Feb. 27, 1940. B. F. LEWIS 2,191,913

TELEPHONE SYSTEM

Filed March 3, 1939 3 Sheets-Sheet 1

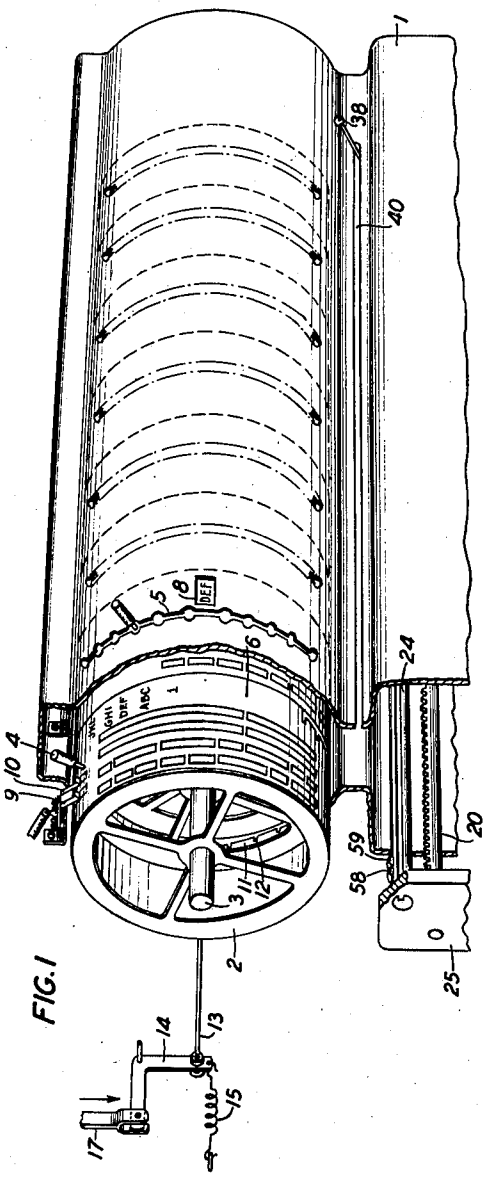

FIG. 1

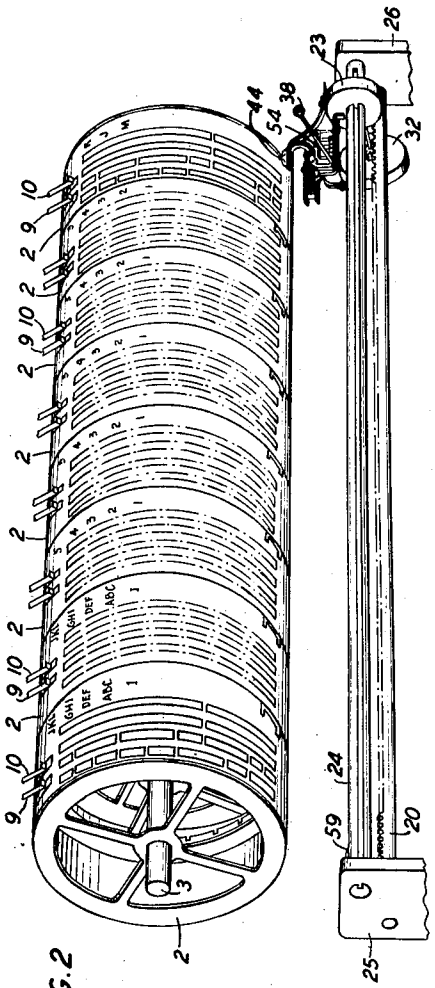

FIG. 2

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Feb. 27, 1940. B. F. LEWIS 2,191,913

