May 1, 1945. F. A. HUBBARD 2,375,109

TELEPHONE CALL TRANSMITTER

Filed March 17, 1943 3 Sheets-Sheet 1

FIG. 1

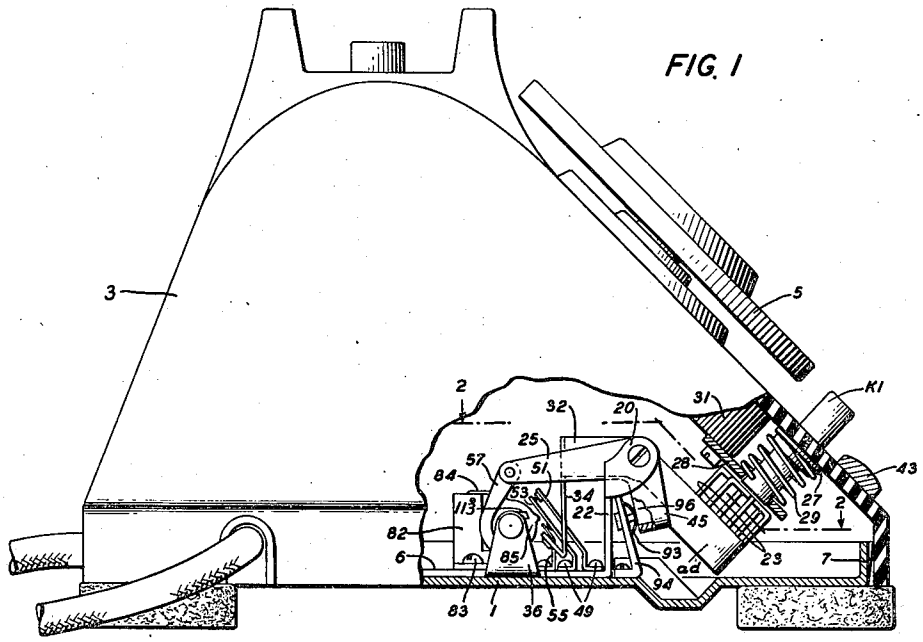


FIG. 13

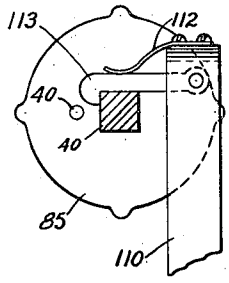


FIG. 9

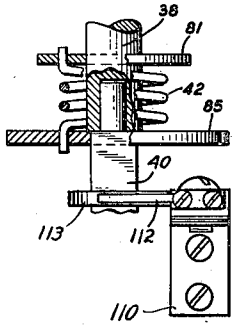


FIG. 2

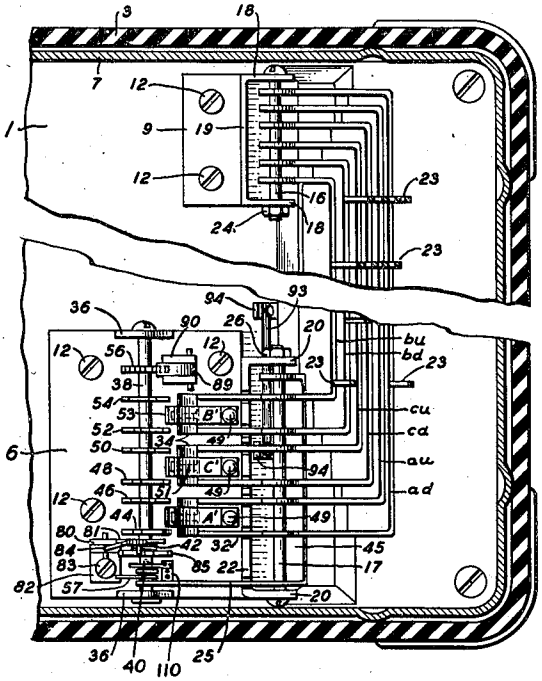
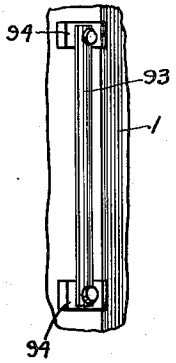


