

Nov. 28, 1944.

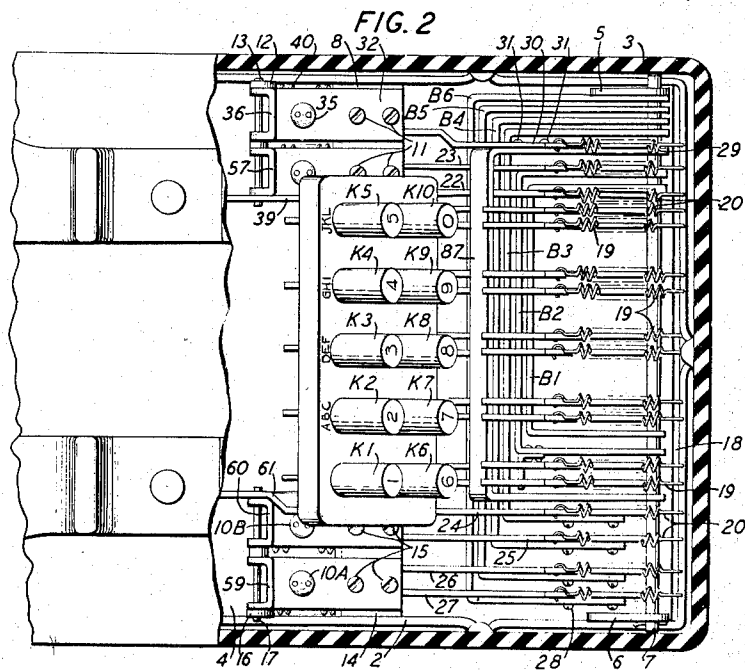
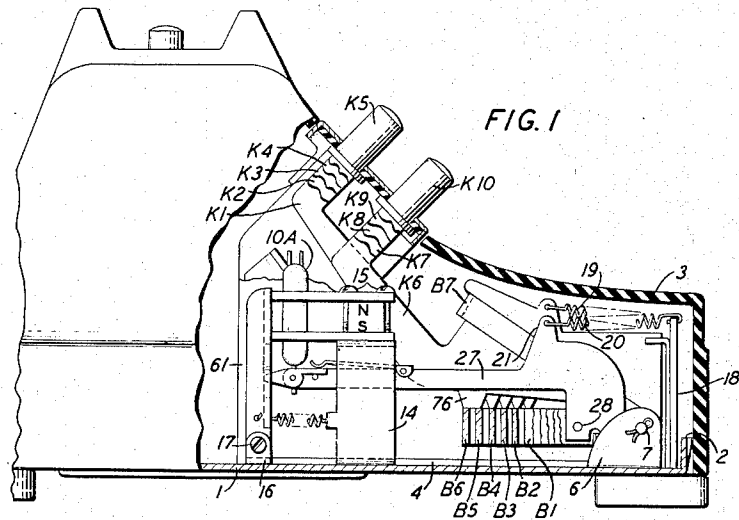
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2,363,671

TELEPHONE SYSTEM

Filed Dec. 31, 1942

5 Sheets-Sheet 1



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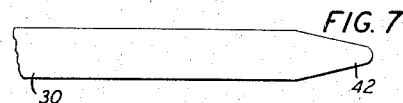
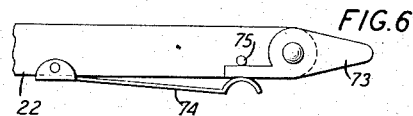
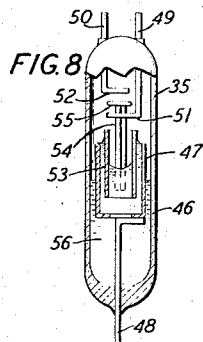
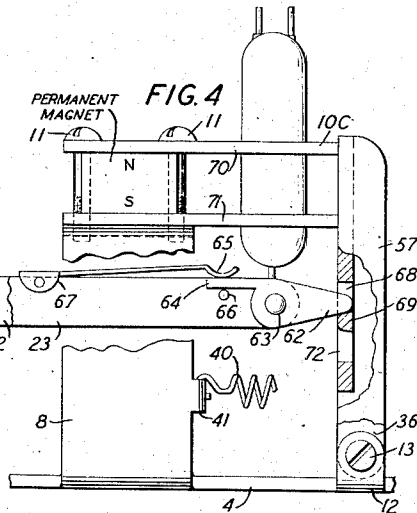
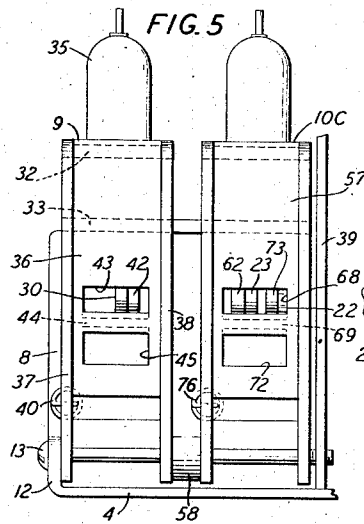
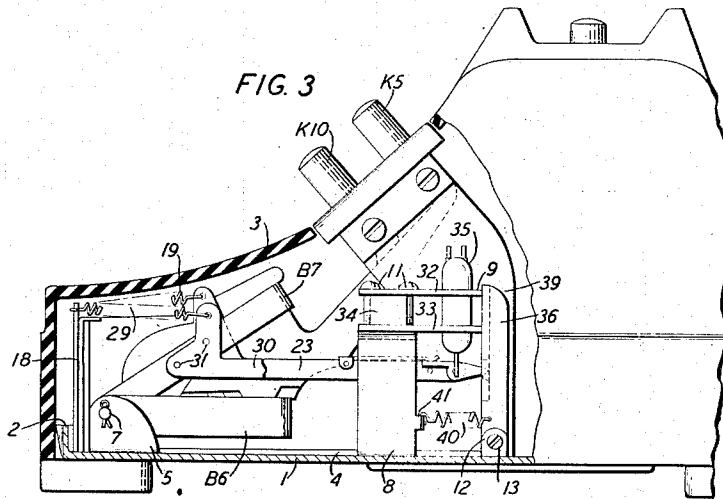
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TELEPHONE SYSTEM

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5 Sheets-Sheet 2



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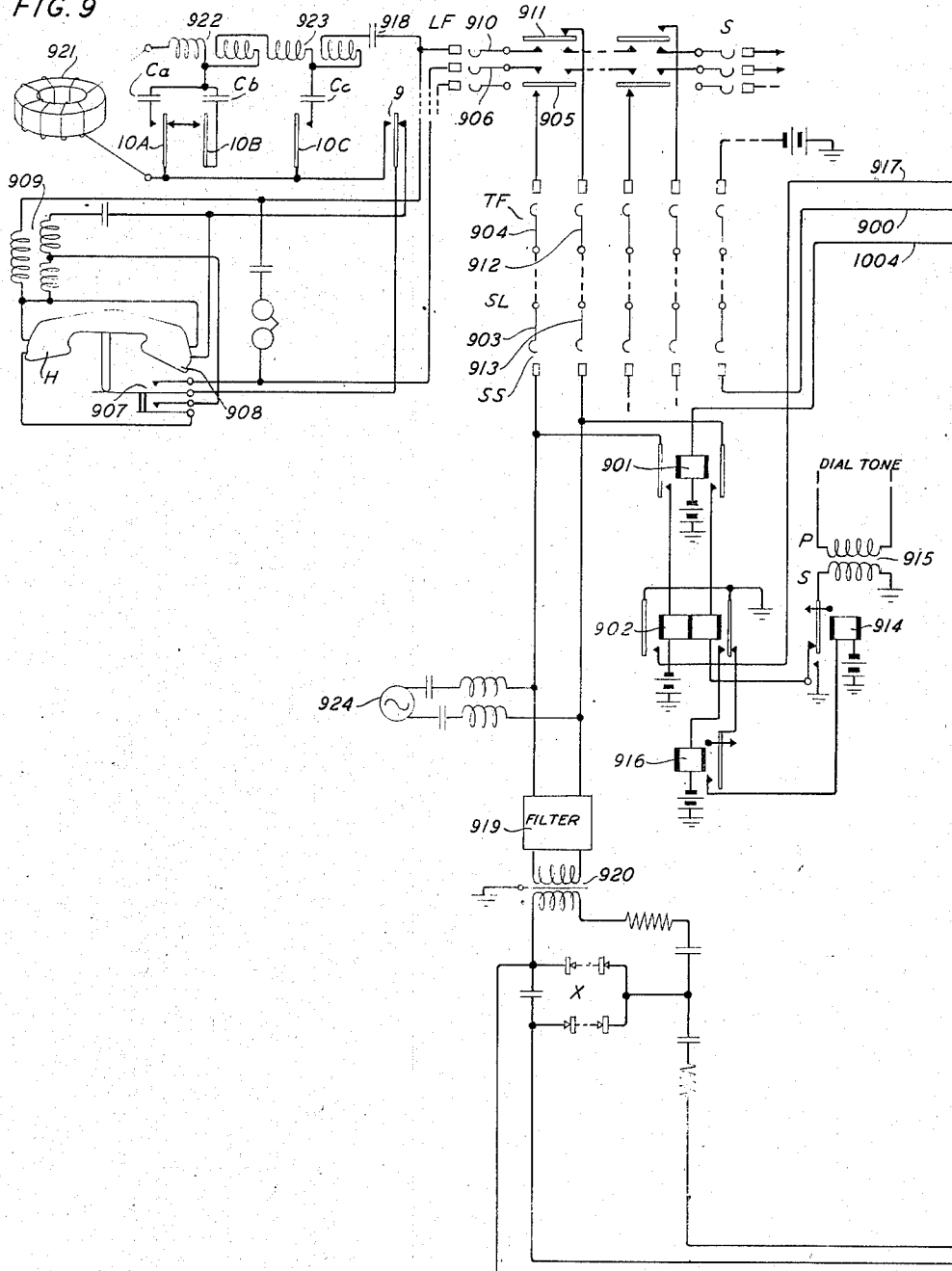
2,363,671