TELEPHONE SYSTEM

Filed March 3, 1939 3 Sheets-Sheet 2

FIG. 3

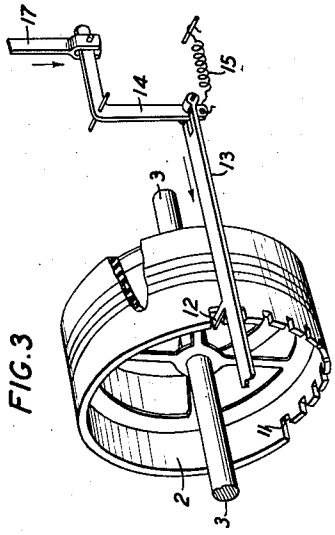


FIG. 6

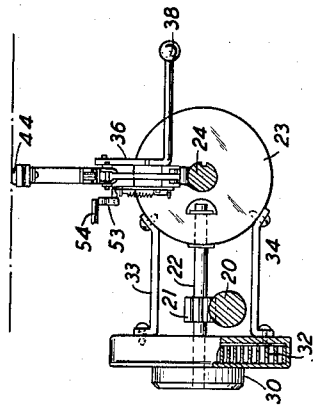


FIG. 5

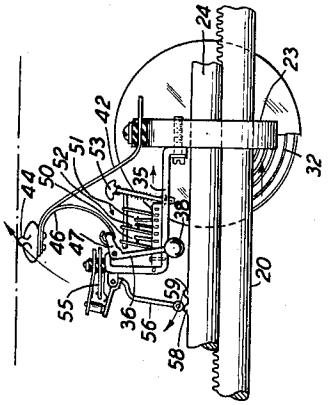
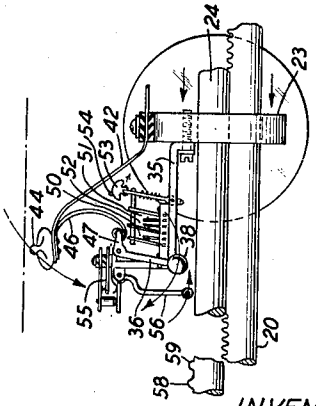


FIG. 4



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TELEPHONE SYSTEM

Filed March 3, 1939 3 Sheets-Sheet 3

FIG. 8

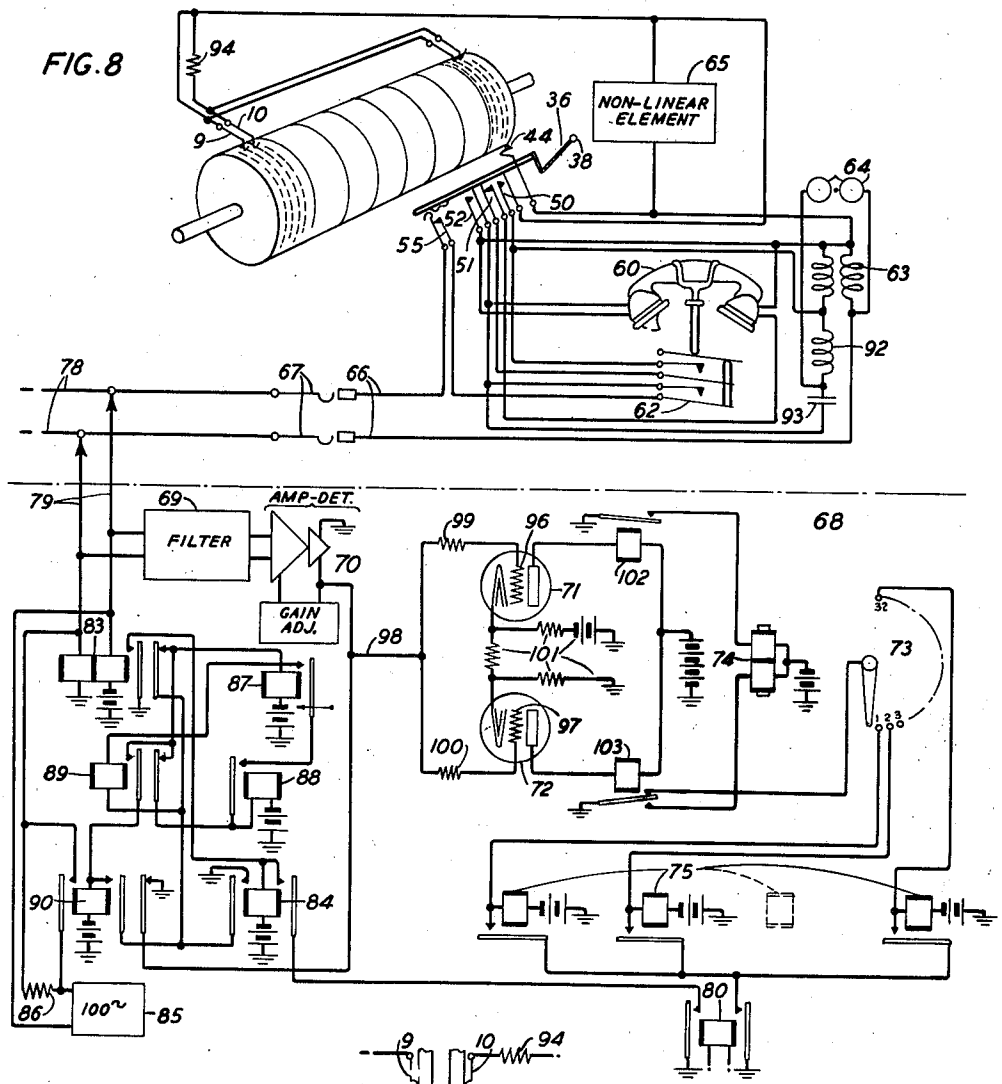
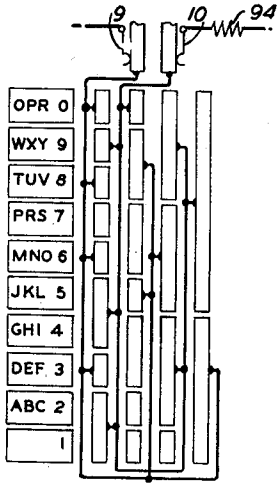


