

April 18, 1944.

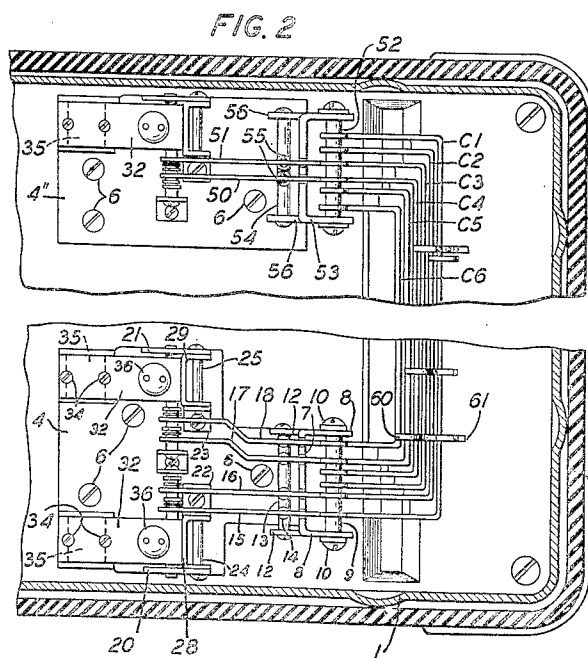
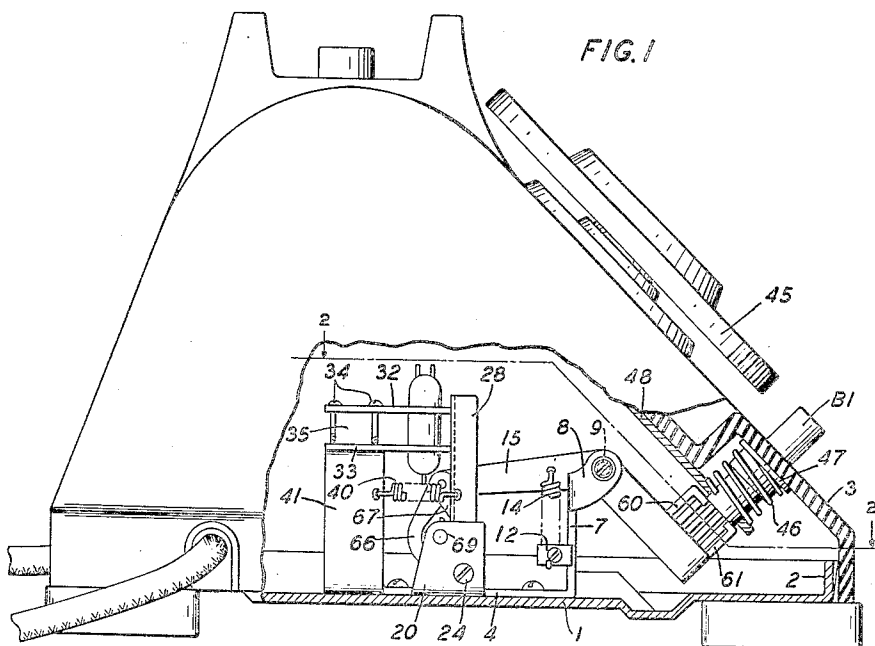
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2,347,108

CALL TRANSMITTER FOR TELEPHONE SIGNALING SYSTEMS

Filed Feb. 5, 1943

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

FIG. 3

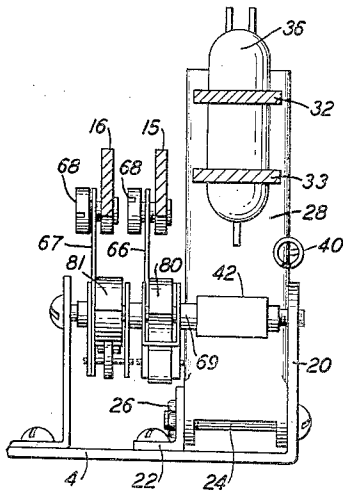


FIG. 4

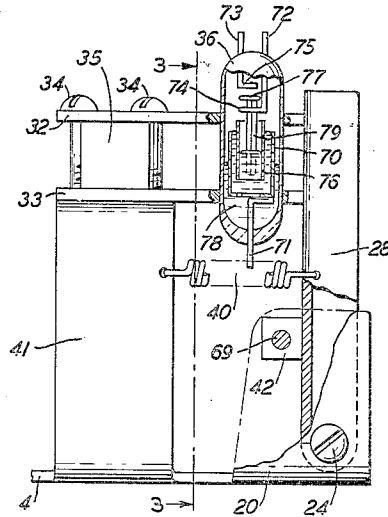
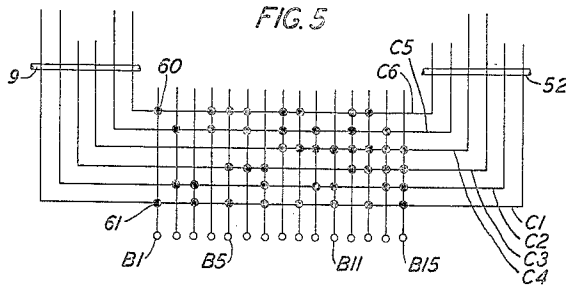


FIG. 6

KEY	CODE		REGISTER RELAYS
	DOWN	UP	
B1	A	B	1'
B2	B	A	2'
B3	A	A	1,2'
B4	B	B	4'
B5	A	B,C	1,4'
B6	B	B,C	2,4'
B7	A	A,C	1,2,4'
B8	B,C	B	3'
B9	A,C	B	1,3'
B10	B,C	A	2,3'
B11	A,C	A	1,2,3'
B12	B,C	B,C	4,3'
B13	A,C	B,C	1,4,3'
B14	B,C	A,C	2,4,3'
B15	A,C	A,C	1,2,4,3'