FIG. 9a



INVENTOR
F. A. HUBBARD

BY A. F. Kane

ATTORNEY

May 1, 1945. F. A. HUBBARD 2,375,109

TELEPHONE CALL TRANSMITTER

Filed March 17, 1943 3 Sheets-Sheet 2

FIG. 3

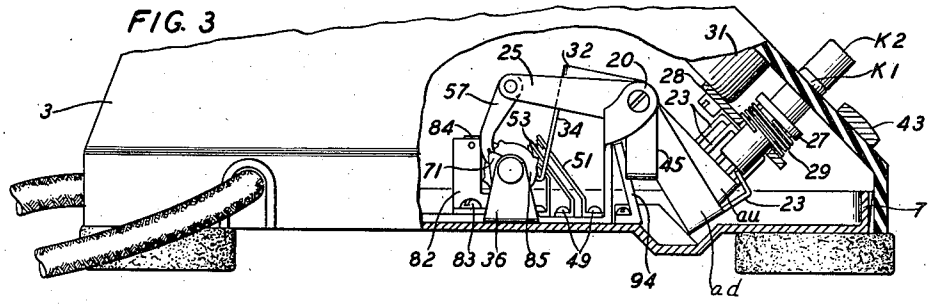


FIG. 4

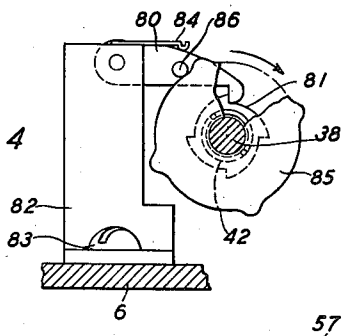


FIG. 5

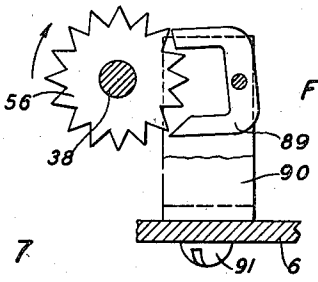


FIG. 7

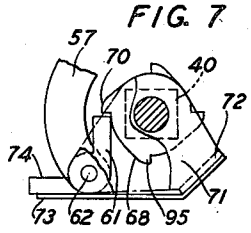


FIG. 6

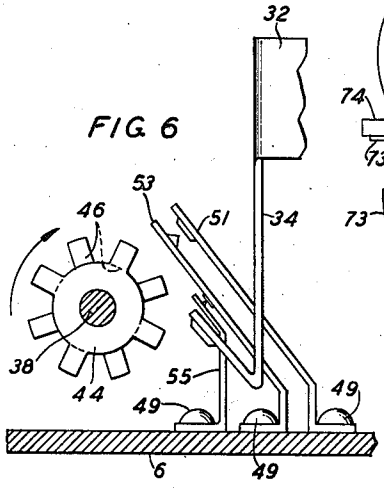


FIG. 8

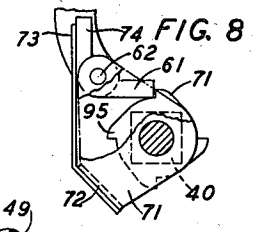
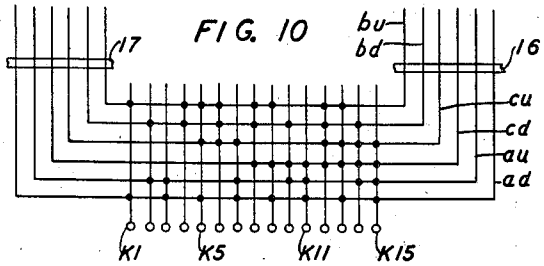


FIG. 11

CODE			
KEY	CONTACTS 1ST	CONTACTS 2ND	REGISTER RELAYS
K1	A	B	1'
K2	B	A	2'
K3	A	A	1', 2'
K4	B	B	4'
K5	A	B, C	1', 4'
K6	B	B, C	2', 4'
K7	A	A, C	1', 2', 4'
K8	B, C	B	8'
K9	A, C	B	1', 8'
K10	B, C	A	2', 8'
K11	A, C	A	1', 2', 8'
K12	B, C	B, C	4', 8'
K13	A, C	B, C	1', 4', 8'
K14	B, C	A, C	2', 4', 8'
K15	A, C	A, C	1', 2', 4', 8'

