to indicate typical sequences of operation during various typical operations.

In order to simplify the disclosure, reference will be made from time to time to functions common to several devices by use of their common letter reference characters without the distinguishing numerals. It is to be understood, however, that such a reference applies to any parts designated in the drawings by those letter reference characters.

For the purpose of simplifying the illustration and facilitating in the explanation, the various parts and circuits constituting the embodiment of the invention have been shown diagrammatically and certain conventional illustrations have been employed; the drawings have been made more with the purpose of facilitating the disclosure as to the principles and mode of operation than with the idea of illustrating the specific construction and arrangement of parts that would be employed in practice. Thus, the various relays and their contacts are illustrated in a conventional manner, and symbols are used to indicate the connections to the terminals of batteries or other sources of electric current instead of bring-

ing all of the wiring connections to those terminals.

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

GENERAL ORGANIZATION

C. T. C. SYSTEM SUPERIMPOSED ON LINE CIRCUIT HAVING OTHER SERVICES

With reference to Fig. 1 of the accompanying drawings, a line circuit having line wires 10 and 11 is shown extending between two repeat coils 16 and 17. Connected across the line wires of this line circuit is a dispatcher's telephone equipment and various way station telephone equipments with each such equipment connected to the line wires 10 and 11 through low-pass filters. Associated with each of the way station telephone equipments is a suitable telephone selector of any well known type connected directly across the line wires 10 and 11 through its respective low-pass filter.

One purpose of the repeat coil 16 is to provide for the repeating of the impulses of the selective telephone ringing equipment into the line circuit, and also provide means of terminating the telegraph line circuit. Similarly, one purpose of the repeat coil 17 is to terminate the telegraph line circuit and still permit the telephone frequencies and the frequencies of the centralized traffic controlling communication system to be repeated in the usual way. If the centralized traffic control is to be terminated at this point, it is to be understood that suitable termination impedances must be associated with or incorporated into the coil 17. The features of proper line termination, of course, have nothing to do with the present invention and should be accomplished in the usual well known manner.

The control office selective ringing equipment effects the transmission of impulses over the line circuit at the rate of about $3\frac{1}{2}$ cycles per second in a manner to form different number codes. The telephone selector for each station is responsive to only the code assigned to its telephone station. When a telephone station is selected, its bell is caused to ring until a stop ringing pulse is transmitted by the selective telephone ringing equipment. The operator at the telephone called will then communicate with the dispatcher by voice. It may be noted that the dispatcher is always listening and will hear any telephone without being called by ringing. If someone at one telephone station desires to communicate with someone at another telephone station, he merely asks the dispatcher to call such another telephone station.

It is, of course, understood that the telephone voice frequencies may have a very wide range, but for all practical voice conversations a range of frequencies between 200 and 2500 cycles is all

that is required. The control office equipment and the field station equipment for the centralized traffic controlling (C. T. C.) system are connected in multiple across the line circuit through suitable coupling units and filters which are designed to pass only the frequencies desired for the operation of the C. T. C. system, whereas the low-pass filters for the telephone equipment are arranged to pass only the frequencies required for voice transmission, namely 200 to 2500 cycles. For the purpose of the present disclosure, the frequencies selected for the C. T. C. system are 3300 and 3500 cycles respectively designated throughout the specification and drawings as frequencies f^1 and f^2 . It is understood, of course, that other suitable frequencies might just as well be selected just so long as they do not interfere with other services already on the line circuit, such, for example, as the telephone voice frequencies.

In systems of this character where various frequencies are to be imposed upon the line circuit, it is desirable to properly terminate the line circuits so as to prevent the reflection of the alternating currents when they reach the end of the line. For example, assuming that the line circuits are improperly terminated, the application of an alternating current potential at one end of the line circuit results in the rotation of the vector or phase relationship in one direction as this potential is taken from the line circuit at successive points away from the control office, and with the line circuit improperly terminated, such alternating current potential is reflected by the improper condition at the end of the line so as to produce potentials which in effect originate at such end of the line and which flow toward the original end of the line with the phase relationship rotating in an opposite direction. This produces nodes and anti-nodes at various points along the line circuit. Thus, if a C. T. C. field station equipment were located at a point along the line circuit at which a node occurs in this improperly terminated line circuit, such field station would not receive signalling current.

However, such undesired "end of line reflections" would not occur if the line circuit were of an infinite length or were properly terminated by the placing of impedances across the ends of the line equal to the natural surge impedance of such line circuit. Thus, it is desirable that suitable terminal impedances be placed at the ends of the line circuit used for the C. T. C. system. With reference to Fig. 1, the repeat coil 16 could be designed to include such impedance, or could have associated therewith such a terminal impedance. Similarly, if the C. T. C. system ended at the repeat coil 17, then it could also have such a terminal impedance associated therewith. Regardless of the particular combination of C. T. C. system and other services, the line circuit must be properly terminated with respect to the C. T. C. portion of the line circuit.

C. T. C. SYSTEM ALONE ON LINE CIRCUIT

In Figs. 2A and 2B, a line circuit having live wires 12 and 13 is shown for a C. T. C. system provided in accordance with the present invention in which there are no other services on the line circuit. These line wires 12 and 13 provide a line circuit which, of course, must have similar characteristics as the one disclosed in connection with Fig. 1, that is, it must be properly terminated so as to prevent reflection from the ends of the line. Thus, terminating impedances 18 and 19 are provided at the opposite ends

of the line to properly terminate the line circuits each having an impedance equal to the natural surge impedance of an infinitely long line having the same characteristics as the line wires 12 and 13.

It is to be understood that the same C. T. C. apparatus is employed with the line circuit of Fig. 1 as is employed with the line circuit of Figs. 2A and 2B. These different combinations are shown for the purpose of disclosing the general application of the present invention. In this connection, it should be noted that the present invention can also be applied to a commercial power distribution system providing alternating current of the usual 60 cycle type. Such an application of the present invention is particularly advantageous in view of the usual organization of signalling systems for railroads in which the field locations are provided with storage batteries having a 60 cycle alternating current trickle charge apparatus associated therewith. Thus, the system of the present invention could be applied to such a railroad signalling system without the installation of added line wires. When the system is superimposed on a power network or line circuit, it is necessary to provide blocking impedances at power connections to such line circuit in order to prevent the escape or attenuation of the carrier frequencies. Also, the ends of such power line circuit would, of course, necessarily have to be provided with terminating impedances in the usual way.

In Figs. 2A and 2B, the line circuit is shown as having a control office at one end and several field stations spaced at intervals along the line circuit toward the other end, but it is to be understood that the system might be arranged to have the control office at some intermediate point with respect to the field stations.

Each field station equipment as well as the control office equipment is connected to the line wires 12 and 13 through condensers 20 and 21 which have a suitable insulation strength to protect the C. T. C. equipment from high voltages.

Each field station and the control office includes code transmitting and receiving apparatus. This transmitting apparatus for the control office or any field station comprises selector apparatus, frequency generating apparatus and the filters required to impress the potential on the line circuit; while the receiving apparatus comprises filters and amplifiers for receiving impulses over the line circuit and directing the impulses of the different frequencies to the proper line relay responsive means which in turn act upon the selector apparatus.

The transmitting apparatus for the control office and any field station has two frequency generators designated respectively " f^1 -Gen." and " f^2 -Gen." which are controlled by the selector apparatus in the control office or at the field station as the case may be to impress alternating current impulses on the line circuit through a suitable "coupling unit" (see Figs. 2A and 2B) connected to the line wires 12 and 13 through the condensers 20 and 21. These frequency generators may be of any suitable type known in the prior art operable subject to conditions herein-after explained in detail. Also, each field station and control office are provided with two line responsive relay means designated F^1 and F^2 which are respectively connected to their respective amplifier and filter units to the line wires 12 and 13 through a "coupling unit" and condensers 20 and 21. Their respective ampli-

fier and filter units are arranged to provide such relay means F^1 and F^2 with energy to pick up their contacts only when their respective frequencies 3300 and 3500 are impressed upon the line circuit. It is, of course, understood that these amplifier and filter units will pass a certain band of frequencies at 3300 and 3500 respectively and also that these particular frequencies have been chosen as examples of frequencies which do not interfere with the telephone equipment illustrated in Fig. 1 and also which do not interfere with radio receiving sets adjacent the line circuit of either Fig. 1 or Figs. 2A and 2B. Detail consideration will not be given in this application to the amplifier and filter arrangement for the receiving units, as they may be of any suitable type known in the art. Similarly, the coupling units may be of any suitable type operable with the particular types of generators and receivers used.

With reference to Figs. 2A and 2B, it will be seen that the frequency generators, amplifier and filter units, and coupling units receiving the two different frequencies have been shown diagrammatically for the control office and for field station No. 1 and the connections to these units extend to dotted rectangles. The selector apparatus for the control office is shown in Figs. 3A and 3B while the selector apparatus for field station No. 1 is shown in detail in Figs. 4A and 4B as designated in the drawings. It will be noted that field stations No. 2 and No. 3 have merely been designated by rectangles bearing the legend "receiving and transmitting apparatus." It is, of course, to be understood that any number of field stations may be connected across the line circuit in accordance with the present invention so long as the selector apparatus for the control office and the field stations is so designed to accommodate codes for the desired number of stations, as will be discussed later as the description progresses.

CONTROL OFFICE APPARATUS

With reference to Figs. 3A and 3B placed side to side, it will be seen that the line responsive relays F^1 and F^2 have been shown in block form in these figures, it being understood that their connections to the amplifying units have been shown in Fig. 2A. These relays as has been mentioned above, respond respectively to frequencies of 3300 and 3500 cycles. Associated with these line relays is a line repeating relay FA which is normally deenergized, but which is caused to repeat each of the impulses impressed on the line circuit as repeated by the line relays F^1 and F^2 except in the case of the permission pulse. The usual cycle demarking relays SA, SB and SC, all of the slow-acting type, are associated with the line repeating relay FA. Two line condition relays L and R are provided to be responsive to the permission impulse at the end of a cycle of operation which permission impulse occurs only if the control office has no more controls to transmit and the line circuit may be employed on a successive cycle of a field station for transmitting indications. In this connection, two starting relays C and CF are provided. The relay C is responsive to manual actuation of start buttons for starting a cycle of operation for the transmission of controls and the relay CF is responsive to a start pulse automatically applied at a field station for starting a cycle of operation for the transmission of indications.

The above mentioned relays together with an impulsing relay E and its repeater EP cause the

operation of the stepping relay bank including stepping relays V and a half-step relay VP.

The control panel has mounted thereon the various control levers, start buttons, indicator lamps and the like, as well as the usual miniature track diagram. Each field station has its group of control levers and a start button B. But for the sake of simplicity only the switch control lever ISML for the switch machine ISM at the field station No. 1, has been shown with an associated start button IB.

A cancel button CNB is located on the panel and is rendered effective when actuated, to cancel the transmission of any new controls that have been set up by the operator.

When a start button B is manually actuated, it causes the picking up of its corresponding change relay CH which in turn acts upon its associated code determining relay LC if the system is then in condition for transmitting control code. This relay LC acts through an associated LCS relay to energize the control starting relay C. The control starting relay then causes the transmitter relays T¹ and T² to be rendered effective to transmit the station code and controls to the desired station. Relay T¹ when energized causes frequency generator "f¹-Gen." to be effective to impress 3300 cycle current on the line circuit, while relay T² when energized causes frequency generator "f²-Gen." to be effective to impress 3500 cycle current on the line circuit.

A slow-acting relay OC is provided to cause the system to go into a period of rest if for some reason the system should fail to properly operate and cause an indefinitely prolonged impulse to be placed upon the line circuit.

Through the line repeating relay FA and suitable circuit connections two relays TON and LON are provided to time the length of the "on" or impulse intervals during the transmission of indications so as to properly control the indication receiving relays, such as ITKR, in accordance with the length of the impulses as well as in accordance with the distinctive frequencies of such impulses.

The station registration relays RF are controlled in accordance with the station selecting code so as to cause the energization of the station relay ST for the particular station then selected to render the indication relays for that station responsive to the character of the impulses received over the line circuit for the remaining impulses of that indication cycle of operation. The relay ITKR is an indication relay of the two-position magnetic-stick type and is associated in this disclosure with the condition of track occupancy at station No. 1. When its contact 22 is positioned to the left, it energizes lamp ITK to indicate that a train is on the associated track section at station No. 1. It might be noted in this connection that the registration relays RF are provided, one for each impulse of the station selecting and registration portion of a code, while there is a relay ST provided for each of the field stations. It is, of course, understood that these relays are controlled through suitable selections which are made in accordance with the regular well-known Baudot code as shown in the prior Patent No. 2,259,561, dated October 21, 1941, granted to Hailes and Brixner.

FIELD STATION APPARATUS

The field station apparatus shown in Figs. 4A and 4B is very similar to the control office apparatus and is to be considered as typical of all field

stations. The line responsive relay means includes the line relays IF¹ and IF². The line repeating relay IFA is associated with these line relays for repeating each of the impulses of a series of impulses which are impressed upon the line circuit. However, relay IFA does not respond to the permission pulse. Cycle demarking relays SA and SB are also provided.

The line condition relays IL and IR are provided at the field station and are conditioned to render the field station effective to transmit only if a permission impulse is placed upon the line circuit following any series of impulses which permission impulses advises each of the field stations and the control office that the system, although at rest, may be initiated into operation for the transmission of indications as well as the transmission of controls. It is through the functioning of these relays and their associated circuits that the control office is made superior or dominant over the field stations so that an operator may transmit controls on successive control cycles to any number of field stations irrespective of the fact that indications may be standing ready at various field stations awaiting transmission. The line repeating relay IFA causes the operation of a stepping relay bank including stepping relays V and a last step relay ILV as well as a half-step relay IVP.

The operation of the system during the transmission of a control code effects the selection of the station through the proper control of the station selecting relay ISO and its repeating relay ISOS, but during the transmission of the impulses for an indication cycle of operation the station is selected for transmitting indication impulses by the proper control of the relay SI and at the same time is registered in the control office on the registering relays RF and station relay ST.

The transmission of a control to the field station after its selection actuates a suitable relay means to a proper position for controlling any desired traffic controlling device which has been typically illustrated in the control of the relay ISMR which in turn controls the switch machine ISM at field station No. 1 over obvious circuits, associated with the switch machine ISM and suitable signals and track circuits. All of the conventional signalling circuits have been omitted but a track relay IT has been shown in block form as well as a signal at stop relay IM. These two relays may act upon a change relay ICH whenever they change their positions to initiate a cycle of operation through a change repeating relay CHP and cause the transmitting relays T¹ and T² to cause the transmission of the impulses of proper frequencies to select that field station and register its indications in the control office. An impulsing relay IE is provided to cause the proper timing of the relays. Associated with this apparatus is a transmitting timer relay ITC and its repeating relay ITCP. Relay ILON is provided to time the long impulses impressed by the line circuit by the field station. It is, of course, understood that the transmitting relay IT¹ and IT² control the frequency generators at the field station in accordance with the code to be transmitted as indicated in Fig. 2B.

It is, of course, understood that various other auxiliary devices and circuits therefor will be employed in a C. T. C. system embodying the present invention, but it is believed that the typical devices and circuits shown will be sufficient for an understanding of the present invention.

OPERATION

The communication system provided by the present invention is normally at rest. When the system is applied to the line circuit arrangement of Fig. 1, it is normally deenergized so far as the C. T. C. communication system is concerned, but it is to be understood that the other services may be employing the line circuit. In Figs. 2A and 2B where the C. T. C. communication system is the only service on the line circuit, it is, of course, obvious that the line circuit is deenergized unless the C. T. C. communication system is in operation.

Any field station or the control office can initiate the system into operation to transmit new indications or controls respectively. If several field stations are ready for transmission at the same time, they are transmitted from such field stations to the control office one cycle for each field station until each of those stations have obtained access to the line circuit for transmitting their indications during any one cycle of operation. If there are new controls ready to be transmitted to several different field stations from the control office at the same time, the controls for each of the stations are transmitted on separate operating cycles, one cycle for each station. And in the event new controls and indications are ready for transmission at the same time, the controls are transmitted first.

NORMAL CONDITIONS

While the system is at rest most of the relays and circuits are deenergized, and are thus organized to save energy while the system is not in operation. However, the line condition relays L and R at the control office and at the field stations are normally energized.

With reference to Fig. 3B, it will be seen that the relays R and L are energized in series from (+), through a circuit including back contact 30 of relay SB, winding of relay L, front contact 31, winding of relay R, to (-). This stick circuit can, of course, be broken only by the picking up of contact 30 of relay SB, in which case the relays R and L both drop away.

When these relays are dropped away and the back contact 30 of relay SB is again closed, the relay R can only be picked up by an energizing circuit closed from (+), and including back contact 30 of relay SB, back contact 32 of relay L, front contact 33 of relay F², winding of relay R, to (-). It will be noted that the picking up of the relay R closes its front contact 31, but the relay L cannot pick up to open its back contact 32 so long as the front contact 33 of relay F² is closed thereby providing a shunt circuit across both terminals of the relay L. However, when the front contact 33 of relay F² is open, at the end of a permission pulse as will be hereinafter described, the relay L then picks up in series with the relay R and is maintained energized through the stick circuit above traced.

With reference to Fig. 4A, a similar energizing stick circuit is normally closed for the relays IR and IL from (+), through a circuit including back contact 34 of relay ISB, windings of relay IL, front contact 37 of relay IR, windings of relay IR, to (-). When relay ISB is picked up, both relays IR and IL are released, but may be again picked up when relay ISB is again released. The pick-up circuit for the relay IR is provided from (+), through a circuit including back contact 34 of relay ISB, back contact 35 of relay IL, front contact 36 of relay IF², windings of relay

IR, to (-). The pick-up circuit for the relay IL is, of course, the same as the stick circuit above traced, but with the pick-up circuit for the relay IR open at front contact 36 of relay IF².