FIG. 5



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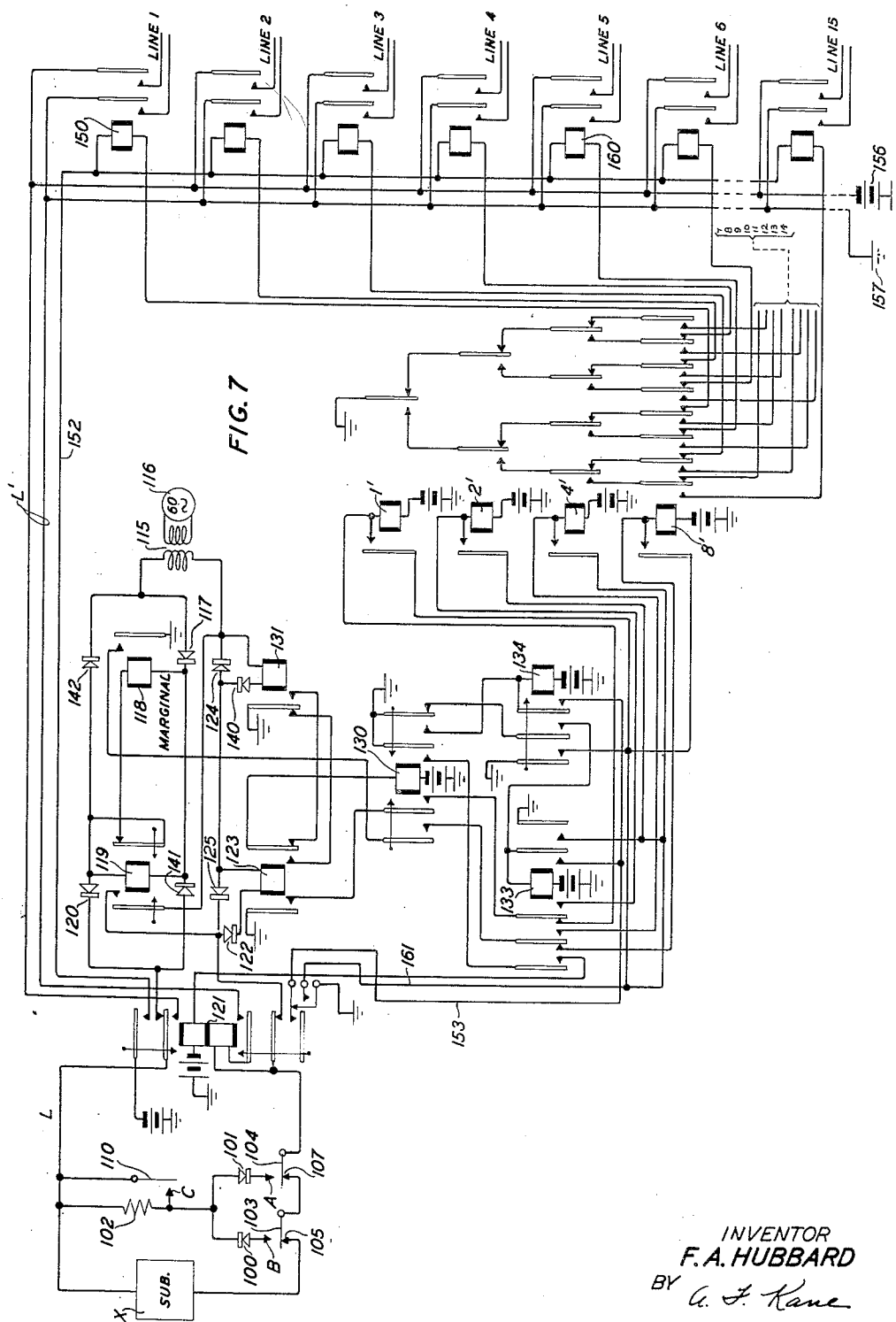
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CALL TRANSMITTER FOR TELEPHONE SIGNALING SYSTEMS

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,347,108

CALL TRANSMITTER FOR TELEPHONE
SIGNALING SYSTEMSFrancis A. Hubbard, Maplewood, N. J., assignor
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Application February 5, 1943, Serial No. 474,782

17 Claims. (Cl. 179—90)

This invention relates to signaling and communication systems and particularly to call transmitters for use in telephone systems of the key calling or executive type.

Key calling telephone systems have been devised primarily to provide facilities whereby telephone connections between a calling subscriber's line and any of a group of frequently called lines may be completed expeditiously and with a minimum of effort on the part of the calling subscriber. Such systems are characterized by a subscriber's telephone set which is provided with a plurality of individually operable keys, or key buttons, each of which is assigned to a particular one of the frequently called lines and functions, when actuated, to set in operation instrumentalities which control the selection of the line corresponding to the particular key actuated. Such systems are particularly suitable for use by executives who find it necessary to communicate frequently with subordinates. In some such system one or more of the keys may be assigned to a central office or private branch exchange line so as to enable the executive to communicate with subscribers whose lines terminate in the central office or private branch exchange and are not directly accessible to the executive. Such connections may be extended to the called line either by the executive operating his telephone dial or by the exchange attendant, depending on whether the called line terminates in a dial exchange or a manual exchange.

A telephone system of the general character described above is disclosed in a copending application, Serial No. 444,772, filed May 28, 1942. This system is characterized by subset keys which function during their downstroke and their upstroke to selectively associate with the line conductors of a calling substation various combinations of oppositely poled rectifiers which serve to selectively pass either or both of the rectified half waves generated by a source of alternating current and to thereby cause the selective operation of a group of register relays which control the extension of the calling line to a particular called line. The rectifiers in this case are connected to the line by means of contact springs which are selectively operated by the individual keys. In order to insure proper operation of the relays which respond to the rectified half waves, it is necessary that the spring contact closures be maintained for a predetermined period of time independent of the speed at which the keys are operated. Such a contingency is provided for in the system disclosed in the copending application

referred to, by the provision of a coil spring which is identified in the said application by the numeral 67 and which functions to introduce a lag between the key operations and the resulting contact operations and thus insure the closure of the rectifier connecting contacts for a predetermined time interval.

It is the object of the present invention to provide an improved key calling telephone system of the type disclosed in the above-identified copending application and wherein a sufficiently long closure of the rectifier connecting contacts on the down and upstrokes of the subscriber's subset keys is assured to permit operation of the proper translating devices.

This object is attained in accordance with a feature of the invention by utilizing as the rectifier connecting medium, magnetically operated timed mercury contacts which function, in response to the actuation of the station selecting keys, to insure a sufficiently long closure of the contacts for each of the down and upstrokes of the keys to permit the proper relays to operate. The units employed are mostly of the transfer type, with a quick operate, slow release characteristic. Such characteristics provide the necessary assurance that the conditions selected on each stroke of a key remain for an interval of time substantially greater than $1\frac{1}{2}$ cycles of the 60-cycle alternating current employed as the signaling current source, so as to permit positive operation of the translating devices, and to insure the clearance of the downstroke condition before the upstroke of the key begins.

Another feature of the invention resides in a novel type of signal receiving circuit which recognizes the conditions established on each of the key-strokes and records them in such a manner as to cause the selective operation of the translating devices which function to extend the calling line to a particular called line.

A further feature of the invention resides in the use of a signal code which precludes the false operation of the system in the event that two adjacent keys of the subset keys are accidentally depressed at the same time. This code requires that but one of two rectifier-connecting contacts be actuated for each stroke of the key and that the two contacts are never operated simultaneously. The contacts are so disposed relative to the operating keys that adjacent keys function during their respective downstrokes to operate a different contact. In other words, the two contacts are operated alternately by consecutively disposed keys. The receiving circuit is so de-

signed that it will recognize the simultaneous operation of the two rectifier connecting contacts and will fail to transmit such a condition to the register circuit.

A still further feature of the invention precludes the possibility of switchhook fumbling at a key calling station transmitting a false signal.

