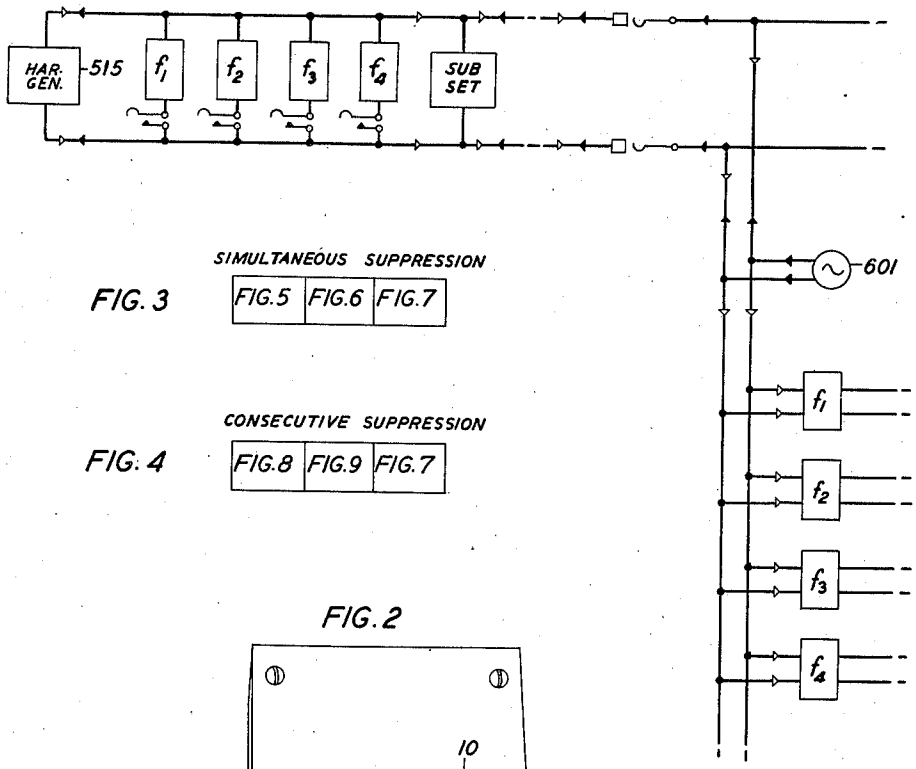
May 21, 1940. A. A. LUNDSTROM ET AL 2,201,296

TELEPHONE SYSTEM

Filed Oct. 18, 1938 6 Sheets-Sheet 1

FIG. 1



SIMULTANEOUS SUPPRESSION

FIG. 3

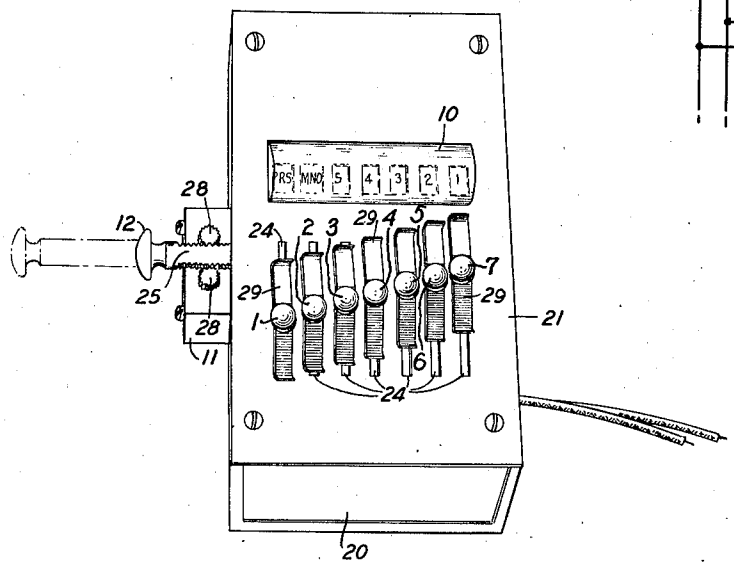
FIG. 5	FIG. 6	FIG. 7

CONSECUTIVE SUPPRESSION

FIG. 4

FIG. 8	FIG. 9	FIG. 7

FIG. 2



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TELEPHONE SYSTEM

Filed Oct. 18, 1938 6 Sheets-Sheet 2

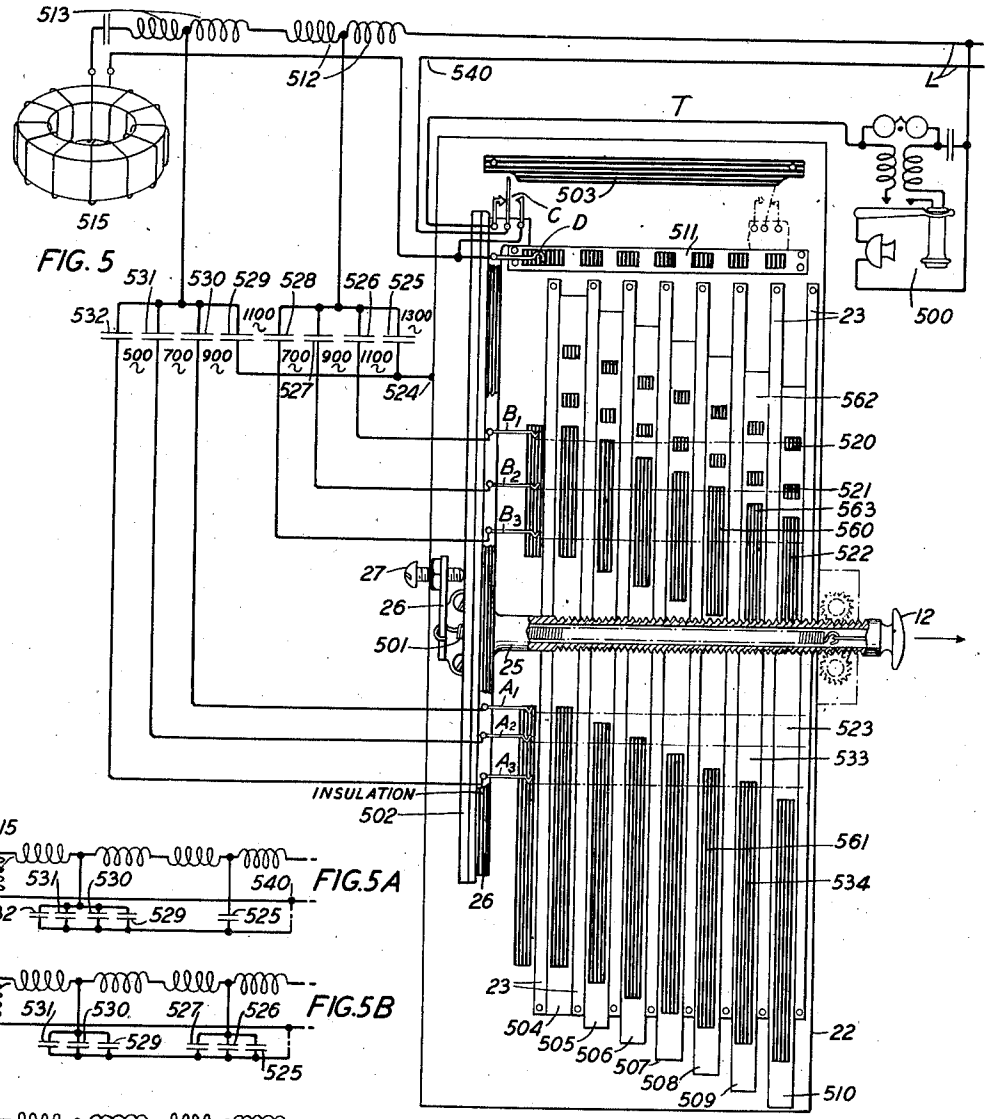

FIG. 5

FIG. 5A

FIG. 5B

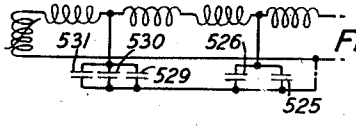

FIG. 5C

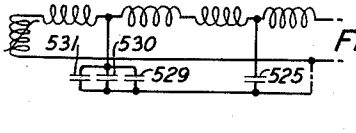

FIG. 5D

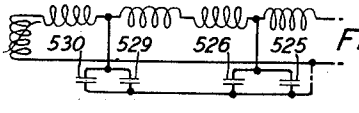

FIG. 5E

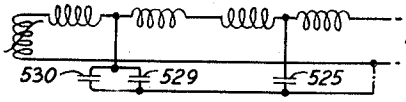

FIG. 5F

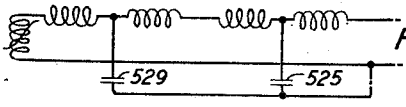

FIG. 5H

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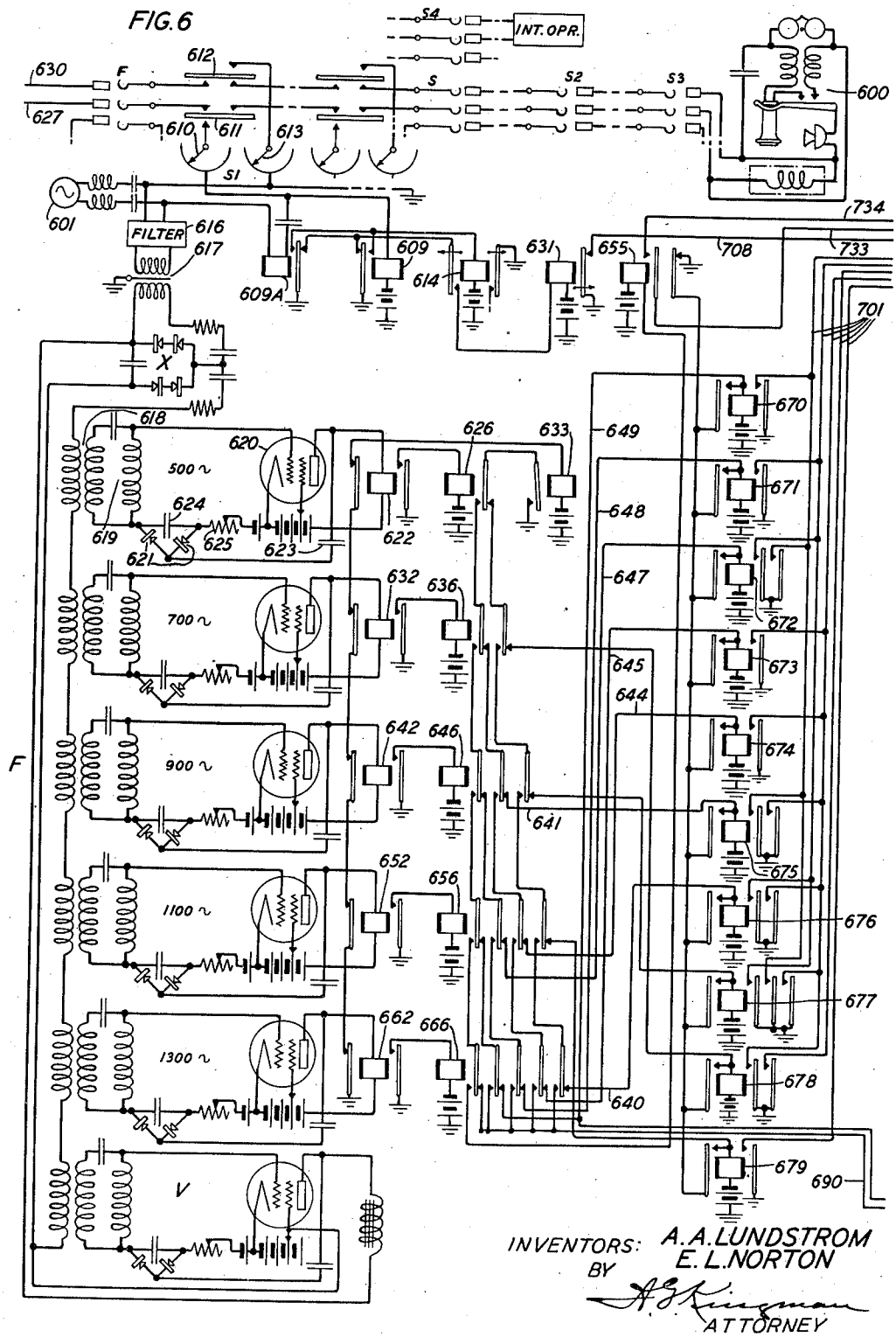
TELEPHONE SYSTEM

