June 29, 1948. A. WEAVER 2,444,078

TROUBLE ALARM SYSTEM

Filed June 10, 1942 6 Sheets-Sheet 1

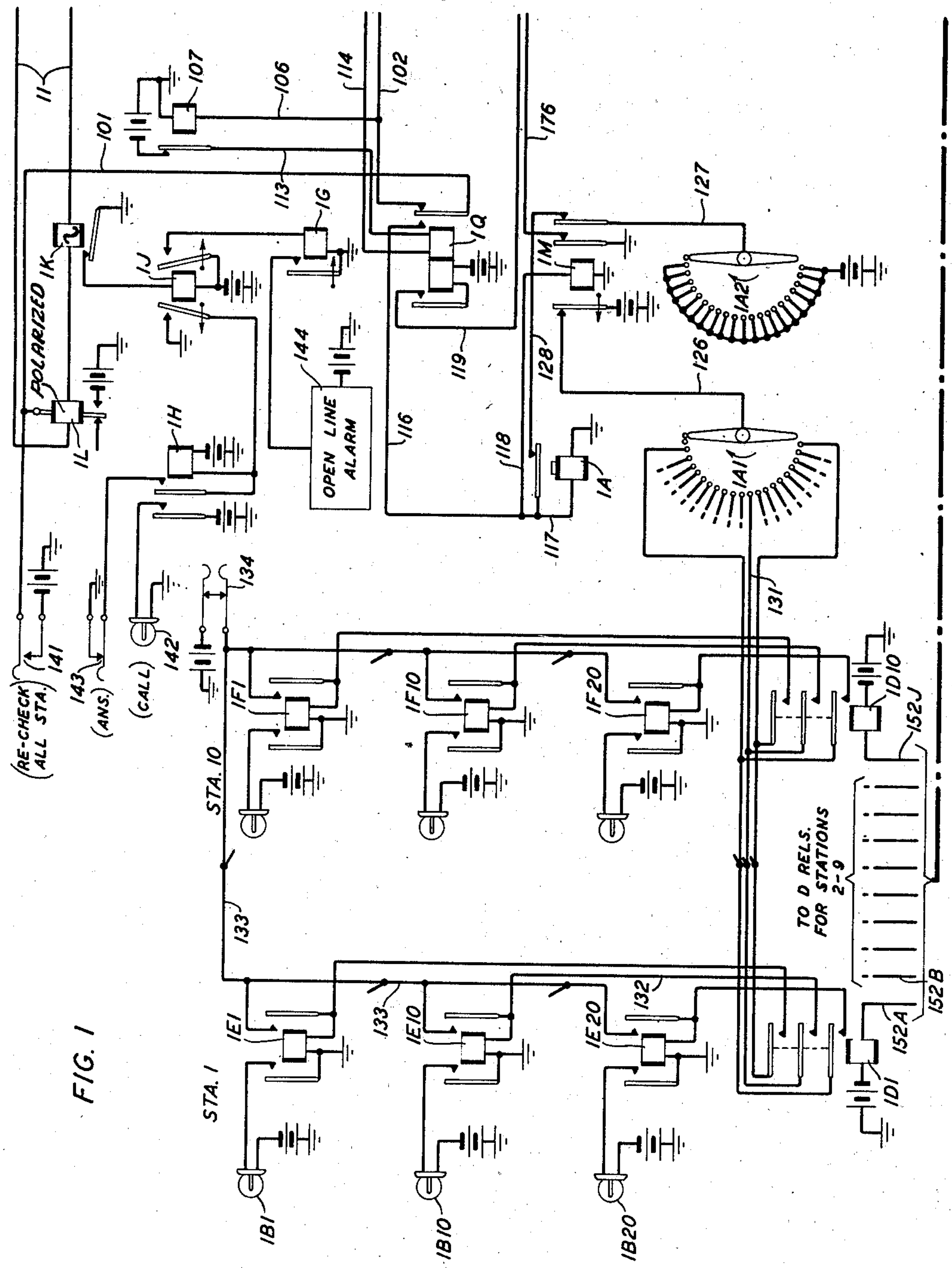

FIG. 1

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TROUBLE ALARM SYSTEM

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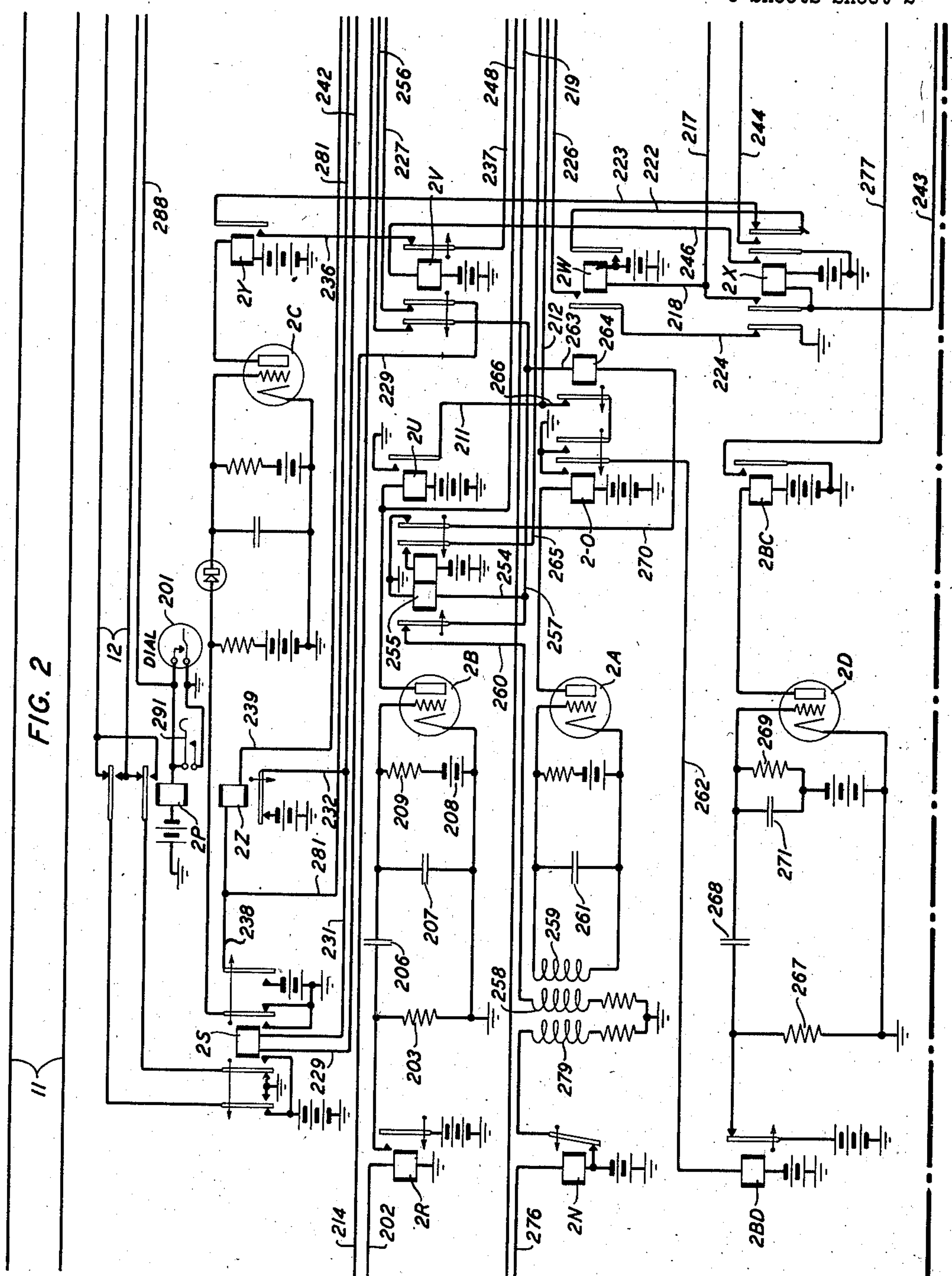
FIG. 2



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TROUBLE ALARM SYSTEM

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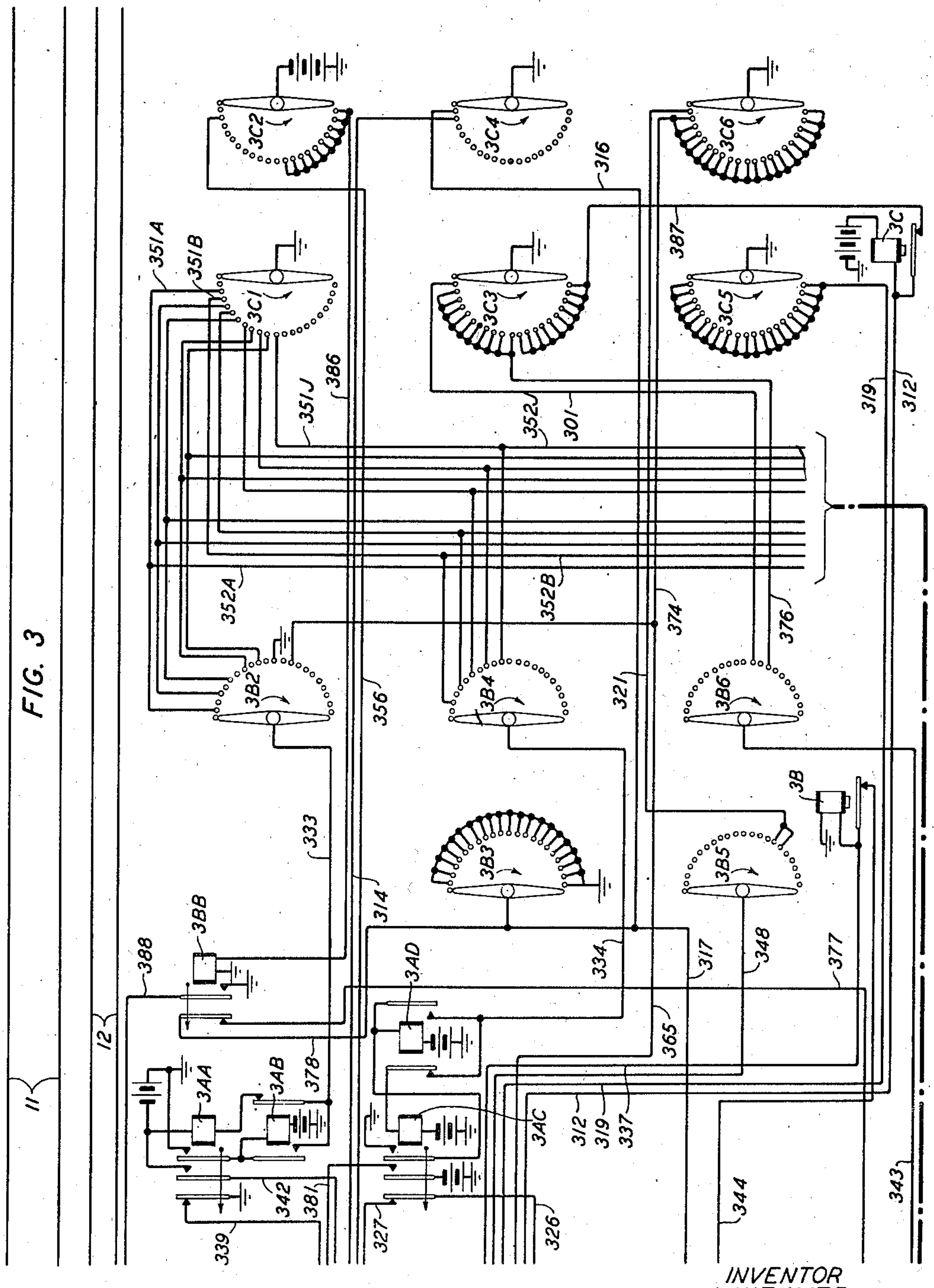
FIG. 3



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TROUBLE ALARM SYSTEM

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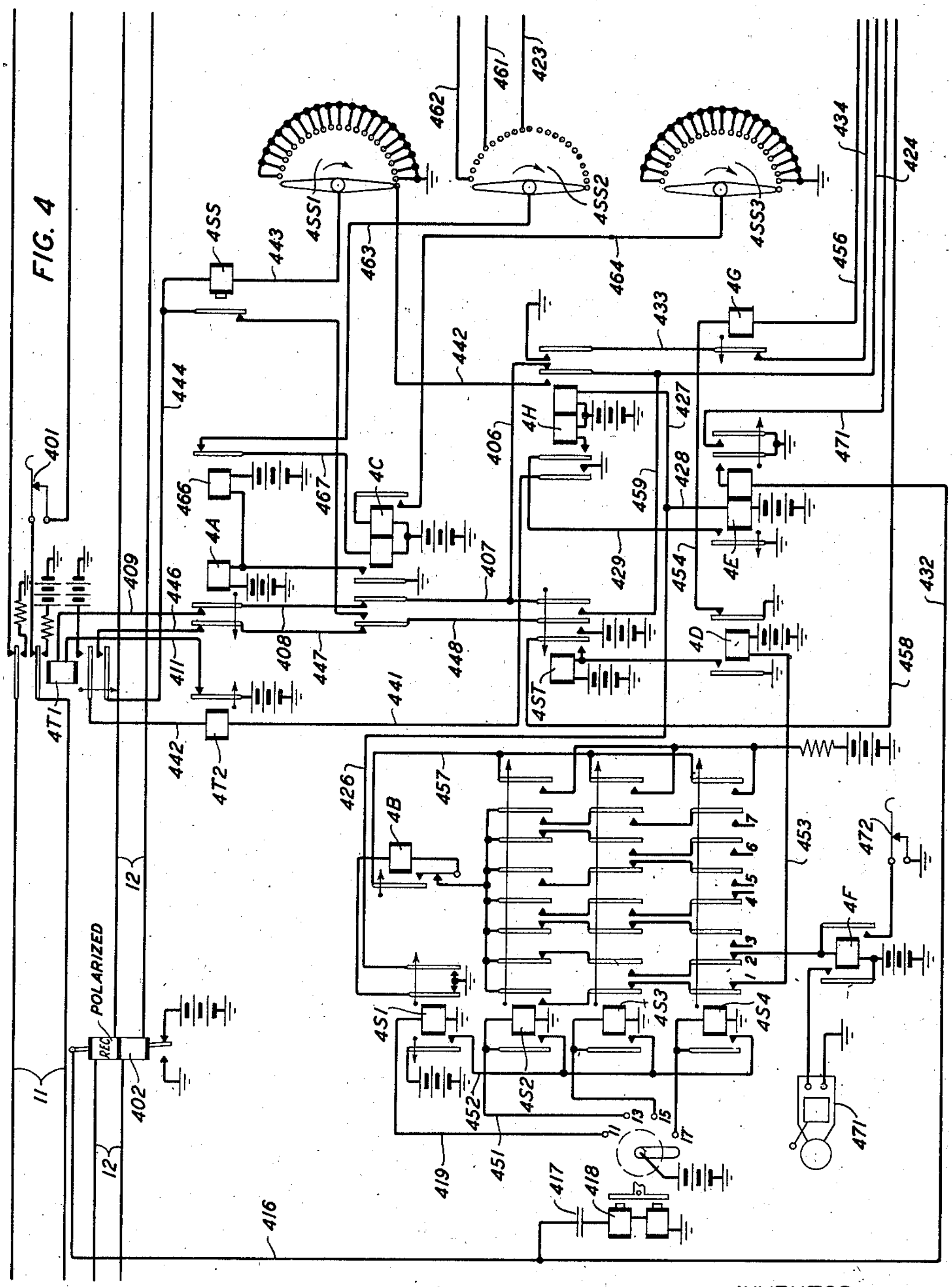

