July 9, 1946. H. M. BASCOM ET AL 2,403,475

TELEPHONE SYSTEM

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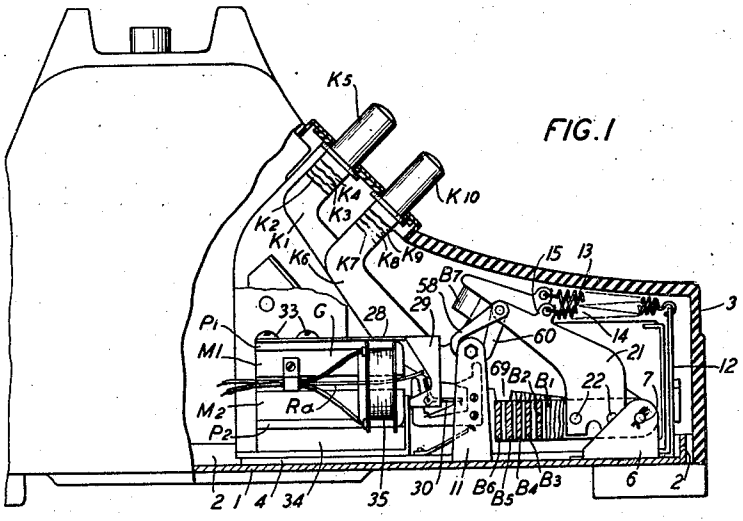


FIG. 1

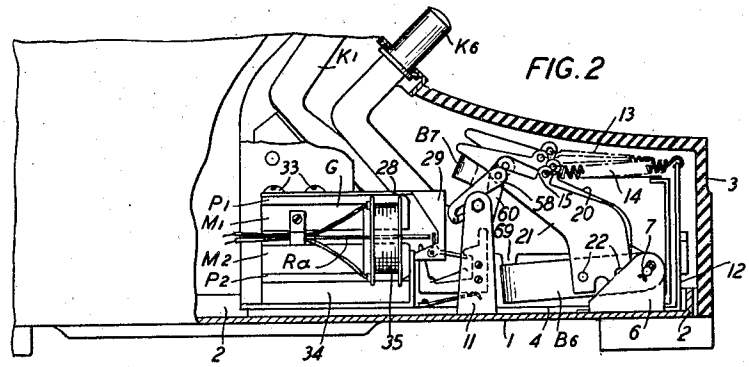


FIG. 2

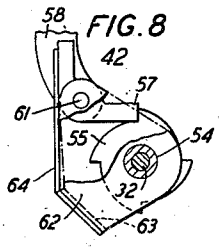


FIG. 8

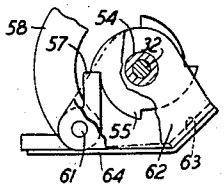


FIG. 9

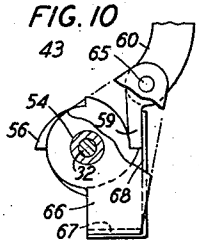


FIG. 10

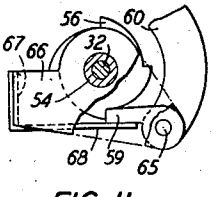


FIG. 11

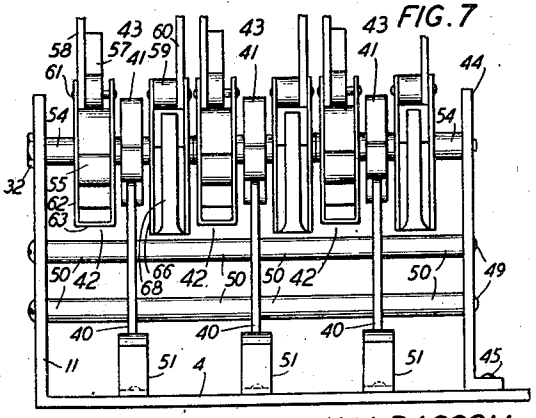


FIG. 7

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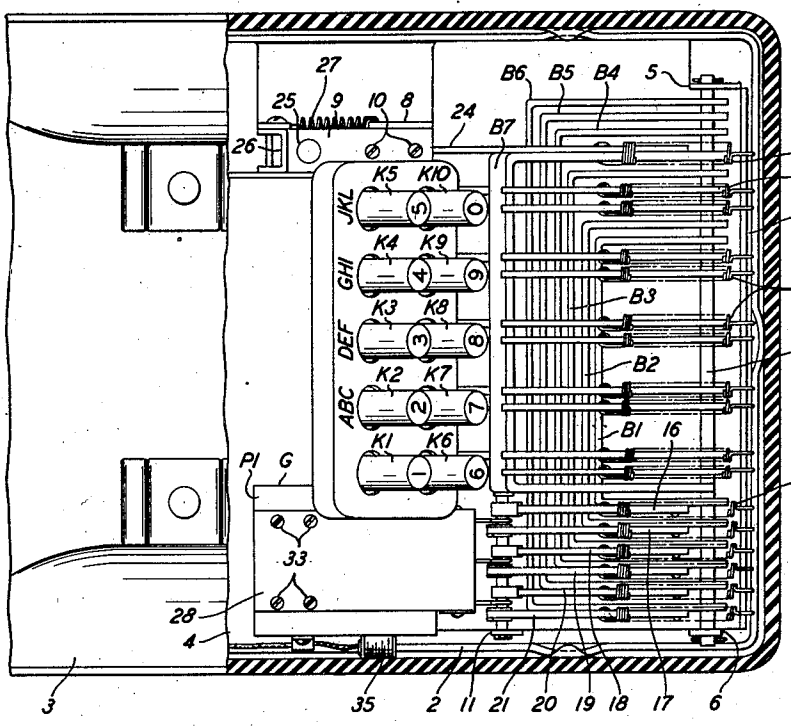


FIG. 3.

FIG. 4.

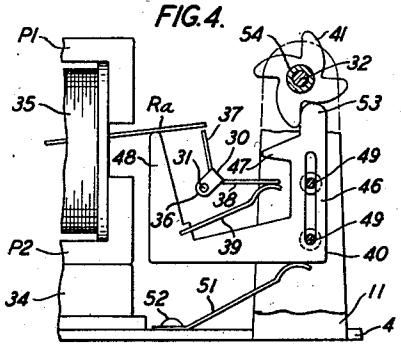
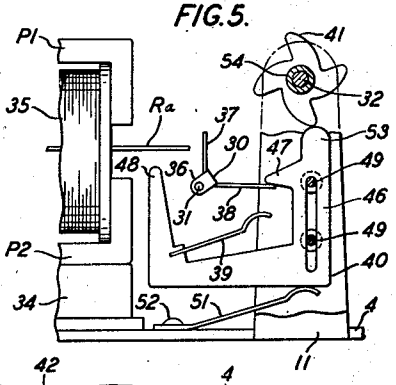


FIG. 5.



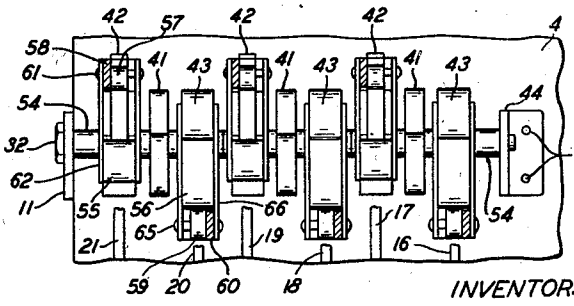


FIG. 6.

