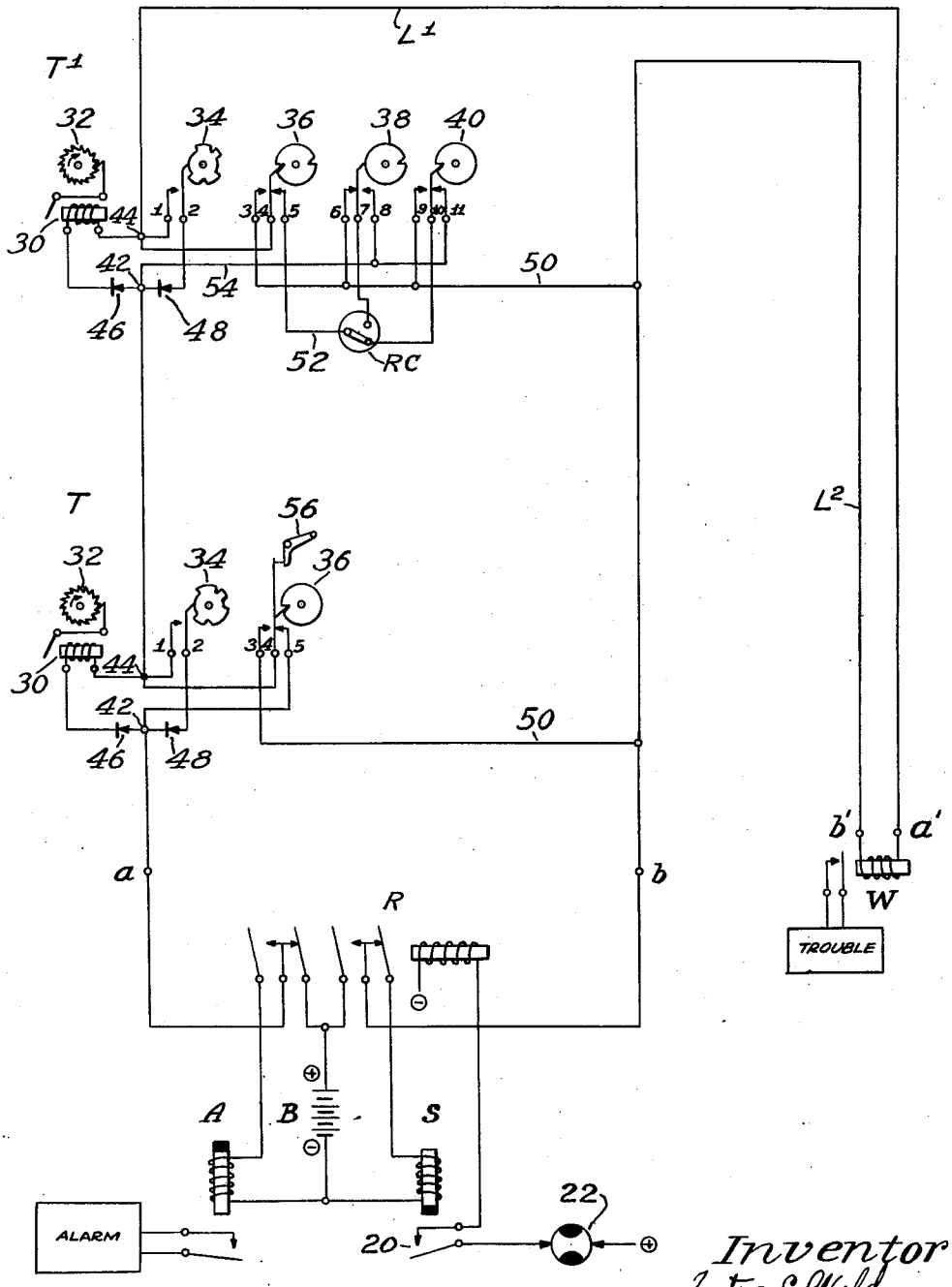
Aug. 15, 1944. F. E. WELD 2,355,934

SIGNALING SYSTEM

Filed June 25, 1942 4 Sheets-Sheet 1

Fig. 1



Witness
Charles T. Olson

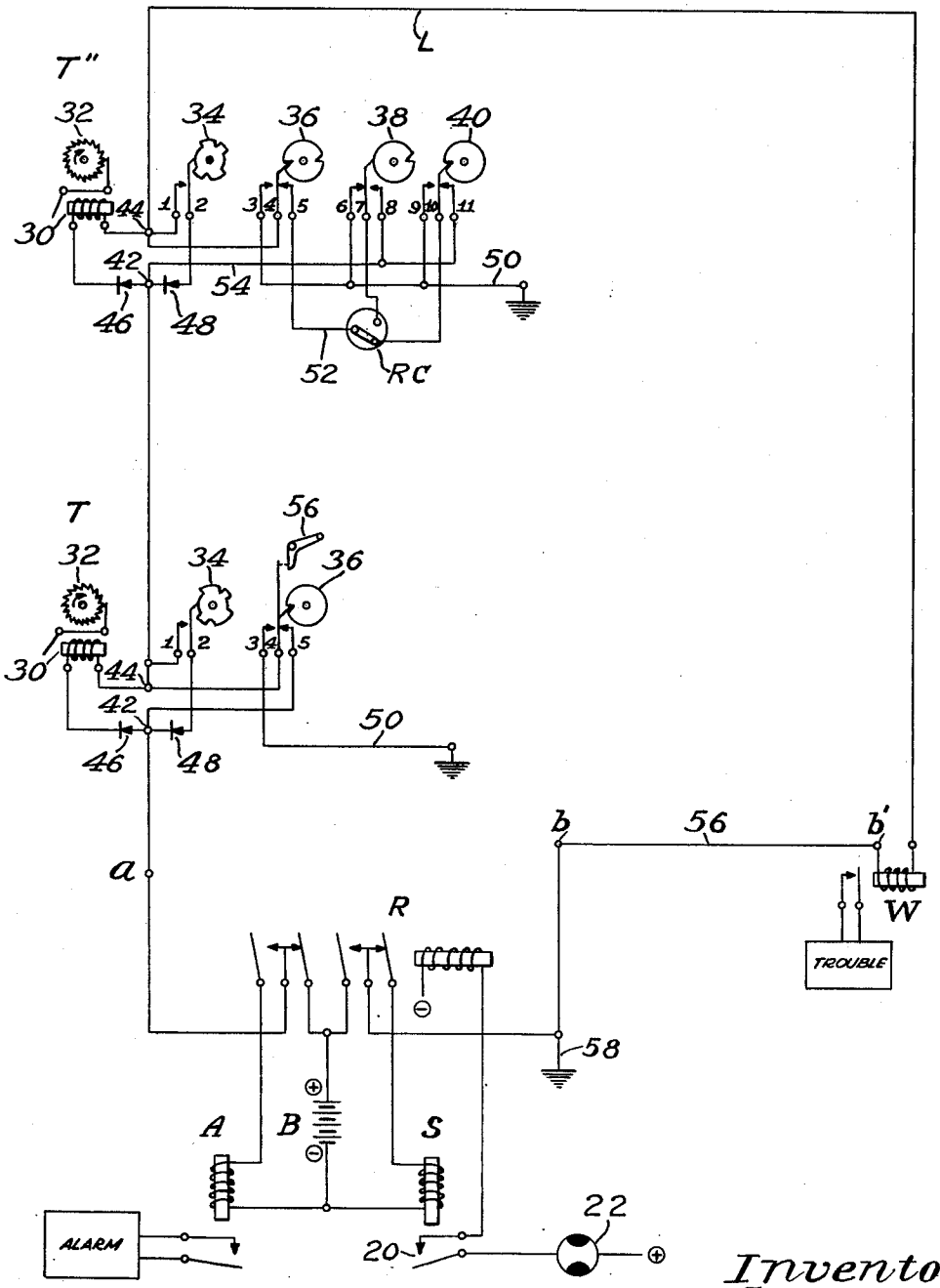
Inventor
Foster E. Weld
by his attorneys
Fish Hildreth Cary & Feeney