These and other features of the invention will be best understood from the following detailed description made with reference to the accompanying drawings in which:

Fig. 1 is a left side elevation view of a telephone subset embodying the invention, the casing being shown with a portion broken away to disclose one of the magnetically operated timed mercury contact units and the key controlled operating mechanism therefor;

Fig. 2 is a top plan view taken along the line 2—2 of Fig. 1 looking in the direction of the arrow. This view is broken through substantially the center to indicate the omission of structural details which would be interposed between the right and left portions of the mechanism disclosed. The parts omitted do not require illustration for a complete understanding of the invention;

Fig. 3 is an enlarged end view of one of the magnetically operated timed mercury contact units and its associated operating mechanism;

Fig. 4 is an enlarged side elevational detail view of the magnetically operated timed mercury contact unit shown in Fig. 3, the latter figure constituting a view taken along the line 3—3 of Fig. 4, looking in the direction of the arrows;

Fig. 5 is a diagrammatic illustration which indicates the various combinations of code bars which are operated by each of the fifteen buttons of the key type sender;

Fig. 6 is a table which illustrates the contacts operated during the down and upstrokes of each of the keys and the translating devices, or register relays which operate in response to the actuation of each key; and

Fig. 7 shows a circuit diagram of a telephone system in accordance with the present invention and includes a key calling subscriber's key controlled contact mechanism; an impulse responsive circuit controlled by the keying equipment at a subscriber's station; a register circuit controlled by the impulse responsive circuit; and a plurality of line connecting relays which are selectively controlled by the register circuit.

The telephone set (transmitter and receiver omitted) as shown in Figs. 1 and 2, comprises a base 1 having upturned edges 2 to which a molded casing 3 is attached. Secured to the base 1 are mounting plates 4 and 4'', the latter located at the right of the set and shown in the upper portion of Fig. 2, and the former being located at the left of the set and shown in the lower portion of Fig. 2. The mounting plate 4 is substantially larger than the mounting plate 4'' in that it serves to support two magnetically operated timed mercury contact units and the operating mechanisms therefor, whereas the plate 4'' accommodates but one such unit and its operating mechanism. The plates 4 and 4'' may be secured to the base 1 in any suitable manner, such as by the screws 6 illustrated.

With particular reference to Fig. 1 and the lower portion of Fig. 2, the mounting plate 4 is provided at its forward end with an upturned integral projection 7 which is provided at each of its upper ends with an integral ear-like projection 8, which projections are apertured to receive the shaft 9 75

which, at each end is internally threaded to receive the screws 10. As will appear more clearly from a later description the shaft 9 serves as a pivot mounting for the code bar extensions.

The upturned projection 7 is also provided at each side thereof with a receding integral lug 12. The lugs 12 serve to support a shaft 13 to which the lower end of each of four coil springs 14 are secured, the upper ends of which are made fast to separate ones of four of the code bar extensions 15, 16, 17 and 18. These springs function to restore the code bars to normal after manual operation as will appear from a later description to be directed to the operation of the device.

The mounting plate 4 is also provided with two upturned projections 20 and 21 interposed between which, and mounted on the plate 4 are two L-shaped brackets 22 and 23. These brackets may be secured to the plate 4 in any suitable manner such as by the screws illustrated. The projection 20 and the bracket 22 constitute supports for the shaft or pin 24 whereas the projection 21 and the bracket 23 constitute supports for the shaft or pin 25. These shafts may be, as shown in Fig. 3, bolts having one end threaded to accommodate a nut such as the nut 26 in Fig. 3. The shaft or bolt 24 serves as a pivot support for a magnetizable armature 28 and the shaft 25 serves the same function with respect to the magnetizable armature 29. These armatures constitute elements of the magnetically operated timed mercury contact units shown on the lower section of Fig. 2. A similar unit is shown in the upper section of Fig. 2.

The magnetically operated timed mercury contact units each comprises two parallelly disposed pole-pieces 32 and 33 clamped by the clamping screws 34 to the pole-piece of a permanent magnet 35. The pole-pieces 32 and 33 are provided near their outer ends with aligned holes in which is supported a switch element 36 of the mercury contact type. A switch element of this type is disclosed in Patent No. 2,295,602, granted September 15, 1942, to C. E. Pollard, Jr. Cooperating with the polar ends of the pole-pieces 32 and 33 is a soft iron armature such as armature 28, referred to above. The armature is channel shaped, the flanges thereof having aligned holes there-through near their lower ends through which a pivot bolt such as shown at 24 extends and on which the armature is pivoted. For holding the armature 28 normally in engagement with the polar ends of the pole-pieces 32 and 33 a retractile spring 40 is hooked at one end to one flange of the armature 28 and at its other end to the extension 41 of the plate 4. This armature 28 is adapted to be cammed away from the polar ends of the pole-pieces 32 and 33 by means of a square-sectioned shaft 42.

While the above description having to do with the magnetically operated timed mercury contact unit is directed specifically to the unit shown at the bottom of the lower section of Fig. 2, it is to be understood that it applies equally well to the unit shown at the top of the lower section of Fig. 2, whose armature is indicated by the numeral 29 and whose pivot support is indicated at 25. The manner in which the armatures are actuated will be described in detail presently.

Extending across the front face of the telephone set and positioned immediately below the dial finger wheel 45 is a row of key buttons, fifteen in number, one of which is shown at B1 in Fig. 1. Each of the key buttons, which in Fig. 5 are indicated by the designations B1 to B15, in-

clusive, is normally and yieldably maintained in the position shown in Fig. 1 by a retractile spring 46, one end of each of which springs abuts against the flange 47 of its respective button, the other end abutting an extension 48 secured in any suitable manner to the under-face of the casing 3, as shown in Fig. 1. The lower end of each button, such as B1, impinges against one or more extensions of the code bars C1 to C6, inclusive, for a purpose to be described presently.

The code bars, six in number, are substantially U-shaped and extend substantially over the entire width of the telephone set and are located directly beneath the row of key buttons B1 to B15, inclusive. As clearly shown in Fig. 2, each code bar has an inwardly projecting integral extension such as 15, 16, 17, 18, 50 and 51. As previously described, the code bars are adapted to pivot about the screw shaft 10 at the left of the set and about a similar screw shaft 52 located at the right of the set. It will be understood that the elements 52, 53, 54, 55 and 57 shown in the upper section of Fig. 2 are identical with the elements 9, 8, 40 and 12, respectively, shown in the lower section of Fig. 2 and perform identical functions except that they serve the right extensions of the code bars whereas the others serve the left extensions of the code bars. The extensions of the code bars C1 to C6, inclusive, may be considered as consisting of three groups with two extensions in each group. The first group may consist of extensions 15 and 16; the second group, of extensions 17 and 18; and the third group, of extensions 50 and 51. Each group of code bars may be defined as having a down bar and an up bar, so characterized because one such bar of each group is effective during the downstroke of a key button to operate a magnetically operated timed mercury contact unit and the other is effective in operating the same unit during the upstroke of a key button.

Each code bar is provided at various points throughout its length with a number of integral projections. These projections are indicated by dots in the graphical representation shown in Fig. 5. As shown in this figure the code bar C1 is provided with eight extensions, the first of which is designated by the numeral 61 which identifies the same projection in Fig. 1; code bar C2 is provided with seven extensions; code bar C3 with seven; code bar C4 with eight; code bar C5 with seven; and code bar C6 with eight, the first of which is designated by the numeral 60 to correspond with the designation applied to this extension in Fig. 1. The code bar extensions are so formed, as shown in Fig. 1, that they are positioned immediately below the key button which is to actuate the corresponding code bars. For example, the code bar extensions 61 and 60 of code bars C1 and C6, respectively, are located, as shown in Fig. 1, in such a manner as to be actuated by button B1 when this button is operated. Similarly button B5, for example, and as indicated in Fig. 5 engages extensions of code bars C1, C3 and C6. An examination of Fig. 5 will clearly indicate which code bars are operated as a result of the actuation of each of the key buttons B1 to B15 inclusive.

