July 4, 1939. R. C. MATHES 2,164,335

TELEPHONE SYSTEM

Filed April 13, 1938 3 Sheets-Sheet 1

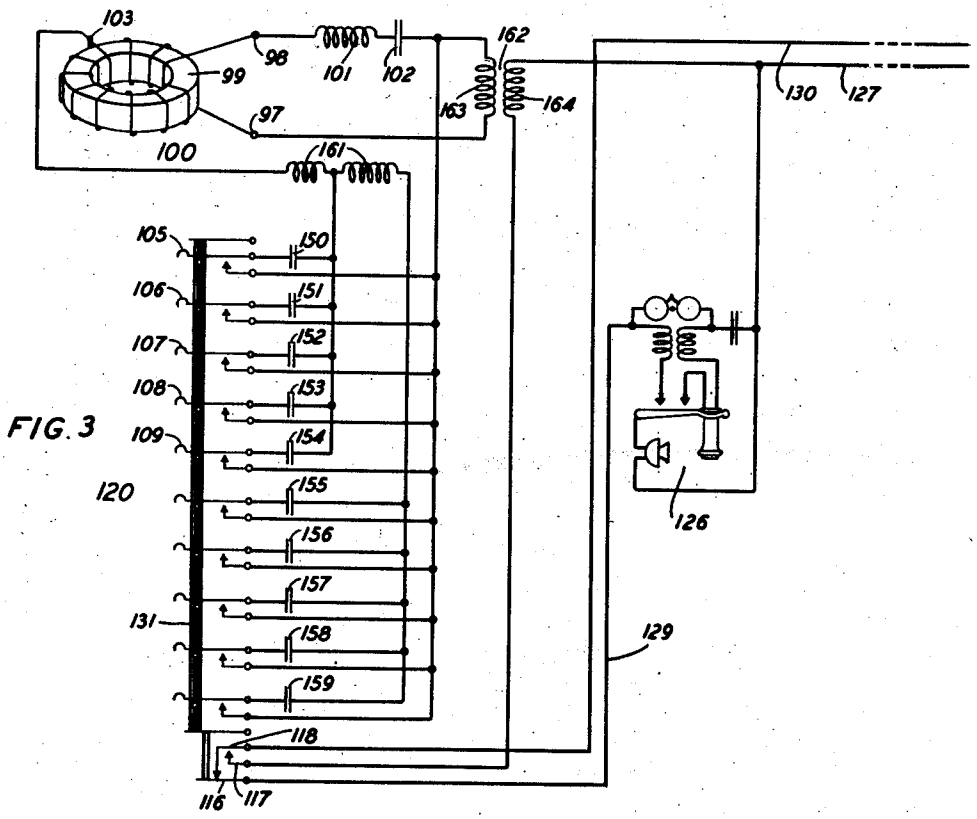

FIG. 3