The change relay ICH (see Fig. 4B) is also normally energized from (+), through a circuit including front contact 27 of relay IT, front contact 38 of relay IM, front contact 39 of relay ICH, lower winding of relay ICH, to (-). It is, of course, understood that the track relay IT is normally energized by a track circuit not shown in detail, and the signals at stop relay IM is also normally energized by circuits not shown. Although these relays IT and IM are shown normally energized with the system at rest, it is to be understood that either or both may be deenergized and the system still remain at rest, the indications associated therewith having been transmitted on some operating cycle and caused the restoration of the change relay ICH to a picked-up position in which it is also maintained energized through its stick circuit through either front or back contacts 27 or front or back contacts 38 until another change in condition occurs.

MANUAL START

At any time that the operator desires to transmit controls to a particular station, he first positions the control levers for that station and then actuates momentarily the start button B associated therewith.

The arrangement of the circuits for the control of the associated relays CHI, ILC, and LCS is such as to provide that only one field station may have controls transmitted thereto at any one time, but these relays and associated circuits are also effective to store a manual start for any one or several field stations until the system is available for the transmission of controls to those stations. This is necessary even though the system is arranged to make the control office superior to the field stations, because at the time the operator actuates a start button B the system may be transmitting indications from some field station or may be transmitting controls to some other field station. The predetermined order in which the controls are transmitted to the different field stations when the operator actuates several start buttons B in quick succession is determined by the interlock between the various CH and LC relays of the interlocked bank as shown and described in our above mentioned Patent No. 2,259,561.

Let us assume that the operator desires to transmit controls to field station No. 1 and properly positions the control levers for that station to the desired positions, such as lever ISML, for example, and then actuates the start button IB. This closes a pick-up circuit through the normally open front contact 40 of button IB, winding of relay CHI, bus wire 41, normally closed front contact 42 of cancel button CNB, to (-). As soon as the relay CHI picks up, a stick circuit is closed from (+) through back contact 43 of relay ILC, front contact 44 of relay CHI, windings of relay CHI, bus wire 41, front contact 42 of cancel button CNB, to (-).

It will, of course, be apparent that the start button IB need be actuated only momentarily by the operator, because the relay CHI is maintained energized by its stick circuit as soon as its front contact 44 is closed.

If the system is at rest, the picking up of the relay CHI closes an energizing circuit for the

relay ILC from (+), through back contact 45 of relay SB, back contact 46 of relay LCS, back contact 47 of relay CF, wire 48, back contact 49 of relay CH2, front contact 50 of relay CH1, upper winding of relay ILC, bus wire 51, front contact 42 of cancel button CNB to (-). It will, of course, be noted that if the system is in operation, the relay SB will be energized and the back contact 45 will be opened so that the relay ILC could not be picked up. Also, the system may have been just initiated by some other start button B or by some change in conditions at the field station causing the pick up of either the relay LCS or the relay CF opening either contact 46 or 47 respectively as will be presently pointed out. However, assuming that the system is at rest, the relay ILC picks up closing a stick circuit from (+), through a circuit including back contact 52 of relay SB, winding of relay LCS, wire 53, front contact 54, lower winding of relay ILC, bus wire 51, front contact 42 of cancel button CNB, to (-). It will be noted that the relay LCS is in series with this stick circuit for the relay LC and as soon as it picks up, it opens its back contact 46 and prevents all other LC relays from being picked up. Also, energy (+) is applied to the right hand terminal of relay LCS by back contacts 91 and 150 of relays C and V⁴ respectively in multiple with back contact 52 of relay SB for reasons later pointed out.

Both the bus wires 41 and 51 are connected to negative potential (-) through normally closed front contact 42 of cancel button CNB, so that if at any time a start button B is actuated prematurely or inadvisedly the operator can immediately cancel such storage of a start condition by the actuation of the cancel button CNB opening front contact 42 and thereby deenergizing any relay CH or LC then picked up.

As soon as the relay ILC picks up and is energized through its stick circuit also energizing the relay LCS to initiate the system into operation, the back contact 43 of relay ILC is opened to deenergize the relay CH1 so that it drops away.

It will be seen that the pick-up circuit for the relay ILC includes back contact 49 of relay CH2 so that if both the buttons 1B and 2B were actuated simultaneously, the relay 2LC would pick up in preference to the relay ILC, but the relay CH1 would remain stuck up so that after an operating cycle had occurred for the transmission of controls to the field station No. 2 corresponding to the relay 2LC, the relay CH1 would then be effective to pick up its associated relay ILC, because at such time the relay 2CH would be dropped away. Under the circumstances, assumed above, where the button 1B has been actuated and the relay ILC picked up, then the actuation of the start button 2B merely causes the energization of relay 2CH which is stored until the transmission of controls has been effected for the station No. 1.

The picking up of the relay LCS closes a pick-up circuit for the control office starting relay C from (+), through a circuit including back contact 55 of relay SB, back contact 56 of relay F², front contact 57 of relay LCS, back contact 58 of relay CF, windings of relay C, to (-). As soon as the relay C picks up, its stick circuit is closed from (+), through a circuit including front contact 59 of relay LCS, front contact 60 of relay C, windings of relay C, to (-). Another stick circuit is also closed for the relay C from (+), through a circuit including back contact 61 of relay SC, front

contact 62 of relay C, windings of relay C, to (-). The picking up of the control office start relay C opens its back contact 62 included in the stick circuit of the field start relay CF. This gives the control office start relay C the priority in the event both the relays C and CF are energized simultaneously and pick up together.

The picking up of the relay C closes an energizing circuit for the transmitting relay T¹ for impressing the frequency f^1 on the line circuit for the conditioning impulse. This circuit for relay T¹ is closed from (+), through a circuit including back contact 63 of relay SC, front contact 64 of relay C, wire 65, back contact 66 of relay LV, back contact 67 of relay V⁴, back contact 68 of relay V³, back contact 69 of relay V², back contact 70 of relay V¹, to the bus wire 75 which extends to the relay T¹, windings of relay T¹, to (-).

The picking up of the contacts of the transmitter relay T¹ closes its front contact 77 (see Fig. 2A) for completing an obvious energizing circuit for the frequency generator " f^1 -Gen." which in turn impresses the frequency f^1 on the line circuit to condition and initiate the apparatus at the control office and each of the field stations for a control cycle of operation. This conditioning impulse is indicated as the first impulse of a cycle in the chart of Fig. 5A showing a typical control cycle.

As heretofore mentioned, this frequency f^1 is always impressed on the line circuit for the conditioning impulse of a control cycle and the length of this conditioning impulse is determined by the sequence of certain relays immediately following the picking up of the relay C.

More specifically, the picking up of the relay C also closes a pick-up circuit for the relay OC from (+), through a circuit including back contact 80 of relay SC, front contact 81 of relay C, back contact 82 of relay CF, windings of relay OC, to (-). The relay OC is, of course, slow acting but it picks up after a short time to close its front contact 83 in readiness to complete a stick circuit and also to supply energy to the impulsing circuits for the transmitter relays T¹ and T² during the operating cycle being initiated.

At the control office, the line responsive relay F¹ responds to the frequency f^1 of the conditioning impulse and closes its front contacts. This completes an energizing circuit for the line repeating relay FA from (+) through a circuit including front contact 84 of relay F¹, windings of relay FA, to (-).

The picking up of the relay FA closes its front contact 85 to complete an obvious energizing circuit for the relay SA; the relay SA in turn closes its front contact 86 to complete an obvious energizing circuit for the relay SB; and the relay SB in turn closes its front contact 87 to complete an obvious energizing circuit for the relay SC. Thus, it will be seen that the relays FA, SA, SB and SC pick up in sequence.

The picking up of the relay SC opens the pick-up circuit for the relay OC at back contact 80, but prepares a stick circuit for the relay OC at front contact 88 which is closed at the termination of the conditioning impulse and during each succeeding impulse. This stick circuit for the relay OC is closed from (+), through a circuit including front contact 83 of the relay OC, front contact 88 of the relay SC, back contact 89 of the relay F¹, back contact 90 of the relay F², windings of the relay OC, to (-). It is noted, how-

ever, that this stick circuit is closed only during the "off" periods of any series of impulses comprising a cycle of operation. In other words, the relay OC is picked up during the conditioning period and is then intermittently energized over a stick circuit closed during each "off" period of a cycle. But the relay OC is sufficiently slow release to remain picked up between successive "off" periods and drops away during a cycle only if some impulse persists for an abnormally long time due to failure of some part of the system. Also, if the conditioning impulse should be maintained for an unusual length of time, the stick circuit would be open at back contacts 89 and 90 and the relay OC would be dropped away.

At the time the relay C picks up, an energizing circuit is closed for the relay E from (+), through a circuit including front contact 91 of the relay C, wire 92, back contact 93 of relay LV, back contact 94 of relay V⁴, back contact 95 of relay V³, back contact 96 of relay V², back contact 97 of relay V¹, back contact 98 of relay VP, wire 99, windings of relay E, to (-).

The picking up of the relay E closes its front contact 101 so that upon the picking up of the relay SB and prior to the picking up of the relay SC opening back contact 88 an energizing circuit is closed for the transmitting relay T¹ from (+) through a circuit including front contact 83 of relay OC, front contact 102 of relay SB, front contact 101 of relay E, front contact 64 of relay C, wire 65, back contact 66 of relay LV, back contact 67 of relay V⁴, back contact 68 of relay V³, back contact 69 of relay V², back contact 70 of relay V¹, to the bus wire 75, and thence through the windings of the relay T¹ to (-). This circuit is maintained closed so that the conditioning impulse is maintained on the line circuit until after the half-step relay VP has operated following the picking up of relay SC, thereby deenergizing the relay E opening its front contact 101 to deenergize the transmitting relay T¹. Thus, it may be expedient to now consider the operation of the stepping relay bank at the control office before considering the manner in which the different frequencies are selected for determining the station selecting code and the controls to be transmitted.

OPERATION OF STEPPING RELAY BANK AT THE CONTROL OFFICE

The stepping relay bank at the control office comprises a series of stepping relays V, a last stepping relay LV and a half-step relay VP. These stepping relays are successively picked up on each "off" period of any series of impulses, while the half-step relay VP assumes an opposite position for each "on" period of the same series. The first operation of the stepping relay bank that occurs subsequent to the actuation of a start button for the transmission of controls is the picking up of the half-step relay VP during the conditioning impulse following the picking up of the slow acting relay SC. These sequential operations of the relays V and VP are indicated in the chart of Fig. 5A where the arrows pointing up and down respectively indicate the picking up or dropping away of the relays with which they are associated.

The pick-up circuit for the relay VP is closed from (+), through a circuit including front contact 45 of relay SB, front contact 103 of relay SC, front contact 104 of relay FA, wire 105, back contact 106 of relay LV, back contact 107 of relay V⁴, back contact 108 of relay V³, back contact 109

of relay V², back contact 110 of relay V¹, windings of relay VP, to (-). As soon as the relay VP picks up, the stick circuit is completed therefor from (+) through a circuit including front contact 45 of relay SB, front contact 103 of relay SC, wire 111, front contact 112 of relay VP, back contact 106 of relay LV, back contact 107 of relay V⁴, back contact 108 of relay V³, back contact 109 of relay V², back contact 110 of relay V¹, windings of relay VP, to (-). This stick circuit is maintained closed until the first stepping relay of the bank is picked up which occurs during the first "off" period of the series of impulses to be transmitted from the control office.

Upon the picking up of the relay VP, back contact 98 is open so that the relay E is deenergized which opens front contact 101 included in the energizing circuit for the transmitting relay T¹ to end the initiating impulse. This, of course, all occurs after the relay SC has picked up. The deenergization of the transmitting relay T¹ causes the first "off" period of the series by removing the frequency F¹ from the line circuit. Thus, the line relay means F¹ becomes deenergized opening front contact 84 which in turn deenergizes the relay FA.

In other words, the relay FA repeats the line responsive relay means regardless of whether it is the relay F¹ or the relay F² which is actuated in response to the corresponding frequencies placed upon the line circuit. The reason for this is because the relay SB picks up and closes front contact 113 so that front contact 114 of relay F² can control the relay FA the same as front contact 84 of relay F¹. It is noted in this connection that the picking up of relay SB opens back contact 30 and deenergizes the line condition relays R and L, opening front contact 115 of relay L, the significance of which will be discussed hereinafter.

Assuming that the first "off" period is repeated by the relay FA, the closure of back contact 104 completes a stick circuit for the relay VP from (+) through a circuit including front contact 45 of relay SB, front contact 103 of relay SC, back contact 104 of relay FA, wire 116, front contact 117 of relay VP, windings of relay VP, to (-). Thus, the relay VP is maintained energized during the "off" periods even though its pick-up circuit is opened at front contact 110 by the picking up of the first step relay V¹, for example.

The first step relay V¹ is caused to be picked up upon the release of the relay FA by reason of a circuit closed from (+) and including front contact 61 of relay SC, back contact 118 of relay FA, wire 119, front contact 120 of relay VP, back contact 121 of relay V⁴, back contact 122 of relay V³, windings of relay V¹, to (-). As soon as the relay V¹ is picked up, its stick circuit is closed from (+), through a circuit including front contact 30 of relay SB, wire 123, back contact 124 of relay V³, front contact 125 of relay V¹, windings of relay V¹, to (-).

The picking up of the stepping relay V¹ closes an energizing circuit for relay E including front contact 97 of relay V¹ and front contact 98 of relay VP; and relay V¹ also prepares a circuit for the energization of the transmitter relays T. This energization of relay E closes its front contact 101 for energizing either relay T¹ or relay T² in accordance with the character of impulse required for the first element of the code for the station being selected.

Disregarding for the moment the particular

character of the next impulse, it is impressed on the line circuit by the picking up of either the transmitting relay T^1 or the transmitting relay T^2 , and such impulse is repeated by the corresponding line responsive relay means F^1 or F^2 which in turn is repeated by picking up of the relay FA.

The opening of back contact 104 of relay FA opens the stick circuit for the relay VP including the front contact 117 of relay VP, the other stick circuit for the relay VP including its front contact 112 already having been opened at back contact 110 by the picking up of the relay V^1 . Thus, the relay VP drops away in response to the second picking up of the relay FA.

This dropping away of the relay VP opens the energizing circuit for the relay E at front contact 98 of relay VP, which causes relay E to terminate that impulse by deenergizing the particular transmitting relay T then energized at open front contact 101.

The second dropping away of the relay FA at the end of the second impulse of the series closes the pick-up circuit for the stepping relay V^2 from (+), through a circuit including front contact 61 of the relay SC, back contact 118 of relay FA, wire 119, back contact 120 of relay VP, back contact 125 of relay LV, back contact 126 of relay V^3 , front contact 127 of relay V^1 , windings of relay V^2 , to (-). As soon as the relay V^2 picks up, its stick circuit is closed by the closure of its front contact 128 completing a stick circuit through back contact 129 of the relay V^4 to the bus wire 123, which bus wire is energized throughout the cycle of operation. The picking up of the stepping relay V^2 prepares the relays T for energization and causes the relay E to be energized by closure of front contact 96.

During the next "on" period of the series of impulses, the relay FA is picked up, and causes another pick-up circuit to be closed for the relay VP by reason of the closure of front contact 104 of relay FA and the closure of front contact 103 of the relay V^2 . This picking up of the relay VP causes the relay E to be again deenergized to terminate that impulse.

During the following "off" period of the series of impulses as repeated by the relay FA, the closure of back contact 118 completes a pick-up circuit for the relay V^3 from (+), through a circuit including front contact 61 of relay SC, back contact 118 of relay FA, wire 119, front contact 120 of relay VP, back contact 121 of relay V^4 , front contact 122 of relay V^2 , windings of relay V^3 , to (-).

As soon as the relay V^3 picks up, it closes front contact 130 to complete a stick circuit through contact 131 of relay LV to the bus 123. The picking up of relay V^3 opens back contact 124 included in the stick circuit of the relay V^1 so that such relay V^1 drops away, its function for this particular cycle of operation having been completed.

From the above description of the operation of the stepping bank up to the point of the picking up of the relay V^3 , it will be seen that the half-step relay VP assumes opposite positions on alternate impulse periods while the successive stepping relays V pick up on the successive "off" periods of the series of impulses. This stepping operation continues until the last stepping relay LV is picked up to end the cycle of operation as will later be described. It is of course understood that the number of stepping relays is commensurate with the number of controls and indications necessary to be transmitted in actual practice.

It will be noted that the last stepping relay LV and the next to the last is maintained energized until relay SB drops at the end of the control cycle.

It will also be noted that each of the other stepping relays is dropped away upon picking up of the second succeeding stepping relay in the stepping relay bank. This serves the purpose that the stepping relays are not using energy for a longer period than necessary and also reduces the amount of current that needs to be broken at any one time upon the dropping away of a stepping relay which would be of a substantial value if all of the stepping relays were maintained until the end of the operating cycle.

FREQUENCY SELECTION FOR CONTROL CODES

When controls are to be transmitted from the control office, the field stations are selected one at a time in accordance with the combination of the different frequencies used for the impulses applied to the line circuit for a portion of the complete code, while the remaining impulses have frequencies selected in accordance with the controls to be transmitted to the selected station. In brief, a complete control code comprises a station selecting code and the controls for the selected station.

As above mentioned, each impulse applied to the line circuit causes the stepping means at the control office and the field stations to take one step irrespective of the particular frequency of such impulse.

