

Dec. 12, 1944.

H. M. BASCOM ET AL  
TELEPHONE SIGNALING SYSTEM

2,364,771

Filed May 28, 1942

3 Sheets-Sheet 1

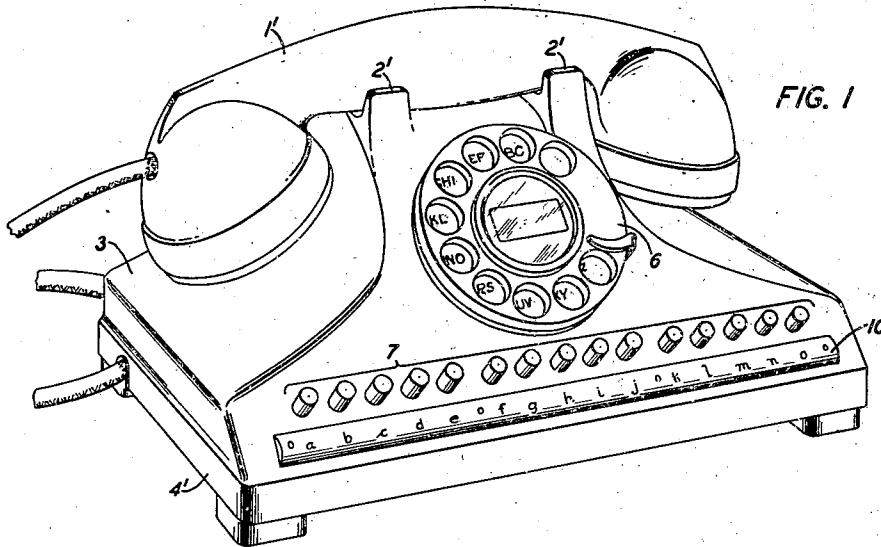


FIG. 1

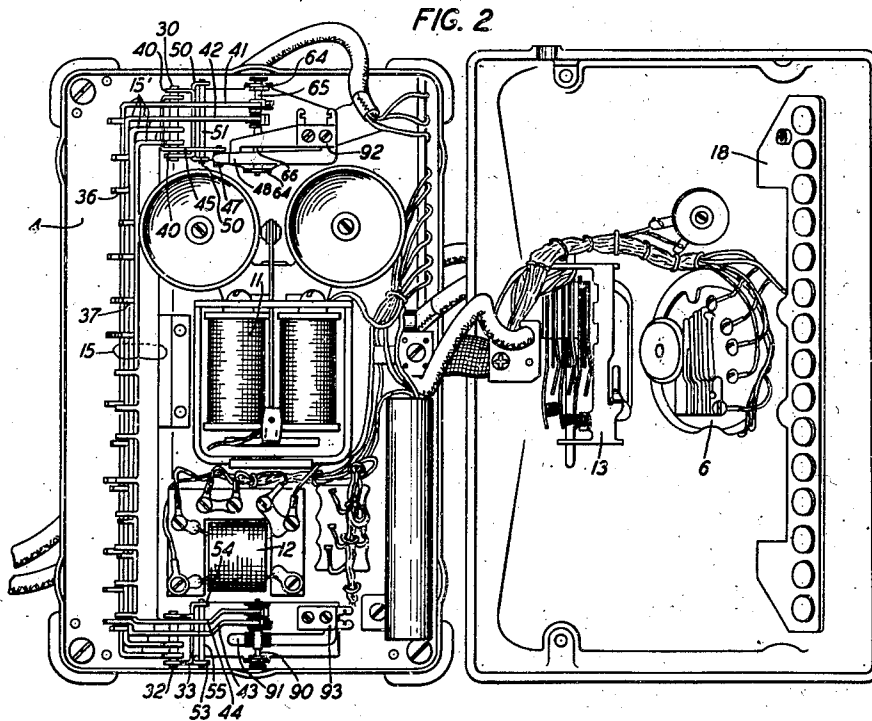


FIG. 2

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3 Sheets-Sheet 2

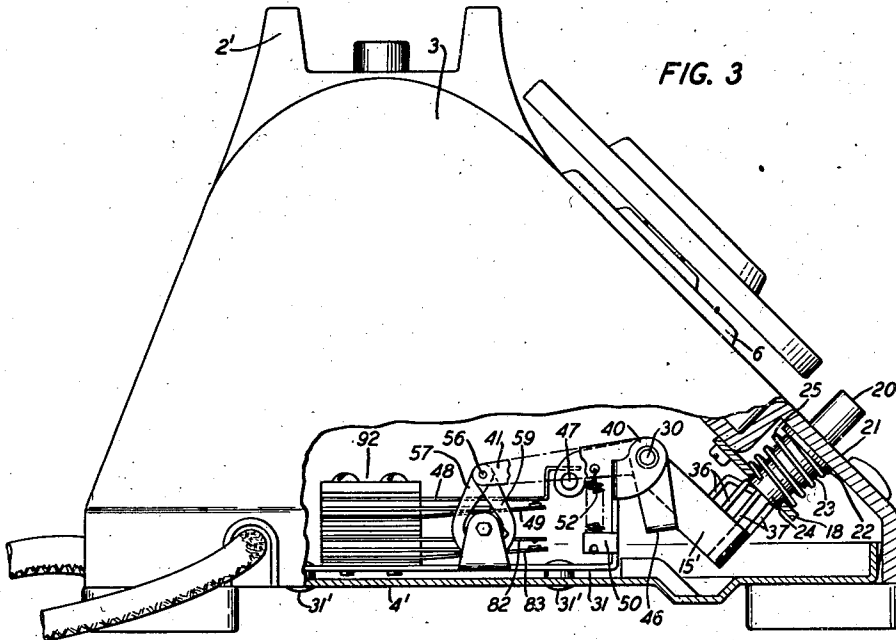


FIG. 3

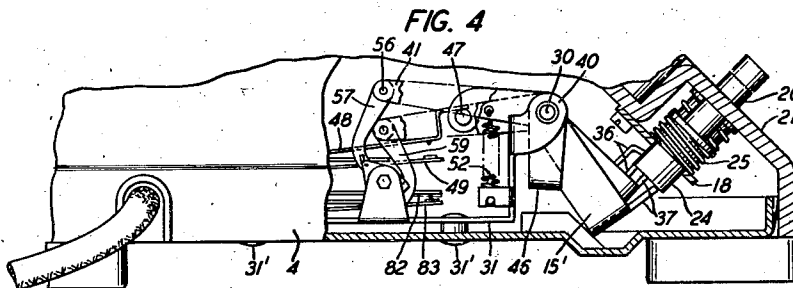


FIG. 4

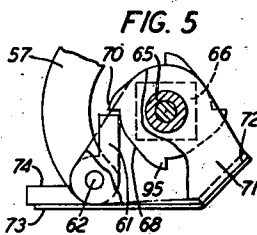


FIG. 5

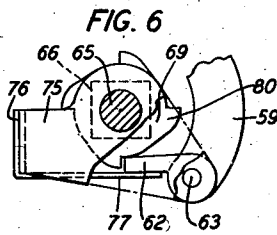


FIG. 6

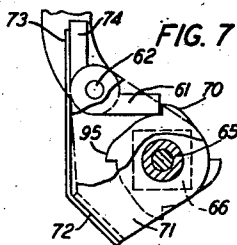


FIG. 7

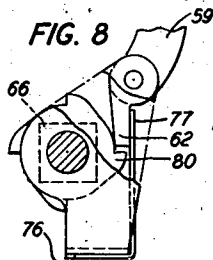


FIG. 8

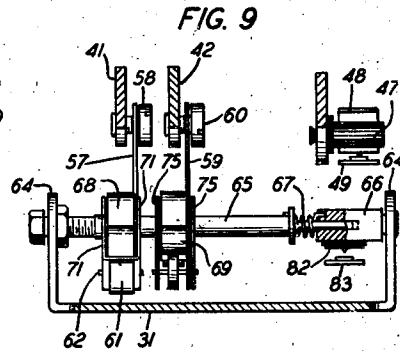


FIG. 9

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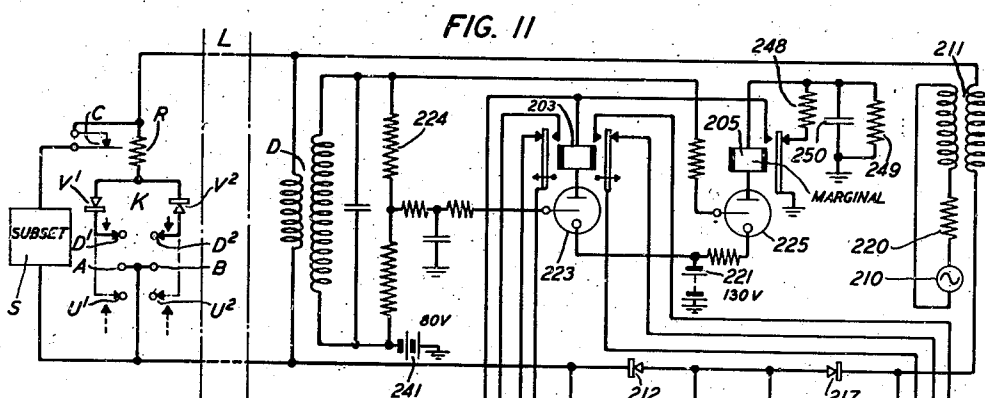
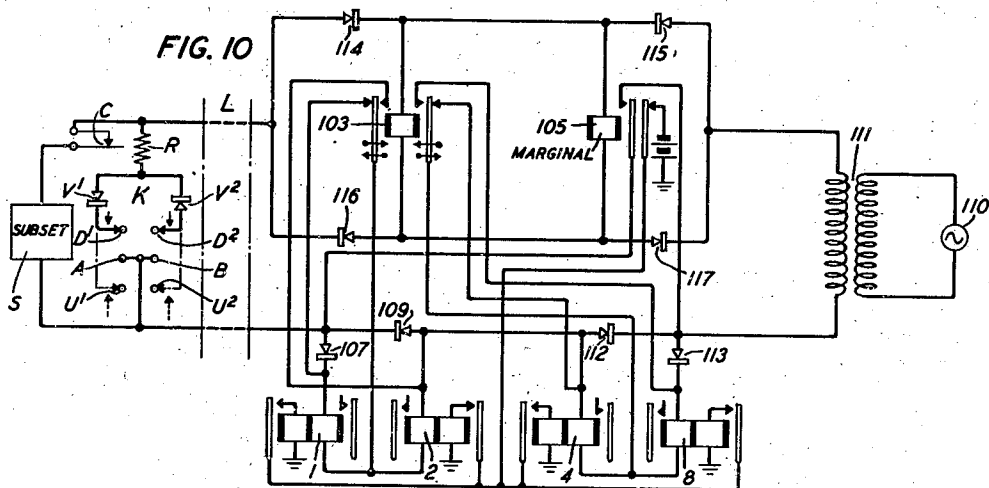
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**FIG. 12**

| KEY | CODE CONTACTS |           | CODE RELAYS OPERATED |
|-----|---------------|-----------|----------------------|
|     | DOWN STROKE   | UP STROKE |                      |
| a   | A             | —         | 1                    |
| b   | —             | A         | 2                    |
| c   | A             | A         | 1, 2                 |
| d   | B             | —         | 4                    |
| e   | A, B          | —         | 1, 4                 |
| f   | B             | A         | 4, 2                 |
| g   | A, B          | A         | 1, 4, 2              |
| h   | —             | B         | 8                    |
| i   | A             | B         | 1, 8                 |
| j   | —             | A, B      | 2, 8                 |
| k   | A             | A, B      | 1, 2, 8              |
| l   | B             | B         | 4, 8                 |
| m   | A, B          | B         | 1, 4, 8              |
| n   | B             | A, B      | 4, 2, 8              |
| o   | A, B          | A, B      | 1, 2, 4, 8           |

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## UNITED STATES PATENT OFFICE

2,364,771

## TELEPHONE SIGNALING SYSTEM

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Application May 28, 1942, Serial No. 444,772

15 Claims. (Cl. 177—353)

This invention relates to signaling systems and particularly to telephone intercommunicating systems of the type wherein telephone connections between calling and called subscribers' stations are established, under control of the calling subscriber, by means of a key-type sender or transmitter, which functions to effect the transmission of station-selecting signals comprising various combinations of positive and/or negative direct current impulses, and wherein the various impulse combinations are registered at a signal receiving point by translating devices which selectively respond to the impulses which characterize the transmitted signals and control the operation of station-connecting relays.

Heretofore, there have been proposed telephone station-selecting systems of the type wherein connections are established, under the control of a calling subscriber, by means of a rectifier-type key-sender which functions to cause the transmission of various combinations of positive and/or negative direct current impulses over a line extending to a central point. The impulses thus transmitted serve to selectively control the operation of translating devices at the central point which function to complete the connection of the calling subscriber's telephone to a particular called telephone. In order that a sufficient number of station selections be possible to render such systems practicable it has been found necessary, in transmitting certain of the station identifying impulse combinations, to utilize signal paths comprising either line conductor and ground. Obviously, such systems require a suitable ground connection at the signal transmitting, or calling subscriber's station.

In U. S. Patent No. 2,278,410, issued April 7, 1942, to Henry M. Bascom et al. there is disclosed an executive telephone call system in which oppositely poled rectifiers are adapted to be connected singly or in combinations, between each line wire and ground at the subscriber's station to effect fifteen distinct station selections. This system functions satisfactorily and serves the purpose for which it is intended in all cases where a suitable ground connection is available at the telephone subscribers' stations. Under some conditions, such a suitable ground connection at the subscribers' stations is not available.

It is the object of this invention to obviate the need for a ground connection at the subscribers' stations of a telephone system in which telephone connections, between calling and called subscribers' stations are established under the control of the calling subscriber, by the transmission of

station-selecting signals which are characterized by various combinations of positive and/or negative direct current impulses over the line wires extending from the signal transmission station to selectively operate signal receiving equipment at a signal receiving station.