TELEPHONE SYSTEM

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5 Sheets-Sheet 3

FIG. 9



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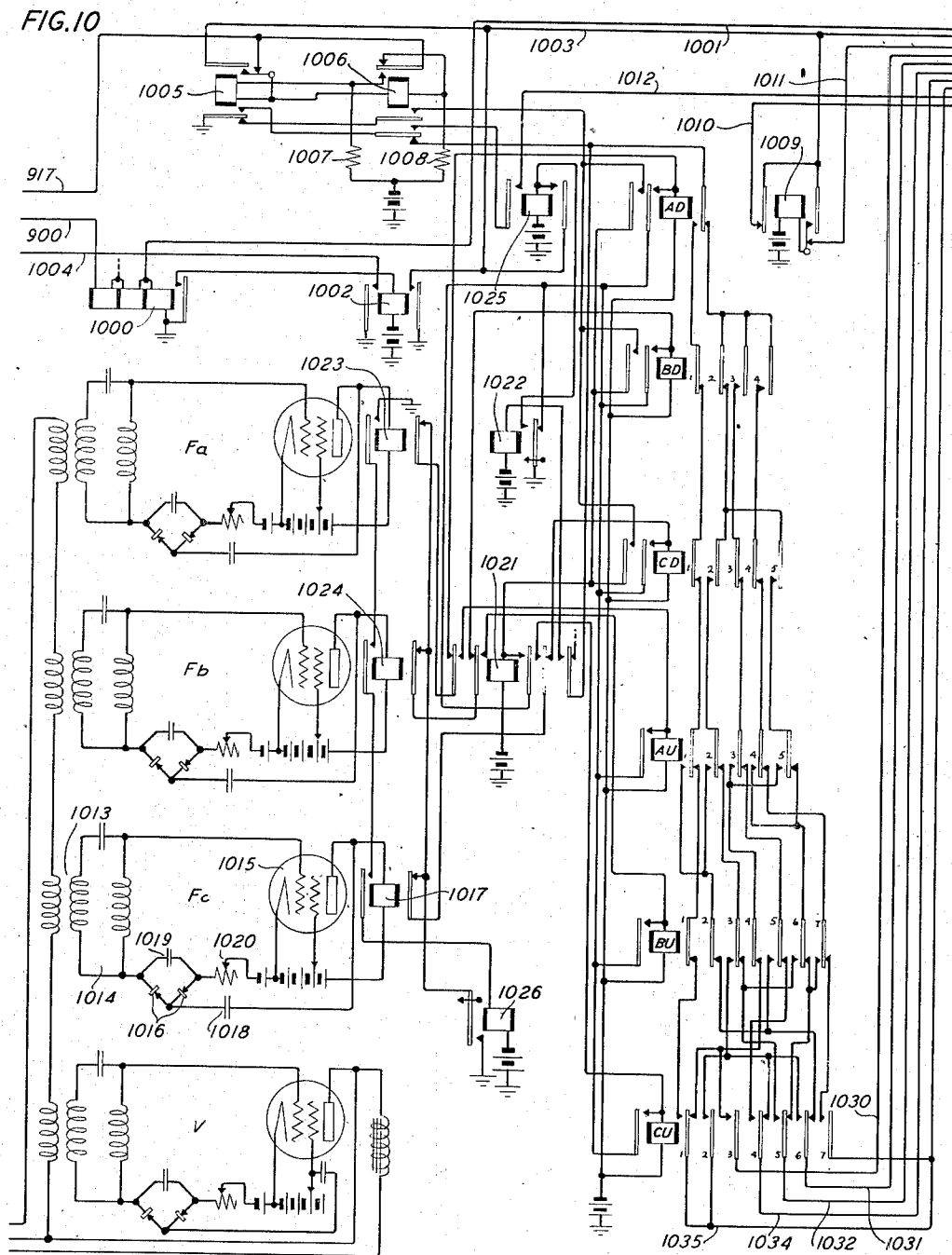
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TELEPHONE SYSTEM

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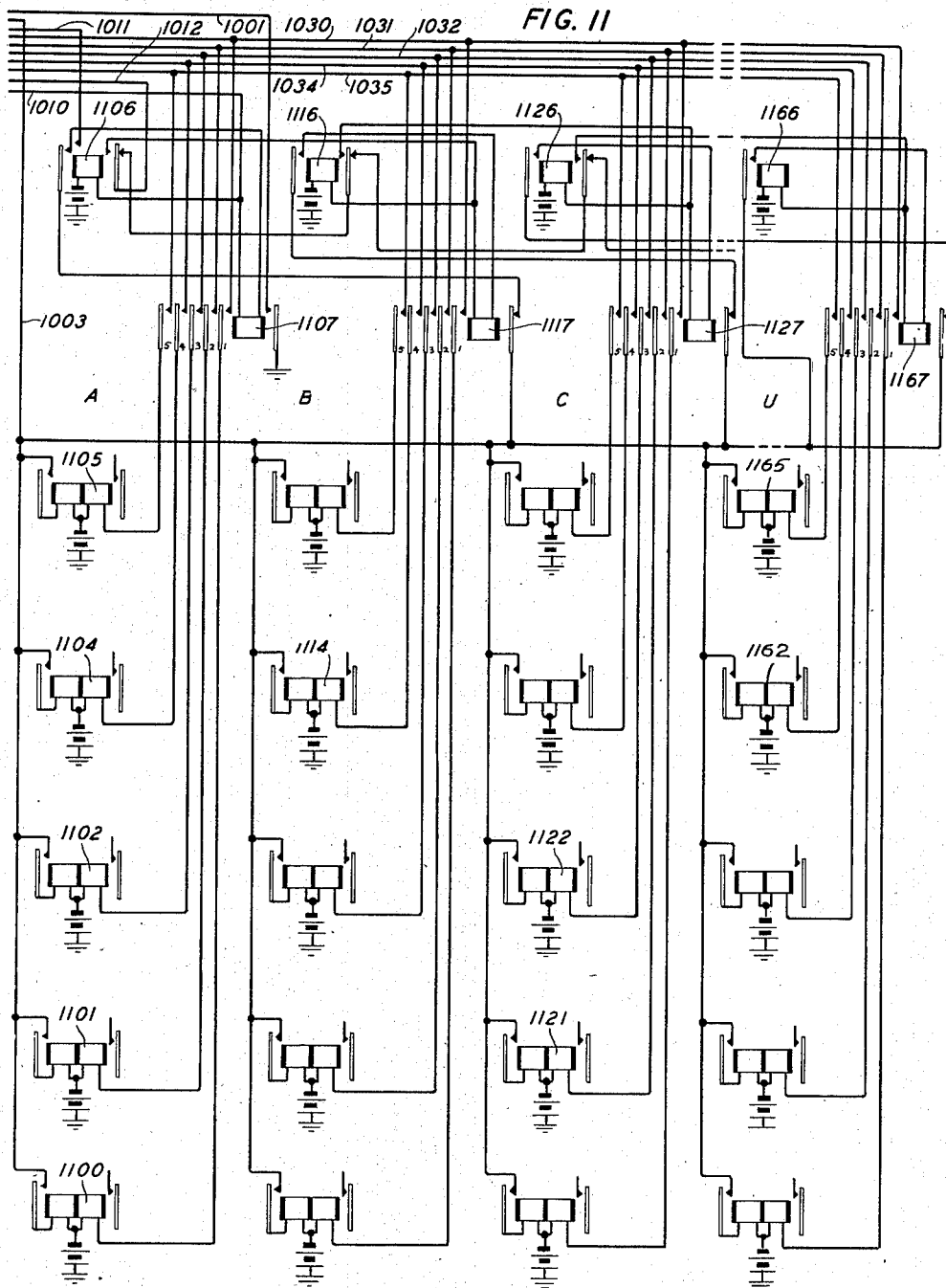
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TELEPHONE SYSTEM

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5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE

2,363,671

TELEPHONE SYSTEM

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Application December 31, 1942, Serial No. 470,724

14 Claims. (Cl. 179—18)

This invention relates to signaling and communication systems and particularly to telephone systems in which automatic switches used in the establishment of telephone connections are controlled by means of alternating current.

Systems have been proposed heretofore in which the designations of called lines are transmitted from one point to another by means of alternating currents of different frequencies transmitted singly or in combination characterizing the different digits or other characters of a wanted line designation. In Patent No. 2,164,335, issued July 4, 1939, to R. C. Mathes, there is disclosed a system of this general character in which a harmonic generator is employed at the subscriber's station which is activated by current of a fundamental frequency generated at the central office to produce harmonics of this fundamental frequency and in which the subscriber is provided with means for selecting certain of the generated harmonics to characterize the digits of a telephone designation and to cause the selected harmonics to be suppressed to control the operation of automatic switches. A further improvement on the system disclosed in the patent to Mathes just referred to is disclosed in Patent No. 2,201,296 issued May 21, 1940, to A. A. Lundstrom and E. L. Norton.

It is the object of the present invention to further improve systems of this type whereby a smaller number of generated harmonics are utilized to characterize the digits of a telephone designation.

It is a further object of the present invention to enable a wider spacing of the utilized harmonics without increasing the outside frequency range whereby a greater discrimination by the receiving channels is secured or a narrower outside frequency range of the harmonics may be employed whereby the difference in attenuation between the highest and lowest frequencies is less.

In accordance with one embodiment of the invention these objects are attained by the provision of mechanism in a call transmitter of the general type disclosed in the Patent No. 2,315,344 granted March 30, 1943, in the name of R. F. Mallina whereby the operation of any one of the ten keys of the key-set is effective upon the down-stroke to selectively suppress one of the harmonics which characterizes the digit corresponding to the depressed key and again upon the up-stroke of the operated key to suppress one or more harmonics which characterize the digit corresponding to the operated key.

In the proposed transmitter a resonant suppression circuit is provided comprising two double-wound retard coils each having its windings connected in series opposition and three condensers. One coil may be tuned to either of two frequencies *a* or *b* by the connection of either the first or the second of the three condensers to the mid-point between the windings by the operation of a first or second switch element, and the second coil may be tuned to the frequency *c* by the connection of a third condenser to the mid-point between its windings by the operation of a third switch element. Preferably the switch elements are of the timed mercury contact type and are selectively operable once during the down-stroke of a key-set key and are selectively operable again during the up or return stroke of an operated key in accordance with a predetermined code.