In accordance with the present invention, each impulse may be either of two frequencies, and the number of different combinations of impulses for the station selecting portion of the control code depends upon the number of impulses used. The different frequencies are arranged in combinations in accordance with that code principle which provides that when two different frequencies are employed two different combinations of code calls are obtained for one step; four different combinations of impulses for two steps; eight combinations for four different steps; sixteen combinations for four steps; thirty-two different combinations for five steps; and so on, each additional step or impulse doubling the number of possible code calls. In the present disclosure, only three steps have been shown, and although any number of steps may be employed, it is believed that this number is sufficient for an understanding of the present invention, and a typical code table is given below.

Typical code table

Number of station code call	Step 1	Step 2	Step 3
1.	f^1	f^1	f^1
2.	f^1	f^1	f^2
3.	f^1	f^2	f^1
4.	f^1	f^2	f^2
5.	f^2	f^1	f^1
6.	f^2	f^1	f^2
7.	f^2	f^2	f^1
8.	f^2	f^2	f^2

With a code call assigned to each field station selections are made between half of the total number of stations on the first station selecting step in accordance with the frequency of the impulse for that step; and similarly on the second station selecting step, selection is made between half of the stations remaining after the first selection, the particular half depending upon the frequency of the second impulse. This selection

continues until the end of the station selecting steps when only one station remains as the selected station.

In accordance with this principle of code selection, the code jumpers in the control office can be arranged to assign any code call to any field station as may be desired. But for the sake of simplicity in assigning the codes, it is probably desirable to assign the codes in the order of the field stations. This has been done for the purposes of the present disclosure to provide that the station No. 1 has code No. 1 assigned to it which requires three impulses of frequency f^1 (see code table above). This is effected by the code jumpers 135, 136, and 137; while the station code call No. 2 for station No. 2 is provided by code jumpers 138, 139 and 140 to give impulses of the frequencies f^1 , f^1 , f^2 . However, it is to be understood that any of the possible codes might be assigned to these stations by merely shifting the positions of these code jumpers. Also, this assignment of codes is for station selection for control cycles of operation which is independent of the code assignment for station selection for indication cycles of operation, as will be explained more in detail hereinafter.

IMPULSING OPERATION AT CONTROL OFFICE

At the beginning of the control cycle of operation the initiating or conditioning impulse is provided by the energization of the transmitting relay T^1 to provide that the pulse is of the frequency f^1 . As above pointed out, this energy for the relay T^1 is supplied through back contact 63 of the relay SC at the same time that the relay E is picked up by its energizing circuit above pointed out. But when the VP relay responds (as is the case as soon as the relay SC picks up), the E relay is dropped so that upon the picking up of the relay SC the continued energization of the relay T^1 for the initiating impulse is continued through front contact 101 of the relay E which very shortly thereafter drops away. The dropping of the relay E, of course, causes the first stepping relay V¹ to pick up.

As soon as the relay V¹ picks up, the circuit for the relays T^1 or T^2 is prepared so that one or the other can be energized in accordance with the character of the code element required for the first step when the relay E picks up and closes its front contact 101 to cause energy to be applied to the proper bus wire 75 or 76 for energizing either the relay T^1 or the relay T^2 .

For example, the relay LC is picked up for the station No. 1 so that the stepping relay V¹ closes its front contact 70 to connect energy to the bus wire 141, which supplies energy through front contact 146 of relay LC and the code jumper 137 to the bus wire 75 for energizing the transmitting relay T^1 .

Similarly, on the second step the relay V² closes front contact 69 to supply energy to the bus wire 142 through contact 147 and code jumper 136 to again energize the bus wire 75 and transmitting relay T^1 .

On the third step the front contact 68 of relay V³ energizes the bus wire 143 to supply energy through front contact 148 and code jumper 135 to again energize the bus wire 75 to energize transmitter relay T^1 .

On the fourth step, the relay V⁴ closes front contact 67 to supply energy to the bus wire 144 which through front contact 149 of relay LC and lever 1SML supplies energy to either the bus wire 75 or the bus wire 76 depending upon the

position of the lever 1SML to energize either the relay T^1 or the relay T^2 . In other words, the impulse of the fourth step is of a f^1 or f^2 frequency depending upon whether a normal or reverse control is desired for the switch machine at the field location.

In a similar manner, the different frequencies to be transmitted can be selected on any number of station selecting steps in accordance with the number of stations in the system; and any number of control steps can be used depending upon the number of switches and signals to be controlled at the station.

END OF CONTROL CYCLE AT THE CONTROL OFFICE

The application of the last impulse of a control cycle to the line circuit is terminated by the dropping away of the relay E which causes the stepping relay LV to pick up but in so doing no energy is applied to the line circuit because there is no connection to the front contact 66 of this relay LV. This cessation of the application of impulses to the line circuit is, of course, repeated by the relay FA which in turn deenergizes the relays SA, SB, and SC successively. The dropping of the relay SC deenergizes the relay OC at its front contact 88 so that no more energy can be applied to the relays T^1 or T^2 through the wire 65 from front contact 83 of relay OC.

It should also be noted that the relay LCS and the relay LC are dropped out when the stepping relay V⁴ is picked up because the back contact 91 of the relay C is, of course, already open and the contact 52 of the relay SB is also open, making the contact 150 of relay V⁴ the last contact required to open the circuit for the relays LC and LCS. As soon as the relay LCS drops away, the front contact 59 is opened conditioning the relay C for deenergization upon the release of the relay SA subsequent to the termination of the last impulse of the control cycle. This stick circuit of the relay C is opened by front contact 74 of relay SA but is again closed by back contact 61 of relay SC.

Thus, when the last cycle demarking relay SC becomes deenergized, a permission impulse is placed upon the line circuit for restoring the line condition relays R and L. This is effected by energizing the transmitting relay T^2 through a circuit closed from (+), and including back contact 151 of relay SC, back contact 152 of relay R, back contact 153 of relay C, to the bus wire 76, windings of relay T^2 , to (-).

The resulting application of an impulse of frequency f^2 causes the line responsive relay means F^2 to be energized at the control office and at each of the field stations. This energization of relay F^2 at the control office does not energize the relay FA, because front contact 113 of relay SB is open as well as the front contact 115 of the line condition relay L. However, the closure of front contact 33 of the relay F^2 closes the pick-up circuit for the relay R, as above described, but the relay L does not pick up until this permission impulse is terminated. The length of this permission pulse is determined by the pick-up period of the relay R in the control office which is made slow-acting for the purpose of timing this impulse.

After a time the relay R picks up to open back contact 152 and cause the impulse to cease by dropping the relay T^2 which, of course, is repeated by the line responsive relay means F^2 in the control office and corresponding relays at each of the field stations. The opening of front

contact 33 of relay F^2 then allows the relay L to pick up so as to close front contact 115 to permit the relay FA to be responsive to any initiating impulse originating at a field location. This will be appreciated by again noting that the initiating pulses from the field locations are of the frequency f^2 while the initiating impulse from the control office is of the frequency f^1 .

OPERATION AT FIELD STATIONS

The reception of a conditioning impulse of frequency f^1 at each of the field stations causes the line responsive relay means to repeat such impulse and effect certain conditioning operations at each of the field stations which can be typically considered in connection with the field station No. 1 disclosed in Figs. 4A and 4B.

More specifically, the picking up of the relay IF^1 closes front contact 154 for energizing the line repeating relay IFA through an obvious circuit. The line repeating relay IFA closes its front contact 155 to energize the relay ISA, which in turn closes its contact 156 to energize the relay ISB. As soon as the relay ISB picks up, it opens back contact 34, deenergizing the line conditioning relays IR and IL to prevent any initiation of an indication cycle from the field station as will be described in detail hereinafter. As soon as the relay ISA picks up it closes front contact 158 while the picking up of relay ISB closes contact 159. Both of these contacts 158 and 159 are in multiple for completing the pick-up circuit for the relay IFA as controlled by contact 160 of relay IF^2 . This is necessary to maintain relay IFA controllable by relay IF^2 inasmuch as the dropping away of the relay IL opens contact 161 which is not again closed until the end of a permission impulse, as will be described in connection with the end of the control cycle at the field station.

The reception of the conditioning impulse at the field locations also closes a pick-up circuit for the station selecting relay SO at each and every station so that any station is available for its selection in accordance with the particular code received. For example, the pick-up circuit for the relays ISO and ISOS is closed from (+) through a circuit including back contact 162 of relay ISB, front contact 163 of relay IF^1 , back contact 164 of relay IF^2 , wire 165, back contact 166 of relay ILV, back contact 167 of relay IV^4 , back contact 168 of relay IV^3 , back contact 169 of relay IV^2 , back contact 170 of relay IV^1 , winding of relay ISOS, winding of relay ISO, to (-).

It is noted that this pick-up circuit for the relays ISO and ISOS is closed upon the reception of the conditioning impulse only until the relay ISB is picked up at which time an immediate shift-over is made to hold the relay ISO through stick circuits. More specifically, the relay ISOS is provided with a stick circuit from (+), through circuit including front contact 171 of relay ISB, front contact 172 of relay IFA, wire 173, front contact 174 of relay ISOS, lower winding of relay ISOS, to (-).

With the relay ISOS thus maintained energized, a holding stick circuit is also closed for the relay ISO from (+), through a circuit including front contact 171 of relay ISB, wire 175, front contact 176 of relay ISOS, front contact 177 of relay ISO, lower winding of relay ISO, to (-).

As soon as the relay ISB picks up during the conditioning period, a pick-up circuit is closed

for the half-step relay IVP from (+), through a circuit including front contact 162 of relay ISB, front contact 293 of relay IFA, wire 294, back contact 295 of relay ILV, back contact 296 of relay IV^4 , back contact 297 of relay IV^3 , back contact 298 of relay IV^2 , back contact 299 of relay IV^1 , winding of relay IVP, to (-). The picking up of relay IVP closes its front contact 300 which completes a shunt circuit for the contact 293 of relay IFA until the stepping relay IV^1 is picked up at which time the front contact 301 of relay IVP completes a stick circuit including back contact 293 of relay IFA which will be understood by analogy to the circuits described for the relay VP in the control office.

With the relay IVP picked up during the conditioning period, together with the picked-up condition of the station selecting relay ISO, the stepping bank is prepared to pick up the stepping relay IV^1 upon the first "off" period following the conditioning period.

More specifically, as soon as the relay IFA is released, a pick-up circuit is closed for relay IV^1 from (+), through a circuit including front contact 34 of relay ISB, back contact 302 of relay IFA, wire 303, front contact 304 of relay ISO, front contact 305 of relay IVP, back contact 306 of relay IV^4 , back contact 307 of relay IV^2 , windings of relay IV^1 , to (-). As soon as the relay IV^1 picks up a stick circuit is closed from (+), through a circuit including front contact 308 of relay ISB, wire 309, back contact 310 of relay IV^3 , front contact 311 of relay IV^1 , winding of relay IV^1 , to (-).

It is believed to be unnecessary to point out in detail the operation of the stepping bank at the field station, inasmuch as the operation of such stepping bank can be readily understood by analogy to the detail operation given with respect to the stepping bank in the control office. However, it should be noted that the circuit for the stepping relays IV at the field station include front contact 304 of the relay ISO, so that if such relay drops away at any point in a control cycle of operation, the stepping operation is immediately stopped. A similar functioning of the system occurs during an indication cycle of operation because at such time the front contact 312 of relay ISI is included in the stepping circuit, and such relay ISI drops out whenever the station fails to be selected for transmitting indications. When the stepping relays V at any station fail to follow the impulses on the line circuit because of the dropping of the corresponding relay SO or SI, the relay VP also ceases its operation.

The stepping operation at the field station may be briefly summarized by stating that the half-step relay IVP is caused to assume an opposite position on alternate impulse periods; while a stepping relay IV is picked up during each succeeding "off" period so long as a station continues to be selected.

STATION SELECTION

Each of the field stations is provided with a station selecting relay SO and an associated relay SOS. At the beginning of each control cycle of operation, the relays SO and SOS are picked up at each of the field stations during the condition impulse. On each of the succeeding impulses forming a part of the station selection code, the station selecting relay SO for each station is selectively maintained energized or is deenergized dependent upon whether the character of the impulse for such impulse period corre-

sponds with the position of the code jumper of that station to complete a selecting stick circuit.

When the station selecting relay SO for a station is maintained selectively energized during an impulse, suitable holding stick circuits are provided for this relay to maintain it energized during the following time space period so that it will be ready to be selectively maintained energized or deenergized in accordance with the character of the succeeding impulse. This is accomplished by the relay SOS which is connected in series with its associated relay SO so that it is picked up for each impulse period and drops for each time space period. But the relay SOS does not drop for a time space period until after the relay FA drops and thus keeps a temporary holding stick circuit closed until the relay FA drops and closes the regular holding stick circuit.

At the beginning of a station selecting impulse, the selecting stick circuit for relay SO is closed (that is, if the code jumper corresponds to the character of the impulse); before the holding stick circuit is opened. In other words, the holding stick circuits for the relay SO have an overlapping time relation with respect to the selecting stick circuit, so that the relay SO is maintained energized so long as the code on the line circuit corresponds on the code required for that station as determined by the positions of its code jumpers. However, if the character of an impulse fails to correspond with the position of the code jumpers for that station, the selecting stick circuit for relay SO is not closed and the relay SOS is not picked up at the beginning of that impulse. Thus, the relay SO is immediately dropped away. Such operation determines that such station will not be selected for that control cycle of operation.

As above explained, the station selecting code is of the exponential type commonly known as the Boudot code. Thus, at the beginning of the operating cycle all of the station selecting relays SO are picked up, then on the first impulse of the station selecting portion of the code, the station selecting relays SO at one-half of the stations are maintained selectively energized in accordance with the character of such impulse, while at the other half of the stations the relays SO are dropped away. On the next succeeding station selecting impulse one-half of those stations which were selected on the preceding impulse have their station selecting relays SO maintained energized in accordance with the character of such impulse, while the other half of such stations have their station selecting relays SO dropped away. This selection continues dividing the number of stations remaining on any preceding impulse in half until only one station remains selected on the last station selecting impulse.

It is believed that this station selecting operation will be best understood by giving further description from the standpoint of the detail operation with respect to the typical field station shown in Figs. 4A and 4B.

It was pointed out above how the relays ISO and ISOS are picked up during the conditioning period through a pick-up circuit and then transferred to holding stick circuits for the remainder of the conditioning period in readiness for the cycle of operation to pass into the first time space period of the cycle.

More specifically, the deenergization of the line circuit at the end of the conditioning period is repeated by the dropping of the relay IFA which

opens front contact 172 deenergizing the relay ISOS. This dropping away of the relay ISOS opens the temporary stick circuit through the lower winding of the relay ISO from open contact 176; but prior to the opening of this temporary stick circuit, the regular stick circuit for the relay ISO is closed from (+) through front contact 171 of relay ISB; back contact 172 of relay IFA, wire 183; front contact 177 of relay ISO; lower winding of relay ISO; to (-). Thus, the relay ISO is maintained energized during the time space period following the initiating or conditioning period.

Also, the first "off" period at the end of the initiating or conditioning impulse causes the stepping relay IV¹ to be picked up opening the pick-up circuit for the relays ISO and ISOS at back contact 170 and connecting the first code jumper 180 so that it will be effective during the succeeding impulse for determining whether the relay ISO is to remain energized for that impulse.

For example, if the next succeeding impulse (first impulse of station selection code) is of frequency f^1 , the line responsive relay means (F¹) picks up and closes a selecting stick circuit from (+) through a circuit including front contact 182 of relay ISO; wire 183; front contact 163 of relay IF¹; back contact 164 of relay IF²; wire 165; back contact 166 of relay IV¹; back contact 167 of relay IV²; back contact 168 of relay IV³; back contact 169 of relay IV²; front contact 170 of relay IV¹; code jumper 180; windings of relay ISOS; windings of relay ISO; to (-). This selecting stick circuit is closed for the relays ISO and ISOS throughout the impulse period so that upon the dropping away of the relay IFA at the end of such impulse period, a holding stick circuit is closed for the relay ISO from (+) and including front contact 171 of relay ISB; back contact 172 of relay IFA; wire 183; front contact 177 of relay ISO; lower winding of relay ISO; to (-).

It is noted that the dropping of the relay IFA for the second "off" period causes its contact 172 to shift from its front point to its back point opening the stick circuit for relay ISOS including front contact 174. But the stick circuit for the relay ISO including front contact 176 of the relay ISOS is closed while the relay ISOS is dropping away, which bridges the shifting time of contact 172 of relay IFA from a front point to its back point so that the holding stick circuit just pointed out for the relay ISO including back contact 172 and front contact 171 is closed without a momentary deenergization of the relay ISO.

This second deenergization of the line circuit also effects the picking up of the second stepping relay IV²; conditioning the circuits for the selection of the ISO relay in accordance with the frequency received on the next succeeding station selecting impulse.

Before pointing out the operation for the second station selecting impulse, it is desired to point out that if the first station selecting impulse after the initiating impulse had been of a frequency f^2 , the relay ISO would not have sustaining energy during the impulse period with the code jumper 180 in its position as shown in Fig. 4B so that the relay ISO would have dropped out opening its contact 182, and inasmuch as the contact 162 of relay ISB is open, no further energization for the relay ISO could occur during the remainder of the operating cycle.

It may also be desirable to point out the selecting stick circuit for the relay ISO if the code

jumper were positioned to render the station responsive to a code having the frequency f^2 for the first station selecting code impulse. More specifically, the selecting stick circuit could then be closed (providing such impulse is of the frequency f^2) from (+), through a circuit including front contact 182 of relay ISO, wire 183, back contact 163 of relay IF¹, front contact 184 of relay IF², wire 185, back contact 186 of relay ILV, back contact 187 of relay IV⁴, back contact 188 of relay IV³, back contact 189 of relay IV², front contact 190 of relay IV¹, through jumper 180 in its dotted position, winding of relay ISOS, winding of relay ISO, to (-).