At the end of each code bar extension there is pivotally secured a depending pawl. The pawl associated with the code bar extension 15 is shown at 65 in Fig. 3 and the pawl associated with the code bar extension 16 is shown at 67 in Fig. 3. These pawls are secured to the extensions 15 and 16 by the screws 68. The pawl 65

serves during the downstroke of code bar C6 to rotate the shaft 69 through the medium of a ratchet mechanism designated by the numeral 80 and fully described in the above-mentioned copending application, whereas pawl 67 functions during the upstroke of code bar C2, through the medium of a ratchet mechanism 81, to further rotate the shaft 69. It is believed unnecessary to describe in detail the mechanism which transmits the code bar movements to the shaft 69 since a complete description thereof is contained in the aforesaid copending application. Suffice it to say that code bar C1 functions during its downstroke to rotate the bar 69 through an arc of 90 degrees, whereas code bar C2 functions during its upstroke to rotate the bar through an arc of 90 degrees. It is to be understood that code bars C3 and C4 and also code bars C5 and C6 are equipped with similar pawls which function to rotate similar bars which serve with the other two magnetically operated timed mercury contact units shown in the upper portion of the lower section of Fig. 2 and in the upper section of Fig. 2.

Each bar, such as bar 69, of the three units is equipped with a square section such as shown at 42 in Figs. 3 and 4, which, as clearly shown in Fig. 4, normally has one face in engagement with its respective armature, such as armature 28. Since all three units operate in the same manner it will suffice to describe the operation of one unit only, such as the unit shown in Figs. 3 and 4. When the code bar C1 is depressed in consequence of the actuation of a button such as the button B1, the bar pivots about the pivot pin 9 causing its extension 15 to be raised which in turn lifts the pawl 65. The pawl 65 thereupon, and in the manner fully described in the above-identified copending application, causes the bar 69 to be rotated through an arc of 90 degrees. The square section 42 of the bar 69 thus cams the armature away from the polar extremities of the pole-pieces 32 and 33 and when the element 42 is rotated its complete distance the restoring action of spring 40 and the attractive force of the permanent magnet 35 will draw the armature again into engagement with the polar ends of the pole-pieces.

The mercury contact switch 36, as best disclosed in Fig. 4, is as previously stated, of the type disclosed in the patent to Pollard hereinbefore referred to and has an envelope of glass or other suitable material within which is a guide sleeve 70 entirely open at its upper end and partially closed at its lower end to add rigidity thereto and supported on and secured to the upper end of the terminal wire 71. The wire 71 is sealed through the bottom of the envelope. The guide sleeve 70 is made of a material such as nickel which is wettable by mercury. Sealed through the upper end wall of the envelope are two parallelly disposed contact members 72 and 73 having their ends which extend into the envelope bent at right angles toward each other to form two stationary contact portions 74 and 75, the upper one 75 of which serves as a front contact and the lower one 74 of which serves as a back contact. The contact portion 75 is wide but the contact portion 74 is narrow. Movable within the guide sleeve 70 is a cylindrical tubular armature 76, the ends of which are entirely open. The armature is made of magnetic material but its surfaces are such that they are readily wettable by mercury. Secured to the inner surface of the armature and movable therewith is a contact

element 77 which may be formed by doubling a length of wire, binding the loop end at right angles and flattening the same to provide a widened contact portion for engagement with the contact portions 74 and 75 of the back and front contact members 72 and 73. A contact of this type has the property of conducting mercury along the capillary ducts formed therein to its upper contact portion from which a small amount of mercury is transferred to the surfaces of the contacts with which it cooperates.

To complete the switch element a measured amount of mercury 78 is deposited in the bottom of the envelope which envelope is then evacuated, refilled with a gas such as hydrogen to a required operating pressure and then sealed. The mercury in the envelope rises within the guide sleeve 70 and within the tubular armature 76 to the position illustrated and the mercury is conducted by the capillary action of the inner surface of guide sleeve 70 and the outer surface of the armature 76 to fill the space between such surfaces. The surface tension of the mercury between the upper edges of the guide sleeve 70 and the armature 76 and the surface tension of the mercury within the armature exert a downward pull upon the armature to normally hold the contact portion 77 firmly against the contact 74 of the back contact member 72. The mercury within the armature also engages the lower end of the contact member 79 whereby mercury is conducted along such member to its upper contact portion 77 and in the normal position of the armature to the contact portion 74 thereby establishing a mercury contact between the contacts 77 and 74.

When the armature 28 of the unit being described is cammed out of engagement with the pole-pieces 32 and 33 all of the flux generated by the permanent magnet 35 is permitted to pass through the armature 76 of the unit and the armature rises within the guide sleeve 70 to center itself within the magnetic field thus created, but will be restrained in its movement by the pull of the surface tension of the mercury pool and the surface tension of the film of mercury between the armature 76 and the sleeve 70. This restraint is not so great, however, but that the film of mercury between the contact portion 74 of the back contact member 72 and the contact portion 77 of the armature contact member 79 will disrupt quickly since the cross-sectional area of the film adjacent to the contact portion 74 is small. The armature will therefore move the contact portion 77 of the contact member 79 quickly out of engagement with the contact portion 74 of contact member 72 and into engagement with the contact portion 75 of the front contact member 73. Mercury adhering to the contact member 77 is now transferred to the front contact member 75 to establish a film of mercury therewith.

Since the armature 28 is cammed away from the pole-pieces 32 and 33 only momentarily, it is quickly restored to establish a low reluctance shunt of the armature 76 of the unit whereupon the magnetic pull on the armature 76 is reduced permitting the surface tension of the mercury pool to pull the armature 76 back into its normal or retracted position, but since the contact areas of the contact portions 75 and 74 are both relatively large, the film of mercury between them will persist unbroken due to the mercury being drawn into the film up the ducts of member 79 while the armature 76 moves in its retractive

movement under the influence of its weight and the surface tension of the mercury pool, until the film finally breaks whereupon the contact portion 77 snaps quickly into engagement with the contact portion 74 of the back contact member 72. This switch element therefore effects a quick make and a slow break of its front contact closure which break should be in the order of 30 or 40 milliseconds, and a quick break and a slow make of its back contact closure. The functions performed by the switch contacts will be described in connection with the operation of the circuit shown in Fig. 7.

It is deemed unnecessary to describe the method of mounting the magnetically operated timed mercury contact unit shown in the upper section of Fig. 2 since this is now apparent from the detailed description directed to the lower portion of Fig. 1. Suffice it to say, however, that this unit is controlled by the extensions 50 and 51 of code bars C4 and C3, and the unit shown in the upper section of Fig. 1 is controlled by the extensions 17 and 18 of code bars C5 and C6, in the same manner in which the unit shown in the lower section of Fig. 2 is controlled by the extensions 15 and 16 of the code bars C1 and C2.