A code may be so selected with respect to the standard arrangement of the keys in the key-set as indicated in a table appearing hereinafter that every key suppresses a single harmonic on the down-stroke and that no two adjacent keys arranged either vertically or horizontally suppress the same harmonic on the down-stroke. In accordance with the code all keys but the key for the digit 0 suppresses a single harmonic on its up-stroke, the key for the digit 0 suppressing two harmonics simultaneously on its up-stroke.

The serially connected suppression coils are connectable to the tip conductor of the substation line through a fourth condenser by an off-normal switch of the timed mercury contact type. This off-normal switch is momentarily operated during the down-stroke movement of any key and is again momentarily operated during the up-stroke movement of the operated key to transfer the substation line from the substation subset to the harmonic generator coil of the call transmitter. By connecting this condenser in series with the generator coil and suppression coils, the off-normal switch when operated, opens the direct current path at the substation whereby central office equipment may be signaled and conditioned to receive voice frequency signals thus eliminating certain difficulties that have heretofore appeared to be inherent in the systems of this type hereinbefore proposed, by entirely separating the signaling condition from the normal talking condition, eliminating interference between the two and by providing a position signal to activate the receiving channel.

The production of two signal impulse conditions by the call transmitter for each keyed digit

requires a modification of the receiving circuits associated with the central office sender whereby three receiving channels are provided responsive to three of the resonant frequencies transmitted by the harmonic generator with each of which channels two groups of recording relays are associated. Each of these groups of relays comprises a relay corresponding to each of the three frequencies, one group being normally associated with the three receiving channels so that one of such relays is selectively operable in response to the suppression of one of the three frequencies suppressed upon the down-stroke of an operated key, and the other group being associated with the three receiving channels following the termination of the first impulse of a digit signal so that relays of such group are selectively operable in response to the suppression of one or more of the three frequencies upon the up-stroke of the operated key. Thus upon the termination of the two impulses of a digit signal a relay of the first group and one or two relays of the second group will remain operated to control the setting of a digit register of the sender.

For a clearer understanding of the invention reference may be had to the following detailed description taken in connection with the accompanying drawings in which:

Fig. 1 is a left side elevation view of the telephone call transmitter embodying the invention, the casing being shown with a portion broken away to disclose the frequency suppression switches and the key-controlled operating mechanism therefor;

Fig. 2 is a top plan view of the call transmitter with a portion of the casing broken away;

Fig. 3 is a right side elevation view of the call transmitter the casing being shown with a portion broken away to disclose one of the frequency suppression switches and operating mechanism therefor;

Fig. 4 is an enlarged side elevational detail view of the frequency suppression switch disclosed in Fig. 3;

Fig. 5 is an enlarged end view of an assemblage of a suppression switch and the off-normal switch;

Fig. 6 is a detail view of the end of the operating levers associated with the suppression switch disclosed in Figs. 4 and 5;

Fig. 7 is a detail view of the end of the off-normal switch operating lever associated with the off-normal switch disclosed in Fig. 5;

Fig. 8 is a detail view, partly in cross-section, of one of the mercury contact switch elements associated with the suppression switches and off-normal switch; and

Figs. 9, 10 and 11, taken together, show a telephone system in accordance with the present invention and in which the call transmitter disclosed in Figs. 1 to 8, inclusive, is employed: Fig. 9 showing the substation circuit in which the call transmitter is installed, a diagrammatic illustration of a line finder, first selector, a sender link comprising a trunk finder and a sender selector and a portion of the circuits of a central office sender; Fig. 10 showing the receiving channels of the sender, the recording relays and other control relays, and Fig. 11 showing certain of the sender registers and progress relays associated therewith.

In the call transmitter of the invention as shown in Figs. 1, 2 and 3, a base 1 is provided having upturned edges 2 to which a molded cas-

ing 3 is attached. Secured to the base 1 is a mounting plate 4 having upturned ears 5 and 6 for supporting a shaft 7 on which the key member K1 to K10, inclusive, are pivotally mounted; an upturned and then inturned bracket 8 upon which the off-normal switch assembly 9 and the suppression switch assembly 10C are secured by the screws 11; an ear 12 for supporting one end of the pivot screw 13 upon which the armatures of the switch assemblies 9 and 10C are pivoted; an upturned and then inturned bracket 14 upon which the suppression switch assemblies 10A and 10B are secured by the screws 15; the ear 16 for supporting one end of the pivot screw 17 upon which the armatures of the switch assemblies 10A and 10B are pivoted; and an upturned plate 18.

Each of the key members K1 to K10, inclusive, is normally and yieldably maintained in the position disclosed in Fig. 1 by a retractile spring 19 each of which springs is hooked at one of its ends to a key member and at the other of its ends to the upper edge of the plate 18.

Also pivotally mounted on the shaft 7 are six U-bars B1 to B6, inclusive, which are operable in different combinations upon the depression of the key members. These bars are normally and yieldably held in the positions disclosed in Fig. 1 by retractile springs 20 which are hooked at one of their ends to the upper edge of plate 18 and at their other ends are hooked to lugs 21 of lever members 22, 23, 24, 25, 26, and 27 which are secured to the U-bars B1, B2, B3, B4, B5, and B6, respectively as by rivets 28.

A U-shaped off-normal bar B7 is also pivoted on shaft 7 and held in operable relation with each of the ten key members K1 to K10 inclusive, by a retractile spring 29 hooked at one of its ends to a lug on the lever 30 secured to the bar B7 as by rivets 31 and at the other of its ends to the plate 18. The lever 30 is effective to control the off-normal switch assembly 9 once when any key of the key-set is operated in a down-stroke and again when the operated key is released in an up-stroke.

The off-normal switch assembly 9 comprises two parallelly disposed pole-pieces 32 and 33 clamped by the clamping screws 11, previously referred to, to the pole-pieces of a permanent magnet 34 as best shown in Fig. 3. The pole-pieces are provided near their outer ends with aligned holes in which is supported a switch element 35 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 is a soft iron armature 36. The armature is channel-shaped, the flanges 37 and 38 thereof having aligned holes therethrough near their lower ends through which the pivot screw 13 extends and on which screw the armature is pivoted. The inner end of the pivot screw is threaded into a tapped opening in the side plate 39 which supports one end of the key-set. For holding the armature 36 normally in engagement with the polar ends of the pole-pieces 32 and 33 a retractile spring 40 is hooked at one end to flange 37 of the armature 36 and at its other end to the extension 41 of the bracket 8 which extension is bent inwardly at right angles to the bracket.

For camming the armature 36 away from the polar ends of the pole-pieces 32 and 33, the horizontal arm of lever 30, which lever is secured to the off-normal bar B7, extends beneath the pole-

piece 33 with its tip 42 engaged in the opening 43 in the armature 36 and above the camming portion 44 thereof. The shape of this camming portion is best disclosed in connection with the armature 57 of the switch assembly 10C disclosed in Fig. 4. When the end of the lever 30 is depressed the camming end of such lever engages with the camming portion 44 of the armature 36 and cams the armature 36 away from the polar ends of the pole-pieces 32 and 33, but when the end of lever 30 is fully depressed, in which position the camming end 42 thereof will be below the cam portion 44 of the armature and within the opening 45 in the armature, the spring 40 and the attractive force of the permanent magnet 34 will draw the armature again into engagement with the polar ends of the pole-pieces. Similarly, in the return movement of the lever 30 when the depressed key-set key is released, the camming end 42 of such lever moving upwardly over the camming portion 44 of the armature again moves the armature away from the pole-pieces until the camming end 42 reenters the opening 43 in the armature.

The mercury contact switch element 35 of the off-normal switch assembly, as best disclosed in Fig. 8, is, as previously stated, of the type disclosed in the patent to Pollard hereinbefore referred to and has an envelope 46 of glass or other suitable material within which is a guide sleeve 47 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 48. The wire 48 is sealed through the bottom of the envelope 46. The guide sleeve 47 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 49 and 50 having their ends which extend into the envelope bent at right angles toward each other to form two stationary contact portions 51 and 52, the upper one 52 of which serves as a front contact and the lower one 51 of which serves as a back contact. The contact portion 52 is wide but the contact portion 51 is narrow. Movable within the guide sleeve 47 is a cylindrical tubular armature 53, 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 member 54 which may be formed by doubling a length of wire, bending the looped end at right angles and flattening the same to provide a widened contact portion 55 for engagement with the contact portions 51 and 52 of the back and front contact members 49 and 50. 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 co-operates.

To complete the switch element a measured amount of mercury 56 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 47 and within the tubular armature 53 to the position illustrated in Fig. 8 and the mercury is also conducted by the capillary action of the inner surface of the guide sleeve 47 and the outer surface of the armature 53 to fill the space between such surfaces. The surface tension of the

mercury between the upper edges of the guide sleeve 47 and the armature 53 and the surface tension of the mercury within the armature exerts a downward pull upon the armature to normally hold the contact portion 55 firmly against the contact 51 of the back contact member 49. The mercury within the armature also engages the lower end of the contact member 54 whereby mercury is conducted along such member to its upper contact portion 55 and in the normal position of the armature to the contact portion 51 thereby establishing a mercury contact between the contact members 55 and 51.

When the armature 36 of the off-normal switch assembly is cammed away from engagement with the pole-pieces 32 and 33 all of the flux generated by the permanent magnet 34 is permitted to pass through the armature 53 of the switch element and the armature rises within the guide sleeve 47 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 53 and the sleeve 47. This restraint is not so great however but that the film of mercury between the contact portion 51 of the back contact member 49 and the contact portion 55 of the armature contact member 54 will disrupt quickly since the cross-sectional area of the film adjacent to the contact portion 51 is small. The armature will therefore move the contact portion 55 of the contact member 54 quickly out of engagement with the contact portion 51 of the back contact member 49 and into engagement with the contact portion 52 of the front contact member 50. Mercury adhering to the contact member 55 is now transferred to the front contact member 52 to establish a film of mercury therewith.