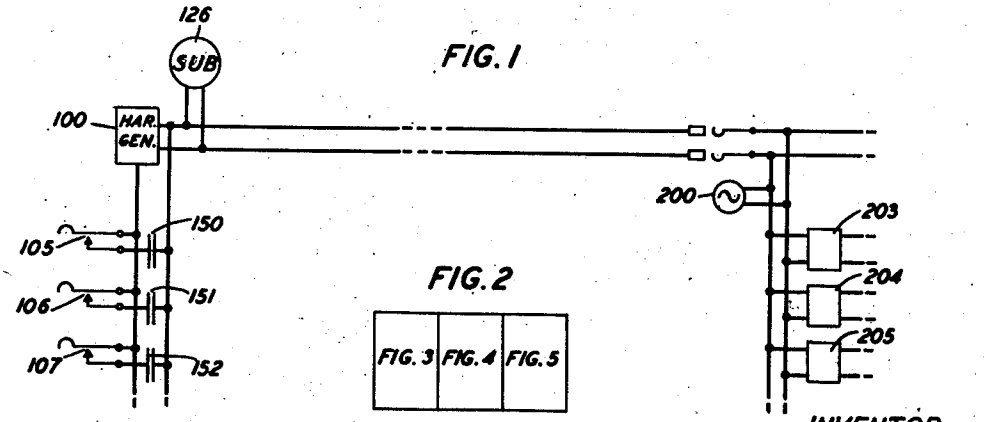

FIG. 1

FIG. 2

FIG. 3	FIG. 4	FIG. 5

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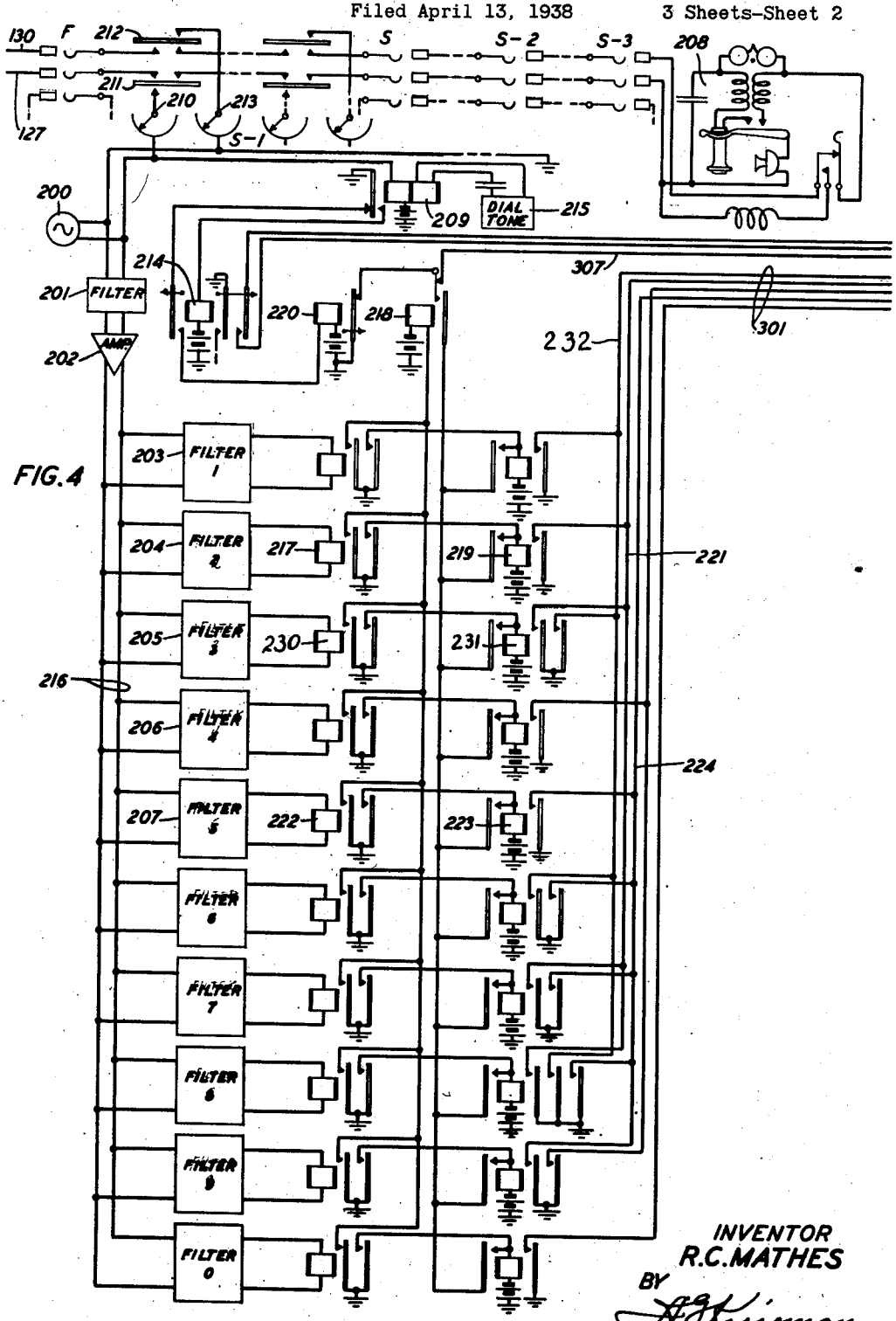