To continue the operation of the control cycle, the application of the second station selecting impulse of a frequency f^1 causes the selecting stick circuit of the relay ISO to be closed through front contact 169 of relay IV² and code jumper 198. Thus, the station selecting relay ISO at this typical field station is selected during the second impulse and is maintained energized during the third "off" period until the next station selecting impulse. It is believed unnecessary to point out the holding stick circuits for the relay ISO which are closed during the third "off" period as these are the same as previously pointed out.

However, it might be well to note that if the second station selecting impulse should be of a frequency f^2 , there would be no energization of the selecting stick circuit for the relay ISO because the code jumper 198 is in a position requiring an impulse of the frequency f^1 . Of course the code jumper 198 could be placed in its lower position to make this station responsive to a second station selecting impulse of the frequency f^2 , if desired.

During the third "off" period, the third stepping relay IV³ is picked up preparing the selecting stick circuit for the relay ISO by closing front contact 168.

When the third station selecting impulse of a frequency f^1 is applied to the line circuit and repeated by the relay IF¹, the selecting stick circuit for the relay ISO is closed through front contact 168 of relay IV³, and code jumper 199. It is of course understood, that if the third code impulse should be of the frequency f^2 , then the relay ISO would be dropped away because the code jumper 199 is not in a position to allow the station to be selected for that character of impulse.

When the last station selecting impulse has been effective to determine whether or not the station is to be selected, the next "off" period of the control code causes the next successive stepping relay to be picked up (which in this case is the relay IV⁴). During the last station selecting impulse period the relay ISO is of course maintained energized in accordance with whether or not the character of the impulse corresponds to the station code call, and as soon as the "off" period occurs, the relay ISO is maintained energized over its temporary stick circuit including front contact 177 of relay ISO and contact 176 of relay ISOS, but as soon as the relay IFA drops away and closes its back contact 172, the relay ISO receives energy over its regular holding circuit including the wire 183 and stick contact 177. In other words, during this "off" period the relay ISO is maintained energized over the same stick circuit as during each of the preceding "off" periods.

However, during this "off" period immediately following the station selecting impulses, the step-

ping relay IV⁴ picks up and closes a permanent stick circuit which is maintained closed throughout the remainder of the control cycle, if the control codes are properly received. More specifically, when the stepping relay IV⁴ picks up, a stick circuit is closed from (+), through a circuit including front contact 171 of relay ISB, wire 175, front contact 191 of relay IV⁴, back contact 192 of relay ILV, wire 193, back contacts 194 and 195 of relays IF¹ and IF², respectively, in multiple, wire 183, front contact 177 of relay ISO, lower winding of relay ISO, to (-).

This stick circuit includes these contacts 194 and 195 of the relays IF¹ and IF² so that if some failure should occur in the code receiving apparatus so as to improperly distinguish between the frequencies f^1 and f^2 , in such a way as to permit both of the relays IF¹ and IF² to be picked up at the same time, when the relay ISO would be dropped away so that the field station would stop its operation although the control office would continue throughout the remainder of that operating cycle. This continuance of the operation of the control office, of course, accomplishes no useful purpose.

It will be noted that this check against "cross-fire" between the frequencies on the line responsive means is effective during an impulse period only after the line circuit conditions have had a chance to settle down or stabilize after the initial application of that impulse at the control office. This is because energy is applied to the stick circuit of the relay ISO through front contact 171 of relay ISB and back contact 172 of relay IFA until the relay IFA picks up following the response of the line responsive relays. In other words, the pick-up time of the relay IFA is sufficient for the line circuit stabilization and if more than one of the line responsive relays IF¹ and IF² is then picked up when relay IFA is picked up, the relay ISO is immediately dropped away.

Attention may now be called to the fact that a similar check is provided during the station selecting portion of the operating cycle as well as during the control portion of the operating cycle described above. More specifically, the holding stick circuit for the relay ISO is not opened upon the application of a station selecting impulse to render the relay ISO dependent upon the correspondence between the frequency of that impulse and the frequency required to select that station as determined by the position of the code jumper for that step, until the relay IFA picks up opening back contact 172. But at the time that back contact 172 is opened, only one of the line responsive relays can be picked up without opening the selecting stick circuit for the relay ISO. For example, if the station code call requires an impulse of the frequency f^1 for that particular step, then the back contact 164 of the relay IF² must be closed in order for energy to be applied to the wire 165 included in the selecting stick circuit for the relay ISO. On the other hand, if the station code requires an impulse of the frequency f^2 for that particular step, then the relay IF¹ must be dropped away closing back contact 163 in order for energy to be applied through front contact 184 of the line responsive relay IF² to the wire 185 included in the selecting stick circuit for the station selecting relay ISO.

Thus, it can be seen from the above description that any "cross-fire" or failure of the code im-

pulse line responsive relay means after a certain period of stabilization resulting in the picked up condition of both line responsive relay means, positively prevents that station from being selected in response to its code or any other code.

In actual practice several steps would be taken for the reception of the controls instead of just the one step IV^4 shown in the present disclosure. In such a case, it should be understood that there will be contacts, such as front contact 191 of the relay IV^4 , on each of such of the additional stepping relays which are in multiple with the contact 191 so that as the stepping progresses the stick circuit is maintained closed although certain of the stepping relays are dropped away. This special or permanent stick circuit, so called, is provided for holding the relay ISO during the control receiving portion of the cycle and is not opened until the last stepping relay, such as relay ILV, picks up and opens its back contact 192 which of course occurs at the end of the operating cycle.

RECEPTION OF CONTROLS

Assuming that the station selecting code has selected the typical field station of Figs. 4A and 4B, and that the station selecting relay ISO has been maintained picked up, then on the succeeding steps the controls will be registered. For the sake of simplicity, the disclosure shows only a single step and this step provides for the control of the relay ISMR, for example. If the lever ISML in the office is in a normal position then the frequency transmitted is f^1 which is repeated by the line relay IF^1 at the field station closing a circuit during the impulse period following the picking up of the stepping relay IV^4 , from (+), through a circuit including front contact 182 of relay ISO, wire 183, front contact 163 of relay IF^1 , back contact 164 of relay IF^2 , wire 165, back contact 166 of relay ILV, front contact 167 of relay IV^4 , through the upper winding of the relay ISMR, to (-). The energy which flows in this circuit causes the polar contacts of the relay ISMR to be actuated to the right and control the switch machine ISM to its normal position by an obvious circuit.

On the other hand, if the frequency f^2 is transmitted because of the lever ISML in a reverse position, then the lower winding of the relay ISMR is energized by a circuit closed from (+), and including front contact 182 of relay ISO, wire 183, back contact 163 of relay IF^1 , front contact 184 of relay IF^2 , wire 185, back contact 186 of relay ILV, front contact 187 of relay IV^4 , lower winding of relay ISMR, to (-). The energy which flows in this circuit causes the polar contact 196 to be actuated to a left-hand position for controlling the switch machine ISM to a reverse position.

A similar operation would occur during each succeeding control impulse period for as many steps as may be required, it being understood that following each impulse a stepping relay is picked up. For the sake of simplicity in the present disclosure, the next stepping relay picked up is the last stepping relay LV. Thus, when the relay ILV is picked up, the back contacts 166 and 186 open all possible flow of energy to control circuits while the back contact 192 opens the permanent stick circuit for the relay ISO.

The present disclosure has been simplified in the reception of controls, but it is to be understood that it may be employed with some suitable

method of registration of the character of the control impulses followed by the execution of such stored characters at the end of an operating cycle, such as shown for example in the prior Patent No. 2,159,922 dated May 23, 1939 granted to R. F. Wells. Inasmuch as all such features of control execution form no part of the present invention, that have been omitted although in practice such features would probably be employed.

END OF CONTROL CYCLE AT FIELD STATION

As above described, the last impulse of the control cycle is effective to position a control relay through front contacts of the fourth stepping relay IV^4 , but the termination of such impulse marks the beginning of a deenergized period on the line circuit conveniently termed the clear-out period. This causes the deenergization of the relays IFA, ISA and ISB in sequence, but the dropping of the relay IFA of course causes the picking up of the last stepping relay ILV before the relay ISB drops away.

The last stepping relay ILV together with the preceding stepping relay is dropped away when the front contact 308 of relay ISB is opened.

It is noted that when the relay ILV is picked up that the relay ISO is dropped away by reason of the opening of back contact 192 which causes the removal of energy (+) from the wire 183.

Even though the dropping away of the relay ISB during the clear-out period of deenergization of the line circuit causes the restoration of the various stepping relays, selecting relays, and the like, it does not energize the line condition relays R and L but merely prepares their pick-up circuits at back contact 34.

After the clear-out period has existed on the line circuit for a sufficient time to permit even the slowest responding field station to be restored to normal, then the control office acts to impress an impulse of a distinctive frequency f^2 on the line circuit for the permission impulse (see Fig. 5A). This impulse has been for convenience termed a permission impulse and acts to restore the line condition relays R and L to normally energized conditions. More specifically the application of the permission impulse of the frequency f^2 closes the front contact 36 of the line responsive relay IF^2 completing the pick-up circuit for the relay IR through back contact 34 of relay ISB and back contact 35 of relay IL. The relay IR picks up and closes its front contact 37, but inasmuch as positive energy is applied to both terminals of the IL, it cannot pick up. At the end of the permission impulse when the front contact 36 of relay IF^2 is opened, the relay IL immediately picks up in series with the stick circuit of the relay IR including front contact 37.

It can now be seen that the front contact 161 of relay IL is not closed until the end of the permission impulse. During the permission impulse, the front contacts 158 and 159 of relays ISA and ISB respectively, are open so that the closure of the front contact 160 of the line responsive relay IF^2 can in no way cause the energization of the relay IFA. In other words, the presence of a permission impulse should not and does not cause any stepping operation.

However, after the cessation of the permission impulse, the presence of an initiating impulse of the frequency f^2 for the initiation of an indication cycle of operation, must be able to cause the response of the relay IFA upon the closure of

front contact 160 so that the field station will properly respond to the initiation of such indication cycle of operation. Thus, the cessation of the permission impulse and the picking up of the relay 1L to close front contact 161 effects the proper conditioning of the relay 1FA so that it is in readiness for the initiation of an indication cycle of operation. The relay 1L in picking up also conditions the field station so that it can initiate an indication cycle of operation by placing a start impulse of the frequency f^2 on the line circuit, as will be described in detail hereinafter.

If several control cycles of operation are required to transmit the new controls to various field stations, then the permission impulse is not placed on the line circuit (see Fig. 5B) so that the line condition relays R and L remain deenergized throughout succession of control cycles. This prevents all of the field stations from applying a starting pulse to the line circuit should one or more of the field stations have new indications ready for transmission. Obviously, this makes the control office superior to the field stations so that controls may be transmitted continuously if necessary.

The clear-out period is made sufficiently long, as above mentioned, by causing the relay SB at the control office (see Fig. 3B) to be slower in releasing than the relay SB at the field stations, and also by the use of an additional cycle marking the relay SC that does not have a corresponding counter-part at the field stations. When the relay SA in the control office drops away at the end of a control cycle and opens its contact 74, the control office start relay C is released in readiness for another control cycle to be initiated as soon as the relay SB closes its back contacts. If a new control is standing ready to be transmitted as soon as the ensuing control cycle of operation ceases, the control office start relay C will be picked up opening a back contact 153 prior to the dropping away of relay SC closing its back contact 151. This prevents a permission impulse from being applied to the line circuit, and allows the control office to transmit a succeeding control cycle of operation.

Thus, if there are new controls to be transmitted to several field stations, the system is so organized that as many control cycles will occur in succession as required to transmit such new controls without interruption or interference from any field station although it may have indications standing ready to be transmitted.

INDICATION CONDITIONS

Assuming that a permission pulse has been applied to the line circuit, then all field stations are in condition to transmit indications if a change occurs in any of their indication contacts. For convenience in the present disclosure, a track relay 1T and a signal-at-stop relay 1M have been shown as representative of various indication conditions which it may be desired to have transmitted to the control office. If any of these indication conditions are so transitory as to appear and then disappear before a cycle of operation can be initiated for the selection and transmission from its station, then storage means may be employed. But all such means have been omitted, it being understood that they may control the system of the present invention in a manner typically shown in connection with the track relay 1T, or the signals at stop relay 1M.

AUTOMATIC START

Let us assume that the track relay 1T drops away, for example, then the movement of contact 27 from a front point to a back point causes the momentary opening of the stick circuit for the relay 1CH which immediately drops away.

With the one relay 1CH deenergized, a pick-up circuit is closed for its change repeating relay 1CHP if the system is not in a cycle of operation for either controls or indications. If the system is in operation, then the relay 1CH merely remains deenergized until the system returns to a normal-at-rest condition, at which time a circuit is closed for picking up the relay 1CHP from (+), through a circuit including back contact 200 of relay 1F², back contact 201 of relay 1SB, back contact 211 of relay 1FA, front contact 202 of relay 1TC, back contact 203 of relay 1TCP, winding of relay 1CHP, wire 204, back contact 205 of relay 1CH, to (-). It will be noted, that the relay CHP at any station cannot be picked up during the clear-out period when relay SB drops away, because relays TC and TCP are deenergized during a control cycle and during an indication cycle when their station is not transmitting, and these relays are not again picked up until a period of rest has existed for a substantial time. This delay is not particularly significant at this time, but will be described in detail in connection with indication cycle distribution.

As soon as the relay 1CHP picks up, it closes front contact 206 to apply negative energy (-) to its right-hand terminal so that the restoration of the change relay CH does not interrupt the supply of negative energy (-) to such terminal. Also, the picking up of the relay 1CHP closes a stick circuit for such relay from (+), through back contact 207 of relay 1SA, back contact 208 of relay 1SI and back contact 209 of relay 1LV in multiple, through front contact 210 of relay 1CHP, back contact 211 of relay 1FA, front contact 202 of relay 1TC, back contact 203 of relay 1TCP, winding of the relay 1CHP, front contact 206 of relay 1CHP, to (-).

Immediately upon the picking up of the relay 1CHP, a restoration circuit is closed for the relay 1CH from (+), through a circuit including front contact 212 of relay 1R, front contact 213 of relay 1CHP, wire 214, upper winding of relay 1CH, to (-). As soon as the relay 1CH is again energized, it closes its front contact 39 so that it is again maintained stuck up through the circuit which may be momentarily broken when new indication conditions occur.

As soon as the relay 1CHP picks up, a pick-up circuit is closed for the transmitting relay 1T² from (+), through a circuit including back contact 215 of relay 1F², back contact 216 of relay 1F¹, front contact 217 of relay 1R, front contact 218 of relay 1L, front contact 219 of relay 1CHP, front contact 220 of relay 1TC, windings of relay 1T², to (-).

The picking up of the transmitting relay 1T² causes a starting or initiating impulse of a frequency f^2 to be impressed on the line circuit. With reference to Fig. 2B, it will be seen that the closure of front contact 221 of relay 1T² closes a circuit through back contact 222 of relay 1FA to energize the frequency generator "f²-Gen." This application of a starting impulse to the line circuit acts to initiate the control office as will be presently described in detail.

Before considering such detail operation in

the control office with regard to the initiation of an indication cycle of operation, it is desired to point out the sequences of operation at the field station. However, it can be noted at this time that immediately upon the application of the starting impulse of frequency f^2 to the line circuit at the field station as above described, the line responsive relays F^1 and F^2 at the control office and at the field station pick up at substantially the same time. The relay F^2 in the control office immediately causes the frequency generator unit " f^2 -Gen." to apply the frequency f^2 to the line circuit even before the control office is initiated into a cycle of operation (see Fig. 2A for the circuit and Fig. 5C for chart of operation). This is because of a circuit closed from the right-hand terminal of the frequency generator unit " f^2 -Gen." through a circuit including front contact 230 of relay F^2 , back contact 234 of relay F^1 , front contact 232 of relay L, back contact 233 of relay SC, back contact 234 of relay EP, to the left-hand terminal of the frequency generator " f^2 -Gen."

At the field station, the picking up of the relay F^2 opens the initial pick-up circuit of the transmitter relay IT^2 at back contact 215, but the transmitter relay IT^2 is maintained energized by a stick circuit closed from (+), through a circuit including front contact 223 of relay ITC, front contact 224 of relay IT^2 , back contact 235 of relay ISB, front contact 220 of relay ITC, windings of relay IT^2 , to (-). Thus, the transmitter relay IT^2 remains picked up and continues to apply energy of the frequency f^2 to the line circuit until the line repeater relay IFA is picked up opening its back contact 222. But by this time the control office has applied the conditioning impulse energy so that the line responsive relays F^2 remain energized. The continued energization of the relay F^2 maintains relay IFA steadily energized.

The timing relay ITC, under proper operation, is maintained energized by reason of a stick circuit closed from (+), through a circuit including front contact 223 of relay ITC, front contact 227 of line responsive relay F^2 , front contact 228 of relay IT^2 , front contact 226 of relay ICHP, windings of relay ITC, to (-). It is noted that this stick circuit for the relay ITC is closed dependent upon the picking up of the line responsive relay F^2 .

This serves to check the integrity of the frequency generator and other transmitting apparatus at the field station, because if such transmitting apparatus should fail to place a starting impulse of frequency f^2 on the line circuit, then the relay F^2 would not be picked up and the relay ITC would drop away after measuring off its release period. This, of course, assumes that no other station is placing a start pulse on the line circuit. In the event that some other station was also placing a start pulse on the line circuit at the same time as this failing station, then in effect there is no failure to start the system into operation and this relay ITC at the station having a poor or failing transmitter does not drop out until that point in the cycle at which the frequency which should be transmitted by it, is not transmitted by any other station. In other words, the relay ITC not only checks the proper operation of the transmitters for the start pulse but also acts throughout the cycle of operation as will be presently described.