FIG. 4

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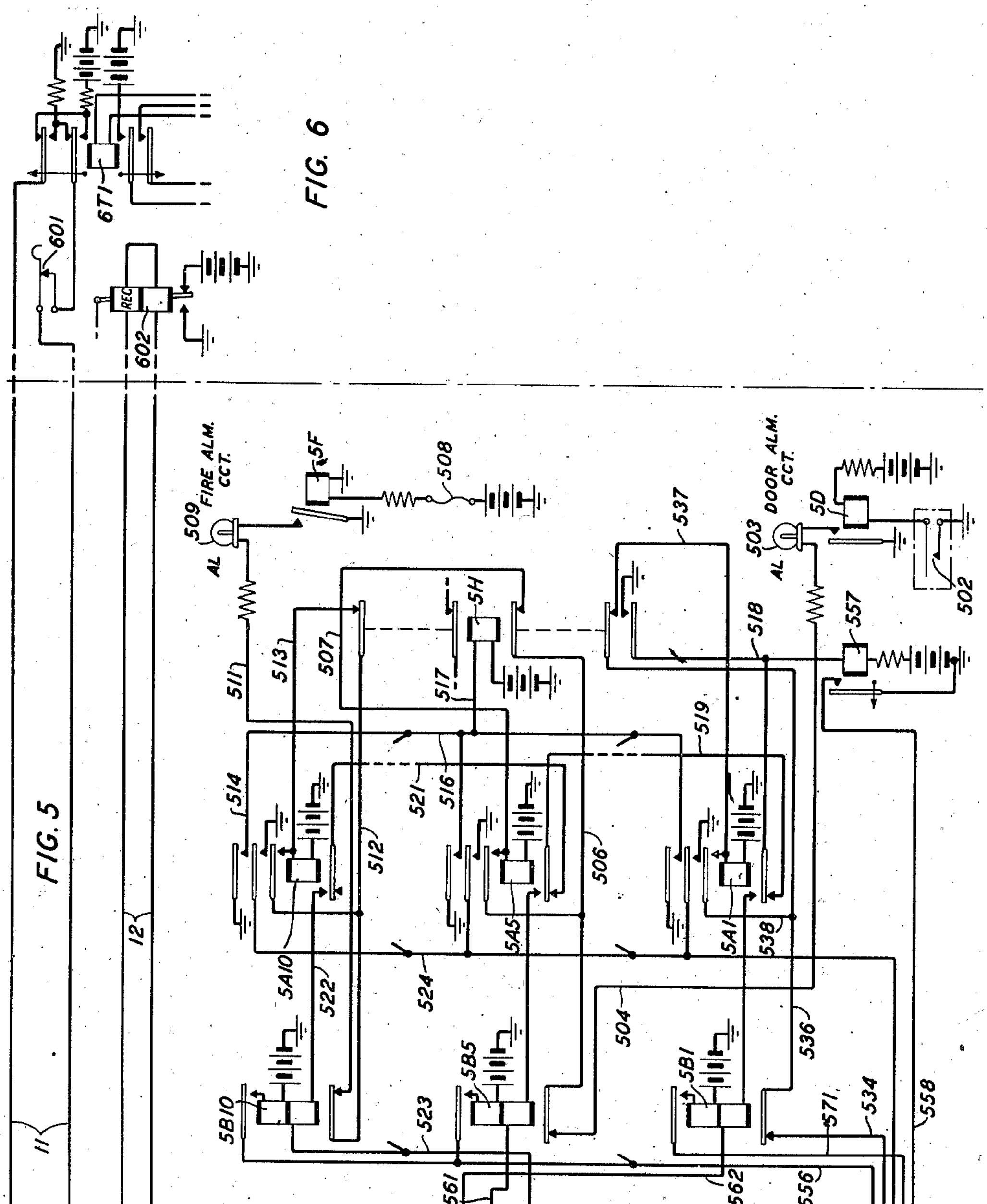

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FIG. 7

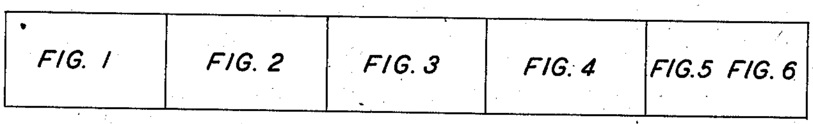


FIG. 8

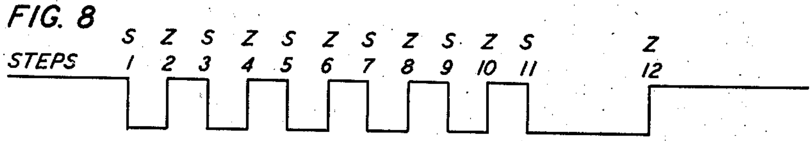


FIG. 9

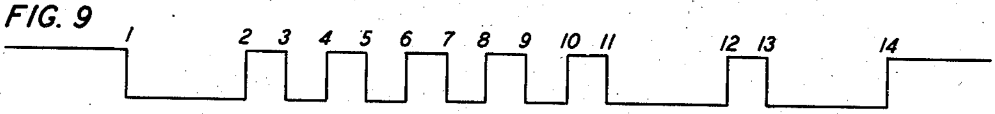


FIG. 10

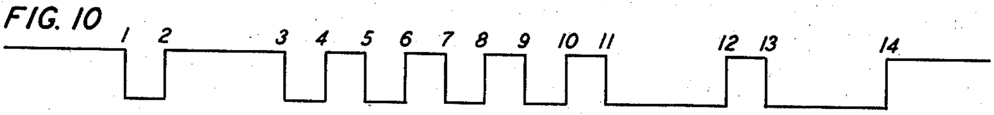


FIG. 11

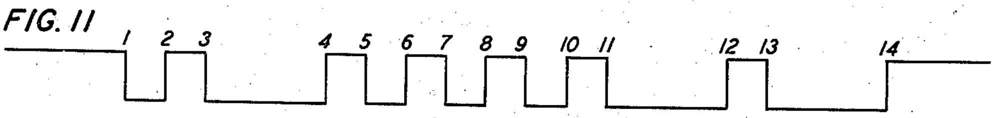


FIG. 12

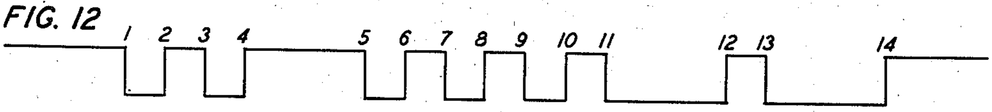


FIG. 13

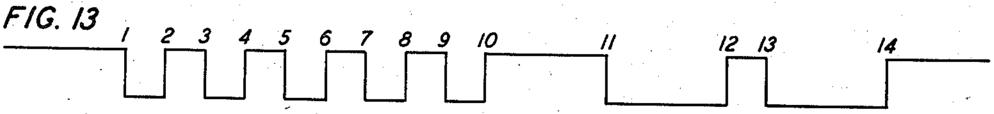
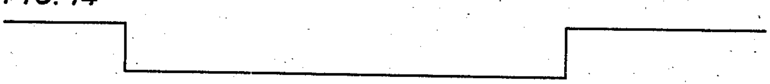


FIG. 14



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Patented June 29, 1948

2,444,078

UNITED STATES PATENT OFFICE

2,444,078

TROUBLE ALARM SYSTEM

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Application June 10, 1942, Serial No. 446,521

12 Claims. (Cl. 177—353)

This invention relates to communication systems and particularly to a system for transmitting from a plurality of outlying stations to a central or principal station indications of the operative condition of such outlying stations.

An object of the invention is to transmit signals indicative of the existence and identity of trouble conditions at the outlying stations.

Another object of the invention is to cause a central station upon receiving an indication of the existence of a trouble condition at an outlying station to perform a roll call of all of the outlying stations in the course of which each outlying station is afforded opportunity to identify any trouble conditions that may exist thereat.

Another object of the invention is to cause the roll call operation to be performed automatically upon the occurrence of a trouble condition at any of the outlying stations.

A further object of the invention is to provide for the transmission from the central office of signals for selectively calling a particular one of the outlying stations which has identified a trouble condition.

A further object of the invention is to provide at the outlying stations means responsive to signals for remedying an existing trouble condition.

The invention features a vibrating relay system for generating the signals for calling the outlying stations.

The invention also features a sequence switch mechanism for controlling the vibratory relay signal generating mechanism to effect the transmission of station calling signals in roll call manner.

In accordance with the preferred embodiment of the invention two communication paths extend between the central or principal station, which may be an attended station, and the outlying or subordinate stations which may be unattended stations. One of these paths is a transmission path from the standpoint of the central station and at the central station the signal transmitting mechanism is associated with this path whereas at the outlying stations the signal receiving mechanisms are associated with this path. The other communication path is a receiving path from the standpoint of the central station and the signal receiving mechanism of the central station is associated with it, whereas the signal transmitting mechanisms of the outlying stations are associated with this path.

Both of the transmission paths are normally in marking condition and when a trouble condition occurs at any one of the outlying stations a relay assigned to the detection of that particular trouble condition will be operated and will cause the central office receiving communication path to go to spacing condition, which is interpreted by the central office as an indication that a trouble condition has occurred at one of the outlying stations.

In response to the spacing condition imposed by one of the outlying stations the central station transmits over the other path a signal which is received by all of the outlying stations to condition them to respond to their respective call signals for reporting whether or not a trouble condition exists at each station as called and the identity of an existing trouble condition.

Following the conditioning of the outlying stations the central station automatically transmits in succession the call signal of each of the outlying stations. As each of the outlying stations is called it transmits a signal consisting of a single impulse in the event that there is no trouble condition thereat, whereas if there is a trouble condition the station transmits a signal consisting of a plurality of impulses, the number of impulses being determined by the identity of the trouble condition.

At the central station there are a plurality of banks of indicators, one bank corresponding to each of the outlying stations and each bank containing at least as many indicators as there are trouble condition detectors at the outlying station plus an indicator for indicating a trouble-free condition of a station. As each of the outlying stations is called by the central station, its bank of indicators becomes associated with a sequence device which is responsive to the signaling impulses transmitted by the outlying stations. The sequence device advances from normal position one step for each impulse received from an outlying station and at the end of the single impulse or train of impulses comprising the signal from an outlying station the trouble condition indicator selected by the sequence device is operated and remains operated. The sequence device returns automatically to normal condition in preparation for reception of the next outlying station signal.

It is within the contemplation of the invention that signal responsive selector mechanisms at the outlying stations may control devices for remedying trouble conditions such as the substitution by switching operations of spare circuits for circuits reported to be defective. It is also within the contemplation of the invention to control by means of the selector mechanism at the outlying stations alarm devices at the outlying station for informing a service attendant that the central office station desires to communicate with him by telephone.

For a complete understanding of the invention reference may be had to the following detailed description to be interpreted in the light of the accompanying drawings wherein:

Fig. 1 is a diagrammatic circuit view showing the trouble condition indicators and their associated selector at the central office station and also showing the receiving relays and associated apparatus thereat;

Fig. 2 is a diagrammatic circuit view showing signal transmitting mechanism at the central office and also showing circuits for timing the automatic operation of that office;

Fig. 3 is a diagrammatic circuit view showing signal generating relay systems at the central office and also showing sequence devices for controlling the sequence of operations thereat;

Fig. 4 is a diagrammatic circuit view showing signal receiving and transmitting mechanism at an outlying station;

Fig. 5 is a diagrammatic circuit view showing trouble condition detecting apparatus at the outlying station;

Fig. 6 is a diagrammatic view indicating another outlying station;

Fig. 7 is a diagrammatic view showing how Figs. 1 to 6, inclusive, may be arranged to show a complete system, Figs. 1, 2 and 3 showing the central office station and Figs. 4, 5 and 6 showing the outlying stations; and

Figs. 8 to 14, inclusive, are diagrammatic representations of various station calling signals.

General description of system

Referring now to the drawings the reference numeral 11 designates a normally closed communication loop which includes at the central office station the polar line relay 1L and the alternating current relay 1K. The communication loop 11 extends through the upper armatures and back contacts of a transmitting relay 4T1 at a first outlying station shown in Figs. 4 and 5 then in serial manner through two armatures and back contacts of transmitting relays of other outlying stations and terminates at the upper armatures of the transmitting relay 6T1 of a final outlying station. At the final outlying station positive battery is connected to the outer upper back contact and to the inner upper front contact of relay 6T1 and ground is connected to the outer upper front contact and to the inner upper back contact of the relay so that when the relay is deenergized, which is the normal condition, positive battery is connected to the upper conductor of the communication loop 11 and ground is connected to the lower conductor of that loop so that current will flow over the loop in a given direction and this direction of flow of current is such as to maintain the armature of receiving line relay 1L (Fig. 1) on its left-hand or marking contact. When relay 6T1 is energized the connections of battery and ground to the communication loop 11 are reversed and the armature of line relay 1L will be shifted to its right-hand or spacing contact which is connected to grounded battery.

At each of the intermediate outlying stations on the communication loop 11 the outer upper front contact of the transmitting relay, such as the relay 4T1 in Fig. 4, is connected to ground and the inner upper front contact is connected to

positive battery, so that when relay 4T1 becomes energized that portion of the communication loop 11 extending toward more remote outlying stations will be disconnected from the portion extending toward the central office station and the flow of current in the portion of the loop extending toward the central office station will be reversed, thus causing the relay 1L to go to its spacing condition. Each of the outlying stations has a break key, designated 401 and 601 in Figs. 4 and 6, respectively, in one side of the loop 11 and when one of the break keys is operated current to the central office station will be cut off. Since the relay 1K at the central office station is an alternating current relay it remains energized as long as current is flowing in either direction in the communication loop and, accordingly, does not release its grounded armature in response to operation of the transmitting relays at any of the outlying stations. However, when current is cut off in the loop 11 due to the operation of one of the break keys the relay 1K becomes deenergized and releases its armature. The function of relay 1K will be described later.

The reference numeral 12 designates the communication loop upon which signals are transmitted from the central office station to the outlying stations. One conductor of the communication loop 12 is connected to the outer back and inner front contacts of a pulse transmitting relay 2P which is normally deenergized and is controlled by pulsing dial 201 and other elements, and the other conductor of the loop 12 is connected to the outer front and inner back contacts of the relay 2P. The two armatures of relay 2P are connected to the two left-hand armatures of a sending relay 2S. The outer left-hand back contact and inner left-hand front contact of relay 2S are connected to grounded battery and the outer left-hand front contact and inner left-hand back contact are connected to ground. It will be apparent from this that the upper conductor of the communication loop 12 is normally connected to positive battery through the outer armatures of relays 2S and 2P and the lower conductor of the loop is normally connected to ground through the inner armatures of the relays. When either of the relays 2S and 2P is energized these connections are reversed, ground becoming connected to the upper conductor of the loop 12 and positive battery becoming connected to the lower conductor of the loop. There is no circumstance under which the relays 2P and 2S should be operated simultaneously as this would establish the same marking condition in the loop that exists when neither of those relays is energized.

At each of the outlying stations a polarized receiving relay, such as the relay 402 in Fig. 4 and 602 in Fig. 6 has its upper winding connected in the upper conductor of loop 12 and its lower winding connected in the lower conductor of the loop. At the final outlying station the loop is completed by connecting the upper winding of relay 602 to the lower winding. The right-hand or marking contact of each of the receiving relays, such as 402 and 602, which is the contact engaged by the armature when the line is in the idle (marking) condition, is connected to grounded battery and the left-hand or spacing contact of each of the receiving relays is connected to ground. Upon the operation of either of the relays 2P or 2S the flow of current through the loop 12 will be reversed and the armatures of all of the receiving relays will go to their left-hand or spacing contacts.

Since the automatic operation of the system results from the occurrence of a trouble condition at one of the outlying stations, the initiation of an alarm will first be considered. Referring to Fig. 5 the outlying station is provided with a plurality of different types of trouble condition detectors. For example, an open door alarm relay 5D is controlled by a switch 502 which is open when the door with which it is associated is closed and which closes when the door is opened, and the switch thereupon remains closed. If desired, a plurality of switches 502 associated with different doors may be connected in parallel for controlling the single open door alarm relay 5D so that the relay will become energized when any one of the doors is opened. The armature of relay 5D is connected to ground and the front contact is connected through local alarm lamp 503, conductor 504, back contact and lower armature of relay 5B5, conductor 506, innermost lower armature and back contact of relay 5H, conductor 507 and winding of relay 5A5 to grounded battery. Fig. 5 also shows a fire detector device which consists of a normally energized relay 5F, the energizing circuit of which includes the fusible conductive link 508. Upon the occurrence of a fire at the outlying station fusible link 508 will be melted, thus interrupting the circuit of relay 5F. The grounded armature of relay 5F is engageable with a back contact from which a conductive path extends through local alarm lamp 509, conductor 511, back contact and lower armature of relay 5B10, conductor 512, one of the armatures and back contacts of relay 5H, in the showing of Fig. 5 the outermost upper armature and back contact, although it might be any other armature and back contact of that relay, conductor 513, and winding of relay 5A10 to grounded battery.