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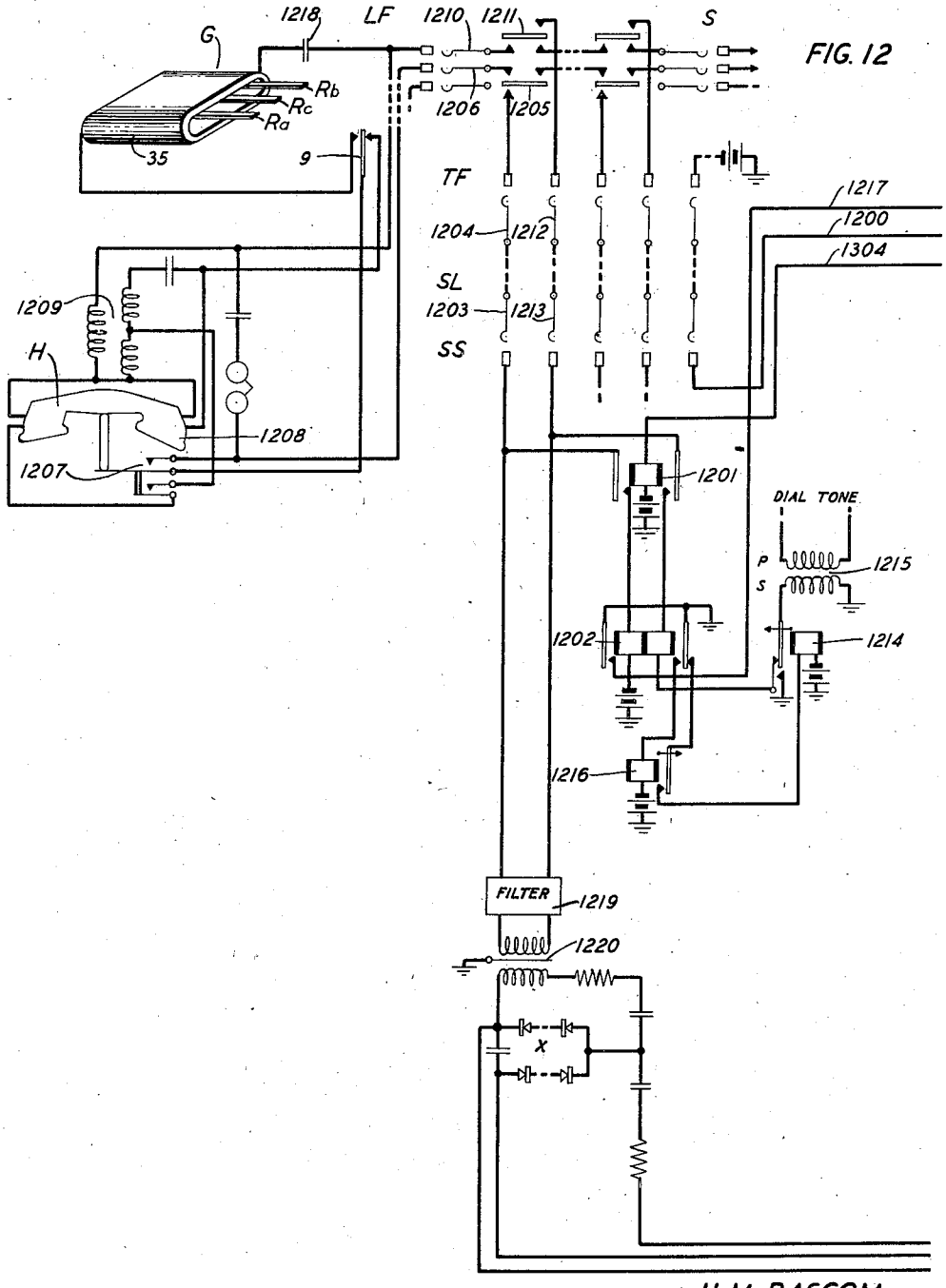


FIG. 12

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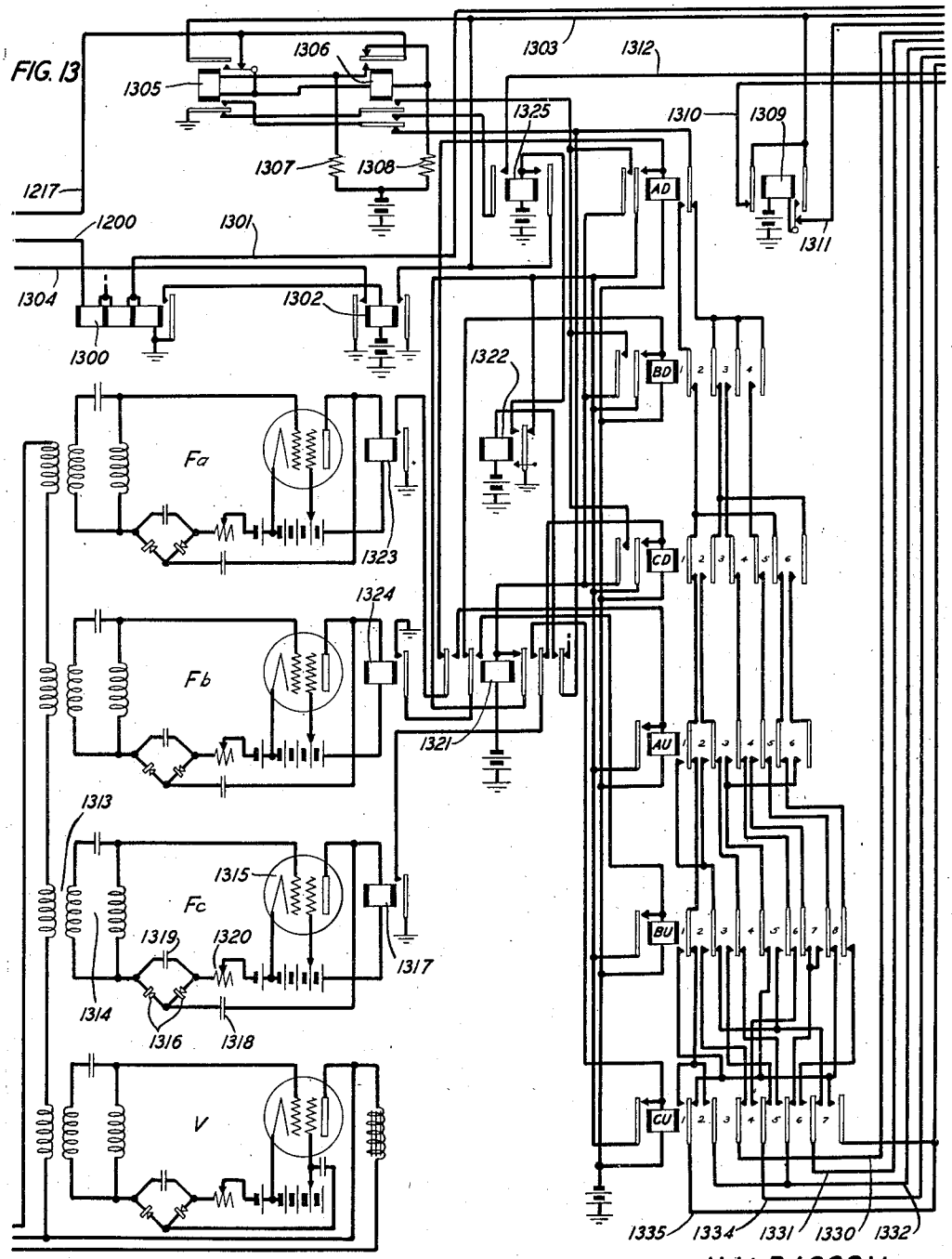
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FIG. 13