The following description is directed to the operation of the subscriber's key-set in connection with a telephone call originated at the subscriber's station X of Fig. 7 and intended for a station connected with line No. 1 indicated at the right of Fig. 7. Before entering into a detailed description of the operation of the system disclosed it may be well to refer briefly to the subscriber's substation circuit illustrated and also to the signal receiving circuit. The subscriber's telephone equipment per se, is indicated schematically at X and aside from the regular transmitter, receiver and auxiliary circuit equipment, the subscriber's set includes two oppositely poled varistors of the dry rectifier type. These varistors are indicated at 100 and 101. A resistance 102 is also provided the purpose of which will be indicated presently. The switch elements 103 and 104 are serially included in one of the line wires extending from the substation X and when operated serve, first to open the line conductor to the station and then to effectively connect their associated varistors across the line. The contact element 104 corresponds to the movable contact element 77 of the magnetically operated timed mercury contact unit hereinbefore described and its back contact 107 and its front contact A correspond respectively to the contacts 74 and 75 of the unit described, which unit corresponds to that shown at the bottom of the lower section of Fig. 2. The contact element 103 and its associated contacts 105 and B correspond to similar elements of the unit shown at the top of the lower section of Fig. 1. The switch 110 controlling the resistance 102 is a simple make contact and will be of the same general design as the magnetically operated timed mercury unit hereinbefore described except that the back contact elements 72 and 74 will perform no circuit function.

The signal receiving circuit comprises essentially relays 119, 118, 123 and 131. Relay 118 is a marginal relay connected in a full wave rectifier bridge circuit and will operate on current of either polarity if of sufficient amplitude. The neutral relays 123 and 131 will operate only on positive and negative current respectively. Relays 123 and 131 are substantially more sensitive than relay 118. The register relays 1', 2', 4'

and 8' are operated by the contacts of relays 123 and 118 and are locking. A progress relay chain, comprising relays 133 and 134, transfers contacts of relays 123 and 118 from register relays 1' and 8' to relays 2' and 4' when the downstroke signal has been recorded. Relay 119 has a speed characteristic such that it will hold up on alternating current, but will release and not reoperate when one half wave is suppressed by either of the varistors at the substation. In its operated position it disables relays 123, 131 and 118.

To initiate a call to a particular station the subscriber at station X actuates the key button assigned to the particular called station after having removed the telephone handset from its support. It will be assumed for descriptive purposes that the called station is located on line No. 1 and that the key button assigned to this station is key button B1. It will be observed from an inspection of the table shown in Fig. 6 that when key B1 is actuated contact A is made on the downstroke of the key and contact B is closed on the upstroke of the key. Thus when key B1 is actuated, the contact A is closed to connect varistor 101 across the line in series with resistance 102 on the downstroke of the key, and contact B is closed to connect varistor 100 across the line in series with resistance 102 on the upstroke of the key, and contact B is closed to connect varistor 100 across the line in series with resistance 102 on the upstroke.

Referring now to Figs. 1 and 5, key B1, when actuated, engages the projections 60 and 61 of code bars C6 and C1 respectively, and causes these code bars to be operated. As hereinbefore described, code bar C1, when depressed, causes extension 15 thereof to function through its associated pawl 66 to rotate the bar 69 through an arc of 90 degrees. Also as hereinbefore mentioned and as described more fully in the above-identified copending application, the depression of key button B1, while causing the operation of the extension 51 of code bar C6, does not serve to operate the square sectioned shaft associated with the magnetically operated timed mercury unit shown in the upper portion of Fig. 2 during this movement of code bar C6 since this bar functions to operate the contacts controlled thereby only during its upstroke. Therefore, during the downstroke of the key B1, code bars C1 and C6 are actuated, the former functioning to operate its associated mercury contact unit, and the latter performing no circuit operating function at this time. They key B1 thus functions during its downstroke to disengage the contact or switch 104 from its back contact and to move it into engagement with contact A. The breaking of the back contact 107 is accomplished quickly and the closure of the front contact is also effected quickly and is maintained for a predetermined period of time (about 30 milliseconds) as hereinbefore described in connection with Fig. 4. The opening of contact 107 disconnects the calling subscriber's telephone set at station X from the line and the closure of contact A connects the positively poled varistor 101 across the line in series with resistance 102.

When the handset at station X was removed from its support and prior to the actuation of key B1, relay 119 operated on the full wave rectified alternating current, from source 116, traversing the line, and at its right armature opened the circuit to relay 118 and at its left armature short-circuited the relays 123 and 131 and their associated varistors. When the varistor 101 is con-

nected across the line incident to the operation of key B1, it suppresses the negative half of the wave, and resistance 102 reduces the positive half to a value insufficient to operate relay 118 but great enough to operate relay 123, it being understood that when the next negative half cycle is applied to the circuit relay 119 releases to connect relay 118 into the full wave rectifier circuit and to remove the short from relays 123 and 131. The operating circuit for relay 123 may be traced from the upper terminal of the secondary winding of transformer 115, whose primary is connected across the alternating current source 116, varistor 117, winding of marginal relay 118, back contact and right armature of relay 119, varistor 120, back contact and upper armature of relay 121, resistance 102, varistor 101, contacts A and 104, middle lower armature and back contact of relay 121, varistor 122, winding of relay 123, varistor 124 to the lower terminal of the secondary winding of transformer 115. Due to the inclusion of resistance 102 in this circuit, marginal relay 118 does not receive sufficient current to operate. Relay 123 is more sensitive and does operate in the circuit traced. Relay 119 though traversed by the positive half wave does not operate.

At its right armature and front contact, relay 123 completes an operating circuit for relay 130 which may be traced from grounded battery, winding of relay 130, right armature and front contact of relay 123, back contact and armature of relay 131, to ground. Register relay 1' now operates in a circuit extending from ground, left armature and front contact of relay 123, inner left armature and front contact of relay 130, innermost left armature and back contact of relay 133, winding of register relay 1' to grounded battery. Relay 134 of the chain relay circuit also operates in a circuit extending from grounded battery, winding of relay 134, front contact and outer right armature of relay 130 to ground. Relay 134 operated, establishes an obvious locking circuit for register relay 1', which circuit includes the outermost armature and front contact of relay 134. Relay 134, operated, locks itself to ground associated with the outermost lower armature of cut-through relay 121. Thus, as a consequence of the downstroke of key B1, relays 123, 130, 134 and 1' operate, the last two locking.

When the timed contact A at the substation releases, relay 119 reoperates on the full wave rectified current. This disables relays 123, 131 and 118 as hereinbefore described. Relay 123, released, causes relay 130 to release its armatures whereupon the second relay 133 of the relay chain operates in a circuit extending from grounded battery, winding of relay 133, front contact and middle armature of relay 134, back contact and outer armature of relay 130 to ground. Relay 133 in operating, transfers the contacts of relays 123 and 118 from register relays 1' and 8' to register relays 2' and 4' which latter two relays are utilized to register the impulse transmitted during the upstroke of the keys, the register relays 1' and 8' serving the same purpose during the downstroke of the keys. Relay 133 locks under control of cut-through relay 121.