FIG. 10



INVENTOR
F. A. HUBBARD
BY
A. F. Kane
ATTORNEY

May 1, 1945. F. A. HUBBARD 2,375,109

TELEPHONE CALL TRANSMITTER

Filed March 17, 1943 3 Sheets-Sheet 3

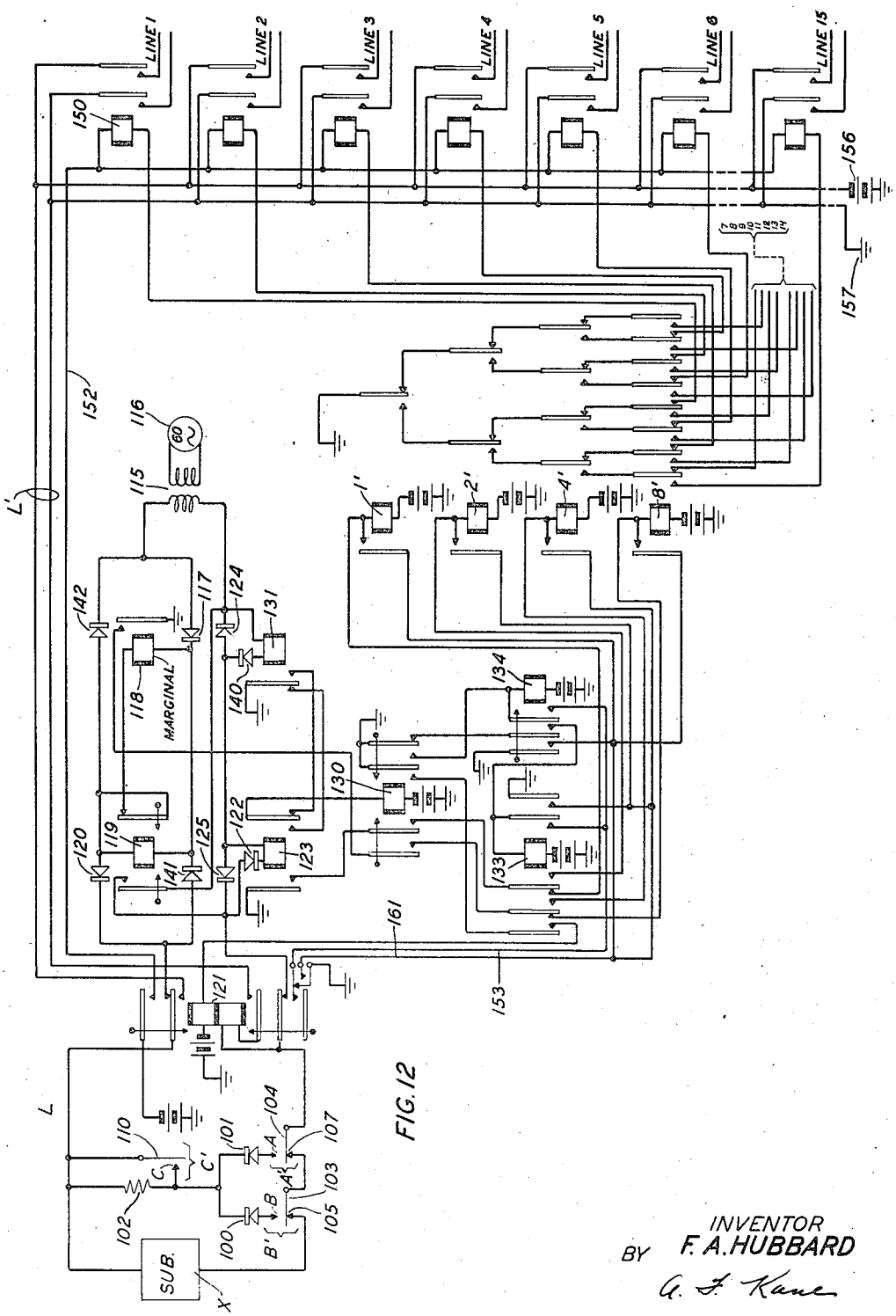


FIG. 12

INVENTOR
F. A. HUBBARD

BY G. F. Kane

ATTORNEY

Patented May 1, 1945

2,375,109

UNITED STATES PATENT OFFICE

2,375,109

TELEPHONE CALL TRANSMITTER

Francis A. Hubbard, Maplewood, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application March 17, 1943, Serial No. 479,417

8 Claims. (Cl. 177—380)

This invention relates to key controlled impulse transmitting devices and more particularly to telephone call transmitters of the type used at subscribers stations of a key-calling telephone system.

Key-calling telephone systems have been devised primarily to provide facilities whereby direct telephone connections to frequently called lines may be completed by a calling subscriber by the simple expedient of actuating keys individually assigned to the stations of a group of frequently called lines.

A key-calling system of this general character is disclosed in United States Patent 2,347,108 of April 18, 1944. In that system each of fifteen lines to which the key-calling subscriber has direct access is selected by the actuation of a key which functions to transmit, over the subscriber's line to a signal receiving point, a station identifying signal characterized by two consecutively transmitted signal components. In order that signal responsive translating devices function properly to record the transmitted signal, it is essential that each signal component be applied to the line for a predetermined interval of time, and that a predetermined interval of time elapses between the transmission of the two components. In the aforementioned copending application means, in the nature of magnetically operated timed mercury contacts, are employed which function to insure the application of each of the two signal conditions to the line for predetermined intervals of time, and to insure the clearance of the first signal condition before the second signal component is transmitted. The use of such devices insures the required time intervals without imposing on the calling subscriber any requirements as to the manner in which the signal control keys are to be actuated.

It is the object of the present invention to provide a telephone call transmitter of the type disclosed in the above-identified patent, and in which the required time intervals are obtained on a purely mechanical basis.

This object is attained by depending entirely upon the use of purely mechanical means in a telephone call transmitter which function, incident to the actuation of any of a group of station selecting keys, to start a complete cycle of events, beginning when the actuated key reaches the bottom of its stroke and completing itself without any further influence from the key. This cycle embodies all three of the time intervals, each of predetermined duration, that are required in transmitting a two-part station identifying signal.

In particular, the call transmitter of this invention embodies a contact controlling mechanism in the nature of a rotatable shaft to which are fixed, in spaced relation, a plurality of cams, each pair of which is adapted to actuate a particular set of contact springs whose closure determines the character of the components of the station identifying signals. The cam shaft is spring coupled to a drive shaft, and during the depression of any of the keys of the transmitter, is held against rotation while the drive shaft is rotated through an arc of ninety degrees to store energy in the coupling spring. When an actuated key is fully depressed the cam shaft is released and, under the action of the coupling spring, is rotated, under control of an escapement mechanism, through an arc of ninety degrees and then is automatically arrested. During the rotation of the cam shaft the cams carried thereby act to operate their corresponding sets of contact springs. The cams and associated contact springs are relatively disposed so that only previously selected cams are effective in operating their contact springs. The cam selection is obtained by means of select fingers, one for each cam, which, under the control of the transmitter keys, may be selectively interposed between their corresponding cams and an associated set of contact springs so that when the cam shaft is rotated the selected cams force the corresponding select finger into engagement with the contact springs causing the springs to operate. Each pair of cams which functions to control the operation of a particular set of contact springs comprises two adjacent identical toothed discs, the teeth of one being peripherally displaced with respect to the teeth of the other so that when the two cams of the same group, or the first cam of any group together with the second cam of any other group are selected in response to the depression of a key and the cam shaft is rotated, contact spring operations are produced sequentially. That is, when the two cams of the same group are selected, the corresponding contact springs are operated and released by the first cam and then reoperated and released by the second cam, and when the first cam of one pair and the second cam of another pair are selected the contact springs controlled by the first cam are operated and released and then the contact springs controlled by the second cam are operated and released. The cam arrangement is such that the

contact closures effected thereby are sustained for predetermined intervals of time and the space of time elapsing between successive contact closures is of sufficient duration to permit the signal condition determined by the first contact closure to clear itself before the second contact closure is produced. In this manner the necessary time intervals are assured.