Aug. 15, 1944. F. E. WELD 2,355,934

SIGNALING SYSTEM

Filed June 25, 1942 4 Sheets-Sheet 2

Fig. 2



Witness
Charles T. Olson

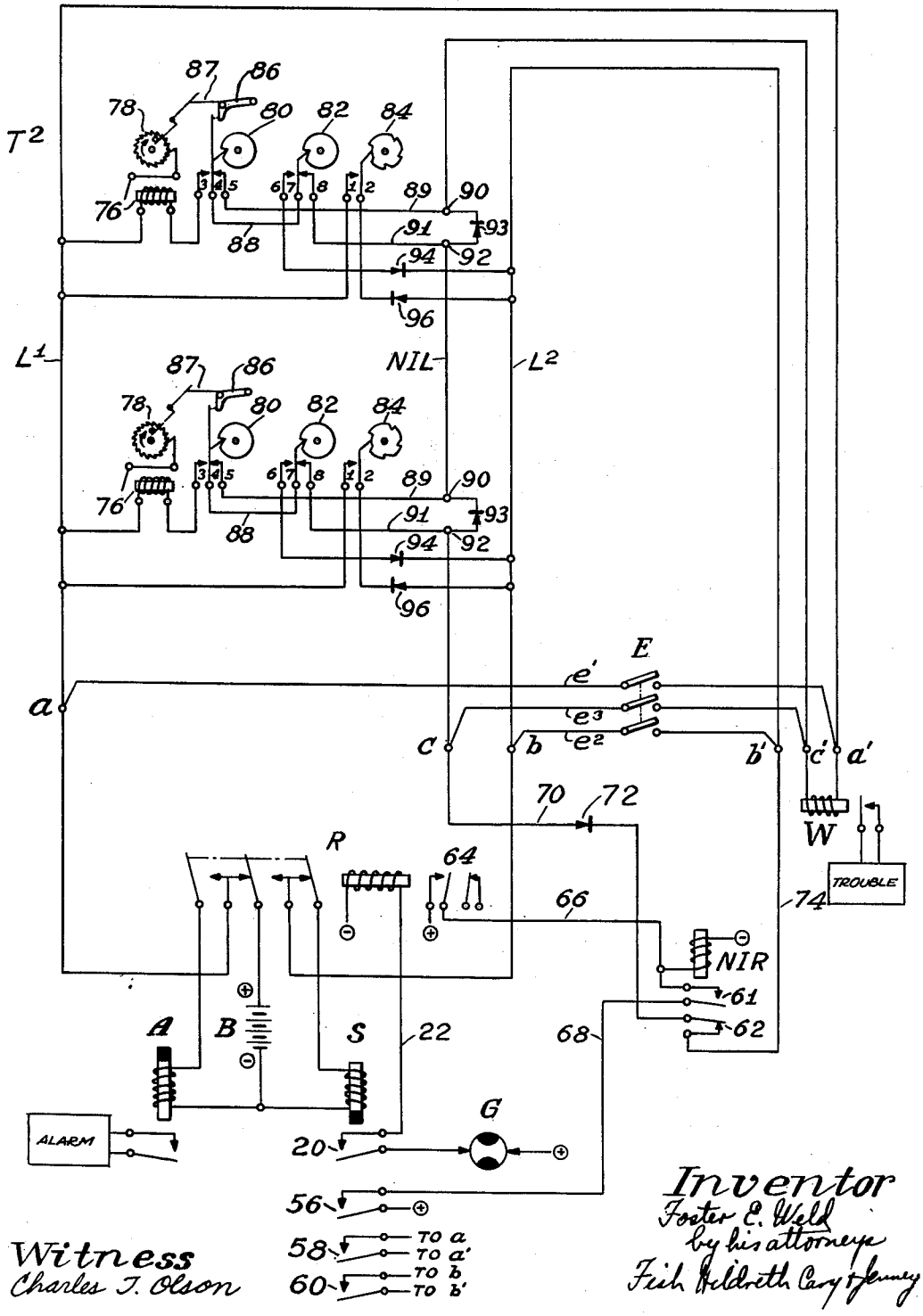
Inventor
Foster E. Weld
by his attorneys
Fish Heidrith Cary & Kenney

Aug. 15, 1944. F. E. WELD 2,355,934

SIGNALING SYSTEM

Filed June 25, 1942 4 Sheets-Sheet 3

Fig. 3



Witness
Charles T. Olson

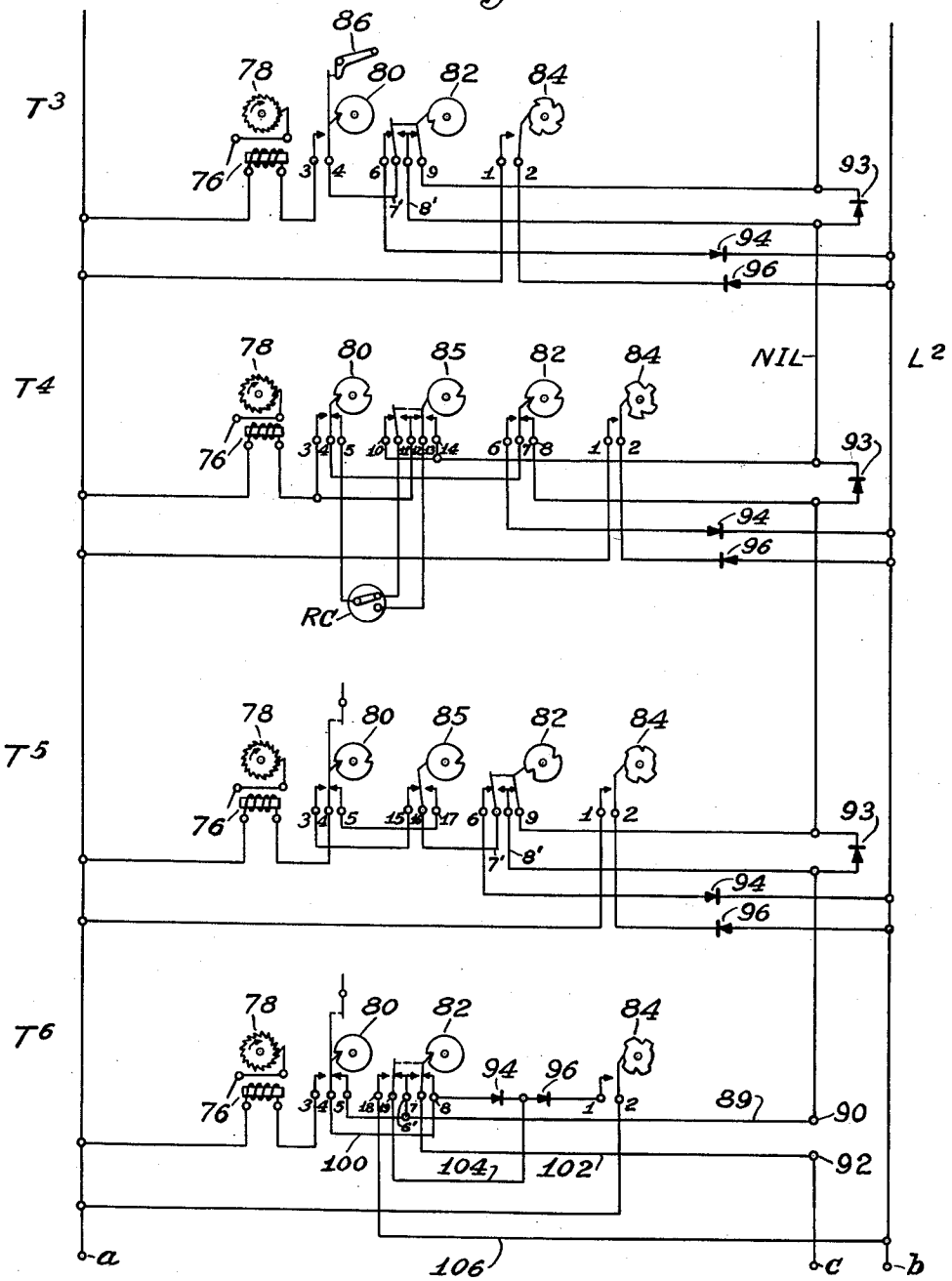
Inventor
Foster E. Weld
by his attorneys
Fish, Goldrath, Cary & Kenney