This object is attained in accordance with a feature of the invention by the provision of a key-type sender of the rectifier type which renders it possible for fifteen distinct station-selecting signals to be transmitted over the metallic loop which interconnects the signal transmitting and receiving stations. More specifically, this object is attained by incorporating in a rectifier-type impulse transmitter, mechanism which functions to provide independent operations of the rectifier-connecting means for each of the down and up-strokes of the individual keys of the impulse transmitter. Such a structure renders it possible to connect one or more rectifiers between the two line wires twice for each complete operation of a station-selecting key. In this manner, certain of the keys of the transmitter function to cause the transmission of two pulses, or two groups of pulses consecutively over the metallic loop for a single complete operation thereof.

Another feature of the invention resides in a particular form of signal receiving circuit which distinguishes between impulses transmitted during the down-stroke of the keys of a key-type sender and impulses transmitted during the up-stroke of the keys, and which functions to register the signals thus transmitted.

A further feature of the invention resides in a signaling system in which more than one signal may be characterized in the same manner, and in which discrimination between signals having the same characterization is obtained by transmitting one signal during one portion of a signal-transmitting period and another signal during a different portion of the signal-transmitting period.

Before entering into a detailed description of the circuits and apparatus disclosed in the accompanying drawings, which are illustrative of a preferred form of rectifier-type key sender and of the receiving circuits which function therewith, the operating mechanism of the sender, or transmitter will be described in a general way.

The telephone set at a subscriber's station is equipped with fifteen buttons or keys each of which, when manually actuated, is adapted to operate one or more U-shaped code bars in a manner similar to that illustrated and described in a copending application, Serial No. 421,572, filed December 4, 1941. Each complete operation

of a key, or button is characterized by a down-stroke and an up-stroke, and the code bars are actuated by the button during its down-stroke and are restored to normal when the button is released, by means of restoring coil springs, there being one such spring for each bar. Each of the four code bars is provided with an integral, inwardly projecting arm which carries at its extreme end a pawl. Each of the four pawls cooperates with a particular one of four ratchet wheels in such a manner as to cause the rotation of its corresponding ratchet wheel through an arc of 90 degrees, either during the down-stroke of a key, or button, or during the up-stroke thereof. For example, two pawls, assigned respectively to two particular code bars, are effective in rotating their corresponding ratchet wheels only during the down-stroke of the key, and are ineffective to rotate the ratchet wheels during the up-stroke of the key. Similarly, two other of the pawls, individually assigned to the other two code bars, are effective in rotating their corresponding ratchet wheels only during the up-stroke of a key, and are ineffective to rotate the wheels during the down-stroke of the key. In this manner any number, one to four, of the ratchet wheels may be operated during a complete operation of a key depending upon the number of code bars actuated by the key.

Two of the four ratchet wheels are fixed to one section of a composite bar comprising a cylindrical portion and a portion having a square cross section, the two portions being coupled by a coil spring so that the portion having the flat surfaces lags slightly behind the cylindrical portion when the latter is rotated. In other words, the rotational movement of the cylindrical portion is transmitted to the flat-sided portion through the coupling spring. As each ratchet wheel is rotated, the composite bar is similarly actuated. The flat-sided section of the bar functions to operate contact springs which control the connection of the varistors between the line conductors.

The other two ratchet wheels are fixed to a second composite bar of the same construction as the bar described in the preceding paragraph, and serve to actuate a second set of contact springs through the flat-sided section of the bar in the manner described above. These contact springs also serve to connect varistors between the line conductors.

The arrangement of the varistor-connecting contact springs and of the four code bars is such that one particular code bar functions to effect the operation of the first-mentioned set of contact springs during the down-stroke of certain keys, and a second code bar functions to operate the same set of springs during the up-stroke of certain other keys. Similarly, a third code bar functions to operate the second-mentioned set of contact springs during the down-stroke of still other of the keys, and the fourth code bar serves to effect the actuation of the same second set of contact springs during the up-stroke of the remaining keys.