Trouble occurs at outlying station

Assuming for the purpose of illustrating the operation of the system that the conductive path just described has been completed by the release of the armature of relay 5F due to the occurrence of a fire, the relay 5A10 will be energized. At its outermost upper armature the relay 5A10 completes an energizing circuit from ground through conductors 514, 516 and 517, winding of relay 5H to grounded battery whereby the relay 5H will be energized. At the innermost upper armature and front contact of relay 5A10 a holding circuit therefor will be completed to conductor 512 and back through the original energizing circuit, including the lower armature and back contact of relay 5B10, to the ground at the armature of relay 5F, so that the relay 5A10 will remain energized after the connection of conductor 513 to conductor 512 has been broken at the outermost upper armature and back contact of relay 5H upon the energization of that relay. At its lower armature the relay 5A10 prepares an energizing circuit for the relay 5B10 from ground through the front contact and lowermost armature of relay 5H, conductor 518, back contact and lower armature of relay 5A1, conductor 519, lower armature and back contact of relay 5A5, conductor 521, lower armature and front contact of relay 5A10, conductor 522, lower winding of relay 5B10, conductor 523, conductor 423 of Fig. 4 to the No. 10 contact of contact bank 4SS2 of stepping switch 4SS. At this time the stepping switch 4SS is in the normal or idle condition with its contact brushes in the zero position so that the energizing circuit for relay 5B10 is merely prepared but is not completed. At its middle upper front contact and armature relay 5A10 completes an energizing circuit for the transmitting relay 4T1 from the grounded front contact and armature of relay 5A10 over conductor 524, conductor 424, inner right-hand armature and back contact of a "Hold" relay 4H, conductors 406 and 407, middle left-hand armature and back contact of relay 4C, conductor 408, inner armature and back contact of relay 4A, conductor 409, winding of transmitting relay 4T1, conductor 411, back contact and armature of relay 4T2 to grounded battery. Relay 4T1 thus becomes energized to place that portion of the communication loop 11 which extends toward the central office station in spacing condition. The relay 5H, in addition to interrupting the original energizing circuit for the relay 5A10, also interrupts the conductive paths to all of the other relays in the series 5A, and at its outermost lower armature and front contact operates relay 557 which prepares a holding circuit from ground on its armature through the front contact and conductors 558 and 458 for a "Start" relay 4ST. No further operation occurs at the outlying station shown in Figs. 4 and 5 as an immediate and direct result of the release of the relay 5F.

Had the trouble condition at the outlying station been that of an open door instead of a fire the relay 5D would have become operated and would have completed an energizing circuit previously described for the relay 5A5. This relay would have become energized and would have caused the energization of relay 5H from the outermost upper grounded armature of relay 5A5, would have completed its own holding circuit to the conductor 506 at its innermost upper armature, would have prepared an energizing circuit for its associated relay 5B5 at its lower armature and front contact to the No. 5 contact of stepping switch bank 4SS2, thus cutting off at its lower back contact the possibility of preparing an energizing circuit for the relay 5B10 or to any other relay in the 5B series numbered above 5B5, in view of the isolation of conductor 521 from the ground provided at the lower armature and front contact of relay 5H. It is to be understood that the dotted lines in the conductor 519 and in the conductor 521 indicate that lower armatures and back contacts of other relays in the 5A series are included in the conductive path extending to the lower armature of relay 5A10. It will also be understood that there may be more than ten relays in the 5A and 5B series for responding to the detection of additional trouble conditions and in the event that additional 5A and 5B relays are required, the lower back contact of the relay 5A10 would have a connection to the lower armature of the next relay in the 5A series. All of the relays in the 5A series have their middle upper armatures connected to the conductor 524 so that upon the operation of any of those relays the energizing circuit for the relay 4T1 is completed.

Central office responds to trouble occurrence

The imposition of a spacing condition on communication loop 11 by the relay 4T1 causes the line relay 1L at the central office station to go to its right-hand or spacing contact, the relay 1K remaining energized by the reversed current in the loop 11. The armature of line relay 1L completes an energizing circuit for slow-operating relay 2R from grounded battery at the spacing contact of relay 1L through the armature, conductor 101, right-hand armature and back contact of relay 1Q, conductor 102, conductor 202, and winding of relay 2R to ground. A circuit is also completed from conductor 102 through conductor 106 and winding of relay 107 to ground, so that relay 107 becomes energized. The armature and back contact of relay 107 are in the energizing circuit of relay 1Q, but as this relay had not yet been energized, the operation of relay 107 has no immediate effect. Relay 107 serves to time the operation of relay 1Q, as will be described later.

The armature of relay 2R is connected to grounded battery and upon engaging its front contact completes a circuit for the flow of current through resistor 203. The battery connection to the armature of relay 2R is positive and condensers 206 and 207 connected in series across resistor 203 become charged to change the potential on the grid of an electron discharge tube 2B from negative with respect to the cathode, as normally provided by the negative terminal of a biasing battery 208, to a positive potential with respect to the cathode, whereby the tube 2B is rendered conductive. The delay afforded by the slow-operating characteristic of relay 2R provides for operation of tube 2B only in response to a long spacing condition of loop 11 so that the tube 2B shall not be operated in response to "hits" on the loop 11. Biasing battery 208 has in series with it a grid leak resistor 209 of relatively high value which permits the charge on condenser 207 to leak off, whereby the battery 208 restores the potential on the grid of tube 2B to a negative value relative to the cathode. Thus the combination of resistors and condensers first operate and then after an interval cut off the tube 2B and the interval during which the tube is operated is independent of relay 2R, which remains operated.

The plate circuit of tube 2B includes the relay 2U which is energized during the interval that tube 2B is conductive. The grounded front contact completes an energizing circuit for the stepping magnet 3C of a stepping switch which will be referred to generally by the reference number 3C and which has six contact brushes and banks of contacts identified 3C1 to 3C6, inclusive. The energizing circuit extends from the grounded front contact of relay 2U through the armature, conductor 211, conductor 212, conductor 312 and winding of stepping magnet 3C to grounded battery. Stepping switch 3C is preferably of the type in which the contact brushes are advanced upon the back stroke of the stepping magnet and accordingly the contact arms are stepped to the No. 1 contact of each bank when the tube 2B is cut off.

With the brushes of stepping switch 3C advanced to the first position, no circuits are established through contact banks 3C1 and 3C2 because their No. 1 contacts have no connection. Ground is connected over the brush and No. 1 contact of bank 3C3 and over conductor 301 to the contact No. 12 of contact bank 3B6 of the sequence switch 3B, but as this sequence switch is at this time in the normal position with its brushes engaging the zero contacts, no circuit is completed through the contact banks 3C3 and 3B6. Contact bank 3C4 completes an energizing circuit for the relay 2W from ground through the brush and No. 1 contact of bank 3C4, conductor 316, conductor 317, conductors 217 and 218, and winding of relay 2W to grounded battery. All of the contacts of sequence switch bank 3C5 except the zero contact are connected together so that when the switch is off-normal a ground connection is extended over conductor 319, conductor 219 and conductor 119 to the left-hand front contact of relay 1Q, the cooperating armature of which is connected to one terminal of the left-hand winding of the relay, the other terminal being connected to grounded battery. The left-hand winding of the relay 1Q is a holding winding but since, as previously stated, the relay 1Q is not yet energized, a holding circuit for that relay is merely prepared at this time by the contact bank 3C5. The No. 1 contact of the bank 3C6 is connected by conductor 321 to contacts Nos. 15 and 16 of contact bank 3B5 of the sequence switch 3B which has not yet advanced from its normal position so that no electrical circuit is established.

From the foregoing it will be apparent that the only operation performed by the stepping switch 3C in the first step while stepping switch 3B remains unoperated is the energization of relay 2W. At its right-hand armature and front contact the relay 2W connects grounded battery over conductor 222, outer right-hand armature and back contact of a relay 2X, which at this time is deenergized, and conductor 223 to the armature of a relay 2Y which at this time is deenergized and as the relay 2Y has no back contact connection, no electrical circuit is completed. At its left-hand armature the relay 2W completes a circuit from the grounded outer left-hand armature and back contact of relay 2X, conductor 224, left-hand armature and front contact of relay 2W, conductor 226, conductor 326, outer left-hand armature and back contact of relay 3AC, conductor 327, conductor 227, inner left-hand armature and back contact of slow-release relay 2V, conductor 229, winding of relay 2S, conductor 231, conductor 232 and armature and back contact of slow-release relay 2Z to grounded battery. The relay 2S thus becomes energized.

Central office sends preliminary signal

At its left-hand armatures the relay 2S reverses the battery and ground connections to transmitting loop 12, thus impressing a spacing condition on the loop 12. The inner right-hand armature of relay 2S is operable between back and front contacts, both of which are connected to ground. The armature is connected to the grid side of the input circuit of an electron discharge tube 2C and the input circuit includes a resistor and battery in series between the grid and cathode, with the battery poled positively toward the grid, a condenser between the grid and cathode, a second resistor and battery in series between the grid and cathode, with the battery poled negatively toward the grid for biasing the discharge tube to cut-off, and a varistor between the first-mentioned resistor and the grid side of the condenser. When the right-hand inner armature of relay 2S is in engagement with either of its contacts the condenser is charged to negative on the grid side by the negative biasing battery and the tube is biased to cut-off. During the interval in which the inner right-hand armature of relay 2S is in transit from one contact to the other ground is removed from the grid side of the input circuit and the battery which is poled positively toward the grid is enabled to charge the condenser through the varistor and thus bias the grid positively with respect to cathode so that the effect of the negative biasing battery is overcome and the tube is rendered conductive. The interval during which ground is removed from the grid side of the input circuit is extremely short but the interval during which discharge tube 2C continues to be conductive is prolonged due to the fact that the varistor prevents the condenser from discharging directly back to ground when the armature of relay 2S completes its transit and the return of the grid to its original condition of negative charge on the grid side is delayed by the grid leak resistance of high value. The plate circuit of the discharge tube 2C includes the relay 2Y so that relay is energized during the interval that the tube remains conductive.

A battery connection from the right-hand armature of the relay 2W to the armature of the relay 2Y has previously been traced. With the relay 2Y now energized this battery connection is extended over conductor **236**, right-hand armature and back contact of relay 2V, conductors **237** and **337**, and winding of stepping magnet 3B of the stepping switch, hereinbefore also referred to as 3B, to ground. Upon the cutting off of plate current in the discharge tube 2C the relay 2Y is released and the stepping magnet 3B advances its associated brushes to their first position on its back stroke.

The outer right-hand front contact of relay 2S is connected to battery and its armature is connected by conductor **238** to one terminal of the winding of relay 2Z the other terminal of which is connected by conductors **239** and **339** to the outermost left-hand back contact of relay 3AA, the armature of which is grounded. Thus the energizing circuit of relay 2Z is completed and that relay operates to interrupt the energizing circuit for relay 2S. The relay 2S releases slowly and (1) restores the loop **12** to marking condition; (2) momentarily removes ground from the grid side of the input circuit to discharge tube 2C to activate the tube and thus effect the advancement of stepping switch 3B another step; and (3) interrupts the energizing circuit for the relay 2Z. The relay 2Z has a slow-to-release characteristic, and upon its release it again completes the energizing circuit for the relay 2S, again sending the loop **12** to spacing, advancing the brushes of stepping switch 3B another step and interrupting its own energizing circuit. From this it will be apparent that the relays 2S and 2Z form a vibratory system for sending out upon the communication loop **12** alternate marking and spacing impulses and for advancing the brushes of stepping switch 3B one step for each transition of the line condition from marking to spacing or spacing to marking.

The odd-numbered contacts of bank 3B2 down to and including contact No. 9 are connected to even-numbered ones of the contacts of bank 3C1 and since the brush associated with bank 3C1 is now in engagement with the contact No. 1 no conductive path is completed to the ground on that brush as the brush of contact bank 3B2 is advanced step by step. The brush associated with contact bank 3B2 is connected by conductor **333** to the right-hand armature and left-hand front contact of relay 3AB. The right-hand back contact of relay 3AB is connected through the winding of relay 3AA to grounded battery, so that the relay 3AA will become energized when the brush of bank 3B2 picks up a ground connection. The odd-numbered ones of the contacts of bank 3B2 are also connected by a group of conductors through the windings of odd-numbered ones of the relays represented by 1D1 and 1D10 but as those relays have grounded battery connection of the same polarity as that connected to the relay 3AA neither the relay 3AA nor any one of the relays 1D1 to 1D10 will be energized as the brush associated with contact bank 3B2 advances over the odd-numbered contacts down to and including the No. 9 contact.

The even-numbered contacts of bank 3B4 are connected to odd-numbered contacts of the bank 3C1, excluding contact No. 1 of bank 3C1, and to even-numbered ones of the series of relays 1D1 to 1D10. The brush associated with contact bank 3B4 is connected by conductor **334** to the right-hand front contact and left-hand back contact of relay 3AD and the left-hand armature of relay 3AD is connected through the winding of relay 3AC to grounded battery which is of the same polarity as the batteries connected to the windings of the relays 1D1 to 1D10, so that the relay 3AC cannot become energized during the advancement of stepping switch 3B while the brush associated with bank 3C1 engages its No. 1 contact.

All of the contacts of bank 3B3 except the zero contact are connected together and to ground and the brush associated with the bank 3B3 is connected to conductor **317** to provide a substitute ground for the energizing circuit of relay 2W which ground is not independently effective at this time since the brush associated with contact bank 3C4 has maintained relay 2W energized through the No. 1 contact of that bank as stepping switch 3B advances.

The earliest connection in the bank 3B5 is at contact No. 15 and in the bank 3B6 is at contact No. 12 but when the several brushes of stepping switch 3B reach their contact No. 11 the brush associated with bank 3B2 finds ground on its contact No. 11 and completes the energizing circuit for the relay 3AA. The relay becomes operated and at its outermost armature it interrupts the energizing circuit for the relay 2Z. By reference to Fig. 8, which represents the signal that is being transmitted by relay 2S, it may be seen that the energization of relay 2S puts the loop **12** in spacing condition and causes the odd-numbered steps of stepping switch 3B and that the energization of the relay 2Z causes the loop to return to marking condition and effects the even-numbered steps of switch 3B, this being accomplished by cutting off relay 2S. It will also be seen that incident to the eleventh step of the sequence switch relay 2S is energized and seeks to energize relay 2Z. However, relay 3AA prevents the energization of relay 2Z and therefore the energizing circuit of relay 2S is not interrupted and the loop **12** remains in spacing condition for a longer interval than the previous spacing intervals, under the control of other factors which will now be described.

The middle armature of relay 3AA cooperates with a front contact that is connected to grounded battery and the armature is connected by conductors **341**, **342** and **242** to conductor **231** extending to the winding of relay 2S so that relay 2S will be held energized should the relative timing of operation of relays 2S, 2Z, 3AA and stepping magnet 3B be such that relay 2Z operates and interrupts the energizing circuit for relay 2S before the energizing circuit of relay 2Z is interrupted at the left-hand armature and back contact of relay 3AA. This is desirable since the slow-release characteristics of relay 2Z might permit relay 2S to release and return the loop **12** to marking condition. The innermost armature and front contact of relay 3AA completes the energizing circuit for relay 3AB which operates. At its left-hand armature and front contact relay 3AB establishes its own holding circuit from ground on contact No. 11 of contact bank 3B2 through conductor 333. At its right-hand armature and back contact the relay 3AB interrupts the energizing circuit for the relay 3AA which releases. Relay 3AA has a slow-release characteristic and upon releasing it removes the holding battery connection for the relay 2S and completes the energizing circuit for the relay 2Z which becomes energized to release the relay 2S. The spacing condition on loop 12 endures until relay 2S has released at which time the loop again goes to marking condition and discharge tube 2C is operated to advance stepping switch 3B to its twelfth position.

There is no connection to contact No. 12 of bank 3B2 and no change of condition is encountered by any of the other brushes of switch 3B except in bank 3B6 where a conductor extends from contact No. 12 to contact No. 1 of bank 3C3. Here ground is applied from the brush associated with bank 3C3 over conductor 301, contact No. 12 and brush of bank 3B6, conductors 343 and 243 and the winding of relay 2X to grounded battery, and relay 2X is operated.

At its inner left-hand armature and front contact the relay 2X provides a holding circuit from conductor 217, which is receiving ground from contact bank 3B3 at every step of the stepping switch and is holding relay 2W. At its outer left-hand armature and back contact the relay 2X interrupts the previously traced energizing circuit for the relay 2S, so as to terminate the vibratory operation of relays 2S and 2Z, with relay 2S remaining in released condition, in which it was placed by the operation of relay 2Z following the release of relay 3AA, and thus maintaining steady marking condition of communication loop 12. At its outer right-hand armature the relay 2X transfers the energizing circuit for stepping magnet 3B from a direct connection through the conductor 337 to an indirect connection through the interrupter contacts of stepping magnet 3B, the circuit being traced from battery through the right-hand front contact and armature of relay 2W, conductor 222, outer right-hand armature and front contact of relay 2X, conductors 244 and 344, interrupter contacts of stepping magnet 3B through the winding of the magnet to ground. The stepping magnet 3B thus operates in buzzer manner, and rapidly and automatically advances its brushes around to the zero or rest position. Until an additional control effected by the relay 2X is described it will be assumed merely that the stepping switch 3B starts to operate in buzzer manner and the brushes leave contacts No. 12.