Aug. 15, 1944. F. E. WELD 2,355,934

SIGNALING SYSTEM

Filed June 25, 1942 4 Sheets-Sheet 4

Fig. 4



Witness
Charles T. Olson

Inventor
Foster E. Weld
by his attorneys
Fish Fildreth Cary & Jenney

Patented Aug. 15, 1944 2,355,934

UNITED STATES PATENT OFFICE

2,355,934

SIGNALING SYSTEM

Foster E. Weld, Newton, Mass., assignor to The Gamewell Company, Newton Upper Falls, Mass., a corporation of Massachusetts

Application June 25, 1942, Serial No. 448,401

19 Claims. (Cl. 177—361)

The present invention relates to signaling systems, and more particularly to systems in which impulses are transmitted from a central station to remote code boxes or "transmitters," and suitable signal or alarm devices are actuated in accordance with the code of an active transmitter. Systems of this type are useful for fire alarms, watch systems, etc.

The principal objects of the present invention are to provide an improved and simplified system in which impulses from the central station are used both to operate the boxes and to signal to the central station in accordance with the box code; to provide exceptional non-interference and succession characteristics; and to afford provision for signaling under severe emergency conditions.

With these and other objects in view, as will hereinafter appear, the invention comprises a system in which impulses of alternating polarity are transmitted from the central station to the boxes, and impulses of one polarity are used to operate an active box, while impulses of the other polarity are used for signaling in dependence on the box code. Proper discrimination between opposite polarities is positively assured, and there is no danger of jumbling, as in cases where reliance is placed on impulse sequences or current magnitudes for distinguishing between the operating and signaling functions.

A further feature of the invention comprises a system involving a non-interference line over which the first operating impulse of the cycle is transmitted, associated with means for positively preventing interference between boxes, even boxes which are activated at the same time. This system also provides for signaling under extremely adverse conditions, such as breaks in any or all lines, with substantial non-interference and succession characteristics under such circumstances.

The system is adapted for use with code transmitters of various types, including remote control stations, alternate signal stations for multiple signals, and others, as will hereinafter be described.

In the accompanying drawings, Fig. 1 is a diagram of a system embodying some of the features of the present invention; Fig. 2 is a diagram of a modified system; Fig. 3 is a diagram of a system embodying the preferred features of non-interference and succession and provision for emergency conditioning; and Fig. 4 is a diagram illustrating several types of transmitters useful in the system of Fig. 3.

System of Fig. 1

The system shown in Fig. 1 comprises a plurality of transmitters T associated with lines L^1 and L^2. The line L^1, which may be referred to as the positive line, extends around the system between central station terminals *a* and *a'*. The line L^2, which may be termed the negative line, likewise extends around the system between central station terminals designated *b* and *b'*.

At the central station there is provided a battery B connected through contacts of a reversing relay R with the *a* and *b* terminals. Connected between the battery and the reversing relay contacts are a starting relay S and an alarm relay A. The starting relay S is of the slow drop type, whereby after its contacts are picked up, they will not be dropped during current reversals, but will be held up until the completion of the signal. The alarm relay A is of the slow pick-up type, for a reason later to be explained.

The arrangement of the contacts of the reversing relay R is clear from the drawings. When the contacts are as shown, the positive terminal of the battery is connected to the terminal *a* of the line L^1 and the negative terminal of the battery is connected through the starting relay S with the terminal *b* of line L^2. When the relay R is energized, the positive battery terminal is connected to line L^2 and the negative battery terminal is connected through the alarm relay A with the line L^1. Energization of the reversing relay causes a reversal of polarity on the lines.

The starting relay S has a pair of contacts **20** in series with an impulse generator **22**, and also in series with the winding of the reversing relay R. The impulse generator is here diagrammatically indicated as a rotary contact device with conducting and non-conducting portions. When the starting relay is energized, the first impulse through the generator **22** energizes the reversing relay R. As the generator **22** operates, the relay R successively picks up and drops its contacts.

A normally energized supervisory relay W of high resistance is connected between the incoming terminals *a'* and *b'* of the lines. Its contacts may be connected to operate any suitable alarm. The relay W serves as a current-limiting device so that the normal current flowing in the circuit is insufficient to energize the relay S.

The boxes or signal transmitters T may be of a number of different types. Two types T and T' are shown in the drawings. The box T is of simplest form, and the box T' is capable of transmitting alternate signals. By an alternate signal

transmitter is meant one which is capable of transmitting a separate signal for each half rotation of a code wheel. For example, the first half rotation may be used to indicate rise of water in a reservoir above a certain level, and the next half cycle may be used to indicate drop of water below a certain level. In each case, both halves of the code wheel will have the same code to indicate the place or origination of the signal, but the difference between rise and fall of level will be indicated by different "pre-signals."

Each transmitter comprises a stepping magnet **30**, controlling the operation of a driving ratchet **32**, which carries on its shaft a code wheel **34** and a full-cycle cam **36**. The box T' also has two transfer cams **38** and **40**. As shown in the drawings, the line L^1 is not continuous, but is connected at each box to terminals **42** and **44**. The stepping magnet **30** is connected in series with a rectifier **46** between the terminals **42** and **44**. The box T is provided with contacts numbered from **1** to **5**, and the box T' has additional contacts **6** to **11** controlled by the transfer cams. Contacts **1** and **2** are the code wheel contacts. Contact **1** is connected direct to the terminal **44** and contact **2** is connected to terminal **42** through a rectifier **48**. Contact **3** is connected to the line L^2 by a wire **50**, and contact **4** is connected to terminal **44** of line L^1. In box T contact **5** is connected to terminal **42**. In box T', this terminal **5** is connected to the movable member of a remote control switch RC by a wire **52**, contacts **7** and **10** are connected to the upper and lower fixed contacts respectively of RC, contacts **6** and **9** are connected to connection **50**, and contacts **8** and **11** are connected, as indicated at **54**, to terminal **42**.

In box T the full-cycle cam **36** has a single notch by which the contact **4** is caused to engage with contact **5**, but in box T' the cam **36** is provided with two two opposed notches, so that the contact **4** may drop into the second notch when the shaft has made a half revolution. The transfer cam **38** has a single notch opposed to the normal starting position, and the transfer cam **40** has a single notch in which the contact **10** is received under inactive conditions. The operation of the box T is initiated by operation of a starting lever indicated at **56**, and of the box T' by movement of the movable contact of RC from the lower fixed to the upper fixed contact.

Under normal or inactive conditions, the stepping magnet **30** of each box is short circuited. For the box T it can easily be seen that normally closed contacts **4**, **5** are connected directly across the terminals **42**, **44**. For the box T', the short circuit path is traced from terminal **42**, through connection **54**, contacts **11**, **10**, the lower fixed and the movable contact of the remote control switch RC, connection **52**, and contacts **5**, **4** to terminal **44**. Under such inactive conditions, therefore, the complete circuit may be traced from the positive terminal of the battery through contacts of the reversing switch to terminal *a* of line L^1, thence over L^1 and through the above described short circuiting contacts of the boxes to terminal *a'*, then through supervisory relay W to terminal *b'*, out over line L^2 to terminal *b*, through contacts of the reversing relay R and the winding of starting relay S back to the negative terminal of the battery.