The escapement mechanism functions to control the speed of rotation of the cam shaft when driven by the coupling spring. Near the bottom of the key stroke a non-linear spring, acted upon during the down-stroke of the key functions with a snap "break through" action which insures the full depression of the keys and functions to restore the actuated keys to normal after the lapse of an interval of time of sufficient duration to allow both signal components to be transmitted.

Having described in a general manner the call transmitter of this invention, the features and operation thereof will now be set forth in the following detailed description made with reference to the accompanying drawings, in which:

Fig. 1 is a side elevation of a telephone set equipped with the call transmitter of this invention, with a part of the casing broken away and showing an end view of the key controlled operating mechanism of the transmitter;

Fig. 2 is a plan view taken along the line 2—2 of Fig. 1 looking in the direction of the arrows;

Fig. 3 is a fragmentary side view of the telephone set shown in Fig. 1 and illustrates the position of the transmitter operating mechanism when one of the actuating buttons, or keys is operated;

Figs. 4, 5, 6, 7, 8, 9, and 9*a* are enlarged views of certain structural details of the transmitter. Fig. 4 shows the latching device which maintains the cam shaft stationary during the depression of the buttons or keys; Fig. 5 shows the escapement mechanism which controls the speed at which the cam shaft is rotated; Fig. 6 shows the normal relative positions of a set of signal determining contact springs, of the toothed cams used to operate the springs and of the select finger which serves to effectively associate the cams with their corresponding contact springs; and Figs. 7 and 8 show the operating mechanism which functions to rotate the drive shaft when any of the buttons or keys is operated. Fig. 7 shows the position of the mechanism prior to the actuation of a key or button and Fig. 8 shows the mechanism when the actuated key or button has been fully depressed. Fig. 9 is an enlarged view of the spring coupling. Fig. 9*a* is an enlarged view of the non-linear restoring spring.

Fig. 10 is a schematic representation showing the six code bars and the manner in which they are actuated in combinations by each of the fifteen station selecting buttons or keys;

Fig. 11 is a table showing the contact combinations effected by each key and the register relays which operate in response to each particular contact combination;

Fig. 12 is a circuit diagram of a key calling telephone system with which the key set or telephone call transmitter of this invention functions; and

Fig. 13 is an end view of the structural elements shown in Fig. 9.

Referring now to Figs. 1 to 9, inclusive, and Fig. 13 of the drawings the telephone subscriber's telephone set consists of the usual handset support of the cradle type formed integrally with the casing **3** and a base **1** formed with vertically extending flanges **7** by virtue of which the casing **3** is fitted to the base. On the front face of the casing **3** is mounted the usual dial finger-wheel **5**, fifteen manually depressible buttons K1 to K15, inclusive, and a designation strip **43** located immediately below the buttons or keys. The strip **43** is transparent and embodies the designations corresponding to the keys or buttons in any suitable manner.

Each of the manually depressible keys or buttons K1 to K15, inclusive, consists of a cylindrical portion protruding through an opening in the casing **3**. Each button is provided with a flange **27** which abuts the inner surface of the front face of the casing **3**, and of a lower cylindrical portion which protrudes through an aperture in the plate **28** which is secured to the underside of the dial cup **31**. Interposed between the lower face of flange **27** and the upper face of the plate **28** is a coil spring wound loosely about the lower cylindrical portion of the key. This spring functions to maintain the button in its normal position as shown in Fig. 1.

The buttons or keys control the operation of six code bars, *ad*, *au*, *cd*, *cu*, *bd* and *bu* which are substantially U-shaped and are located at the forward end of the telephone set. The inwardly projecting portions of the U-shaped bars are apertured to accommodate the rods **16** and **17** about which the bars are adapted to be rotated. The rod **16** which may be a screw bolt accommodating the nut **24** is supported by two oppositely disposed ear-like extensions **18** formed integrally with a vertical extension **19** of a mounting plate **9** secured to the base **1** by screws **12**. The rod **17** is supported in a similar manner by the ear-like extensions **20** of the vertical extension **22** of a mounting plate **6** and is threaded at one end to accommodate the nut **26**.

Each U-bar is provided with an integrally formed inwardly projecting extension **32** which has fixed to its inner end a hook-shaped select finger **34**. Thus, there are six select fingers such as shown at **34** each individually and integrally associated with one of the code bars through the extension **32**. The elongated portions of the U-bars which extend across the front portion of the telephone set below the row of selecting buttons K1 to K15, inclusive, are provided with projections or fingers **23** located in various positions throughout the length of the bars. These extensions are so arranged that the bottom face of each button will engage one or more thereof when the button is depressed. Thus, when any button is depressed, a certain number of the projections **23** will be engaged to cause a corresponding combination of code bars to be rotated about the pivot rods **16** and **17**. The rotation of the U-bars in this manner causes the corresponding select fingers **34** to be moved upwardly for a purpose to be hereinafter described.