Filed Oct. 18, 1938 6 Sheets-Sheet 3

FIG. 6



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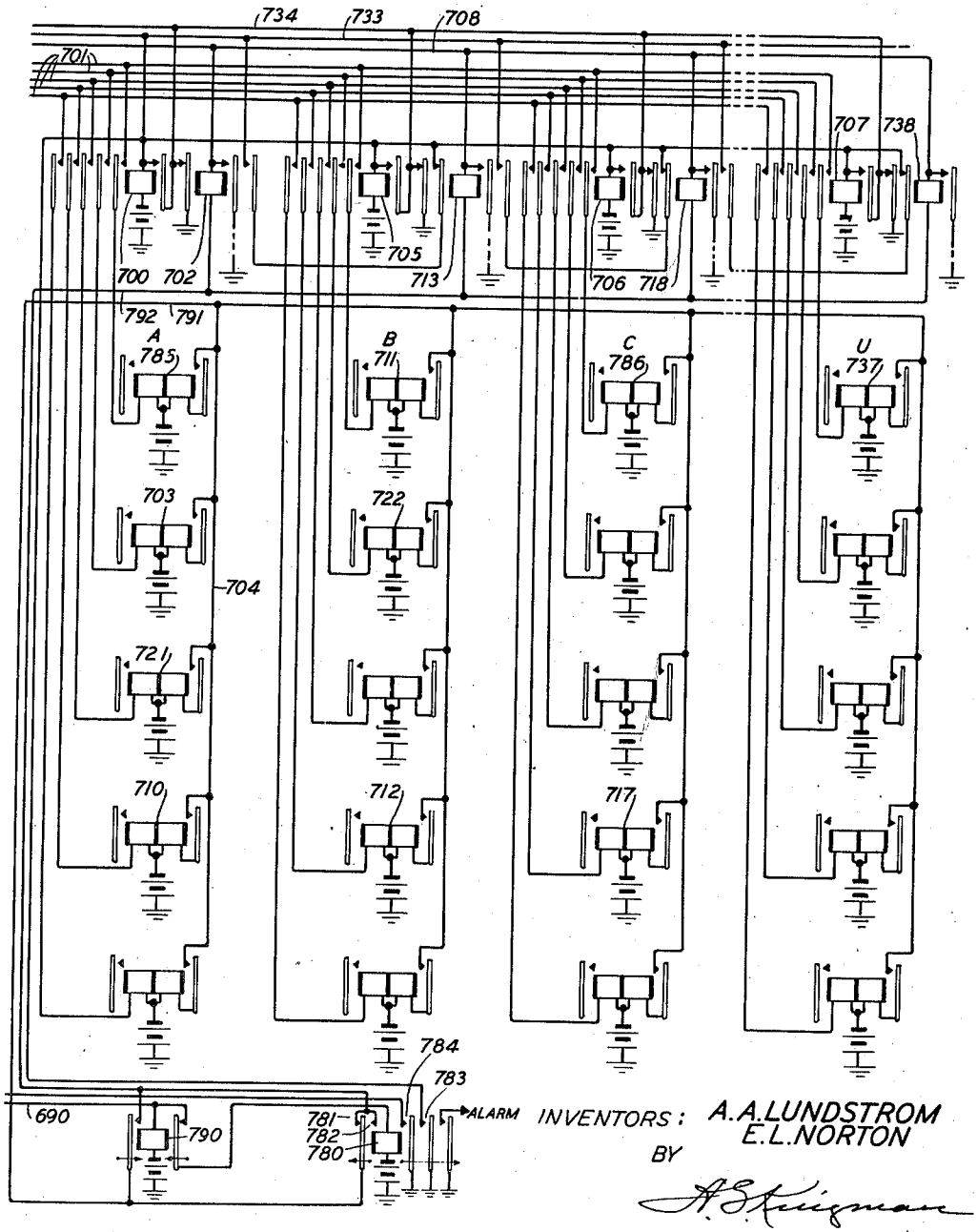
TELEPHONE SYSTEM

Filed Oct. 18, 1938 6 Sheets-Sheet 4

FIG. 7.