FIG. 4

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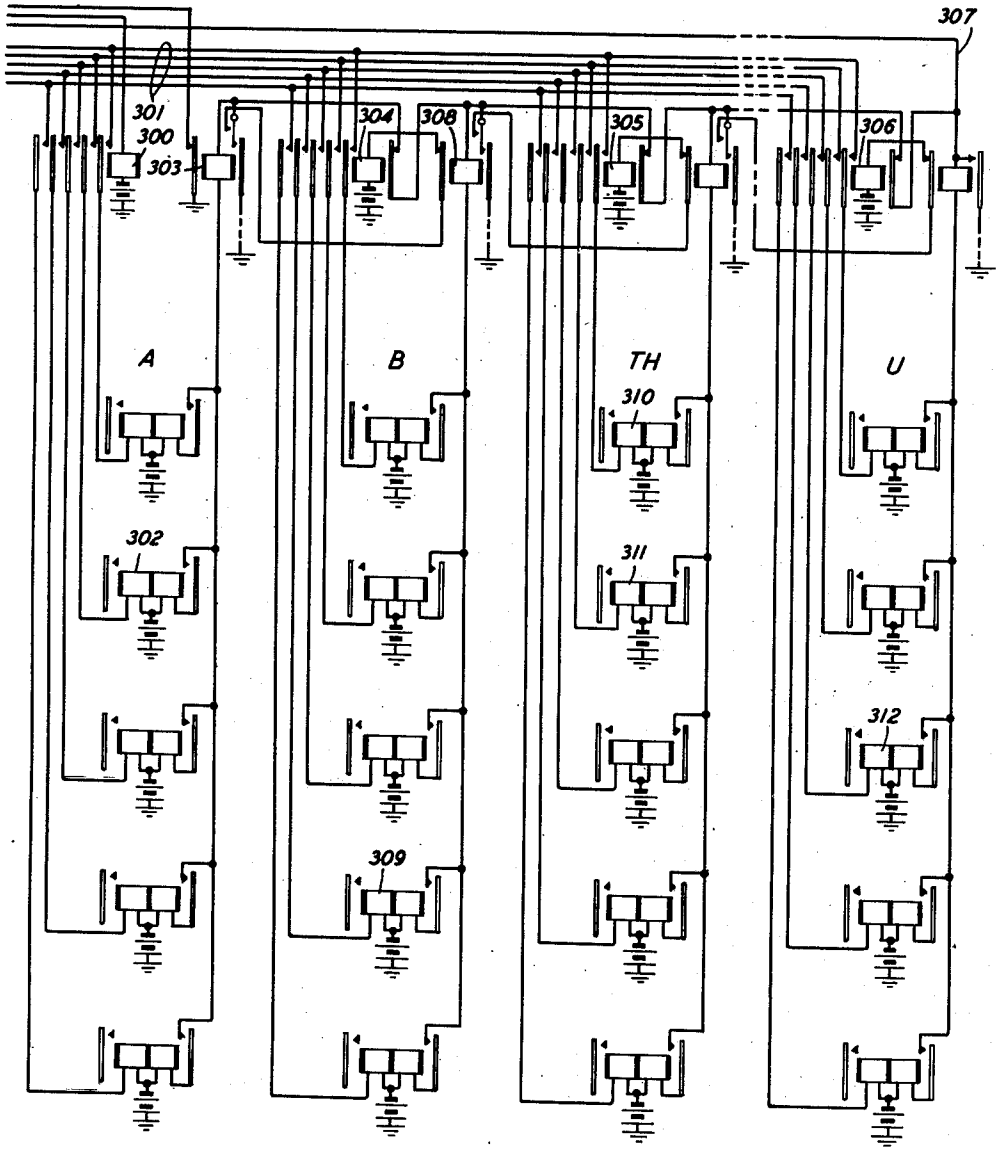
FIG. 5



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UNITED STATES PATENT OFFICE

2,164,335

TELEPHONE SYSTEM

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Application April 13, 1938, Serial No. 201,756

6 Claims. (Cl. 179—16)

This invention relates to signaling and communication systems and particularly to a method and means for transmitting telephone designations from one point to another.