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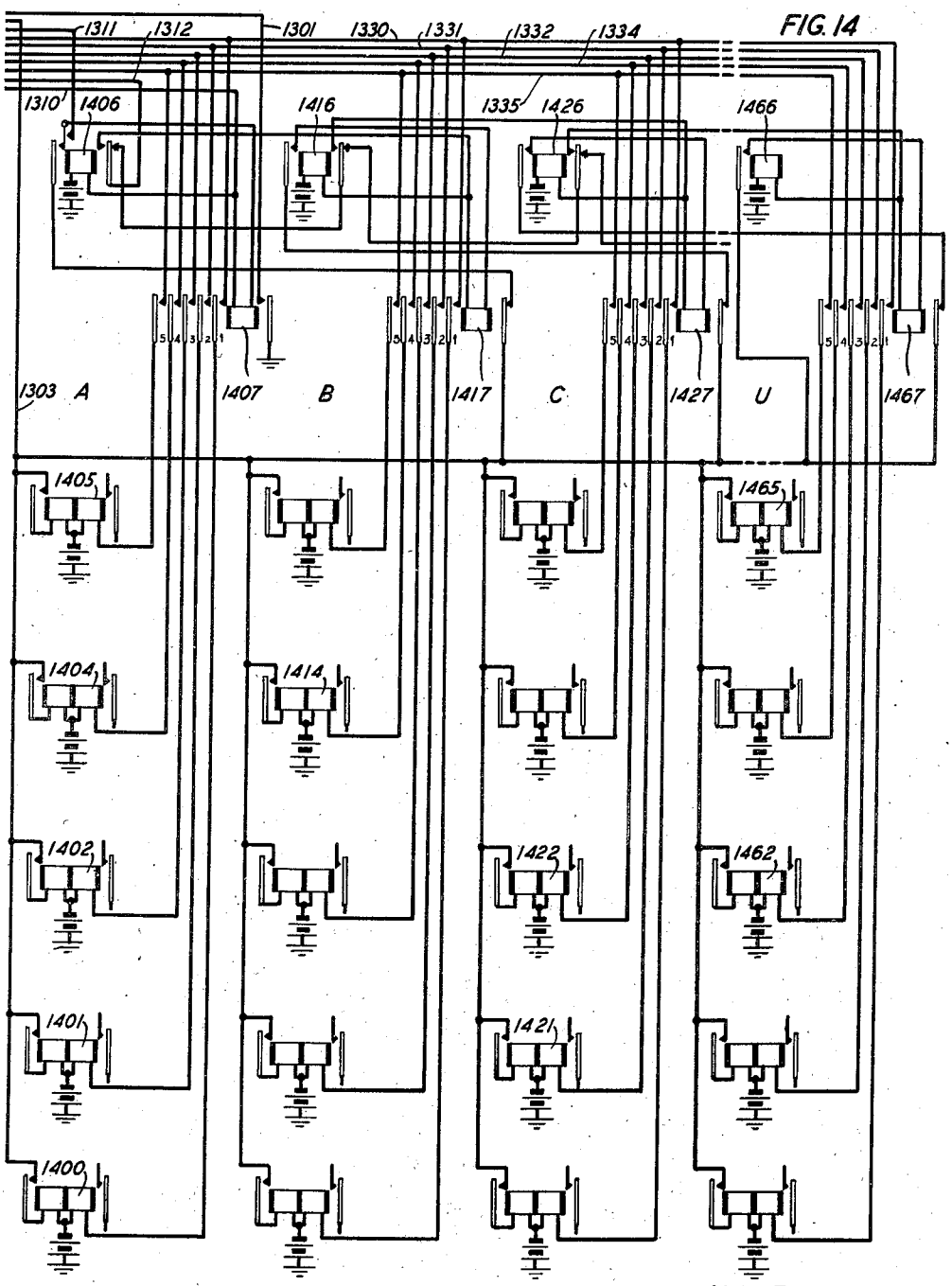
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FIG. 14



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Patented July 9, 1946

2,403,475

UNITED STATES PATENT OFFICE

2,403,475

TELEPHONE SYSTEM

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Application January 13, 1943, Serial No. 472,202

7 Claims. (Cl. 179—90)

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This invention relates to telephone systems and more particularly to a system employing a call transmitter which is an improvement over the telephone call transmitter disclosed in United States Patent No. 2,315,344, granted March 30, 1943, to R. F. Mallina.

In the transmitter described in that application a set of key members is used for actuating U-shaped bars in predetermined combinations for releasing normally pretensioned vibrative elements or reeds in similar combinations, by the operation of latch members or pawls normally holding the vibrative elements in their pretensioned positions, the operation of the vibrative elements in the magnetic field of the generator being effective to transmit signals corresponding to the numerical values of the successively operated members.

In this transmitter five vibrative elements having five different fundamental frequencies are employed which elements are released for vibration through the operation of five U-bars which are allocated respectively to the five vibrative elements. The U-bars are operated in different combinations of two at a time by the depression of the different keys of the ten-button key-set thereby resulting in the release of the vibrative elements in corresponding combinations of two at a time. The release of the vibrative elements occurs for a brief interval only during the depression movement of a key-set key. The characteristics of the vibrative elements may be so chosen that their vibration in the magnetic field of the generator causes the generation of currents of, for example, 700, 900, 1100, 1300 and 1500 cycles.

Studies of this transmitter and the operation thereof have indicated to the applicants that there would be several advantages if the vibrative elements could be released for vibration either during the down-stroke or the up-stroke of an operated key-set key. The studies which have been made of the time intervals required for the satisfactory registration of the signals transmitted by a substation generator of the type just referred to and observations of the speed with which the keys of the key-set are operated indicates that it would be possible to generate a signal impulse which could be registered accurately on either or both the down-stroke and the up-stroke of a key-set key. In receiving circuits which have been developed for use with the call transmitter above referred to a signal duration of 20 to 25 milliseconds or less is all that is utilized for effecting a registration of such signal,

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the major portion of the signal being consumed in the functioning of the unit of the receiving circuit which indicates that a signal is present and which activates the receiving channels of the receiving circuit for a period of 5 to 8 milliseconds. Since it appears to be unusual for a key stroke to be completed in less than 100 milliseconds, it would therefore be entirely possible to secure two separate signals on each key stroke.

The principal advantage which is gained from this method of operation is that the number of vibrative elements may be reduced from five to three, since the selective release of the three members may be made first during the down-stroke of any key to send one signal impulse and again during the up-stroke of the key to send a second signal impulse. The reduction of the number of vibrative elements enables a corresponding reduction of the number of receiving channels required in the receiving circuit at the central office. This reduction permits the frequency spacing between channels to be doubled for the same outside frequency range which would reduce the discrimination required from channel filters. For example, the channels could be designed to be responsive to signals of the three frequencies 700, 1100 and 1500 and, of course, the vibrative elements of the call transmitter would be selected to cause the generation of such frequencies. Alternatively, the outside frequency range could be made smaller so that the difference in attenuation between the highest and lowest frequencies would be less.

It is, therefore, the object of the present invention to arrange a call transmitter of the released reed type so that the reeds thereof are selectively released on the down-stroke and on the up-stroke of any key of the key-set.

A further object of the invention is to enable a wider spacing of the frequencies generated by a reed type call transmitter without increasing the outside frequency range whereby a greater discrimination by the receiving channels is obtained.

An alternative object of the invention is to enable a narrower outside frequency range of the frequencies generated by a reed type call transmitter whereby the difference in attenuation between the highest and lowest frequencies is lessened.

These objects are attained by the provision of mechanism in a call transmitter of the type disclosed in the patent to Mallina hereinbefore referred to, whereby the operation of any one of

the ten keys of the key-set is effective upon the down-stroke to selectively release one of three vibrative elements or reeds and is effective upon its up-stroke to selectively release one or more of the three vibrative elements. In the proposed transmitter only three vibrative elements or reeds are required. To pluck these reeds a releasing mechanism of the improved type disclosed for example in United States Patent No. 2,307,537, granted January 5, 1943, to D. B. Parkinson, may be employed. The reed-releasing member associated with each reed is operable by a cam four times during each revolution of the cam. Each cam has two ratchet wheels connected thereto, each of which ratchet wheels may be advanced through four steps per revolution by an associated stepping pawl which is pivoted to the end of a pawl lever connected to a U-bar. The two pawls associated with the two ratchet wheels connected to each cam are disposed so that the cam is advanced one step or quarter revolution upon the operation of the U-bar to which one of the two pawls is connected and may be advanced a second step or quarter revolution upon the release of the U-bar to which the other of the two pawls is connected.

Of the six U-bars thus required three are instrumental when operated in response to the down-stroke of certain keys of the key-set to cause the selective releasing of the three reeds and the other three are instrumental when released in response to the up-stroke of certain keys of the key-set to cause the selective releasing of the same three reeds. The selective releasing of the reeds in response to the down-strokes and up-strokes of the ten key-set keys causes the generation of signals of the three frequencies *a*, *b* and *c* which might, for example, be of 700, 1100 and 1500 cycles frequency.

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 releases a single reed on the down-stroke and that no two adjacent keys arranged either vertically or horizontally release the same reed on the down-stroke. Hence, if two keys are depressed at once, two reeds will be released and the receiving circuit can be arranged to recognize this as a false signal.