At its inner right-hand armature and front contact the relay 2X completes the energizing circuit for the relay 2V from ground through the armature and front contact, conductor 246 and winding of relay 2V to grounded battery. The relay 2V further interrupts at its right-hand armature and back contact the direct energizing circuit for the stepping magnet 3B for which the buzzer energizing circuit has already been substituted. At its inner left-hand armature and back contact the relay 2V further interrupts the energizing circuit for the relay 2S which has already been interrupted by the relay 2X. The operation of relay 2V causes its outer left-hand armature to be disengaged from a back contact from which a conductive path not yet identified extends to the No. 2 contact of the stepping switch bank 3C2. Since the brushes of the stepping switch 3C are not yet in engagement with their No. 2 contacts the relay 2V does not interrupt an electrical circuit and from this it will be apparent that the operation of relay 2V at this time performs no direct operation.

When the brush associated with the contact bank 3B5 encounters the contact No. 15 of that bank a circuit is completed through the contacts Nos. 15 and 16, which are connected together, from ground on the brush associated with bank 3C6 through the No. 1 contact of that bank, conductor 321, contact No. 15 and in the next step contact No. 16 of bank 3B5, brush associated with that bank, conductors 348 and 248 and winding of relay 2U to grounded battery.

As previously set forth the outer armature of relay 2U connects ground to the conductive path consisting of conductors 212 and 312 extending to stepping magnet 3C so that the magnet is energized preparatory to stepping the brushes to the No. 2 contacts. As the brushes of stepping switch 3B pass from contact No. 16 to contact No. 17, relay 2U is released and the brushes of stepping switch 3C are stepped to the No. 2 contacts. The brushes of the stepping switch 3B in the meantime continue to be advanced to their zero positions and no circuit changes are effected as the brushes complete their cycle and move into normal or zero position except that as the brush associated with contact bank 3B3 moves out of engagement with the last of the interconnected contacts and into the zero position, ground on the interconnected contacts is removed from conductors 317 and 217 in the holding circuits for the relays 2W and 2X so that those relays are released and the relay 2V which was held energized by the relay 2X is also released.

Before describing the sequence of operations which occurs as a result of the stepping of the brushes of stepping switch 3C to the No. 2 contacts, the effect produced at the outlying stations by the transmission of the alternate marking and spacing signals, in accordance with the pattern shown in Fig. 8 due to the vibratory operation of the relays 2S and 2Z, as influenced following the eleventh transition by the relays 3AA and 3AB will be described.

Outlying stations respond to preliminary signal

At each of the outlying stations, as exemplified in Fig. 4, the armature of the polar receiving relay 402 is connected by conductor 416 to one terminal of a condenser 417, the other terminal of which is connected to one terminal of a polar magnet 418, the other terminal of which is connected to ground. The polar magnet 418 is the operating instrumentality of a step-by-step selector mechanism such as that disclosed in Patent 1,343,256, granted June 15, 1920, to J. C. Field. The disclosure of the patent is incorporated herein by reference as part of the present specification. Briefly, such a selector consists of a polar magnet having an armature which is rocked clockwise or counterclockwise from a center or neutral position in response to polar impulses of current. The armature is provided with an arm which operates a pawl mechanism for stepping a contact wheel or disc and the disc is advanced two steps for each full cycle of oscillation of the armature lever, by which is meant from the neutral position to one side, then to the opposite side and back to the neutral position. The contact wheel or disc is provided with selectively located pins which will be engaged by a check pawl associated with the armature lever when the armature lever is momentarily permitted to be at rest in the neutral position after having been operated through a plurality of cycles or half cycles and such pawl prevents the contact disc or wheel from returning to normal position under the influence of its restoring spring. When a plurality of such selectors with differently located stop pins respond to signals consisting of current reversals, a pause in the transmission of signals will cause those which have stop pins presented to their check pawls to be held in the positions to which they have been advanced, whereas all selectors which have no stop pins in those positions will return to normal position under the influence of the disc restoring springs. When transmission of current reversals is resumed, those discs which were held in advanced positions are further advanced from those positions whereas in all of the selectors the discs of which were restored to normal, those discs are again advanced from the normal position.

Step-by-step selectors of the type disclosed in the patent to Field are provided with contacts which are engaged by a contact arm carried by the step-by-step wheel or disc for the completion of electrical circuits. The electrical circuits are completed through the check pawl as a circuit element, so that as the contact arm comes into engagement with a contact, as it is being advanced step by step, an electrical circuit is not completed if the advance continues but only if there is a pause in the signal train which permits the check pawl to engage a stop pin and hold the disc or wheel in the position to which it has been advanced. When selectors of this type are employed in a system, all may have their electrical contacts in the same relative positions, such as in the eleventh, thirteenth, fifteenth and seventeenth steps as shown in Fig. 4. Taking the thirteenth step as an example, it is not necessary to send thirteen impulses in regular succession in order to cause the selector to reach that position. The selector may be provided with one or two stop pins intermediate the rest position and the thirteenth step, whereby the thirteenth step may be reached by the transmission of sets of impulses which total thirteen, with a pause between each two sets of impulses. During the pause at the end of the first set of impulses those selectors which have stop pins in the positions to which the discs of all of the selectors have been advanced, will be held and the discs of the remaining selectors will be restored to normal. In a two-digit system only one disc would be so held and all of the others would be returned. In a three-digit system a plurality of discs would be held and the remainder would be restored to normal. Upon the resumption of transmission of impulses, all of the selector discs would again be advanced, some from their initial positions and one or more from its advanced position. At the end of the second group of impulses the disc of one selector closes an electrical circuit if the system operates on a two-digit call and all of the remaining discs return to their normal positions, with the exception that the second set of impulses may correspond to the first digit for some other selector in the system and the disc of that selector may be held in its first digit position, although it will close no electrical circuit in this position. Following the closure of the electrical circuit the transmission of a single impulse will restore all of the selectors to normal. If the system is operable upon a three-digit call a plurality of discs will be held at the end of the second set of impulses, the number being smaller than the number which were held at the end of the first set of impulses. At the end of the third set of impulses only one of the discs will have been advanced to a position to close an electrical circuit.

In the arrangement shown in Fig. 4 only a single battery on the marking contact of line relay **402** is employed for energizing selector magnet **418** but the condenser **417** serves to give a polar effect to impulses. In the idle condition the condenser is charged positively on the side toward the battery and negatively on the side toward the magnet **418**, and no current is flowing through the magnet. When the relay **402** goes to spacing the condenser discharges through the magnet **418** and rocks the armature to one side of the magnet. If the relay **402** returns to marking before the discharging current has died out condenser **417** will be recharged and the charging current will rock the armature to the other side of magnet **418** without any pause of the armature in the neutral position. A pause in the signaling train of either marking or spacing nature will permit the armature of magnet **418** to go to its neutral position because the charging or discharging current for condenser **417** dies out before the end of the pause.

Since as shown in Fig. 8 the signal transmitted by the relays **2S** and **2Z** consists of eleven transitions followed by a pause of spacing nature, the contact discs of all of the selectors in the system will be advanced to the eleventh step. At each of the outlying stations a similar electrical circuit will be completed which, in the case of the station shown in Figs. 4 and 5, extends from grounded battery through the selector disc and contact arm, the eleventh step contact, conductor **419**, and winding of relay **4S1** to ground. At its left-hand armature and front contact the relay **4S1** prepares a holding circuit for the relays **4S2**, **4S3** and **4S4**, none of which is at this time energized. At its inner right-hand armature and grounded back contact the relay **4S1** removes ground connection from a relay **4B**, which has no effect because the relay **4B** is not at this time energized. At its outer right-hand armature and grounded front contact relay **4S1** completes the energizing circuit for the "hold" relay **4H** through conductor **426**, conductor **427** and the right-hand winding of relay **4H** to grounded battery. The relay **4S1** also completes the energizing circuit for relay **4E** over conductors **426** and **428** and winding of relay **4E** to grounded battery.

At its left-hand armature and front contact the relay **4E** establishes a holding circuit for relay **4H** over conductor **429**, inner left-hand armature and front contact and left-hand winding of relay **4H** to grounded battery. At its inner right-hand armature and front contact the relay **4E** prepares its own holding circuit from ground through its right-hand winding, conductor **432** and conductor **416** to the armature of line relay **402**. At its outer right-hand armature and front contact relay **4E** prepares a holding circuit for the relay **5B1**, which will be traced later. Relay **402** returns to marking following the long spacing pause after the eleventh step and completes the holding circuit for relay **4E**. The relay **402** also steps the discs of all of the selectors to the twelfth step, where none of the selectors has a holding pin and accordingly all are returned to the normal position, thus releasing the relay **4S1** and corresponding relays at all of the outlying stations and leaving the relays **4E** and **4H** energized and held at all outlying stations.

Reference is made to the fact that the relay 5A10 has been assumed to be energized due to the operation of the fire detection apparatus at the station shown in Figs. 4 and 5 and that this has caused the relay 4T1 to be operated to place the communication loop 11 leading to the central office station in spacing condition. The following sequence of operations is predicated upon this assumption but the operational differences which would result from a trouble-free condition of the station shown in Figs. 4 and 5 will also be mentioned.

At its outer right-hand armature and front contact the relay 4H connects ground through conductor 433, armature and back contact of relay 4G, conductors 434 and 534, back contact and lower armature of relay 5B1 to the second lowest armature of relay 5H. From the back contact with which this armature of relay 5H cooperates, conductor 537 extends to one terminal of the relay 5A1 the other terminal of which is connected to grounded battery. Thus if relay 5H were not energized, the relay 5A1 would become energized to indicate that no trouble condition existed at the station and the relay 5A1 would be held from its innermost upper armature and front contact to conductor 536 and to the outer right-hand armature and front contact of relay 4H through conductor 538. The relay 5A1 would in turn energize relay 5H, so that after relay 4H has been operated, relay 5H will be in the operated condition. Since it has been assumed that relay 5H was previously energized the relay 5A1 does not become energized.

At its outer left-hand armature and front contact the relay 4H connects ground over conductor 441, winding of relay 4T2, conductor 442, innermost lower armature and front contact of relay 4T1 to grounded battery. The single armature of the relay 4T2 removes battery from the conductor 411 in the energizing circuit for the relay 4T1 so that that relay is deenergized. The relay 4T1 is slow-to-release and accordingly an interval elapses before it releases to restore the comunication loop 11 toward the central office station to marking condition. At its inner right-hand armature the relay 4H transfers the ground connection supplied over conductor 424 beginning at the upper middle armature and front contact of relay 5A10, and previously extended to relay 4T1 over the back contact of relay 4H, to a front contact and over conductor 442, zero contact and brush of the contact bank 4SS1 of stepping switch 4SS, conductor 443, winding of stepping magnet 4SS, conductor 444 to the lower outer armature of relay 4T1, conductor 446, back contact and outer armature of relay 4A, conductor 447, back contact and outer left-hand armature of relay 4C and conductor 448 to the middle armature of "start" relay 4ST. The back contact with which the armature of relay 4ST cooperates is connected to grounded battery but as the relay is not energized at this time and relay 4T1 is in process of being released an electrical circuit through the stepping magnet 4SS is not yet completed.

When relay 4T1 releases it opens the energizing circuit for relay 4T2 which is also a slow-release relay and which upon release restores the battery connection to conductor 411 extending to the winding of relay 4T1. However, the latter relay will not at this time be reenergized because ground connection has been removed at the inner right-hand armature of relay 4H.

Central office prepares to conduct roll call of outlying stations

The operations which take place at the outlying stations in response to reception of the signal represented in Fig. 8 occur during the long spacing interval following the eleventh transition. Following this there is a steady marking interval on loop 12, the duration of which is determined by the time involved in the restoration of stepping switch 3B to normal and by the release time of the relay 2V which is slow to release. The restoration of the marking condition on the communication loop 11 due to the release of relay 4T1 causes the relay 1L to be driven to the marking condition whereby the relay 2R is released. This does not cause tube 2B to operate, since positive battery is disconnected from condenser 206. The relay 1L also release the relay 107, the purpose of which will be described later.

With the brushes of stepping switch 3C advanced to the No. 2 contacts as previously described, a circuit is completed from ground on the brush associated with bank 3C1 through the No. 2 contact of the bank, conductor 351A, conductor 352A, conductor 152A in Fig. 1 and winding of relay 1D1 to grounded battery. Relay 1D1 thus becomes energized and attracts its armatures, of which there are as many as there may be trouble conditions at outlying stations to be registered. The armatures of the relay 1D1 are connected to individual contacts of bank 1A1 of a stepping switch 1A. The front contacts of the relay 1D1 are individually connected to the windings of relays, such as relays 1E1, 1E10 and 1E20, which control individual alarm lamps 1B1, 1B10 and 1B20. Additional conductors 351B to 351J are connected to contacts No. 3 to No. 11, inclusive, of bank 3C1 and extend through conductors 352B to 352J and conductors 152B to 152J to additional relays of the 1D series, of which only the relay 1D10 is shown. All of the 1D relays have their armatures connected to the conductors extending to the contacts of stepping switch bank 1A1 and their front contacts connected to individual relays for controlling alarm lamps. Thus the front contacts of the relay 1D10 are connected to lamp controlling relays, of which the relays 1F1, 1F10 and 1F20 are shown. It will be understood that there will be as many of the 1D series relays as there are outlying stations in the system and that there will be as many relays in each of the series represented by the 1E relays and the 1F relays in Fig. 1 as there are trouble conditions to be registered.

Upon the release of relay 107 a circuit is completed from the grounded brush associated with contact bank 3C4 through the No. 2 contact of that bank, conductors 314, 214 and 114, right-hand winding of relay 1Q, conductor 113, armature and back contact of relay 107, assuming that relay 107 has released, to grounded battery. At its left-hand armature and front contact the relay 1Q completes a holding circuit from grounded battery through the left-hand winding of the relay, conductors 119, 219 and 319 through the interconnected contacts of contact bank 3C5, all of which are connected together except the zero contact, to the grounded brush through contact No. 2 of that bank which the brush at this time engages. It will be apparent that relay 1Q will be held energized until the brushes of stepping switch 3C2 have completed a cycle and have been restored to their zero positions. At its right-hand armature the relay 1Q transfers the connection of the armature of receiving line relay 1L from the energizing circuit of the relays 107 and 2R to the stepping magnet of stepping switch 1A through the right-hand front contact of relay 1Q, conductor 116 and conductor 117, winding of stepping magnet 1A to ground. A conductive path extends in parallel with the one just described, from conductor 116, through conductor 118 and winding of slow-release relay 1M to ground.

Neither the stepping magnet 1A nor the relay 1M will become energized at the instant that relay 1Q is operated, because relay 1Q can become energized only when relay 1L is in marking condition with its armature engaging the dead left-hand or marking contact. The reason for this is that the energizing circuit for the relay 1Q is controlled not only by the arrival of the brushes of stepping switch 3C at their No. 2 contacts, but also by the relay 107, and the relay 107 is controlled by the relay 1L prior to the energization of relay 1Q so that the relay 107 cannot prepare nor complete the energizing circuit for the relay 1Q until the relay 1L has been restored to marking condition. The purpose of this timing control of the energization of relay 1Q by the receiving relay 1L is to prevent the energization of relay 1Q before the loop 11 has been restored to marking condition due to release of the relay 4T1, at the outlying station where a trouble condition exists, under the control of the "Hold" relay 4H at that station. If this timing control were not provided and the stepping switch should be stepped to the No. 2 contacts before the relay 1L had gone to marking condition an energizing circuit for the stepping magnet 1A and the relay 1M would be completed by the relay 1Q and the energization of these instrumentalities is not desired at this time. Since the right-hand armature of relay 1Q effects a transfer of the connection from the armature of relay 1L, the energizing circuit for the relays 107 and 2R are opened at that point so that those relays will not respond to nor follow any signals thereafter received from outlying stations during the time that relay 1Q is held energized from contact bank 3C5.

The release of the relay 2V at the end of the first cycle of stepping switch 3B results in the completion of a circuit from grounded battery on the brush associated with the stepping switch bank 3C2 through the No. 2 contact of that bank, conductor 356, conductor 256, outer back contact and outer left-hand armature of relay 2V, conductor 257, left-hand armature and back contact of a relay 255, conductor 260 and primary winding 258 of a transformer to ground. A circuit is also completed in parallel with the primary 258 of the transformer from conductor 257 through conductor 254, left-hand winding of relay 255 to ground. Relay 255 has a slow-to-operate characteristic and accordingly its operation is delayed. The rise in flow of current through transformer primary 258 will produce an impulse in the secondary 259 of the transformer which is connected across the input circuit of an electron discharge tube 2A between the grid and cathode of that tube. The polarity of the impulse will be such as to charge condenser 261 positively on the grid side of the input circuit, thereby overcoming the effect of the negative biasing battery which is in series with the high value grid leak resistor connected between the grid and cathode. Tube 2A will be rendered conductive and will continue to conduct until the charge on condenser 261 which was produced by the impulse in the transformer leaks off through the grid leak resistor and negative bias is restored to discharge tube 2A. The plate circuit of the discharge tube 2A includes the winding of relay 2—0. During the interval in which relay 2—0 is energized ground is connected through its inner front contact and armature and through conductor 262 and the winding of relay 2BD to grounded battery.