The objects of the invention are to simplify the acts required of subscribers and operators in initiating automatic telephone calls; to increase the speed of telephone designation transmission from one point to another and to otherwise improve automatic telephone systems.

Systems have been proposed heretofore in which the designations of called lines or trunk circuits are transmitted from one point to another by means of alternating currents of different frequencies, which singly or in combination serve to characterize the different numerals or other characters of the designation.

According to the present invention advantages are secured over systems of the prior art by providing the substation of a telephone line with a harmonic generator and with subscriber controlled means for selecting the generated harmonics to characterize the different digits of a wanted number and cause them to be transmitted to the central office to control the operation of automatic switches used in extending a connection from the substation to a called line. The harmonic generator at the substation may be in the form of a toroidal coil wound upon a core of permalloy or other suitable material and may be energized by current of a fundamental frequency generated at the central office. The toroidal coil, or "kick" coil, is provided with a core material of very high permeability at low magnetizing forces, but which saturates sharply at relatively low fields. The harmonic voltages which appear across the coil are therefore large and travel back to the central office where they may be separated from the fundamental frequency and caused to operate the central office equipment. The generated harmonics may be selected by the subscriber by including in the line circuit tuning devices such as condensers, singly or in combinations to characterize the digits of the wanted designations. These harmonics may control selectively operable filter circuits at the central office to selectively operate the central office registors, which in turn control the selective operation of the switches used in the establishment of the desired connection.

The invention will be readily understood from the following detailed description made with reference to the accompanying drawings in which:

Fig. 1 is a schematic representation of the system embodying the features of the invention and enables one to comprehend at a glance the fundamental elements which characterize the system and their relative locations;

Fig. 2 is a block diagram illustrating how the several figures of the drawings are to be combined to form a complete system;

Fig. 3 is a schematic representation of the equipment located at a subscriber's station;

Fig. 4 discloses the central office switches and selective receiving circuits; and

Fig. 5 illustrates the relay register circuits which function with and are controlled by the selective receiving circuits shown in Fig. 4.

Before proceeding to the operation of the system disclosed, a description of the equipment used will be given, including the substation sending mechanism and the receiving and register circuits of the central office.

The subscriber's station, as shown in Fig. 3, is furnished with the usual telephone set **126**, frequency generating and selecting equipment and a transformer **162** which serves to inductively associate the latter equipment with the line circuit during the transmission of telephone designations from the subscriber's station. The frequency generating means **100** comprises a core **99** of permalloy or other suitable material and a coil wound upon the core and connected across that section of the line associated with the winding **163** of transformer **162**. Interposed between one terminal of the transformer winding **163** and a corresponding terminal **98** of the coil of generator **100** is a tuned circuit consisting of the impedance coil **101** and condenser **102**. This combination is tuned to the frequency of the source **200** at the central office. From a point **103** on the coil of the harmonic generator **100** there extends a lead including the impedance coil **161**. Two pairs of tuning circuits, each comprising five separate paths are associated with the coil **161** in such a manner that one of the pairs extends from one end of the coil whereas the other pair is connected to a suitable tap on the coil **161**. Two groups of five tuning circuits are used instead of one group of ten and are connected in the manner shown for the reason that such an arrangement permits more practicable values of capacity to be assigned to the condensers which constitute the individual tuning circuits. The condensers **150**, **151**, etc. are normally on open circuit with respect to the line circuit, each being associated with its respective spring contact of the keyboard sender **120**. The sender **120** comprises ten keys, one for each of the characters of a telephone designation. It is to be understood that the key-

board sender 120 will carry the same numerals and letters as generally appear on the telephone dial in common use today and the numerals and letters are to be arranged in the same combinations employed in the present type dial. More specifically, the first key 105 will carry the numeral 1 to correspond to the digit 1 of a telephone designation; the second key 106 will bear the numeral 2 and the letters ABC; the third key 107 will carry the numeral 3 and the letters DEF and so forth, thus carrying out the pattern of the present dial.