The key-type transmitter is also equipped with a smaller U-shaped bar which is operated whenever any one of the code-bars is actuated. This U-shaped bar functions to open a set of normally closed contacts which control the connection of the subscriber's telephone set to the line. Thus, whenever any one of the station-selecting keys, or buttons, is actuated, the subscriber's telephone

set is disconnected from the line and remains disconnected until the actuated key is restored to normal. This insures the disconnection of the telephone set from the line during the transmission of impulses.

Reference will now be made to the accompanying drawings, in which:

Fig. 1 is a perspective view of a telephone set equipped with fifteen buttons arranged in accordance with applicants' invention;

Fig. 2 is a general view of the apparatus which is housed in the telephone set shown in Fig. 1, and the mechanism controlled by the buttons located externally of the set, as shown in Fig. 1;

Fig. 3 is a side view of the telephone set shown in Fig. 1 with part of the housing broken away to show details of the button-controlled or key-controlled switching mechanism;

Fig. 4 is a fragmentary side view of the telephone set shown in Fig. 3 and illustrates the position of the switch contact controlling mechanism when one of the actuating buttons, or keys is operated;

Figs. 5, 6, 7 and 8 are enlarged fragmentary views of the contact controlling mechanism. Figs. 5 and 6 illustrate the positions of the down and up pawls just prior to the actuation of a station-selecting button and in reality, constitute enlarged views of the contact actuating mechanism in the normal position shown in Fig. 3. Figs. 7 and 8 correspond to Figs. 5 and 6 but show the contact operating mechanism after a station-selecting button has been depressed. In reality, Figs. 7 and 8 constitute enlarged views of the contact operating mechanism in the position it occupies in Fig. 4;

Fig. 9 is another fragmentary view of the contact operating mechanism taken looking down on Fig. 3;

Fig. 10 is a circuit diagram showing an all-relay type of receiving circuit which functions to register the impulses transmitted during the operation of the station-selecting buttons shown in Fig. 1. In this figure, the contact-controlling mechanism is schematically illustrated at the left of the vertical broken lines;

Fig. 11 is a circuit diagram similar to Fig. 10 except that a gas-filled tube type of receiving circuit is shown instead of an all-relay type; and

Fig. 12 is a table showing the various contact combinations which are effected for the actuation of each button, or key, and the corresponding code relays which respond to each key operation.

Referring now to Figs. 1 to 9, inclusive, of the drawings, the subscriber's telephone consists of a handset 1' mounted on a cradle 2' formed integrally with the housing 3 of the telephone set, the housing being supported on a base plate 4'. On the front surface of the housing 3 is shown the usual dial mechanism 6 and fifteen buttons arranged in a single row 7 below the dial. Immediately in front of the row of buttons, and fixed on the housing 3 is a transparent plate 10 under which the designations corresponding to the individual buttons, or keys may be placed.

In Fig. 2 is shown the general arrangement of the apparatus housed inside the telephone set. This apparatus comprises a ringer 11; induction coil 12; a switching contact arrangement 13 controlled in the usual manner by the handset 1' when placed in the cradle 2', or removed therefrom; the dial 6; button-controlled U-bars or levers 15; the groups of contact springs controlled

thereby; and a mounting plate 18 for the buttons.

Each button consists of a cylindrical portion 20 (Figs. 3 and 4) protruding through an opening in the inclined front portion 21 of the housing 3. The button is provided with a flange 22 that abuts the inner surface of the inclined portion 21 of the housing 3; with an inner cylindrical portion 23 of larger diameter than the cylindrical portion 20; and with a cylindrical portion 24 of somewhat lesser diameter than the portion 23. A helical spring 25 is wound around the shank portions 23 and 24 of the button so that one end thereof abuts the flange 22 and the other end abuts the mounting plate 18 secured to the front portion 21 of the telephone set. The shank portion 24 protrudes through an opening in the mounting plate 18 so that the button may be caused to move axially downwardly in the opening, or aperture in the mounting plate 18 when the button is manually depressed, and is caused to return to normal position by the restoring action of spring 25. The normal position of the button is determined by the flange 22 and the extent to which it may be depressed is determined by the shoulder formed at the junction of the shank portions 22 and 23 and its engagement with the plate 18.

The buttons control the operation of four levers, or code bars 15 (Fig. 2) which are substantially U-shaped and are located at the forward end of the telephone set. Each bar consists of an elongated portion extending substantially the entire width of the base plate 4', and a right-angle extension 15' integrally formed with the elongated portion and located at each extremity thereof. As shown in Fig. 2, these extensions are provided with apertures which accommodate the pins 30 and 32, the pin 30 serving the extensions 15' on the left, and the pin 32 serving the extensions 15' on the right, looking towards the front of the telephone set. The bars are thus mounted for rotation about the pins 30 and 32. The pin 30 is supported between two ear-like appendages 40 of a spider-like bracket 31 which is secured to the base plate 4' by means of rivets 31' as clearly shown in Figs. 3 and 4. The pin 32 is supported in a similar manner by the bracket 33 shown in Fig. 2, which is similarly secured to the base plate 4'. The left extensions 15' of the two lower bars 15, when viewed from the front of the telephone set, are each provided with an integral projection which extends inwardly from pivot pin 30, the functions of which will be set forth in greater detail hereinafter. These projections are identified by the numerals 41 and 42. Similarly, the right or lower extensions 15' (Fig. 2) of the two upper bars 15 are each provided with an integral projection which extends inwardly from the pivot pin 32, the functions of which will be described hereinafter. These extensions are indicated by the numerals 43 and 44.

The elongated portions of the U-bars 15 are provided with projections or fingers, such as 36, 37, and others located in various positions throughout the length of the bars. Some of these projections are bent inwardly and others project straight up from the bars. These extensions are so arranged that the bottom surface of each button portion 24 will engage one or more thereof when the button is depressed. Thus, when any button is depressed, a certain number of the projections, such as 36 and 37, will be engaged to

cause a corresponding combination of bars 15 to be rotated about the pivot pins 30 and 32.

Also supported between the ear-like appendages 40 of the bracket 31 is a short U-shaped bar 46 which is adapted to be rotated about the pivot pin 30. This bar 46 is located under the integral projections 15' of the bars 15 and is adapted to be rotated about the pivot whenever any one of the bars or levers 15 is actuated. This U-bar also carries an integral projection which extends inwardly from the pivot pin 30 and has fixed thereto, at its end, an insulating stud 47 which, when the bar 46 is operated, engages an extension of the contact spring 48 and disengages the spring 48 from its mate spring 49. Thus, whenever any button is depressed, the normally closed contacts of springs 48-49 are opened for a purpose to be hereinafter explained.

The bracket 31 is provided with two integral horizontal projections 50, both of which are shown in Fig. 2, and only one of which appears in Figs. 3 and 4, which support a rod or pin 51. This rod serves as an anchorage for one end of each of a plurality of coil springs 52 whose other ends are individually anchored to the inwardly projecting arms of the U-bars 15 and 46, such as the arms 41 and 42. These springs function to restore the U-bars 15 and 46 to normal position after the manual depression of the corresponding buttons. The bracket 33 is similarly provided with a pair of horizontal projections 53 and 54 which serve to support the rod or pin 55, which provides a means for anchoring one end of springs, similar to the springs 52, the other ends of which are secured to the inwardly projecting arms 43 and 44 of the U-bars 15. These springs also serve to restore the U-bars 15 to normal after actuation.

At the outer extremity of the arm 41 there is pivotally mounted, at 56, a pawl 57. This pawl may be associated with the arm 41 by means of a screw 58 as clearly shown in Fig. 9. Similarly, the outer extremity of the arm 42 pivotally supports a pawl 59. The screw 60 serves to associate the pawl 59 with the arm 42. The pawl 57 is provided at its lower end with a dog 61 pivotally supported on the pawl at 57. The pawl 59 is provided at its lower end with a similar dog 62 pivotally supported on the pawl 59 at 63.

The pawl 57 may be characterized as a "down" pawl and the pawl 59 as an "up" pawl, since these pawls perform their respective functions during the down and up strokes, respectively, of certain of the buttons as will be fully described hereinafter.

The bracket 31 is provided with two vertically spaced projections 64 which support a rod 65. The rod 65, viewing particularly Fig. 9, consists of a cylindrical portion to which the numeral 65 is applied, and a portion 66 having a square cross section. The portion 65 is coupled to the portion 66 by means of a coil spring 67, the purpose of which is to introduce a time lag between the rotational movement of the portion 65 and the portion 66. The rod is capable of rotational movement under the action of the pawls 57 and 59 as will appear presently.