The resistance of the supervisory relay W is sufficiently high so that the current is limited to a value which will not cause the starting relay S to pick up its contacts. The relay W remains normally energized in readiness to give a suitable signal upon de-energization.

Transmission of signals from an active box

The operation of the system for signal transmission will first be described in connection with the simple box T. If the starting lever **56** is operated, contacts **4**, **5** are separated and contact **4** closes on **3**. From terminal **42**, the circuit is now traced through rectifier **46**, stepping magnet **30**, contacts **4**, **3** and connection **50** to line L^2. This operation shunts out the supervisory relay W and causes a sufficient increase of line current through the starting magnet S to pick up its contacts **20**.

The energization of the magnet **30** advances the driving pawl for the ratchet **32**. The ratchet itself is advanced one tooth by retraction of the pawl upon de-energization of the magnet. Upon energization of the starting relay S, the first pulse transmitted by the impulse generator **22** through the contacts **20** energizes the reversing relay R. This results in positive potential being applied to terminal *b* of line L^2 and negative potential to line L^1 through the alarm relay A. The circuit may be traced from line L^2, which is now positive, through connection **50**, contacts **3**, **4**, and code contacts **1**, **2** (if they are closed), and rectifier **48** to terminal **42** of the line L^1. Therefore, an impulse is transmitted to the alarm relay A if the code contacts are closed. The purpose of the slow pick-up construction of the relay A is to insure that the ratchet has been advanced when the relay picks up.

Upon the next positive impulse transmitted through reversing relay R, the stepping magnet is again energized. The successive positive impulses, therefore, operate the stepping magnet and the intervening negative impulses transmit the signal as determined by the code wheel to the alarm relay. The showing of the relay A is diagrammatic, and it will be understood that it may comprise or be connected with any suitable recorder, audible alarm, or the like. At the conclusion of the cycle represented by one revolution of the full-cycle cam **36**, contact **4** drops into the notch of its wheel. The starting lever **56** having been released, the system is restored to its original inactive condition.

For the box T, which is arranged to transmit alternate signals, the operation is initiated by movement of the movable contact of the remote control switch RC from the lower fixed contact to the upper fixed contact. This breaks the previously traced short circuit path around the stepping magnet of the box and allows the box to operate in a manner similar to that described for the transmitter T. Upon a positive impulse, the stepping magnet is energized through rectifier **46**. Upon a negative impulse, a signal circuit is traced from line L^2 through connection **50**, contacts **3**, **4**, code contacts **1**, **2** (if closed by the code wheel), and rectifier **48** to line L^1. At the end of a half revolution, contact **4** drops into the opposed notch of the full-cycle cam, and contact **7** drops into the notch of the transfer cam **38**. Inactive conditions are now restored, since the short circuit path of the stepping magnet may now be traced from terminal **42**, through connections **54**, contacts **8**, **7**, the upper fixed and the movable contact of RC, connection **52**, and contacts **5**, **4** to terminal **44**.

At some later time, the alternate signal will be transmitted when the remote control switch is moved from its upper fixed to its lower fixed con-

tact. The stepping and signaling impulses are transmitted under exactly the same conditions as previously described, until the contacts 4 and 10 drop into the notches of their respective cams, thereby restoring the system to the condition shown in Fig. 1. It will be noted that the only effect of the remote control switch is to allow transmission of the first stepping impulse to the magnet 30. Hence, if the movable contact of RC is moved from its upper to its lower position during the first half-cycle, it will have no effect on the operation during said half-cycle, but the second half-cycle will start immediately upon contact 7 dropping into the notch of its cam 38.

Non-interference and succession characteristics

After the operation of a transmitter has been initiated, all transmitters farther away from the central station (as measured from terminals *a* and *b*) are prevented from cutting in. As can be seen from Fig. 1, if the box T is operating, it is impossible to direct a stepping impulse through the stepping magnet of transmitter T'. However, any such farther box will transmit its signal if its starting lever 56 or its remote control switch RC is in activating position when the nearer box has concluded its signal.

Any box for which the operation is initiated will be cut out of operation by the initiation of a signal from a box nearer the central station. The nearer box will transmit its complete signal, and the farther box will resume its signaling operation thereafter.

SYSTEM OF FIG. 2

The system of Fig. 2 is a simplified form, having the general features of operation of the system previously described. It involves only a single line L. In place of the line L^2, a ground conductor is used, the connections 50 of the separate boxes being grounded. The terminals designated *b* and *b'* are connected together, as indicated at 56, and are grounded at 58. Under normal conditions, a supervisory current flows through the line L. Under signaling conditions, an active box operates exactly as described for the system of Fig. 1, except that the ground path is substituted for the path over the line L^2. The system has the same non-interference and succession characteristics as the system of Fig. 1.

The system of Fig. 2 has the disadvantage that the ground connections are not supervised, but otherwise it includes all the features of the system first described and offers the advantage of materially reduced installation expense, as well as lowered resistance.

SYSTEM OF FIG. 3

The system shown in Fig. 3 is similar to that of Figs. 1 and 2 in that it operates on impulses of alternating polarity, but it affords positive non-interference and succession with complete supervision, and is arranged to transmit under extremely adverse circumstances.

The system comprises three lines, namely a positive line L^1, a negative line L^2 and a non-interference line designated NIL. The line L^1 extends around the system between central station terminals designated *a* and *a'*. Line L^2 extends around the system between terminals designated *b* and *b'*. The line NIL extends between central station terminals *c* and *c'*; this line is not continuous, but passes through certain series contacts of the transmitters.

The battery B, the impulse generator G, and the relays R, S and A are, except for some additional contacts, similar to corresponding parts of Fig. 1.

The starting relay S has three additional pairs of normally open contacts indicated at 56, 58 and 60. The contacts 56 control a holding circuit for the non-interference relay NIR which is now to be described.

The non-interference relay has a pair of normally open contacts 61 and a pair of normally closed contacts 62. The relay winding is energized from a pair of contacts 64 of the reversing relay R. A connection 66 runs from one contact of pair 64 to one side of the NIR winding and to one contact of pair 61. From the other contact 61 a connection 68 runs to contacts 56 of relay S, whereby when relays S and NIR are both energized a holding circuit for NIR is established until the completion of the signal. The NIR contacts that are important for non-interference are those designated at 62. A connection 70 runs from terminal *c* through a rectifier 72, contacts 62, and a connection 74 to the terminal *b'* of line L^2. The contacts 62 are normally closed, but are opened when the relay NIR is energized, and hence they remain open during the entire signaling operation.

A normally energized supervisory relay W of high resistance is connected between the *a'* and *c'* terminals.

The boxes or signal transmitters may be of a number of different types, as will hereinafter be explained. In Fig. 3 only the boxes of simplest type are shown, since this type will suffice to describe the operation of the system. Each box T^2 comprises a stepping magnet 76 connected at one side to the line L^1 and adapted to operate a ratchet 78. Mounted on the same shaft with the ratchet 78 are three cams, namely, a full-cycle cam 80, a non-interference cam 82 and a code wheel 84. Contacts numbered 1 to 8 are provided for the three cams, as indicated. The box may be set into operation by a manual starting lever 86, which is then held in operative position by a latch 87 articulated with the drive wheel 78, so that the starting lever is released at some time prior to completion of the signal. Contacts 1 and 2 are the code contacts controlled by code wheel 84. Contact 4, which is controlled by the starting lever 86, is normally closed on contact 5, but upon operation of the starting lever is closed on contact 3. Contact 4 is connected by a wire 88 with contact 7, and contact 5 is connected by a wire 89 with a terminal 90 to which NIL is connected. Contact 7 is normally closed on 8, which in turn is connected by a wire 91 to NIL at terminal 92. A rectifier 93 is connected between terminals 90 and 92, for a purpose to be hereinafter described. Contact 6, upon which 7 is closed after the first step of the drive mechanism, is connected through a rectifier 94 with the line L^2. The code contacts 1 and 2 are connected in series with a rectifier 96 between the lines L^1 and L^2.