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TELEPHONE SYSTEM

Filed Oct. 18, 1938 6 Sheets-Sheet 5

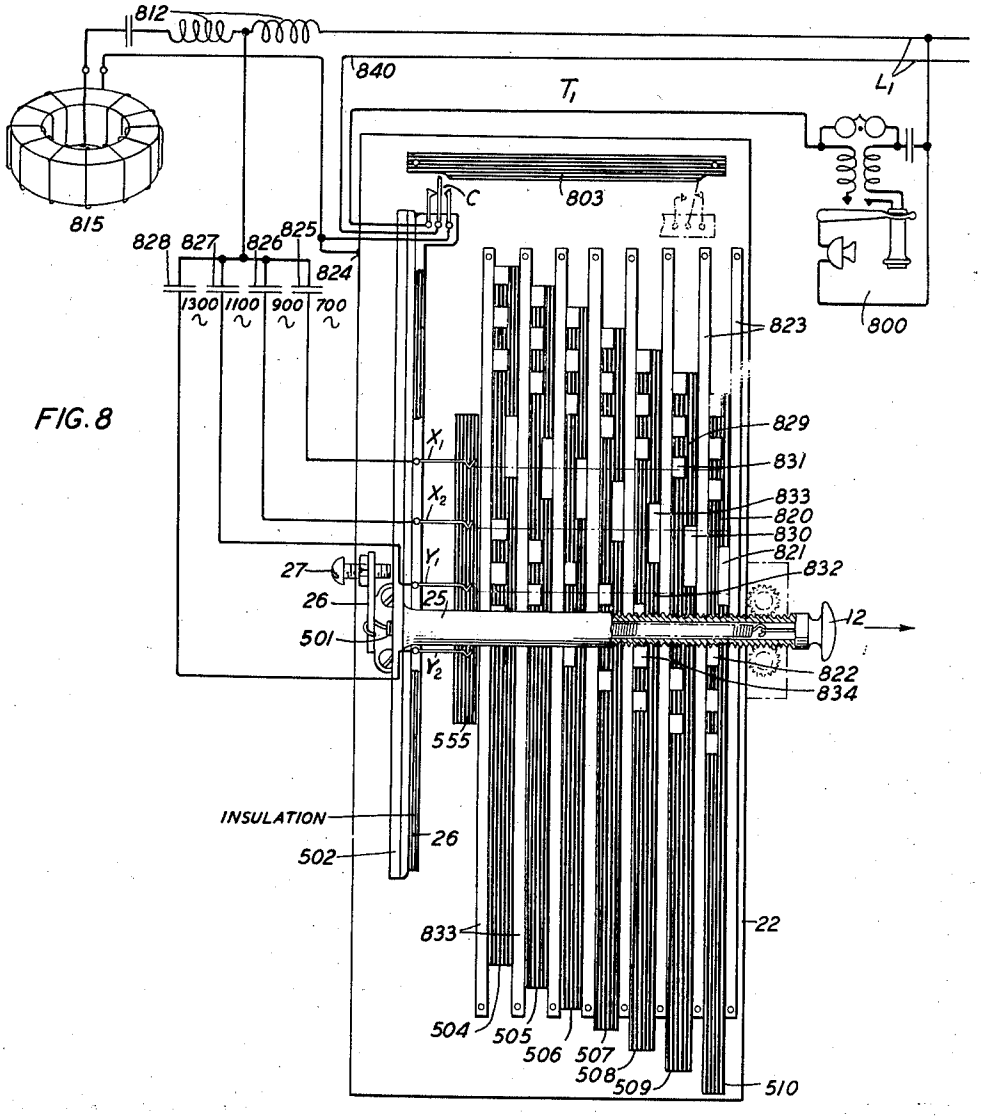

FIG. 8

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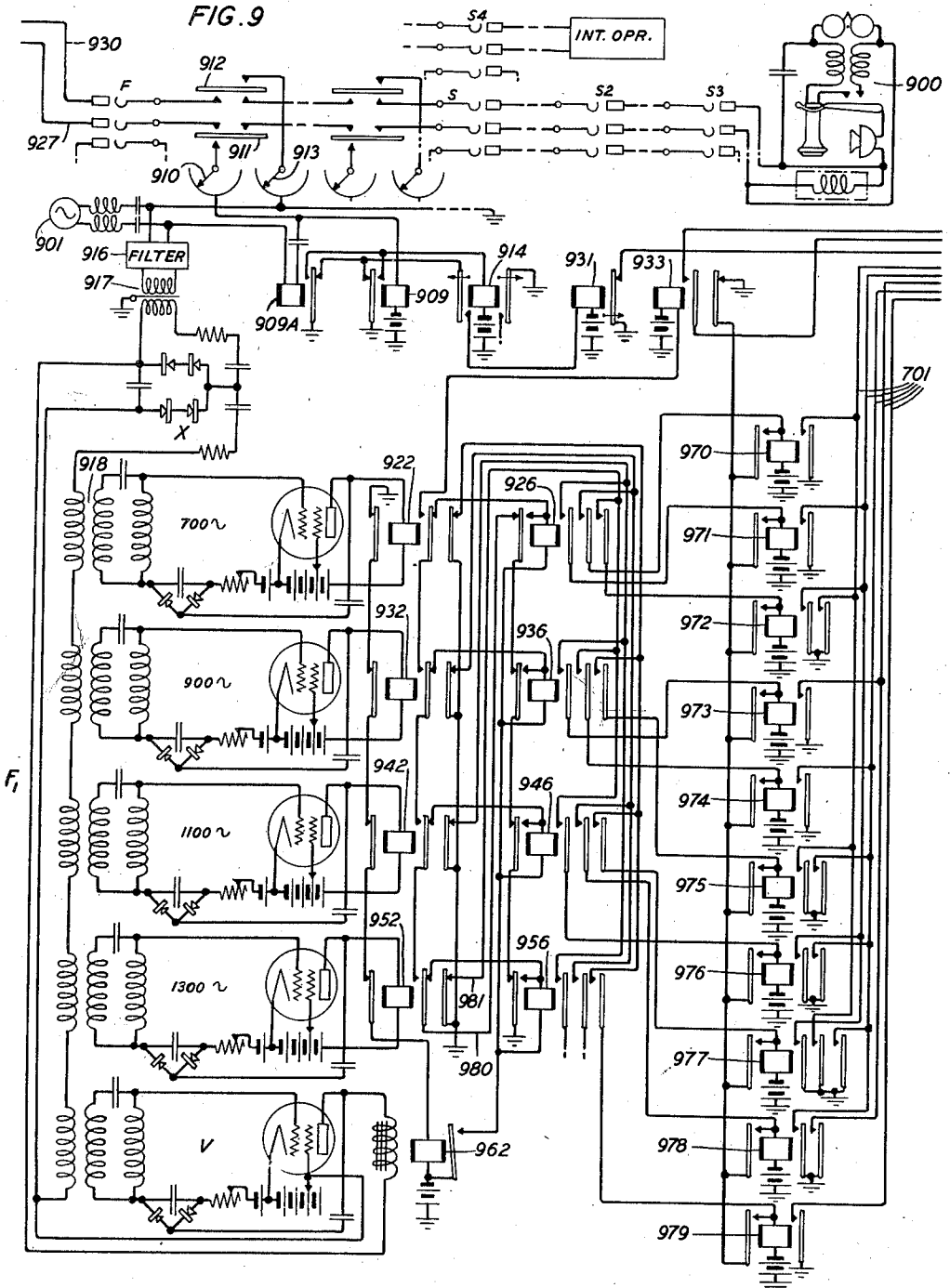
TELEPHONE SYSTEM

Filed Oct. 18, 1938 6 Sheets-Sheet 6

FIG. 9



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Patented May 21, 1940 2,201,296

UNITED STATES PATENT OFFICE

2,201,296

TELEPHONE SYSTEM

Alexis A. Lundstrom, East Orange, and Edward L. Norton, Summit, N. J., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application October 18, 1938, Serial No. 235,548

13 Claims. (Cl. 179—16)

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

The objects of this invention are to simplify the transmission and registration of signals, such as telephone designations and to decrease the time interval heretofore consumed in transmitting such signals from one point, such as a subscriber's station, to another point, such as a central office.

Systems have been proposed heretofore in which the designations of called lines and the like are transmitted from one point to another by means of alternating currents of different frequencies, the frequencies transmitted singly or in combinations characterizing the different digits or other characters of the designation. In Patent 2,164,335 issued July 4, 1939 to R. C. Mathes, there is disclosed a system of this general character in which a harmonic generator is employed at the subscriber's station and is activated by current of a fundamental frequency generated at the central office to produce harmonics of the fundamental frequency, and in which the subscriber is furnished with means for selecting certain of the generated harmonics to characterize the digits of a telephone designation and cause the selected harmonics to be transmitted to the central office to control the operation of automatic switches.

According to the present invention improvements over prior systems are obtained by providing the substation of a telephone line with a harmonic generator and with other means controlled by the subscriber for suppressing the generated harmonics in various combinations. The harmonic generator which is of the type disclosed in the above-identified patent may be activated by alternating current of a base frequency supplied over the line circuit from the central office. The suppressed frequencies characterize the different digits of a designation and when suppressed in a manner to be more fully explained hereinafter, serve to control the release of translating devices normally selectively responsive to the suppressed frequencies in a characteristic manner to effect the registration of the designation.

In accordance with one embodiment of the invention each digit of a telephone designation is characterized by two frequencies and the two frequencies are suppressed simultaneously, whereas, in a preferred form of the invention the two frequencies which characterize the digits are suppressed consecutively.

A feature of the invention resides in the particular structure of the designation sender with which each subscriber's station is equipped. These senders are of the preset design which may be operated with ease by the calling subscriber and which display the called number set up by the subscriber, thereby insuring against the "dialing" of wrong numbers.

Another feature of the invention resides in controlling the volume of the designation signals received at the central office. This feature obviates the necessity for a higher degree of suppression of the frequencies on short line loops than on line loops of greater lengths and insures a substantially uniform signal volume at the central office regardless of the length of line over which the frequencies are normally transmitted.

These and other features of the invention will be described more fully in the following specification.

In the drawings accompanying this specification:

Fig. 1 constitutes a diagrammatic representation in skeletonized form of the essential equipment employed at the subscriber's station and at the central office and illustrates at a glance, the general operation of the system embodying the features of the invention. In this figure the direction of the fundamental frequency current from source 601, as the case may be, is indicated by the full arrow heads whereas the path for the frequencies generated by the harmonic generator 515 at the subscriber's station is indicated by the open-head arrows;

Fig. 2 is a view of the designation sender with which each subscriber's station is equipped and on which a calling subscriber may set up telephone designations and subsequently cause said designations to be transmitted to a central office to control automatic switches employed in completing connections from the calling station to any desired called station;

Fig. 3 is a block diagram illustrating the manner in which the drawings which disclose one embodiment of the invention are to be assembled to effect a complete system. In the system made up of the drawings shown in block in Fig. 3, each digit or character of a telephone designation is characterized by two frequencies which are suppressed simultaneously;

Fig. 4 is a block diagram illustrating the manner in which the drawings which disclose another embodiment of the invention are to be as-

sembled to effect a complete system. In the system made up of the drawings shown in block in Fig. 4, each digit or character of a telephone designation is characterized by two frequencies which are suppressed consecutively. It will be noted that Fig. 7 is common to both systems;

Fig. 5 is a diagrammatic representation of the equipment located at a subscriber's station. In this drawing there is illustrated the mechanical structure of that portion of the designation sender shown in Fig. 2 which functions to selectively suppress the frequencies generated by the device 515 and the manner in which it fits into the subscriber's line circuit;

Figs. 5A, 5B, 5C, 5D, 5E, 5F and 5H illustrate the circuit conditions effected by the designation sender of Fig. 5 when the latter has been set to transmit the telephone designation SO–5–4321;

Fig. 6 is a circuit diagram illustrating schematically the central office switches and the receiving equipment employed in that embodiment of the invention wherein the selected frequencies are suppressed simultaneously;

Fig. 7 is a circuit diagram illustrating the central office registers into which the circuits of Fig. 6 and Fig. 9 work and which serve to register the designations transmitted from the subscribers' stations by the designation senders shown in Fig. 5 and Fig. 8;

Fig. 8 corresponds to Fig. 5 and shows the equipment at the subscriber's station which functions to select and suppress consecutively the frequencies which characterize the characters or digits of a telephone designation; and

Fig. 9 corresponds to Fig. 7 and represents the central office receiving circuits used when the selected frequencies are suppressed consecutively.

The system shown in the drawings is abbreviated to a considerable extent, all parts not essential to a complete understanding of the invention being omitted for the sake of clearness and brevity. The invention relates particularly to the transmission of wanted designations over a telephone line or circuit for the purpose of controlling the selective operations necessary to complete the corresponding connections to subscribers' lines, to operators' positions or to other stations. It is therefore applicable to a wide variety of types of communication systems and particularly to those of the kind in which register mechanisms are employed at the central office for registering the designations transmitted and for controlling the selective operation of automatic switches to complete the 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 the well-known step-by-step switches or switches of the cross-bar type.

Referring to the drawings, a subscriber's line is shown appearing in the contact bank of the line-finder switch F. The subscriber's line L, Fig. 5 or L_1, Fig. 8, is equipped at the substation with a designation transmitter T or T_1, which is designed to suppress the frequencies generated by the generator 515 or 815, the frequencies selected for suppression either simultaneously or consecutively, being chosen to represent the different letters or numerals constituting a wanted designation. The suppression of these frequencies control the operation of receiving equipment at the central office in such a manner as to cause the desired designation to be registered on the registering equipment at the central office.

The line finder F is joined to a first or district selector S and these two switches together constitute a link for extending subscribers' lines to trunks leading to an incoming selector S—2. The selector S—2 in turn has access to a final selector S—3 which serves to complete the connections to called subscribers' lines. One of these lines is shown appearing in the terminals of the final selector S—3.

The line finder and district link have access through a sender-selector switch S—1 to any one of a number of common register-sender mechanisms. Figs. 6 and 7, and 9 and 7, disclose in detail some of the essential parts of these register senders. 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 code registers and the numerical part of the designation usually requires four registers. In the present system three office code registers A, B and C are shown. Also the units numerical register U is shown, it being understood that the thousands, hundreds and tens registers would be provided and inserted between the units register U and the office register C as illustrated in Fig. 7 by the broken lines. These registers, each of which comprises five register relays, are operated, to register the corresponding parts of a designation, by means of the frequency selecting circuits F or F_1. These frequency selecting circuits are explained more fully in a later description.

Before proceeding with a description of the operation of the systems of Figs. 3 and 4, the designation sender located at the subscriber's station will be described.

Referring particularly to Figs. 2 and 5 the designation sender comprises essentially a casing 20 which is rectangular in shape and has a capacity sufficiently large to house the several condensers employed in suppressing the generated harmonics and the harmonic generator 515 which consists of a core of permalloy or other suitable material and a coil wound upon the core. A cover 21 is secured to the casing 20 in any suitable manner, as for example, by screws as illustrated. Secured to the under side of the cover is a metal plate 22 (Fig. 5) to which there are secured, in any suitable manner, guide strips 23. In Figs. 5 and 8 there are shown eight such strips. Each strip is made of insulation and has a T-shaped cross-section. The over-hanging portions of adjacent strips 23 cooperate in forming a confining space or slot into each of which is slidably fitted a commutator bar such as bars 504, 505, etc. The commutator bars are of metal and on the surfaces thereof exposed in Fig. 5, there are inserted the insulating segments 520, 521, 522 and 534. These segments are so proportioned and positioned on the bars as to form a definite prearranged pattern. The pattern is the same for each bar. Integrally associated with each bar is a vertically extending pin or its equivalent which are screw-threaded at their upper ends to provide for the mounting of the knobs 1 to 7, inclusive. The vertically extending pins protrude through slots in the plate 22 which are in alignment with and of the same dimensions as the slots 24 in the cover 21. It will be observed from the description so far advanced, that each of the commutator bars 504, 505, etc. may be slidably moved

in its respective guide formed by two adjacent insulating members 23 by the subscriber grasping a corresponding knob 1 to 7 and pulling it downwardly. Each knob is provided with a substantially V-shaped compression spring 29 which tends to force the corresponding knob away from the casing cover 21 thereby insuring good contact between the under side of the commutator bars 504, 505, etc. and the plate 22 upon which they slide. On the surface of each bar opposite to the surface bearing the insulating segments is a series of characters which correspond to the characters appearing on the number plate of the subscriber's dial in general use today. Immediately above the slots 24 in the cover 21 are a series of windows which coincide with corresponding openings in the plate 22. There is one window for each bar 504, 505, etc. so that for each setting of the knobs 1 to 7 a particular character will appear in the corresponding windows. The windows are covered with any suitable transparent material 10. In this manner any designation a subscriber sets up on the designation sender appears in the windows as a check, thereby minimizing the possibility of a subscriber "dialing" a wrong number.