Fixed to the rod or shaft 65 near its left end, viewing Fig. 9, there are two ratchet wheels 68 and 69, each of which is provided with four teeth displaced about the periphery at 90-degree intervals. As shown in Figs. 5 and 6, which illustrate the pawl and ratchet arrangements in their normal positions, the dog 61 of pawl 57 is so located with respect to the ratchet teeth that, as

the pawl is moved upwardly under the action of a button, the edge of the dog engages the tooth 70 and causes the ratchet wheel 68 to rotate through 90 degrees in a clockwise direction. The position of the dog 61 and ratchet tooth 70 after the down-stroke of a button has been completed is illustrated by Fig. 7. The pawl 59, as hereinbefore described, has pivotally associated therewith the dog 61, the pivotal association being effected by the pin 62. The pin 62 also serves to support a pair of substantially triangularly shaped members 71 which are integrally joined at one end to effect, substantially, an enclosure for the ratchet wheel 68. The integral union is effected at 72. The two side pieces of this enclosure, or the two triangularly-shaped members 71 are apertured to receive the rod 65 and to be rotatable relative thereto. Fixed to the enclosure effected by the members 71 and their integrally associated uniting portion 72, is a spring 73 against which one element 74 of the V-shaped dog rests and which functions to maintain the element 61 of the dog in constant engagement with the ratchet wheel 68. By virtue of the association of the spring-supporting enclosure effected by members 71 and 72 and the V-shaped dog consisting of the projections 61 and 74, with the pawl 57, which association is effected by the pin 62, whenever the pawl is raised in consequence of the depression of a button, the enclosure is rotated on the rod 65 and the dog element 61 is similarly moved to cause the ratchet wheel 68 to be rotated. The position of the spring 73, as well as that of the dog elements 61 and 74 after the operation of a button is illustrated in Fig. 7.

Referring now particularly to Figs. 6 and 8, the pawl 59 which heretofore has been referred to as the "up" pawl, is associated with a spring-supporting element made up of the two side portions 75 and the joining portion 76, the spring 77 being fixed to the enclosure portion 76 in any suitable manner. Normally, the dog 62 which, with the enclosure portions 75 is associated with the pawl 59 by means of the pin 63, assumes the position shown in Fig. 6. When a button is depressed so as to raise the pawl 59, the enclosure, comprising elements 75 and 76 and spring 77, together with the dog 62 are moved so as to assume the positions shown in Fig. 8. It will be noted that the edge of the dog 62 has moved to such a position, relative to the ratchet wheel 69, as to be in readiness to engage the tooth 80 when the actuating button is released, and the U-bar 15, with which the pawl 59 is associated returns to normal under the action of its restoring spring 52. Thus, during the down-stroke of the button, the dog 62 rides over the curved periphery of tooth 80 of ratchet wheel 69 without effecting any movement of the ratchet wheel, and during the up-stroke of the button, the dog 62 causes the rotation of the ratchet wheel 69 through 90 degrees.

From the description thus far advanced, it is apparent that whenever a button or key is depressed so as to operate a U-bar 15 with which the "down" pawl 57 is associated, the ratchet wheel 68 is rotated through an arc of 90 degrees. Similarly, when a key is depressed so as to operate a U-bar 15 with which the "up" pawl 59 is associated, the ratchet wheel 69 remains stationary, and during the return stroke of the button, the ratchet wheel 69 is rotated through an arc of 90 degrees. It is well at this time to indicate that, though the pawl 57 functions during the down-stroke of a key or button to rotate the

ratchet wheel 68 through an arc of 90 degrees, the dog 61 does not cause the actuation of the ratchet wheel during the up-stroke of the key, though the pawl 57 is moved downwardly to its normal position at that time. That this is the case is apparent from an examination of Fig. 7 which shows the dog 61 in the position it occupies just prior to the release of the actuated button.

The mechanism just described, which functions when the U-bars 15, with which the projections 41 and 42 are associated are operated, is duplicated at the bottom of Fig. 2, (or at the right of the handset interior, Fig. 2) so that the same ratchet wheel operations are effected by the U-bars 15 with which the integral extensions 43 and 44 are associated. Thus there are two U-bars 15 which are effective in rotating a ratchet wheel during the down-stroke of certain buttons and two which are effective in rotating a ratchet wheel during the up-stroke of certain other buttons. More specifically, the U-bars 15 with which the integral extensions 41 and 43 are associated function to operate a ratchet wheel during the down-stroke of a button, and the U-bars 15 with which the integral extensions 42 and 44 are associated function to effect the rotation of a ratchet wheel during the up-stroke of a button.

As shown to the right of Fig. 9, the section 66 of the ratchet supporting bar 65 is operatively associated with a contact spring 82, which spring 82 is adapted to be moved into engagement with the contact spring 83. As the bar section 66 rotates under the action of the pawls 57 and 59 it serves as a cam to move the spring 82 into engagement with the spring 83 in such a manner that the contact springs 82 and 83 are in engagement during a portion of the rotational movement of bar section 66 and are disengaged before the bar section completes its 90-degree rotation.

It is understood that a similar set of contact springs is located at the bottom of Fig. 2 to be actuated in a similar manner by the square-sectioned portion of the rod 90 which is controlled through the medium of the U-bar extensions 43 and 44. These contact springs are indicated by the numeral 91.

As clearly disclosed in Fig. 3, the bracket 31 serves as a support for the spring pile-up 92 which includes the springs 48, 49, 82 and 83. The spring pile-up 93 which includes the springs 91 is similarly mounted on the bracket 33 shown at the bottom of Fig. 2.

In order to more fully explain the operation of the key, or button-type sender described above, the various mechanical operations which follow the operation of several of the keys will now be described. It will be assumed that the button *a* to the extreme left of Fig. 1 is depressed and released and that this button causes the operation of only the outermost U-bar 15 (Fig. 4) by virtue of the engagement of the bottom of the shank portion 24 with a single projection 37 associated with the U-bar. The U-bar 15 assumes the position illustrated in Fig. 4 and by virtue of the engagement of the integral projection 15' thereof with the smaller U-bar 46, the insulating stud 47 engages the contact spring 48 and disengages it from the spring 49. The purpose of these contact springs will appear from a description of the circuits of Figs. 10 and 11 to be made hereinafter. At the same time, the integral extension 41 of the actuated U-bar 15 is moved upwardly by virtue of its pivot support 30. In moving upwardly, the arm 41 pulls the pawl 57 up-

wardly causing the dog 61 associated therewith to engage the tooth 70 of ratchet wheel 68 and rotate the wheel 68 through an arc of 90 degrees. The ratchet wheel 68 being fixed to the bar 65 causes the latter to rotate through the same arc. The rotational movement of the bar 65 is transmitted to the square-sectioned portion 66 through the coupling effected by spring 67 so that the portion 66 rotates 90 degrees, its rotational movement lagging slightly behind that of the bar 65. In rotating through an arc of 90 degrees, the square-sectioned portion 66 causes contact spring 82 to approach, engage, and disengage the contact spring 83 for a purpose to be described hereinafter. Thus, during a portion of the down-stroke of the button, the contact springs 82 and 83 are closed and before the button reaches the lower limit of its down-stroke these contacts are opened. This sequence of contact operations is produced by the square periphery of the rod section 66.

When the button is released, it is restored to normal under the action of its associated spring 25, and spring 52 associated with the actuated U-bar functions to restore the actuated U-bar. Thus, the U-bar extension moves downwardly and during the downward movement thereof the element 61 moves back over the surface of the ratchet wheel 68 to assume a position under the next succeeding tooth 95 in preparation for a subsequent key operation. During this return movement, the ratchet wheel 68 remains stationary. Thus, for a complete operation of the key, or button *a*, which includes its down-stroke and its up-stroke, the contact springs 82 and 83 are actuated once. Obviously, when the actuated U-bar returns to normal, the auxiliary U-bar 46 restores under the action of its individual coil spring and the contact springs 48 and 49 are again closed.

Should a key or button be actuated which causes the operation of a U-bar 15 which has associated therewith the integral arm 42, the pawl 59 is raised to cause the dog 62 to ride over the periphery of the ratchet wheel 69 and position itself opposite the tooth 80 thereof. During this downward movement of the key or button, the ratchet wheel 69 does not rotate and the contact springs 82 and 83 remain unactuated. The contact springs 48 and 49, however, are disengaged.

When the button is released, a spring 52 restores the actuated U-bar to normal, that is, the arm 42 is moved downwardly causing the dog 62 to engage the tooth 80 of the ratchet wheel 69 and move the wheel through an arc of 90 degrees. The bar section 66, accordingly, is rotated during the up-stroke of the key or button to close the contact springs 82 and 83.

By virtue of the fact that certain of the buttons or keys engage two or more of the U-bar projections 36, 37, it is apparent that more than one U-bar, and up to four, may be actuated in response to the operation of a button. Under these circumstances the U-bars associated with the integral projections 41 and/or 43 function during the down-stroke of the keys to operate the contact springs 82—83, and/or 91, respectively, while on the up-stroke of the keys the U-bars associated with the integral projections 42 and/or 44 function to operate the contact springs 82—83 and/or 91, respectively.

The operation of a signaling system involving the key-type sender just described, and the signal receiving circuit disclosed in Fig. 10 of the drawings will now be described.