Since the armature 36 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 53 of the switch element whereupon the magnetic pull on the armature 53 is reduced permitting the surface tension of the mercury pool to pull the armature 53 back into its normal or retracted position but since the contact areas of the contact portions 52 and 55 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 54 while the armature 53 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 55 snaps quickly into engagement with the contact portion 51 of the back contact member 49. 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 off-normal switch assembly is effective to transfer the substation line from the telephone set to the harmonic generator and suppression coils of the call transmitter as will be later described.

The suppression switch assemblies 10A, 10B and 10C are similar in construction to the off-normal switch assembly 9 just described except for the construction of the camming ends of their associated operating levers 22, 23, 24, 25, 26, and 27. The armature 57 of the switch assembly 10C is pivotally supported on the same pivot screw 13 upon which the armature 36 of the off-normal switch assembly 9 is pivoted, the two armatures

being suitably spaced apart by the spacer 58 supported on the pivot screw 13 and interposed between the armatures. The suppression switch assemblies 10A and 10B have their armatures 59 and 60 pivotally supported on the pivot screw 17 which extends through the ear 16, through aligned holes in the flanges of the armatures and into a threaded hole in the side plate 61 which supports one end of the key-set.

Each of the suppression switch assemblies is so arranged that its switch element may be operated either in response to the depression of a key-set key, in response to the releasing movement of an operated key or in response to both movements of the key, dependent upon the impulse code employed. For controlling the operation of these switch assemblies two operating levers are associated with each assembly, levers 26 and 27 connected to U-bars B5 and B6, respectively, being associated with assembly 10A, levers 24 and 25 connected to U-bars B3 and B4, respectively, being associated with assembly 10B, and levers 22 and 23 connected to U-bars B1 and B2, respectively, being associated with assembly 10C.

Referring now to Figs. 4 to 6, inclusive, the lever 23 has a cam member 62 pivoted at 63 to the end thereof, the tail portion 64 of such member being normally held by the leaf spring 65 against the stop pin 66, also secured to the lever 23. The leaf spring 65 is provided with two parallelly disposed ears 67 bent at right angles thereto and positioned on either side of the upper edge of the lever 23 by which the spring is riveted to the lever. The outer end of the camming portion 62 normally extends through the opening 68 in the armature 57 of the assembly 10C above the upper camming surface of the cam portion 69 of the armature. When the cam member 62 is moved downwardly by the lever 23 upon the depression of a key of the key-set, such member engages the upper edge of the cam portion 69 and the member therefore tends to rotate in a counter-clockwise direction. Since, however, the cam member 62 is prevented from rotating in a counter-clockwise direction by the stop pin 66, the member is effective in its downward movement to cam over the cam portion 69 and thereby move the armature 57 from its bridging engagement with the pole-pieces 70 and 71 of the switch assembly 10C. The armature of the switch element of such assembly is thereupon quickly moved to a position in which its movable contact is disengaged from its back contact and is engaged with its front contact. As the member 62 continues its downward movement it moves past the cam portion 69 of the armature 57 into the opening 72 thereby permitting the spring 76 to reengage the armature 57 with the pole-pieces 70 and 71 whereupon the armature of the associated switch element is restored to normal to move its movable contact out of engagement with its front contact and into engagement with its back contact.

When the depressed key is released and lever 23 is permitted to rise, the end of cam member 62 carried thereby engaging the lower edge of the cam portion 69 of the armature the cam member 62 rotates in a clockwise direction against the tension of leaf spring 65 without causing the armature to be cammed out of its normal position. Therefore, the associated switch element is not operated upon the releasing or upward movement of the lever 23.

The other operating lever 22 also associated with the same switch assembly 10C has its cam member 73 reversely pivoted to the lever as dis-

closed in Fig. 6. Normally, this cam member 73 extends through the opening 68 in the armature 57 and when the lever 22 is depressed in response to the depression of a key-set key, the member 73 is moved downwardly into engagement with the upper surface of the cam portion 69 of the armature, and such member rotates in a counter-clockwise direction against the tension of the associated leaf spring 74 without camming the armature away from the ends of the pole-pieces 70 and 71, until it snaps off of the cam portion 69 and remains positioned in the opening 72 of the armature when the operated key is fully depressed.

When the depressed key is released and lever 22 is permitted to rise, the cam portion 73 engages the lower surface of the cam portion 69 and therefore tends to rotate in a clockwise direction, but the tail of the member 73 now engages the stop pin 75 thus preventing such rotation of the member 73 whereby the member 73 is effective to momentarily cam the armature 57 away from the pole-pieces 70 and 71 until the end of cam member 73 passes over the cam portion 69 and enters the opening 68 in the armature. It is thus apparent that the depression of lever 23 is effective to cause the functioning of the switch element of the assembly 10C only during the depression movement of the lever 23 and that the depression of lever 22 is effective to cause the functioning of the switch element of the assembly 10C only during the return movement of lever 22. The switch assemblies 10A and 10B are operable in a similar manner by their associated levers.

The U-bars B1, B3 and B5 through their associated levers 22, 24 and 26 may be considered as up-stroke bars and the U-bars, B2, B4 and B6 through their associated levers 23, 25 and 27 may be considered down-stroke bars.

To illustrate the manner in which the call transmitter functions it will be assumed that the key member K1 for transmitting impulses of a code for the digit 1 is depressed. By reference to the following table it will be noted that for the digit 1 it is necessary to operate the switch assembly 10A to suppress frequency *a* during the down-stroke of the key K1 and to again operate the switch assembly 10A to suppress the frequency *a* during the up-stroke of key K1 whereby two suppressions of frequency *a* are effective at the central office sender. To accomplish this, the under-surface of the key member K1 is provided with an extension 76 which engages the upper edges of both U-bars B6 and B5 so that upon the down-stroke of the key member both of these U-bars are depressed. The depression of the U-bar B6 through the associated lever 27 causes a timed operation of the switch element of the switch assembly 10A and through the off-normal bar B7 and associated lever 30 causes a timed operation of the switch element 35 of the off-normal switch assembly 9 whereby the frequency *a* is momentarily suppressed.

The depression of the U-bar B5 is not effective through its associated lever 26 to operate the switch assembly 10A during the down-stroke movement of such U-bar and lever but when the depressed key is released and the depressed U-bars B6 and B5 are returned to normal by their associated springs 20, the lever 26 is effective to again operate the switch element of the switch assembly 10A and at the same time the up-stroke of the operated off-normal bar B7 under the in-

fluence of the retractile spring 29 causes the operation of the switch element 35 of the off-normal switch assembly 9 whereby the frequency *a* is again suppressed for a short interval.

The keys K1 to K10, inclusive, of the key-set are so designed that they are effective to operate the U-bars B1 to B6, inclusive, and the suppression switch assemblies 10A, 10B and 10C to control the suppression of frequencies *a*, *b* and *c* in the manner indicated in the following table:

Key	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10
U-bars operated.....	B6, B5	B2, B1	B4, B3	B2, B3	B6, B1	B2, B5	B4, B5	B2, B1, B3	B4, B1	B2, B1, B5
Switch operated on down-stroke.....	10A	10C	10B	10C	10A	10C	10B	10C	10B	10C
Switch operated on up-stroke.....	10A	10C	10B	10B	10C	10A	10A	10B 10C	10C	10A 10C

The call transmitter of Figs. 1 to 8, inclusive, is applicable to a wide variety of types of dial switching systems and particularly to those of the type in which register mechanisms are employed at the central office for registering the designations transmitted for controlling the selective operation of automatic switches to complete connections. Accordingly, the system chosen to illustrate the invention is one in which the central office is equipped with automatic switches of the panel type and with register senders for registering the designations transmitted to the central office from subscriber stations. It will be obvious that other forms of switches may be used for establishing connections such as switches of the well-known step-by-step and cross bar types.

Referring to Figs. 9, 10 and 11 of the drawings, a subscriber's line is shown appearing in the contact bank of the line finder LF. The line finder is joined to a first or district selector S and these two circuits together form a link for extending subscribers' lines to trunks extending to other selectors (not shown) by which a connection from a calling line may be extended to a wanted subscriber's line. The line finder and district link has access through a sender link SL, comprising a trunk finder TF and a sender selector SS, to a plurality of common register senders. Figs. 9, 10 and 11 disclose such parts of a sender as are necessary for an understanding of the present invention. The number of registers employed in these senders will, of course, vary with the requirements of the exchange area. In some of the larger areas office codes require two or three office code digit registrations and the numerical part of the designations usually requires four registrations. In the present disclosure three office code digit registers A, B and C are shown in Fig. 11 and the units numerical register U is also shown, it being understood that the thousands, hundreds and tens numerical registers would be provided and inserted between the units register U and the office code digit register C. These registers each comprise five register relays which are selectively operated under the control of the six recording relays AD, BD, CD, AU, BU and CU and the frequency receiving channels Fa, Fb, Fc of Fig. 10.

It will be assumed that to initiate a call at the substation illustrated in Fig. 9 the subscriber removes the handset H of the substation instrument from the cradle whereupon a circuit is established over the substation line to the central office which is instrumental in causing the line-

finder LF to hunt for and establish a connection with the calling line, after which the line finder-first selector link becomes associated over the sender link SL with an idle sender. Upon the association of the sender with the substation a circuit is established from battery over brushes of the trunk finder TF and sender selector SS, conductor 900 and windings of relay 1000 to ground. Relay 1000 operates and closes an obvious operating circuit for relay 1002. Relay 1002

upon operating connects ground over its right contacts to off-normal ground conductor 1003, to provide locking ground for other relays of the sender and over its left contacts and conductor 1004 establishes the circuit of relay 901.