The transmission of two signal impulses by the call transmitter for each keyed digit requires a modification of the receiving circuit associated with the central office sender, whereby three receiving channels are provided to receive the three different frequencies transmitted by the call transmitter, 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 reception of one of the three frequencies transmitted 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 reception of one or more of the three frequencies transmitted 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 side elevation view of the telephone call transmitter embodying the invention, the casing being shown with a portion broken away to disclose the reeds in their pretensioned positions and to disclose the key-operated reed-releasing mechanism;

Fig. 2 is a side elevation view similar to Fig. 1 but in which a portion of the reed-releasing mechanism is shown in the position assumed upon the depression of a key and one of the reeds is shown released for vibration;

Fig. 3 is a top view of the call transmitter with a portion of the casing broken away;

Fig. 4 is an enlarged detail view showing a reed-releasing mechanism in the normal position in which the associated reed is held pretensioned;

Fig. 5 is a detail view similar to Fig. 4 showing the reed-releasing mechanism in its operated position in which the associated reed is freed for vibration;

Fig. 6 is a top plan view of the cams and associated ratchet assemblies for operating the reed-releasing members;

Fig. 7 is a front elevation view of the cams and associated ratchet assemblies;

Fig. 8 is a side view, with a portion cut away, of one of a pair of cam operating ratchet assemblies shown in its normal position and effective when moved to the position shown in Fig. 9 upon the down-stroke of a key-set key to rotate the associated cam when the operated key returns to normal on its up-stroke;

Fig. 9 is a side view of the ratchet mechanism shown in Fig. 8 in the position to which it is moved at the end of the down-stroke of a key-set key;

Fig. 10 is a side view, with a portion cut away, of the other of a pair of cam operating ratchet assemblies shown in its normal position and effective during its movement to the position shown in Fig. 11 in response to the down-stroke of a key-set key to rotate the associated cam;

Fig. 11 is a side view of the ratchet wheel assembly shown in Fig. 10 in the position to which it is moved at the end of the down-stroke of a key-set key; and

Figs. 12, 13 and 14 taken together show a telephone system to which the improved call transmitter is applicable; Fig. 12 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. 13 showing the receiving channels of the sender, the recording relays and other control relays; and Fig. 14 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 up-turned edges 2 to which the molded casing 3 is attached. Secured to the base 1 is a mounting plate 4 having up-turned ears 5 and 6 for supporting a shaft 7 on which the key members K1 to K10, inclusive, are pivotally mounted; an up-turned and then in-turned bracket 8 upon which the off-normal switch assembly 9 is secured by the screws 10; an up-turned ear 11 the purpose of which will be later discussed, and an up-turned plate 12. 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 13 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 12.

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 position disclosed in Fig. 1 by retractile springs 14 which are hooked at one of their ends to the upper edge of the plate 12 and at their other ends are hooked to the lugs 15 of lever members 16, 17, 18, 19, 20 and 21 which are secured to the U-bars B1, B2, B3, B4, B5 and B6, respectively, as by rivets 22.

A U-shaped off-normal bar B7 is also pivoted on the shaft 7 and is held in operable relation with each of the ten key members K1 to K10, inclusive, by a retractile spring 23, hooked at one of its ends to a lug on the lever 24, secured to the bar B7 as by rivets and at the other of its ends to the plate 12. The lever 24 is effective to control the off-normal switch assembly 9 once when any key of the key-set is operated on a down-stroke through the operation of the off-normal bar B7 and again when the operated key is released in an up-stroke.

The off-normal switch assembly may be of the type fully disclosed in the copending application Serial No. 470,724, filed December 31, 1942, in the name of F. A. Hubbard. In general it comprises a permanent magnet to the pole faces of which are attached two parallelly extending pole-pieces having aligned holes therethrough in which is supported a switch element 25 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., and has the characteristic that when its armature is operated a contact member moving therewith quickly disengages a back contact member and quickly engages a front contact member, but that when the armature is released the movable contact member is slow to break away from the front contact member. Normally the switch element is prevented from operating in the field of the flux set up by the permanent magnet, by a low reluctance shunt member 26 held in bridging engagement with the pole-pieces of the off-normal switch assembly by a retractile spring 27. The end of lever 24 is so positioned with respect to a cam surface on the shunt member 26 that when the end of lever 24 is lowered in response to the down-stroke of any operated key, the shunt is momentarily cammed away from the pole-pieces to permit one operating cycle of the switch element and that when the end of lever 24 is raised in response to the up-stroke of the operated key, the shunt is again momentarily cammed away from the pole-pieces to permit a second operating cycle of the switch element. The off-normal switch assembly is effective to transfer the substation line from the telephone subset to the field winding of the call transmitter generator as will be later described.

On the mounting plate 4 is a voltage generator G provided with two permanent magnets M1 and M2 between which are positioned three vibrative elements or reeds Ra, Rb and Rc the characteristics of which are so chosen as to give these elements different natural periods of oscillation. Associated with the outer pole faces of the magnet are two L-shaped pole-pieces P1 and P2, the short arms of which are in-turned toward each other to provide pole faces between which the free ends of the reeds may vibrate. Positioned on the upper surface of the pole-piece P1 is a bracket member 28 having two downwardly extending ears 29 between which the latching member 30 is pivotally supported on the pin 31. The previously described elements of the generator are clamped together by screws 33 which pass freely through aligned holes in the bracket member 28, pole-piece P1, magnet M1, the reeds, magnet M2 and into threaded holes in the pole-piece P2. Interposed between the pole-piece P2 and the base plate 4 is a separator 34 preferably of non-magnetic material. The generator assembly may be secured to the plate 4 in any suitable manner as by screws (not shown) extending through holes in the plate and separator 34 into threaded holes in the pole-piece P2.

Positioned between the pole-pieces P1 and P2 in the space between the ends of the magnets M1 and M2 and the inner faces of the in-turned ends of the pole-pieces is a coil 35 having a central sleeve through which the reeds Ra, Rb and Rc extend with sufficient clearance to permit them to vibrate freely.

The latching member 30, as best disclosed in Figs. 4 and 5, is substantially L-shaped having ears 36 at its ends which serve as bearing members by which the member is pivoted on the pin 31. The vertically disposed arm 37 of the member 30 is normally positioned as disclosed in Fig. 4 with its upper edge positioned beneath the ends of the three reeds Ra, Rb and Rc. The horizontal arm 38 of the latching member is normally engaged by the ends of leaf springs 39 carried by the reed releasing members 40.

For releasing each of the reeds for vibration a releasing member 40, operating cam 41 and a pair of cam-operating ratchet assemblies 42 and 43, are provided. The operating cams and associated ratchet assemblies are mounted for rotation on a pivot screw 32 which is supported in the ear 11 and in the bracket 44 which bracket may be secured to the base plate 4 in any suitable manner as by rivets 45. The releasing members 40 are each provided with a slotted vertical arm 46, a horizontal latch-operating projection 47 and a vertically extending reed-releasing finger 48. The members 40 are supported for vertical movement on rods 49 which extend through holes in the ear 11 and bracket 44 and through the slots in the members 40. For spacing the members 40 for alignment with the reeds with which they function respectively, tubular spacers 50 are positioned on the rods 49. Each releasing member 40 is normally held with the end of its finger 48 engaged against the reed with which it cooperates to pretension such reed as disclosed in Fig. 4, by a leaf spring 51 which is secured at one end to the base plate 4 as by a rivet 52 with its free end engaged beneath the member 40. The upper end of the vertical arm 46 of each member 40 is provided with a rounded cam surface 53 which is normally engaged in the depression between two lobes of the associated operating cam 41.

Each operating cam 41 is provided with four camming lobes and is secured to a sleeve 54. Also secured to the sleeve 54 on one side of the cam 41 is the ratchet wheel 55 of a ratchet assembly 42 and on the other side of the cam is the ratchet wheel 56 of a ratchet assembly 43, each of which ratchet wheels is provided with four teeth equally spaced around its periphery.

As disclosed in Figs. 8 and 9 each ratchet as-

sembly 42 comprises a ratchet wheel 55 with which an L-shaped pawl 57 is adapted to cooperate. The pawl 57 is pivoted by the pin 61 to the lower end of a pawl arm 58, the upper end of which is pivoted to the forwardly extending arm of a lever member such as 21 which is in turn connected to one of the U-bars, such as B6. The pin 61 also extends through aligned holes in the parallelly disposed walls of a housing 62 which embraces the faces of the ratchet wheel 55. The housing is also provided with other aligned holes through which extends the sleeve 54 on which the ratchet wheel 55 is secured. The walls of the housing are united by web 63 to which one end of a leaf spring 64 is secured, the free end of such spring being engaged with one arm of the pawl 57 whereby the other end of such pawl is held yieldingly in engagement with the periphery of the ratchet wheel 55.