Extending transversely of the casing 20 and mounted in any suitable manner on the under side of the cover 21, as for example, by means of brackets depending from the cover and apertured to receive it, is a hollow rod 25 provided at one end with a hand grip or knob 12. At the other end of the rod there is secured an elongated brush carrying arm 502 provided with an insulating member 26 upon which are mounted the brushes B_1, B_2, B_3, A_1, A_2, A_3, D and the contact springs C. Internally of the knob end of the rod 25 is secured one end of a coil spring 501, the other end of which is fastened to the bracket 26 secured to the plate 22 by means of screws. The bracket 26 also carries a screw 27 which serves as a stop against which the brush carrying arm 502 abuts when in its normal position. When the rod 25 is moved to the left (Fig. 2), or to the right (Fig. 5), the spring 25 is elongated so that when the rod is released it is returned to normal under the action of the spring. The rod 25 is threaded, or grooved on opposite sides and travels between the gears 28 which cooperate with a damping device of any suitable design housed in the smaller casing 11. The speed of the rod 25 during its return travel under the influence of spring 501 is accordingly governed.

Immediately above the insulating strips 23 there is rigidly fixed to the plate 22 a transverse commutator bar 511 over which the brush D wipes as the rod 25 is manipulated. It is to be understood that the metal portion of the bar 511 is in electrical contact with the plate 22 as are also the under surfaces of the commutator bars 504, 505, etc.

An insulating bar 503 is secured at the upper end of the plate 22 and is so positioned relative to the contact springs C that as the rod 25 is moved to the right (Fig. 5), the longer of the springs is engaged by the bar 503 and maintained out of engagement with its alternate spring until the rod reaches its extreme right (Fig. 5) position and then when the rod is released the longer spring is caused to break the normal spring after engaging its alternate spring and is held in contact therewith during the return movement of the rod 25. The normally closed contact of the contact springs C controls the connection and disconnection of the subset 500 to and from the line. In the normal position of the contacts of springs C the subscriber's set is connected to the line circuit. During the return travel of the brush carrying arm 502 the substation is disconnected from the line and the designation sending equipment effectively associated therewith.

The brushes A_1, A_2, A_3, B_1, B_2 and B_3 are adjusted so that as the bar 25 and its associated brush-carrying arm 502 travel back and forth, they wipe over the commutator bars 504, 505, etc. for a purpose to be fully explained hereinafter.

Except for the omission of the commutator bar 511, the pattern of the individual commutator bars 504, 505, etc. and the number of brushes carried by the brush carrying arm 502, the designation sender disclosed in Fig. 8 is identical with that of Fig. 5 as just described.

After a particular designation has been set up on the designation senders of Figs. 5 and 8, the knob 12 is pulled to the right (Figs. 5 and 8) to its extreme position. The brushes A_1, A_2, A_3, B_1, B_2, B_3 (or the X and Y brushes) wipe over the commutator bars 504, 505, etc. but no circuit functions are performed since the contact springs C are maintained in their normal positions, these springs serving when operated to effectively associate the designation sender with the subscriber's line circuit after removing the subscriber's talking circuit from the line. When the knob 12 is released, the rod 25 and its associated brush carrying arm 502 returns to normal under the action of spring 501 at a definite speed determined by the governor contained in the housing 11. The brushes A_1, A_2, A_3, B_1, B_2 and B_3 accordingly wipe over the commutator bars 510, 509, etc. in that order and since the contact springs C are now operated the tuning of the line circuit is varied in accordance with the pattern of the commutator bars wiped over by the brushes and certain frequencies are suppressed in various combinations of two frequencies to characterize the digits of the designation set up by the subscriber on his designation sender.

It is apparent that the designation sender is capable of other structures than the one disclosed and it is to be understood that applicants do not intend that their invention be limited to the particular design of sender disclosed.

The operation of the system involving the designation sender shown in Fig. 5 which functions to suppress, simultaneously, two frequencies for each digit of a telephone designation will now be described and for this purpose it will be assumed that the subscriber at station 500 (Fig. 5) wishes to call the subscriber at station 600 (Fig. 6). It will be assumed further that the designation of substation 600 is SO–5–4321.

Since the designation sender at station 500 is of the preset type, the calling subscriber proceeds to set up the designation SO–5–4321 by manipulating the knobs 1 to 7 shown in Fig. 2 until the desired number appears in the windows located above the knobs and which are covered by the transparent material 10. The knob 1 is pulled downwardly until the letters "PRS" appear in the window immediately above the knob 1; the knob 2 is similarly actuated until the letters "MNO" appear in the window immediately above the knob 2; the knob 3 is next manipulated until the numeral "5" appears in the window immediately above the knob 3; the knobs 4, 5, 6 and 7 are actuated in similar manners to cause the appearance of the numerals "4", "3", "2" and "1" in the windows immediately above these knobs. When the knobs are set accurately there is in

evidence before the subscriber a record of the number about to be transmitted to the central office. Any error in setting up the number may be corrected by correctly positioning the knob or knobs which may have been incorrectly set. In this manner the subscriber has definite assurance that she has not "dialed" a wrong number.

With the knobs 1 to 7 set as above described, the commutator bars 504 to 510 inclusive, will have been positioned as shown in Fig. 5.

The subscriber at station 500 now lifts the receiver from its switchhook to initiate the call. The subscriber's line circuit is accordingly closed in the well-known manner and the line 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 winding of line relay 609, Fig. 6, in the sender, over brush 610, contact of spring 611 on a controlling sequence switch, thence over the brush of finder F, over conductor 627 of the subscriber's line to the point 540 through the normal contact of springs C, through the switchhook contacts at station 500, returning over conductor 630, through the upper brush of finder F and sequence switch contacts 612, brush 613 of the 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 609 operates in this circuit and closes an obvious circuit for the slow-release relay 614. At the same time the 100 cycle tone is sent from the source 601 and serves to notify the calling subscriber that the central office equipment is ready to receive the wanted designation.

The calling subscriber now pulls the rod 12 (Fig. 2) of the designation sender to the extreme left and releases it. Under the action of coil spring 501 (Fig. 5) the rod is returned to its normal position, its return speed being governed by the governor enclosed in the casing 11 (Fig. 2).

With particular reference to Fig. 5, it will be noted that when the rod 12 is moved to the right (as viewed in Fig. 5, this figure being a view looking at the underside of the commutator bars included in the designation sender) the brush carrying arm 502, which is integrally associated with the rod 12, experiences a similar movement. The arm 502 carries the two groups of brushes A_1, A_2 and A_3, B_1, B_2 and B_3, the brush D and contact springs C. The contacts C are a make-before-break transfer which normally has the harmonic generator and filter circuit open and the subscriber's talking circuit closed onto the line. When the arm 502 is pulled to the extreme right (Fig. 5) the springs C operate to transfer the line from the talking circuit to the designation sender. As the rod 12 and its associated arm 502 is moved from right to left, looking at Fig. 5, the brushes A_1, A_2, A_3, B_1, B_2 and B_3 wipe over the segments of the commutator bars 504 to 510, inclusive, but no circuit functions are performed at this time owing to the fact that the contact springs C are not operated. During this motion of the bar 502, the longer spring of the set C engages the beveled portion of the member 503 and wipes over the lower edge thereof to insure the springs of set C being held normal until the arm 502 reaches its extreme right-hand position. Just prior to reaching this position, the longer spring of set C moves off the member 503 and as the arm 502 starts its return movement under the action of coil spring 501, this spring is actuated by the member 503 to cause the transfer of the contacts C and maintain them operated during the return movement of the brush arm. During the signaling period, supervision is maintained by using an extra line relay 609A which is capable of being actuated by the 100 cycle current. This is necessary because during this period the transfer spring C of Fig. 5 will have opened the direct current circuit from relay 609.

As the arm 502 moves to the left on its return movement (Fig. 5), the two sets of brushes A_1, A_2, A_3 and B_1, B_2, B_3 wipe over the commutator bars 510, 509, 508, 507, 506, 505 and 504 in that order. The brush D in like manner wipes over the segments of the strip 511, which, like the member 503 is rigidly fixed. The strip 511 consists of alternate conducting and insulating segments, or more accurately, of a conducting bar upon which insulating segments are placed at spaced intervals.

Reverting back to the central office equipment at this time, it will be noted that when the finder F associated the calling line with the sender selector S—1, the alternating current source 601 was connected to the brushes 610 and 613 of the sender selector which, as already described, are now connected to the calling line. Accordingly, when the calling subscriber releases the knob 12 and the alternate contact of springs C is closed, current from the source 601 travels out over the line circuit, through the coils 512 and 513 at the subscriber's station and thence through the winding of the harmonic generator 515. The frequency of the source 601, as stated before, is assumed to be 100 cycles though the invention is not limited to this particular frequency. The source 601 delivers the 100 cycles through a series circuit tuned to 100 cycles for the purpose of placing a pure tone on the line and isolating the generator from the line circuit so that it can be used with other sender circuits. The harmonic generator 515 is accordingly energized by current from the source 601 and functions to generate the harmonics of the base frequency (100 cycles) of the central office source 601. These generated frequencies thereupon are reflected back into the line circuit and travel back to the central office where they pass through the base frequency elimination filter 616, shielded transformer 617, through circuit X and thence through the primary winding sections of transformer 618. Associated with each section of the primary winding of transformer 618 is a frequency receiving channel consisting of a secondary winding of the transformer 618, a series tuned circuit such as 619, a single vacuum tube such as 620 with feedback through the copper-oxide units such as 621 and a relay such as 622. The operation of the circuit just described is briefly as follows: Initially the vacuum tube is biased nearly to cut-off, a small received signal is amplified and fed back through the condenser 623 and the copper-oxide units 621 to charge up the condenser 624. This condenser is poled to reduce the negative bias on the grid of the tube 620 with the result that the gain of the tube is increased and the amount of voltage on the grid increased further. The final result is that a relatively small signal is sufficient to produce a sharp rise in plate current through the relay 622. The sensitivity of the individual channels is adjusted

by means of the variable resistance 625. This method controls the sensitivity by changing the alternating current feedback and does not affect the tuning. It will be noted that the selectivity of each channel is accomplished entirely by a single tuned circuit per channel. The tuning may be made as sharp as desired since the received frequency is always an exact multiple of the carrier or base frequency which may be accurately controlled at the central office.

From the immediately preceding description, it will be apparent that each relay such as relay 622 in each channel, will respond to a single harmonic with a relatively high discrimination against the others. In the present description, it will be assumed that the first channel is tuned to a frequency of 500 cycles; the second channel to a frequency of 700 cycles; the third to 900 cycles; the fourth to 1100 cycles and the fifth to 1300 cycles.