With ground connected to conductor 1003 a circuit is established therefrom over the left back contact of relay 1009, conductor 1010 to battery through the winding of progress relay 1106, whereupon relay 1106 operates and locks in a circuit from battery through its winding and the winding of progress relay 1107, over the outer left front contacts of relay 1106, and over the back contact of progress relay 1117 to ground on conductor 1003. Relay 1107 does not operate in this locking circuit since its winding is shunted as long as ground remains connected to conductor 1010. When relay 1106 operates a circuit is also established from ground on conductor 1003 over the back contact of relay 1117, the outer left contacts of relay 1106, conductor 1011 and to battery through the right normal contacts and winding of relay 1009. Relay 1009 thereupon operates, locks over its right alternate contacts to ground on conductor 1003 and at its back contact removes ground from conductor 1010, whereupon relay 1107 operates in the locking circuit of relay 1106; prepares operating circuits for relays 1100, 1101, 1102, 1104 and 1105 of the first code digit register A over conductors 1030, 1031, 1032, 1034 and 1035; and at its right contacts connects ground to conductor 1001 to shunt the right winding of relay 1000 whereby the current flowing over the operating circuit of relay 1001 is increased as a signal to the line finder-selector link.

Relay 901, upon operating, connects the winding of battery feed relay 902 to the calling line substation over a circuit which may be traced from battery through the left winding of relay 902, the left contacts of relay 901, brush 903 of sender selector SS, brush 904 of the trunk finder TF, contact of sequence switch cam 905, brush 906 of line finder LF, the ring conductor of the calling line, switchhook contacts 907, the back contact of the off-normal switch assembly 9, through the transmitter 908, the left winding of repeating coil 909, the tip conductor of the calling line, brush 910 of the line finder LF, contacts of sequence switch cam 911, brush 912 of trunk finder TF, brush 913 of sender selector SS, the ring contacts of relay 901, the right winding of relay 902 and the normal contacts of relay 914 to ground through the secondary winding of the dial tone coil 915. Relay 902 operates over this

circuit and dialing tone is applied thereover to apprise the calling subscriber that he may proceed to key up the digits of the desired telephone number. Relay 902, upon operating, establishes an obvious circuit for relay 916 which also operates to prepare an operating circuit for relay 914 and relay 902 establishes a circuit from ground over its left contacts, conductor 917, over the upper normal contacts and through the winding of relay 1005, and through resistance 1007 to battery and, in parallel therewith, through the winding of relay 1006 and resistance 1008 to battery. Relay 1005 operates and locks over its upper alternate contacts to ground on conductor 1003, but the winding of relay 1006 being shunted so long as ground is applied to conductor 917, does not operate. The closure of the lower front contact 1005 is without function at this time.

In response to the reception of dial tone, the calling subscriber proceeds to key up the digits of the wanted line number which number, it will be assumed is CH3-1067. When the key K2, which in addition to the digit value 2 has the letter designations ABC, is depressed to transmit signal impulses for the first code letter C, the off-normal switch assembly 9 is momentarily operated and then released during the down-stroke of the key and in the interval that the movable contact of such switch assembly is in engagement with the front contact thereof, the suppression switch assembly 10C is momentarily operated. Again when the depressed key is released, the off-normal switch assembly 9 is momentarily operated and released and during the interval that the movable contact of such assembly is in engagement with the front contact thereof, the suppression switch assembly 10C is again momentarily operated for a purpose to be later described.

The movement of the movable contact of the off-normal switch assembly 9 from its back or normal contact position disconnects the subset transmitter 908 from its bridged connection across the substation line and the engagement of the movable contact with the front contact, connects the harmonic generator 921 in series with the suppression coils 922 and 923 and condenser 918 across the line. There being no direct current bridge across the substation line at the substation so long as the movable contact of the off-normal switch assembly 9 is out of engagement with its back contact, relay 902 of the sender releases in turn opening the circuit of relay 916 and removing ground from conductor 917. Relay 916, however, being slow to release does not release during the interval that the movable contact of the off-normal switch assembly is disengaged from its back contact. With relay 902 released and relay 916 operated, an obvious circuit is established for relay 914 which operates and at its contacts disconnects the secondary winding of the dial tone coil 915 from the calling line loop to discontinue the application of dial tone current thereover and connects direct ground to the calling line loop. The removal of ground from conductor 917 removes the shunt from the winding of relay 1006 which now operates in a circuit from ground on conductor 1003 over the upper alternate contacts of relay 1005 through the winding of relay 1006 and resistance 1008 to battery.

With the movable contact of the off-normal switch assembly 9 in engagement with its front contact, a circuit is established from the source of alternating current 924 which, for example, may be of 100 cycles frequency, thence over the

circuit traced from the sender to the tip conductor of the calling line, through condenser 918, coils 923 and 922, the two windings of each of which coils are wound to be series opposing, through the coil of the harmonic generator 921, over the front contact of the off-normal switch assembly 9, over the switchhook contacts 907, over the ring conductor of the calling line and thence over the circuit previously traced to the source 924. The harmonic generator 921 is accordingly energized by current from the source 924 and functions to generate the harmonics of the base frequency (assumed to be 100 cycles) of the source 924. These generated harmonics thereupon travel back to the central office where they pass through the base frequency elimination filter 919, shielded transformer 920, through circuit X and thence through the primary windings of the input transformers associated with the receiving channels Fa, Fb, Fc and V.

Associated with each input transformer such as 1013, is a frequency receiving channel consisting of a secondary winding of such transformer, a series tuned circuit 1014, a single vacuum tube such as 1015 with a feedback through the copper-oxide units, such as 1016, and a relay, such as 1017. Initially the vacuum tube is biased nearly to cut-off. A small received signal is amplified and fed back through the condenser 1018 and the copper-oxide units 1016 to charge up the condenser 1019. This condenser is poled to reduce the negative bias on the grid of the tube 1015 with the result that the gain of the tube is increased and the amount of voltage on the grid is increased further. The final result is that a relatively small signal is sufficient to produce a sharp rise in plate current through the winding of relay 1017. The sensitivity of each individual channel is adjusted by means of the variable resistance, such as 1020. This method of controlling the sensitivity by changing the alternating current feedback does not affect the tuning of the channel. From the foregoing it will be apparent that each relay such as 1017 of each channel will respond to a single frequency with a relatively high discrimination against the others.

In the present description, it will be assumed that the first channel Fa is tuned to the *a* frequency harmonic generated by the coil 921 of 700 cycles; the second channel Fb is tuned to the *b* frequency harmonic of 1100 cycles and the third channel Fc is tuned to the *c* frequency harmonic of 1500 cycles. Since all harmonics of the base frequency are transmitted back over the line by the generator 921 before any one of the suppression switches has had time to function, the channels all initially respond and their associated channel relays 1017, 1023 and 1024 are all operated. With these channel relays all operated, a series circuit is established over their front contacts for relay 1026 which also operates.

When the key K2 was depressed for the first code letter C of the wanted line designation the suppression switch assembly 10C was operated during the downstroke of the key and after the off-normal switch assembly 9 was operated to connect the harmonic generator 921 and the suppression coils 922 and 923 to the calling line whereby condenser Cc was connected from the junction between the windings of the suppression coil 923 over the front contact of the switch 10C and over the front contact of switch 9 and the switchhook contacts 907 to the ring side of the line whereby the condenser Cc is effective to

suppress the frequency *c* of 1500 cycles, whereupon relay 1017 of the receiving channel *Fc* releases, relays 1023 and 1024, however, remaining operated. Relay 1017, upon releasing, opens at its front contact the circuit of relay 1026 which releases after an interval.

Relay 1017 upon releasing and before relay 1026 releases, establishes a circuit from ground over the contacts of relay 1026, the back contact of relay 1017, the middle right back contact of transfer relay 1021, through the winding of recording relay CD to battery. Relay CD, thereupon operates, locks over its inner left contacts to ground over the back contact of release relay 1022, and at its outer left contacts prepares a circuit for relay 1021. Upon the termination of the signaling period, when the off-normal switch assembly 9 reestablishes the direct current bridge at the substation through the subset transmitter, relay 902 reoperates to establish the circuit of relay 916 and to reconnect ground to conductor 917 whereupon such ground is extended over the upper front contact of relay 1006 to a point between the winding of relay 1005 and resistance 1007. Relay 1005 being now shunted releases. Relay 1006 is, however, maintained operated following the release of relay 1005 over a circuit from ground on conductor 917, over the upper normal contacts of relay 1005, through the winding of relay 1006 and resistance 1008 to battery. With relay 1005 released and relay 1006 operated, the circuit of relay 1021 is now completed from ground over the lower back contact of relay 1005, the inner lower front contact of relay 1006, the outer left contacts of relay CD to battery through the winding of relay 1021.

Relay 1021 now operates, locks over its inner right front contact to ground over the right back contact of relay 1022; at its back contacts, disconnects the windings of recording relays AD, BD and CD from the contacts of the channel relays 1023, 1024 and 1017, respectively; connects the windings of recording relays AU, BU and CU with the contacts of the channel relays all of which are at this time operated and at its outer right front contact prepares a circuit for relay 1022. When the off-normal switch assembly 9 restores to its normal position thus disconnecting the harmonic generator from the substation line, the frequencies *a*, *b* and *c* are no longer generated and transmitted to the receiving channels of the sender and channel relays 1023, 1024 and 1017 thereupon all release, but relay 1026 being now released, the channel relays are ineffective to establish circuits for the recording relays.

During the return or up-stroke movement of the operated key K2, the off-normal spring assembly 9 is again operated and released and during that interval, the suppression switch assembly 10C is again operated and released to again suppress the frequency *c*. During the interval that the direct current loop at the substation is interrupted by the off-normal switch assembly 9, relay 902 releases to remove ground from conductor 917 thereby releasing relay 1006. During this same interval, the harmonic generator 921 being connected across the calling line at the substation, the frequencies *a*, *b* and *c* generated thereby cause the response of the channel circuits *Fa*, *Fb* and *Fc* and the operation of the channel relays 1023, 1024 and 1017. With these relays all operated, relay 1026 again operates. In response to the momentary operation of the suppression switch assembly 10C, the frequency

c is suppressed resulting in the release of channel relay 1017 and the release of relay 1026. During the releasing time of relay 1026 and with transfer relay 1021 operated, a circuit is established from ground over the contacts of relay 1026, the back contact of relay 1017, the middle right front contact of relay 1021 to battery through the winding of recording relay CU. Relay CU, upon operating, locks over its left contacts to ground over the back contact of relay 1022.