FIG. 7



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Patented Feb. 27, 1940 2,191,913

UNITED STATES PATENT OFFICE

2,191,913

TELEPHONE SYSTEM

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Application March 3, 1939, Serial No. 259,530

7 Claims. (Cl. 179—16)

This invention relates to telephone systems and particularly to signal sending and receiving arrangements in automatic telephone systems.

It is an object of the present invention to improve and simplify mechanisms for transmitting, receiving and recording digit designations.

Another object is to employ designations that are comparatively free from line disturbances.

Heretofore systems have been employed in which digit designations have consisted of harmonics of a fundamental frequency specially selected to represent telephone designations, and different methods have been proposed for recording these designations.

It is a feature of the present invention to provide means for representing digit designations by harmonics modified as to energy levels, each digit comprising a combination of signals and the various signals comprising harmonics that are modified as to their energy levels.

Another feature of the invention is to provide a receiving and recording mechanism for said signals including thermionic tubes biased to become active in response to corresponding signals and recording means controlled by said tubes to record the signals as corresponding digit designations.

The invention has been illustrated in the accompanying drawings in which Figs. 1 to 7 show various details of an impulse transmitting mechanism and recording devices in accordance with the invention.

Of these figures, Fig. 1 shows a general assembly of the transmitter with certain portions of the housing removed;

Fig. 2 shows the commutator drums and brushes to modify circuits to produce digit impulses;

Fig. 3 shows details of a locking device for the drums;

Figs. 4, 5 and 6 show various details of the brush and contact arrangements in different positions;

Fig. 7 shows the arrangement of the contact elements on a drum; and

Fig. 8 shows a diagrammatic representation of the transmitting apparatus and also the circuits for the receiving apparatus that records the digits as they are received.

Referring now to Figs. 1 to 6, there is shown in Fig. 1 a housing 1 enclosing a series of drums, the first of which has been marked 2. These drums are mounted on a common shaft 3 supported in the housing. Each of these drums is provided with four rows of contacting elements separated sufficiently to provide insulating portions between them and between the rows. The width of the contacting elements is practically equal to the insulation spaces between the four rows, as shown in Fig. 7. At the right-hand end of each drum there is provided a handle 4 that projects through an opening 5 in the housing 1 and by means of which the drums may be set in various positions as indicated by the enlarged portions in the openings 5. These drums may be set in from one to ten positions in most cases. The apparatus shown indicates that eight of these drums may be mounted on the shaft 3 for the setting of the drums to select eight succeeding digits. Each drum is also provided with an extension 6 on the right side thereof on which the digits are marked, and in the housing 1 there is a window for each drum such as window 8 so located in relation to the legends on the drum that when the drums are moved, the legends will be visible through the windows. At the top of the housing 1 there are located two springs 9 and 10 for each drum that always engage two special contact strips on the drum so that no matter in what positions the drums are set, these brushes 9 and 10 will always connect with certain contact elements. The contact strips may be connected by any suitable means such as connecting wires in the manner shown in Fig. 7 to establish different combinations of connections between the contact elements and the brushes 9 or 10 as determined by the setting of the drums. The purpose of these connections will become apparent as the description proceeds. At the edge of the extension 6 of each drum there are a number of notches 11 as illustrated in Fig. 3 one of which may be engaged by a projection 12 for each drum. These projections extend from a bar 13 operated by a lever arrangement 14 and held by a spring 15 in such a position that all drums are locked by the projections 12 engaging the notches 11 in the drums. The lever 14 may be connected by any suitable means such as the bar 17 to the switchhook in the regular telephone set at the subscriber's station so that when the receiver is on the switchhook, the bar 17 is depressed and moves lever 14 and bar 13 to remove the projections 12 from notches 11 to permit the drums to be rotated for the setting of the various digits. At the bottom of the housing 1 there is located a brush carriage arrangement comprising a rack 20 and a pinion 21 engaging this rack and rotatably secured at one end by means of a shaft 22 to a disc 23 slidably mounted on bar 24. The rack 20 and bar 24 are supported at both ends