When relay 255 operates it interrupts at its left-hand armature and back contact the circuit through transformer primary 258 thus causing the current through that circuit to die out. This causes to be produced in transformer secondary 259 a pulse in the opposite direction which charges condenser 261 in the reverse direction. Thus the tube 2A is cut off if current had not already ceased to flow in its plate circuit. It will be apparent from this that relay 255 should be sufficiently slow to operate, that it will not open the circuit of transformer primary 258 until tube 2A has operated relay 2—0 which in turn has operated relay 2BD. The relay 255 establishes a holding circuit for itself from grounded battery through the right-hand winding of the relay, front contact and inner right-hand armature, conductors 265, 365 and 374 to the No. 2 contact of contact bank 3C6 which at this time is engaged by its grounded armature. Since all of the contacts of bank 3C6 except the zero and No. 1 contacts are connected together, the relay 255 will remain energized until the stepping switch 3C has completed its cycle and its brushes have returned to their zero positions. The reason for interrupting the circuit of transformer primary 258 following the activation of tube 2A will be set forth hereinafter.

At the same time that the pulse is generated in secondary 259 of the transformer for activating discharge tube 2A a circuit is completed from conductor 257 through conductor 263, winding of relay 264, conductor 270, outer right-hand armature and back contact of relay 255 to ground. At its armature and back contact the relay 264 prevents the completion of a circuit which the relay 2—0 seeks to complete from ground through its outer front contact and armature, armature and back contact of relay 264, conductors 266, 212 and 312 and winding of stepping magnet 3C to grounded battery. Were it not for the provision of the relay 264 the brushes of sequence switch 3C would be stepped to their third contact at this time, which is not desired. If the relay 2—0 has a slightly retarded operating characteristic which will not prevent it from operating during the time that the discharge tube 2A is conductive but which will permit relay 264 to operate before the relay 2—0 operates, the stepping of sequence switch 3C will be prevented. Since the energizing circuit of relay 264 includes the outer right-hand armature and back contact of relay 255, that circuit will be interrupted when relay 255 becomes operated and held. Relay 264 preferably has a slow-to-release characteristic such that it does not release until relay 2—0 has released. Thus the relay 264 prevents the energization of stepping magnet 3C in response to the first operation of relay 2—0, but will not prevent such energization in response to subsequent operations of relay 2—0 while relay 255 remains operated and held.

The armature of relay 2BD is connected to positive battery and the back contact with which the armature cooperates is connected to the grid side of the input circuit of a discharge tube 2D. The input circuit of the tube 2D is similar to that of tube 2B, the difference being that the second condenser in the circuit is in shunt with the leakage resistor only instead of being in shunt with the leakage resistance and the biasing battery. Under the normal condition the tube 2D is biased negatively to cut-off by its biasing battery, although current is flowing through resistor 267 and condenser 268 is charged. Upon the energization of relay 2BD the positive battery is disconnected from the grid circuit and condenser 268 discharges but tube 2D is not rendered conductive. Upon the release of relay 2—0 the energizing circuit of relay 2BD is interrupted and after an interval the relay 2BD releases. Condenser 268 becomes recharged and raises the potential of the grid of tube 2D so that the tube is rendered conductive. The interval during which tube 2D is conductive is controlled by leakage resistor 269 and the second condenser 271.

Central office sends first selective signal of roll call

The plate circuit of tube 2D includes the winding of relay 2BC which completes an energizing circuit for the relay 2W over its grounded armature and front contact, conductors 277 and 377, back contact and outer armature of relay 3BB, conductors 378, 317, 217 and 218, winding of relay 2W to grounded battery. As before, the relay 2W completes the energizing circuit for the relay 2S which operates and sends the loop 12 extending to the outlying stations to spacing condition. Relay 2W also prepares an energizing circuit for the stepping magnet 3B, which is completed by the relay 2Y as discharge tube 2C responds to the operation of relay 2S. As in the first cycle of operation of stepping switch 3B ground is applied from contact bank 3B3 when the brushes step to the No. 1 contact to hold relay 2W operated and this ground remains connected throughout the cycle of switch 3B. At the bank 3B2 ground is applied from the brush associated with bank 3C1 through the No. 2 contact of that bank, No. 1 contact and brush of bank 3B2, conductor 333, right-hand armature and back contact of relay 3AB and winding of relay 3AA to grounded battery. As in the case of the long spacing interval after the eleventh transition as shown in Fig. 8 the relays 3AA and 3AB control the relays 2S and 2Z to prolong the spacing interval following the first transition, as shown in Fig. 9. Following the operation of relay 3AB and the release of relay 3AA the control of relay 2S is restored to relay 2Z and these relays operate in vibratory manner to transmit marking and spacing impulses of uniform duration and to advance the brushes of stepping switch 3B step by step until the brush associated with bank 3B2 reaches the No. 11 contact which is connected to ground. This causes another cycle of the relays 3AA and 3AB to control the relays 2S and 2Z to introduce a long spacing interval following the eleventh transition, as in the first cycle of stepping switch 3B, and this long interval is shown in Fig. 9.

Upon the release of relay 3AA by the relay 3AB relay 2Z releases relay 2S to produce a twelfth transition to marking and the brushes of stepping switch 3B are stepped to the twelfth position. The marking interval thus produced is only of normal length because the relay 2S interrupts the circuit of relay 2Z which releases to complete the circuit for 2S which again becomes energized to drive the loop 12 to spacing condition and to step the brushes of stepping switch 3B to the No. 13 contact. In the twelfth position of the brushes of stepping switch 3B the brush associated with bank 3B6 did not receive ground connection from the brush and bank 3C3 as it did in the preceding cycle because the brushes of switch 3C are now on the No. 2 contacts and the contacts Nos. 2 to 11, inclusive, are connected to contact No. 14 of bank 3B6 by conductor 376.

In the thirteenth position the brush associated with contact bank 3B2 again receives ground connection this time from the brush and No. 2 contact of stepping switch bank 3C6 and conductor 374 so that another cycle of the relays 3AA and 3AB is introduced to control the relays 2S and 2Z with the result that a long spacing interval is introduced after the thirteenth transition. After the relays 3AA and 3AB have operated relay 2S is released to restore the loop 12 to marking condition and the brushes of sequence switch 3B are stepped to the No. 14 contacts.

At contact No. 14 in the bank 3B6 ground is applied from bank 3C3 over conductors 376, 343 and 243 to energize relay 2X which in turn energizes relay 2V. These relays perform the same functions as previously described, namely; interruption of the energizing circuit for the relay 2S and transfer of the energizing circuit for the stepping magnet 3B to include the interrupter contacts. As the brush associated with stepping switch bank 3B5 traverses contacts Nos. 15 and 16, the energizing circuit for the relay 2U is not completed as it was in the previously described cycle because ground connection is no longer applied to conductor 321 on the contact No. 1 of bank 3C6. Thus the brushes of stepping switch 3C remain on their No. 2 contacts while the brushes of stepping switch 3B are rapidly advanced to their zero position. When the brushes reach the zero position, the brush associated with bank 3B3 removes the holding ground connection from relays 2W and 2X which release, the latter in turn releasing the relay 2V. Upon the release of relay 2V the same circuit changes occur which took place upon its release at the end of the preceding cycle of stepping switch 3B, namely; preparation of an energizing circuit for the relay 2S, at the inner left-hand armature and back contact of relay 2V, which circuit however is now open at the left-hand armature and front contact of relay 2W, and preparation of an energizing circuit for the stepping magnet 3B at the right-hand armature and back contact of relay 2V, which circuit is open at the armature and front contact of relay 2Y and at the right-hand armature and front contact of relay 2W. At its outer left-hand armature and back contact the relay 2V reconnects grounded battery, still supplied at the brush and No. 2 contact of contact banks 3C2, to conductor 257. Since relay 255 has previously disconnected the primary 258 of the transformer from conductor 257 the transformer does not become energized. Were it not for the provision of relay 255 to interrupt the path to transformer primary 258, the transformer, upon the release of relay 2V, would be reoperated to render tube 2A conductive which in turn would operate relay 2—0 which in turn would operate relay 2BD. Since relay 2BD renders tube 2D conductive through relay 2BC and the latter relay operates relay 2W to start sequence switch 3B through another cycle, another station calling signal would be transmitted on loop 12 without awaiting a response to the station calling signal, the transmission of which was accomplished in the cycle of stepping switch 3B just completed. The relay 255 prevents the restarting of stepping switch 3B under the control of relay 2V.

All outlying stations react to first signal of roll call

The signal comprising the succession of impulses shown in Fig. 9 which has been transmitted during the second cycle of the stepping switch 3B is received at all of the outlying stations associated with loop 12 and operates the receiving line relays, such as the relay 402, in accordance therewith. The receiving line relays operate the magnets, such as 418, of the step-by-step selector, and since a long pause of spacing nature follows the first impulse the contact disc of that one of the selectors which has a stop pin in the first step position will be held at the first step during the long spacing interval and all of the others will be restored to normal position. It will be assumed for the purposes of this description that the selector in the outlying station shown in Figs. 4 and 5 is the one which holds on the first step and all others are restored to normal. Following the long spacing interval the transitions numbered 2 to 11, inclusive, are received and step the selectors ten steps, the selectors at the station shown in Figs. 4 and 5 reaching the eleventh position and the selectors at all other stations reaching the tenth position. The contact discs at all of the stations except the one shown in Figs. 4 and 5 and except the one at the station which has a pin on the tenth step will be restored to normal in the interval following the eleventh transition. The station with the pin in the tenth position will be restored to normal following the thirteenth transition. Since, as previously stated, all of the selectors have a stop pin in the eleventh position the selector shown in Fig. 4 will be held at the eleventh position and the relay 4S1 will be operated. All of the controls which relay 4S1 is capable of effecting were effected when the relay 4S1 was operated in response to the signal shown in Fig. 8 and, accordingly, no further operations are performed except the preparation of a holding circuit for relays 4S2, 4S3 and 4S4. Following the long interval the twelfth and thirteenth pulses are received followed by another pause of spacing nature. The selector shown in Fig. 4 is advanced to the thirteenth position and is held by a stop pin.

First outlying station is selected

At the station shown in Figs. 4 and 5 a circuit is completed from grounded battery, contact disc and arm and thirteenth contact of the step-by-step selector, conductor 451, and winding of relay 4S2 to ground. At its left-hand armature and front contact the relay 4S2 completes a holding circuit through conductor 452 and the left-hand front contact and armature of relay 4S1 to grounded battery. The energizing circuit for the relay 4S1 was interrupted when the contact disc of the selector stepped from the eleventh to the thirteenth position but since the relay 4S1 is slow to release, the holding circuit for relay 4S2 is in fact completed. The relay 4S2 also completes a circuit from ground through the back contact and inner right-hand armature of relay 4S1 when that relay has released, winding of relay 4B, movable front and stationary back contact of relay 4B operable in make-before-break manner, innermost right-hand armature and front contact of relay 4S2 which is very slow to release and therefore holds even after relay 4S1 has released, inner right-hand armatures and back contacts of relays 4S3 and 4S4, conductor 453 and winding of relay 4D to grounded battery. Relays 4B and 4D both become energized but as the relay 4B has a slow-to-operate characteristic relay 4D becomes operated first.

At its right-hand armature and back contact the relay 4D seeks to interrupt the holding circuit for any relay in the series 5B, the circuit extending from ground, right-hand armature and back contact of relay 4D, conductor 454, winding of relay 4G, conductors 456 and 556 to the upper armatures of all of the relays in the series 5B. It has previously been assumed that the energizing circuit for the relay 5B10 had been prepared but not completed. Accordingly, there had been no circuit completed through the upper armatures of any of the 5B series relays and the operation of the right-hand armature of relay 4D has no effect, either on the relay 5B10 or on the relay 4G. The left-hand armature of relay 4D completes the energizing circuit for the "Start" relay 4ST which has a slow-to-operate characteristic. The relay 4B attracts its armature after the relay 4D has operated, establishes a holding circuit for itself from the ground at the back contact and inner armature of relay 4S1, winding of relay 4B, front contact and armature of relay 4B, conductor 457 and outermost armature and front contact of relay 4S2 to grounded battery, and interrupts the energizing circuit for the relay 4D through the chain of armatures and contacts of relays 4S2, 4S3 and 4S4. Ground is thus removed from the armatures at the head of all of the chain circuits controlled by the relays 4S2, 4S3 and 4S4 so that no other chain circuit path can be inadvertently completed.

The relay 4E, which became energized along with the "Hold" relay 4H in response to the code for preparing all outlying stations to transmit and which was held over conductors 432 and 416 from the armature and marking contact of relay 402, has a sufficiently slow-release characteristic that it does not release in response to any of the long spacing intervals contained in calling codes transmitted from the central office station and thus it has remained energized and has held the relay 4H energized through the holding circuit therefor previously described.

First outlying station transmits trouble identifying signal

The relay 4ST upon being energized completes its own holding circuit at its innermost front contact and armature through conductors 458 and 558, front contact and armature of relay 557 to ground. At the outer right-hand armature and front contact of relay 4ST an energizing circuit for the transmitting relay 4T1 is completed from ground at the middle upper front contact and armature of energized relay 5A10, over conductors 524, 424, 459, outer right-hand front contact and armature of relay 4ST, conductor 407, middle left-hand armature and back contact of relay 4C, conductor 408, inner armature and back contact of relay 4A, conductor 409, winding of relay 4T1, conductor 411 and back contact and armature of relay 4T2 to grounded battery. The relay 4T1 impresses a spacing impulse on the loop 11 extending to the central office station by means of its two upper armatures.

At the middle armature and front contact of relay 4ST a circuit is completed from grounded battery through conductor 448, outer left-hand armature and back contact of relay 4C, conductor 447, outer armature and back contact of relay

4A, conductor 446, outer lower front contact of relay 4T1 and armature by which it is engaged upon the energization of the relay, conductor 444, winding of stepping magnet 4SS, conductor 443, brush and zero contact of bank 4SS1, conductor 442, front contact and inner right-hand armature of relay 4H to conductor 424 which is receiving ground connection from the upper middle armature of relay 5A10. Thus the stepping magnet 4SS is energized preparatory to stepping its brushes on the back stroke. At its inner lower armature the relay 4T1 completes the energizing circuit for relay 4T2 which becomes energized to interrupt the circuit for the relay 4T1 which releases after an interval, thus returning the loop 11 to marking condition. The relay 4T1 interrupts the energizing circuit for the relay 4T2 and the energizing circuit for stepping magnet 4SS at its lower armatures and front contacts so that the brushes of the sequence switch 4SS are stepped to their No. 1 contact.

All of the contacts in the bank 4SS1 are connected to ground with the exception of the zero contact and this is true of the bank 4SS3. The numbered contacts of the bank 4SS2 are connected to the energizing windings of the corresponding ones of the series of relays 5B. Thus the No. 10 contact of bank 4SS2 is connected by conductors 423 and 523 to relay 5B10 as previously described. Similarly, the No. 5 contact is connected by conductors 461 and 561 to relay 5B5 and the No. 1 contact is connected by conductors 462 and 562 to relay 5B1. Following the stepping of brushes of stepping switch 4SS to the No. 1 contacts, direct ground is applied at the bank 4SS1 to the stepping magnet 4SS thus providing such ground connection independently of the inner right-hand armature of relay 4H and the middle upper armature of relay 5A10. Since the relay 5B10 is the only relay of the 5B series, the energizing circuit for which has been assumed to be prepared by its associated 5A series relay, namely, 5A10, no electrical circuit is completed by the brush associated with bank 4SS2 over conductor 463, back contact and armature of a relay 466, conductor 467 and energizing winding of relay 4C to grounded battery, so that the relay 4C is not at this time energized. The brush associated with contact bank 4SS3 prepares, in all positions except the zero position, a holding circuit for the relay 4C from ground over conductor 464 to the front contact associated with the right-hand armature of relay 4C.