Assuming that the system operates properly however, the apparatus at the field station is ini-

tiated into a cycle of operation in the usual manner. More specifically, the picking up of the relay F^2 closes its front contact 160 to energize the relay IFA through front contact 161 of relay IL. The picking up of relay IFA of course causes the relays ISA and ISB to pick up in sequence and as soon as the front contact 158 of relay ISA is closed, the front contact 161 of relay IL is shunted so that the dropping of such relay IL upon the picking up of relay ISB does not in any way affect the control of the relay IFA by the relay F^2 . The relay ISB, of course, closes contact 159 to also supplement the shunting of contact 161.

As soon as the relay F^2 picks up in response to the starting impulse, it closes a pick-up circuit for the station selecting relay ISI from (+), through a circuit including back contact 162 of relay ISB, back contact 163 of relay F^1 , front contact 184 of relay F^2 , wire 185, back contact 186 of relay ILV, back contact 187 of relay IV^4 , back contact 188 of relay IV^3 , back contact 189 of relay IV^2 , back contact 190 of relay IV^1 , wire 236, front contact 237 of relay IL, front contact 238 of relay ICHP, wire 239, back contact 240 of relay ISO, back contact 241 of relay IV^1 , back contact 242 of relay IV^2 , back contact 243 of relay IV^3 , back contact 244 of relay IV^4 , back contact 245 of relay ILV, upper winding of relay ISI, to (-).

As soon as the relay ISI is picked up, it closes front contact 246 to complete a stick circuit from (+), through a circuit including front contact 246 of relay ISI, back contact 240 of relay ISO, back contact 241 of relay IV^1 , back contact 242 of relay IV^2 , back contact 243 of relay IV^3 , back contact 244 of relay IV^4 , back contact 245 of relay ILV, upper winding of relay ISI, to (-). This stick circuit maintains the relay ISI energized until the first stepping relay is picked up during the first "off" period at which time a holding stick circuit is closed through a back contact of relay IFA. This holding stick circuit is closed until the first impulse period when relay IFA opens its back contact 255 to render the relay ISI dependent for energization upon the first station selecting jumper if the frequency of the first impulse agrees with the code assigned to the station.

The application of the start pulse to the line circuit by the field station causes the control office to apply the conditioning impulse immediately as above mentioned, but this conditioning impulse is prolonged in accordance with the length of impulse that is usually required for conditioning the various relays in the control office as will be hereinafter pointed out, but it is desired to point out at this time that this conditioning impulse as applied at the office continues sufficiently long to permit even the slowest responding field station to be initiated into a cycle of operation. Thus, the conditioning impulse will continue to maintain the relay F^2 picked up even after the relay ISB has opened its back contact 235 and released the transmitter relay IT^2 .

When the transmitter relay IT^2 has dropped away, a stick circuit for the relay ITC is closed from (+), through a circuit including front contact 223 of relay ITC, back contact 224 of relay IT^2 , back contact 225 of relay IT^1 , front contact 226 of relay ICHP, windings of relay ITC, to (-). Thus, this stick circuit for the relay ITC can be considered to be closed at the time or slightly prior to the release of the relay F^2 at

the end of the conditioning period opening its contact 227 included in the previously described stick circuit for the relay ITC.

This stick circuit for the relay ITC is closed during each of the "off" periods throughout the ensuing indication cycle of operation, assuming, of course, that this station properly transmits its indication impulses. It was pointed out above, that the stick circuit for the relay ITC (including the contact 227 of the relay IF²) provided a check on the operation of the frequency generator unit "f²-Gen." by allowing the relay ITC to drop away if such impulse is not impressed upon the line circuit to which the line responsive relay IF² can respond, or if the line responsive relay IF² should fail to respond due to a failure in its amplifier unit. The same condition is, of course, true for impulses of the frequency f¹ because for such impulses the stick circuit for relay ITC includes front contact 341 while the corresponding impulse of the frequency f¹ is being impressed on the line circuit. Thus, if the relay ITC drops out during an impulse period, this holdover stick circuit above described as including back contacts 224 and 225 of the relays IT¹ and IT² will, of course, not be closed on the following "off" period. These checking features will be discussed more in detail hereinafter.

With the relay IFA picked up during the conditioning period, the relay IVP is picked up as soon as the relay ISB responds to the conditioning impulse and is thus in readiness for the picking up of the first stepping relay during the "off" period following the conditioning impulse.

The release of the relay IFA at the end of the conditioning impulse closes a holding stick circuit for the relay SI from (+), through a circuit including front contact 250 of relay ISB, wire 251, front contact 253 of relay ISI, wire 254, back contact 255 of relay IFA, wire 256, front contact 257 of relay ISI, lower winding of relay ISI, to (-).

The apparatus at the field station is thus prepared for the indication cycle of operation during the conditioning impulse period. Before considering how the different frequencies are capable of selecting or rejecting the station selecting relay ISI in accordance with the code assigned to the station, it is thought expedient to point out the manner in which the station selects the different frequencies to be placed on the line circuit at the field station and how these frequencies are impressed on the line circuit in accordance with the impulsing operation at the field station instead of at the control office.

FREQUENCY SELECTION FOR INDICATION CODES

As previously mentioned, there are two transmitter relays at the field station, namely, relays IT¹ and IT² for respectively transmitting impulses of frequencies f¹ and f². With reference to Fig. 2B, it will be seen that the picking up of the relay IT¹ closes front contact 258 to energize the impulse frequency generator "f¹-Gen." through a circuit also including the back contact 222 of relay IFA.

On the other hand, if the transmitter relay IT² is picked up for an impulse, then the closure of its front contact 221 energizes the impulse frequency generator "f²-Gen." through a circuit also including back contact 222 of relay IFA.

Extending from these relays IT¹ and IT² are bus wires 260 and 261 (see Fig. 4A), to which the code jumpers for the field station as well as the indication contacts selectively apply energy to effect the energization of the transmitter relays

in accordance with the frequency desired to be transmitted for the various impulses of an indication cycle of operation.

For convenience in the consideration of the manner in which the system operates in accordance with the principle of code superiority, the station code call No. 3 of the typical code table has been assigned to this station No. 1, although any other code might be assigned to the station. Ordinarily, it is probably preferable to assign the codes in the order of the stations.

More specifically, the code No. 3 assigned to this station requires three station registering impulses of frequencies f¹, f² and f¹. Thus, the code jumpers 162, 163 and 164 are positioned as shown in the drawings (see Fig. 4B).

When the first stepping relay IV¹ is picked up during the first "off" period following the conditioning period (see chart of Fig. 5C and drawings of Figs. 4A and 4B), then energy can be applied to the bus 260 for energizing the transmitter relay IT¹ as soon as the impulsing relay IE picks up by reason of a circuit closed from (+), through a circuit including front contact 207 of relay ISA, front contact 265 of relay IE, front contact 266 of relay ITC, wire 267, front contact 268 of relay ISI, back contact 269 of relay ILV, back contact 270 of relay IV⁴, back contact 271 of relay IV³, back contact 272 of relay IV², front contact 273 of relay IV¹, jumper 162 to the bus 260 for energizing the transmitter relay IT¹. This, of course, causes an impulse of the frequency f¹ to be applied to the line circuit which is of a duration determined in accordance with the impulsing characteristics of relay IE as will be presently described. It is sufficient for the present to note that the impulse is terminated and during the following "off" period, the next stepping relay is picked up so as to close front contact 272 and connect the code jumper 163 to the bus 261 to cause the following impulse to be of the frequency f². The circuit for this is obvious and will not be pointed out in detail.

Following the application of the second impulse, the third stepping relay IV³ is picked up closing front contact 271 so as to connect the code jumper 164 to the bus 260 in readiness to cause the next impulse to be of the frequency f¹ as soon as the circuit is completed at contact 265 of the relay IE which determines the impulsing timing characteristics at the station.

After the third impulse, the following "off" period causes the stepping relay IV⁴ to be picked up which completes a circuit to energize either the bus 260 or 261 in accordance with the position of the indication contact 274 in a similar manner as that pointed out for the code jumpers. After such impulse has been applied to the line circuit for a time period determined by the impulsing characteristics of the station, then the following "off" period occurs which causes the last stepping relay ILV to be picked up opening back contact 269 to disconnect all energy from the bus 260 and 261. In this manner impulses of various frequencies are applied to the line circuit for each indication cycle of operation in which this station is effectively registered in the control office. It will be noted that if the code fails to select the station on any particular impulse then the relay ISI is dropped away, as will be presently explained, which opens front contact 268 and prevents the energization of the transmitter relays on any of the following steps of the cycle of operation, but assuming that the station is selected the complete cycle causes the

complete operation of this field station and the transmission of the indication pulses after the station has been selected in accordance with the position of the indication contacts.

IMPULSING OPERATION AT FIELD STATION

At the termination of the conditioning period which is measured by the control office, the release of the relay 1FA causes the picking up of the stepping relay 1V¹. This completes an energizing circuit for the relay E (see Figs. 4A and 4B) from (+), through a circuit including front contact 275 of relay 1SI, back contact 276 of relay 1LV, back contact 277 of relay 1V⁴, back contact 278 of relay 1V³, back contact 279 of relay 1V², front contact 280 of relay 1V¹, front contact 281 of relay 1VP, wire 282, winding of relay 1E, to (-).

As soon as the relay 1E picks up, it closes its front contact 265 to complete the energizing circuit for the particular transmitter relay 1T¹ or 1T² as the case may be for the particular station code to be transmitted. This, of course, assumes that the relay 1SI was picked up during the conditioning period as above pointed out and was maintained energized during the "off" period following the conditioning period in a manner also pointed out. This is necessary because front contact 268 of relay 1SI is included in the transmitting circuit just described for the transmitter relays 1T¹ and 1T². The impulse is, of course, impressed upon the line circuit and is repeated by the particular line responsive relay 1F¹ or 1F² in accordance with the particular frequency of that impulse. As soon as such impulse is repeated, the relay 1FA is energized irrespective of the character of the impulse and thereby immediately opens the circuit at back contact 222 for the particular frequency generator then selected (see Fig. 2B).

However, before this happens (i. e., before the field station can terminate this first impulse), the control office impresses on the line circuit an impulse corresponding in frequency to the character of the impulse impressed by the field station, unless two field stations are transmitting and each station puts on the line circuit a different frequency, in which case the control office impresses the superior frequency as, for example, frequency f^1 . This will be described in detail hereinafter, but for the present it is sufficient to note that this frequency impulse is applied by the control office and is repeated by the field station so as to continue the energization of the relay 1FA without interruption although the field station has withdrawn.

In brief, the field station impresses an impulse on the line circuit, and immediately upon the reception of this impulse in the control office, the apparatus in the control office acts to impress an impulse of the same frequency on the line circuit (see Fig. 5C). Even though the field station withdraws its impulse before the full impulse period has elapsed, its impulse is sufficiently long to overlap with the impulse applied by the control office.

As the impulse applied by the control office continues slightly longer than the impulse period as is measured in the field station by the response of the relay 1E in dropping away upon the shifting of the relay 1VP, it will be seen that the control office impulse is effective to continue the energization of relay 1FA by reason of the picked up condition of the particular line responsive relay 1F¹ or 1F². Thus, the field station

cannot take the next step until the relay 1FA is released upon the cessation of the impulse applied by the control office.

On the other hand, if the impulsing relay 1E at the field station should happen to become slower in responding than the control office, that is, if the control office impulse ceases before the relay 1E releases, then the field station is provided with means to prevent such field station taking the next step until the impulsing relay 1E at the field station has assumed a proper position.

More specifically, the present invention provides that regardless of the fact that the impulse may be terminated at the control office, the field station does not release its relay 1FA (while it is still transmitting and has a chance of being the selected station) until the station has timed the impulse period in accordance with its stepping operation and the operation of its impulsing relay 1E. This is accomplished by providing a stick circuit for the relay 1FA closed from (+), including front contact 283 of relay 1SI, wire 284, front contact 285 of relay 1E, front contact 286 of relay 1SB, front contact 287 of relay 1FA, windings of relay 1FA, to (-).

From the above it will be seen that the relay 1E determines the impulse timing of the field station and this relay 1E is in turn controlled by the stepping relays 1V¹, 1V², etc., in a similar manner as the relay E in combination with the stepping relays determines the impulse timing in the office.

We can consider the impulse cycle at the field station by considering the following sequences. The picking up of the relay 1FA in response to an impulse, causes the shifting of the contacts of the relay 1VP to new positions, which in turn deenergizes the relay 1E. The dropping away of the relay 1E terminates the impulse period at the field station (dependent, of course, upon the control office having removed its impulse energy), and permits the relay 1FA to drop away and cause the next stepping relay V to be picked up, which in turn causes the energization of the relay 1E to terminate the "off" period. This sequence of events has been indicated in the chart of Fig. 5C for an indication cycle of operation. In this chart no specific times of operation have been indicated, because such times would vary in practice. This chart merely shows the relative sequences to indicate that the stepping relays and the E relay are picked up during the "off" periods, as indicated by the arrows adjacent their reference designations, and that the half-step relay VP and the impulsing relay E assume deenergized positions during each of the impulse periods as indicated by the arrows adjacent their reference designations.

In the first impulse period following the conditioning period, the relay 1VP is dropped away which causes the contact 281 to open its front point and close its back point. This deenergizes the relay E which in turn opens its front contact 285 to allow the relay 1FA to become deenergized for the "off" period. Relay 1E also opens its front contact 265 to drop the particular transmitter relay 1T¹ or 1T² then energized although the actual impulse as applied by the field station was terminated by the picking up of the relay 1FA.

The dropping away of the relay E is arranged to be slightly delayed during the station selecting portion of the indication cycle by reason of the shunting of this relay 1E by the resistor 290,

which shunt circuit is opened by contact 291 of relay IV⁴ as soon as the station has been selected. The dropping of the relay IE also closes its back contact 292 to complete the holding circuit for the relay ISI during the following "off" period just slightly ahead of the release of the relay IFA which closes its back contact 255 to also complete such holding circuit for the relay ISI.

As soon as the relay IFA drops away, it causes the next stepping relay to be picked up, which in the present case is the stepping relay IV². This closes front contact 279 which completes a circuit for the relay IE through back contact 281 of the relay IVP so that the next impulse is then applied to the line circuit by the energization of the particular transmitter relay IT¹ or IT² then selected by the code jumper 163. It will thus be seen that this process of impulsing the line circuit by the operation of the relay IE acting on the transmitter relays is effective throughout the remaining portion of the indication cycle of operation.

RETRANSMISSION OF STATION CODES FROM CONTROL OFFICE

It was above mentioned that the application of the start impulse by a field station is effective to pick up the line responsive relay F² in the control office to close a circuit at front contact 230 for causing the oscillator or frequency generator "f²-Gen." to place conditioning energy of the frequency f² on the line circuit (see Fig. 2A). The picking up of the line responsive relay F² in the control office closes its front contact 114 to energize the relay FA (see Fig. 3B), which in turn, of course causes the sequential energization of the relays SA, SB and SC. But immediately upon the picking up of the line responsive relay F² and before the relay SB can possibly pick up, a pick-up circuit is closed for the field starting relay CF from (+), through a circuit including back contact 55 of relay SB, front contact 56 of relay F², front contact 313 of relay R, front contact 314 of relay L, windings of relay CF, to (-). As soon as the relay CF picks up a stick circuit is closed from (+), through a circuit including back contact 61 of relay SC, back contact 62 of relay C, front contact 315 of relay CF, windings of relay CF, to (-). Before the relay SC can pick up and open this stick circuit for the relay CF, the relay SA, of course, closes its front contact 74 to apply energy to the stick circuit just pointed out.

As soon as the field start relay CF picks up, it closes front contact 82 for energizing the relay OC by energy received through back contact 80 of the relay SC. The picking up of the relay SC opens back contact 80 to remove energy from the pick-up circuit of the relay OC but closes front contact 38 to complete its stick circuit as previously pointed out.

With the relays CF and OC picked up, a circuit is closed for the control of the oscillator or frequency generator "f²-Gen." from the right-hand terminal of such frequency generator (see Fig. 2A) to front contact 230 of relay F², back contact 231 of relay F¹, front contact 316 of relay CF, front contact 317 of relay OC, back contact 234 of relay EP, to the left-hand terminal of the frequency generator "f²-Gen.". This circuit is closed prior to the opening of the circuit including back contact 233 of relay SC. Thus, the conditioning impulse is maintained on the line circuit until the control office responds

to cause the stepping operation and the impulsing relay EP is picked up in a manner presently to be pointed out. This application of the indication conditioning impulse is obviously longer than the application of the start impulse applied at the field station in view of the fact that the energization of the line responsive relay IF² at the field station causes the picking up of the relay IFA which in turn immediately opens the circuit for the energization of the oscillator "f²-Gen." at back contact 222 (see Fig. 2B).

At the control office, the picking up of the relay CF closes an energizing circuit for the impulsing relay E (see Fig. 3B) from (+) through a circuit including front contact 318 of relay CF, wire 92, back contact 93 of relay LV, back contact 94 of relay V⁴, back contact 95 of relay V³, back contact 96 of relay V², back contact 97 of relay V¹, back contact 98 of relay VP, wire 99, winding of relay E, to (-). This energization of the relay E opens its back contact 319 to prevent the energization of the relay EP upon the picking up of the relay SC. But the relay SC closes its front contact 103 and causes the picking up of the half-step relay VP as previously pointed out which in turn opens the energizing circuit for the relay E at back contact 98 and after it consumes its release time, an energizing circuit is closed for the relay EP from (+) through a circuit including front contact 320 of relay CF, back contact 319 of relay E, front contact 321 of relay SC, windings of relay EP, to (-).