In Fig. 10 of the disclosure, the key-sender located at the transmitting station, which may be a telephone subscriber's station, is indicated schematically at K. In this showing, the controlling contacts are identified by the letters A and B. The contacts A correspond to the contacts 82—83 in Figs. 3 and 4, and the contacts B are intended to correspond to the contacts indicated at 91 in Fig. 2. Since each of these contacts may be operated during the up-stroke or the down-stroke of a key, applicants have illustrated, in the schematic illustration, two other pairs of contacts D<sup>1</sup>, D<sup>2</sup> and U<sup>1</sup> and U<sup>2</sup>, the D designation indicating that the contacts D<sup>1</sup> and D<sup>2</sup> engage with contacts A and B, respectively, during the down-stroke, and the U designation indicating that the contacts U<sup>1</sup> and U<sup>2</sup> engage with contacts A and B, respectively, during the up-stroke of a key. When a key, or button is depressed, it is assumed, in accordance with the schematic showing of the key-sender K, that the contacts D<sup>1</sup> and/or D<sup>2</sup> approach and engage contacts A and/or B, respectively, while during the up-stroke of a key the contacts U<sup>1</sup> and/or U<sup>2</sup> approach and engage the contacts A and/or B, respectively.

Before entering into a detailed description of the operation of the system shown in Fig. 10, it may be well to mention the particular sequence of contact operations which is followed for a complete operation of a key, that is, for a combined down-stroke and up-stroke thereof. Normally, the circuit is as illustrated. The rectifiers V<sup>1</sup> and V<sup>2</sup> are open-circuited and the line loop is open at the contacts of the subscriber's telephone set. When the telephone set is removed from its support, the line loop is closed through the subscriber's substation set by way of the contact C. Contact C corresponds to the contacts 48—49 of Figs. 3 and 4. As soon as a key starts its down-stroke, the contact C is opened as described hereinbefore and this opening is, or may be, immediately followed by the closure of the line loop through either one or both rectifiers V<sup>1</sup> and V<sup>2</sup> and resistance R. The opening of the contact C disconnects the telephone subset from the line L. Just as a key reaches the end of its down-stroke, the line loop is completely opened, that is, contact C remains open and the actuated contact A or B reopens. During the up-stroke of a key, the line loop is, or may be, again closed through rectifiers V<sup>1</sup> or V<sup>2</sup>, singly or in combination, and resistance R. As the key reaches its normal position, the line loop is closed through the subscriber's subset owing to the closure of contact C, it being understood that the key-sender is so designed that contact C opens upon the actuation of any key and remains open until the key resumes its normal unoperated position. Thus the subscriber's set is disconnected from the line during pulsing.

Located at the receiving station, or central office, is an all-relay receiving circuit which is supplied with power from the alternating current source 110 by way of the transformer 111. The receiving equipment comprises four code relays, designated 1, 2, 4 and 8, and two control relays, designated 103 and 105. The code relays are connected in pairs across single oppositely poled rectifiers. Rectifiers 107 and 109 are associated with the pair of relays consisting of relays 1 and 2, and rectifiers 112 and 113 are associated with the pair of relays 4 and 8. The control relays 103 and 105 are connected in a full-wave rectifier circuit comprising the rectifiers 114, 115, 116 and 117. The circuit arrangement is such that



relays 1 and 4 register the impulses transmitted during the down-stroke of the keys of the key sender, while relays 2 and 8 register the impulses transmitted during the up-stroke of the keys. Furthermore, relays 1 and 2 register the positive direct current impulses, while relays 4 and 8 register the negative impulses.

Control relay 105 is marginal and will operate when the line loop is closed through the subscriber's subset S, that is, when the subscriber removes the telephone set from its cradle support, but will not hold operated when resistance R is connected to the line. The resistance R is connected in series with the rectifiers V<sup>1</sup> and V<sup>2</sup> and is adjusted to have at least twice the impedance of the subset S at the frequency of the source 110. Thus relay 105 will release as soon as any key of the key-sender is operated, and will remain unoperated until the key returns to normal. The release of relay 105 prepares the relays 1, 2, 4 and 8 to receive the transmitted signals by removing a short from the rectifiers 109 and 112. This short is effected at the front contact and inner armature of relay 105. At its outer armature and back contact, relay 105 provides locking battery for the impulse receiving relays.

Control relay 103 is made slightly slow to operate and to release. It is more sensitive than relay 105 and will hold operated through resistance R, but will release when the loop is completely opened at the end of the down-stroke of the individual keys. Relay 103 serves to transfer the registration circuit from the down-stroke relays 1 and 4 to the up-stroke relays 2 and 8. The code relays will serve to transfer the code received, to selectively operated mechanism such as station-connecting relays to connect the calling subscriber to the called subscriber as described in the above-identified Patent 2,278,410. Relay 103, furthermore, if released, will not operate through resistance R, but if operated, will hold operated when resistance R is included in the signaling circuit.

When any key of the key-sender at the calling, or code transmitting station is depressed, the first result is the release of relay 105. Then according to the U-bars 15 selected by the key, the down-stroke registration will be recorded by relays 1 or 4, or by both or neither. At the end of the down-stroke, relay 103 will release, shorting relays 1 and 4 and removing the shorts from relays 2 and 8, which relays will then be available to receive the code registration on the up-stroke of the key. When the key restores to normal the relays 1, 2, 4 and 8 return to their normal condition.

A description of the operation of the system shown in Fig. 10 will now be made. It is deemed unnecessary to describe in detail the operation of the system which follows the actuation of each key of the key-sender, and that a thorough understanding of the operation of the system will be had from a description involving the operation of but a few of the keys.

It will now be assumed that the subscriber at the calling station desires to establish a telephone connection with a subscriber's station to which the key *a* is individually assigned. The subscriber, accordingly, removes the telephone handset from its support and depresses the key *a* and then allows it to restore to normal under the action of the restoring spring. Removal of the handset from its support closes the line loop through the subscriber's subset. As hereinbefore

indicated, relay 105 operates under this condition. The circuit in which relay 105 operates may be traced as follows: during the first half-cycle of current from the source 110, the upper terminal of the secondary winding of transformer 111 may be assumed to be positive and the lower terminal negative, so that the circuit extends from the upper terminal of the secondary of transformer 111, through rectifier 115, winding of relay 105, rectifier 116, over the tip conductor of line L, closed contacts C, through the subscriber's subset S, ring conductor of line L, rectifier 107, back contact and left armature of relay 103, operating winding of relay 2, rectifier 112 to the lower terminal of the secondary winding of transformer 111. On the next half-cycle, the circuit may be traced from the lower terminal of the secondary winding of transformer 111, rectifier 113, operating winding of relay 8, right armature and back contact of relay 103, rectifier 109, ring conductor of line L, through the subscriber's set S, closed contacts C, tip conductor of line L, rectifier 114, winding of relay 105, rectifier 117, to the upper terminal of the secondary winding of transformer 111. Relay 105, therefore, operates on the rectified alternating current traversing the circuits just traced. Relay 103 being connected in parallel with relay 105 also operates in these circuits a short interval after relay 105 operates. The operating windings of relays 2 and 8 being included, each in one of the circuits just traced, these relays may operate but will release immediately upon the operation of relay 105. The operating windings of relays 1 and 4 are short-circuited by the armatures and back contacts of relay 103.

When the key is depressed, contact C is opened and removes the subset S from the line loop causing relay 105 to release. Relay 103 being slow to release, holds operated sufficiently long to permit the closure of either contact A or B, or both, by the actuated key *a*, to reestablish the loop circuit by way of resistance R, as will appear presently. Contact C, open, removes the subscriber's telephone set from the line L.

The opening of contact C is followed immediately by the closure of contact A effected by the operation of key *a*. In the schematic showing of the key-sender K in Fig. 10, the contact D<sup>1</sup> is now in engagement with contact A, and all other contacts are considered to be out of engagement, as shown. This contact engagement persists substantially until the key *a* reaches the end of its down-stroke, when the loop circuit is completely opened.

During the engagement of contact D<sup>1</sup> with contact A, a circuit exists which may be traced from the upper terminal of the secondary winding of transformer 111, rectifier 115, windings of relays 105 and 103 in parallel, rectifier 116, tip conductor of line L, resistance R, rectifier V<sup>1</sup>, contacts D<sup>1</sup> and A, ring conductor of line L, rectifier 107, operating winding of relay 1, left armature and front contact of relay 103, rectifier 112, to the lower terminal of the secondary winding of transformer 111. Relay 1 operates in this circuit and, at its left armature and front contact, locks to battery at the outer armature and back contact of relay 105. At its right armature, relay 1 performs a switching function which may be utilized to control the operation of a station-connecting switching device in a manner known in the art.

When the key *a* reaches the end of its down-stroke, the line loop is completely open so that

relay 103 restores its armatures. In restoring its armatures, relay 103 short-circuits the operating windings of relays 1 and 4, to render these relays unresponsive to impulses transmitted on the up-stroke of key *a*, and to render relays 2 and 8 available for the receipt of such impulses.

As indicated on the table (Fig. 12), contact A is made on the down-stroke of key *a* and neither contact A nor B is closed on the up-stroke. Therefore, when the key *a* is depressed and released, only contact A and rectifier V<sup>1</sup> are utilized to transmit a station-selecting impulse which is registered by the relay 1.

With the return to normal of key *a*, the contact C is again closed causing relay 105 to again operate to remove the locking battery from the relays causing the operated relays to release and restore their armatures.

It will now be assumed that instead of actuating key *a* the calling subscriber actuates key *b* in order to effect a different station selection. Relays 105 and 103 will be operated as described hereinbefore.