Since each of the relays 4T1 and 4T2 interrupts the energizing circuit of the other these relays form a vibratory system which causes alternate marking and spacing impulses to be impressed upon loop 11. Each time that relay 4T1 is energized it completes the energizing circuit for stepping magnet 4SS and each time it is released it restores the loop 11 to marking condition and interrupts the circuit of magnet 4SS so that the brushes of stepping switch 4SS are advanced one step immediately following each spacing impulse. This transmission of alternate impulses and advancement of the brushes continues until the brush associated with the bank 4SS2 reaches contact No. 10 at which time the energizing circuit of relay 5B10 is completed over the previously described circuit which includes the operating winding of relay 4C. At its upper armature and front contact the relay 5B10 completes its holding circuit through relay 4G to the ground on the right-hand armature of relay 4D and at its lower armature and back contact it interrupts the holding circuit for the relay 5A10 which releases. Relay 5A10 releases relay 5H and removes the ground connection for the energizing circuit of transmitting relay 4T1 so that that relay cannot be reenergized and the loop 11 extending to the central office station will remain in marking condition. Although relay 5F may remain released to connect ground through lamp 509, seeking to reenergize relay 5A10, this relay cannot be reenergized as long as the relay 5B10 remains held, which is until relay 4D becomes again energized. Relay 4G operates to interrupt the conductive path from ground on the outer right-hand front contact of relay 4H to the armature next to the outermost of the lower armatures of relay 5H, so that with relay 5H released, the energizing circuit for relay 5A1 will not be completed. The reason for preventing the energization of relay 5A1 at this time will be set forth hereinafter.

The relay 4C completes its own holding circuit at its right-hand armature and front contact and therefore is held energized until the brush associated with bank 4SS3 has been advanced to its zero position. At its inner left-hand armature and front contact relay 4C completes the energizing circuit for relay 4A which at its inner armature and back contact introduces another interruption in the energizing circuit for the relay 4T1 and at its outer armature and back contact interrupts the direct energizing circuit for stepping magnet 4SS, which is also additionally interrupted at the outer lower armature and front contact of relay 4T1. At the inner left-hand armature and front contact the relay 4C also completes the energizing circuit of relay 466 in parallel with relay 4A, and the relay 466 interrupts the circuit through the operating winding of relay 4C, so that the circuit cannot be completed again until relay 4C, which is now held through its right-hand winding, is released. The purposes of relay 466 is to provide for the transmission of signals to identify two or more trouble conditions when they exist at one outlying station, as will be described later. At its outer left-hand armature the relay 4C transfers the battery connection supplied over the middle armature of relay 4ST to the stepping magnet 4SS through its interrupter contacts. The magnet 4SS thereafter operates in buzzer manner to advance its brushes to the zero contacts, where advancement is interrupted due to movement of the brush 4SS1 out of engagement with a grounded contact.

When the brush associated with bank 4SS3 reaches its zero position it releases the relay 4C which in turn releases the relay 4A, the relay 466. The relays 4A and 4C again prepare the energizing circuit for relay 4T1 and the direct energizing circuit for stepping magnet 4SS but these circuits are not completed because relay 5A10 remains released under the control of relay 5B10. From this it will be seen that ten spacing impulses separated by marking impulses have been transmitted to the central office station to indicate that the trouble condition represented by the relays 5A10 and 5B10 exists at the outlying station, and the outlying station remains with relays 4E, 4H, 4G and 5B10 energized. The relay 5A10 is precluded from operating to send the loop 11 to spacing condition but no other one of the series of relays 5A at that station is precluded from responding to the occurrence of its trouble conditions.

Outlying station operation when two or more trouble conditions exist

Assuming, as previously set forth, that no other trouble condition than that represented by the relay 5A10 existed, the relay 5H was released by the relay 5A10 when the latter was released, and accordingly, the relay 557 became released. The releasing characteristic of relay 557 is slow enough that it does not release, and in turn release the relay 4ST until the brushes of the stepping switch 4SS have been restored to the zero positions. Were this delay not provided, battery for operating the stepping magnet might be disconnected by relay 4ST before the advancement of the brushes had been completed.

Before describing the operation of the central office station in response to the signal transmitted to identify the trouble condition represented by the relay 5A10 the operation of the station shown in Figs. 4 and 5 when two trouble conditions have occurred will be described. It will be assumed for this purpose that following the energization and locking of relay 5A10 under the control of relay 5F but before the completion of transmission of the signal controlled by the relay 5A10 and the relay 5B10, the relay 5D operated and attempted to complete the energizing circuit for the relay 5A5. That circuit could not be completed while the relay 5A10 remained energized because the circuit was interrupted at the innermost lower armature and front contact of relay 5H, which was held energized by the relay 5A10. Consequently, no energizing circuit for the relay 5B5 was prepared at the lower armature of relay 5A5, so that the brush associated with contact bank 4SS2 could not complete an energizing circuit for relay 5B5 as it encountered the No. 5 contact of that bank. Upon the release of relay 5A10 as the relay 5B10 became energized through the contact bank 4SS1 and relay 4C, relay 5H became released and the effect of its release is to close the prepared energizing circuit for the relay 5A5, which reenergizes the relay 5H and prepares an energizing circuit for the relay 5B5. The relay 5A5 also applies ground through conductors 524, 424, inner right-hand armature and front contact of relay 4H and conductor 442 to the zero contact of bank 4SS1 in preparation for reenergization of stepping magnet 4SS and in parallel to conductor 459, outer right-hand armature and front contact of relay 4ST to the middle left-hand armature of relay 4C in preparation for the reenergization of relay 4T1, which at this time is prevented due to the fact that the relay 4C is energized.

Upon the arrival of the brushes of sequence switch 4SS in their zero positions, the brush associated with bank 4SS1 extends the ground connection from relay 5A5 through the stepping magnet 4SS and the relays 4A and 4C, upon releasing, complete the energizing circuit for the stepping magnet and for the transmitting relay 4T1. The relay 466 also releases and again completes a conductive path between the brush associated with bank 4SS2 and the operating winding of relay 4C. The relays 4T1 and 4T2 again operate in vibratory manner to transmit alternate spacing and marking impulses to loop 11 and the brushes of stepping switch 4SS advance until the brush associated with contact bank 4SS2 reaches its No. 5 contact and completes the energizing circuit for relay 5B5 through relay 4C. Five spacing impulses with intervening marking impulses have been transmitted and loop 11 is thereupon restored to marking condition, relay 5B5 is locked through its upper winding to relay 4D and the energizing circuit of stepping magnet 4SS is transferred to its interrupter contacts whereby the brushes are advanced in buzzer manner to their zero positions where they come to rest and release relays 4A, 4C and 466.

It will now be assumed that the trouble conditions to which the relays 5D and 5F are responsive occur in the reverse order, namely, with the relay 5D becoming energized before the relay 5F, or possibly even simultaneously. If they occur in succession the relay 5A5 will be energized and will prepare the energizing circuit for relay 5B5 and will energize the relay 5H. If they occur simultaneously, both the relays 5A5 and 5A10 will be energized and locked but only the energizing circuit for the relay 5B5 will be prepared since the relay 5A5 interrupts at its lower armature and back contact the conductive path to the lower armature of relay 5A10 through which the energizing circuit for the relay 5B10 will be prepared subsequently. Relays 4T1 and 4T2 are set in operation to transmit alternate marking and spacing impulses to loop 11 and the brushes of stepping switch 4SS are advanced step by step until the No. 5 contacts are reached when relays 5B5, 4C, 4A and 466 will be energized, relay 5B5 being held to the back contact and right-hand armature of relay 4D, and relay 4C being held to the ground on contact bank 4SS3 and in turn holding the relays 4A and 466. Stepping magnet 4SS is put in operation in buzzer manner to advance the brushes rapidly and relay 5A5 is released by the relay 5B5, thus completing the conductive path through its lower armature and back contact to the lower armature of relay 5A10. If relay 5A10 had become energized simultaneously with the relay 5A5 the release of relay 5A5 results directly in preparation of the energizing circuit for relay 5B10. If the relay 5A10 had not become energized simultaneously with the relay 5A5 but was waiting to be energized relay 5H would be released by relay 5A5, relay 5A10 would become energized and immediately reenergize relay 5H and would prepare the energizing circuit for relay 5B10. As the brushes of stepping magnet 4SS in advancing rapidly encounter the No. 10 contacts, the energizing circuit of relay 5B10 is not completed because the energizing circuit of relays 5B10 and relay 4C is interrupted at the back contact and armature of relay 466. Thus the brushes of sequence switch 4SS continue to advance in buzzer manner to their zero positions whereupon another cycle is initiated due to the fact that relay 5A10 has remained energized and relay 5B10 has not become energized and a second signal consisting of ten spacing impulses with intervening marking impulses will be transmitted while the brushes are reaching the No. 10 contact whereupon relay 5B10 will be operated and locked to the relay 4D, relay 5A10 will be released and the brushes of sequence switch 4SS will advance to their zero positions and come to rest. It will be apparent from the foregoing that the stepping switch 4SS will undergo one cycle of operation for each trouble condition that has occurred prior to the calling of the outlying station shown in Figs. 4 and 5 or that comes in during the transmission of trouble alarm signals from that station and that a separate set of alternate spacing and marking impulses representing a trouble condition will be transmitted during each cycle of the sequence switch 4SS. It will also be apparent that the signal to identify any trouble condition will not be transmitted more than once without specific call for such retransmission by the central office, since the 5B series relays, such as 5B5 and 5B10 become locked to the D relay which is operable only under the control of signals received from the central office station, and each 5B relay prevents the reoperation of its associated 5A relay, such as 5A5 and 5A10.

Operation of outlying station when no trouble condition exists

The transmission of a signal to indicate that a station is trouble-free is controlled by the relays 5A1 and 5B1. It will be noted that when the "hold" relay 4H became energized ground was connected from its outer right-hand front contact and armature, through conductor 433, armature and back contact of relay 4G, conductors 434 and 534, back contact and lower armature of relay 5B1, conductor 536, armature and back contact next to the outermost lower armature of relay 5H, which will be deenergized if there is no trouble condition, conductor 537 and winding of relay 5A1 to grounded battery. The relay 5A1 becomes operated and held in a manner similar to the relays 5A5 and 5A10, operates the relay 5H, and prepares an energizing circuit for the relay 5B1. Upon the operation of the relay 4ST in response to the roll call signal for the station shown in Figs. 4 and 5 the system of relays 4T1 and 4T2 is started and the brushes of stepping switch 4SS are stepped to the No. 1 contact following the first spacing impulse transmitted to loop 11. At the No. 1 contact of bank 4SS2 the energizing circuit for relay 5B1 is completed through the relay 4C whereby the transmission of further spacing impulses is estopped and the stepping magnet 4SS is put into buzzer operation to restore the brushes to the zero position. The relay 5B1 locks, not to the relay 4D as in the case of the relays 5B5 and 5B10 but instead to the outer right-hand armature and front contact of relay 4E. The reason for this is that when the relay 4E is released under the control of a release signal as will be presently described, the relay 5B1 is released in order to place the station shown in Figs. 4 and 5 in such condition that it is capable of responding to the next roll call and indicating that it is trouble-free if that condition still exists. It is not desirable to release the other relays in the 5B series, such as relays 5B5 and 5B10 when the station release signal is received as this would permit the continuing trouble conditions to reassert themselves as they did in the beginning. Accordingly, the other relays in the 5B series are locked to the relay 4D so that they will not be released until after the trouble conditions have been cleared and the station has again been called, whether in roll call of all stations or by specific individual call to test the station.

It should be noted that when any one of the relay series 5B, such as the relay 5B5 or 5B10, becomes energized its locking circuit is completed through the winding of relay 4G which thereupon becomes operated and held, thus interrupting the potential energizing circuit for the relay 5A1. The purpose in thus interrupting that circuit is to prevent the transmission of the signal indicating a trouble-free condition following the transmission of a signal indicating a trouble condition. When the "hold" relay becomes energized it completes the energizing circuit for the relay 5A1 if there is no trouble condition at the station, otherwise it does not complete the circuit of relay 5A1 for the reason that a trouble condition results in the energization of relay 5H which prevents the energization of relay 5A1. However, following the transmission of the signal which identifies a trouble condition the relay 5H is released and would thereupon complete the energizing circuit for the relay 5A1 were it not for the provision of the relay 4G to interrupt such energizing circuit. Operation of relay 5A1 following the transmission of a trouble signal would, upon the return of the stepping switch brushes to normal, restart relays 4T1 and 4T2 and the advancement of the stepping switch brushes to effect the transmission of one spacing impulse, and the energization and locking of the relay 5B1, whereby a false indication of absence of a trouble condition would be transmitted. There is the possibility that a trouble condition may occur after relay 4H has become energized and before the stepping switch brushes have returned to their zero positions incident to transmission of the "no-trouble" signal. Under these circumstances the stepping switch will restart immediately for the transmission of the trouble signal, thus producing contradictory reports at the central office station. The fact that the trouble condition is of recent occurrence may be deduced from such contradictory reports, or the outlying station may be rechecked, in which case the transmission of the "no-trouble" signal will be estopped, and only the trouble signal will be transmitted.

Outlying station relinquishes line

Reference has previously been made to the fact that when relay 5H becomes energized it completes at its lowermost armature and front contact the energizing circuit of a slow-release relay 557 which prepares a circuit from its grounded armature through the front contact, conductors 558 and 458, to the innermost armature of the "start" relay 4ST for holding the relay 4ST energized through its innermost front contact and winding of the relay to grounded battery when the relay 4ST is operated by the relay 4D. The purpose of the relay 557 is to enable the station shown in Figs. 4 and 5 to determine when the transmission of all trouble signals has been completed so as to preclude the station from transmitting signals to identify trouble conditions which may subsequently occur during the roll call of stations. Relay 5H is energized as long as any relay in the series 5A is energized and when any relay in the 5A series is waiting to be energized, such waiting being due to the fact that another of the relays in the series is already energized, the relay 5H will be released only long enough for the waiting relay to be energized and will be immediately reenergized. However, when signals representing all of the trouble conditions have been transmitted and the relays in the series 5A have been released, the relay 5H will be released and will not be reenergized. The relay 557 will thereupon be released and after a delay interval will interrupt the holding circuit for the relay 4ST which will release. This will prevent the relay 4T1 from being operated under the control of a subsequently occurring trouble condition so that the station has now been deprived of the ability to transmit trouble identification signals. Were it not for the provision of the release of relay 4ST following the transmission of signals appropriate to the then existing condition of the station, the station could at any time during the roll call seize control of the loop 11 extending toward the central office and transmit signals indicative of the trouble condition, which would be likely to interfere with the transmission of signals from the station then in process of transmitting and which would in any case result in registering the signal thus interjected on the loop 11 in an incorrect one of the banks of indicators at the central office station. Thus the final condition of an outlying station, such as that shown in Figs. 4 and 5, at the end of signal transmission is that all relays are released except the relays 4E and 4H and also with the possible exception of relay 4G, if there was a trouble condition whereby one of the relays in the series 5B other than the relay 5B1 became energized and held.

Central office registers received signals

The trouble identification signals consisting of alternate spacing and marking impulses are received at the central office station and are followed by the armature of relay 1L. Since the relay 1Q is now energized the armature of relay 1L controls the stepping magnet of stepping switch 1A and also controls the relay 1M in parallel therewith over conductor 101, right-hand armature and front contact of relay 1Q, conductor 116, conductor 117 and winding of stepping magnet 1A to ground and in parallel therewith through conductor 118 and winding of relay 1M to ground. Relay 1M has a slow-to-release characteristic such that it will not follow the oscillations of the armature of relay 1L but will release only in response to a steady marking signal following a set of alternate impulses comprising a trouble condition identifying signal. Upon the energization of relay 1M its left-hand armature disconnects grounded battery from the back contact which is connected by conductor 126 to the brush associated with stepping switch bank 1A1. At its outer right-hand armature the relay 1M interrupts a circuit from the brush associated with contact bank 1A2 through conductor 127, outer right-hand armature and back contact of relay 1M, conductor 128 and the interrupter contacts of stepping magnet 1A to the grounded winding of that magnet. All of the contacts of bank 1A2 except the zero contact are connected together and to grounded battery. The back contact with which the grounded inner right-hand armature of relay 1M cooperates is connected by conductors 176 and 276 through the winding of relay 2N to grounded battery. From this it will be apparent that relay 1M, when energized, interrupts the conductive paths to the brushes of sequence switch 1A and also releases the normally energized relay 2N. The front contact of relay 2N is connected to positive battery and its armature is connected to a second primary winding 279 of the previously mentioned transformer which has secondary winding 259. The impulse generated in the secondary of the transformer as relay 210 is released is of such polarity as to aid rather than oppose the biasing battery of discharge tube 2A so that the tube is not rendered conductive.