The picking up of the relay EP causes the termination of the conditioning impulse in the control office by opening its back contact 234 (see Fig. 2A) thus effectively deenergizing the frequency generator "f²-Gen."

This termination of the conditioning impulse of course causes an "off" period. The deenergization of the relay FA in the control office causes the picking up of the first stepping relay V¹ in a manner previously pointed out. Similar conditions occur at the field station except that the relay IFA cannot be released until the relay IE at the field station drops away in accordance with the impulsing characteristics of the field station in case that field station should be unduly slow. When the relay IFA is released and the stepping relay IV¹ is caused to pick up, an impulse of a character, as selected in accordance with the station code, is impressed upon the line circuit as previously explained. The application of this impulse on the line circuit, of course, causes the response of the line responsive relays F both at the control office and at the field stations. The picking up of either of the relays IF¹ and IF² at the field station, of course, causes the picking up of the relay IFA terminating that impulse insofar as the field station is concerned by opening back contact 222 (see Fig. 2B).

At the control office, the picking up of either line responsive relay F¹ or F², of course, causes the corresponding frequency generator to be actuated through circuits including back contact 234 of relay EP which is now closed because relay EP is deenergized by the picking up of the relay E as soon as the first stepping relay V¹ closes its front contact 97 during the "off" period following the conditioning period. Thus, the control office receives the impulse and returns an impulse of the same frequency which impulse continues until the relay EP is picked up. This picking up of

the relay EP, of course, occurs after the relay FA has picked up causing the release of the relay VP and release of the relay E.

In this manner the indication cycle continues, the field station causing an impulse to be applied to the line circuit after a measured period of time and the control office returning an impulse of the same character for a measured period of time. It will be noted that the field station measures the "off" periods while the control office measures or determines the "impulse" periods.

STATION SELECTION

As above explained, the initiation of the system for a cycle of operation for the transmission of indications is always effected by a conditioning period having energy of the frequency f^2 . This causes the picking up of the station selecting relays SI at all of the field stations having their change relays CHP picked up in a manner typically explained in connection with the typical field station of Figs. 4A and 4B. But assuming that only one field station has indications to transmit, then only that field station has its selecting relay SI energized during the conditioning period so that the ensuing cycle of operation provides a code in accordance with the code of its station and that relay SI is maintained energized throughout such cycle of operation. Such a typical cycle of operation will now be described, first pointing out how a station code selects its station and then allows the indications to be transmitted to the control office. At the same time, certain checking features will be pointed out with respect to the reliability of the frequency generators.

It has been explained above how the transmitter relays IT^1 and IT^2 are controlled to transmit impulses forming the station code.

During the conditioning period the relay SI is picked up as above explained and during the first "off" period the closure of back contact 292 completes a holding stick circuit for the relay ISI before the temporary stick circuit for the relay ISI including front contact 246 and back contacts 241, 242, 243, 244 and 245 is opened by the picking up of the relay IV^1 . As soon as the first impulse is applied to the line circuit having a frequency in accordance with the station selecting code, then either the relay IF^1 or the relay IF^2 is picked up which closes a selecting stick circuit for the relay ISI providing the frequency of such impulse corresponds to the frequency required in accordance with the code for that station.

It has been assumed that the typical field station of Figs. 4A and 4B has been assigned the station code No. 3 so far as the station selection and registration of this station for an indication cycle is concerned. This means that the first impulse is of a frequency f^1 which energizes the line responsive relay IF^1 and closes a circuit from (+) through a circuit including front contact 250 of relay ISB, wire 251, front contact 253 of relay ISI, wire 254, front contact 322 of relay IF^1 , wire 323, code jumper 324, front contact 241 of relay IV^1 , back contact 242 of relay IV^2 , back contact 243 of relay IV^3 , back contact 244 of relay IV^4 , back contact 245 of relay ILV, upper winding of relay ISI, to (-). This selecting stick circuit is closed prior to the opening of the holding stick circuit at back contact 255 of relay IFA, and back contact 292 of relay IE. It is understood, of course, that relay IE picks up to cause the impulse to be applied and the relay

IFA responds to such impulse. Thus, the relay ISI is maintained energized and the half-step relay IVP shifts its position so that upon the next "off" period the stepping relay IV^2 is picked up in readiness for the second station selecting impulse. It will, of course, be seen that if the station code jumper 324 was located in its upper position requiring an impulse of the frequency f^2 for the station code call then this selecting stick circuit for the relay ISI would be open at the code jumper 324 so that such relay would immediately drop out at the beginning of the station selecting impulse just described. Because of open front contact 312, the stepping relay IV^2 could not be picked up on the following "off" period.

The second station selecting impulse is of the frequency f^2 causing the line relay IF^2 to be energized closing the selecting circuit from (+), through a circuit including front contact 250 of relay ISB, wire 251, front contact 253 of relay ISI, wire 254, front contact 325 of relay IF^2 , wire 326, code jumper 327, front contact 242 of stepping relay IV^2 , back contact 243 of relay IV^3 , back contact 244 of relay IV^4 , back contact 245 of relay ILV, upper winding of relay ISI, to (-). It is obvious that this selecting stick circuit would not be closed if the station code were to call for a frequency f^1 on this step with the code jumper 327 in its lower position. Similarly if the code applied to the line circuit called for the frequency f^1 with the code jumper 327 in its present position this selecting stick circuit would also be open.

It can be seen from the above description how the field station operates to step along and maintain its selecting relay SI energized so long as the code received by the field station corresponds to its code jumpers. It might be well to point out that inasmuch as the control office measures the length of the impulse period and causes it to be sufficiently long to allow the response of the slowest acting field station, then the relay IE at the field station is always capable of assuming its deenergized position before the control office removes the particular station selecting impulse which it is returning to that field station. This causes the back contact 292 of the relay IE to close the holding stick circuit for the relay ISI before the selecting stick circuit is opened by the cessation of the selecting impulse and the dropping away of the line responsive relay IF^1 or IF^2 .

In this connection, it may be well to point out the manner in which the response of the code transmitters and receivers are checked during an indication cycle. It is, of course, obvious that if a field station transmitter fails, then no impulse is transmitted to the control office and the impulsing stops at that point in the control cycle allowing the relays SA, SB, etc., to drop away terminating that cycle of operation.

On the other hand, a field station might transmit an impulse of a particular frequency and the control office either fail to receive such impulse or its transmitter fail to retransmit such impulse. In either case, there would be no impulse returned to the field station. However, it is apparent that the application of an impulse by a field station causes not only the response of the line receiving means in the control office but also its own receiving means which in turn causes the picking up of its relay FA. However, the picking up of the relay FA effects the shifting of the relay VP and the impulsing operation as previously described in connection with the field station so that both of the back contacts 255 and 292 are

opened at the field station during a certain measured period of time. As soon as the relay IFA picks up at the field station, it removes the transmitting impulse from the line circuit by reason of open back contact 222 (see Fig. 2B), but the relay IFA is maintained picked up through its stick circuit including front contact 285 even though no impulse energy is then on the line circuit. Thus, if the control office does not return an impulse to the field station corresponding to the one which it transmitted, then there is a time during which the selecting stick circuit for the field station is opened before the impulsing relay IE closes its back contact 292. This causes the dropping out of the relay ISI upon the failure of retransmission from the control office, the same as if an impulse were actually transmitted but differed in the frequency called for by its station code. A release of the relay ISI of course opens its front contact 246 and its front contact 283 releasing the relay IFA and also opening the front contact 312 causing the stopping of any further stepping operation. The opening of front contact 275 prevents any further application of impulses to the line circuit by the field station until after it has returned to a normal condition and is again initiated into operation.

The checking feature provided by this short period of time during which impulse energy must be received from the control office following the impulse energy received by the field station from its own transmitter in order to maintain the station selecting relay ISI energized, must not be confused with the checking feature provided by contacts 227 and 341 used in controlling the relay ITC. Even though the control office might fail to retransmit the indication impulses transmitted by the field station, such impulses as are transmitted by that field station and will, of course, be received by its own line responsive relay means resulting in the picking up of either the relay IF¹ or IF² to close the contacts 341 and 227 respectively. Such momentary closures of these contacts would maintain the relay ITC energized so long as the station transmitted, even though no impulses were returned by the control office. It can thus be seen that the checking feature applied to the control of the relay ISI serves to check the reliability of the control office receiving and transmitting apparatus.

After the station selecting impulses have been transmitted and the station remains selected, then during the "off" period following the last station selecting impulse, the next stepping relay is picked up which in the case of the typical field station shown in Figs. 4A and 4B is the stepping relay IV⁴. This closes a stick circuit for the relay ISI from (+), through a circuit including front contact 250 of relay ISB, wire 251, front contact 253 of relay ISI, front contact 244 of relay IV⁴, back contact 245 of relay ILV, upper winding of relay ISI, to (-). If it were not for the manner in which the stepping relays are released sequentially during the cycle, such a permanent holding circuit for the remainder of the cycle could be closed by a single contact of the stepping relay IV⁴, for example. However, the relay IV⁴ is representative of the stepping relay to be picked up following the station selecting impulses and may be dropped out, although this is not specifically shown in the present disclosure because the stepping relay after the relay IV⁴ is the last step relay ILV. But in view of the fact that this relay IV⁴ might be dropped out if the stepping bank were enlarged as it undoubtedly would be

for an actual installation providing the usual number of steps, then it would be dropped out and stick circuits must be provided including front contacts of each of the succeeding stepping relays also including the last step relay LV. Without pointing out the complete circuit, it will be evident that the picking up of the stepping relay ILV closes its front contact 245 to continue the stick circuit just pointed out for the relay ISI.

Following the station selecting impulse, the field station having been selected for the transmission of indications proceeds to transmit the next impulse having a frequency in accordance with the indication to be transmitted from that field station. In the present disclosure, this is an indication in accordance with the position of the track relay IT. With the track relay IT energized, the frequency transmitted is f² but if the track relay is deenergized then the frequency of the impulse is f¹. The transmission of this impulse has been previously explained but the system is so organized that any impulse may be prolonged by the field station, or it may be made of the usual length, which provides two additional conditions for the purpose of transmitting an additional indication. Thus, the disclosure is arranged so as to cause this indication impulse following the station selecting impulse not only to be of a particular frequency in accordance with the position of the track relay IT, but to also be of a short or a long duration in accordance with the position of the signals at stop relay IM.

If the relay IM is picked up, then the impulse is of the usual length and the operation of the relays at the field station is the same as has been above described. On the other hand, the relay IM may be deenergized with the signals cleared, in which case, upon the picking up of the relay IV⁴, a circuit is closed for the long "on" measuring relay ILON from (+), through a circuit including back contact 330 of relay IM, front contact 331 of relay IV⁴, back contact 332 of relay IVP, front contact 333 of relay ISI, wire 334, back contact 335 of relay IFA, winding of relay ILON, to (-).

The picking up of the relay ILON closes a stick circuit for the particular transmitter relay IT¹ or IT² then picked up at the termination of the "off" period. As, for example, the track relay IT may be in its normal position to cause the picking up of the relay IT², when the relay IE picks up, in which case a stick circuit is closed for this relay IT² from (+), through a circuit including front contact 275 of relay ISI, wire 336, front contact 337 of relay ILON, front contact 338 of relay IT², windings of relay IT², to (-). Obviously, this stick circuit will remain closed until the relay ILON is dropped away which occurs upon the picking up of the relay IFA. Referring to Fig. 2B, it will be seen that the front contact 222 of relay IFA is shunted by contact 340 of relay ILON. Thus, instead of the impulse applied by the field station being terminated as soon as the relay IFA picks up, the picking up of the relay IFA releases the timing relay ILON at back contact 335 which relay ILON has a shunt contact 340 around the contact 222 so that the impulse applied by the field station is prolonged for a time period measured by the release of the relay ILON. In this way, any indication impulse may be made long or left short, regardless of its particular frequency, depending upon the position of a particular indication contact for that step of the cycle of operation.

It has been pointed out above that the proper operation of the frequency generator at a field station is checked during the start pulse and during each pulse transmitted during an indication cycle of operation by reason of the control of the relay ITC at the field station. More specifically, during an indication cycle, the relay ITC receives energy during each "off" period of such cycle through a stick circuit closed from (+) and including front contact 223 of relay ITC, back contact 224 of relay IT², back contact 225 of relay IT¹, front contact 226 of relay ICHP, windings of relay ITC to (-).

If during an "on" period with a transmitter relay picked up while this holding stick circuit is opened, the line responsive means does not report impulse energy corresponding to the frequency that should be transmitted, then relay ITC is not supplied with energy by the picking up of either the contact 227 or the contact 341 in response to the reception of an impulse by the line responsive means, so that the relay ITC drops away and in so doing opens front contact 202 releasing the relay ICHP. This means that the field station does not try to transmit another cycle of operation until a new change in indication conditions occurs at which time the relay ITC will, of course, be in its normal condition. It might be noted that the dropping of the relay ITC causes the dropping of the relay ICHP and the picking up of its repeater relay ITCP by reason of closure of back contact 223. The opening of front contact 266 of relay ITC prevents the further transmission from the field station by preventing the application of energy to the transmitter relays until after the station has been restored to normal conditions.

Thus, it will be seen that the relay ITC will be maintained energized so long as the transmitter at the field station applies impulses of the proper frequencies to the line circuit and the field station receiver is sufficiently operative to respond to such locally applied impulses.

If the field station failed to receive a retransmitted impulse, the station selecting relay SI is that station would be dropped out, but so long as the relay CHP for such station remains picked up, that station would endeavor to transmit indications on the next operating cycle. This would mean that a failing station would continue to initiate the system into operation for the transmission of indications without allowing a sufficient period of rest between such successive cycles of operation as to permit the line circuit to become available to other field stations having new indications to transmit which occurred subsequent to the first initiation of the system by the failing station. (This characteristic of the system which provides that those field stations having indications to transmit at any one time can cause successive indication cycles to transmit their indications but cannot again transmit or initiate the system until a prolonged period of rest has occurred on the line circuit, is described under the heading "Distribution of indication cycles"). However, the present invention provides that failure of the station to receive a retransmitted impulse, also causes the relay CHP at that station to be deenergized which prevents such station from again endeavoring to transmit indications until another change in the indication conditions at that station has taken place. This feature is applied to the control of the change storing relay CHP at each field station by relating it to the line circuit conditions.

With this organization, a station failing to receive retransmitted impulses is removed from the line circuit until new indication conditions have occurred at that station, thus, placing it on an equal basis with all other field stations in such a way that it cannot monopolize the line circuit.

With reference to the typical station of Figs. 4A and 4B, it will be seen that during each "off" period, the relay ICHP is maintained energized through its stick circuit above pointed out as including back contact 211 of relay IFA. This is supplemented by a circuit completed through front contact 201 of relay ISB and back contact 392 of relay IE placed in multiple with the back contact 211 of relay IFA. When any impulse is received at the field station, either the contact 390 or the contact 391 of the line responsive relays IF² and IF¹ respectively are closed to maintain the stick circuit of the relay ICHP closed while both of the contacts 211 and 392 of the relays IFA and IE are opened during the impulse period as measured at the field station.

Thus, when either of the relays IF¹ or IF² picks up and causes the opening of back contact 211, the stick circuit of the relay ICHP is also opened at back contact 392. If the field station properly receives the retransmitted impulse from the control office, then either the contact 390 or 391 is closed to maintain the relay ICHP energized until after the relay IE releases and closes back contact 392 at the end of the impulse period.

But, if the retransmitted impulse is not properly received by the field station, due to a weak or faulty receiver such as might be caused by a burned out vacuum tube or the like, then the relay IF¹ or IF² drops away as soon as the locally applied impulse is removed upon the picking up of the relay IFA. This removal of the locally applied impulse is maintained because the relay IFA is maintained energized so long as the relay IE is picked up during the impulse period by reason of a stick circuit for the relay IFA which includes front contact 285 of relay IE. Under such circumstances, the dropping of the line responsive relay opening either front contact 390 or 391 obviously causes the relay CHP to drop away.

It will be remembered that the change relay ICH was restored to its normal position when the relay ICHP was picked up. Thus, if the relay ICHP is dropped away during a cycle of operation due to faulty reception, then this particular field station will not endeavor to initiate another indication cycle of operation until another change occurs in the indication conditions at that field station, such as for example a change in the position of the indication contacts of the track relay IT. Also, inasmuch as the retransmitted impulses from the control office must be received at the field station in order to maintain the station selecting relay ISI energized at this particular field station, then such station is prevented from further applying impulses of its code to the line circuit as soon as the failure of retransmission and/or the failure of the station receiver occurs. This is necessary because this particular failing station might have a code superior to the code of some other station trying to also transmit indications, and if it continued transmitting such superior code while improperly receiving, the station with the inferior code would not be selected and this station with the superior code would also fail to be selected because its receiver

would be improperly responding to the retransmitted impulses from the control office.

In brief, the organization of the system with respect to the relays SI and CHP causes a station to stop its transmitting as soon as that station fails to be selected, due either to the presence of a superior code call upon the line circuit of the ensuing cycle of operation, or due to the failure of faulty retransmission and/or reception on the part of the field station. This dropping out of the field station is not only effective for the ensuing cycle but prevents such field station from again transmitting until a different or new indication is ready for transmission in such field station.

END OF INDICATION CYCLE AT FIELD STATION

Assuming that the field station operates through an indication cycle in the normal and proper manner, then the relay ISI is still picked up when the last stepping relay LV is picked up so that both of the contacts 208 and 209 are open as well as the back contact 207 of the relay ISA. This removes all energy from the relay ICHP so that it drops away restoring it to normal until another change in indication conditions occurs at this station.