Also supported between the ear-like appendages or lugs **20** for pivotal movement about the rod **17** is a common U-bar **45**. This bar, as clearly shown in Fig 1, is located immediately below the inwardly projecting left arms of the six code bars so as to be operated thereby when any of the code bars is actuated. The inner edge of the upper or right arm (viewing Fig. 2) of the common bar **45** normally rests against the center line of an elongated spring **93** which is supported on the mounting plate **6** by means of two brackets **94**. This spring has a non-linear characteristic and functions with a snap "break through" action when the bar **45** is actuated and serves to restore

the bar 45 to its normal position. The purpose of this "break through" action of spring 93 will be set forth in detail hereinafter.

Three sets of contact springs A', B' and C' (Fig. 2) are mounted on the mounting plate 6 so that each set is adapted to be engaged by two adjacent select fingers 34 as will appear from a later description. The two outer sets of contact springs A' and B' are identical and are of the transfer type comprising three springs 51, 53 and 55 mounted on the plate 6 by means of screws 49, as shown in Fig. 6. Each spring carries a contact, and springs 55 and 53 function as break springs while the springs 53 and 51 constitute make springs. The center set of contact springs C' consists of only two springs similar to the springs 51 and 53 of Fig. 6.

The contact control mechanism comprises a square sectioned drive shaft 40 and a cam shaft 38 each of which has an outer end passing through an aperture in a vertically extending lug 36 of the mounting plate 6. The cam shaft 38 carries six identical toothed discs or cams 44, 46, 48, 50, 52 and 54 which are so disposed on the shaft 38 as to constitute three sets of cams each consisting of two toothed discs. Cams 44 and 46 which are in substantial alignment with the select fingers 34 of code bars *ad* and *au* respectively, constitute one group; cams 48 and 50, which are in substantial alignment with the select fingers 32 of code bars *cd* and *cu*, respectively, constitute a second group; and the cams 52 and 54, which are in substantial alignment with the select fingers 32 of code bars *bd* and *bu*, respectively, constitute the third group. The cams are normally out of physical engagement with the contact springs corresponding thereto, but when any of the code bars is actuated the corresponding select finger is moved upwardly so as to be interposed between its corresponding cam and the corresponding set of contact springs, so that when the cam shaft is rotated, subsequent to the actuation of the code bars, the contact springs of the sets A', B' and C' are operated in combinations corresponding to the combination of select fingers actuated. As shown in Fig. 6 the cams of each pair of cams are identical toothed discs but are so peripherally displaced on the shaft 38 that the teeth of one are displaced forty-five degrees relative to the teeth of the other. Thus, when the shaft 38 is rotated one cam of a pair functions (if its corresponding select finger has been actuated) to operate the corresponding contact springs during one interval of the period of rotation of the shaft and the other cam functions (if its corresponding select finger has been actuated) to operate the contact springs during a succeeding interval of the period of rotation of the shaft.

The cam shaft 38 and square sectioned shaft 40 are coupled together by means of a spiral spring 42, the opposite ends of which are fixed respectively, to the cam 85 and ratchet 81, the former fixed to shaft 38 and the latter to the square sectioned shaft 40. Thus the square sectioned shaft 40 functions through the spring 42 to drive the cam shaft 38 in a manner which will be described in greater detail hereinafter. As clearly shown in Fig. 9 the square sectioned shaft 40 is provided with an integral pin-like extension which fits into one end of shaft 38. This pin serves as a bearing for one end of shaft 40.

Near its upper or right end (viewing Fig. 2) the cam shaft 38 carries an escapement wheel 56 which cooperates with an escapement pawl 89 to control the speed of rotation of the shaft 38. The pawl 89 is pivotally supported between the two arms of a U-shaped bracket 90 fixed to the plate 6 by screw 91 as shown in Fig. 5.

The square sectioned drive shaft 40 is actuated in response to the operation of any of the keys or buttons K1 to K15, inclusive, through the mechanism shown, particularly, in Figs. 7 and 8. On one end of the shaft 40 is fixed a ratchet wheel having four teeth two of which are identified by the numerals 70 and 95. The common bar 45 is provided with an inwardly projecting arm 25 which pivotally carries at its end a pawl 57, which in turn, pivotally supports at its end a dog consisting of two arms 61 and 74 which are disposed at right angles to each other. This dog is carried by the pivot pin 62. When a key or button is depressed it actuates one (or more) of the code bars which acts (or act) upon the common bar 45 causing it to rotate about the rod 17 and to raise the extension 25. The pawl 57 is accordingly lifted causing the dog end 61 to engage the ratchet tooth 70 and to rotate the square sectioned shaft through ninety degrees. The position of the ratchet and pawl after such operation is shown in Fig. 8. The ratchet is partially enclosed by two sheet spring elements 71 joined at 72 and provided with a spring extension 73 which, by engagement with the dog end 74, serves to maintain the dog in contact with the ratchet during the actuation of the pawl 57. When the common bar 45 restores to normal the pawl 57 is lowered carrying the dog with it so that the portion 61 thereof engages the next succeeding tooth 95 of the ratchet in preparation for a subsequent actuation of the transmitter.