Normal or inactive condition

Under normal conditions, current flows from the positive terminal of the battery through appropriate contacts of the reversing relay R to the *a* terminal, thence over line L^1 to the *a'* terminal, through the supervisory relay W to the *c'* terminal, over the line NIL to the *c* terminal, then through connection 70 and rectifier 72 through normally closed contacts 62 of relay NIR to the *b'* terminal, over line L^2 to *b* terminal, and finally through contacts of the reversing relay and the starting winding S back to the negative terminal

of the battery. The resistance of the supervisory relay W is so high that the current is insufficient to energize the starting relay S.

It will be understood that in tracing out the circuit over the line NIL, the path includes contacts 5, 4, 7, 8 of the several boxes in series. That is, in tracing out the NIL circuit, it passes from terminal 90 through the above-mentioned contacts to terminal 92 of each box. The rectifier 93, which is connected between the terminals 90 and 92, does not enter into this circuit, because it is pointed in the direction opposite to the flow of current.

Box signaling

When a box is started by operation of the lever 86, contact 4 closes on 3, thereby establishing a circuit through the stepping magnet from the positive line L^1, magnet 76, contacts 3, 4, 7, 8 and terminal 92 to NIL. The path then continues to terminal *c* through contacts 5, 4, 7, 8 of any intervening boxes. From terminal *c* the path is continued through connection 70 and rectifier 72, contacts 62 of NIR, connection 74 to terminal *b'* of the line L^2, thence through line L^2 to terminal *b*, through appropriate contacts of reversing relay R, and finally starting relay S to the negative side of the battery.

The path thus traced through the stepping magnet of the activated box is established without including the supervisory relay W. Since the relay W is of high resistance, a considerable increase in current through the starting relay S occurs when the relay W is excluded as above described. The relay S then picks up its contacts 20 and 56 and sets the entire system into operation for transmission of the characteristic signal of the box.

Upon energization of the starting relay S, the first pulse transmitted by the impulse generator through the contacts 20 energizes the reversing relay R. The energization of R performs two functions. First it operates the contacts which control the reversal of line current, and it also closes the contacts 64. This latter operation results in energization of the non-interference relay NIR, whose contacts then remain held up through its own contacts 61 and the contacts 56 of the starting relay. The connection between the non-interference line and the negative line L^2 is thus broken at 62.

Meanwhile the impulse directed through the stepping magnet of the active box has advanced the ratchet 78 one tooth, thus advancing the cams 80, 82, and 84. Cam 80 operates to hold contact 4 on 3 during the rest of the cycle, even though the arm 86 is released. Cam 82 shifts contact 7 from 8 to 6 so that the box is now isolated from NIL. Cam 84 is a code wheel, controlling the code contacts 1 and 2.

The reversal of polarity of the lines due to the operation of the reversing relay R causes positive potential to be applied to the line L^2 and negative potential to the line L^1, whereby current may flow between L^2 and L^1 through the code wheel contacts 1, 2 of the active box (if such contacts are closed by the code wheel). Flow of current in the proper direction is permitted by the rectifier 96, while the rectifier 94 prevents current from flowing through the stepping magnet. The impulse transmitted through the code contacts passes through the alarm relay A.

In the next interruption of the current at the impulse generator G, the reversing relay is deenergized and the original polarity is restored to the lines L^1 and L^2, whereby the stepping magnet is again energized to advance the drive another tooth. The energizing circuit for the magnet now runs to the line L^2 through rectifier 94, instead of to the line NIL. The rectifier 96 prevents the code contacts, if closed, from short-circuiting the magnet.

The various reversals follow in rapid succession under the influence of the impulse generator. On each positive impulse (that is, when the positive battery terminal is connected with the *a* terminal), the stepping magnet of the box is operated, and on each negative impulse the signal is transmitted through the code wheel contacts. The transmitted signal is dependent, of course, upon the particular code of the wheel. The alarm relay A responds whenever a pulse is directed through closed code wheel contacts.

Mention has been made of contacts 58 and 60 of relay S. These contacts are normally open, but are closed during the entire signaling operation. They simply connect terminals *a* and *a'* of L^1 together, and terminals *b* and *b'* of L^2 together. The signaling operation is not changed in any way, and the purpose of these contacts is to insure completion of a signal, if either line or both lines are broken after a box starts to signal. It will be observed that after a break, current may flow to the box through either side of the line (or lines).

When the signaling cycle is completed, the last step of the wheel 78 causes contacts 4 and 7 to drop into the notches of cams 80 and 82, respectively. On the next "positive" impulse, current is unable to flow through the stepping magnet 76 or the starting relay S. The relay S soon drops its contacts, and the system is restored to inactive condition, in readiness for subsequent signaling operations.

The rectifier 72 has been referred to. Its function is only to prevent a reverse flow of current through NIL if the first operation of the reversing relay R should succeed in reversing the line polarities while the box magnet still remains energized and before the relay NIR becomes energized. Under such circumstances, which are unlikely though possible, current might flow through the stepping magnet and hold it energized during the "negative" impulse, and thus prevent advancement of the ratchet. The rectifier 72 prevents such action.

Non-interference and succession features

The description thus far is based on the supposition that only a single box is in operation at any time. If, during the signaling operation by an activated box, another box is tripped, the latter cannot break in, and in fact it will get no current for its stepping magnet until the transmission of the signal by the first box is completed. This follows from the fact that for the second box the stepping magnet circuit is connected through contacts 7 and 8 with NIL, which is now isolated from L^2 at the open contacts 62 of the relay NIR. Thus, an energizing circuit for the stepping magnet 76 cannot be traced through any of the various lines at any time during the signaling operation of the first box.

When the first box has concluded its signal, the second box will start. This follows because the starting lever 86 of the second box has been left in such a position that contacts 3, 4 are closed. Therefore, after the central station has been restored to normal, the second box takes up its operation in the manner previously described.

If two boxes "start" at the same time, that is,

if they are tripped under such conditions that they attempt to energize their stepping magnets simultaneously, the box nearest the central station will first gain control. This situation arises occasionally if, while one box is transmitting, a second box and a third box are tripped (not necessarily at the same instant). In such a case, the second and third boxes both attempt to gain control of the line immediately after the first box completes its signaling. From the description thus far given, however, it will be apparent that the box farther removed from the central station cannot get a stepping impulse to its magnet **76** because the circuit through which the impulse may be transmitted is open at contacts **4, 5** of the tripped box that is nearer the central station. (The terms "nearer" and "farther" refer to distances measured along the various lines from terminals *a, b* and *c.*)

Emergency operation

The supervisory relay W normally holds its contacts open. When the relay is de-energized, its contacts close and thereby actuate a suitable alarm. These contacts remain closed during the entire period of signal transmission from a box. If, at the time of operation of the supervisory alarm, no signal is received at the central station, a break in at least one of the lines is indicated. The system may then be converted for emergency signaling by means of the switch E.

The switch E, when closed, connects the *a* and *a'* terminals together by a connection *e'*, the *b* and *b'* terminals together by a connection e^2, and the *c* and *c'* terminals together by a connection e^3. Any box which now is tripped will be able to transmit its signal, even though a break may be present in any or all of the three lines. A single break in any or all of the lines will not interfere with the ability of any box in the system to transmit a signal. Even a double break in any or all lines will not render the system completely inoperative, but will only disable such boxes as are isolated between the two breaks.