Upon the picking up of the last stepping relay ILV, the opened back contact 269 prevents the transmitting relays IT¹ and IT² from being further energized so that a prolonged deenergization of the line occurs. This causes the relays ISA and ISB to be deenergized in sequence, which then releases the relays ISI and ILV at about the same time.

Inasmuch as the relay ICHP drops away when the last stepping relay ILV is picked up, then the relay ITC has its pick-up circuit opened at front contact 226 although the transmitter relays IT¹ and IT² remain deenergized. The deenergization of the relay ITC and the energization of its repeater relay ITCP causes the opening of the pick-up circuit for the relay ICHP until the relay ITC is restored to normal. The relay ITC cannot be picked up until the permission impulse is received by the field station to cause the picking up of the relays IR and IL closing front contacts 217 and 218 in a manner previously explained. Thus, the relay ICHP is prevented from being picked up even though back contacts 200 and 201 are closed during the clear-out period.

REGISTRATION OF INDICATION CODE IN THE CONTROL OFFICE

The conditioning period at the beginning of an indication cycle of operation of course picks up the relays SA, SB and SC (see Fig. 3B) in sequence as previously explained, but before the relay SA can pick up the relay CF is picked up immediately closing a pick-up circuit for the "on" timing relay TON as soon as the first "off" period occurs, from (+), through a circuit including front contact 345 of relay CF, back contact 346 of relay FA, windings of relay TON, to (-). During the "off" period, the relay E is picked up closing a stick circuit for the relay TON from (+), through a circuit including front contact 345 of relay CF, front contact 347 of relay E, front contact 348 of relay TON, windings of relay TON, to (-). The relay EP also has a contact 349 included in multiple with the contact 347 of the relay E so that the release of the relay EP during an "off" period completes the stick circuit for the relay TON which is not again opened until after the relay E has been deenergized for a pre-

determined time which occurs during a prolonged "on" period. But before considering the manner in which this slow acting relay TON causes a long impulse period to be stored in the relay LON, let us consider the manner in which the station registering impulses are registered in the control office in accordance with the character of their frequency.

More specifically during each "on" period or impulse period during the station selecting portion of the indication cycle, positive or negative potential (B+) or (B-) is applied to a station registering circuit depending upon whether the line responsive relay F¹ or F² is picked up. More specifically the first stepping relay V¹ is, of course, picked up during the first "off" period following the conditioning period. Then upon the following impulse period which is in accordance with the station code, an executing circuit is closed as soon as the relay FA picks up from either (B+) or (B-) depending on which of the frequencies has been applied to the line circuit, through a circuit including front contact 350 of relay FA, back contact 351 of relay EP, front contact 352 of relay CF, back contact 353 of relay V⁴, back contact 354 of relay V³, back contact 355 of relay V², front contact 356 of relay V¹, upper winding of relay RF¹, to (B-). In other words, if the frequency of the station selecting pulse is f¹ then the relay F¹ is picked up applying (B+) to this circuit which in turn causes the registering relay RF¹ to be picked up. On the other hand, if the frequency is f² then the relay F² connects (B-) to this circuit so that the relay RF¹ remains deenergized. In the particular case under consideration, as the field station of Fig. 4A and 4B is transmitting the station code No. 3 for its registration in the control office, it will be noted that the frequency f¹ is applied so that the relay RF¹ is picked up. As soon as the relay RF¹ is picked up, a stick circuit is closed for this relay from (+), through a circuit including front contact 357 of relay SC, wire 358, front contact 359, lower winding of relay RF¹, to (-). A similar circuit is provided for each of the relays RF because the contact 357 supplies positive energy (+) to the bus wire 358 and the picking up of any one or more of these relays RF closes a stick contact similar to contact 359 which maintains the relays energized until the end of the cycle of operation when relay SC is deenergized.

During the following "off" period, the next stepping relay is picked up in a manner previously described, preparing the circuit for the picking up or leaving deenergized of the station registering relay RF² in accordance with the character of the next station registering code. Assuming that the code is transmitted from station 1, then the second element of this code will be an impulse of frequency f² on the second step which, of course, will not cause energy to be supplied to the relay RF² so that this relay remains deenergized.

On the following step, the third code element is of a frequency f¹ so that positive energy (B+) is applied to front contact 350 of relay FA causing the relay RF³ to be picked up in an obvious manner. As soon as it is picked up, it, of course, closes its front contact 360 to complete its stick circuit.

During the following "off" period an energizing circuit is closed for the station relay IST by reason of the code registered on the relays RF from (+), through a circuit including front contact 361 of relay CF, wire 362, back contact 363 of re-

lay VP, front contact 364 of relay V³, back contact 365 of relay V⁴, front contact 366 of relay RF³, back contact 367 of relay RF², front contact 368 of relay RF¹, windings of relay IST, to (-). As soon as this relay IST picks up, it closes its front contact to complete a stick circuit from (+), through a circuit including front contact 361 of relay CF, and back contacts 369 and 370 of relays F² and F¹, respectively, in multiple, wire 371, front contact 372 of relay IST, windings of relay IST, to (-).

This stick circuit for the station registering relay IST is necessary inasmuch as its pick-up circuit is opened as soon as the next succeeding stepping relay is picked up. It is noted that this stick circuit for the relay IST, and, of course, this would be true of all the other station relays of which this relay IST is typical, includes back contacts 369 and 370 of the line responsive relays F² and F¹ in multiple. This furnishes a certain check on the proper registration of indications, because if, at any time, there should be cross fire between the line responsive means in the office or by some accident two frequencies should be impressed on the line circuit at the same time, then the stick circuit for the registration relay ST would be opened and it would drop out preventing the improper registration of such indications.

Assuming, however, that the relay IST remains properly picked up for the continuation of the indication cycle, then the indication relays are properly positioned in accordance with the indications transmitted.

On the first impulse following the station selecting impulse, the relay ITKR is positioned in accordance with the frequency of such impulse by reason of the application of either (B+) or (B-) depending upon whether the line responsive relay F¹ or F² is picked up to a circuit including front contact 350 of relay FA, back contact 351 of relay EP, front contact 352 of relay CF, front contact 353 of relay V⁴, bus wire 313, front contact 374 of station relay IST, windings of relay ITKR, to (CN). If (B+) is applied to this circuit then the contacts of the relay ITKR are operated to the left, but if (B-) is applied to this circuit then the contacts of relay ITKR remain in their previous position. Obviously, the contact of the relay ITKR is moved to the left due to the fact that the track relay IT at the field station was assumed to be deenergized causing the frequency f¹ to be replaced on the line circuit. This causes the OS indicator lamp ITK to be energized through a circuit including contact 22 advising the operator that a train is on the corresponding track section.

As previously explained in connection with the field station, this impulse may either be short or long in accordance with whether the signals at stop relay IM is picked up or deenergized. If the relay IM is picked up, then the impulse applied by the field station is short so that the relay E in the control office drops away and picks up the relay EP following the picking up of the relay FA. This leaves the relay TON deenergized only until the impulse is removed from the line circuit allowing the relay FA to drop away and close back contact 346 before the relay TON can drop away. Thus, this relay TON is maintained energized for a short impulse period. With this condition existing, the relay LON is maintained deenergized during such impulse period and the ensuing "off" period because of open back contact 375.

On the other hand, if the relay FA is maintained picked up because of a long impulse applied

to the line at the field station, then the relay TON has time to drop away and close a pick-up circuit for the relay LON from (+), through a circuit including front contact 345 of relay CF, back contact 375 of relay TON, windings of relay LON, to (-). If the relay LON is picked up, it is maintained picked up during the following "off" period by reason of a stick circuit closed from (+), and including front contact 345 of relay CF, front contact 376 of relay EP, front contact 377 of relay LON, windings of relay LON, to (-). Thus, the condition of the relay TON is determined by whether the impulse period is long or short, and this condition is transferred to the storage relay LON which condition is maintained throughout the succeeding "off" period.

After the impulse period the dropping away of the relay FA causes either (B+) or (B-) to be applied to an executing circuit through contact 378, back contact 379 of relay FA, front contact 380 of relay EP, front contact 381 of relay CF, wire 382, front contact 383 of relay VP, front contact 384 of relay V⁴, bus wire 385, front contact 386 of relay IST windings of relay ISK, to (CN).

It should be noted in this connection that the field station in order to accomplish this purpose must hold the impulse on the line circuit for a longer period than the control office normally holds its checking impulse on the line circuit so that the front contact 376 of relay EP is closed when the relay LON is picked up and remains closed until the succeeding "on" period at which time the relay EP drops and opens its front contact 380 included in the executing circuit thereby restoring the relay LON to normal in condition to be positioned if the following impulse is long.

STATION LOCK-OUT BY SUPERIORITY OF CODE

It may happen that several field stations will have indications to transmit at the same time, in which event each station will place its starting impulse on the line circuit and the conditioning period will occur as above explained. However, when the first station selection impulse is placed on the line circuit it may happen, depending upon what stations are transmitting, that all of the impulses are of the same frequency as applied by these field stations in which event the control office will return a corresponding frequency and the relays SI at each of the field stations will remain picked up. On the other hand, it may happen that certain of the stations have their codes calling for a frequency f¹ while others of the stations have their codes calling for a frequency f², in which event the control office upon receiving impulses of both frequencies, causes the frequency f¹ to be returned to the field stations instead of the frequency f² or both. This is because the contacts 230 and 231 (see Fig. 2A) are interlocked so that if the line responsive relay F¹ is picked up, it places the frequency f¹ on the line circuit in preference to the frequency f².

In other words, the frequency f¹ has been arbitrarily given superiority over the frequency f². If the frequency f¹ is returned to the line circuit in such a case, all those stations which call for the frequency f² have their relays SI dropped out as will be obvious from the consideration of the station selecting operation as above described. If all of the stations should endeavor to transmit at the same time then half of the stations would be dropped out on the first impulse and half of the remaining stations on the second impulse and so on until only one field station remains on the line

circuit. But it is to be understood that any combination of field stations may start to transmit at the same time and all of the stations are dropped out for the ensuing cycle except one. This dropping out action occurs on that impulse of the station code where the dominating or superior code differs from the code of the station which is dropped out.

Stating the matter still another way, it will be seen that the particular station which calls for the greatest number of impulses of a frequency f^1 in its station selecting code for any given cycle will be dominant over all other stations during that cycle, because the control office returns code impulses of a frequency f^1 in preference to the impulses of frequency f^2 .

INTERLOCK BETWEEN CONTROL OFFICE AND FIELD STATIONS

It will, of course, be apparent that one or more field stations may have indications ready to transmit at the same time that the operator desires to transmit controls. Thus, a positive interlock is provided between the control office and the field stations to allow only a control cycle or an indication cycle for any one operation of the system, and this interlock is so organized as to give priority to the control office or to the field stations depending upon which change occurs first. In doing this, the interlock is so arranged that in practice there can not be what might be called an actual simultaneous start condition.

With reference to Figs. 3A and 3B, the presence of a new control to be transmitted causes the picking up of an LC relay in series with the relay LCS which closes at front contact 57 the pick-up circuit for the relay C and at the same time closes front contact 59 in a stick circuit for the relay C. It is noted that the picking up of the relay C opens back contact 62 included in the stick circuit for the relay CF so that if the front contact 56 of the line responsive relay F^2 were closed just after the picking up of the relay C, it might pick the relay CF up, but it would not remain stuck up after the relay SB picked up. Under such conditions, it might happen that the relay C picks up just as the line responsive relay F^2 is picking up so that there is a time period in which the control office returns the frequency f^2 by reason of the closure of front contact 230 (see Fig. 2A) but this returning of the frequency f^2 is stopped and the frequency f^1 is impressed on the line circuit as soon as the relay T^1 can respond to the picking up of the relay C. The application of conditioning energy of the frequency f^1 causes the line responsive relay F^1 to pick up opening back contact 231 so that the frequency f^2 is removed from the line circuit.

Under these circumstances, it is seen that the frequency f^2 being placed upon the line circuit by the field station and continued for a short time by the control office causes the SI relay at the field station or stations which may be endeavoring to transmit, to be picked up. But the returning of the frequency f^1 and the removal of the frequency f^2 causes relay SO at every field station to be picked up and the opening of back contact 240 of relay ISO (see Fig. 4B), for example, deenergizes the relay SI at any field station that may have such relay picked up.

On the other hand, if a field station transmits a start impulse of the frequency f^2 to the control office in sufficient time to get the relay F^2 picked up to close front contact 56 before energy is supplied to the relay C, then the ensuing cycle of op-

eration is for indications and the control office cannot supersede such an indication condition.

It is thus seen that the shift over from controls to indications is then on the contact 56, and with this arrangement the shift is either made after the relay C has a possibility of being picked up or is made before it receives any energy at all. So that if a control start occurs first then it has priority but if it does not occur first then indications have control of the line. To state the matter in still another way, the field start conditions have control of the line to determine the shift of a contact from control to indication starts, but if a control start can be effected before the shift then it has priority.

Obviously, the picking up of the relay C and the placing of the frequency f^1 on the line circuit prevents the start circuit at all field stations from being closed, as, for example, at open back contact 216 of Fig. 4A for field station No. 1.

It may happen that an indication cycle is in progress or a control cycle may also be in progress when the operator actuates one or more start buttons for other field stations. This means that there should be a succession of control cycles and this is effected in the manner in which the permission pulse is prevented from being placed upon the line circuit.

At the end of a cycle of operation, the relays LC and LCS are dropped away upon the picking up of the last stepping relay which provides for the transmission of control impulses, as, for example, in the case of the opening of back contact 150 on relay V^4 of Fig. 3A. The dropping of the particular relay LC which is then up in series with the relay LCS permits the picking up of another LC relay in series with the relay LCS as soon as the relay SB is released. Such second picking up of the relay LCS closes a pick-up circuit for the relay C with SB released so that the relay C picks up and sticks opening back contact 153 before back contact 151 of relay SC can close. This prevents the application of the permission impulse at the end of a cycle of operation (see chart of Fig. 5B). If the permission impulse is not placed on the line circuit, then the relays R and L at all of the field stations remain deenergized preventing any field station from impressing a start impulse on the line circuit by reason of open contacts 217 and 218 of Fig. 4A, for example, and also preventing the picking up of the relays SI.

At the end of an indication cycle of operation, or at the end of a control cycle when there are no further controls to be transmitted, the release of the relay SC closes back contact 151 to apply energy through contacts 152 and 153 to the transmitter relay T^2 to impress the permission impulse on the line circuit which is of a frequency f^2 . This completes the pick-up circuit for the relay R as previously explained and in so doing opens back contact 152 cutting off the permission impulse and as soon as the relay F^2 releases permits the relay L to pick up in series with the relay R. The same operation with respect to the relays R and L occurs at each of the field stations so that as soon as the relay L picks up in response to the deenergization of the line at the end of the permission impulse, the field stations may then place a start pulse on the line circuit.

In this way, the control office is made superior to the field stations in that it may send as many control cycles of operations as may be desired without any interruptions by the field stations.

DISTRIBUTION OF INDICATION CYCLES

It may happen that some field station will have a large number of indications to transmit due to many switching movements at that location or the like, or it may happen that the relay CH at some station will become deenergized and fail to be restored. In either event that station would cause a substantially continuous succession of indication cycles of operation, and if its station code were superior to one or more other field stations, such other field stations would find it impossible to transmit their indications.

However, in accordance with the present invention, the system is arranged so that those field stations having indications to transmit at any one time can cause successive indication cycles to transmit their indications, but cannot again transmit or initiate the system until a prolonged period of rest has occurred on the line circuit. After such prolonged period of rest all field stations then having new indications to transmit from another group, so to speak, and cause a succession of indication cycles from those stations one at a time in turn in accordance with the relative superiority of their respective station codes. This feature of allowing only one cycle of transmission from a station until a prolonged period of rest occurs, has been conveniently termed "cycle distribution" to give every station equality in transmitting its indications although its station code may be of an inferior relationship to some other field station which may have more indications to transmit, or may have a non-self-correcting fault.

This is accomplished by the relay TC and its repeating relay TCP. Normally the relay TC at each of the field stations is energized but when a station has transmitted with its relay CHP picked up, the relay TC is dropped away at that station when the relay CHP at such station is released at the end of its indication cycle. Inasmuch as the relay TC includes a front contact in the pick-up circuit of the relay CHP, such relay CHP cannot again pick up until a period of time has elapsed in which the relay TC may be picked up.

Perhaps this will be better understood by specific reference to Figs. 4A and 4B where it is seen that relay TC has its stick circuit opened at front contact 226 when the relay ICHP is released at the time of the picking up of the relay ILV at the end of an indication cycle of operation.

The relay ITC does not have its pick-up circuit closed until after the relays IR and IL are picked up following a permission pulse. But if some field station, included within a group of stations having had indications ready to transmit at the same time, is standing ready to start the system, then it impresses its start pulse on the line circuit causing the opening of back contact 215 of relay IF² before the relay ITC can be picked up during such a short period of rest between successive cycles of operation (see chart of Fig. 5D). Thus, the relay ITC maintains its contact 202 open and prevents the relay ICHP from picking up although the back contact 205 of relay ICH is continuously closed. When all field stations included within the group of stations have transmitted their indications, then there can be no interruption of the period of rest at the end of a permission pulse until the relays ITC and TCP which have been dropped out are again picked up.

It will be noted that those field stations which are not ready to transmit indications at the same time when the group of stations is formed, have their relays TC dropped away because the pick-up circuits for the TC relays at such stations are opened as soon as a line responsive relay such as IF² is picked up, and is maintained open throughout the cycle of operation by reason of the dropped away condition of the contacts 217 and 218 for the relays IR and IL, for example.