During the rotation of the drive shaft 40 under the influence of an actuated key or button the coupling spring 42 is wound up since, during this interval it is unable to transmit the movement of the drive shaft 40 to the cam shaft 38 because the latter is held against rotation by a latch 80, pivotally mounted on the bracket 82, which normally engages one of four teeth of the ratchet 81 and is held in engagement with the ratchet by the spring 84. The ratchet 81 is fixed to the cam shaft 38. The latch 80 is provided with a pin 86 which is normally in engagement with a cam 85 fixed to the drive shaft 40. When the drive shaft is rotated with its cam 85 through an arc of substantially ninety degrees one of the camming teeth of the cam 85 acts upon the pin 86 to cause the latch 80 to be disengaged from the ratchet 81. When this occurs the cam shaft 38 is released and is rotated under the influence of the spring 42. A pawl 113 pivotally mounted on bracket 110 is held in engagement with the square shaft 40 by means of spring 112. This pawl permits the shaft 40 to rotate in one direction when a key is actuated and precludes rotation thereof in the reverse direction. When the cam shaft has rotated through an arc of ninety degrees the latch 80 engages the next succeeding tooth in the ratchet 81 to prevent any further rotation of the shaft. During this period of rotation of shaft 38 the contact spring sets, A', B' and C', are actuated in accordance with the combination of cams selected by the actuated select fingers 34. The first cam of each group functions during a first interval of rotation of the shaft 38 while the second cam of each group functions during a subsequent interval, the two intervals being spaced by a time

interval during which the contact springs operated during the first interval are restored to normal.

As hereinbefore indicated the non-linear spring 93 is engaged by the common bar 45 whenever a key or button is actuated. As the depressed key nears the bottom of its stroke the spring 93 flexes with a snap which serves to insure the key being fully depressed. The non-linear spring 93 associated with the common bar 45 in flexing with a snap, provides a break through key action which is assisted by the sudden release of the pawl, or latch 80 to throw the actuated key all the way down. With this break-through key action the need for a latching mechanism for insuring that the select finger, or fingers remain in operative position until engaged by the cams is precluded since it requires a certain amount of time to reverse the motion of the fingers. When the subscriber releases the depressed key the spring 93 functions to restore the common bar 45 and the actuated code bar or bars.

It will be observed that any partial actuation of a key or button will not result in the operation of any contact springs. This is due to the fact that the contact controlling mechanism, cam shaft 38, cannot operate until the latch 80 is disengaged from the ratchet 81 and this does not occur until the cam 85 has been rotated through substantially ninety degrees and acts upon pin 86 to raise the latch.

The following description is directed to the operation of the call transmitter of this invention and for this purpose it will be assumed that the key K1 is depressed. When the key K1 is depressed code bars *ad* and *bu* are actuated in accordance wih the showing in Fig. 10, by virtue of the engagement of the lower face of the key with the projections 23 extending from the code bars *ad* and *bu*. The select fingers 34 integrally associated with the extensions 32 of the actuated code bars are accordingly raised so as to be interposed between springs 53 of the contact sets A' and B' and their corresponding cams 44 and 54. At the same time common bar 45 is actuated by the actuated code bars and raises its arm 25 whereupon the pawl 57, fixed thereto functions through the mechanism shown in Figs. 7 and 8 to rotate the square sectioned drive shaft 40 through an arc of ninety degrees. The coupling spring 42 is accordingly wound up since the cam shaft 38, at this time, is held against rotation by the latch 80 and its engagement with the ratchet 81. Thus energy to drive the cam shaft is stored in the spring 42. When the drive shaft is rotated almost ninety degrees the cam 85 fixed thereto trips the latch 80 thereby releasing the cam shaft 38. The shaft 38 thus rotates under the action of spring 42 at a rate of speed determined by the escapement mechanism. During the rotation of the cam shaft 38, a tooth of cam 44, through its corresponding select finger 34 actuates the contact springs A' causing the spring, such as spring 53 to move out of engagement with the spring, such as spring 55 and into engagement with a spring such as spring 51. When the tooth of cam 44 rides off its corresponding select finger 34 the set A' of contact springs resumes its normal unoperated position. The tooth of cam 54 then becomes effective to operate the spring contact set B' through its corresponding select finger and when this tooth rides off the select finger the contact springs resume their normal positions. It will be observed that this sequence of contact spring operations is started when the latch 80 is disengaged from the ratchet 81, that is when the actuated key K1 has been fully depressed and is completed independently of any further influence of the actuated key. When the shaft 38 has been rotated through ninety degrees the latch 80 functions to arrest any further movement thereof. It will also be observed that the actuated common bar 45 and code bars *ad* and *bu* are restored to normal under the influence of spring 93. While the coil spring 29 will function to restore the actuated key K1 to normal it will be noted that this spring may be omitted if desired since the restoration of the actuated code bars by the spring 93 will also cause the key K1 to return to normal because of the engagement of the code bar projections 23 therewith.

The following description is directed to the operation of the subscriber's telephone call transmitter in connection with a telephone call originated at the substation X and intended for a station on line No. 1 indicated at the right of Fig. 12. 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 rectifiers of the dry disc type. These varistors or rectifiers are indicated at 100 and 101. A resistance 102 is also provided for a purpose 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 rectifiers across the line. The contact element 104 corresponds to a contact spring, such as spring 53 of Fig. 6 and its back contact 107 and its front contact A correspond respectively to the contacts associated with springs such as springs 55 and 51 of Fig. 6. The contact element 103 and its associated back and front contacts correspond respectively to a contact spring such as spring 53 of Fig. 6 and the contacts of springs such as 55 and 51 of Fig. 6 which, actually constitute the spring set B' shown in Fig 2. The switch 110 controlling the resistance 102 is a simple make contact spring arrangement and corresponds to the contact set C' shown in Fig. 2.