As each key is depressed a corresponding condenser 50, 51, etc., is connected across the line to cause a particular frequency to be selected and transmitted to the central office. Each key also controls a common switching element for a purpose to be set forth hereinafter in greater detail. By actuating several keys in succession, eight keys for an eight digit designation, a corresponding number of different frequencies are transmitted in succession to the central office to control the equipment thereat in a manner to be described hereinafter.

A brief description will now be given of the circuits and other equipment at the central office. The subscriber's lines, each of which is provided with one of the senders or transmitters shown in Fig. 1, extend to the central office and appear in line-finder switches such as the line finder F. The line finder F serves to extend a calling line through to the first selector S and a sender selector switch S—1 serves to extend the calling line to one of the common central office register senders such as the one shown in Figs. 4 and 5. The common register sender includes a number of controlling relays and consists essentially of a frequency detecting and selecting mechanism and a number of relay registers. A source 200 of alternating current of suitable frequency, such as 100 cycles, is provided for supplying the subscriber's line with current to excite the substation transmitter. The alternating currents representing the designations are selected as a group by a filter 201, amplified by an amplifier 202, and applied to a series of individual selective filters 203, 204, 205, etc. The number of digital registers will depend upon the size of the exchange area. It may be assumed, in the present case, that the designations in this particular area consist of two letters and four numerical digits. The letter designations are recorded on the relay registers A and B and the numerical digits are recorded on the four relay registers, two of which, the thousands and units registers, are shown. The intermediate hundreds and tens registers will be the same as those shown and have been omitted for purposes of simplicity. The alternating currents transmitted over the subscriber's line and having frequencies representing the different designation characters are selected by the filters 203, 204, etc., and then cause the operation of the register relays to register these designation characters for further use in controlling the selective switches S, S—2 and S—3 to complete the connection through to the called subscriber's line. For a complete understanding of the operation of the register relays in controlling such switches, reference may be made to Patent 1,862,549, issued June 14, 1932, to R. Raymond et al.

The operation of the system will now be described and for this purpose it will be assumed that the subscriber at station 126 wishes to call the subscriber at station 208. It will be assumed further that the designation of substation 208 is AL—1234 and that the letter A is the equivalent of the numeral 2 and that the letter L is the equivalent of the numeral 5. When the subscriber at station 126 lifts his receiver to initiate the call, the line circuit is closed, and the finder F is started in operation in a well-known manner to seize the calling line. At the same time the sender selector S—1 becomes effective to extend the calling subscriber's line through to an idle sender. When these operations have been completed, a circuit is closed from battery through the left-hand winding of line relay 209 in the sender, over brush 210, contact of spring 211 on a controlling sequence switch, thence over the brush of finder F, over conductor 127 of the subscriber's line through the switchhook contacts, closed springs 116 and 118, conductor 129 and returning over conductor 130, through the upper brush of finder F and sequence switch contact 212, brush 213 of sender selector S—1 to ground in the sender. The sequence switch referred to herein may be of the type well known in automatic systems of the kind in which panel selector switches are used. The line relay 209, which is not responsive to current from the alternating current source 200, operates in response to the flow of direct current in the circuit just traced and closes an obvious circuit for the slow-release relay 214. Relay 214 closes an obvious circuit for relay 300 (Fig. 5) and the latter relay operates and extends the register operating conductors 301 through to the windings of the relays of the first code register A preparatory to the operation of these relays. At the same time a tone is sent from the tone device 215 to notify the calling subscriber that the central office equipment is ready to receive the wanted designation.