It will be seen that when terminals of the positive line L^1 are connected together, proper potential will be transmitted to any box over one section or the other of the line, regardless of the position of the break. The same applies to the negative line L^2. For the non-interference line NIL, completion of the circuit for the first stepping operation requires that the current be permitted to flow over NIL to the *c'* terminal, if there is a break in NIL between the activated box and the *c* terminal. In such a case, current flows through the rectifier **93** of the activated box; hence a rectifier **93** is provided for each box in the system. In any case the starting circuit is completed and thereafter all operations continue over the lines L^1 and L^2, exactly as if there were no break in the lines, because *a—a'* and *b—b'* are connected at **58, 60** and NIL is disconnected at **62** from the rest of the system.

Even with broken lines, therefore, the system is non-interfering with respect to any box that is tripped during the transmission of a signal by another box. That is to say, after the first box has established its stepping magnet connection to the line L^2, a later tripped box will be unable to gain control until the first box has completed its signal.

However, interference is possible if two or more boxes are tripped under such conditions that their magnets are energized at the same time. In such a case, an energizing circuit for the "farther" box can be established through its rectifier **93** (but only if there is no break in NIL beyond it). Hence, both boxes may gain control on the first impulse, whereby upon operation of the stepping magnet their cams are advanced to connect the stepping magnet circuits to the line L^2. Both boxes will transmit their signals, which will therefore be jumbled. It will be clear from the foregoing that the only circumstances under which the non-interference and succession features are lost are improbable, even when the system is conditioned for emergency operation.

Types of transmitters

The system of Fig. 3 is not limited for use with transmitters of the type indicated at T^2. Various other forms of transmitters for various purposes may be used. Some modified forms of transmitters are shown in Fig. 4.

The transmitter T^3 is similar to that previously described, except that after being tripped, it advances one step, regardless of conditions elsewhere in the system, and gives a non-interference impulse on the second step. This type of box is particularly useful when the tripping means acts only momentarily, so that the signal is transmitted later if the box should be tripped while the system is otherwise busy.

The box T^3 comprises the wheels **78, 80, 82** and **84**, as in the box T^2. The starting lever **86** is shown without the latching arrangement, to indicate that it may be released immediately after operation. The full-cycle cam **80** has contacts **3** and **4** only; the non-interference cam **82** has a fixed contact **6**, a movable contact **7'**, a fixed double contact **8'** and a movable contact **9**; and the code contacts **1** and **2** are as in the transmitter T and are similarly connected between the positive and negative lines. It will be observed that the notch in the non-interference cam is offset one step from the notch in the full-cycle cam.

Contact **4** is connected with **7'**, contact **6** is connected through the rectifier **94** with the line L^2, and contacts **8'** and **9** are connected to NIL at terminals **92** and **90** respectively. Upon operation of the lever **86**, closing contact **4** on **3**, the stepping magnet is energized by a circuit traced from line L^1 through contacts **3, 4**, thence through contacts **7', 6** and rectifier **94** to the negative line L^2. This initial energization of the stepping magnet occurs whenever line L^1 is positive and line L^2 is negative, and hence may take place even though another box on the system is in process of signaling. The first step carries contact **9** into the notch of the non-interference cam **82**. This changes the connection of the stepping magnet circuit from line L^2 to NIL, as may be seen by continuing a circuit from contact **4**, through contact **7'** and contact **8'**. If the system is not busy, the next positive impulse will advance the stepping ratchet another tooth, exactly as in the case of the transmitter T, and the signal will be transmitted in the usual manner. If, however, the system is busy when contact **9** drops into the notch of cam **82**, it is impossible to energize the stepping magnet on the next positive impulse, because the non-interference line NIL is dead, but after the system is restored to normal, the transmitter will transmit its signal. It will be observed that the code wheel is arranged so that its contacts **1** and **2** are not permitted to close until at least the second step.

Another form of transmitter is shown at T^4.

This is an alternate-signal transmitter with a remote control switch. It comprises the wheels 78, 80, 82 and 84, as in the previously described transmitters. The full-cycle cam and the non-interference cam, however, are each provided with two diametrically opposed notches, whereby the alternate signals are controlled. A transfer cam 85 is also provided, and this has a single notch opposite the point of initial support of the contacts.

The full-cycle cam has the contacts 3, 4, 5, and the non-interference cam has the contacts 6, 7, and 8, as in the transmitter T^2. For the transfer cam 85, contacts numbered 10 to 14 are provided, as indicated in the drawings. A remote control switch RC has a movable contact connected to contact 5 of the full-cycle group and two fixed contacts connected with the movable contacts 11 and 13 of the transfer group. The stepping magnet is connected to contacts 3 and 12. Contacts 10 and 14 of the transfer group are connected to terminal 90. The remaining contacts are connected in the same fashion as similarly numbered contacts of the transmitter T^2.

The transmitter T^4 is set into operation by movement of the movable contact of the remote control switch from the upper fixed contact to the lower fixed contact, whereby the stepping impulse is transmitted through the stepping magnet contacts 12, 13, contacts of RC, contacts 5, 4, and contacts 7, 8 to NIL. The first step operates on contacts 4 and 7 to change the stepping magnet connections from NIL to the negative line, exactly as in the case of the transmitter T^2. No change in the transfer group of contacts takes place until the first signal is completed, when contact 13 drops into the notch of the transfer cam 85. At this time, if the remote control switch is on the lower contact, the signal stops and the original electrical connections are restored. When the movable contact of RC engages the upper contact, the stepping magnet is again energized, this time through contacts 12, 11, contacts of RC, contacts 5, 4 and contacts 7, 8. The box then signals over the second half-cycle, after which it is restored to its original condition. It will be observed that the box may wait at the half-way position as long as necessary without in any way affecting the characteristics of the system as a whole.

Another type of alternate-signal transmitter is shown at T^5, arranged to give a non-interference impulse on the second step. One example of its usefulness is in watch systems, wherein a signal is to be given for the opening of a door, and another signal for closing of the same door. It is essential that the closing operation should not cancel the signal for the opening, if the system is busy when the door is opened and continues busy until after the door is closed. The box will properly transmit signals to indicate that both the opening and closing operations have occurred, even though such signals may be delayed because of the necessity of waiting for another box.

The box T^5 utilizes a starting lever, which, in the above example, is operated by opening of the door, and released upon closing of the door. The box has contacts 3, 4 and 5 for the full-cycle cam 80. The non-interference group of contacts comprises a contact 6, a contact 7', a contact 8' and a contact 9, the contacts 7' and 9 being movable. The notches of the non-interference cam 82 are in each case offset one step from those of the full-cycle cam. Contacts 15, 16 and 17 are provided for the transfer cam 85.

The starting lever is connected with contact 4, as will be apparent from the drawings. When contact 4 is closed on 3, the magnet is energized by a circuit traced through contacts 4, 3, contacts 15, 16, contacts 6, 7', and rectifier 94 to line L^2, whereby on the first step the contacts of the non-interference group drop into the notch of the cam 82. Then the stepping magnet connections are shifted to NIL, whereby the transmitter must wait, if necessary, for a clear line before it can transmit its signal, but with assurance that when the line is clear the box will operate.

At the end of the half-cycle, contacts 9 and 16 drop into the notches of their respective cams. If the starting lever is still held in operated position (the door remaining open), the transmitter stops at the half-way position, since the stepping magnet circuit is now open at 15, 16. When the lever is released, so that contact 4 closes on contact 5, or, if such contacts are closed when the half-way position is reached due to previous release of the starting lever, another initiating impulse for the stepping magnet is fed through contacts 4, 5, contacts 17, 16, contacts 7, 6 and rectifier 94 to line L^2, and thereafter the same conditions obtain for the remaining half-cycle as for the initial half-cycle.