of the housing in suitable bearings such as 25 at one end and 26 at the other. The shaft 22 extends into a housing 30 and is connected to the inner end of a spiral spring 32, the other end of which is connected to the housing 30. This housing in turn is connected by the supports 33 and 34 to the disc 23. On disc 23 there is mounted a bracket 35 supporting a lever 36 having a knob 38 extending outside of the housing 1 through a slot 40. The disc 23 also supports the flexible brush member 42 which is insulated from the disc 23 but is provided with a brush 44 for engagement with the drums as will be described hereinafter. This member 42 has an extension 46 that engages the end 47 of the lever 36. The purpose of these parts, as illustrated in Figs. 4 to 6 in detail, is to provide means whereby the brush 44 may be swept transversely over the drums in succession when the drums have been set. Attached to the disc 23 is also three pairs of spring contacts 50, 51 and 52 that are operated by a lever 53 as will hereinafter be described. This lever is actuated by a projection 54 attached to the housing near the left-hand end thereof. Another pair of contacts 55 are operated by a lever 56. This lever is actuated by the two projections 58 and 59 in succession. The contacts 55 and the lever 56 are attached to the bracket 35 and the projections 58 and 59 attached to the bar 24.

The operation of this mechanism is as follows: The subscriber first sets the drums by moving the handles 4 thereof to various positions depending on the digits desired. The subscriber then removes the receiver from the switchhook and the arm 17 is released to operate lever 14 to cause the arm 13 to be shifted towards the left under tension of spring 15 so that the projection 12 engages the various slots 11 in drums 2 to lock them in actuated positions. The subscriber then listens to dial tone which is produced as will presently be described. When dial tone is heard the subscriber engages the knob 38 of the lever 36 and rotates this lever on its pivot to disengage the brush 44 from contact with the drums and then moves the lever, the disc 23 and the associated apparatus towards the left locking at Fig. 1. This will rotate the ratchet 21 on the rack 20 and thus cause the spring 32 to be wound up in the housing 30. When the subscriber has moved these parts all the way towards the left, he will release the knob 38 and the tension of the spring 32 will then return the parts to normal as the spring 32 will act on the pinion 21 to rotate it back over the rack 20. A speed governing device (not shown) may be employed to regulate the speed at which the pinion is rotated back over rack 20. As soon as this mechanism is released the brush 44 will contact with and sweep over the drums transversely and engage the contact segments as encountered. It should however be noted that immediately after the disc 23 left the normal position the lever 53 will be engaged by the projection 54 and this lever 53 will thereby be swung over in an operative position toward the right as illustrated in Fig. 4 to cause the springs 50 to be closed, 51 to be opened and 52 to be closed. Immediately after the disc starts on its return to normal lever 56 will be engaged in succession by projections 58 and 59, as illustrated in Fig. 5, thus causing the contacts 55 to be opened twice in succession. When the disc 23 has completely returned to normal the lever 53 will be returned to normal position by engaging the projection 54 and thus restore the springs 50, 51 and 52 to normal position. When the conversation is completed the switchhook is replaced which causes the bar 17, lever 14, bar 13 and projections 12 to be restored to release the drums. The drums may then be returned to normal as left in the positions in which they have been set as desired.

In Fig. 8 the impulse sending mechanism described above has been disclosed in diagrammatic form showing drums 2 with contacts 9 and 10 engaging them, the lever 36 and the contacts 50, 51, 52 and 55, and a telephone set 60 operating on switchhook contacts 62. The circuit at the substation comprises the usual induction coil 63, ringer 64 and a non-linear element 65 arranged as will hereinafter be described. The line from the subscriber's set is marked 66 and extends to a line finder 67 which has been shown in diagrammatic form. The line finder may be connected to a registering device 68 shown below the dash-dotted line. This registering device includes a number of different circuits and apparatus such as the filter 69, amplifier-detector and gain control devices 70, vacuum tubes 71 and 72, a step-by-step switch 73, operated by the magnet 74, a number of register relays, three of which have been shown in full and marked with the numeral 75, and other relays and apparatus, the purpose of which will become apparent as the description proceeds.