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 positive or negative 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 signal component transmitted during the first signaling interval 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 rectifiers 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 K1. It will be observed from an inspection of the table shown in Fig. 11 that when key K1 is actuated contact A is first made followed by the making of contact C. In a previous description it was pointed out that when key K1 was actuated the contact set A' of Fig. 2 was first actuated by cam 44 and then the contact set B' was actuated by cam 54. Thus when key K1 is actuated contact A of the set A' is closed to connect rectifier 101 across the line in series with resistance 102 and contact B is subsequently closed to connect rectifier 100 across the line in series with resistance 102 and each time a rectifier such as 101 or 100 is connected across the line, the line conductor to the station X is opened at the back contacts 107 and 105, respectively.

When the handset at station X was removed from its support and prior to the actuation of key K1, relay 119 operated on the full wave rectified 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 relays 123 and 131 and their associated rectifiers. When the cam shaft 38 rotates after the key K1 is fully depressed as previously described, the cam 44 functions to operate the spring contact set A' so that the station X is disconnected from the line at contact 107 and rectifier 101 is connected to the line at contact A. With rectifier 101 connected across the line it suppresses the negative half of the wave and resistance 102 reduces the positive half of the wave 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, rectifier 117, winding of marginal relay 118, back contact and right armature of relay 119, rectifier 120, back contact and inner upper armature of relay 121, resistance 102, rectifier 101, contacts A and 104, middle lower armature and back contact of relay 121, rectifier 122, winding of relay 123, rectifier 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 locks to ground associated with the outermost lower armature of cut-through relay 121. Thus, as a consequence of the rotation of shaft 38 through the first portion of its operation during which cam 44 is effective, relays 123, 130, 134 and 1' operate, the last two locking.

When the tooth of cam 44 rides off its corresponding select finger 34 the springs of contact spring set A' restore to normal whereupon 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 second signal transmitting interval, the register relays 1' and 8' serving the same purpose during the first signal transmitting interval. Relay 133 locks under control of cut-through relay 121.

Upon continued rotation of cam shaft 38 the cam 54 next becomes effective and operates the contact springs of the set B'. Thus contact 105 is opened to disconnect the substation from the line and contact B is closed to connect rectifier 100 across the line in series with resistance 102. With rectifier 100 connected across the line the positive half wave is suppressed and resistance 102 limits the amplitude of the negative half wave to a value insufficient to operate relay 118.

Relay 119 releases and on the ensuing negative half cycle relay 131 operates in a circuit extending from the lower terminal of the secondary of transformer 115, winding of relay 131, rectifiers 140 and 125, back contact and middle lower armature of relay 121, contacts 104 and 107, contacts 103 and B, rectifier 100, resistance 102, inner upper armature and back contact of relay 121, rectifier 141, winding of relay 118, right armature and back contact of relay 119, rectifier 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 is operated at this time no other register relay operates. Hence register relay 1' alone responds to the actuation of key K1, and functions to cause the extension of the calling line to the called line to which key K1 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 con-

tact 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 ground 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 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. 11 indicates the contact operations which result from the operation of each of the keys K1 to K15 inclusive, of the subscriber's telephone call transmitter 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, a more complete description, contained in the above-identified patent, is applicable to the circuit disclosed in Fig. 12 of this application.

It will be observed that in the table of Fig. 11 the column headed "Contacts" is divided into two smaller columns headed respectively "1st" and "2nd." It is to be understood that the contacts listed in column "1st" are operated by such cams as cams 44, 48 and 52 during the first interval of the signal transmitting period while the contacts listed in column "2nd" are operated by such cams as cams 46, 50 and 54 during the second signal transmitting interval, and that the two intervals are time spaced by an interval corresponding to the time during which the first contacts operated are released and before the second contacts are operated. Thus the contact controlling cam shaft functions to provide the three intervals required in the transmission of a signal comprising two consecutively transmitted signal components.

It is to be noted also that the contact spring set C' shown in Fig. 2, is operated together with either the contact spring set A' or the contact spring set B' for certain key operations and that when thus operated the springs of the set C' function to effectively exclude the resistance 102 from the signaling circuit which, as fully described in the aforementioned patent application increases the amplitude of the unsuppressed half wave to a value sufficient to operate marginal relay 118.

What is claimed is:

1. In a call transmitter, the combination of a plurality of depressible keys, a plurality of sets of contact springs, a control mechanism for operating said sets of contact springs comprising a rotatable shaft, a pair of cams for each set of contact springs mounted on said shaft and spaced from said springs so as to be normally inoperative to actuate said springs when said shaft is rotated, a select finger adapted to be interposed between each of said cams and a corresponding set of contact springs for rendering the cams operative to actuate their corresponding contact springs when said shaft is rotated, a plurality of depressible keys, means controlled by said keys during the depression thereof for selectively interposing said select fingers between their respective cams and a corresponding set of contact springs, and means operative when any of said keys is fully depressed for causing said shaft to rotate.