After the first initiating impulse has been given to the driving ratchet, the complete cycle of operations above described must take place, even though the starting lever is returned to its initial position before the first half-cycle is completed. Even if the door is opened and closed while the system is busy, both the opening and closing signals will be transmitted in proper order.

The boxes of any and all types as above described may be combined in a single system. The particular type of box will be dictated by the kind of signal to be sent from its transmitting station. Under normal line conditions the several types of boxes will be completely non-interfering and successive, and under emergency conditions they will present the same degree of non-interference and succession as the simpler boxes previously described. It will be understood that the various types described above are not intended to be exclusive, since other types of transmitters for special purposes may be used with the system.

In all the transmitters previously described for use in the system of Fig. 3, the rectifier 93 is included as an essential element in order that the first stepping impulse for the magnet 76 may be directed over NIL in either direction when the lines are conditioned for emergency operation. Whereas the rectifiers 94 and 96 have a connection in common, the rectifier 93 has no part in common with the others. For reasons of simplicity, it is desirable to avoid the use of the rectifier 93, and this may be accomplished by providing additional contacts in the box and rearranging the internal connections.

A transmitter which operates like T^2 but avoids the use of the third rectifier is shown at T^6. This transmitter has the same wheels as T^2, and the same contacts, except that for the contact 6 a double contact 6' is substituted, and additional contacts 18 and 19 for the non-interference wheel 82 are provided. The connection from contact 4 is made by a wire 100 to contact 8, and contact 7 is connected by a wire 102 with the terminal 92, which connects with the non-interference line NIL. The other terminal 90 is connected by

the wire 89 with contact 5. The mid-point of rectifiers 94 and 96, instead of being connected to the line L^2, is connected to contact 19 by a wire 104, and contact 18 is connected by a wire 106 with line L^2. Contact 6', instead of being connected to the rectifier 94, is connected to the wire 89 and contact 8 is connected to the rectifier 94. In all other respects, the connections are as in box T^2.

Under inactive conditions, continuity of the non-interference circuit is maintained through contacts 5, 4, 8 and 7. For initiation of the signaling operation, contact 4 is closed on 3, and the initiating impulse for the stepping magnet is established through contacts 3, 4, connection 100, contacts 8, 7, and connection 102 to the lower NIL terminal 92, and also from contact 8 through rectifier 94, connection 104, contacts 19, 6' and wire 89 to the upper NIL terminal 90. Therefore, the circuit for the first stepping impulse may be completed in either direction through the non-interference line, as is necessary when the system is conditioned for emergency operation. After the wheel 82 advances one step, contact 7 opens away from 8, and 19 closes on 18, thereby transferring the stepping magnet connections from NIL to L^2. The positive impulses for stepping the magnet then take place through contacts 3, 4, connection 100, rectifier 94, connection 104, contacts 19, 18 and connection 106 to line L^2. The code impulses of reversed polarity are transmitted from line L^2 through connection 106, contacts 18, 19, connection 104, rectifier 96 and code contacts 1, 2 (if closed) to line L^1. When the system is in normal condition, as between two boxes which are activated at the same time, only the nearer box can gain control, since the first stepping magnet impulse for the farther box is isolated from NIL at the open contacts 4, 5 and at the rectifier 94 of the nearer box.

The box T^6 operates in all respects identically with the box T^2 and maintains the same degree of non-interference and succession, both under normal and emergency conditions. The other types of transmitters (alternate signal, remote control, non-interference impulse on the second step, etc.) may likewise be modified to provide the same features of operation without the necessity of using the rectifier 93.

Conclusion

From the foregoing description, it will be seen that the system operates with exceptional reliability. It may be used in fire, watchman's report, burglar, and automatic signal systems, and transmitters of various types for different services may be combined in a single system. Several types of transmitters have been described in sufficient detail to indicate their usefulness for various services, but it will be understood that the types described are not exclusive, and various modifications may be made for combinations of effects for special signaling purposes.

The preferred form of system is that shown in Fig. 3, which provides perfect non-interference and succession characteristics over normal lines, and a high degree of non-interference and succession even when one or more lines are broken. The systems of Figs. 1 and 2, however, may be used when cost of installation is important, since they may provide adequate non-interference characteristics, if the signal density is not too high. Any of the described systems possess the advantage of absolute discrimination between driving impulses and code impulses.

Having thus described the invention, I claim:

1. A signaling system comprising two signaling conductors, a current limiting device across the conductors, a plurality of transmitters, each transmitter having driving means and code means, the driving means including a driving magnet and a rectifier, the code means including code contacts and a rectifier, activating means for each transmitter normally shunting the driving means and for connecting said driving and code means between the conductors and shunting said current-limiting means, means for transmitting a succession of impulses, alernately of opposite polarities, over the conductors, means controlled by the shunting of said current-limiting means for initiating operation of the impulse transmitting means, the driving magnet being energized by impulses of one polarity and the code means by impulses of opposite polarity, and signal means operated by said impulses of opposite polarity only when the code contacts are closed.

2. A signaling system comprising two signaling lines, a non-interference line, all the lines being connected in series, a plurality of transmitters each of which includes driving means and code means, impulse transmitting means to transmit over the lines a succession of impulses of alternating polarity, activating means for each transmitter, said activating means operating initially to energize the driving means by connection between the signaling lines and to transfer the connection therefor from one of the signaling lines to the non-interference line, means operated by a subsequent impulse to restore the driving connections to the signaling lines, and means for disabling the non-interference line, said driving means and code means having devices to render them respectively responsive to impulses of different polarities.

3. A signaling system comprising two signaling conductors and a non-interference conductor, each conductor having two central station terminals, means normally connecting all of the conductors in series, means for transmitting impulses of alternating polarities over the conductors, a plurality of transmitters having driving means responsive to impulses of one polarity and code means to control passage of impulses of opposite polarity, said transmitters having connections between one signaling conductor and the non-interference conductor, cycle-initiating means for each transmitter having provision for transferring connections from the non-interference conductor to the other signaling conductor, and emergency conditioning means to connect together the central station terminals of the individual conductors.

4. A transmitter for a signaling system comprising signaling line terminals and non-interference line terminals, a connection including normally closed contacts between the non-interference line terminals, driving means, activating means for connecting the driving means between one of the signaling line terminals and one of the non-interference line terminals and for interrupting the connection between the non-interference line terminals, means for transferring the connection of the driving means from the non-interference line terminal to the other signaling terminal, code means connected between the signaling terminals, and means for rendering the driving means and code means selectively operable upon impulses of different polarities.

5. A transmitter for a signaling system comprising signaling line terminals and two non-in-

terference line terminals, a connection including normally closed contacts between the non-interference line terminals, driving means, activating means for connecting the driving means between one of the signaling line terminals and one of the non-interference line terminals and for interrupting the connection between the non-interference line terminals, means for transferring the connection of the driving means from the non-interference line terminal to the other signaling terminal, code means connected between the signaling terminals, and rectifiers for rendering the driving means and code means selectively operable upon impulses of different polarities.

6. A transmitter for a signaling system comprising signaling line terminals and two non-interference line terminals, a connection including normally closed contacts between the non-interference line terminals, driving means, activating means for connecting the driving means between one of the signaling line terminals and one of the non-interference line terminals and for interrupting the connection between the non-interference line terminals, means for transferring the connection of the driving means from the non-interference line terminal to the other signaling terminal, code means connected between the signaling terminals, means for rendering the driving means and code means selectively operable upon impulses of different polarities, and a rectifier between the non-interference line terminals to permit the initial driving impulse to be applied to both non-interference line terminals while blocking passage of an initiating impulse from more remote transmitters.