When the upstroke of key B1 begins, the code bars C1 and C6 are returned to their normal positions under the restoring action of their respective retractile springs. The code bar C1 performs no circuit controlling function during

its return movement, but code bar C6, through its extension 18 and its associated pawl (similar to pawl 67, Fig. 3) causes the bar, corresponding to bar 69 of Fig. 3, associated with the timed mercury contact unit shown in the upper portion of the lower section of Fig. 1, to be rotated through an arc of 90 degrees, in a manner now apparent. The rotation of this bar and its associated square section causes the associated timed mercury contact unit to function to first, quickly open contact 105 (Fig. 1), and then to quickly close contact B, the latter remaining closed for about 30 milliseconds.

The opening of contact 105 disassociates the telephone set at station X from the line and the closure of contact B connects the negatively poled varistor 100 across the line in series with resistance 102.

Relay 119 releases on the next positive half cycle, and on the ensuing negative half cycle relay 131 operates. Varistor 100, connected across the line, suppresses the positive half cycle of current and the resistance 102 reduces the negative half cycle to a value insufficient to cause relay 118 to operate. Relay 131, however, operates in a circuit extending from the lower terminal of the secondary of transformer 115, winding of relay 131, varistor 140, varistor 125, back contact and middle lower armature of relay 121, contacts 104 and 107, contacts 103 and B, varistor 100, resistance 102, first upper armature and back contact of relay 121, varistor 141, winding of relay 118, right armature and back contact of relay 119, varistor 142, to the upper terminal of the secondary of transformer 115. Relay 119, though traversed by this current does not operate.

Relay 131, operated, causes relay 130 to operate in a circuit extending from grounded battery, winding of relay 130, right armature and back contact of relay 123, front contact and armature of relay 131 to ground. With relays 131, 130 and 133 operated, no circuit is traceable to either of the register relays 2' and 4'. The operating circuit to relay 2' is opened at the left armature contacts of relay 123 and the operating circuit to relay 4' is opened at the armature contacts of relay 118, and since neither relay 123 nor relay 118 operated on the upstroke of key B1, no other register relay operates at this time. Hence register relay 1' alone responds to a complete operation of key B1 and functions to cause the extension of the calling line to the called line to which the key B1 is individually assigned, as will now be described.

With register relay 1' operated and locked under control of relay 134, an operating circuit for line connecting relay 150 is prepared which extends from ground, armature and front contact of register relay 1', first armature and back contact of register relay 2', second armature and back contact of register relay 4', fourth armature and back contact of register relay 8', winding of line connecting relay 150, conductor 152 to the front contact associated with the outer upper armature of relay 121. Relay 150, however, does not operate until cut-through relay 121 operates to supply battery to the circuit just traced. Relay 121 is slow to operate. When relay 130 operated subsequent to the operation of the second chain relay 133, as described, a circuit was completed extending from grounded battery, upper winding of relay 121, front contact and outermost left armature of relay 133, front contact and inner right armature of relay 130 to ground.

Relay 121 operates in this circuit and at its outer upper armature and front contact connects battery to conductor 152 causing line connecting relay 150 to operate. The contacts controlled by the outermost lower armature of relay 121 are of the make-before-break variety so that the ground associated with this armature is connected to conductor 161 before it is disconnected from the conductor 153 thereby insuring the completion of a substitute locking circuit for register relay 1' before the locking circuit to relays 133 and 134 is opened, the latter of which relays, up to this time, maintained relay 1' locked operated. Thus register relay 1' is held operated under control of relay 121 which relay also serves to complete the operating circuit for line connecting relay 150.

At its inner upper and its innermost lower armatures and front contacts relay 121 extends the calling line L to the link L' which in turn is extended to the called line No. 1 by the operation of line connecting relay 150. The lower winding of relay 121 is now included in the completed line connection and this relay is thus held operated from battery and ground, 156 and 157, which are shown connected to the link L'. The operation of relay 121 also opens the signal receiving circuit including relays 119, 118, 123 and 131. With the locking circuit for relays 133 and 134 opened at the back contact and outermost lower armature of relay 121, these relays are restored to normal and with the exception of cut through relay 121, register relay 1' and line connecting relay 150, all relays of the system disclosed are in their normal unoperated condition.

The table shown in Fig. 6 indicates the contact operations which result from the operation of each of the keys B1 to B15, inclusive, of the subscriber's key-type sender and also the register relays which operate in response to these contact operations. It is believed unnecessary to describe the operation of the system in response to the actuation of each of the station selecting keys. However, it is believed desirable to include a description of the operation of the system which involves the short-circuiting of resistance 102 and the consequent operation of marginal relay 118 of the signal receiving circuit. For this purpose it will be assumed that the subscriber at station X desires to communicate with the subscriber on line No. 5 and accordingly, actuates key button B5 after having removed the telephone set from its support.

Reference to the table of Fig. 6 indicates that when key B5 is actuated, contact A is closed on the downstroke and both contacts B and C are closed on the upstroke of the key. Reference to Fig. 5 shows that when key B5 is actuated it engages projections of code bars C1, C3 and C6 with the result that these code bars are simultaneously actuated. As in the case just described, the code bar C1 functions during its downstroke to close contact A and code bar C6 functions to close contact B during its upstroke. The code bar C3 functions during its upstroke and through its extension 51 (Fig. 2), to close contact C.

The operation of the system in so far as the downstroke of key B5 is concerned is the same as when key B1 was depressed as previously described, so that this portion of the description need not be repeated. Suffice it to say that relay 123 operated causing relay 130 to operate and the two combined to operate register relay 1'. Chain relay 134 also operated to provide a locking

circuit for relay 1' and locked itself under control of relay 121. Thus for the downstroke of key B5 register relay 1' and chain relay 134 operate and lock.

When the timed contact A at the substation X releases, relay 119 reoperates, as previously described, to disable relays 123, 131 and marginal relay 118. In this condition of the circuit the second chain relay 133 operates and locks in the manner previously described, and transfers the contacts of relays 123 and 118 to the register relays 2' and 4'. When the upstroke of key B5 begins, the code bars C3 and C6, previously depressed, restore under the action of their respective retractile springs and rotate their respective square shafts, in a manner now apparent, and cause the closure of contacts C and B, respectively. The closure of contact B suppresses the positive half cycle, and the resistance 102, now effectively shorted by the closure of contact C permits the negative half cycle to flow at full strength. Thus relays 118 and 131 operate in a circuit extending from the lower terminal of the secondary winding of transformer 115, winding of relay 131, varistor 140, varistor 125, back contact and middle lower armature of relay 121, contacts 104 and 107, contacts 103 and B, varistor 100, closed switch 110 and its associated contact C, inner upper armature and back contact of relay 121, varistor 141, winding of marginal relay 118, back contact and right armature of relay 119, varistor 142 to the upper terminal of the secondary winding of transformer 115. Relay 119 does not operate on this current.

Relays 131 and 118 operate in the circuit just traced. Relay 118 causes relay 130 to operate in a circuit extending from grounded battery, winding of relay 130, right armature and back contact of relay 123, front contact and armature of relay 131 to ground. The outer left armature and front contact of relay 130 and the armature and front contact of relay 118 cooperate with the middle left armature and front contact of relay 133 in completing an operating circuit for register relay 4'. Relay 4' operated, locks to ground at the front contact and outer right armature of relay 133, which is itself locked to ground at the back contact and outermost lower contact of relay 121.