As soon as key *b* starts its down-stroke, the contact C is opened to remove the subscriber's set from the line. Relay 105 accordingly releases, and relay 103 holds operated as described in connection with the actuation of key *a*. During the down-stroke of key *b* no operation of the ratchet wheel 69 (Fig. 9) is effected and therefore no rectifier connection to the line results. However, when the key *b* reaches its lower limit, the line circuit is completely opened and relay 103 releases, shorting relays 1 and 4 and removing the shorts from relays 2 and 8 which latter relays are then available to register the impulses transmitted during the up-stroke of key *b*. During the return or up-stroke of key *b* the ratchet wheel 69 is rotated to cause a closure of contact A, or contacts 82-83 of Figs. 3 and 4. That is, referring to the schematic K of Fig. 10, the contacts U<sup>1</sup> and A engage each other during the up-stroke of key *b*. During this engagement a circuit may be traced extending from the upper terminal of the secondary winding of transformer 111, rectifier 115, windings of relays 105 and 103 in parallel, rectifier 116, resistance R, rectifier V<sup>1</sup>, contacts U<sup>1</sup> and A, rectifier 107, back contact and left armature of relay 103, operating winding of code relay 2, rectifier 112 to the lower terminal of the secondary winding of transformer 111. Relay 2 operates in this circuit and at its front contact and right armature locks in an obvious circuit. At its left armature and front contact, relay 2 may control the operation of a station-connecting relay. Thus, on the return stroke of key *b*, a positive impulse is transmitted over the line and is registered by relay 2. When key *b* reaches its normal position the receiving circuit is restored to normal and the contact C is closed to reconnect the subscriber's telephone set to the line.

The station selections thus far described were effected by the transmission of pulses of a single polarity only, which were generated on the down-stroke of the key *a* and on the up-stroke of key *b*, respectively. It will now be described how a station selection is effected by the transmission of a signal comprising both positive and negative current impulses generated during the down-stroke of a key. For this purpose, it will be assumed that the subscriber at station S actuates the key *e*, which, in accordance with the table (Fig. 12) causes both contacts A and B

to be rendered effective during the down-stroke of the key.

When the key *e* is depressed, contact C is opened and contacts D<sup>1</sup> and D<sup>2</sup> engage contacts A and B, respectively, of the key-sender shown schematically in Fig. 10. While these contacts are in engagement, positive and negative current impulses traverse the line loop to cause the operation of code relays 1 and 4. The operating circuit for relay 1 is the same as described in connection with the operation of key *a*. Relay 4 operates in a circuit which may be traced from the lower terminal of the secondary winding of transformer 111, rectifier 113, front contact and right armature of relay 103, operating winding of code relay 4, rectifier 109, contacts B and D<sup>2</sup>, rectifier V<sup>2</sup>, resistance R, tip conductor of line L, rectifier 114, windings of relays 103 and 105 in parallel, rectifier 117 to the upper terminal of the secondary winding of transformer 111. Relays 1 and 4 accordingly are operated when key *e* is actuated to register the signal transmitted by this key.

When the key *e* reaches the end of its down-stroke, the loop circuit is opened causing the release of relay 103, but since no impulses are transmitted during the up-stroke of key *e*, the release of this relay performs no useful purpose in this particular instance. When the key *e* restores to normal, contact C is again closed to reconnect the subset S to the line L and to reoperate relay 105.

The condition will now be described in which impulses are transmitted over the line loop during both the down- and up-strokes of a station-selecting key. For this purpose it will be assumed that the calling subscriber actuates the station-selecting key *g*. It will be noted, by reference to the table (Fig. 12), that both contacts A and B function during the down-stroke of key *g* and that only contact A is involved in the up-stroke thereof.

When the key *g* is depressed, contact C is opened and contacts D<sup>1</sup> and D<sup>2</sup> engage contacts A and B, respectively. The engagement of contacts D<sup>1</sup> and D<sup>2</sup> with contacts A and B effectively connects rectifiers V<sup>1</sup> and V<sup>2</sup>, respectively, across the line L by way of resistance R in the manner described in connection with the operation of key *e*. Relays 1 and 4, accordingly, operate and lock, as previously described, during the down-stroke of key *g*. When the key *g* reaches the end of its down-stroke, the loop circuit is completely opened as previously described, so that relay 103 restores its armatures. Relay 103, in restoring its armatures, prepares relays 2 and 8 for the reception of impulses transmitted during the up-stroke of the key *g*. During the up-stroke of key *g*, contacts U<sup>1</sup> and A of the key-sender K come into engagement so that a positive current impulse traverses a circuit extending from the upper terminal of the secondary winding of transformer 111, rectifier 115, windings of relays 105 and 103 in parallel, rectifier 116, upper conductor of line L, resistance R, rectifier V<sup>1</sup>, contacts U<sup>1</sup> and A of the key-sender, lower conductor of line L, rectifier 117, back contact and left armature of relay 103, operating winding of code relay 2, rectifier 112 to the lower terminal of the secondary winding of the transformer 111. Relays 4, 1 and 2, accordingly, respond to the operation of key *g* of the key-sender and cooperate to effect the selection of a called station corresponding to the key *g*.

In describing the operations of the circuit

which follow the actuation of keys *a*, *b*, *e*, and *g*, the following conditions have been covered.

1. The transmission of a single pulse of positive direct current during the down-stroke of key *a*.

2. The transmission of a single pulse of positive direct current during the up-stroke of key *b*.

3. The transmission of a positive and a negative current impulse during the down-stroke of key *e*.

4. The transmission of a positive and a negative current impulse during the down-stroke of key *g* and a positive current impulse during the up-stroke of key *g*.

It is believed unnecessary to describe the results which follow the operation of the remaining keys, since the table, Fig. 12, clearly illustrates the contact operations effected by each key and the code relays which operate in response to such key operations.

The circuit arrangement shown in Fig. 11 is alternative to that shown in Fig. 10. The registration, or code relays 1, 2, 4 and 8 of Fig. 10 can be made to operate on a half-cycle of current of the proper polarity. It is required, therefore, that a full half-cycle of each polarity is included in the contact closures for each direction of operation of a station-selecting key. For 60-cycle supply, which is the intended frequency of the supply source 110 in Fig. 10, this would require a minimum closure of about 20 milliseconds each way. In the key-sender illustrated in Figs. 1 to 9, inclusive, the necessary time closure of the contacts is insured by the coupling springs 67 which guarantees contact closures of sufficient lengths of time without imposing on the subscriber any requirement as to the manner in which the keys of the key-sender are to be operated.

Another way of coping with the situation referred to above is to increase the supply frequency, so that a full cycle will occupy less time. For example, if a frequency of 200 cycles is used, the minimum contact closure required would be slightly over 5 milliseconds, which could be obtained without the introduction of the coupling spring 67 in the key-sender. However, this would reduce proportionately the time of operation of the code relays. The circuit shown in Fig. 11 has been devised to illustrate the use of a supply source designated 210, which has a frequency of approximately 200 cycles, and gas-tube type receiving equipment which has the speed of operation required at such a frequency.

The arrangement of the subset is the same as in Fig. 10, and the functions of the several parts of the receiving circuit are substantially equivalent to those of the corresponding elements of the circuit of Fig. 10. The registration relays 1, 2, 4 and 8 are operated through gas-filled tubes 230, 234, 233 and 235, respectively, which lock when operated.

Control relays 203 and 205 perform substantially the same functions as relays 103 and 105, respectively, of Fig. 10 and have the same marginal discrimination. This discrimination is on an operate basis rather than a release basis as in the circuit of Fig. 10. The input transformer D is bridged directly across the line loop L and the 200-cycle supply 210 is fed through resistance 220. Thus the potential across the transformer D will be a minimum when contact C is closed; will be greater when this contact is opened, since resistance R is considerably higher

than the impedance of the subset S; and will be further increased to the full supply voltage when the loop is opened at the down-stroke of a key. The full secondary voltage of transformer D is applied to the control gap of the tube 225 associated with relay 205 while that applied to the tube 223 associated with relay 203 is reduced by the potentiometer 224. The batteries 221 and 241, the former of 130 volts and the latter of 80 volts furnish anode potential for the tubes 223 and 225.

The values are so chosen that neither tube breaks down as long as contact C is closed, while the increased potential drop through resistance R, when C is opened, is sufficient to break down tube 225 and operate relay 205. Relay 203 will operate only when a key reaches the end of its down-stroke and opens the line loop thus applying the full supply voltage at the terminals of transformer D. Relay 205 activates the registration circuit by putting ground on the secondary windings of transformers E and F, and provides an operating path for relay 203.

A description of the operation of the receiving circuit shown in Fig. 11 will now be made and for this purpose it will be assumed that keys *a*, *b*, *e*, and *g* will be operated to effect four different station selections.