Hereinbefore it was described how the harmonics of the carrier frequency 100 cycles are generated by the device 515 at the subscriber's station and reflected back into the line circuit to eventually traverse the primary windings of the transformer 618 at the central office. The frequencies 500, 700, 900, 1100 and 1300 cycles are accordingly received by their respective receiving channels to cause the operation of the corresponding channel relays 622, 632, 642, 652 and 662.

It will be noted that relay 633 is normally held operated by way of the left back contacts of relays 622, 633, etc., so that prior to the receipt of the generated harmonics, this relay is in its operated position. When the generated harmonics are received by the individual frequency receiving channels and relays 622, 632, etc. and their associated relays 626, 636, etc. operate, the circuit for relay 633 is opened so that this relay now releases its armature. In attracting their innermost armatures relays 626, 636, 646, 656 and 666 complete an operating circuit for relay 655 which relay operates and completes an obvious circuit for relay 700, Fig. 7 which relay operates and connects the register operating conductors 701 to the relays of the first register A. In attracting its right-hand armature relay 700 locks under control of relay 702 independently of relay 655. The register A is now ready to receive the first character of the selected designation.

As the brush carrying arm 502 (Fig. 5) commences its return movement under the action of spring 501, the brushes B_1, B_2 and B_3 and A_1, A_2 and A_3 engage the first commutator bar 510 with the following results: brush B_1 engages the insulating segment 520, the brush B_2 engages the insulating segment 521, brush B_3 engages the insulating segment 522, brush A_1 engages the conducting segment 623 as do also brushes A_2 and A_3. A short time later the brush D engages the conducting portion of commutator bar 511 located immediately above the commutator bar 510. The chief purpose of the commutator bar 511 is to insure that the combination of any of the brushes A_1, A_2, A_3, B_1, B_2, B_3 shall be in position before the whole is connected to the line. In this way a false suppression is avoided due to possible connection of one brush before the rest. In this position of the brush carrying arm 502, the condenser 525 is connected across the line circuit from the center tap on coil 512, through condenser 525, to the point 524 on the plate 22, that conducting portion of bar 511 immediately above the commutator bar 510, brush D_1, closed alternate contact of springs C and thence to the point 540 on the other line conductor. The condensers 526, 527 and 528 are on open circuit since their respective brushes B_1, B_2 and B_3 are in engagement with the insulating segments 520, 521 and 522, respectively, of the commutator bar 510. Condenser 529 is connected from the center tap of coil 513 to the other line conductor in parallel with condenser 525 by way of the circuit previously traced for condenser 525. As previously stated, the brushes A_1, A_2 and A_3 are now passing over the conducting segment 523 of commutator bar 510 so that their corresponding condensers 530, 531 and 532 are connected in parallel across the line circuit from the center tap of coil 513 to the point 540 on the line conductor by way of their respective brushes, conducting segment 523 of commutator bar 510, the conducting portion of bar 511 immediately above the commutator bar 510, brush D and closed alternate contact springs C. The circuit condition which exists as the result of the brushes B_1, B_2, B_3, A_1, A_2 and A_3 engaging the commutator bar 510 is illustrated diagrammatically in Fig. 5A. The condenser 525 functions to suppress the generated frequency 1300 cycles and the capacities of condensers 529 to 532 inclusive add up to effect the suppression of the generated frequency 500 cycles.

Accordingly the generated frequencies 1300 and 500 cycles are simultaneously suppressed with the result that relays 662 and 622 are released. These relays thereupon cause the release of relays 666 and 626 which in turn cause relay 655 to release. A circuit is now established extending from ground at the inner left-hand armature and back contact of relay 633, armature and back contact of relay 626, outer armature and front contact of relay 636, third armature and front contact of relay 646, fourth armature and front contact of relay 656, fifth armature and back contact of relay 666, conductor 640, winding of relay 676 through battery to ground. Relay 676 operates in this circuit, locks to ground at the outer right armature and back contact of relay 655, and at its right-hand armatures connects ground potential to two of the register operating conductors 701 which potential passes by way of corresponding contacts of relay 700 (Fig. 7) to cause the register relays 703 and 710 to operate by way of their left-hand windings.

Register relays 703 and 710 operate and establish locking circuits for themselves extending from ground, battery, right-hand windings and right armatures and front contacts of relays 710 and 703, conductors 704 and 791, contact 781 of relay 780, conductor 792, winding of relay 702, conductor 708 to ground by way of the back contact and armature of relay 631. Relay 702 operates in this circuit and in attracting its left armature opens the holding circuit for relay 700 which relay releases, disconnecting the register A from the register control conductors 701. At its inner right armature, relay 702 establishes a locking circuit for itself and for the operated register relays 703 and 710. At its outer right armature relay 702 prepares an operating circuit for relay 705 which extends by way of the back contact and inner left armature of relay 713, outer right armature and front contact of relay 702 to the conductor 733 which is now disconnected from the conductor 734 at the outer armature and back contact of stepping relay 655 whose circuit was opened when relays 622 and 662 were released as described above.

The operated register relays 703 and 710 are now locked in the circuit including the winding of relay 702 as above indicated and serve to store the digit 7, or in the case described, the character S for subsequent use in controlling the automatic switches shown in Fig. 6 in a manner well known and as described in Patent 1,862,549 issued June 14, 1932 to Raymond et al.

As the brush carrying arm 502 continues its return movement under control of the coil spring 501, the brushes B_1, B_2, B_3, A_1, A_2 and A_3 move off the commutator bar 510 and engage the commutator bar 509. The brush D experiences a similar movement and in passing from the conducting segment of bar 511 immediately above the commutator bar 510 to the conducting segment immediately above the commutator bar 509 it wipes over an intervening insulating segment of bar 511 whereupon the circuit between the condenser selecting circuits and the point 540 of the line circuit is opened. All the harmonics generated by the generator 515 are accordingly again reflected back into the line circuit and relays 662 and 632 are again operated. Under this condition relay 655 is again operated and in closing its inner contacts completes the circuit to relay 705 which was partially completed by the operation of relay 702 as already described. Relay 705 accordingly operates and locks to the outer left armature of relay 713 and connects the register control conductors 701 to the register B for the receipt of the next digit. The operation of relay 655 also opens the locking circuit for relay 676 which relay thereupon releases. All relays 622, 632, 642, 652 and 662 as well as their associated relays 626, 636, 646, 656 and 666 are therefore operated between digits and, except for the stepping action just described, perform no other useful function at this time.

When the brush carrying arm 502 reaches the second commutator bar 509, the brushes B_1 and B_2 engage the conducting segment 562, while brush B_3 engages the insulating segment 563. Brushes A_1 and A_2 engage the conducting segment 533 and brush A_3 contacts the insulating segment 534, while brush D will be in contact with that conducting portion of the bar 511 immediately above the commutator bar 509. Under this condition condensers 525 and 529 will, as in the previous case be connected across the line circuit; condensers 526 and 527 and also condensers 530 and 531 will also be connected across the line circuit by way of their respective brushes B_1, B_2, A_1 and A_2, conducting segments of the commutator bar 509 and bar 511, brush D and closed alternate contact of springs C. The circuit condition which prevails at this moment is shown in Fig. 5B. The capacities of condensers 531, 530 and 529 combine to cause the suppression of the 900 cycle frequency while the capacities of condensers 527, 526 and 525 combine to suppress the frequency 700 cycles. Relays 632 and 642 accordingly release and in restoring their right-hand armatures cause the release of relays 636 and 646. The release of relays 636 and 646 causes the circuit for stepping relay 655 to be opened whereupon this relay restores its armatures which perform no useful function other than to prepare a locking circuit for the next relay of relays 670 to 679 inclusive to be operated.

A circuit now exists which may be traced from ground, back contact and inner left-hand armature of relay 633, armature and front contact of relay 626, inner armature and back contact of relay 636, middle armature and back contact of relay 646, conductor 641, winding of relay 675 to battery and ground. Relay 675 operates in this circuit and in attracting its two right-hand armatures connects ground potential to two other conductors of the register control conductors 701 and thence by way of corresponding left-hand contacts of relay 705, through the left-hand windings of register relays 711 and 712 of register B. These register relays operate and lock in a circuit including their right-hand windings and armatures, conductor 791, contact 781 of relay 780, conductor 792, winding of relay 713, conductor 708 to ground at the armature and back contact of relay 631. Relay 713 operates in this circuit and at its outer left armature and back contact opens the locking circuit to relay 705 which relay restores its armatures. In releasing its left armatures relay 705 disconnects the register B from the register control conductors 701. Relay 713, at its inner right armature establishes a locking circuit for itself and at its outer right armature prepares an operating circuit for relay 706. The register relays 711 and 712 are now locked and store the character O of the selected designation SO–5–4321. Relay 675 operated, locks to ground at the outer armature and back contact of relay 655.

In the manner previously described, the brushes B_1, B_2, B_3, A_1, A_2 and A_3 continue their return movement and eventually engage, or wipe over, the commutator bar 508 which is in the position indicated in Fig. 5. The brush D in like manner wipes over the next succeeding insulating segment of bar 511 and contacts the conducting portion thereof immediately above the commutator bar 508. Passage of the brush D over the insulating segment opens the selecting circuits and permits all the generated frequencies to be sent back to the central office. As in the previous case, those relays of relays 622, 632, 642, 652 and 662 which were released for the transmission of the second digit of the telephone designation and the corresponding relays of relays 626, 636, 646, 656 and 666 are again operated so that the circuit to relay 633 is again opened and the circuit to stepping relay 655 again closed. The closure of the inner contacts of relay 655 completes the energizing circuit for relay 706 which was prepared by the operation of relay 713 as previously described. Relay 706 accordingly operates and locks to the outer left-hand armature of relay 718. At its left armatures and front contacts relay 706 connects the register control conductors 791 to the register C for the receipt of the next digit "5" of the desired designation.

When the brushes B_1, B_2, B_3, A_1, A_2 and A_3 engage the commutator bar 508, brushes B_2 and B_3 contact the insulating segment 560 while brush A_3 is in engagement with the insulating segment 561. The brushes B_1, A_1 and A_2, as shown, contact the conducting segments of the bar 508. Accordingly, condensers 527, 528 and 532 will be open-circuited while condensers 525, 526, 529, 530 and 531 will be rendered effective in suppressing the frequencies 1100 and 700 cycles. The circuit condition now prevailing at the subscriber's station is shown in Fig. 5C.

Due to the suppression of the 1100 and 700 cycle frequencies, relays 652 and 632 release, restoring their armatures and causing the release of relays 656 and 636. With these latter relays released, the circuit to stepping relay 655 is opened causing the release of this relay. A circuit now exists which extends from ground, armature and back contact of relay 633, armature

and front contact of relay 626, inner armature and back contact of relay 636, middle armature and front contact of relay 646, third armature and back contact of relay 656, conductor 644, winding of relay 674 to battery and ground. Relay 674 operates in this circuit and at its right-hand armature connects ground to another conductor of the register control conductors 701, which passes over a corresponding front contact and left armature of relay 706 and thence to battery and ground through the left-hand winding of relay 717 in register C. Relay 717 accordingly operates and locks in a manner similar to the now locked up relays of registers A and B. Relay 718 operates as a result of the operation of relay 717 and opens the locking circuit to relay 706, and establishes a locking circuit for itself. Relay 706 in releasing its left armature disconnects the register control conductors 701 from register C. Relay 674 operated, locks to the outer back contacts of relay 655. In Fig. 7, only four registers are shown, A, B, C for the office codes and U for the units digit. It is to be understood that the thousands, hundreds and tens registers are included in the complete system. In attracting its outer right armature relay 718 prepares an operating circuit for the next succeeding relay of the thousands register, such as relays 700, 705 and 706 of registers A, B and C, and in attracting its inner right armature relay 718 locks in an obvious circuit with the register relay 717 of register C.