2. In a call transmitter, the combination of a rotatable shaft, a plurality of cams fixed to said shaft and having mutually peripherally displaced camming areas, a plurality of contact springs disposed relative to said cams and spaced therefrom so as to be inoperative directly by the camming areas of said cams when said shaft is rotated, means for selectively rendering said cams operative to actuate said springs comprising a select finger for each of said cams, a plurality of depressible keys, means controlled by said keys when depressed for selectively interposing said select fingers between their respective cams and said contact springs, whereby said springs are acted upon by the camming areas of said cams through said select fingers when said shaft is rotated, and means operative when any of said keys is fully depressed for causing the rotation of said shaft.

3. In a call transmitter, the combination of a rotatable shaft, a pair of identical toothed cams fixed to said shaft and arranged thereon so that the teeth of one are peripherally displaced relative to the teeth of the other, a set of contact springs disposed relative to said cams and spaced therefrom so as to be inoperative directly by said cams when said shaft is rotated, means for rendering said cams operative to actuate said springs comprising a select finger for each of said cams, a depressible key, means controlled by said key when depressed for interposing said select fingers between their respective cams and said contact springs whereby the teeth of said cams alternately operate said contact springs through their respective select fingers when said shaft is rotated, and means operative only when said key is fully depressed for causing the rotation of said shaft.

4. The combination in a call transmitter of a

rotatable shaft, a plurality of cams fixed thereto in spaced relation and having mutually peripherally displaced camming areas, a select finger for each of said cams, a plurality of contact spring sets normally in disengaged association with said cams and each set so located with respect to a pair of said cams as to be operated by the camming areas thereof when one of said select fingers is interposed between its corresponding cam and the associated set of contact springs and said shaft is rotated, control means for each of said select fingers, a plurality of depressible keys for actuating said control means selectively in various combinations whereby a corresponding combination of select fingers are interposed between their corresponding cams and the associated sets of contact springs when any of said keys is depressed, means controlled during the depression of any of said keys for preparing said shaft for rotation, and means operative only when any of said keys is fully depressed for causing the rotation of said shaft whereby a combination of contact spring operations corresponding to the combination of select fingers interposed between the contact springs and the corresponding cams is effected.

5. In a call transmitter, the combination of a plurality of depressible keys, contacts, a contact control mechanism comprising a rotatable shaft having fixed thereto a pair of contact operating cams normally dissociated from said contacts and adapted to function successively upon the rotation of said shaft to actuate said contacts, key-operated means, means controlled by said key-operated means during the depression of any of said keys for preparing said shaft for rotation and for selectively associating said cams with said contacts whereby said contacts are selectively operated by said cams successively when said shaft is rotated, means operative when said key is fully depressed for causing said shaft to rotate, and means comprising a non-linear spring engaged by said key-operated means during the depression of said key for restoring said key-operated means to normal a predetermined interval of time after the full depression of said key.

6. The combination in a signaling system in which a station-selecting signal is characterized by two successively transmitted signal components, of a line, and a signal transmitter for successively transmitting the signal components over the line comprising a plurality of sets of contact springs each of which when operated determines the character of a signal component, a rotatable shaft, a pair of cams for each set of contact springs mounted on said shaft in inoperative association with the corresponding set of contact springs, the first cam of each pair corresponding to one portion of a signal transmitting period and the second cam of each pair corresponding to another portion of a signal transmitting period, a plurality of depressible keys, means controlled by said keys during the depression thereof for selecting any combination of a first and second cam of said pairs of cams and operatively associating them with their corresponding contact springs whereby the selected cams are rendered operable to actuate their corresponding contact springs when said shaft is rotated, and means operative only when a key is fully depressed for causing the rotation of said shaft, whereupon each of the selected cams functions during its corresponding signaling interval to actuate its corresponding set of contact springs.

7. In a call transmitter, the combination of a plurality of sets of contact springs and means for actuating and releasing the contact springs of one of said sets and thereafter actuating and releasing the contact springs of another of said sets comprising a rotatable shaft, a pair of contact spring operating cams for each set of contact springs carried by said shaft, each pair of cams comprising two identical toothed discs so relatively disposed on said shaft that the teeth of one are peripherally displaced with respect to the teeth of the other whereby one cam of each pair is effective to actuate its corresponding set of contact springs ahead of the other cam when said shaft is rotated, depressible keys, cam-selecting means, means controlled during the depression of certain of said keys for actuating said cam-selecting means to cause them to selectively render a different cam of each pair of cams operable to actuate its corresponding set of contact springs whereby the selected cams function to operate and release one of said sets of contact springs and to thereafter operate and release another of said sets of contact springs when said shaft is rotated, means responsive to the full depression of any of said keys for causing said shaft to rotate, and means operative independently of said keys after the full depression thereof for causing said cam-selecting means to function for a predetermined interval of time and to thereafter restore said cam-selecting means to normal.

8. In a call transmitter, the combination of a rotatable shaft, depressible keys, means responsive to the full depression of any of said keys for rotating said shaft, means for arresting the motion of said shaft after it has been rotated through an arc of predetermined length, contact springs, means for operating and releasing said contact springs during the interval said shaft is rotating through a portion of the said predetermined arc and for reoperating and releasing said contact springs during the interval said shaft is rotating through a subsequent portion of the said predetermined arc comprising a pair of cams carried by said shaft and consisting of two identical toothed discs so relatively disposed on said shaft that the teeth of one are peripherally displaced with respect to the teeth of the other and are normally inoperative to actuate said springs when said shaft is rotated, and means controlled during the depression of any of said keys for selectively rendering said cams effective to operate said springs.

FRANCIS A. HUBBARD.