The calling subscriber now manipulates the key 106 which characterizes the first letter A in the designation of the called subscriber. Key 106 actuates the common rod 131 and connects the condenser 151 across the winding 163 of transformer 162 in series with the left-hand portion of coil 161 and that portion of the coil of generator 100 included between terminal 97 and tap 103. At the same time the rod 131 separates springs 116 and 118 and connects the latter to spring 117 to close the winding 164 of transformer 162 so that the circuit extending from the central office now leads by way of conductor 127, through the coil 164, conductor 132, through the closed springs 117 and 118, conductor 129 and over conductor 130 as previously traced. The springs 116, 117 and 118 are so arranged that the continuity of the line circuit is preserved while the generator 100 is being introduced into the line circuit. Alternating current from the source 200 flows over this circuit and through the coil of generator 100. As previously stated the current generated by the source 200 has a frequency of 100 cycles though the invention is not limited to this particular frequency. The harmonic generator 100 now being excited by the fundamental frequency of 100 cycles functions to generate the harmonics of this fundamental frequency. The condensers 150, 151, 152, to 159, inclusive, are tuned to the odd harmonics F_1, F_3, F_5, etc. The actuation of key 106 results in the selection of the frequency F_3 which is now transmitted back over the line circuit and is applied to amplifier 202 by way of filter 201 and thence to the input circuits of the several filters connected to the common circuit 216. There are as many of these

filters as there are keys at the subscriber's station and the several filters are selectively designed to pass the frequencies corresponding to the respective keys at the substation. Therefore, the frequency F_3 in the circuit 216 resulting from the actuation of key 106 is selectively passed by filter 204 and is excluded by all other filters connected to the calling line.

Current passing through the filter 204 and amplified, if necessary, causes the operation of relay 217. This relay 217 operates common relay 218 and also relay 219. Relay 219 locks in a circuit from battery through its winding and left contact, through the make-before-break contact of relay 218 to ground at the back contact of relay 220. Relay 219 at its right contact connects ground over conductor 221 through a contact of relay 300, Fig. 5, to battery through the left-hand winding of relay 302. Relay 302 operates to register the digit and prepares to lock in a circuit which will be described presently. When the key 106 is released by the subscriber, contacts 116, 117 and 118 restore to normal and the generator 100 is removed from the line circuit. Current therefore ceases to flow in the filter circuit 204 and relay 217 releases, in turn releasing relay 218. Relay 218 in releasing, closes its normal contacts before opening its front contacts. Therefore, before the locking circuit of relay 219 is opened to permit the release of this relay, a holding circuit is closed as follows for the register relay 302; battery through the right winding and contacts of relay 302, winding of relay 303, right normal contacts of relays 304, 305 and 306, conductor 307, normal contacts of relay 218 to ground at the contact of relay 220. Relay 302 locks in this circuit and relay 303 operates. When relay 218 fully releases, it opens the locking circuit of relay 219, and the latter relay releases. Relay 303 releases relay 300 to disconnect the common leads 301 from register A. Relay 303 also closes an operating circuit for relay 304. This circuit may be traced from battery through the winding of relay 304, normal left contact of relay 308 to ground at the contacts of relay 303. Relay 304 operates and extends the leads 301 through to the register B. The operated register relay 302 and relay 303 are now held in a circuit extending to ground through the front contacts of relay 303. The equipment is now in readiness for the receipt of the second digit of the called designation.

When the subscriber manipulates key 109 to transmit the second letter L, the condenser 154 is connected in the circuit in the same manner as was condenser 151 upon the actuation of key 106 and the generator 100 is introduced into the line circuit. The connection of condenser 154 in the line circuit causes a different one of the frequencies generated by the device 100 to be selected and transmitted over the line circuit to the central office. This frequency characterizes the digit 5, or the letter L of the assumed designation and is passed by the selective network 207 and relays 222, 223 and 218 operate. Relay 223 locks as above described and applies ground to the common conductor 224, which now extends through the corresponding contact of relay 304 to operate the register relay 309 of register B. When the subscriber releases the key 109, the generator 100 is removed from the circuit and the relays 222 and 218 release. Relay 218 in releasing closes a locking circuit for relay 309 traceable from the right winding and contact of said relay, winding of relay 308, thence as previously traced over conductor 307 to ground. Relay 309 locks and relay 308 operates in this circuit before the holding circuit of relay 223 is broken. On the full release of relay 218, the holding circuit of relay 223 is open and the latter relay releases. Relay 308 in operating causes the release of relay 304 to disconnect the leads from the register B. Relay 308 also closes an obvious circuit for the operation of relay 305 which extends the leads 301 through to the relays of the thousands registers Th. The operated register relay 309 and relay 308 now hold in a circuit extending to ground through the right contacts of relay 308.