Stepping magnet 1A becomes energized on the transition of relay 1L to spacing in response to the first spacing impulse received from the outlying station and releases to advance the brushes to the No. 1 contact when the armature is restored to marking at the end of the first spacing impulse. For each spacing impulse the brushes are advanced one step and assuming that the signal received contains ten spacing impulses the brushes will come to rest on their No. 10 contacts due to the fact that no further spacing impulses are received as the brushes of stepping switch 4SS in Fig. 4 are advanced in buzzer manner to their zero positions. After the armature of relay 1L has remained on its marking contact for an interval slightly longer than the marking impulses contained in the code combination received from the outlying station, the relay 1M releases. This interval should be as short as possible commensurate with the prevention of release of the relay 1M in response to marking impulses contained in a signal received from an outlying station, for the reason that the brushes of the sequence switch 1A are advanced no farther until the relay 1M is released, whereas in the meantime the brushes of stepping switch 4SS are being advanced in buzzer manner to their zero positions and upon arrival in such positions they release the relays 4C and 4A. The relay 4A determines the time at which the brushes of stepping switch 4SS will be started on another cycle if there is another trouble condition existing at the outlying station and such cycle should not be restarted until the brushes of the stepping switch 1A have been restored to their zero positions so that they will be able to advance step by step therefrom in response to another set of impulses from the same outlying station if there is another trouble condition at that station.

Upon the release of the relay 1M its left-hand armature establishes a circuit through the brush associated with contact bank 1A1, No. 10 contact of that bank, since it has been assumed that the brushes have advanced to the No. 10 contact, conductor 131, middle armature and front contact of relay 1D1, conductor 132 and winding of relay 1E10 to ground, whereby the relay 1E10 will be energized. The relay 1E10 completes the circuit of lamp 1B10 through its left-hand armature and front contact and completes its own holding circuit through its right-hand armature and front contact, conductor 133, normally closed key 134 to grounded battery.

At its outer right-hand armature and back contact relay 1M establishes an energizing circuit for the stepping magnet 1A through the interrupter contacts whereby the brushes of stepping switch 1A will be advanced in buzzer manner to their zero positions and upon arrival of the brushes in those positions the energizing circuit for stepping magnet 1A will be interrupted at the brush and zero contact of bank 1A2. At its inner right-hand armature and back contact the relay 1M reestablishes the energizing circuit for the relay 2N. This relay controls the advancement of sequence switch 3C and the starting of sequence switch 3B on another cycle wherefor the relay 2N should be very slow operating to afford time for the relay 557 at an outlying station to release and in turn release the holding circuit for the relay 4ST, so that the relay 2N will not be operated until the outlying station has determined that it has no further trouble signals to transmit.

If the relays 4T1, 4T2 and the stepping switch 4SS enter upon another set of trouble signal transmitting operations, the relay 557 will be prevented from releasing and the first spacing impulse of the signal will cause the relay 1M to be reenergized before the relay 2N has had time to operate. Accordingly, the stepping switch 1A will again be advanced until no further spacing impulses are received whereupon the relay 1M will be released and the lamp in the 1B series corresponding to the point at which the brushes of switch 1A stop will be lighted. The lighting of this lamp will identify the second trouble condition existing at the outlying station.

Central office transmits second selective signal of roll call

Assuming that there are no further trouble conditions at the outlying station, that station will be cut off by the release of the relay 4ST and after an interval governed by the characteristics of the relay 2N that relay will be operated, the brushes of switch 1A having in the meantime advanced to their zero positions. The operation of relay 2N will result in a flow of current through primary winding 279 of the transformer in Fig. 2 which will cause an impulse in the secondary 259 of the proper polarity to overcome the biasing battery and render the tube 2A conductive. Tube 2A operates the relay 2—0 which operates relay 2BD by means of its inner armature and front contact and operates stepping magnet 3C by means of its outer armature and front contact through the armature and back contact of relay 264 which is now deenergized due to the fact that relay 255 is held energized. The only circuit changes that are effected by the brushes of stepping switch 3C upon advancement to the No. 3 contact occur at the contact banks 3C1 and 3C2. At the bank 3C1 ground is disconnected from conductor 351A and becomes connected to conductor 351B to release relay 1D1 and to energize the next relay in the 1D series over conductors 351B, 352B and 152B. At the contact bank 3C2 battery connection is removed from conductor 356 but this has no effect as relay 255 is now held energized and the other circuits supplied over conductors 356, 256 are open at the left-hand and outer right-hand armatures of relays 255.

The control of relay 2—0 over the relay 2BD is the same as that previously described, namely, to operate the relay 2BC which in turn operates the relay 2W. The result of this is to start the transmission of a signal to call another outlying station by the vibratory operation of the relays 2S and 2Z and to advance stepping switch 3B step by step incident to each line current transition. When the brushes of stepping switch 3B reach the No. 2 contacts, which occurs incident to the second signal transition, the character of which is from spacing to marking due to the energization of relay 2Z and the consequent release of relay 2S, a circuit is completed from ground on the brush associated with contact bank 3C1, the No. 3 contact of that bank, conductors 351B and 352B to which the No. 2 contact of contact bank 3B4 is connected, brush associated with bank 3B4, conductor 334, back contact and left-hand armature of relay 3AB and winding of relay 3AC to grounded battery. The relay 3AC thus becomes energized.

At its outer armature and back contact the relay 3AC disconnects ground supplied to relay 2S through the outer left-hand armature and back contact of relay 2X, so that the relay 2S is prevented from being reenergized due to the release of relay 2Z by relay 2S. At its middle armature and front contact the relay 3AC connects grounded battery over conductors 381 and 281 so as to hold the relay 2Z energized and prevent the application of battery to relay 2S. This will result in a prolonged marking impulse on loop 12 which will endure until relay 3AC is released and this relay has a slow-to-release characteristic. This prolonged marking interval is shown following the second transition in Fig. 10 which is a representation of the signal transmitted to call the second outlying station.

At its inner armature and front contact the relay 3AC completes the energizing circuit for a relay 3AD which, at its left-hand armature and back contact interrupts the energizing circuit for relay 3AC, and at its right-hand armature and front contact establishes its own holding circuit from grounded battery through conductor 334 back to the ground on the brush associated with stepping switch bank 3C1 from which relay 3AC was originally energized. Upon the release of relay 3AC the circuits of relays 2S and 2Z are restored to their previous condition and these relays resume buzzer operation to continue transmission of the station calling signal and to advance sequence switch 3B. As the brushes of that stepping switch leave the No. 2 contacts the holding circuit for relay 3AD is interrupted and that relay releases.

Thereafter the cycle of operation of stepping switch 3B is exactly like the preceding cycle and a signal is transmitted which from the third current transition to the end is exactly like the one previously transmitted as shown by comparing Figs. 9 and 10. The long spacing intervals following the eleventh and thirteenth transition are introduced by the operation of the relays 3AA and 3AB but the long marking impulse following the second transition is produced by the operation of the relays 3AC and 3AD whereas the long spacing impulse following the first transition of the previously transmitted cycle was produced by the relays 3AA and 3AB. Following the transmission of the final long spacing impulse after the thirteenth transition, relays 2X and 2V are operated as previously to prevent further operation of the relay 2S and to reestablish buzzer operation of stepping magnet 3B whereby the brushes are advanced rapidly to their zero positions and come to rest, the brushes of stepping switch 3C remaining on their No. 3 contacts.

Second outlying station responds

It will be remembered that the armatures of the signal responsive step-by-step selectors at the outlying stations come to neutral during a pause in a signal train whether that pause is of marking or spacing nature. Since the first pause in the signal shown in Fig. 10 follows the second current transition whereas that shown in Fig. 9 occurs after the first current transition the step-by-step selectors will be advanced two steps before their armatures are permitted to come to neutral position and the contact disc of a step-by-step selector at a different outlying station will be held, the discs at all other stations will be released. Following the pause the discs will be advanced nine steps thus bringing the disc which was previously held at its eleventh step where it will again be held. At its second step to the one station at which the contact disc is held in the eleventh position the disc will be advanced in response to the twelfth and thirteenth signal transitions to the thirteenth contact of the step-by-step selector where the relay corresponding to the relay 4S2 will be operated to operate in turn the relay corresponding to relay 4D and the relay corresponding to relay 4ST. This will start the transmission of signals from the called outlying station to indicate the operative condition of that station.

Central office registers signal from second station

At the central office station the receiving apparatus responds in the same manner as previously described to the signal received from the second called station and if the signal contains only one spacing impulse, to indicate a "no trouble" condition the brushes of stepping switch 1A are advanced only to the No. 1 contact. Following the release of relay 1M a circuit is completed over the uppermost armature and front contact of the relay (not shown) associated with the conductor 152B to operate the uppermost lamp relay in the second series, corresponding to the relay 1E1 to effect the lighting of the uppermost lamp in the second series, corresponding to the lamp 1B1. The release of relay 1M also results in buzzer operation of the stepping magnet 1A to restore the brushes of the stepping switch to zero position and in reoperation of relay 2N.

Central office transmits further selective signal

Again the relay 2N energizes transformer secondary 259 to initiate those operations which result in the stepping of the brushes of stepping switch 3C to the No. 4 contacts and in the operation of relay 2W to initiate the transmission of another station calling signal and the advancement of the brushes of stepping switch 3B.

With the brushes of stepping switch 3C engaging their No. 4 contacts a circuit will be completed for the energization of the third relay in the series 1D1 to 1D10 and from the same grounded brush which completes the energizing circuit for that relay a circuit will be prepared to the No. 3 contact of bank 3B2 for the energization of the relay 3AA. Thus when the stepping switch 3B reaches the No. 3 contact incident to the transmission of the third current transition which is from marking to spacing, a long spacing interval will be introduced due to the operation of relays 3AA and 3AB and a signal as represented in Fig. 11 will be transmitted to effect the selective calling of another outlying station. The called station will respond and transmit a "no-trouble" signal or a trouble signal identifying the condition existing thereat and the corresponding lamp in the third series of lamps will be lighted at the central office station. Relay 2N will then be operated to advance the brushes of stepping switch 3C to the No. 5 contact and to start another cycle of switch 3B. With the brushes of stepping switch 3C engaging the No. 5 contacts the brush associated with bank 3C1 completes the circuit for the next relay in the series 1D1 to 1D10 and prepares a ground path for the energization of relay 3AC through the No. 4 contact of contact bank 3B4. When the brushes of stepping switch 3B reach the No. 4 contacts which occurs incident to the transmission of the No. 4 signal transition which is from spacing to marking, a long marking interval will be introduced by the relays 3AC and 3AD to effect the transmission of the signal shown in Fig. 12 for selectively calling another outlying station. The called station will respond and transmit one or more signals appropriate to its condition whereupon the relay 2N will again be operated.

From the foregoing it will be apparent that the signals are varied to selectively call the outlying stations by the alternate employment of the pair of relays 3AA and 3AB and the pair of relays 3AC and 3AD under the alternate control of contact banks 3B2 and 3B4 to introduce alternate long spacing and marking intervals at progressively later points in the signals as the transmission of successive signals proceeds. This operation continues until all of the outlying stations have been called and their operative conditions have been registered on the banks of lamps in Fig. 1.

Central office releases outlying stations and returns to normal

Following the reception of the incoming signal from the last outlying station to be called the brushes of stepping switch 3C are stepped to the next set of contacts which in the specific embodiment of the invention disclosed, involving ten outlying stations, would be the No. 12 contacts. In the bank 3C1 there are no connections to any of the contacts beyond No. 11, so that no circuits will be completed to energize the relays 3AA or 3AC during the remainder of the cycle of stepping switch 3C1. At the contact bank 3C2 battery is connected from the brush through all of the contacts from No. 12 to the end of the bank over conductor 386 and winding of relay 3BB to ground. At bank 3C3 ground is connected by its associated brush over all of the contacts from No. 12 to the last contact in the bank and through conductor 387, interrupter contacts of stepping magnet 3C and winding of that magnet to grounded battery. Thus the stepping switch 3C is set in operation in buzzer manner to advance its brushes rapidly to their zero positions. No change in connections occurs at any of the other three banks of contacts of stepping switch 3C prior to arrival of the brushes in the zero position.

At its inner armature and front contact the relay 3BB connects ground over conductors 388, 288 and winding of relay 2P to grounded battery whereby the relay 2P becomes energized to drive the loop 12 to spacing condition. This spacing condition continues until the brushes of stepping switch 3C have been advanced to their zero positions and the relay 3BB, which has a slow-to-release characteristic, releases. At its outer armature and back contact the relay 3BB disconnects the front contact of relay 2BC from the winding of relay 2W so that the latter relay cannot become energized under the control of relay 2BC. It is to be remembered that the operation of the relay 2—0 under the control of relay 2N which caused the brushes of stepping switch 3C to step to their No. 12 contacts also caused the operation of relay 2BD which, upon release, causes the operation of relay 2BC. Were it not for the preparatory opening of the circuit of relay 2W at the outer armature and back contact of relay 3BB the relay 2W would be operated by the relay 2BC and would in turn operate the relay 2S. This would not only restore the loop 12 to marking condition, thus interfering with the transmission of the long spacing signals, but would also cause the operation of relay 2Y to restart the stepping switch 3B through another cycle. This is not desired since the automatic signal transmitting apparatus at the central office station is in the process of restoring to normal position. Upon the arrival of the brushes of stepping switch 3C in the zero positions, the energizing circuit for relay 3BB is interrupted so that that relay releases and restores the loop 12 to marking condition and ground is disconnected from the interrupter contact energizing circuit for the stepping magnet 3C so that the brushes are arrested in their zero positions. At the contact bank 3C5 ground is removed from the holding circuit of relay 1Q which releases and at the contact bank 3C6 ground is removed from the holding circuit of relay 255 which releases. Thus the central office station is restored to the identical condition which existed initially with the exception that at least one lamp in each of the banks of lamps in Fig. 1 is energized to denote the condition of the outlying stations which the banks of lamps represent. After the condition of the lamps has been noted and a record made of those which are lighted, if desired, the holding circuits for the lamp operating relay may be released by momentarily opening the key 134.

The long spacing signal imposed on loop 12 by relay 2P sends the receiving line relays at all of the outlying stations, exemplified by the relay 402 in Fig. 4, to the left-hand or spacing contact for a long interval. This advances the step-by-step selectors at all of the stations one step and when the discharging current for the condenser in series with the selector dies out the contact discs will be released and restored to normal at all of the stations except at that station the calling signal of which has a long spacing interval following the first signaling current transition. Fig. 9 represents that particular signal and in the description of the operation of the system the station shown in Figs. 4 and 5 was identified as the one responsive to the signal shown in Fig. 9. Accordingly, it may be assumed that at this station the contact disc of the step-by-step selector is held at the No. 1 step. The contact disc completes no circuit in this position so that this operation is of no consequence.

With the receiving relay 402 in spacing condition for an interval considerably longer than any of the long spacing intervals that were contained in the station calling signals the relay 4E and corresponding relays at all of the outlying stations have their holding circuits interrupted long enough for the relays to release. The relay 4E releases the relay 4H and the relay 5B1, if it had been held energized following the transmission of a signal indicating trouble-free condition of the station, is released by the relay 4H. Thus at all of the stations which were indicated to be trouble-free the entire set of station apparatus is restored to normal condition. At those stations which reported the existence of trouble conditions, corresponding ones of the relays in the 5B series remain held through the right-hand armature and back contact of relays corresponding to the relay 4D. Upon restoration of the loop 12 to marking following the release of the relay 2C all of the step-by-step selectors are again stepped one step. Since it has been assumed that the contact disc of the selector at the station shown in Figs. 4 and 5 was held at the first step in response to the transition to spacing condition, that disc will be stepped to the second step in response to the restoration to marking condition. The disc has no holding pin in the second step position and, accordingly, the disc is restored to normal. At all of the other outlying stations the contact discs return to normal after being stepped one step.

Central office sends signals to remedy troubles or to register call for attendant

Following the reception of trouble-free and trouble-indicating signals from all of the outlying stations the attendant at the central office station may take appropriate action with reference to a trouble condition at any stations which exhibit such conditions. The dial 201 which controls the transmitting relay 2P permits the attendant to transmit code signals which will cause specific operations to be performed at any station selectively; for example, if the trouble condition is such that no remedy can be effected automatically under remote control and it is necessary to dispatch a service attendant to remedy the trouble. It is sometimes the practice to provide a telephone at the central office station and one at each of the outlying stations, all interconnected by a common circuit which includes no equipment for ringing. The selective calling equipment according to the present invention affords means for registering a calling-in signal at any outlying station whereby a service attendant may be instructed to communicate with the central office by telephone. This may be accomplished in the case of the station shown in Figs. 4 and 5 by the transmission of a dial code which will cause the step-by-step selector to step to the eleventh step and pause, where the circuit of relay 4S1 will be completed, and then to the fifteenth step and pause by the transmission of four additional line current transitions to effect the energization of relay 4S3. Upon the release of the relay 4S1, which occurs after relay 4S3 is energized a circuit will be completed from the grounded back contact and inner armature of relay 4S1, winding of relay 4B, movable front contact and stationary back contact of the relay, second innermost armature and back contact of relay 4S2, second innermost armature and front contact of relay 4S2, second innermost armature and back contact of relay 4S4 and winding of relay 4F to grounded battery. The relay 4F will set in operation the alarm 471 and the relay 4F will be held by the key 472 which an attendant may operate to release relay 4F.