Prior to the operation of the key *a* in making a first station selection, the circuit elements are in the condition illustrated. When the key *a* is operated, the contact C is opened in the manner previously described, to remove the telephone set S from the line. The operation of key *a* causes contact A to engage the contact D<sup>1</sup> of the key-sender schematically shown at K, so that the increased potential drop through resistance R is sufficient to break down the tube 225 to cause the operation of control relay 205. The control gap of the tube 225 extends from ground, through battery 221, control electrodes of tube 225, secondary winding of transformer D, through battery 241 to ground. As indicated, the potential impressed on this tube is now of sufficient magnitude to cause the tube to "fire," so that relay 205 operates. Relay 205 operates in a circuit extending from grounded battery 221, main gap of tube 225 to the anode thereof, winding of relay 205 to ground by way of condenser 250. The condenser 250 charges up at this time and when relay 205 operates the resistance capacity network serves to hold relay 205 operated for a small interval of time before it releases. Resistance 249 is used primarily to prevent contact sparking.

At its armature, relay 205 applies ground potential to the point 251 which is common to the secondary windings of transformers E and F. By virtue of this ground connection the registration circuit including relays 1, 2, 4 and 8 becomes activated. Relay 205 also supplies ground to the anode circuit of tube 223 to prepare relay 203 for operation.

A circuit may now be traced from the upper terminal of the secondary winding of transformer 211, upper conductor of the line L, resistance R, rectifier V<sup>1</sup>, contacts D<sup>1</sup> and A, lower conductor of line L, primary winding of transformer E, rectifier 217, to the lower terminal of the secondary winding of transformer 211. The voltage appearing across resistance 227 connected across the secondary winding of transformer E causes the tube 230 to "fire." The circuit for tube 230 extends from ground, battery 231, control electrodes of tube 230, back contact and left armature of

relay 203, resistance 227 to ground by way of the front contact and armature of relay 205. Register relay 1 now operates in a circuit extending from grounded battery 231, main gap of tube 230, winding of relay 1, to ground by way of battery 253. The circuit to battery 253 is shown in broken lines to indicate that this circuit, in which the operated tubes lock, may be controlled in any suitable manner so as to release and reset the register relays. While the locking circuit could be placed under the control of relay 205, it might well be controlled in some other manner, such as by a supervisory relay in the telephone system.

Thus code relay 1 operates and locks during the downstroke of key *a* and at its armature may control the operation of station-connecting switching devices to effect a connection to the telephone line to which the key *a* is assigned.

When the key *a* reaches the bottom of its down-stroke, the line loop is opened causing the application of the full supply voltage to the terminals of transformer D. When this occurs relay 203 operates since the voltage now applied to the control electrodes of tube 223 is of such a magnitude as to cause the tube to "fire." Relay 205 remains operated. Relay 203, operated, opens the circuits to the control electrodes of tubes 230 and 233 and completes the circuits to the control electrodes of tubes 234 and 235. Thus relays 2 and 8 are rendered available to register the impulse transmitted during the up-stroke of the key *a*. Which of relays 2 or 8, if either, operates depends upon the polarity of the transmitted impulse. As shown by the table, Fig. 12, no rectifier connecting contacts are operated on the up-stroke of key *a* so that the key restores to normal without effecting the transmission of an impulse during its return movement. When key *a* returns to normal the contact C is closed to reconnect the subset S to the line. This reduces the potential applied to the control electrode of tube 225 and the tube deionizes. The condenser-resistance network associated with the relay 205 serves to hold the relay operated for a brief interval of time (in the order of a few milliseconds) and then permits it to release when the potential applied to the control electrode is reduced to a value insufficient to sustain ionization. This reduction in potential occurs, as stated, when the subset S is reconnected to the line incident to the return of a key *a* to its normal position. Relay 205, released, opens the anode circuit of tube 223 permitting this tube to deenergize and release relay 203. The circuit is now restored to its normal condition.

Should key *b* be operated, contact C would open in a manner now apparent, and relay 205 would operate as described in connection with the operation of key *a*. Relay 205 prepares the register circuit for the receipt of the transmitted impulses. As indicated by the table, Fig. 12, no rectifier connecting contact closure is effected during the down-stroke of key *b*. The loop circuit is opened when the key reaches the end of its down-stroke, whereupon relay 203 operates in the manner hereinbefore described. With relay 203 operated, code relays 2 and 8 are rendered available to register the impulse transmitted during the up-stroke of key *b*.

On the up-stroke of key *b*, contact U<sup>1</sup> engages contact A so that, during this engagement, a circuit may be traced from the upper terminal of the secondary winding of transformer 211, upper conductor of the line L, resistance R, rectifier V<sup>1</sup>, contacts A and U<sup>1</sup> of the key-sender schematically shown at K, lower conductor of the line L, primary

winding of transformer E, rectifier 217, to the lower terminal of the secondary winding of transformer 211. Thus a voltage appears across resistance 227 which causes the operation of gas tube 234. The circuit for tube 234 may be traced from ground, battery 231, cathode and control electrode of tube 234, front contact and left armature of relay 203, resistance 227, to ground by way of the front contact and armature of relay 205.

When the tube 234 operates, code relay 2 operates in a circuit extending from battery 253, winding of relay 2, anode and cathode of tube 234 to ground by way of battery 231. Relay 2, operated, controls the operation of a station connecting relay, not shown, to complete a connection to the line to which the key *b* is assigned.

When the key *b* reaches its normal position, contact C is closed to reconnect the subset S to the line, whereupon the circuit is restored to normal, as previously described.

When key *e* is actuated in initiating a call to a called subscriber's station, both contacts A and B are actuated on the down-stroke of the key as indicated by the table, Fig. 12. When this occurs, relay 205 operates when contact C is opened, and code relays 1 and 4 function to register the transmitted impulses. Relay 1 operates to register the positive impulse in the same circuit described in connection with the operation of this relay following the actuation of key *a*, and relay 4 operates as a result of the transmission of the negative impulse. The circuit for the negative impulse may be traced from the lower terminal of the secondary winding of transformer 211, primary winding of transformer F, rectifier 212, lower conductor of line L, contacts B and D<sup>2</sup> of the key-sender K, rectifier V<sup>2</sup>, resistance R, upper conductor of line L, to the upper terminal of the secondary winding of transformer 211. Due to the current flow in primary winding of transformer F, there is produced a voltage drop across resistance 229 which results in the operation of tube 233. The circuit for tube 233 may be traced from ground, battery 231, cathode and control electrode of tube 233, back contact and right armature of relay 203, resistance 229, to ground at the front contact and armature of relay 205. Code relay 4 now operates in a circuit extending from grounded battery 253, winding of relay 4, anode and cathode of tube 233, battery 231 to ground. Thus, code relays 1 and 4 operate as a result of the down-stroke of key *e* to register the signal characterized by the combined positive and negative impulses transmitted. These relays may be used to control the operation of switching devices which effect a connection to the called line to which key *e* is assigned.

When key *e* reaches the end of its down-stroke the line loop is opened causing control relay 203 to operate and to substitute code relays 2 and 8 for code relays 1 and 4 in their association with the line circuit, whereby code relays 2 and 8 are rendered available to register the impulses, if any, transmitted during the up-stroke of key *e*. As indicated by the table, Fig. 12, no impulses are transmitted during the up-stroke of key *e* so that the key restores to normal without effecting any further contact operations. When it reaches its normal position, the key *e* closes contact C to reconnect the telephone set S to the line which results in the release of relays 205 and 203.

In the event key *g* is operated to effect a connection between the subscriber's station at which the key-sender K is located and a subscriber's line to which key *g* is assigned, contacts A and

B, as shown in the table, Fig. 12, function during the down-stroke of the key to transmit a positive and a negative impulse over the line. In response to these impulses code relays 1 and 4 operate in the same manner as when key *e* was employed. When key *g* reaches the end of its down-stroke the line circuit is opened to cause relay 203 to operate so as to prepare code relays 2 and 8 for the registration of the impulses, if any, transmitted during the up-stroke of the key. As shown in the table, Fig. 12, the contact A is employed during the up-stroke of key *g* to cause the transmission of a positive impulse over the line which operates code relay 2. It is believed unnecessary to describe in detail the circuits completed during the up-stroke of key *g* which result in the operation of code relay 2, since they are identical to those effected during the up-stroke of key *b* previously described. Suffice it to say that relay 2, operated during the up-stroke of key *g* and relays 1 and 4, operated during the down-stroke of key *g* function collectively to control the operation of switching equipment (not shown) which results in the extension of a connection to the telephone line assigned to key *g*.

By referring to Fig. 12 it will be noted that certain signals effected by the key-sender of this invention are characterized in the same manner. For example, the signals transmitted incident to the actuation of keys *a* and *b* are each characterized by an impulse of positive polarity; also, the signals transmitted incident to the actuation of keys *d* and *h* are each characterized by an impulse of negative polarity; similarly, the signals transmitted incident to the actuation of keys *e* and *j* are each characterized by a positive and a negative impulse. Thus more than one signal is characterized in the same manner. The discrimination between signals having the same characterization is effected by transmitting one signal, such as the signals transmitted incident to the actuation of keys *a*, *d* and *e* during the first portion of a signal transmitting period, whereas the signals transmitted incident to the operation of keys *b*, *h* and *j* are transmitted during the second portion of a signal transmitting period. A signal transmitting period is considered to embrace both the down-stroke and up-stroke of a key. Thus applicants' system renders it possible to utilize the same characterization for more than one signal and to discriminate between signals having the same characterization by transmitting one signal during one portion of a signal transmitting period and another signal during a different portion of the signal transmitting period.