By virtue of the journaling of the housing 62 on the sleeve 54 and the pivoted connection of the pawl arm 58 to such housing, the housing and pawl 57 are rotated about the sleeve 54 as an axis upon either the downward or the upward movement of the pawl arm 58. The normal position of the pawl 57 with respect to the teeth of the ratchet wheel 55 is disclosed in Fig. 8. When, however, a U-bar and lever member connected thereto are depressed by the depression of one of the keys of the key-set the housing 62 is rotated by the pawl arm 58 in a counter-clockwise direction whereby the pawl 57 moves freely over a tooth of the ratchet wheel 55 without causing the rotation of such ratchet wheel until, when the U-bar has become fully depressed, the ratchet assembly assumes the position disclosed in Fig. 9. In this position the end of pawl 57 has been forced by the spring 64 to engage beneath a tooth of the ratchet wheel 55. When thereafter the operated key is released resulting in the restoration of the depressed U-bar, the pawl arm 58 moving upwardly causes a clockwise rotation of the housing 62 and pawl 57, thereby causing a rotation of the ratchet wheel 55 and associated cam 41 through a quarter of a revolution.

As disclosed in Figs. 10 and 11 each ratchet wheel assembly 43 comprises a ratchet wheel 56 with which a pawl 59 is adapted to cooperate. The pawl 59 is pivoted by the pin 65 to the lower end of a pawl arm 60 the upper end of which is pivoted to the forwardly extending arm of a lever member, such as 20, which is, in turn, connected to one of the U-bars, such as B5. The pin 65 also extends through aligned holes in the parallelly disposed walls of a housing 66 which embraces the faces of the ratchet wheel 56. The housing is also provided with other aligned holes through which extends the sleeve 54 on which the ratchet wheel 56 is secured. The walls of the housing are united by a web 67 to which one end of a leaf spring 68 is secured, the other end of such spring being engaged with the pawl 59 whereby the pawl is held yieldingly in engagement with the periphery of the ratchet wheel 56.

By virtue of the journaling of the housing 66 on the sleeve 54 and the pivoted connection of the pawl arm 60 to such housing, the housing and pawl 59 are rotated about the sleeve 54 as an axis upon either the downward or the upward movement of the pawl arm 60. The normal position of the pawl 59 with respect to a tooth of the ratchet wheel 56 is disclosed in Fig. 10. When, however, a U-bar and lever member connected thereto are depressed by the depression of one of the keys of the key-set the housing 66 is rotated by the pawl arm 60 in a clockwise direction whereby the pawl 59 normally engaged with a tooth of the ratchet wheel 56 rotates such ratchet wheel and connected cam 41 through a quarter revolution until the ratchet assembly 43 assumes the position disclosed in Fig. 11 at which time the U-bar has become fully depressed. When thereafter the operated key is released resulting in the restoration of the depressed U-bar the pawl arm 60 moving upwardly causes a counter-clockwise rotation of the housing 66 and pawl 59 whereby the pawl 59 moves freely over a tooth of the ratchet wheel 56 without causing the rotation thereof.

From the foregoing description of the ratchet wheel assemblies 42 and 43 it will be noted that the assembly 43 causes a quarter revolution of the associated cam 41 on the down-stroke of a key-set key and the consequent down-stroke of a U-bar, such as B5, and that the assembly 42 causes a quarter revolution of the associated cam 41 on the up-stroke of an operated key and the consequent up-stroke of the previously operated U-bar. Thus, U-bars B1, B3 and B5 through which the three ratchet assemblies 43 are operated, may be considered to be down-stroke bars and the U-bars B2, B4 and B6 to which the three ratchet assemblies 42 are operated may be considered to be up-stroke bars. Any cam 41 may thus be rotated under the control of either an associated down-stroke U-bar, such as B5, or an associated up-stroke U-bar, such as B6.

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 transmit an impulse of the frequency *a* during the down-stroke of the key K1 and to transmit a second impulse of the frequency *a* during the up-stroke of key member K1. To accomplish this the under-surface of the key member K1 is provided with an extension 69 which engages with the upper edges of both the 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 B5 through the associated lever member 20 and pawl arm 60 causes a quarter revolution of the cam 41 which momentarily depresses the releasing member 40 associated therewith and with the generator reed R*a*. Upon the downward movement of the member 40 the spring 39 is moved away from the horizontal arm 38 of the latching member 30, the end of finger 48 is moved away from the reed Ra to permit the reed to engage with the upper edge of the vertical arm 37 of the member 30 and thereafter the projection 47 of member 40 engages the horizontal arm 38 of member 30 to rotate such member about the pivot pin 31 to remove its vertical arm 37 from beneath the end of the reed. The Reed R*a* is thereby freed from its pretensioned position and vibrates within the coil 35 and between the pole-pieces P1 and P2 of the generator G. Current of the frequency *a* is thereby generated in the coil 35 and transmitted therefrom over the substation line.

When the releasing member 40 restores to its normal position under the influence of the spring 51 after the operating cam 41 has completed a quarter revolution under control of the down-stroke movement of the U-bar B5, the end of finger 48 engages with the reed R*a*, damps its vibration and restores it to its pretensioned po-

sition and the spring 39 carried by the member 40 engaging with the arm 38 of the latching member 30 moves the vertical arm of such member beneath the end of the reed as disclosed in Fig. 4.

The depression of the U-bar B6 through the associated lever member 21 and pawl arm 58 is ineffective to rotate the cam 41 during such down-stroke movement of the bar but the pawl 57 of the ratchet assembly 42 is so positioned that upon the up-stroke movement of the bar B6 when the key K1 is released, it is effective to rotate the cam 41 through a second quarter revolution and to thereby again cause the release of the reed R*a* in the manner previously described to generate a second impulse of current of the frequency *a* and to transmit it over the substation line.

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, to control the generation of current of the frequencies *a*, *b* and *c* in the manner indicated in the following table:

	Key				
	K1	K2	K3	K4	K5
U-bars operated	B5, B6	B3, B4	B1, B2	B2, B3	B2, B5
Down-stroke frequency	*a*	*c*	*b*	*c*	*a*
Up-stroke frequency	*a*	*c*	*b*	*b*	*b*

	Key				
	K6	K7	K8	K9	K10
U-bars operated	B3, B6	B1, B6	B4, B5	B4, B1	B2, B3, B6
Down-stroke frequency	*c*	*b*	*a*	*b*	*c*
Up-stroke frequency	*a*	*a*	*c*	*c*	*b* + *a*

The call transmitter of Figs. 1 to 11, 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 designation transmitted and 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 subscribers' stations. It will be obvious that other forms of switches may be used for establishing the connections such as switches of the cross bar type and switches of the well-known step-by-step type.

Referring to Figs. 12, 13 and 14 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 switches together form a link for extending subscribers' lines to trunks extending to other selectors (not shown) by which a connection from a calling subscriber's line may be extended to a wanted subscriber's line. The line finder and district link have access through a sender link SL comprising a trunk finder TF and a sender selector SS to a plurality of common register senders. Figs. 13 and 14 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 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 designation usually requires four registrations. In the present disclosure three office code digit registers A, B and C are shown in Fig. 14 and the units numerical register U is also shown, it being understood that the thousands, hundreds and tens registers would be provided and inserted between the units register U and the 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 F*a*, F*b* and F*c* of Fig. 13.

It will be assumed that the subscriber at the substation illustrated in Fig. 12 removes the handset H of the subset from the cradle to initiate a call 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, whereafter the line-finder first selector link becomes associated over the sender link SL comprising the trunk finder TF and the sender selector SS 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 1200 and windings of relay 1300 to ground. Relay 1300 operates and closes an obvious operating circuit for relay 1302. Relay 1302 upon operating connects ground over its right contacts to the off-normal conductor 1303 to provide locking ground for other relays of the sender and over its left contacts and conductor 1304 establishes the circuit of relay 1201.