As the brush arm 502 continues its return travel, the brushes B_1, B_2, B_3, A_1, A_2 and A_3 wipe over the commutator bars 507, 506, 505 and 504 in succession to cause the selection of corresponding condensers in the selecting circuits at the subscriber's station. The brush positions on the commutator bars are clearly shown in Fig. 5. When bar 507 is engaged for the thousands digit "4" of the desired designation, brushes B_1, B_2 and B_3 engage insulating segments as does also, brush A_3 while brushes A_1 and A_2 are in contact with conducting segments of the bar. Under this setting of the brushes a circuit condition, such as is shown in Fig. 5D is effected. The frequencies 1300 and 700 cycles are accordingly suppressed. Relays 662 and 632 therefore, release as do relays 666 and 636. The latter two relays in releasing cause the operation of relay 673 by way of conductor 645. Relay 673 causes the operation of a relay in the thousands register which corresponds to relay 721 in the A register and locks to the outer back contacts of relay 655.

When the brushes B_1, B_2, B_3 and A_1, A_2, A_3 engage the commutator bar 506 for the hundreds digit "3" brushes B_2, B_3, A_2 and A_3 engage insulating segments as shown in Fig. 5 whereas brushes B_1 and A_1 contact conducting segments so that the selecting circuit resulting is as shown in Fig. 5E. This results in the suppression of the 1100 and 900 cycle frequencies which causes the release of relay 652 and 642 and their associated relays 656 and 646. The release of the latter two relays results in the operation of relay 672 by way of conductor 647. The operation of relay 672 causes the operation of two relays in the hundreds register which correspond to the relays 711 and 722 of the B register.

When commutator bar 505 is reached for the tens digit "2" by the brushes B_1, B_2, B_3 and A_1, A_2, A_3 all brushes except brush A_1 are in engagement with insulating segments so that the circuit condition such as is shown in Fig. 5F results. This causes the suppression of the 1300 and 900 cycle frequencies. Relays 662 and 642 therefore release as do their associated relays 666 and 646 causing the grounding of conductor 648 and the consequent operation of relay 671. Relay 671 causes the operation of a relay in the tens register corresponding to relay 703 in the A register.

When the commutator bar 504 becomes effective in suppressing frequencies corresponding to the units digit "1" of the designation, the selecting circuit effected is as shown in Fig. 5H which causes the suppression of frequencies 1300 and 1100 cycles. Relays 662 and 652 at the central office therefore release as do relays 666 and 656 with the result that relay 670 operates over conductor 649. Relay 737 in the units register U will accordingly operate and lock up to store up the units digit "1". Relay 738 operates and locks in the same manner as do relays 702, 713 and 718 as previously described.

When the brush carrying arm 502 reaches its normal position the brushes B_1, B_2, B_3, A_1, A_2, A_3 and D assume the positions shown in Fig. 5 and the contact springs C transfer the loop from the subscriber signaling sender to the talking set.

The desired designation SO—5—4321 is now stored up in the registers for subsequent use in controlling the switches S, S—2, and S—3 (Fig. 6) in a manner fully disclosed in the above-identified Raymond et al. patent to extend the connection to the called station 600.

It is to be understood that after the registration of each digit in its corresponding register, the stepping relay 655 functions to cause the register control conductors 701 to be connected to the next succeeding register as already described in connection with the operation of such relays as 705 and 706. This stepping function is the immediate result of the designation brushes leaving the commutator bars which results in the transmission of all generated harmonics to the central office. Therefore, after the registration of the tens digit and all the frequencies are sent back to the central office during the time the designation brushes are passing from commutator bar 505 to commutator bar 504, relay 707 operates in the same manner as did relays 705 and 706 to transfer the register control conductor 701 to the units register U for the reception of the units digit "1".

It will be noted from the foregoing description that each character or digit of a telephone designation is characterized by two frequencies suppressed simultaneously. If, due to faulty manipulation of the designation sender by the subscriber or for any other reason, only one frequency is suppressed, an indication of such an occurrence is given at the central office. For descriptive purposes it will be assumed that during the transmission of the first character S of the telephone designation SO–5–4321 the frequency 500 cycles has not been suppressed and that only the frequency 1300 has been suppressed. Under this condition relay 662 and its associated relay 666 will restore to normal whereas all other corresponding relays will remain operated. A circuit therefore is established which extends from ground on the back contact and inner armature of relay 633, armature and front contact of relay 626, inner armatures and front contacts of relays 636, 646 and 656, innermost armature and back contact of relay 666, conductor 690 and thence to two parallel paths, one extending to battery and ground by way of the winding of slow-to-operate relay 790 and the other to bat-

tery and ground by way of the right armature and back contact of relay 790 and the winding of slow-to-release relay 780. Relay 780 operates immediately. In attracting its left armature, relay 780 opens its contact 781 which is normally included in the locking circuit for the various relays of the registers A, B, C, etc., such as relays 703, 712, 786 and 737 (to identify one such relay in each register) and relays 702, 713, 718 and 738. If any of these relays had been operated they would accordingly release. However, since the present description is confined to the occurrence of the unstandard condition (transmission of a single frequency instead of the characteristic two frequencies) during the transmission of the first character of the designation, none of these relays are operated. In closing its contact 782, relay 780 reestablishes the locking circuit for the register relays for subsequent use as will be described presently.

When the contact 783 of relay 780 is closed all the register switching relays 705, 706 and 707 operate over obvious circuits, it being understood that relay 700 is already operated and locked to ground at the back contact and left armature of relay 702. By the operation of relays 700, 705, 706 and 707 the relays of the several registers A, B, C, etc., are connected to the register control conductors 701.

The relay 780 is adjusted so that the contact 782 makes before the contact 784. When the latter contact is closed an obvious circuit for relay 670 (Fig. 6) is closed. Relay 670 accordingly operates and at its right armature and front contact puts ground potential on the first of the register control conductors 701 whereupon relays 785, 711, 786 and 737 of registers A, B, C and U respectively, as well as corresponding relays of the thousands, hundreds and tens registers, operate. These relays in attracting their right-hand armatures cause their corresponding relays 702, 713, 718 and 738 to operate in circuits extending from battery and ground, the right-hand windings of relays 785, 711, 786 and 737, their respective front contacts and right armatures, conductor 791, contact 782 of relay 780, conductor 792, through the windings of relays 702, 713, 718 and 738 in parallel, conductor 703 to ground by way of the back contact and armature of relay 631 (Fig. 6). Relays 702, 713, 718 and 738, as well as corresponding relays of the thousands, hundreds and tens registers operate in these circuits and in attracting their right-hand armatures lock to ground with their corresponding register relays 785, 711, 786 and 737 independently of the ground at the back contact and armature of relay 631 (Fig. 6).

When slow-to-operate relay 790 finally operates it opens the operating circuit for relay 780 and at its left armature shunts the left armature and contact 782 of relay 780 to insure the holding circuit for the operated register relays being maintained during the transfer of the left armature of relay 780 from its front contact to its back contact. Relay 780 is made slow-to-release to insure the closure of the left armature contacts of relay 790 before the contact 782 of relay 780 is opened. When contact 781 of relay 780 is finally closed the original locking circuits for the register relays is reestablished. These relays are now locked up to be used to control the district selector S—4 in the well-known manner, which switch functions to extend the calling station to an intercepting operator who will complete the call in a well-known manner.

It may be desirable to not only route the call under the above described condition to an operator but to also bring in an alarm signal in the central office. The outermost right armature of relay 780 serves in this capacity.

The suppression of a single frequency instead of the charactertistic two frequencies may occur for any digit. Regardless of when it occurs the relays 780 and 790 function in the manner just described to cause the call to be routed to an operator.

The operation of the system involving the use of the designation sender shown in Fig. 3 which serves to suppress two frequencies per digit consecutively will now be described and for this purpose it will be assumed that the subscriber at station 800 (Fig. 8) wishes to call the subscriber at station 900 (Fig. 9). It will be assumed further that the designation of substation 900 is the same as that of station 600, that is SO–5–4321.

Since the designation sender at station 800 is of the preset type, the calling subscriber proceeds to set up the designation SO–5–4321 by manipulating the knobs 1 to 7 shown in Fig. 2 in the same manner as in the preceding description until the desired number appears in the windows. The receiver is now lifted from its switchhook and the line circuit is thereupon closed, causing the finder F, Fig. 9, to be 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 line through to an idle sender. When these operations have been completed a circuit is closed from battery, through the winding of relay 909 in the sender, over brush 910, contact of spring 911 on a controlling sequence switch, thence over the brush of finder F, over conductor 927 to the point 840 of the subscriber's line, normal closed contact of springs C, through the switchhook contacts at station 800, returning over conductor 939, through the upper brush of finder F and sequence switch contact 912, brush 913 of the sender selector S—1 to ground in the sender. The line relay 909 operates in this circuit and closes an obvious circuit for the slow-release relay 914.

When the finder F associated the calling line with the sender selector S—1 the alternating current source 901 at the central office was connected to the brushes 910 and 913 of the sender selector which brushes as already described are now connected to the calling line. Accordingly, current from the source 901, which we assume to be a 100-cycle frequency source travels out over the line circuit and serves as a tone signal to the subscriber to notify the subscriber that the central office equipment is ready to receive and store the desired designation. The subscriber thereupon pulls the knob 12 to the extreme right (Fig. 8) and releases it. As in the previous case the alternate contact of springs C is closed as the brush arm 502 starts its return movement and the harmonic generator 815 is connected to the line. The harmonic generator 815 is accordingly energized by current from the source 901 and functions to generate the harmonics of the fundamental frequency 100 cycles, of the central office source. These frequencies thereupon are reflected back into the line circuit and travel back to the central office where they passs through the base frequency elimination filter 916, transformer 917, pass through circuit X and

thence through the primary winding sections of transformer 918. Each section of the transformer primary is coupled with a receiving channel identical with the receiving channels shown in Fig. 6 and hereinbefore described. It will be noted that there are but four receiving channels in the embodiment being described as compared to five channels in the system in which the frequencies are suppressed simultaneously. In like manner, but four of the harmonics generated at the subscriber's station are utilized to control the central office equipment. In this description it will be assumed that the first channel, terminating in relay 922, is tuned to pass only the frequency 700 cycles; the second channel, terminating in relay 932, to pass only the frequency 900 cycles; the third channel, terminating in relay 942, to pass only the frequency 1100 cycles and the fourth channel, terminating in relay 952, to pass only the frequency 1300 cycles.