What is claimed is:

1. In a signaling system in which a called station is characterized by a particular combination of impulses and in which complementary portions of the station-characterizing impulse combination are transmitted over a line consecutively from a calling station, a plurality of keys at the calling station each having a down-stroke and an up-stroke, and means controlled by said keys for transmitting one portion of the station-characterizing impulse combination over the line during the down-stroke of a key and for transmitting the other portion of the station-characterizing impulse combination over the line during the up-stroke of the key.

2. In a signaling system in which a called station is characterized by a particular combination of positive and/or negative current impulses and

in which complementary portions of the station-characterizing impulse combination are transmitted over a line consecutively from a calling station, a key at the calling station having a down-stroke and an up-stroke, means effective during the down-stroke of said key for causing the transmission over the line of the first complementary portion of the station-characterizing impulse combination, and means effective during the up-stroke of said key for causing the transmission over the line of a second complementary portion of the station-characterizing impulse combination.

3. In a signaling system in which a called station is characterized by two groups of positive and/or negative current impulses and in which the two groups of impulses are transmitted consecutively over a line extending from a calling station, a signal transmitting key at the calling station whose complete signal transmitting operation embraces both its down-stroke and its up-stroke, and means controlled by said key during its down-stroke and its up-stroke for causing the transmission of a different one of the two groups of current impulses.

4. In a signaling system in which a station-selecting signal is characterized by two separate groups of impulses, each of which is made up of one or more positive and/or negative impulses, a line, a key having a down-stroke and an up-stroke, and means controlled by said key for transmitting one of the groups of impulses over said line during the down-stroke of said key and the other group of impulses during the up-stroke of said key.

5. In a signaling system in which a station-selecting signal is characterized by a particular combination of positive and/or negative current impulses transmitted, in code, over a line, a key having a down-stroke and an up-stroke, and means controlled by said key for transmitting, in code, a portion of the signal-characterizing impulse combination only during the down-stroke of said key and for transmitting, in code, another portion of the signal-characterizing impulse combination only during the up-stroke of said key.

6. In a signaling system in which a station identifying signal is characterized by two groups of current impulses, a sending station, a receiving station, a key at said sending station having a down-stroke and an up-stroke, means controlled by said key during its down-stroke for transmitting one of the groups of current impulses over the line, and means controlled by said key during its up-stroke for transmitting the other group of impulses over the line whereby the transmission of a station-identifying signal over said line is completed only when said key is operated through both its down-stroke and its up-stroke.

7. In combination in a signaling system, a sending station, a receiving station, a two-wire line inter-connecting said stations, a source of alternating current connected to said line, means at said sending station for transmitting direct current impulses from said source over said line, a key at said sending station having a cycle of operation, which includes the down-stroke and the up-stroke thereof, means controlled by said key for connecting said direct current impulse transmitting means to said line during the down-stroke of said key and again during its up-stroke, whereby direct current impulses are transmitted consecutively over said line, and means at said

receiving station for registering the impulses transmitted over said line.

8. In a signaling system in which two groups of positive and/or negative current impulses are transmitted over a line consecutively to characterize a station-selecting signal, a key having a down-stroke and an up-stroke, means controlled by said key during its down-stroke for transmitting one group of impulses over said line and, during its up-stroke, for transmitting another group of impulses over said line, a receiving circuit comprising a group of translating devices for responding to and registering the impulses transmitted during the down-stroke of said key and a group of translating devices for responding to and registering the impulses transmitted during the up-stroke of said key, and means controlled by said key for rendering each of said groups of translating devices available to register the impulses transmitted during a corresponding stroke of said key.

9. In a signaling system in which a station-selecting signal is characterized by two separate combinations of positive and/or negative current impulses, a key having a down-stroke and an up-stroke, means controlled by said key for transmitting the two separate combinations of positive and/or negative current impulses over said line consecutively, a group of translating devices for registering the combination of impulses first transmitted over said line, a group of translating devices for registering the combination of impulses next transmitted over said line, means controlled by said key when beginning its down-stroke for rendering the first said group of translating devices effective to register the first transmitted impulses, and means controlled by said key upon completion of its down-stroke for rendering the second said group of translating devices effective to register the next transmitted impulses.

10. The combination in a signaling system in which certain signals are characterized by direct current impulses transmitted consecutively over a two-wire line interconnecting signal transmitting and receiving stations, of a signal receiving circuit comprising two groups of selectively responsive translating devices; a source of alternating current connected to the line, and means for effecting the consecutive transmission of direct current impulses from said source over the line comprising a key-type sender including a plurality of manually operable keys, a rectifier, means controlled by a certain one of said keys and effective during the down-stroke thereof for connecting said rectifier between the two wires of said line to cause the transmission of a direct current impulse over said line to operate a certain one of the selectively responsive translating devices of one of said groups, means controlled by said key when it reaches the end of its down-stroke for preparing the other of said groups of selectively responsive translating devices for operation, and means controlled by said key and effective during the up-stroke thereof for reconnecting said rectifier between the two wires of said line to cause the transmission of a second direct current impulse over said line whereby a certain one of the selectively responsive translating devices of said other group is operated.

11. The combination in a signaling system in which certain signals are characterized by direct current impulses of opposite polarities transmitted consecutively over a two-wire line inter-

connecting signal transmitting and receiving stations, of a signal receiving circuit comprising two groups of selectively responsive translating devices, a source of alternating current connected to the line, and means for effecting the consecutive transmission of direct current impulses of opposite polarities from said source over said line comprising a key-type sender including a plurality of manually operable keys, a pair of oppositely poled rectifiers, means controlled by a certain one of said keys and effective during the down-stroke thereof for connecting one of said rectifiers between the two wires of said line to cause the transmission of a direct current impulse of one polarity over said line whereby a certain one of the selectively responsive translating devices of one of said groups is operated, means controlled by said key when it reaches the end of its down-stroke for preparing the selectively responsive translating devices of the other of said groups for operation, and means controlled by said key and effective during the up-stroke thereof for connecting the other of said rectifiers between the two wires of said line to cause the transmission of a direct current impulse of a different polarity over said line, whereby a certain one of the selectively responsive translating devices of said other group is operated.

12. The combination in a signaling system in which certain signals are characterized by two groups of direct current impulses, each comprising a positive and a negative impulse, transmitted consecutively over a two-wire line interconnecting signal transmitting and receiving stations, a signal receiving circuit comprising two groups of translating devices, each group including a device selectively responsive to impulses of each polarity, a source of alternating current connected to the line, and means for effecting the consecutive transmission of two groups of positive and negative direct current impulses from said source over said line comprising, a key-type sender including a plurality of manually operable keys, a pair of oppositely poled rectifiers, means controlled by a certain one of the keys of said sender and effective during the down-stroke thereof for simultaneously connecting both said rectifiers between the two wires of said line to cause the transmission of a positive and a negative direct current impulse over said line, whereby the translating devices of one of said groups thereof are operated, means controlled by said key when it reaches the end of its down-stroke for preparing the translating devices of the other group thereof for operation, and means controlled by said key and effective during the up-stroke thereof for reconnecting both said rectifiers between the two wires of said line to cause the transmission of a positive and a negative direct current impulse over said line, whereby the translating devices of the other of said groups thereof are operated.

13. The combination in a signaling system, of a line, an impulse transmitter comprising a key having a down-stroke and an up-stroke and capable of transmitting an impulse over said line for each stroke thereof, impulse receiving equipment for receiving the impulse transmitted by said key during its down-stroke, impulse receiving equipment for receiving the impulse transmitted by said key during its up-stroke, and means controlled by said key for rendering said impulse receiving equipments effective to receive the impulse transmitted during corresponding strokes of said key.

14. The combination in a signaling system, of



a line, an impulse receiving circuit, and means for transmitting impulses over said line to said impulse receiving circuit comprising a pair of pulsing contact springs whose period of closure determines the length of impulse transmitted over said line, a key, a sectionalized rod having one section thereof in operative association with said contact springs and the other coupled to said key, whereby said rod is rotated when said key is actuated to effect the closure of said contact springs, and means comprising a spring coupling the two sections of said rod, whereby the period of closure of said contact springs incident to the actuation of said key is rendered independent of the speed of operation of said key.

15. In combination in a key-type sender for transmitting station-selecting impulses of positive and/or negative polarities, singly or in combination over a line, rectifying means for determining the polarity of the transmitted impulses,

5 contact means for connecting said rectifying means to said line, a key having a down-stroke and an up-stroke, levers operatively associated with said key, a ratchet wheel, a pair of arms depending from said levers and operatively associated with said ratchet wheel in such a manner that when said key is depressed to raise said levers one of said arms functions to rotate said ratchet wheel through an arc of substantially ninety degrees and when said key is released to permit said levers to be lowered the other of said arms functions to rotate said ratchet wheel through an arc of substantially ninety degrees, and means associated with said ratchet wheel for operating said  
10  
15 contact means whereby said rectifying means is connected to said line once for each of the up- and down-strokes of said key.

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