When the off-normal switch assembly 9 again releases, relay 902 reoperates and causes the reoperation of relay 1005 over the circuit previously traced. With relay 1005 operated and relay 1006 unoperated, a circuit is established from ground over the lower front contact of relay 1005, the lower back contact of relay 1006, the right back contact of relay AD, the No. 2 right back contact of relay BD, the No. 2 right front contact of operated relay CD, the No. 2 right back contact of relay AU, the No. 3 right back contact of relay BU, the No. 5 right front contact of operated relay CU, conductor 1032, the No. 3 left contacts of progress relay 1107 to battery through the right winding of relay 1102 of the A code digit register. Relay 1102 thereupon operates and locks over its left winding and left contacts to ground on conductor 1003 and with the remaining relays 1101, 1104, 1105 and 1100 of the A register unoperated serves to register the first office code letter C. The removal of the harmonic generator from the calling line when the off-normal switch assembly is fully restored causes the release of all of the channel relays 1023, 1024 and 1017.

A circuit is also established upon the operation of relay 1005 from ground over its lower front contact, the lower back contact of relay 1006, over the outer right front contact of relay 1021 to battery through the winding of relay 1022 which operates after an interval sufficient to insure that the digit signals recorded by the operation of recording relays have been effective to cause the registration thereof in a digit register of the sender; at its back contact opens the locking circuit of the operated recording relays, in the case assumed relays CD and CU which thereupon release; opens the locking circuit of transfer relay 1021 which releases; and at its front contact establishes an obvious circuit for relay 1025. Relay 1025 operates, locks over its front contact to off-normal ground on conductor 1003, and at its left contacts prepares a circuit for operating the progress relay 1116. When relay 1021 releases, relay 1022 also releases.

When the subscriber depresses the key K4 for the second office code letter H, which has a numerical value of 4, the off-normal switch assembly 9 is operated momentarily to open the direct current loop at the substation and to connect the harmonic generator 921 to the substation line. During the interval that the switch is thus operated, the frequency suppression switch 10C is momentarily operated. With the generator connected to the line, all of the channel relays 1023, 1024 and 1017 operate, followed by the operation of relay 1026 and when the switch 10C is momentarily operated to suppress frequency *c* channel relay 1017 releases in turn causing the release of relay 1026. During the releasing time of relay 1026 and with transfer relay 1021 now released, a circuit is established from ground over the contacts of relay 1026, the back contact of relay 1017, the

middle right back contact of relay 1021 to battery through the winding of recording relay CD. Relay CD upon operating locks under the control of relay 1022 and prepares the circuit of relay 1021 as previously described. When the line loop is opened at the substation by the off-normal switch assembly, relay 902 releases and by removing ground from conductor 917, permits relay 1006 to operate in the manner previously described. With relays 1005 and 1006 now both operated and relay 1025 operated, a circuit is established from ground over the lower front contact of relay 1005, the lower front contact of relay 1006, the left contacts of relay 1025, conductor 1012, the right front contact of progress relay 1106 to battery through the winding of progress relay 1116. Relay 1116 operates and locks through its winding and the winding of progress relay 1117 over the left contacts of relay 1116 and the back contact of progress relay 1127 to ground on conductor 1003. Relay 1117 being shunted so long as ground remains connected to conductor 1012 does not operate.

When the off-normal switch assembly 9 is restored, the transmission of harmonic frequencies by generator 921 ceases and all of the operated channel relays 1023, 1024 and 1017 release and the direct current loop is reestablished at the substation resulting in the reoperation of relay 902 and the reconnection of ground to conductor 917. As before described, relay 1006 is now held operated to this ground and relay 1005 is shunted and releases. With relay 1005 released and relay 1006 operated, the circuit of transfer relay 1021 previously prepared through the operation of recording relay CD is completed and relay 1021 operates and locks as previously described under the control of relay 1022. Relay 1005, upon releasing, also removes ground from conductor 1012 whereupon progress relay 1117 operates in the locking circuit of relay 1116; connects the windings of the relays of the B code digit register to conductors 1031, 1032, 1034, 1035 and 1030, extending to contacts of the recording relays, and at its back contact opens the locking circuit of relays 1106 and 1107 which now release since their operating circuit was opened upon the previous operation of relay 1009.

Upon the up-stroke of the depressed key K4, the off-normal switch assembly 9 is again momentarily operated to open the direct current loop at the substation and to connect the harmonic generator 921 to the substation line. With the generator reconnected to the line, the receiving channels of the sender all respond to the generated frequencies a , b and c resulting in the reoperation of channel relays 1023, 1024 and 1017 and the reoperation of relay 1026. With the direct current loop open at the substation, relay 902 releases removing ground from conductor 917 whereupon relay 1006 releases as previously described. During the interval that the off-normal switch is thus operated, the frequency suppression switch assembly 10B is momentarily operated and connects the condenser Cb from the junction point of the winding of suppression coil 922 over the front contact of switch 10B and the back contact of switch 10A to the ring side of the line to suppress the frequency b whereupon the channel relay 1024 releases followed by the release of relay 1026. With transfer relay 1021 now operated, a circuit is established during the releasing time of relay 1026 from ground over its contacts, the back contact of relay 1024, the inner left front contact of relay 1021 to bat-

tery through the winding of recording relay BU. Relay BU upon operating locks over its left contacts under the control of relay 1022.

When the off-normal switch assembly 9 is again restored, the harmonic generator 921 is disconnected from the substation line resulting in the release of all of the channel relays 1023, 1024 and 1017 and the direct current loop is reestablished at the substation, resulting in the reoperation of relay 902, followed by the reoperation of relay 1005 as previously described. With relay 1005 operated, and relay 1006 unoperated, a circuit is established from ground over the lower front contact of relay 1005, the lower back contact of relay 1006, the right back contact of relay AD, the No. 2 back contact of relay BD, the No. 2 right front contact of relay CD, the No. 2 right back contact of relay AU, the No. 3 right front contact of relay BU, the No. 4 right back contact of relay CU, conductor 1034, over the No. 4 left contacts of relay 1117 through the right winding of relay 1114 of the office code register B to battery. Relay 1114, upon operating locks over its left winding and left contacts to ground on conductor 1003 and with the remaining relays of the B register unoperated, serves to register the second office code letter H.

The operation of relay 1005 with relay 1006 unoperated, also establishes the previously traced circuit of relay 1022 which operates after an interval to cause the release of the operated recording relays CD and BU and the release of the transfer relay 1021. When relay 1021 releases, relay 1022 also releases.

When the subscriber depresses the key K3 for the third office code digit 3, the off-normal switch assembly is operated momentarily to open the direct current loop at the substation and connects the harmonic generator 921 to the substation line. During the interval that the switch is thus operated, the frequency suppression switch 10B is momentarily operated. With the generator connected to the line, all of the channel relays 1023, 1024 and 1017 operate followed by the operation of relay 1026 and when the switch 10B is momentarily operated to suppress the frequency b , channel relay 1024 releases in turn causing the release of relay 1026. During the releasing time of relay 1026 and with transfer relay 1021 now released, a circuit is established from ground over the contacts of relay 1026, the back contact of relay 1024, the inner left back contact of relay 1021 to battery through the winding of the recording relay BD. Relay BD, upon operating, locks under the control of relay 1022 and prepares a circuit for relay 1021 as previously described. When the line loop is opened at the substation by the off-normal switch assembly 9, relay 902 releases and by removing ground from conductor 917, permits relay 1006 to operate in the manner previously described. With relays 1005 and 1006 now both operated, and relay 1025 operated, a circuit is established from ground over the lower front contact of relay 1005, the lower front contact of relay 1006, the left contacts of relay 1025, conductor 1012, right back contact of relay 1106, right front contact of relay 1116, to battery through the winding of progress relay 1126. Relay 1126 operates and locks through its winding and the winding of progress relay 1127 over the left contacts of relay 1126 and to ground on conductor 1003, over the back contact of the progress relay (not shown) associated with the thousands digit register and corresponding to progress relay 1127.

Relay 1127 being shunted does not operate so long as ground remains connected to conductor 1012.

When the off-normal switch assembly 9 is restored, the transmission of harmonic frequencies by the generator 921 ceases and all of the operated channel relays 1023, 1024 and 1017 release and the direct current loop is reestablished at the substation resulting in the reoperation of relay 902 and the reconnection of ground to conductor 917. As before described, relay 1006 is now held operated to this ground and relay 1005 is shunted and releases. With relay 1005 released and relay 1006 operated, the circuit of transfer relay 1021 previously prepared by the operation of the recording relay BD, is completed and relay 1021 operates and locks as previously described under the control of relay 1022. Relay 1005, upon releasing, also disconnects ground from conductor 1012 whereupon progress relay 1127 operates in the locking circuit of relay 1126; connects the windings of the relays of the C code digit register to conductors 1031, 1032, 1034, 1035 and 1030, extending to contacts of the recording relays and at its right back contact opens the locking circuit of progress relays 1116 and 1117 which now release since their operating circuit was opened upon the removal of ground from conductor 1012.

Upon the up-stroke of the depressed key K3, the off-normal switch assembly 9 is again momentarily operated to open the direct current loop at the substation and to connect the harmonic generator 921 to the substation line. When the generator is reconnected to the line, the receiving channels of the sender all respond to the generated frequencies *a*, *b* and *c* resulting in the reoperation of channel relays 1023, 1024 and 1017 and the reoperation of relay 1026. With the direct current loop open at the substation, relay 902 releases removing ground from ground conductor 917 whereupon relay 1006 releases as previously described. During the interval that the off-normal switch is thus operated, the frequency suppression switch assembly 10B is momentarily operated to suppress the frequency *b* whereupon the channel relay 1024 releases, followed by the release of relay 1026. With transfer relay 1021 now operated, a circuit is established during the releasing time of relay 1026 as previously described through the winding of recording relay BU. Relay BU, upon operating, locks over its left contacts under the control of relay 1022.