7. A transmitter for a signaling system comprising signaling line terminals and two non-interference line terminals, a connection including normally closed contacts between the non-interference line terminals, driving means, activating means for connecting the driving means between one of the signaling line terminals and one of the non-interference line terminals and for interrupting the connection between the non-interference line terminal, means for transferring the connection of the driving means from the non-interference line terminal to the other signaling line terminal, code means connected between the signaling terminals, rectifiers for rendering the driving means and code means selectively operable upon impulses of different polarities, and connections including one of said rectifiers to complete a circuit for the initial driving impulse to both non-interference terminals while blocking passage of an initiating impulse from more remote transmitters.

8. A transmitter for a signaling system comprising signaling line terminals, two non-interference line terminals, a driving magnet, a code wheel, code contacts, a non-interference cam, means associated with the driving magnet and the code contacts to render the magnet responsive to impulses of one polarity and to control passage of impulses of opposite polarity in accordance with the operation of the code contacts, internal connections between the non-interference line terminal, activating means for directing a cycle-initiating impulse through the driving means to one of the non-interference line terminals and for opening said internal connections, and contacts operated by the non-interference cam for thereafter connecting the driving magnet and code contacts between the signaling line terminals.

9. A transmitter for a signaling system comprising signaling line terminals, non-interference line terminals, a driving magnet, a code wheel, code contacts, a non-interference cam, means associated with the driving magnet and the code contacts to render the magnet responsive to impulses of one polarity and to control passage of impulses of opposite polarity in accordance with the operation of the code contacts, internal connections between the non-interference line terminals, activating means for directing a cycle-initiating impulse between the signaling terminals through the driving means to advance the latter one step, the non-interference cam having contacts to transfer the driving connections from one of the signaling terminals to one of the non-interference line terminals on the first step and to transfer the connection back to the signaling terminals on a subsequent step.

10. A signaling system comprising two signaling lines, a non-interference line, a plurality of transmitters each of which includes driving means and code means, impulse transmitting means to transmit over the lines a succession of impulses of alternating polarity, activating means for each transmitter operable to energize the driving means by a connection between one signaling line and the non-interference line, means controlled by the activating means for disabling the non-interference line to prevent energization of other transmitters during the signaling cycle of the activated transmitter, means operated by the driving means for connecting the driving means between the two signaling lines, means for operating the driving means by impulses of one polarity, and signal means operable upon an impulse of opposite polarity in dependence on the code means of the transmitter.

11. A signaling system comprising two signaling lines, a non-interference line, a plurality of transmitters each of which includes driving means and code means, impulse transmitting means to transmit over the lines a succession of impulses of alternating polarity, activating means for each transmitter operable to energize the driving means by a connection between one signaling line and the non-interference line, means controlled by the activating means and independent of the driving means for disabling the non-interference line to prevent energization of other transmitters during the signaling cycle of the activated transmitter, means operated by the driving means for connecting the driving means between the two signaling lines, means for operating the driving means by impulses of one polarity, and signal means operable upon an impulse of opposite polarity in dependence on the code means of the transmitter.

12. A signaling system comprising two signaling lines, a non-interference line, a current-limiting device for the lines, a plurality of transmitters each of which includes driving means and code means, impulse transmitting means to transmit over the lines a succession of impulses of alternating polarity, activating means for each transmitter operable to energize the driving means by a connection between one signaling line and the non-interference line, said connection acting to increase the current in the signaling line by shunting the current-limiting device, means operated by said increase of current for disabling the non-interference line to prevent energization of other transmitters during the signaling cycle of the activated transmitter, means for connecting the driving means between the two signaling lines, means for operating the

driving means by impulses of one polarity, and signal means operable upon an impulse of opposite polarity in dependence on the code means of the transmitter.

13. A signaling system comprising two signaling lines, a non-interference line, a current-limiting device for the lines, a plurality of transmitters each of which includes driving means and code means, impulse transmitting means to transmit over the lines a succession of impulses of alternating polarity, activating means for each transmitter operable to energize the driving means by a connection between one signaling line and the non-interference line, said connection acting to increase the current in the signaling line by shunting the current-limiting device, means operated by said increase of current for disabling the non-interference line to prevent energization of other transmitters during the signaling cycle of the activated transmitter, means operated by the driving means for connecting the driving means between the two signaling lines, means for operating the driving means by impulses of one polarity, and signal means operable upon an impulse of opposite polarity in dependence on the code means of the transmitter.

14. A signaling system comprising two signaling lines, a non-interference line, a plurality of transmitters each of which includes driving means and code means, impulse transmitting means to transmit over the lines a succession of impulses of alternating polarity, activating means for each transmitter operable to energize the driving means by a connection between one signaling line and the non-interference line, means controlled by the activating means for disabling the non-interference line to prevent energization of other transmitters during the signaling cycle of the activated transmitter, means operated by the driving means for connecting the driving means between the two signaling lines, and rectifiers for the driving means and code means to effect operation of the driving means by impulses of one polarity and to transmit code signals by impulses of opposite polarity.

15. A signaling system comprising two signaling lines, a non-interference line, a plurality of transmitters each having a driving means and code means, the several transmitters having normally closed contacts through which the non-interference line passes in series, cycle-initiating means for each transmitter operating to open said contacts and to concurrently energize the driving means through a connection between one signaling line and the non-interference line, said connection for some of the transmitters including the said normally closed contacts of at least one other transmitter, means for transferring connections of the transmitter driving means to the signaling lines after operation of the cycle-initiating means, means for transmitting impulses of alternating polarity, and rectifiers for directing impulses of opposite polarities through the driving means and code means.

16. A signaling system comprising two signaling lines, a non-interference line, a plurality of transmitters each having driving means and code means, the several transmitters having normally closed contacts through which the non-interference line passes in series, cycle-initiating means for each transmitter operating to open said contacts and to concurrently energize the driving means through a connection between one signaling line and the non-interference line, central station means operated following the initiation of a cycle by a transmitter to disable the non-interference line, said connection for some of the transmitters including the said normally closed contacts of at least one other transmitter, means for transferring connections of the transmitter driving means to the signaling lines after operation of the cycle-initiating means, means for transmitting impulses of alternating polarity, and rectifiers for directing impulses of opposite polarities through the driving means and code means.

17. A signaling system comprising two signaling lines, a non-interference line, a plurality of transmitters each having driving means and code means, the several transmitters having contacts through which the non-interference line passes in series, cycle-initiating means for each transmitter operating to open said contacts and to energize the driving means through a connection between one signaling line and the non-interference line, means for transferring connections of the transmitter driving means to the signaling lines after operation of the cycle-initiating means, means for transmitting impulses over the lines, an emergency connection between the ends of the non-interference line, and rectifier means bridging said contacts for each transmitter to prevent transmission of an initiating impulse from a more remote transmitter under normal line conditions but to direct an initiating impulse from an activated transmitter over the non-interference line in either direction under emergency conditions.

18. A transmitter for a signaling system comprising signaling line terminals and non-interference line terminals, a connection including normally closed contacts between the non-interference line terminals, driving means, means whereby the driving means may be connected between one of the signaling line terminals and one of the non-interference line terminals and whereby concurrently the connection between the non-interference line terminals may be interrupted, means for thereafter transferring the connection of the driving means from the non-interference line terminal to the other signaling terminal, code means connected between the signaling terminals, and means for rendering the driving means and code means selectively operable upon impulses of different polarities.

19. A transmitter for a signaling system comprising signaling line terminals and two non-interference line terminals, a connection including normally closed contacts between the non-interference line terminals, driving means, means whereby the driving means may be connected between one of the signaling line terminals and one of the non-interference line terminals and whereby concurrently the connection between the non-interference line terminals may be interrupted, means for thereafter transferring the connection of the driving means from the non-interference line terminal to the other signaling terminal, code means connected between the signaling terminals, means for rendering the driving means and code means selectively operable upon impulses of different polarities, and a rectifier between the non-interference line terminals to permit the initial driving impulse to be applied to both non-interference line terminals while blocking passage of an initiating impulse from more remote transmitters.

FOSTER E. WELD.