The chain circuit paths through the other sets of armatures and back or front contacts of the relays 4S2, 4S3 and 4S4 which may be completed by the operation of those three relays in permutational combinations provide, in cooperation with relay 4B controlled by relay 4S1, circuits for effecting remedies automatically. For example, these selectively operable circuits may control the switching in of auxiliary batteries, the starting or stopping of an auxiliary gasoline engine for supplying emergency power by means of an auxiliary generator, or the releasing of sleet repeaters which may have been connected automatically into the circuit as a result of a sleet condition. These are merely examples of controls which may be effected by signals transmitted from the central office station and there may be numerous other types of operations which it may be desired to accomplish in the same manner.

It should be noted that each of the station calling codes shown in Figs. 9 to 13, inclusive, contains fourteen line current transitions, the effect of which is to step the step-by-step selector at the called station to its fourteenth position. The contact disc completes circuits at the odd-numbered contacts beginning with 11 and accordingly has holding pins for those positions, but it has no holding pins for the even-numbered positions from fourteen to eighteen, inclusive. Accordingly, when the armature of magnet 418 goes to neutral position following the fourteenth transition the disc is released and is restored to normal by its restoring spring. In the case of transmission of calling codes from dial 201 a different situation exists since the dial has no provision for transmitting long pulses and the exact number of current transitions must be transmitted to effect the stepping of the step-by-step selector at the called station to the desired positions. Thus, upon the signal responsive operation of the step-by-step selector operated by magnet 418 to its fifteenth contact to effect the operation of relay 4F the contact disc will remain in the advanced position until dial 102 is again operated. In order to release the selector it is necessary for the attendant at the central office station to operate the dial to transmit one additional pulse, which will step the contact disc shown in Fig. 4 to its sixteenth step where it will not be held but will be permitted to return to normal position.

The dial 102 is of a type which closes its contacts to energize the relay 2P and reopens its contacts to release the relay in response to each two digital steps of the dial. Thus if an even number is dialed the dial contacts are in the same condition at the end of the dialing operation as they were at the beginning but when an odd number is dialed the dial contacts are left in the opposite condition from that which existed before the dialing operation. These references to odd and even numbers refer to each digit dialed and not to the matter of whether the number representing a call is odd or even. The calling codes shown in Figs. 9 to 13, inclusive, and also the calling code shown in Fig. 8 and the releasing signal shown in Fig. 14 contain an even number of current transitions and accordingly the loop 12 is always left in the same condition, namely, the marking condition. Similarly, the dialing of the digit 1 following the dialing of codes for selecting relays 4S2, 4S3 or 4S4 represents the transmission of one current transition in addition to the previously transmitted odd number of current transitions and, accordingly, restores the loop to marking condition.

In the process of advancing the contact disc at the station shown in Fig. 4 to contact 13, 15 or 17 to perform an operation at the outlying station, the contact disc came to rest momentarily on the eleventh contact thus completing the energizing circuit for the relay 4S1 from which the relays 4E and 4H became energized and held through their holding circuits. Thereafter the contact disc stepped to the next selected position or positions and ultimately came to rest on one of the contacts 13, 15 or 17 where it remained until the additional single pulse was transmitted to release it. The pulse which stepped the disc to the final selecting position is of spacing nature and accordingly, while the disc remains in that position, relay 402 remains in spacing position and releases the holding circuit for relay 4E which has a slow-to-release characteristic. If the attendant at the central office station delays the dialing of the digit 1 to release the step-by-step selector for an interval longer than the release time of relay 4E, that relay will be released. However, if the attendant transmits the additional impulse promptly the relay 402 will be restored to marking condition and will hold the relays 4E and 4H energized. In order that it will not be necessary to place dependence upon delaying the dialing of the digit 1 and in order to provide a positive operation for releasing the relay 4E the normally open key 291 connected between ground and the winding of relay 2C has been provided. Upon the operation of this key the relay 2P is operated and should be held closed for an interval which is amply sufficient to effect the release of relay 4E. Loop 12 will remain in spacing condition while key 291 is closed and will return to marking condition when the key is released. In connection with the operation of key 291 all of the step-by-step selectors at the outlying stations will respond in the same manner that they did to the long spacing interval which was transmitted, to effect the release of all of the outlying stations and the contact discs of all of the selectors will return to normal.

Central office may recheck all stations for troubles

If an attendant at the central office station should for any reason find it necessary to recheck for trouble conditions at outlying stations following a roll call and reception of the signals from the stations or should the attendant desire to make a check of the stations even though none has indicated a trouble condition, by starting the automatic roll call mechanism, he may accomplish this by closing key 141, which will connect grounded battery over conductor 101, right-hand armature and back contact of relay 1Q and conductors 102 and 202 to the relay 2R, for a sufficient length of time to effect the energization of the relay 2R. The effect of this is the same as if relay 1L had gone to spacing condition for a sufficient interval to energize relay 2R and will start the automatic roll call apparatus. Since the calling or rechecking of a station for trouble condition reports results in the operation of relay 4D over conductor 453, the holding circuit for any one of the relays in the series 5B that is energized will be interrupted. This permits the associated relay in the 5A series to be reoperated, if the trouble still exists so that the trouble will again be reported.

Attendant at outlying station may call central office

It has previously been stated that each of the outlying stations has a normally closed key, such as the key 401', in one side of the loop 11 the operation of which will open the loop. It has also been stated previously that the relay 1K is an alternating current relay and will not release in response to polar signals on loop 11 but will release in response to opening of the loop. When relay 1K releases it interrupts the energizing circuit for relay 1J which at its left-hand armature and back contact completes the energizing circuit for a relay 1H. At its outer armature and front contact the relay 1H completes the circuit of a lamp 142, the purpose of which may be to indicate to the attendant at the central office station that an attendant at an outlying station desires to convey informaion by telephone. At its inner armature and front contact the relay 1H completes a holding circuit through normally closed key 143 so that the lamp 142 may be operated as a result of a momentary opening of loop 11 and the lamp will remain in operation until it is released by operation of key 143. The relay 1J has a slow-to-release characteristic so that it will not be released and cause false operation of lamp 142 in response to "hits" on loop 11.

At its right-hand armature and back contact the relay 1J completes the energizing circuit of a relay 1G which is made very slow to operate. The operating time of relay 1G may be from thirty seconds to several minutes for example. At its armature and front contact the relay 1G completes the operating circuit for an open line alarm device 144 which may be a lamp or gong for attracting the attention of the attendant. If the alarm 144 becomes operated it will indicate to the attendant that the loop 11 is in trouble by having become open at some point, because it will be an operating routine that a service attendant will not operate a line opening key at an outlying station, such as the key 401 or 601, for a sufficient interval to bring in the open line alarm when such attendant is seeking to operate the lamp 142 as a calling-in signal.

Although a specific embodiment of the invention has been disclosed in the drawings and described in the foregoing specification, it will be understood that the invention is not limited to such specific embodiment but is capable of modification and rearrangement without departing from the spirit of the invention and within the scope of the appended claims.

What is claimed is:

1. In a communication system, a principal station, a plurality of subordinate stations, a communication channel interconnecting said stations, means at said subordinate stations for transmitting signals over said channel to said principal station, a plurality of register devices at said principal station of which one is allocated to each subordinate station, means controlled by signals received from said subordinate stations for actuating said register devices, a stepping switch having a contact bank for associating said registers with said actuating means in succession, and means responsive to cessation of signals from a subordinate station for a predetermined interval for advancing said stepping switch.

2. In a communication system, a principal station, a plurality of subordinate stations, a communication channel interconnecting said stations, means at said subordinate stations for transmitting signals over said channel to said principal station, a plurality of banks of register devices at said principal station of which one bank is allocated to each subordinate station, a stepping switch operable in response to signals received from said subordinate stations for selecting a particular register device in a bank to be operated, a second stepping switch for associating said banks of registers with said first stepping switch in succession, and means responsive to cessation of signals from a subordinate station for a predetermined interval for advancing said second stepping switch.

3. In a communication system, a principal station, a plurality of subordinate stations, a communication channel interconnecting said stations, means at said subordinate stations for transmitting combinations of signaling impulses over said channel to said principal station, a plurality of banks of register devices at said principal station of which one bank is allocated to each of said subordinate stations, a stepping switch at said principal station having a contact bank and a traversing brush operable to traverse the entire contact bank in response to each combination of signaling impulses received from a subordinate station for selectively operating one of the register devices in a bank for each traversal of the contact bank, a second stepping switch for associating said banks of registers with said first stepping switch in succession, and means responsive to cessation of signals from a subordinate station for a predetermined interval for advancing said second stepping switch.

4. In a communication system, a principal station, a subordinate station, transmitting and receiving line circuits interconnecting said stations, means at said subordinate station individually responsive to various trouble conditions thereat for placing the transmitting line circuit extending to said principal station off normal, means at said principal station responsive to said off-normal condition for transmitting over the transmitting line circuit extending to said subordinate station a preliminary conditioning signal, means at said subordinate station responsive to said preliminary signal for restoring its transmitting line circuit to normal, means at said principal station for automatically transmitting a calling signal immediately following said preliminary signal, and means at said subordinate station operable in response to said calling signal for transmitting over its transmitting line circuit a signal indicative of said trouble condition.

5. In a communication system, a principal station, a subordinate station, transmitting and receiving line circuits interconnecting said stations, means at said subordinate station individually responsive to various trouble conditions thereat for placing the transmitting line circuit extending to said principal station off normal, means at said principal station responsive to said off-normal condition for transmitting over the transmitting line extending to said subordinate station a preliminary conditioning signal, means at said subordinate station responsive to said preliminary signal for restoring its transmitting line circuit to normal, means at said principal station for automatically transmitting a calling signal immediately following said preliminary signal, means at said subordinate station operable in response to said calling signal for transmitting over its transmitting line circuit a signal indicative of said trouble condition, and lock-out means at said subordinate station for precluding repetitious off-normal conditioning of the transmitting line circuit extending from said subordinate station by the continuance of the trouble condition.

6. In a communication system, a principal station, a plurality of subordinate stations, a line circuit for transmitting signals from said principal station to all of said subordinate stations, a line circuit for transmitting signals from all of said subordinate stations to said principal station, means at each of said subordinate stations individually responsive to various trouble conditions thereat for placing the second-mentioned line circuit off normal, means at said principal station responsive to said off-normal condition for transmitting over the first-mentioned line circuit a preliminary conditioning signal, means at each of said subordinate stations responsive to said preliminary signal for conditioning the station to transmit signals indicative of the presence or absence of a trouble condition thereat, means responsive to the preliminary signal at the subordinate station which placed the second-mentioned line circuit off normal for restoring said line circuit to normal condition and at all other subordinate stations for estopping the placing of said line circuit off normal upon the occurrence of a trouble condition thereat, means at said principal station for automatically transmitting over said first-mentioned line circuit the selective station calling signals for all of said subordinate stations in succession, and means at each of said subordinate stations operable in response to its selective calling signal for transmitting over said second-mentioned line circuit signals indicative of trouble conditions thereat or alternatively, a signal indicative of a trouble-free condition.

7. In a communication system, a principal station, a plurality of subordinate stations, a line circuit for transmitting signals from said principal station to all of said subordinate stations, a line circuit for transmitting signals from all of said subordinate stations to said principal station, means at each of said subordinate stations individually responsive to various trouble conditions thereat for placing the second-mentioned line circuit off normal, means at said principal station responsive to said off-normal condition

for transmitting over the first-mentioned line circuit a preliminary conditioning signal, means at each of said subordinate stations responsive to said preliminary signal for conditioning the station to transmit signals indicative of the presence or absence of trouble conditions thereat, means also responsive to said preliminary signal at the subordinate station which placed said second-mentioned line circuit off normal for restoring said line circuit to normal condition and at all other subordinate stations for estopping the placing of said line circuit in off-normal condition upon the occurrence of a trouble condition thereat, means at said principal station for automatically transmitting selective calling signals for all of said subordinate stations in succession, means at each of said subordinate stations operable in response to its selective calling signal for transmitting over the second-mentioned line circuit signals indicative of trouble conditions thereat or alternatively, a signal indicative of trouble-free condition of the station, and means at each subordinate station effective following the transmission of signals indicative of all trouble conditions existing thereat or of trouble-free condition for depriving the station of further control over said second-mentioned line circuit.

8. In a communication system, a principal station, a plurality of subordinate stations, a line circuit for transmitting signals from said principal station to all of said subordinate stations, a line circuit for transmitting signals from all of said subordinate stations to said principal station, means at each of said subordinate stations individually responsive to various trouble conditions thereat for placing the second-mentioned line circuit off normal, means at said principal station responsive to said off-normal condition for transmitting over the first-mentioned line circuit a preliminary conditioning signal, means at each of said subordinate stations responsive to said preliminary signal for conditioning the station to transmit signals indicative of the presence or absence of trouble conditions thereat, means also responsive to said preliminary signal at the subordinate station which placed said second-mentioned line circuit off normal for restoring said line circuit to normal condition and at all other subordinate stations for estopping the placing of said line circuit in off-normal condition upon the occurrence of the trouble condition thereat, means at said principal station for automatically transmitting selective calling signals for all of said subordinate stations in succession, means at each of said subordinate stations operable in response to its selective calling signal for transmitting over the second-mentioned line circuit signals indicative of trouble conditions thereat or alternatively, a signal indicative of trouble-free condition of the station, means at each subordinate station effective following the transmission of signals indicative of all trouble conditions existing thereat or of trouble-free condition for depriving the station of further control over said second-mentioned line circuit, and means at said principal station for delaying the transmission of each succeeding selective calling signal until the last-mentioned means at the previously called station has operated.

9. In a communication system, a principal station, a plurality of subordinate stations, a signal transmission channel interconnecting all of said stations, means at each of said subordinate stations for transmitting over said channel a signal common to the occurrence of any of a plurality of trouble conditions, means at said principal station responsive to said common signal for transmitting over said channel the selective calling signals of all of said subordinate stations in succession, means at said subordinate station responsive to their respective calling signals for transmitting over said channel signals representing the identity of any trouble condition existing thereat, and means at each of said subordinate stations for precluding transmission of said common signal during selective calling and responsive signal transmission of all of said subordinate stations.

10. In a communication system, a principal station, a plurality of subordinate stations, a signal transmission channel interconnecting all of said stations, means at each of said subordinate stations for transmitting over said channel a signal common to the occurrence of any of a plurality of trouble conditions, means at said principal station responsive to said common signal for transmitting over said channel the selective calling signals of all of said subordinate stations, means at said subordinate stations responsive to their respective calling signals for transmitting over said channel signals representing the identity of any trouble conditions existing thereat, and means at each of said subordinate stations for precluding transmission of any signals whatsoever during selective calling and responsive signal transmission of said subordinate station except in response to its own selective calling signal.

11. In a communication system, a principal station, a plurality of subordinate stations, a communication channel interconnecting said stations, means at said subordinate stations for transmitting combinations of signaling impulses over said channel to said principal station, means for causing each subordinate station to transmit a separate combination of signaling impulses for each of any two or more concurrently existing trouble conditions, a plurality of banks of register devices at said principal station of which one bank is allocated to each of said subordinate stations, a stepping switch at said principal station having a contact bank and a traversing brush operable to traverse the entire contact bank in response to each combination of signaling impulses received from a subordinate station for selectively operating one of the register devices in a bank for each traversal of the contact bank, and a second stepping switch for associating said banks of registers with said first stepping switch in succession.

12. In a communication system, a principal station, a plurality of subordinate stations, a communication channel interconnecting said stations, means at said subordinate station for transmitting combinations of signaling impulses representing trouble conditions over said channel to said principal station, means at said principal station for transmitting combinations of signaling impulses representing selective station calls over said channel to said subordinate stations, means responsive to a trouble condition at any subordinate station for causing the transmission of a general trouble signal, means responsive to reception of said general trouble signal at said principal station for initiating roll-call transmission of said selective station calls, means for causing each subordinate station to transmit a separate combination of signaling impulses for each existing trouble condition thereat, means at said principal station for detecting cessation of transmission from any called subordinate station, and

means controlled by said detecting means for causing resumption of said roll call transmission.

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