With ground connected to conductor 1303 a circuit is established therefrom over the left back contact of relay 1309, conductor 1310 to battery through the winding of progress relay 1406 whereupon relay 1406 operates and locks in a circuit from battery through its winding and the winding of progress relay 1407, over the inner left front contacts of relay 1406 and over the back contact of progress relay 1417 to ground on conductor 1303. Relay 1407 does not operate in this locking circuit since its winding is shunted so long as ground remains connected to conductor 1310. When relay 1406 operates a circuit is also established from ground on conductor 1303, over the back contact of relay 1417, the outer left contacts of relay 1406, conductor 1311 and to battery through the right normal contacts and winding of relay 1309. Relay 1309 thereupon operates, locks over its right alternate contacts to ground on conductor 1303 and at its back contact removes ground from conductor 1310 whereupon relay 1407 operates in the locking circuit of relay 1406; prepares operating circuits for the relays of the first code digit register A over conductors 1331, 1332, 1334, 1335 and 1330 and at its right contact connects ground to conductor 1301 to shunt the right winding of relay 1300 whereby the current flowing over the operating circuit of relay 1300 is increased as a signal to the line-finder selector link.

Relay 1201 upon operating connects the windings of battery feed relay 1202 to the calling line substation over a circuit which may be traced from battery through the left winding of relay 1202, the left contacts of relay 1201, brush 1203 of sender selector SS, brush 1204 of the trunk finder TF, contacts of sequence switch cam 1205, brush 1206 of line finder LF, the ring conductor of the calling line, switchhook contacts 1207, the back

contact of the off-normal switch assembly 9, through the transmitter 1208, the left winding of repeating coil 1209, the tip conductor of the calling line, brush 1210 of the line-finder LF, sequence switch contacts 1211, brush 1212 of trunk finder TF, brush 1213 of sender selector SS, right contacts of relay 1201, right winding of relay 1202, normal contacts of relay 1214 to ground through the secondary winding of the dial tone coil 1215. Relay 1202 operates over this circuit and dialing tone current is applied thereover to apprise the calling subscriber that he may proceed to key up the digits of the desired telephone number. Relay 1202, upon operating, establishes an obvious circuit for relay 1216 which also operates to prepare an operating circuit for relay 1214, and relay 1202 establishes a circuit from ground over its left contacts, conductor 1217, over the upper normal contacts and through the winding of relay 1305, and through resistance 1307 to battery and in parallel therewith through the winding of relay 1306 and resistance 1308 to battery. Relay 1305 operates and locks over its upper alternate contacts to ground on conductor 1303 but the winding of relay 1306 being shunted so long as ground is applied to conductor 1217, does not operate. The closure of the lower front contact of relay 1305 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 a reed of the generator G is caused to vibrate to generate a current impulse of a predetermined frequency. 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 thereof is in engagement with its front contact, a reed will be vibrated to generate a second current impulse of a predetermined frequency. By referring to the preceding table, it will be noted that when key K2 is depressed, the frequency *c* is generated both upon the down and upstrokes thereof. This frequency might, for example, be of 1100 cycles.

The movement of the movable contact of the off-normal switch assembly 9 from its back or normal contact position disconnects the subset transmitter 1208 from its bridged connection across the substation line and the engagement of the movable contact with the front contact connects the coil 35 of the call transmitter generator G across the line through the condenser 1218. 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 1202 of the sender releases in turn opening the circuit of relay 1216 and removing ground from conductor 1217. Relay 1216, however, being slow to release does not release during the interval that the movable contact of the off-normal switch assembly 9 is disengaged from its back contact. With relay 1202 released and relay 1216 operated an obvious circuit is established for relay 1214 which operates and at its contacts disconnects the secondary winding of the dial tone coil 1215 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 1217 removes the shunt from the winding of relay 1306 which now operates in a circuit from ground on conductor 1303, over the upper alternate contacts of relay 1305, through the winding of relay 1306 and resistance 1308 to battery.

When the first impulse of current of the frequency *c* is transmitted over the line, it passes over the previously traced circuit through the sender link, through the broad band-pass filter 1219 and the primary winding of the transformer 1220 and is impressed through the circuit X and the primary windings of the input transformers associated with the receiving channels *Fa*, *Fb*, *Fc* and V. Associated with each input transformer, such as 1313, is a frequency receiving channel consisting of a secondary winding of such transformer, a series tuned circuit 1314, a single vacuum tube such as 1315 with a feedback through the copper-oxide units, such as 1316, and a relay, such as 1317. Initially, the vacuum tube is biased nearly to cut-off. A small received signal is amplified and fed back through the condenser 1318 and the copper-oxide units 1316 to charge up the condenser 1319. This condenser is poled to reduce the negative bias on the grid of the tube 1315 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 relay 1317. The sensitivity of each individual channel is adjusted by means of the variable resistance, such as 1320. This method controls the sensitivity by changing the alternating current feedback and does not affect the tuning of the channel.

From the preceding description it will be apparent that each relay, such as relay 1317 in each channel, will respond to a single frequency with a relatively high discrimination against the others. In the present description it has been assumed that the first channel *Fa* is tuned to the *a* frequency of 700 cycles; the second channel *Fb* is tuned to the *b* frequency of 1100 cycles; and the third channel *Fc* is tuned to the *c* frequency of 1500 cycles.

Upon the receipt of the first impulse of frequency *c* the channel *Fc* responds resulting in the operation of channel relay 1317. Relay 1317 upon operating establishes a circuit from ground over its contacts, the middle right back contact of transfer relay 1321, 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 1322 and at its outer left contacts prepares a circuit for relay 1321. Upon the termination of the signal impulse when the off-normal switch assembly 9 reestablishes the direct current bridge at the substation through the subset transmitter, relay 1202 reoperates to establish the circuit of relay 1216 and to reconnect ground to conductor 1217 whereupon such ground is extended over the upper front contact of relay 1306 to a point between the winding of relay 1305 and resistance 1307. Relay 1305 being now shunted releases. Relay 1306 is, however, maintained operated following the release of relay 1305 over a circuit from ground on conductor 1217, over the upper normal contacts of relay 1305, through the winding of relay 1306, and resistance 1308 to battery. With relay 1305 released and relay 1306

held operated the circuit of relay 1321 is now completed from ground over the lower back contact of relay 1305, the inner lower front contact of relay 1306, the outer left contacts of relay CD to battery through the winding of relay 1321.

Relay 1321 now operates; locks over its inner right front contact to ground over the back contact of relay 1322; at its back contacts disconnects the windings of recording relays AD, BD and CD from the contacts of the channel relays 1323, 1324 and 1317, 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 released, and at its outer right front contact prepares a circuit for relay 1322.

During the transmission of the second signal impulse assumed to be also of the frequency c the off-normal spring assembly 9 being again operated momentarily, relay 1202 again releases to remove ground from conductor 1217 thereby releasing relay 1306. Channel circuit Fc again responds to the receipt of the frequency c and the channel relay 1317 upon operating and with transfer relay 1321 operated establishes a circuit from ground over the contacts of relay 1317, the middle right front contact of relay 1321 to battery through the winding of recording relay CU. Relay CU upon operating locks over its left front contact to ground over the back contact of relay 1322.

When the off-normal spring assembly 9 again releases to terminate the second frequency impulse the reoperation of relay 1305 over the circuit previously traced is effected by the reoperation of relay 1202. With relay 1305 operated and relay 1306 unoperated a circuit is established from ground over the lower front contact of relay 1305, the lower back contact of relay 1306, 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 1332, the No. 3 left contacts of progress relay 1407, to battery through the right winding of relay 1402 of the A code digit register. Relay 1402 thereupon operates and locks over its left winding and left contacts to ground on conductor 1303 and with the remaining relays 1401, 1404, 1405 and 1400 of the A register unoperated, serves to register the first office code letter C.

A circuit is also established upon the operation of relay 1305 over its lower front contact, the lower back contact of relay 1306, over the outer right front contact of relay 1321 to battery through the winding of relay 1322, which operates after an interval sufficient to insure that the digit signals recorded through 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 circuits of the operated recording relays, in the case assumed relays CD and CU, which thereupon release; opens the locking circuit of transfer relay 1321 which releases and at its front contact establishes an obvious circuit for relay 1325. Relay 1325 operates, locks over its right contacts to off-normal ground on conductor 1303 and at its left contacts prepares a circuit for operating the progress relay 1416. When relay 1321 releases relay 1322 also releases.