When the off-normal switch assembly 9 is again restored, the harmonic generator 921 is disconnected from the substation line resulting in the release of all of the channel relays 1023, 1024 and 1017 and the direct current loop is established at the substation resulting in the reoperation of relay 902 followed by the reoperation of relay 1005 as previously described. With relay 1005 operated and relay 1006 unoperated a circuit is established from ground over the lower front contact of relay 1005, the lower back contact of relay 1006, the right back contact of relay AD, the No. 3 right front contact of relay BD, the No. 3 right back contact of relay CD, the No. 3 right back contact of relay AU, the No. 5 right front contact of relay BU, the No. 6 right back contact of relay CU, conductor 1031, the No. 2 left contacts of progress relay 1127, to battery through the right winding of relay 1121 of the code digit register C. A second circuit is established from ground applied over the right back

contact of relay AD, the No. 4 right front contact of relay BD, the No. 4 right back contact of relay CD, the No. 7 right front contact of relay BU, the No. 5 right back contact of relay CU, conductor 1032, the No. 3 left contacts of progress relay 1127 to battery through the right winding of relay 1122 of the C code digit register. Relays 1121 and 1122, upon operating, lock over their left windings and left contacts to ground on conductor 1003 and with the other relays of the C code digit register unoperated, serve to register the third office code digit 3.

The operation of relay 1005 with relay 1006 unoperated, also establishes the previously traced circuit of relay 1022 which operates after an interval to cause the release of the operated recording relays BD and BU and the release of transfer relay 1021 followed by the release of relay 1022.

In a similar manner in response to the keying of the thousands numerical digit 1, the frequency *a* is suppressed once in response to the operation of the switch assembly 10A upon the depression of the key K1 and again upon the release of such key, resulting in the operation of recording relays AD and AU. In response to the keying of the hundreds digit 0, the frequency *c* is suppressed upon the depression of the key K10 through the operation of the switch assembly 10C and the frequencies *a* and *c* are both simultaneously suppressed upon the release of the depressed key through the operation of the switch assemblies 10A and 10C resulting in the operation of recording relays CD, AU and CU. In response to the keying of the tens digit 6, the frequency *c* is suppressed upon the depression of the keys K6 through the operation of the switch assembly 10C and the frequency *a* is suppressed upon the release of the depressed key upon the operation of the switch assembly 10A resulting in the operation of the recording relays CD and AU and in response to the keying of the units digit 7, the frequency *b* is suppressed upon the suppression of the key K7 through the operation of the switch assembly 10B and the frequency *a* is suppressed upon the release of the depressed key through the operation of the switch assembly 10A. It is to be noted that when switch 10A operates it connects the mid-point between the windings of coil 922 through condenser Ca to the ring side of the line and renders switch 10B ineffective.

With recording relays AD and AU operated in response to the keying of the thousands digit 1, then when ground is applied to the right armature of relay AD, a circuit is established over the right front contact of relay AD, the No. 1 right back contact of relay BD, the No. 1 right back contact of relay CD, the No. 1 right front contact of relay AU, the No. 2 right back contact of relay BU, the No. 6 right back contact of relay BU to conductor 1031 and thence over the No. 2 left contacts of an operated progress relay, similar to relay 1107 but associated with the thousands digit register, to battery through the winding of a relay of that register, corresponding to relay 1101, whereby such relay operates and locks and with the other relays of such register unoperated, registers the thousands digit 1.

With recording relays CD, AU and CU operated, in response to the keying of the hundreds digit 0, then when ground is applied to the right armature of relay AD, a circuit is established over the right back contact of relay AD, the No. 2 right back contact of relay BD, the No. 5 right

front contact of relay CD, the No. 5 right front contact of relay AU, the No. 4 right back contact of relay BU, the No. 3 right front contact of relay CU to conductor 1030 and thence over the No. 1 left contacts of an operated progress relay, similar to relay 1107 but associated with the hundreds digit register, to battery through a winding of a relay of that register corresponding to relay 1100, whereupon such relay operates and locks to register the hundreds digit 0.

With recording relays CD and AU operated, in response to the keying of the tens digit 6, then when ground is applied to the right armature of relay AD, a first circuit is completed over the right back contact of relay AD, the No. 2 right back contact of relay BD, the No. 2 right front contact of relay CD, the No. 2 right front contact of relay AU, the No. 2 right back contact of relay BU, the No. 6 right back contact of relay CU, conductor 1031 and thence over the No. 2 left contacts of an operated progress relay, similar to relay 1107 but associated with the tens digit register, to battery through the winding of a relay of such register corresponding to relay 1101, whereupon such relay operates and locks. A circuit is also established from ground applied over the right back contact of relay AD, the No. 2 right back contact of relay BD, the No. 5 right front contact of relay AU, the No. 4 right back contact of relay BU, the No. 1 right back contact of relay CU, conductor 1035 and thence over the No. 5 left contacts of an operated progress relay, similar to relay 1107 but associated with the tens digit register, to battery through the winding of a relay of that register corresponding to relay 1105, which thereupon operates and locks. With these two register relays operated, and the other relays of the tens digit register unoperated, the tens digit 6 is registered.

With recording relays BD and AU operated, in response to the keying of the units digit 7, then when ground is applied to the right armature of relay AD, a first circuit is completed over the right back contact of relay AD, the No. 4 right front contact of relay BD, the No. 4 right back contact of relay CD, the No. 4 right front contact of relay AU, the No. 6 right back contact of relay BU, the No. 5 right back contact of relay CU, over conductor 1032 and thence over the No. 3 left contacts of the operated progress relay 1167 to battery through the right winding of relay 1162 of the units digit register U. A second circuit is also completed over the right back contact of relay AD, the No. 3 right front contact of relay BD, the No. 3 right back contact of relay CD, the No. 3 right front contact of relay AU, the No. 4 right back contact of relay BU, the No. 1 right back contact of relay CU, over conductor 1035 and thence over the No. 5 left contacts of relay 1167 to battery through the right winding of relay 1165 of the units digit register U. Relays 1162 and 1165, upon operating, lock over their left windings and left contacts to ground on conductor 1003 and with the other relays of this register unoperated, serve to register the units digit 7.

All of the digits of the wanted line number keyed by the subscriber are now registered in the sender and the sender may proceed to control selector switches to extend a connection over the district selector S and other selectors (not shown) in accordance therewith after which the sender link SL is released to release the sender to make it available for other calls.

In the preceding discussion, the keying and reg-

istration of letters or digits having the digit values 1, 2, 3, 4, 6, 7 and 0 have been discussed. If the digit 5 is keyed by the operation of key K5, then upon the depression of the key, switch assembly 10A is operated to suppress the frequency *a* and upon the release of the depressed key, the switch assembly 10C is operated to suppress the frequency *c* resulting in the operation of the recording relays AD and CU. With these relays operated, then when ground is applied to the right armature of relay AD, a circuit is completed over the right front contact of relay AD, the No. 1 right back contact of relay BD, the No. 1 right back contact of relay CD, the No. 1 right back contact of relay AU, the No. 1 right back contact of relay BU, the No. 1 right front contact of relay CU to conductor 1035 to cause the operation of the relay of a register, such as relay 1105 of the first code digit register A.

If the digit 8 is keyed by the operation of key K8, then upon the depression of the key, the switch assembly 10C is operated to suppress the frequency *c* and upon the release of the depressed key, the switch assemblies 10B and 10C are operated to suppress the frequencies *b* and *c* resulting in the operation of recording relays CD, BU and CU. With these relays operated, then when ground is applied to the right armature of relay AD, a first circuit is completed over the right back contact of relay AD, the No. 2 right back contact of relay BD, the No. 2 right front contact of relay CD, the No. 2 right back contact of relay AU, the No. 3 right front contact of relay BU, the No. 6 right front contact for relay CU, to conductor 1031. A second circuit is completed over the right back contact of relay AD, the No. 2 right back contact of relay BD, the No. 5 right front contact of relay CD, the No. 5 right back contact of relay AU, the No. 6 right front contact of relay BU and the No. 5 right front contact of relay CU to conductor 1032 and a third circuit is established over the right front contact of relay AD, the No. 2 right back contact of relay BD, the No. 2 right front contact of relay CD, the No. 2 right back contact of relay AU, the No. 3 right front contact of relay BU and the No. 2 right front contact of relay CU to conductor 1035. With ground applied to conductors 1031, 1032 and 1035, relays of a digit register, such as relays 1101, 1102 and 1105 of the first code digit register A, are operated to register the digit 8.

If the digit 9 is keyed by the operation of key K9, then upon the depression of the key, the switch assembly 10B is operated to suppress the frequency *b* and upon the release of the depressed key, the switch assembly 10C is operated to suppress the frequency *c*, resulting in the operation of recording relays BD and CU. With these relays operated, then when ground is supplied to the armature of relay AD, a first circuit is completed over the right back contact of relay AD, the No. 3 right front contact of relay BD, the No. 3 right back contact of relay CD, the No. 3 right back contact of relay AU, the No. 5 right back contact of relay BU and the No. 4 right front contact of relay CU to conductor 1034 and a second circuit is established from ground over the right back contact of relay AD, the No. 4 right front contact of relay BD, the No. 4 right back contact of relay CD, the No. 4 right back contact of relay AU, the No. 7 right back contact of relay BU and the No. 7 right front contact of relay CU to conductor 1035. With ground applied to conductors 1034 and 1035, relays of a digit register, such as relays 1104 and 1105 of the first code

digit register A, are operated to register the digit 9.

What is claimed is:

1. The combination in a signaling system of a line having a station thereon, a source of alternating current of a base frequency at the central office, means for connecting said source to said line to supply current thereto, a harmonic generator at said station responsive to current from said source to generate harmonics of the base frequency in said line, means at the central office selectively responsive to the harmonics generated at said station, a plurality of keys at said station each having a down and an up-stroke and means controlled by said keys for selectively suppressing one of said generated harmonics during the down-stroke of a key and for selectively suppressing one or more of said generated harmonics during the up-stroke of the operated key.

2. The combination in a signaling system of a line having a station thereon, a source of alternating current of a base frequency at the central office, means for connecting said source to said line to supply current thereto, a harmonic generator at said station responsive to current from said source to generate harmonics of the base frequency in said line, means at the central office selectively responsive to the harmonics generated at said station, a plurality of keys at said station each having a down and an up-stroke and means controlled by said keys for selectively suppressing one of said generated harmonics during the down-stroke of a key and for selectively suppressing one or two of said generated harmonics during the up-stroke of the operated key.