With register relays 1' and 4' operated, an operating circuit for line connecting relay 160 is prepared which may be traced from ground, armature and front contact of relay 1', first armature and back contact of register relay 2', second armature and front contact of register relay 4', third armature and back contact of register relay 8', winding of line connecting relay 160, conductor 152 to the front contact associated with the outer upper armature of relay 121. As previously described, cut through relay 121 operates when relay 133 and relay 130 operated and connects battery to the conductor 152 to complete the operating circuit to line connecting relay 160.

Relay 121, operated, performs the same functions ascribed to it in the previous description, and relay 160, operated, extends the calling line, by way of the link L' to the called line No. 5. Register relays 1' and 4' remain locked under control of relay 121 and the remainder of the circuit restores to normal as previously described.

The connections are terminated when the calling subscriber at station X restores the telephone set to its support thus opening the station

loop circuit in the well-known manner and releasing relay 121. Relay 121 in restoring its armatures releases the locked-up register relays and reconnects the signal receiving equipment to the line L in preparation for the next call.

While the line connecting relays are shown to connect other subscribers' lines to the link L', it is to be understood that one or more thereof may be used to extend the link L', and therefore the line L to a central office or private branch exchange where the connection may be further extended either by the attendant thereat or by the operation of the dial at the calling station.

As hereinbefore mentioned relay 119 is so designed that it will hold operated when its winding is traversed by full wave rectified current which occurs when the telephone at the calling station is removed from its mounting and prior to the actuation of a line selecting key. This relay releases when either half wave is suppressed and will not immediately reoperate. Thus it is apparent that should the flow of full wave rectified current be interrupted as would happen should the calling subscriber fumble the telephone so as to cause an opening and reclosure of the switchhook contacts, relay 119 would release its armatures and maintain them released until its winding is again traversed by a complete cycle of rectified current. During this interval, relays 123 and 131 would be rendered operative as would also relay 118 by the released condition of the armatures of relay 119. Under this condition relays 123 and 131 may operate in response to the switchhook fumbling but no registration of the transmitted impulse results. This is due to the fact that the operating circuit of relay 130 is not completed when both relays 123 and 131 are operated, the armature contact arrangement of these relays being such that the operating circuit to relay 130 is completed only when but one of the two relays is operated and the other restored. With relay 130 unoperated, the register circuit is opened to prevent the registration of an impulse resulting from switchhook fumbling.

Inspection of Fig. 6 reveals the facts that the code is such that every key-stroke operates either contact A or B, but never both together, and that consecutive keys operate these keys alternately on the downstroke. Two advantages are derived from this arrangement. In the first place, each key-stroke is marked by a change from two-way conduction through the subset to one-way conduction through one or the other of the rectifiers 100 and 101. In the second place, the accidental depressing of two adjacent keys simultaneously will close both contacts A and B, which will prevent operation of the selecting mechanism.

What is claimed is:

1. The combination in a telephone system, of a subscriber's line and a substation on said line comprising a telephone subset having a telephone handset, a source of alternating current connectable to said line when the handset at said substation is removed from its support, means at said substation for selectively suppressing the half waves generated by said source comprising a pair of oppositely poled rectifiers, a transfer switch assembly for each of said rectifiers comprising a mercury contact switch which functions, when operated, to transfer said line from said subset to its respective rectifier, and key controlled means for selectively operating said mercury contact switches.

2. The combination in a telephone system, of a subscriber's line and a substation on said line comprising a telephone subset having a telephone handset, a source of alternating current connectable to said line when the handset at said substation is removed from its support, means at said substation for selectively suppressing the half waves generated by said source comprising a pair of oppositely poled rectifiers, a transfer switch assembly for each of said rectifiers comprising a mercury contact switch which functions, when operated, to transfer said line from said subset to its respective rectifier, a plurality of keys, and means controlled by said keys for selectively operating said mercury contact switches on either the downstroke or the upstroke of said keys.

3. The combination in a telephone system, of a subscriber's line and a substation on said line comprising a telephone subset having a telephone handset, a source of alternating current connectable to said line when the handset at said substation is removed from its support, means for selectively suppressing the half waves generated by said source comprising a pair of oppositely poled rectifiers, a transfer switch assembly for each of said rectifiers comprising a mercury contact switch which functions, when operated, to transfer said line from said subset to its respective rectifier, a plurality of keys, and means controlled by said keys for selectively operating said mercury contact switches, each of said switches functioning independent of the time duration of the operation of said keys to disconnect said subset from said line, to connect its respective rectifier to said line for a predetermined interval of time, and to thereafter reconnect said subset to said line.

4. The combination in a telephone system, of a subscriber's line and a substation on said line comprising a telephone subset having a telephone handset, a source of alternating current connectable in said line in response to the removal of the handset at said substation from its support, a rectifier for suppressing the positive half waves generated by said source, a rectifier for suppressing the negative half waves generated by said source, a resistance normally included in circuit with each of said rectifiers, a mercury contact switch for each of said rectifiers operable to disconnect said subset from said line and to connect its respective rectifier to said line, a mercury contact switch operable to short-circuit said resistance, separate means for controlling the operation of said mercury contact switches, and means comprising manually operable keys for operating said mercury contact switches in various combinations whereby either of said rectifiers may be selectively connected directly to said line or to said line in series with said resistance.

5. The combination in a telephone system, of a subscriber's line and a substation on said line comprising a telephone subset having a handset, a source of alternating current connectable to said line when the handset at said substation is removed from its support, a key controlled half wave suppressor, and a transfer switch assembly including a mercury contact switch operable upon the depression of a key to first disconnect said subset from said line, to thereafter connect said half wave suppressor to said line for a predetermined interval of time independent of the length of time the key is held depressed, and to then disconnect said half wave suppressor from

said line and reconnect said subset to said line.

6. The combination in a telephone system, of a subscriber's line and a substation on said line comprising a telephone subset having a handset, a source of alternating current connectable to said line when the handset at said substation is removed from its support, a key controlled half wave suppressor, a second key controlled half wave suppressor, a transfer switch assembly for each of said suppressors including a mercury contact switch, a key having a downstroke and an upstroke, means controlled during the downstroke of said key for initiating the operation of one of said mercury contact switches which thereupon operates independent of any further control by said key to disconnect said line from said subset, to connect its associated suppressor to said line for a predetermined interval of time and to thereafter reconnect said subset to said line, and means controlled during the upstroke of said key for initiating the operation of the other of said mercury contact switches which thereupon functions independent of any further control by said key to disconnect said line from said subset, to connect it to the other of said suppressors for a predetermined interval of time and to thereafter reconnect said subset to said line.

7. The combination in a telephone system, of a subscriber's line and a substation on said line comprising a telephone subset having a handset, a source of alternating current connectable to said line when the handset at said substation is removed from its support, a half wave suppressor, a plurality of keys each having a downstroke and an upstroke, a switch assembly for transferring said line from said subset to said half wave suppressor comprising a magnetic circuit including a permanent magnet, a magnetically controlled switch included in said magnetic circuit, a shunt of magnetic material normally positioned to shunt flux generated by said magnet away from said switch, means controlled by the downstroke of one of said keys for moving said shunt to permit the operation of said switch, and means controlled by the upstroke of another of said keys for moving said shunt to permit the operation of said switch.