Thus, all stations having indications ready to transmit at the same time have an equal chance of entering the group of stations for transmitting one indication cycle in a succession of indication cycles and all indication changes which take place after that must come in the second or next successive group to be formed. This general feature of cycle distribution has been previously disclosed in our prior Patent No. 2,259,561, dated October 21, 1941, but it has been applied to the present system in a rather novel manner and contributes to the general usefulness and adaptability of the present system to various different operating problems in actual practice.

SUMMARY

A centralized traffic controlling communication system has thus been shown and described as employing alternating currents which may be superimposed on line circuits having other services, and which currents are coded in order to transmit controls and indications between a central control office and a plurality of field stations. The system has been so organized that the field stations in transmitting their indications do not interfere with one another, but are allotted the line circuit with a predetermined order or priority. This priority is established between the stations on what has been conveniently termed the superiority of code basis, which superiority of code basis has been further modified by allowing only one transmission from each station of any group of stations that may be ready to transmit at the same time. This last feature has been termed "cycle distribution."

Even though the system of the present invention is of the carrier current type, it is so organized that the reliability of the frequency generators and amplifying units are checked in their operation to assure that a burned out amplifier tube or the like cannot produce erroneous or undesired results. These various features of checking have been explained in detail above, and will not be repeated, but it is desired to state that they serve to make practical the use of such carrier current type communication systems for the control of railway signalling apparatus.

Another important accomplishment of the present invention is to so organize the system that regardless of the number of field stations which may be transmitting their impulses of alternating current, there can be no loss or failure of response of any field station to any other field station during the station selecting portion of an indication cycle due to various alternating current line circuit phenomena by reason of the retransmission from the control office of all conditioning and station selecting impulses.

Having thus described a centralized traffic controlling communication system as one specific embodiment of the present invention, it is desired to be understood that this form is selected to facilitate in the disclosure of the invention rather than to limit the number of forms which it may assume; and, it is to be further under-

stood that various modifications, adaptations, and alterations may be applied to the specific form shown to meet the requirements of practice, without in any manner departing from the spirit or scope of the present invention except as limited by the appended claims.

What we claim is:

1. In a communicating system of the carrier current coded type, a line circuit connecting the control office with a plurality of field stations, code transmitting means at each field station for applying a series of alternating current impulses of different frequencies to said line circuit to form a code assigned to its field station, code receiving and transmitting means in the control office responsive to each impulse of a code applied to said line circuit by a field station for retransmitting a similar impulse in overlapping relation to the impulse applied by the field station to thereby transmit a series of impulses corresponding to the code call of a particular station as determined by that station, code receiving means at each station including filter, vacuum tube amplifiers, and line responsive relay means for each distinctive frequency, station selecting means controlled by said line responsive relay means for selecting that station in response to a series of impulses received from said control office corresponding to its station code call as determined by the code transmitted from its field station, said station selecting means being rendered ineffective to select its station if more than one of said line responsive relay means is picked up at the same time during any impulse of its code, whereby the failure of a filter or vacuum tube amplifier to properly distinguish between the distinctive frequencies results in the non-selection of its station.

2. In a code type communication system employing carrier currents, a line circuit connecting a control office with a plurality of field stations, code transmitting means at each field station acting when initiated to apply a series of alternating current impulses of selected frequencies to said line circuit to comprise a code characteristic of its station and to comprise the indications for its station, indication change storing means at each field station rendered effective in response to each change in indication conditions at its station for storing such change until a new indication has been transmitted, said change storing means acting to initiate its associated code transmitting into operation, code receiving and transmitting means at the control office responsive to each impulse applied to said line circuit by any field station for retransmitting an impulse of the same frequency in overlapping relation to the impulse applied to the field station to thereby transmit a series of impulses comprising the code of a particular station as determined by that station, code receiving means at each station including filters, vacuum tube amplifiers, and a separate line responsive relay means for each different frequency, station selecting means controlled by said line responsive relay means so as to be selectively responsive to only the series of impulses transmitted from said control office as determined by its field station for selecting that station to thereby allow it to transmit indication impulses to said control office, and means controlled by said line responsive relay means for rendering said station selecting means and said change storing means ineffective during any series of impulses in which the code receiving means at the station fails to re-

ceive impulse energy from said control office during any impulse period although it may have received impulse energy from its own station or some other station code transmitter during the same impulse period, whereby the failure of a vacuum tube amplifier to receive impulse energy from the distant control office results in the non-selection of its station and the dropping out of the change storing relay means until a subsequent change occurs in the indication conditions at that station.

3. In a communication system of the carrier current coded type, a single line circuit connecting the control office with a plurality of field stations, code transmitting means at the control office for applying alternating current impulses of either of two different frequencies on said line circuit to form different station codes and the controls for such stations, code receiving means at each field station responsive to the impulses applied to said line circuit, station selecting means at each station controlled by its associated code receiving means so as to be effective to select that field station for the reception of controls only in response to the series of impulses forming a code characteristic of such field station, whereby any given field station can be selected for the reception of controls, code transmitting means at each field station at times rendered effective to transmit a series of alternating current impulses each of which is one or the other of two different frequencies in accordance with its particular station code, code receiving means at the control office responsive to the impulses transmitted from any field station for causing said transmitting means at the control office to transmit code impulses of frequencies corresponding to the coded impulses received, other station selecting means at each station controlled by its associated code receiving means when its associated transmitting means is rendered effective to cause the selection of its station for the transmission of indications only in response to the series of impulses transmitted from the control office and forming a code characteristic of its station, whereby that field station causes its own selection, and means at the control office acting on said code receiving means to cause alternating current impulses of one particular frequency as received at the control office from a field station to be selected for transmission in preference to the other frequency when two frequencies are transmitted from different field stations at the same time, whereby a plurality of field stations endeavoring to transmit at the same time are caused to be selected in accordance with the relative superiority of their respective codes.

4. In a code type communication system for connecting a control office with a plurality of field stations, a code transmitter at the control office capable of transmitting different series of code elements of distinctive character to form different codes, code receiving means at each field station effective to select that field station only in response to a series of code elements forming a code characteristic of such field station, code transmitting means at each field station capable of transmitting a series of distinctive code elements to form its particular station code, code receiving means at the control office responsive to a series of code elements transmitted from any station, means at the control office controlled by its code receiving means for causing its transmitting means to retransmit a code

corresponding to the code received by said receiving means from any field station, whereby any field station can cause its own selection by transmitting its particular code to the control office for retransmission, and means at the control office effective, when a plurality of field stations are transmitting their codes endeavoring to cause their own selection, to cause said codes to be selected for retransmission in accordance with a predetermined preference, whereby said field stations are selected one at a time in accordance with the relative predetermined preference of their respective codes.

5. In combination, a line circuit connecting a control office with a plurality of field stations, a code transmitter at said control office capable of transmitting different series of distinctive impulses to form different station codes, certain of said impulses being made arbitrarily superior to others, code receiving means at each field station responsive to select that field station in response to a series of impulses forming its particular station code, code transmitting means at each field station capable of transmitting a series of impulses forming a code characteristic of its station by using distinctive impulses the same as may be applied at said control office by said control office transmitting means, code receiving means at the control office responsive to the series of impulses transmitted from any field station, means at the control office governed by its code receiving means and acting when a plurality of field stations are transmitting their codes for causing the code transmitting means at the control office to apply a series of impulses to said line circuit forming a code for that particular one of said stations then transmitting a code and having the greatest number of superior code impulses included in it as compared to the codes being transmitted by the other station or stations of the plurality, whereby said field stations are selected one at a time in accordance with the relative superiority of their respective codes.

6. In a communication system of the carrier current coded type, a line circuit connecting a control office with a plurality of field stations, a movable device at each station, a code transmitter at each station each operating when initiated to deliver a code to said line circuit indicative of the condition of the associated movable device, said code comprising a series of coded impulses of distinctive alternating current frequencies, means for initiating each code transmitter in response to a change in the condition of the associated movable device, means including code responsive means at each station effective at the various stations if the devices at several different stations have changed their condition prior to the initiation of the code transmitter at one of the stations to separate these stations into a group comprising those at which the movable devices have changed their positions at substantially the same time and cause the stations of that group to deliver their codes one at a time in a predetermined order, means delaying the initiation of the code from any station not included in said group in response to a change in the condition of its movable device which occurs during the transmission of said different codes from the stations of said group until all of said different codes have been transmitted, and means at each station controlled by said code responsive means at that station in such a way when it is included in said group that the failure of such station to be responsive to code impulses im-

pressed on said line circuit renders it ineffective to transmit until another change in the condition of its movable device.

7. In a communication system of the carrier current coded type, a line circuit connecting a control office with a plurality of field stations, a code transmitter at the control office for applying different series of coded impulses of alternating current of distinctive frequencies on said line circuit to form different station codes and control codes for such stations, code receiving means at each field station including filter-amplifier means and a separate line responsive relay means for each different frequency, station selecting means at each station controlled by said line responsive means so as to be rendered active in response to any series of coded impulses including a code characteristic of such field station to condition that station for the reception of the control impulses of that series, control receiving means at each field station controlled by said line responsive relay means when its station selecting means is rendered active so as to be responsive to the control impulses of that series then being transmitted from said control office, and circuit means at each field station effective if more than one of said line responsive relay means is energized at the same time on any control impulse of a series to restore said station selecting means to its inactive condition to prevent said control receiving means from being controlled by said line responsive relay means on that or any subsequent impulse of the series.

8. In a multiple impulse code communication system of the carrier current type, a line circuit connecting a control office with a distant field station, code transmitting means at the field station acting when rendered effective to impress a series of code impulses on said line circuit each impulse being a carrier current of either of two relatively high frequencies depending upon the code to be transmitted, code receiving and transmitting means at the control office responsive to each impulse of a series received from the field station for contemporaneously applying an impulse of carrier current of the same frequency to said line circuit, and code receiving means at said field station responsive to each impulse transmitted from said control office over said line circuit for maintaining said transmitting means at the field station effective to transmit the next impulse of the series then being transmitted.

9. In a multiple impulse code communication system of the carrier current type, a line circuit connecting a control office with a distant field station, carrier current code transmitting means at the field station acting when rendered effective to transmit a series of code impulses of selected frequencies over said line circuit, said code transmitting means being operable step by step for each impulse of a series, code receiving and transmitting means at the control office responsive to each carrier current impulse received over said line circuit for at the same time applying a carrier current impulse of corresponding frequency to said line circuit which impulse continues for a short time interval following the cessation of the impulse from said field station, and code receiving means at said field station responsive to each carrier current impulse transmitted over said line circuit from said control office following the transmission of an impulse by its associated transmitting means to cause said code transmitting means at that field sta-

tion to take the next step for transmitting the next impulse of the series.

10. In a multiple impulse coded communication system of the carrier current type, a single uninterrupted line circuit connecting a control office with a plurality of field stations, code transmitting means at each of said field stations for impressing a series of carrier current impulses of at least two distinctive frequencies on said line circuit from sources at that station in different combinations in accordance with its station code call and indication conditions at such station, code receiving means at said control office responsive to the distinctive frequency impulses of any series for registering the station code call and the indications of that series, code transmitting means at said control office acting in response to the reception of a station code for retransmitting the same code by carrier current impulses of corresponding distinctive frequencies, said code transmitting means acting in the event several stations transmit codes at the same time to retransmit the code of one of such stations in preference to the others to render that one station superior to the others, and station selecting means at each field station governed over said line circuit by said retransmitted code impulses to select that station in response to its station code call and effective to stop operation of said code transmitting means at that station when the code call of a more superior station is retransmitted over said line circuit.

11. In a normally-at-rest code communication system of the carrier current type, a single uninterrupted line circuit connecting a control office with a distant field station, code transmitting means at the control office and at the field station for impressing carrier current impulses of distinctive frequencies on said line circuit to comprise a cycle of operation for transmitting control codes from said control office to said field station and indication codes in the opposite direction, and means for allowing only the control office or the field station to transmit at any one time comprising initiating means at the control office responsive to manual control for causing said associated code transmitting means to initiate a control cycle of operation by transmitting a first impulse of one particular frequency and responsive to the reception of a momentary impulse from said field station for initiating an indicating cycle of operation by transmitting a first impulse of a different frequency, means at the field station effective to transmit a momentary impulse from said field station when a change in indication conditions occur, said means also causing its transmitting means to operate only if an impulse of said different frequency is received from said control office, and means at the control office acting on said initiating means to cause it to transmit said one frequency in preference to said different frequency when said manual control and said impulse from said field station are existent at the same time.

12. In a communication system of the multiple frequency coded type for providing communication between a control office and a plurality of field stations, code transmitting means at each of the field stations for transmitting a series of energy impulses of distinctive frequencies to form a code for that station, code receiving and transmitting means at the control office responsive to each energy impulse of any series transmitted by any given field station for transmitting energy impulse of the same frequency to

prolong that impulse period for a predetermined time interval, code responsive means at each field station differently responsive to the distinctive energy impulses at its station as transmitted from said control office, and means at each field station controlled by its code responsive means so as to be selectively conditioned only by the distinctive impulse energy transmitted from said control office during the prolonged time interval of each impulse period.

13. In a communication system of the multiple frequency coded type for providing communication between a control office and a plurality of field stations, code transmitting means at each of the field stations for transmitting a series of energy impulses of distinctive frequencies to form a code for that station, code receiving and transmitting means at the control office responsive to each energy impulse of any series transmitted by any given field station for transmitting energy impulse of the same frequency to prolong that impulse period for a predetermined time interval, code responsive means at each field station distinctively operated in response to the distinctive energy impulses at its station as transmitted from said control office, and station selecting means at each field station governed by the distinctive operation of its code responsive means so as to be selectively controlled only by the distinctive impulse energy transmitted from said control office during said prolonged time interval of each impulse period in a manner to select its station when such impulses form a code corresponding to the code transmitted by its station code transmitting means, whereby each station is selected by a series of impulses characteristic of its station code and is non-selected by any other series of impulses, and whereby such station selection of one station and the non-selection of other stations is effected without it being necessary for each station to receive impulse energy at its station as transmitted by any of the other stations.

14. In a communication system of the multiple frequency coded type for providing communication between a control office and a plurality of field stations, code transmitting means at each field station for transmitting energy impulses of different frequencies to form a code assigned to its field station, code receiving and transmitting means at the control office responsive to each energy impulse transmitted by a field station for retransmitting a similar energy impulse during a time interval following the cessation of that impulse transmitted by the field station to thereby transmit a series of impulses corresponding to the code call of a particular station as determined by that station and acting in case a plurality of energy impulses of different frequencies are applied during the same impulse period to retransmit an impulse of only a predetermined one of such frequencies, code receiving means at each field station responsive to each energy impulse of said different frequencies transmitted by said control office, and station selecting means at each station distinctively controlled by said code receiving means at that station in accordance with the different frequencies of the energy impulses received for selecting its station when the series of retransmitted energy impulses correspond to its station code call but to remain non-selected when the retransmitted series of impulses corresponds to the code call of some other station, whereby only one station is se-

lected even though several stations transmit their code calls at the same time.

15. In a communication system of the multiple frequency coded type for providing communication between a control office and a plurality of field stations, a code transmitter at said control office for transmitting energy impulses of distinctive frequencies to form different station codes and controls for such station, code receiving means at each field station, station selecting means at each field station controlled by its code receiving means and effective to select that field station for the reception of controls only in response to a series of energy impulses forming a code characteristic of such field station, whereby controls can be transmitted from said control office to any desired field station, transmitting means at each field station at times rendered effective to transmit energy impulses of distinctive frequencies to form its station code and transmit indications from such station when it is selected, code receiving means at the control office responsive to the energy impulses of a series transmitted from any single field station to cause said code transmitter at the control office to retransmit corresponding impulses for selecting that field station to allow the transmission of indications, said code receiving means also acting when a plurality of field stations are transmitting their station codes at the same time to retransmit for each impulse of the series a particular preferential distinctive frequency and thereby select the field station of the plurality having the most superior station code with respect to said preferential frequency.

16. In a communication system of the multiple frequency coded type for providing communication between a control office and a plurality of field stations, code transmitting means at each field station for transmitting energy impulses of different frequencies to form a code assigned to its field station, code receiving and transmitting means at the control office responsive to each energy impulse transmitted by a field station for retransmitting an energy impulse similar to that impulse transmitted by the field station to thereby transmit a series of impulses corresponding to the code assigned to a particular station as determined by that particular station, code receiving

means at each field station responsive to each energy impulse of said different frequencies transmitted by said control office, station selecting means at each field station controlled by said code receiving means at that station in accordance with the different code receiving means for selecting its station when that series of retransmitted energy impulses corresponds to its station code call, said station selecting means being rendered ineffective to select that station whenever a retransmitted impulse fails to correspond with the original impulse transmitted from that station, and means acting to stop transmission from a station whenever its station selecting means is rendered ineffective.

17. In a code system of the multiple impulse type, a single line circuit connecting a control office with a plurality of field stations, code transmitting means at each of the field stations effective to transmit a series of distinctive frequency impulses including station selecting code impulses characteristic of that field station and including indication impulses characteristic of the indication conditions at such field station, code receiving and transmitting means at the control office responsive to each distinctive station selecting code impulse applied to said line circuit by any given field station for contemporaneously applying an impulse of the same frequency to said line circuit, whereby the station selecting portion of said series of impulses transmitted by any given field station is retransmitted from said control office, station selecting means at each field station selectively responsive to only the retransmitted impulses applied to said line circuit at said control office for selecting its station providing such retransmitted impulses correspond to the code for that station to permit the transmission of the indication impulses of the series then being transmitted, and indication storing means at the control office for each station controlled by said code receiving means at the office in accordance with the indication impulses of a series belonging to that station when it has been selected by the station selecting code portion of such series.

WILLIAM D. HAILES,
FREDERICK W. BRIXNER.