As above described, when the source 901 is connected to the calling line the generator 815 functions to transmit the generated harmonics back to the central office. The frequencies 700, 900, 1100 and 1300 cycles accordingly are received by their respective channels and cause relays 922, 932, 942 and 952 to operate. These relays in operating remove ground potential from the winding of relay 962 causing this relay, which was normally operated, to release its armature, thereby connecting battery to one terminal of the windings of relays 956, 946, 936 and 926 for a purpose to be hereinafter described. In attracting their inner right-hand armatures, relays 922, 932, 942 and 952 complete an energizing circuit for relay 933 which extends from ground over the back contacts and left-hand armatures of relays 926, 936, 946 and 956, conductor 980 and the front contacts and inner right-hand armatures of relays 922, 932, 942 and 952 to grounded battery through the winding of relay 933. Relay 933 accordingly operates and causes relay 700 (Fig. 7) to operate in a circuit extending from grounded battery, winding of relay 700, conductor 733, front contact and armature of relay 933, conductor 734 and back to the back contact and left-hand armature of relay 702. Relay 700 operates in this circuit and locks under the control of relay 702. In attracting its left-hand armatures relay 700 extends the register control conductors 701 to the first register A preparatory to the operation of the register relays in accordance with the operation of the subscriber's designation sender as will appear presently.

As the rod 12 is released, it and its associated brush arm 502 start to return to normal position under the influence of coil spring 501. (Like numerals, where possible, are used in Figs. 5 and 8 to identify similar parts of the designation senders.) As the brush arm 502 travels to the left (Fig. 8) the brushes X_1, X_2, Y_1 and Y_2 first engage and wipe over the commutator bar 510. During the travel of these brushes over the first half of bar 510, brushes X_1, X_2 and Y_2 contact the insulating segment 820 whereas brush Y_1 contacts the conducting segment 821. Under these circumstances condensers 825, 826 and 828 are on open circuit while condenser 827 is connected across the line in a circuit extending from the center tap of coil 812, condenser 827, brush Y_1 conducting segment 821 of commutator bar 510, through the frame to the point 824, closed alternate contact of springs C and thence to the point 840 on the line conductor. This results in the suppression of the 1100-cycle frequency.

As the brush arm continues its return movement the brushes X_1, X_2, Y_1 and Y_2 wipe over the second half of the commutator bar 510 at which time brushes X_1, X_2 and Y_1 engage the insulating segment 820 and brush Y_2 contacts the conducting segment 822. Condensers 825, 826 and 827, associated with brushes X_1, X_2 and Y_1 are therefore on open circuit and condenser 828 is connected across the line circuit in a circuit extending from the tap of coil 812, condenser 828, brush Y_2, conducting segment 822 of commutator bar 510, point 824 on the frame, closed alternate contact of springs C to the point 840. This results in the suppression of the 1300 cycle frequency.

The frequencies 1100 and 1300 cycles have accordingly been consecutively suppressed by the passage of brushes X_1, X_2, Y_1 and Y_2 over commutator bar 510. Relay 942 therefore restores to normal and is then followed by relay 952. When relay 942 releases its armature and before relay 952 releases, a circuit for operating relay 946 is established which may be traced from grounded battery, armature and back contact of relay 962, winding of relay 946, back contact and inner right-hand armature of relay 942, front contact and inner right armature of relay 952, conductor 980, back contacts and left armatures of relay 926, 936, 946 and 956 to ground. Relay 946 operates in this circuit and in attracting its left armature removes ground from the lead 980 to prevent the operation of any of the relays 926, 936 and 956 and locks up to ground at the left armature and back contact of relay 956. Now when relay 952 releases, owing to the suppression of the 1300-cycle frequency, a circuit is established which may be traced from ground, outer right armature and back contact of relay 952, conductor 981, front contact and innermost right armature of relay 946, conductor 972, winding of relay 976 to battery and ground. Relay 976 operates in this circuit and performs the same functions as does relay 676 of Fig. 6. Since these functions have been set forth in detail hereinbefore it is considered unnecessary to repeat them at this time. Suffice it to say that register relays 703 and 710 of the A register (Fig. 7) operate and lock to store the first digit of the desired designation. Also that relay 702 operates to open the circuit to relay 700 which latter relay restores its armatures to disconnect the register control conductors 701 from register A. Relay 702 in attracting its outer right armature prepares an operating circuit for relay 705 by way of the back contact and inner left armature of relay 713, outer right armature and front contact of relay 702, conductor 733 to the open contacts of relay 933 which relay released upon the release of relay 952.

The first digit of the desired designation is now stored by the relays 703 and 710 of the register A.

As the brushes X_1, X_2, Y_1 and Y_2 leave the commutator bar 510 and approach the next bar 509 they wipe over the intervening insulation 823. During the travel of the brushes over this element all the condensers 825 to 828 inclusive, are open-circuited so that all the frequencies generated by the generator 815 are reflected back into the line circuit. Relay 952, therefore, again operates. It will be understood that relay 942 reoperated when the brush Y_1 left the conducting segment 821 of the commutator bar 510. All the receiving relays 922, 932, 942 and 952 are there-

fore operated so that stepping relay 933 now operates in a circuit extending from grounded battery, winding of relay 933, front contacts and inner right armatures of relays 922, 932, 942 and 952, conductor 980 to ground by way of the back contacts and left armatures of relays 926, 936, 946 and 956. Relay 933 in attracting its armature completes the operating circuit for relay 705 which was prepared when relay 702 operated as described above. Relay 705 accordingly operates and locks to ground by way of the back contact and outer left armature of relay 713. In pulling up its left armatures relay 705 connects the register control conductors 701 to the B register preparatory to the operation of the B register relays to store the second digit of the desired designation.

In passing off the insulation 823 to contact the commutator bar 509, brushes X_1, Y_1 and Y_2 engage the insulation 829, while brush X_2 contacts the conducting segment 830 with the result that condensers 825, 827 and 828 are open-circuited and condenser 826 is connected to the point 840 of the line conductor. This results in the suppression of the frequency 900 cycles. As the brushes continue their travel over the commutator bar 509, brushes X_2, Y_1 and Y_2 contact the insulation 829 whereas brush X_1 engages the conducting segment 831. The condenser 825 is accordingly introduced in the line circuit and condensers 826, 827 and 828 are excluded therefrom. This results in the suppression of the frequency 700 cycles. The frequencies 900 and 700 cycles have accordingly been suppressed consecutively by the passage of the brushes over the commutator bar 509.

As a result of the suppression of the 900-cycle frequency relay 932 releases its armatures. At its inner armature, relay 932 opens the circuit for relay 933 which relay releases but performs no function, since relay 705 (Fig. 7) is now held operated at the back contact and outer left armature of relay 713 associated with register B. In closing its inner right back contact relay 932 establishes a circuit for relay 936 which extends from grounded battery, armature and back contact of relay 962, winding of relay 936, back contact and inner right armature of relay 932, front contacts and inner right armatures of relays 942 and 952, conductor 980, back contacts and left armatures of relays 926, 936, 946 and 956 to ground. Relay 936 operates in this circuit and locks in a circuit extending from grounded battery, armature and back contact of relay 962, winding of relay 936 and its front contact and left armature to ground over the back contact and left armature of relay 956.

New when the frequency 700 cycles is suppressed as described above, relay 922 falls back. Relay 926, however, cannot operate since its operating circuit is opened at the back contact and left armature of relay 936, now operated and locked. A circuit for the operation of relay 975 now exists which extends from grounded battery, winding of relay 975, outermost right armature and front contact of relay 936, back contact and outer right armature of relay 922 to ground. Relay 975 operates in this circuit and in attracting its right armatures connects ground potential to two of the register control conductors 701 which passes over corresponding armature contacts of relay 705 to effect the operation of relays 711 and 712 of register B. These relays operate and lock in a circuit including the winding of raly 713, conductor 708 and ground at the armature and back contact of relay 931. Relay 713 operates in this circuit and locks to ground by way of its front contact and inner right armature. At its outer right armature relay 713 prepares an operating circuit for relay 706 and at its outer left armature opens the locking circuit for relay 705. Relay 705 accordingly releases and disconnects the register B from the register control conductors 701.

The second digit of the desired designation is now stored by relays 711 and 712 of register B.

The description of the operation of the system involving the use of the designation sender of Fig. 8 has so far, illustrated the receipt and storage of the first two digits of the called designation by relays of registers A and B and has also covered the method of stepping from one register to the next between digits. In the earlier description of the system involving the designation sender of Fig. 5, it was shown how the relays of the C, thousands, hundreds, tens and units registers were operated to store the balance of the designation, 5—4321, and also how these relays where controlled by the operation of relays 674, 673, 672, 671 and 670, respectively, of Fig. 6. It is to be understood that relays 974, 973, 972, 971 and 970 of Fig. 9 correspond to relays 674, 673, 672, 671 and 670, respectively, of Fig. 6 and perform identical functions. It is therefore believed that the remainder of the description of the system involving the designation sender of Fig. 8 need cover only the manner in which relays 974, 973, 972, 971 and 970 are operated and no further reference to the register circuits of Fig. 7 need be made. The following description therefore will be confined to the operation of relays 974, 973, 972, 971 and 970 as the brush arm 502 of Fig. 8 continues its return movement.

As the brushes X_1, X_2, Y_1 and Y_2 leave the commutator bar 509 they pass over the insulation between the bars 509 and 508 to cause the register stepping function which has already been described. The brushes then move onto the commutator bar 508 and in doing so brushes X_1, Y_1 and Y_2 engage the insulating portion 832 of bar 508 while brush X_2 contacts the conducting portion 833. Condensers 825, 827 and 828 are accordingly open-circuited and condenser 826 is connected across the line between the tap of coil 812 and point 840 in a manner which is now obvious. The frequency 900 cycles is accordingly suppressed. As the brushes continue their travel over bar 508, brushes X_1, X_2 and Y_1 engage the insulation 832 while brush Y_2 contacts the conducting segment 834 with the result that condensers 825, 826 and 827 are open-circuited and condenser 828 becomes effective in suppressing the frequency 1300 cycles. The frequencies 900 and 1300 cycles have accordingly been suppressed consecutively and characterize the third digit "5" of the desired designation.

Upon the suppression of the 900-cycle frequency, relay 932 (Fig. 9) releases its armatures and at its inner right armature and back contact causes relay 936 to operate and lock in the same manner as did relay 946 hereinbefore described. When the 1300-cycle frequency is suppressed relay 952 releases whereupon a circuit for the operation of relay 974 is completed. This circuit extends from grounded battery, winding of relay 974, middle right armature and front contact of relay 936, back contact and outer right armature of relay 952. Relay 974 operates to perform the same functions performed by relay 674 hereinbefore described.

As the brushes X_1, X_2, Y_1 and Y_2 continue their travel from the commutator bar **508** they pass over the next insulation strip to effect the transmission of all generated frequencies back to the central office which results in the register stepping function and the association of the register control conductors **701** with the next register, which is the thousands register, preparatory to the receipt of the next digit "4" of the desired designation.