When the subscriber depresses the key K4 to transmit impulses 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 generator G to the substation line. During the interval that the switch is thus operated the reed Rc is released to transmit an impulse of the frequency c which, upon being received in the receiving channel Fc of the sender results in the operation of channel relay 1317 and, with transfer relays 1321 now released, in the operation of recording relay CD over the circuit previously traced. Relay CD upon operating locks under the control of relay 1322 and prepares the circuit of relay 1321 as previously described. When the line loop is opened at the substation by the off-normal switch assembly, relay 1202 releases and by removing ground from conductor 1217 permits relay 1306 to operate in the manner previously described. With relays 1305 and 1306 now both operated and relay 1325 operated, a circuit is established from ground over the lower front contact of relay 1305, the lower front contact of relay 1306, the left contacts of relay 1325, conductor 1312, the right front contact of progress relay 1406 to battery through the winding of progress relay 1416 which operates and locks through its winding and the winding of progress relay 1417 over the left contacts of relay 1416 and the back contact of progress relay 1427 to ground on conductor 1303. Relay 1417 being shunted so long as ground remains connected to conductor 1312, does not operate.

At the end of the first impulse for the second code digit, with the off-normal switch assembly 9 restored, the transmission of the frequency c ceases, channel relay 1317 releases, and the direct current loop is reestablished at the substation resulting in the reoperation of relay 1202 and the reconnection of ground to conductor 1217. As before described relay 1306 is now held operated to this ground and relay 1305 is shunted and releases. With relay 1305 released and relay 1306 operated, the circuit for transfer relay 1321, previously prepared through the operation of recording relay CD, is completed and relay 1321 operates and locks as previously described under the control of relay 1322. Relay 1305 upon releasing also removes ground from conductor 1312 whereupon progress relay 1417 operates in the locking circuit of relay 1416; connects the windings of the relays of the B code digit register to conductors 1331, 1332, 1334, 1335 and 1330, extending to contacts of the recording relays and at its right back contacts opens the locking circuit of relays 1406 and 1407 which now release since their operating circuit was opened upon the previous operation of relay 1309.

Upon the up-stroke of the depressed key K4 the off-normal switch assembly 9 is again operated momentarily to open the direct current loop at the substation and to connect the generator G to the substation line. During the interval that the switch is thus operated the reed Rb is released to transmit the frequency b which upon being received in the receiving channel Fb of the sender results in the operation of channel relay 1324 and, with transfer relay 1321 now operated, in the operation of recording relay BU over a circuit extending from ground over the contacts of relay 1324, the inner left front contact of relay 1321 to battery through the winding of relay BU. Relay BU upon operating locks over its left contacts under the control of relay 1322. With the direct current loop now open at the

substation, relay 1202 releases followed by the release of relay 1306 as previously described.

When the off-normal switch assembly 9 again releases to terminate the second frequency impulse, relay 1202 again operates thereby causing the reoperation of relay 1305 over the circuit previously traced. With relay 1305 operated and relay 1306 unoperated, a circuit is established from ground over the lower front contact of relay 1305, the lower back contact of relay 1306, the right back contact of relay AD, the No. 2 back contact of relay BD, the No. 2 front contact of relay CD, the No. 2 back contact of relay AU, the No. 3 front contact of relay BU, the No. 4 back contact of relay CU, conductor 1334, the No. 4 front contacts of progress relay 1417 to battery through the right winding of relay 1414 of the office code register B. Relay 1414 upon operating in this circuit locks over its left winding and left contacts to ground on conductor 1303 and with the remaining relays of the B register unoperated serves to register the second office code letter H.

The operation of relay 1305 with relay 1306 unoperated also establishes the previously traced circuit for relay 1322 which operates after an interval to cause the release of the operated recording relays CB and BU and the release of the transfer relay 1321. When relay 1321 releases, relay 1322 also releases.

When the subscriber depresses the key K3 to transmit impulses for the third code digit 3, the off-normal switch assembly 9 is operated momentarily to open the direct current loop at the substation and to connect the generator G to the substation line. During the interval that the switch is thus operated the reed R*b* is released to transmit an impulse of the frequency *b* which upon being received in the receiving channel F*b* of the sender results in the operation of the channel relay 1324 and, with transfer relay 1321 not operated, in the operation of recording relay BD over a circuit extending from ground over the contacts of relay 1324, the inner left back contact of relay 1321 to battery through the winding of relay BD. Relay BD upon operating locks under the control of relay 1322 and prepares the circuit of relay 1321 as previously described. When the line loop is opened at the substation by the off-normal switch assembly relay 1202 releases and by removing ground from conductor 1217 permits relay 1306 to operate in the manner previously described. With relays 1305 and 1306 now both operated and relay 1325 operated, a circuit is established from ground over the lower front contact of relay 1305, the lower front contact of relay 1306, the left contacts of relay 1325, conductor 1312, the right back contact of relay 1406, the right front contact of relay 1416, to battery through the winding of progress relay 1426. Relay 1426 operates and locks through its winding and the winding of progress relay 1427, over the left contacts of relay 1426 and to ground on conductor 1303, over the back contact of the progress relay (not shown) associated with the thousands digit register and corresponding to progress relay 1427. Progress relay 1427 being shunted does not operate so long as ground remains connected to conductor 1312.

At the end of the first impulse for the third code digit with the off-normal switch assembly 9 restored, the transmission of the frequency *b* ceases, channel relay 1324 releases and the direct current loop is reestablished at the substation resulting in the reoperation of relay 1202 and reconnection of ground to conductor 1217. As before described, relay 1306 is now held operated to this ground and relay 1305 is shunted and releases. With relay 1305 released and relay 1306 operated a circuit for transfer relay 1321, previously prepared through the operation of recording relay BD, is completed and relay 1321 operates and locks as previously described under the control of relay 1322. Relay 1305 upon releasing also removes ground from conductor 1312 whereupon progress relay 1427 operates in the locking circuit of relay 1426; connects the windings of the relays of the C code digit register to conductors 1331, 1332, 1334, 1335 and 1330 extending to contacts of the recording relays and at its right back contact opens the locking circuit of relays 1416 and 1417 which now release since their operating circuit was opened upon the removal of ground from conductor 1312.

Upon the up-stroke of the depressed key K3 the off-normal switch assembly 9 is again operated momentarily to open the direct current loop at the substation and to connect the generator G to the substation line. During the interval that the switch is thus operated the reed R*b* is released to transmit the frequency *b* which upon being received in the receiving channel F*b* of the sender results in the operation of the channel relay 1324 and, with transfer relay 1321 operated, in the operation of recording relay BU. Relay BU upon operating locks over its left contacts under the control of relay 1322.

When the off-normal switch assembly 9 again releases to terminate the second frequency impulse, relay 1202 again operates thereby causing the reoperation of relay 1305 over the circuit previously traced. With relay 1305 operated and relay 1306 unoperated, a first circuit is established from ground over the lower front contact of relay 1305, the lower back contact of relay 1306, 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 1331, the No. 2 left contacts of progress relay to battery through the right winding of relay 1421 of the code digit register C, and 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. 4 right back contact of relay AU, the No. 7 right front contact of relay BU, the No. 5 right back contact of relay CU, conductor 1332, the No. 3 left contacts of progress relay 1427 to battery through the right winding of relay 1422 of the code digit register C. Relays 1421 and 1422 upon operating lock over their left windings and left contacts to ground on conductor 1303 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 1305 with relay 1306 unoperated also establishes the previously traced circuit of relay 1322 which operates after an interval to cause the release of the operated recording relays BD and BU and the release of transfer relay 1321 followed by the release of relay 1322.

In a similar manner in response to the keying of the thousands numerical digit 1 two impulses of frequency *a* are sent resulting in the operation of recording relays AD and AU. In response to the keying of the hundreds digit 0 an impulse of frequency *c* followed by an impulse of frequencies

a and *b* are sent resulting in the operation of recording relays CD, AU and BU. In response to the keying of the tens digit 6 an impulse of frequency *c* followed by an impulse of frequency *a* are sent resulting in the operation of recording relays CD and AU and in response to the keying of the units digit 7 an impulse of frequency *b* followed by an impulse of frequency *a* are sent resulting in the operation of recording relays BD and AU.

With recording relays AD and AU operated to record the receipt of signal impulses for 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 CU to conductor **1331** and thence over the No. 2 left contacts of an operated progress relay, similar to relay **1407** but associated with the thousands digit register, to battery through the winding of a relay of that register corresponding to relay **1401** whereby such relay operates and locks and with the other relays of such register unoperated registers the thousands digit 1.