In a similar manner the depression of the keys corresponding to the four numerical digits causes the operation of relays of the thousands, hundreds, tens and units registers. The depression of key 105 for the thousands digit 1 produces a current of a definite frequency in the common circuit 216 which is passed by the filter 203 to cause the ultimate operation of register relay 310 of the thousands register. The actuation of key 106 for the hundreds digit 2 causes the operation of a relay in the hundreds register corresponding to the relay 311 of the thousands register. The manipulation of key 107 for the tens digit 3 produces a current of definite frequency in the common circuit 216 which is passed by the filter 205. Relay 230 thereupon operates causing relay 231 to operate and apply ground potential to conductors 221 and 232 leading to the tens register. This results in the operation of two relays of the tens register corresponding to relays 310 and 311 of the thousands register. Finally the actuation of key 108 for the units digit 4 causes the operation of units register relay 312.

In a manner well known in the art and as fully disclosed in the hereinbefore-identified Raymond et al. patent, the operated register relays now serve to control the selective operations of the switches S, S—2 and S—3 to complete the extension of the calling line through to the called line 208. Thereafter, the register sender is restored to normal and the parties converse with each other. At the end of conversation release of the switching equipment takes place in the well-known manner.

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 given frequency at a 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, and means at said station for selecting the generated harmonics for transmission to the central office.

2. The combination in a signaling system of a line having a station thereon, a source of alternating current of a given frequency at a central office, means for connecting said source to the line to apply current thereto, means at said station responsive to current from said source to generate harmonics of the given frequency and reflect them into said line, means controlled by the subscriber at said station for causing certain of the generated harmonics to be successively transmitted to said central office to characterize the characters of a telephone designation, and means at said central office selectively responsive to the transmitted harmonics.

3. The combination in a signaling system of

a line having a station thereon, a source of alternating current of a given frequency at a central office, means responsive to the initiation of a call at said station for connecting said source to said line, a designation sender at said station, a coil at said station having a core material of very high permeability at low magnetizing forces and which saturates at relatively low fields, means at said station for introducing said coil into said line circuit to be excited by current from said source and generate harmonics of the given frequency, said means functioning to simultaneously introduce into said line circuit other means for selecting a particular one of the generated harmonics and cause it to be transmitted to the central office, and means at the central office selectively responsive to the transmitted harmonic.

4. The combination in a signaling system of a line having a station thereon, a source of alternating current of a given frequency at a central office, means responsive to the initiation of a call at said station for connecting said source to said line, a harmonic generator at said station responsive to current from said source for generating harmonics of the given frequency, a tuned circuit for each of a given number of the generated harmonics, and means at said station for repeatedly connecting said generator to said line and for successively associating said tuned circuits with said line to cause corresponding harmonics to be selected and transmitted to said central office, and means at said central office selectively responsive to the transmitted harmonics.

5. The combination in a telephone system of a line having a station thereon, a source of alternating current and means for connecting the same to said line, a harmonic generator at said station responsive to current from said source for generating harmonics of the frequency of said source, a tuning circuit including a variable reactance associated with said generator, manually operated means at said station for including variable amounts of said reactance in circuit with said generator to variably tune said tuning circuit to the frequencies generated by said harmonic generator, means for coupling said tuning circuit to said line to produce in the line currents having frequencies determined by said variable reactance, and means controlled by the currents in said line for registering the designations of telephone subscribers.

6. The method of transmitting telephone designations from one point to another which comprises generating at one point a fundamental frequency, utilizing the fundamental frequency at the other point to generate harmonics of the fundamental frequency, selecting the generated harmonics in a manner to characterize the characters of the telephone designation, transmitting the selected harmonics to said first point and registering them thereat.

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