It is believed unnecessary to go any further into the description of the contacting of the brushes X_1, X_2, Y_1 and Y_2 with the commutator bars **507**, **506**, **505** and **504**, since it is clear from the preceding description and from the disclosure in Fig. 8 just what elements of the bars the brushes engage during their wiping action. However, reference will be made to which frequencies are suppressed during the balance of the return movement of the brushes in order to illustrate what group of two frequencies and the order of their suppression which characterize the remaining digits 4, 3, 2, 1 of the desired designation.

As the brushes wipe over commutator bar **507** the condensers **826** and **827** are consecutively introduced into the line circuit with the result that the frequencies 900 and 1100 cycles are consecutively suppressed. The suppression of the 900-cycle frequency results in the release of relay **932** and the consequent operation of relay **936** which relay locks in a manner now well known. The suppression of the 1100-cycle frequency causes relay **942** to restore its armatures. With relay **936** operated and relay **942** released relay **973** operates in a circuit extending from grounded battery, winding of relay **973**, innermost right armature and front contact of relay **936**, back contact and outer right armature of relay **942** to ground. Relay **973** operated, performs the same functions as relay **673** previously described.

After passing over the insulation strip between commutator bars **507** and **506** to cause the hundreds register to be associated with the register control conductors **701** in a manner hereinbefore described, the brushes X_1, X_2, Y_1 and Y_2 wipe over bar **506** of the designation sender. By referring to Fig. 8 it will be noted that this operation results in the connection of condenser **825** and then the connection of condenser **828** across the line circuit causing the consecutive suppression of frequencies 700 and 1300 cycles. Relay **922** accordingly releases to effect the operation of relay **926** and then relay **952** restores its armatures. With relay **926** operated and relay **952** released relay **972** operates in a circuit extending from grounded battery, winding of relay **972**, outermost right armature and front contact of relay **926**, back contact and outer right armature of relay **952** to ground. Relay **972** corresponds to relay **672** of Fig. 6 and performs the same function, that is, the operation of relays in the hundreds register which store the digit "3" of the desired designation.

After the register stepping function is again performed the brushes X_1, X_2, Y_1 and Y_2 wipe over the tens commutator bar **505** causing condensers **825** and **827** to be consecutively inserted in the line circuit to cause the consecutive suppression of the frequencies 700 and 1100 cycles which characterize the tens digit "2" of the designation. Relay 922 accordingly releases and causes the operation of relay **926**. Relay **942** then releases with the result that relay **971** operates in a circuit extending from grounded battery, winding of relay **971**, innermost right armature and front contact of relay **926**, back contact and outer right armature of relay **942**. Relay **971** corresponds to relay **671** of Fig. 6 and controls the register relays of the tens register in the same manner as previously described.

For the units digit "1" the brushes X_1, X_2, Y_1 and Y_2 wipe over the commutator bar **504** causing the consecutive association of condensers **825** and **826** with the line circuit and the corresponding suppression of the frequencies 700 and 900 cycles. Relay **922** accordingly releases and causes relay **926** to operate. Relay **932** then releases whereupon relay **970** operates in a circuit extending from grounded battery, winding of relay **970**, middle right armature and front contact of relay **926**, back contact and outer right armature of relay **932** to ground. Relay **970** corresponds to relay **670** of Fig. 6 and controls the operation of the relay **737** of the units register U in the same manner.

When the brushes return to their home positions they come to rest on the insulation bar **555** whereupon all the generated frequencies are sent back to the central office. The designation of the wanted line **900** having thus been registered on the registers of the sender, the sender now proceeds in the well-known manner to control the selective operation of the automatic switches in accordance with the designation to complete the connection through to the called subscriber's line. The sender is then released in any well-known manner, and, following the conversation between the subscribers, the established connection is also restored to normal.

Until now, no reference has been made to the volume control which, as indicated in the statement of invention is an important feature of the equipment. Since this feature is common to both embodiments of the invention described, it was deemed proper to include a description thereof after the descriptions of the operation of the two embodiments to which it applies.

As shown in Figs. 6 and 9 an auxiliary control channel V is added to the signal receiving channels and is an exact duplicate thereof. This channel is made selectively responsive to a frequency just above the frequencies utilized for designation transmission. A frequency of 1500 cycles is suitable in the two cases described.

With the receiving apparatus used on a short loop it is obvious that a very high degree of suppression to the harmonics would be necessary at the subscriber's set in order to reduce them well below the level normally received on long loops. To avoid this, the extra harmonic receiving channel V is used which is not affected by the signaling processes and serves only to control the input to the apparatus. As above stated, the volume control channel is a duplicate of the signaling channels and is placed just above them in frequency. The change in plate current is used to change the resistance of a copper oxide shunt circuit. A suitable input circuit X may consist of two 700 ohm resistances and two 10 microfarad electrolytic condensers in one of the two series arms and four ¼ inch discs of copper oxide connected to effect a T-network as shown. The two condensers referred to as well as the condenser in the other series arm are blocking condensers.

At low levels the direct current through the copper oxide discs is low and the copper oxide resistance is high. The circuit X will therefore cause but little loss, but as the level increases, the direct current will increase sharply, reducing the resistance of the copper oxide units and

accordingly increasing the loss and thereby reducing the level at which the transmitted signals are received in their respective receiving channels. In this manner the transmitted signals are received at a substantially constant level irrespective of the length of line loop over which they are transmitted.

What is claimed is:

1. The combination in a signaling system of a line having a station thereon, a source of alternating current of a base frequency, 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 circuit, means operated selectively upon the generation of certain of said harmonics in said line circuit, and means at said station for suppressing said certain harmonics in various combinations to effect the release of corresponding certain ones of said operated means.

2. The combination in a signaling system of a line having a station thereon, a source of alternating current of a base frequency, 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 and reflect them into said line, means comprising a plurality of selectively operated translating devices normally operated by the harmonics reflected into said line and means at said station for selectively suppressing certain of said harmonics to cause the release of corresponding certain ones of said translating devices.

3. The combination in a signaling system of a line, a station thereon, a source of alternating current of a base frequency, 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 and reflect them back into said line, means for suppressing two of the generated harmonics for each digit of a telephone designation, and means normally selectively responsive to the suppressed harmonics and functioning upon the suppression thereof to effect the registration of a designation digit corresponding to the suppressed harmonics.

4. The combination in a signaling system of a line, a station thereon, a source of alternating current of a base frequency, 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 and reflect them back into said line, means for simultaneously suppressing two of the generated harmonics for each digit of a telephone designation and means normally selectively responsive to the suppressed harmonics and functioning upon the simultaneous suppression thereof to effect the registration of a designation digit corresponding to the suppressed harmonics.

5. The combination in a signaling system of a line, a station thereon, a source of alternating current of a base frequency, 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 and reflect them back into said line, means for consecutively suppressing two of the generated harmonics for each digit of a telephone designation and means normally selectively responsive to the suppressed harmonics and functioning upon the consecutive suppression thereof to effect the registration of a designation digit corresponding to the suppressed harmonics.

6. The combination in a telephone signaling system of a line circuit, a station thereon, a source of alternating current of a base frequency, means responsive to the initiation of a call at said station for connecting said source of current to said line circuit, means at said station normally connected to said line circuit and responsive to current from said source for generating harmonics of the base frequency in said line circuit, translating devices operated in response to the generation of harmonics at said station, a designation transmitter at said station for introducing in said line circuit a different reactance to suppress a different combination of the generated harmonics for each digit of a telephone designation whereby said translating devices are released in various combinations, and means controlled by said translating devices for registering the designation.

7. The combination in a telephone signaling system of a line circuit, a station thereon, a source of alternating current of a base frequency, means responsive to the initiation of a call at said station for connecting said source of current to said line circuit, means at said station normally connected to said line circuit and responsive to current from said source for generating harmonics of the base frequency in said line circuit, translating devices operated in response to the generation of harmonics at said station, a designation transmitter at said station for simultaneously introducing in said line circuit two groups of reactances in various combinations to effect the simultaneous suppression of two of the generated harmonics for each digit of a telephone designation, whereupon a corresponding pair of said translating devices is released and means controlled by said translating devices for registering the designation.

8. The combination in a telephone signaling system of a line circuit, a station thereon, a source of alternating current of a base frequency, means responsive to the initiation of a call at said station for connecting said source of current to said line circuit, means at said station normally connected to said line circuit and responsive to current from said source for generating harmonics of the base frequency in said line circuit, translating devices operated in response to the generation of harmonics at said station, a designation transmitter at said station for consecutively introducing in said line reactances of different values for each digit of a telephone designation whereupon the generated harmonics are consecutively suppressed in combinations of two harmonics for each digit of the designation to effect the consecutive release of said devices in combinations of two translating devices and means controlled by said translating devices for registering the designation.

9. In a system of transmitting and receiving signals composed of selectively transmitted frequencies which characterize the digits of a telephone designation, a receiving channel for each of the frequencies employed to characterize the digits of a telephone designation, a receiving channel for each of the frequencies employed to characterize the designation digits, a separate receiving channel for a frequency other than the frequencies employed to characterize the des-

ignation digits, a common input circuit for all of said receiving channels, a loss network included in said input circuit, and means included in said separate receiving channel for affecting the loss in said network upon variations in the level at which the transmitted signals are received.

10. In a system of transmitting and receiving signals composed of selectively transmitted frequencies which characterize the characters of a telephone designation and which may be received at different levels depending upon the distance between the transmitting and receiving points, a receiving channel for each of the frequencies employed to characterize the designation characters, a separate receiving channel for a control frequency, a common input circuit for all of said receiving channels, a network having a shunt resistance included in said input circuit, means included in said separate receiving channel for causing the resistance of said shunt to vary with the level at which said signaling frequencies are received and means for transmitting said signaling and control frequencies.

11. In a system of transmitting and receiving signals composed of selectively transmitted frequencies which characterize the characters of a telephone designation and which are received at levels which vary with the distance between the transmitting and receiving points, a receiving channel for each of the designation characterizing frequencies, a separate receiving channel for a control frequency, a common input circuit for all of said receiving channels, means controlled by said separate receiving channel for introducing a loss in said common input circuit which varies with the level at which the signaling frequencies are transmitted and means for transmitting said signaling and control frequencies.

12. In combination, a telephone line circuit, a frequency generator, means for energizing said generator to produce a plurality of frequencies in said line circuit, a tuning circuit having a plurality of reactance elements and means for associating said reactance elements with said line circuit in various combinations to selectively suppress the generated frequencies in combinations of two frequencies, said means comprising a designation transmitter consisting of a plurality of elongated commutator bars, each of said bars having an identical pattern formed of insulating and conducting segments, a brush for each of said reactance elements, means for positioning said bars relative to one another to effect a plurality of different patterns extending transversely across said bars and means for causing said brushes to transversely wipe over said bars.

13. The method of transmitting telephone designations from one point to another which comprises generating at said other point a base frequency, transmitting said base frequency to said first point, generating harmonics of said base frequency at said first point and transmitting them back to said other point, utilizing said transmitted frequencies at said other point to prepare for the registration of the designation, suppressing certain of the generated frequencies at said first point to characterize the characters of the designation and registering such suppression at said other point.

ALEXIS A. LUNDSTROM.
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