With the recording relays CD, AU and BU operated to record the receipt of signal impulses for 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. 2 right front contact of relay CD, the No. 2 right front contact of relay AU, the No. 2 right front contact of relay BU, the No. 3 right back contact of relay CU to conductor **1330** and thence over the No. 1 left contacts of an operated progress relay, similar to relay **1407** but associated with the hundreds digit register, to battery through the winding of a relay of that register corresponding to relay **1400** whereupon such relay operates and locks to register the hundreds digit 0.

With recording relays CD and AU operated to record the receipt of signal impulses for 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, No. 2 right back contact of relay BU, the No. 6 right back contact of relay CU, conductor **1331** and thence over the No. 2 left contacts of an operated progress relay, similar to relay **1407** but associated with the tens digit register, to battery through the winding of a relay of such register corresponding to relay **1401** whereupon such relay operates and locks. A second 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. 6 right front contact of relay CD, the No. 6 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 **1335** and thence over the No. 5 left contacts of an operated progress relay, similar to relay **1407** but associated with the tens digit register, to battery through the winding of a relay of that register corresponding to relay **1405** 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 to record the receipt of signal impulses for 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 **1332** and thence over the No. 3 contacts of the operated progress relay **1467**, to battery through the right winding of relay **1462** 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, conductor **1335** and thence over the No. 5 contacts of relay **1467** to battery through the right winding of relay **1465** of the units digit register U. Relays **1462** and **1465** upon operating lock over their left windings and left contacts to ground on conductor **1303** 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 over 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 registration of letters or digits having the digit values 1, 2, 3, 4, 6, 7 and 0 have been described. If the digit 5 is keyed by the operation of key K5 then an impulse of frequency *a* would be sent followed by an impulse of frequency *b* resulting in the operation of recording relays AD and BU. 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 front contact of relay BU, the No. 1 right back contact of relay CU to conductor **1335** to cause the operation of a relay of a register, such as relay **1405** of the first code digit register A.

If the digit 8 is keyed by the operation of key K8, then an impulse of frequency *a* is sent followed by an impulse of frequency *c* resulting in the operation of recording relays AD 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 front contact of relay AD, the No. 1 right back contact of relay BD, the No. 5 right back contact of relay CD, the No. 5 right back contact of relay AU, the No. 8 right back contact of relay BU and the No. 6 right front contact of relay CU to conductor **1331**; a second 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 and the No. 2 right front contact of relay CU to conductor **1332** and a third circuit is established over the right back 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 and the No. 1 right front contact of relay CU

to conductor 1335. With ground applied to conductors 1331, 1332 and 1335 relays of a digit register, such as relays 1401, 1402, 1405 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 an impulse of frequency *b* is sent followed by an impulse of frequency *c* resulting in the operation of recording relays BD and CU. With these relays operated, then when ground is supplied to the right 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 1334 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 1335. With ground applied to conductors 1334 and 1335, relays of a digit register such as relays 1404 and 1405 of the first code digit register A are operated to register the digit 9.

What is claimed is:

1. In a telephone system in which the selection of wanted lines is effected by transmitting over a line extending from a calling station impulse combinations made up of a plurality of frequencies within the voice frequency range, an impulse generator at the calling station comprising a plurality of differently tuned reeds vibratable in an electromagnetic field, a plurality of keys each having a down-stroke and an up-stroke movement and means controlled by said keys for selectively operating said reeds for causing the transmission of one impulse of a combination during the down-stroke of a key and for selectively operating said reeds for causing the transmission of the remaining impulse of a combination during the up-stroke of the operated key.

2. In a telephone system in which the selection of wanted lines is effected by transmitting over a line extending from a calling station impulse combinations made up of a plurality of frequencies within the voice frequency range, an impulse generator at the calling station comprising three differently tuned reeds vibratable in an electromagnetic field, a plurality of keys each having a down-stroke and an up-stroke movement and means controlled by said keys for selectively operating one of said reeds for causing the transmission of one impulse of a combination during the down-stroke of a key and for selectively operating one or two of said reeds for causing the transmission of the remaining impulse of a combination during the up-stroke of the operated key.

3. In a telephone system in which the selection of wanted lines is effected by transmitting over a line extending from said calling station impulse combinations made up of a plurality of frequencies within the voice frequency range, an impulse generator at the calling station comprising a plurality of differently tuned reeds vibratable in an electromagnetic field, a plurality of keys each having a down-stroke and an up-stroke movement, a timing switch momentarily operable once during the down-stroke of an operated key and again during the up-stroke of an operated key, and means controlled by said keys for selectively operating said reeds for causing the transmission of one impulse of a combination, timed by said switch, during the down-stroke of a key and for selectively operating said reeds for causing the transmission of the remaining impulse of a combination, timed by said switch, during the up-stroke of the operated key.

4. In a telephone system in which the selection of wanted lines is effected by transmitting over a line extending from a calling station impulse combinations made up of a plurality of frequencies within the voice frequency range, an impulse generator at the calling station comprising a plurality of differently tuned pretensioned reeds vibratable in an electromagnetic field, a releasing member associated with each of said reeds, a plurality of keys each having a down-stroke and an up-stroke movement, a pair of bars associated with each of said reed-releasing members, means controlled by the operation of the first bar of any pair for operating the associated reed-releasing member, means controlled by the release of the second bar of any pair when operated for operating the associated reed-releasing member and means controlled by said keys for selectively operating and then releasing said bars to cause the selective operation of said reed-releasing members, whereby one impulse of a combination is transmitted during the down-stroke of a key and the remaining impulse of a combination is transmitted during the up-stroke of the operated key.

5. In a telephone system in which the selection of wanted lines is effected by transmitting over a line extending from a calling station impulse combinations of frequencies within the voice frequency range, an impulse generator at the calling station comprising a plurality of differently tuned pretensioned reeds vibratable in an electromagnetic field, a release member associated with each of said reeds, a plurality of keys each having a down-stroke and an up-stroke movement, a pair of depressible bars associated with each of said reed-releasing members, means controlled by the depression of the first bar of any pair for operating the associated reed-releasing member, means controlled by the releasing movement of the second bar of any pair, if depressed, for operating the associated reed-releasing member, and means controlled by said keys for selectively depressing and then releasing said bars to cause the selective operation of said reed-releasing members, whereby one impulse of a combination is transmitted during the down-stroke of a key and the remaining impulse of a combination is transmitted during the up-stroke of the operated key.

6. In a telephone system in which the selection of wanted lines is effected by transmitting over a line extending from a calling station impulse combinations of frequencies within the voice frequency range, an impulse generator at the calling station comprising a plurality of differently tuned pretensioned reeds vibratable in an electromagnetic field, a releasing member associated with each of said reeds, a rotatable cam for operating each releasing member, a plurality of keys each having a down-stroke and an up-stroke movement, a pair of depressible bars associated with each of said cams, a ratchet assembly controlled by the depression of the first bar of any pair for rotating said cam to operate the associated reed-releasing member, a ratchet assembly controlled by the releasing movement of the

second bar of any pair, if depressed, for rotating said cam to operate the associated reed-releasing member and means associated with said keys for selectively depressing and then releasing said bars to cause the selective operation of said reed-releasing members, whereby one impulse of a combination is transmitted during the down-stroke of a key and the remaining impulse of the combination is transmitted during the up-stroke of the operated key.

7. In a telephone system in which the selection of wanted lines is effected by transmitting over a line extending from a calling station impulse combinations of frequencies within the voice frequency range, an impulse generator at the calling station comprising a plurality of differently tuned pretensioned reeds vibratable in an electromagnetic field, a releasing member associated with each of said reeds, a rotatable cam for operating each releasing member, a pair of ratchet assemblies associated with each of

said cams, a pair of depressible bars associated with each pair of ratchet assemblies, one of said bars being effective upon its depression through one of said associated ratchet assemblies to rotate the associated cam to operate the associated reed-releasing member and the other of said bars being effective upon its releasing movement, if depressed, through the other of the associated ratchet assemblies to rotate the associated cam to operate the associated reed-releasing member, a plurality of keys each having a down-stroke and an up-stroke movement and means associated with said keys for selectively depressing and then releasing said bars to selectively operate said reed-releasing members, whereby one impulse of a combination is transmitted during the down-stroke of a key and the remaining impulse of the combination is transmitted during the up-stroke of the operated key.

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