3. The combination in a signaling system of a line having a station thereon, a source of alternating current of a base frequency at the central office, means for connecting said source to said line to supply current thereto, a harmonic generator at said station responsive to current from said source to generate harmonics of the base frequency in said line, means at the central office selectively responsive to the harmonics generated at said station, a plurality of keys at said station each having a down and an up-stroke, a timing switch momentarily operable once during the down-stroke of any operated key and again during the up-stroke of such operated key, means controlled by said switch for connecting said harmonic generator to said line for a timed interval and means controlled by said keys for selectively suppressing one of said generated harmonics during the operation of said switch in response to the down-stroke of an operated key and for selectively suppressing one or more of said generated harmonics during the operation of said switch in response to the up-stroke of an operated key.

4. The combination in a signaling system of a line having a station thereon, a source of alternating current of a base frequency at the central office, means for connecting said source to said line to supply current thereto, a harmonic generator at said station responsive to current from said source to generate harmonics of the base frequency in said line, means at the central office selectively responsive to the harmonics generated at said station, a tuning circuit at said station including a variable reactance associated with said generator, a plurality of keys at said station having a down and an up-stroke and means controlled by said keys for including variable amounts of said reactance in circuit with said generator for selectively suppressing one of

said generated harmonics during the down-stroke of a key and for including variable amounts of said reactance in circuit with said generator for selectively suppressing one or more of said generated harmonics during the up-stroke of the operated key.

5. The combination in a signaling system of a line having a station thereon, a source of alternating current of a base frequency at the central office, means for connecting said source to said line to supply current thereto, a harmonic generator at said station responsive to current from said source to generate harmonics of the base frequency in said line, means at the central office selectively responsive to the harmonics generated at said station, a tuning circuit at said station including a variable reactance associated with said generator, a plurality of keys at said station having a down and an up-stroke and a plurality of switch elements controlled by said keys for including variable amounts of said reactance in circuit with said generator for selectively suppressing one of said generated harmonics during the down-stroke of a key and for including variable amounts of said reactance in circuit with said generator for selectively suppressing one or more of said generated harmonics during the up-stroke of the operated key.

6. The combination in a signaling system of a line having a station thereon, a source of alternating current of a base frequency at the central office, means for connecting said source to said line to supply current thereto, a harmonic generator at said station responsive to current from said source to generate harmonics of the base frequency in said line, means at the central office selectively responsive to the harmonics generated at said station, a tuning circuit at said station including a variable reactance associated with said generator, a plurality of keys at said station each having a down and an up-stroke and a plurality of switch elements controlled by said keys for including variable amounts of said reactance in circuit with said generator for selectively suppressing one of said generated harmonics during the down-stroke of a key and for including variable amounts of said reactance in circuit with said generator for selectively suppressing one or more of said generated harmonics during the up-stroke of the operated key, two of said switch elements being connected in series relation whereby if both of them are simultaneously operated by the erroneous operation of two keys the circuit closure of one of said two switches is nullified.

7. The combination in a signaling system of a line having a station thereon, a source of alternating current of a base frequency at the central office, means for connecting said source to said line to supply current thereto, a harmonic generator at said station responsive to current from said source to generate harmonics of the base frequency in said line, means at the central office selectively responsive to the harmonics generated at said station, a tuning circuit at said station including a variable reactance associated with said generator, a plurality of keys at said station each having a down and an up-stroke and a plurality of timed switch elements controllable by said keys for including variable amounts of said reactance in circuit with said generator for selectively suppressing one of said generated harmonics for a timed interval during the down-stroke of a key and for including variable amounts of said reactance in circuit with said generator

for selectively suppressing one or more of said generated harmonics for a timed interval during the up-stroke of the operated key.

8. The combination in a signaling system of a line having a station thereon, a source of alternating current of a base frequency at the central office, means for connecting said source to said line to supply current thereto, a harmonic generator at said station responsive to current from said source to generate harmonics of the base frequency in said line, means at the central office selectively responsive to the harmonics generated at said station, a tuning circuit at said station including a variable reactance associated with said generator, a plurality of keys at said station each having a down and an up-stroke, a timing switch momentarily operable during the down-stroke of an operated key and again during the up-stroke of such operated key for associating said generator and tuning circuit with said line and a plurality of timed switch elements controlled by said keys for including variable amounts of said reactance in circuit with said generator for selectively suppressing one of said generated harmonics for a timed interval during the down-stroke of a key and for including variable amounts of said reactance in circuit with said generator for selectively suppressing one or more of said generated harmonics for a timed interval during the up-stroke of the operated key.

9. The combination in a signaling system of a line having a station thereon, a source of alternating current of a base frequency at the central office, means for connecting said source to said line to supply current thereto, a harmonic generator at said station responsive to current from said source to generate harmonics of the base frequency in said line, means at the central office selectively responsive to the harmonics generated at said station, a tuning circuit at said station including a variable reactance associated with said generator, a plurality of keys at said station each having a down and an up-stroke, a plurality of switch elements for including variable amounts of said reactance in circuit with said generator and selectively operable to suppress different generated harmonics, a pair of bars associated with each of said switch elements, means controlled by the operation of the first bar of any pair for operating the associated switch element, means controlled by the release of the second bar of any pair when operated for operating the associated switch element and means controlled by said keys for selectively operating and then releasing said bars to cause the selective operation of said switch elements whereby one of said generated harmonics is suppressed during the down-stroke of a key and one or more of said harmonics is or are suppressed during the up-stroke of the operated key.

10. The combination in a signaling system of a line having a station thereon, a source of alternating current of a base frequency at the central office, means for connecting said source to said line to supply current thereto, a harmonic generator at said station responsive to current from said source to generate harmonics of the base frequency in said line, means at the central office selectively responsive to the harmonics generated at said station, a tuning circuit at said station including a variable reactance associated with said generator, a plurality of keys at said station each having a down and an up-stroke, a plurality of switch elements for including variable amounts of said reactance in circuit with said generator

and selectively operable to suppress different generated harmonics, a pair of bars associated with each of said switch elements, a cam member connected to the first bar of each pair for momentarily operating the associated switch element only upon the operation of said bar, a cam member connected to the second bar of each pair for momentarily operating the associated switch element only upon the release of such bar and means controlled by said keys for selectively operating and then releasing said bars to cause the selective operation of said switch elements whereby one of said generated harmonics is suppressed during the down-stroke of a key and one or more of said harmonics is or are suppressed during the up-stroke of the operated key.

11. The combination in a telephone system of a line having a station thereon, a source of alternating current of a base frequency at the central office, means for connecting said source to said line to supply current thereto, a harmonic generator at said station responsive to current from said source to generate harmonics of the base frequency in said line, means at the central office responsive respectively to the harmonics generated at the station, a plurality of keys at said station each having a down and an up-stroke, means controllable by said keys for selectively suppressing one of said generated harmonics during the down-stroke of a key and for selectively suppressing one or more of said generated harmonics during the up-stroke of the operated key, two groups of recording relays at the central office, each group comprising as many relays as there are harmonic responsive means and means controlled over said line for rendering a relay of the first group responsive to said responsive means upon the suppression of one of said harmonics during the down-stroke of an operated key and for thereafter rendering one or more relays of the second group of relays responsive to said responsive means upon the suppression of one or more of said harmonics during the up-stroke of an operated key.

12. The combination in a telephone system of a line having a station thereon, a source of alternating current of a base frequency at the central office, means for connecting said source to said line to supply current thereto, a harmonic generator at said station responsive to current from said source to generate harmonics of the base frequency in said line, means at the central office responsive respectively to the harmonics generated at said station, a plurality of keys at said station each having a down and an up-stroke, means controllable by said keys for selectively suppressing one of said generated harmonics during the down-stroke of a key and for selectively suppressing one or more of said generated harmonics during the up-stroke of the operated key, two groups of recording relays at the central office, each group comprising as many relays as there are harmonic responsive means, means controlled over said line for rendering a relay of the first group responsive to said responsive means upon the suppression of one of said harmonics during the down-stroke of an operated key and for thereafter rendering one or more relays of the second group responsive to said responsive means upon the suppression of one or more of said harmonics during the up-stroke of an operated key, a plurality of registers and means for successively setting said registers in accordance with successive joint settings of said groups of recording relays.

13. In a telephone system, a calling line, a central office, means for extending a connection from said line to said office, means at the substation of said line for generating current of a plurality of different voice frequencies, means for transmitting over said line two impulses of selected voice frequencies in accordance with any of ten digit values, means at said central office responsive respectively to said different voice frequencies, two groups of recording relays, each group comprising as many relays as there are frequency responsive means, a transfer relay for associating either of said groups of relays with said responsive means and means controlled over said line for controlling said transfer relay for rendering one of said groups of relays responsive to said responsive means to register the first impulse of a transmitted digit signal and for thereafter rendering the other of said groups of relays responsive to said responsive means to register the other impulse of the same digit signal.

14. In a telephone system, a calling line, a central office, means for extending a connection from said line to said office, means at the substation of said line for generating current of a plurality of different voice frequencies, means for transmitting over said line two impulses of selected voice frequencies in accordance with any of ten digit values, means at said central office respon-

sive respectively to said different voice frequencies, two groups of recording relays, each group comprising as many relays as there are frequency responsive means, a first and a second counting relay, means controlled over said line for operating said first counting relay prior to the transmission of the first impulse of each digit signal, for operating said second counting relay during the transmission of said first impulse, for releasing the first counting relay prior to the transmission of the second impulse of each digit signal and for releasing said second counting relay during the transmission of said second impulse, a transfer relay for associating either of said groups of recording relays with said responsive means, an operating circuit for said transfer relay effective upon the release of said first counting relay while said second counting relay is still operated and means for releasing said transfer relay effective upon the subsequent release of said second counting relay and the reoperation of said first counting relay, whereby one of said groups of relays is rendered responsive to said responsive means to register the first impulse of a transmitted digit signal and the other of said groups of relays is thereafter rendered responsive to said responsive means to register the other impulse of the same digit signal.

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