8. The combination in a telephone system, of a subscriber's line and a substation on said line comprising a telephone subset having a handset, a source of alternating current connectable to said line when the handset at said substation is removed from its support, a half wave suppressor, manually operable keys each having a downstroke and an upstroke, a transfer switch assembly comprising a mercury contact switch which functions, when operated, to transfer said line from said subset to said half wave suppressor, and means controlled during the downstroke of certain of said keys and during the upstroke of certain other of said keys for causing the operation of said mercury contact switch.

9. The combination in a telephone system, of a subscriber's line and a substation on said line comprising a telephone subset having a handset, a source of alternating current connectable to said line when the handset at said substation is removed from its support, a half wave suppressor, a transfer switch assembly comprising a mercury contact switch which functions, when operated, to transfer said line from said subset to said suppressor and back to said subset in a predetermined time sequence, a key having a downstroke and an upstroke, means controlled by said key

during its downstroke for causing the operation of said mercury contact switch, and means controlled by said key during its upstroke for causing the reoperation of said mercury contact switch.

10. In a telephone system, a subscriber's line and a substation on said line comprising a telephone subset having a handset, a source of alternating current connectable to said line in response to the removal of the handset at said substation, key controlled means for selectively suppressing the positive and negative half waves generated by said source comprising a pair of oppositely poled rectifiers, and a pair of switch assemblies for transferring said line from said subset to said half wave suppressing means, each of said switch assemblies comprising a mercury contact switch operable either during the downstroke of a key or during the upstroke of a key, for disconnecting said subset from said line and for thereafter connecting the half wave suppressing means to said line for a predetermined interval of time dependent solely upon the time characteristics of the said mercury contact switches.

11. The combination in a telephone system, of a subscriber's line and a substation on said line comprising a telephone subset, a source of alternating current connectable to said line when the receiver of said subset is removed from its support at said substation, a rectifier for suppressing half waves of a particular polarity generated by said source, a depressible key, and means controlled by said key for disconnecting said subset from said line and for connecting said rectifier to said line for an interval of time the length of which is independent of the length of time said key is depressed, said means comprising a mercury contact switch having a normally closed back contact through which said subset is connected to said line and a normally open front contact through which said rectifier is connectable to said line, and which operates in response to the depression of said key to quickly open its back contact, close its front contact and maintain it closed for the said interval of time and thereafter reclose its back contact.

12. The combination described in claim 11 in which the operating functions ascribed to said mercury contact switch are completed before the return movement of said key is started.

13. The combination in a signaling system of a line having a station thereon, a source of alternating current, means for connecting said source to said line, a plurality of keys at said station each having a downstroke and an upstroke, a pair of oppositely poled rectifiers at said station, and means controlled by said keys during the down and upstrokes thereof for connecting said rectifiers to said line singly and in various combinations, whereby positive and/or negative direct current impulses are consecutively transmitted from said source over said line, said means comprising magnetically operated timed mercury contacts which function to maintain the selected rectifiers connected to said line for a time interval which is independent of the time duration of the key strokes.

14. The combination in a telephone system in which station selecting signals are characterized by positive and/or negative half cycles transmitted over a line singly or in combinations, a station on said line, a source of alternating current connectable to said line when a call is initiated at said station, a pair of oppositely poled rectifiers for suppressing the half waves generated by said source, a mercury contact switch

for each of said rectifiers comprising a back contact, a front contact and a contact member movable from the back contact to the front contact upon actuation of said switch, and said switch having a time characteristic such that when the switch is operated the said movable contact thereof quickly moves out of engagement with its back contact and into engagement with its front contact and maintains engagement with its front contact for a predetermined interval of time, and the movable contact members and their associated back contacts of said switches normally maintaining a conductor of said line in electrical continuity with said station, and the front contacts of said switches normally maintaining a different one of said rectifiers disconnected from said line, key controlled means for selectively operating said switches whereby said station is disconnected from said line in response to the depression of a key and one or the other of said rectifiers is connected to said line for a predetermined interval of time independent of the length of time the key is depressed and half wave impulses of a particular polarity are transmitted over said line, a receiving circuit including a relay selectively responsive to the transmitted impulses, and a register relay controlled by the operation of said first relay to register the impulses transmitted during the depression of the said key.

15. The combination in a signaling system of a register circuit comprising relays for registering impulses transmitted over a line from a station on said line, a source of alternating current, means at said station for connecting said source of alternating current to said line, means at said station for selectively causing the transmission of rectified positive and negative half waves of said source over said line, a control circuit for said register circuit, a receiving circuit for the transmitted rectified half waves comprising a first relay responsive solely to rectified positive half waves, a second relay responsive solely to rectified negative half waves, a third relay operable solely on full wave rectified current to disable said first and said second relays, whereby said first and second relays are rendered inoperative during the passage of full wave rectified current over said receiving circuit, and contacts included in said register control circuit and cooperatively controlled by said first and second relays whereby said register control circuit is maintained open when said first and second relays operate concomitantly in response to the passage of full wave rectified current over said receiving circuit during an unoperated condition of said third relay.

16. The combination in a signaling system of a register circuit comprising relays for registering signals transmitted over a line from a station on said line, said signals comprising rectified positive and/or negative half waves, a source of alternating current, a full wave rectifier circuit interposed between said source and said line, means responsive to the removal of the telephone at said station from its support for connecting said source to said line whereupon full wave rectified current is caused to traverse said line, means at said station for selectively causing the transmission of rectified positive and negative half waves from said source over said line, a control circuit for said register circuit, a receiving circuit for the transmitted rectified half waves included in said full wave rectifier circuit and including a first relay responsive solely to recti-

fied positive half waves, and a second relay responsive solely to rectified negative half waves, a third relay connected in said full wave rectifier circuit and operable solely on full wave rectified current from said source to disable said first and said second relays whereby said first and second relays are rendered inoperative during the passage of full wave rectified current over said receiving circuit, said third relay having a characteristic such that it releases should the telephone switchhook at said station be fumbled to interrupt the passage of full wave rectified current over said line and does not immediately reoperate upon reclosure of the switchhook contacts, thereby rendering both said first and second relays operative during an interval in which full wave rectified current is traversing said receiving circuit, and contacts included in said register control circuit and cooperatively controlled by said first and second relays whereby said register control circuit is maintained open when said first and second relays operate concomitantly in response to the passage of full wave rectified cur-

rent over said receiving circuit during the release condition of said third relay.

17. In combination, in a telephone code signaling system in which a plurality of differently characterized signals are effected from two contact elements operated in various combinations under control of a plurality of manually depressible keys arranged in a row on the face of a telephone set, and in which each signal characterizing contact combination is characterized by the operation of one or the other but not of both contacts when any one of the keys is depressed, a receiving circuit for the signals produced by the various contact combinations, and register relays controlled thereby, said receiving circuit embodying means for preventing the operation of said register relays should both said contact elements be actuated simultaneously, and said keys being so disposed relative to one another and with control means for said contact elements that consecutively disposed keys, when depressed, operate a different one of said two contact elements.

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