The operation of this system may be as follows: After the subscriber has set the drums he removes his receiver from the switchhook to lock the drums in actuated position as hereinbefore described. Contacts 62 are now closed. This closes a connection across the line 66 over contacts 55 and 62, the transmitter and the right-hand winding of induction coil 63 and causes the line finder 67 to connect the calling line 66 to a central office sender in the usual manner. This connection then extends over leads 78 to a first selector which has not been shown as apparatus of that kind is well known in the art. However, prior to the extension of a connection over this first selector operations may take place in any manner well known in the art to establish over leads 78 a connection through the usual sender connector to the registering apparatus 68. When this connection is made the relay 80 is operated in any well-known manner to provide certain locking circuits as will hereinafter be described. Relay 83 is also operated over the direct current circuit now established from battery and ground through the windings of this relay, the tip and ring connection through conductors 79, line finder 67, conductors 66, contacts 55, the lower set of the switchhook contacts 62, the transmitter and the right-hand winding of induction coil 63. Relay 83 in operation closes a circuit for relay 84 which locks to ground at contacts of relay 80. The purpose of relay 84 will become apparent as the description proceeds. It should also be noted that alternating current from the hundred cycle source 85 is now also connected back to the calling line. The resistance 86 is inserted in series with source 85 to limit the volume of the current from this source so as to make it suitable as a dial tone for the subscriber's receiver.

The contacts 9 and 10 of the various drums are connected to certain contact elements of the drums as seen in Fig. 7. When the subscriber hears the dial tone the transmission of the selected digits may begin. To this end the subscriber will now engage the knob 38 of lever 36 and remove the brush 44 from connection with

the drums and move the brush carriage all the way towards the left and then release the lever 36 at which time the brush 44 engages the first drum ready for the transmission of the impulses as determined by the settings of these drums. The first effect, however, of the movement of the carriage towards the left is that the projection 54 will engage the lever 53 to close contacts 50 and 52 and open contacts 51, then when the carriage starts on its return to normal, the contacts 55 will be opened twice in succession by the projections 58, 59 to open the connection to the register 68. The immediate result of the first opening of the connection between contacts 55 is that the direct current connections completed on the removal of the receiver from the switchhook opens the circuit from battery and ground through the windings of relay 83 over the conductors 79 and 66. The release of relay 83 closes the circuit for relay 87 from battery, winding of this relay and contacts of relays 83 and 84 to ground. Relay 88 is also operated on the release of relay 83 over a circuit from battery, winding of this relay and contacts of relays 89, 83 and 84 to ground. When relay 83 operates after the first operation of the connection at contacts 55, relay 89 will be operated from battery, winding of relay 88, contacts of this relay and relay 87, winding of relay 89 to ground at relay 84. Relay 87 is slow in releasing so it does not release at this time. When the relay 83 releases in response to the second opening of the contacts 55, relay 90 will operate from battery through the winding of this relay, contacts of relays 89 and 83 to ground at relay 84. Relay 90 in operating removes ground at its outer right-hand armature and back contact to enable the tubes 71 and 72 to operate as will be described hereinafter. This relay also closes a shunt across the resistance 86 and consequently the full effect of the alternating current from the hundred cycle source at 85 is transmitted back over the line. Relay 90 locks to ground and contacts of relay 84.

Now it should be observed that the next step will be that the brush 44 will proceed to travel transversely over the drums in succession and contact with the segments in accordance with the setting of the drums. However, before the brush 44 engages any contact segment of the first drum, it touches insulation and there is no connection through contacts 9 and 10 to brush 44. Consequently, at this time the non-linear element 65 is shunted across the left-hand winding of the induction coil 63 in place of the receiver and receives the hundred cycle energy from the line by the transformer action of the induction coils 63 and 92. The non-lineal characteristics of element 65 cause this energy to be transformed into certain harmonics which are transmitted back to the line by the induction coil. The effect of this transmission is aided by the condenser 93. These harmonics are transmitted back over the line at a certain normal energy level. The arrangement in register 68 is such that these harmonics will cause the switch 73 to take one step each time they are applied to the register after the circuit begins to function and it is for that purpose that they are applied to the line before the brush 44 engages each row of segments in each drum. These harmonics are then modified by the segments encountered on the drums in their various settings to either be reduced in their energy levels to an intermediate value or be extinguished to produce, as will hereinafter be explained three different effects. To effect the two last-mentioned energy levels the non-linear element may either be partially shunted by connecting one side of this element through the brush 44 to certain contact elements in the drum through the brush 10 and the resistance 94. This produces harmonics of an energy level lower than the normal level. On the other hand this non-linear element may be directly shunted by a connection established by the brush 44 through certain other contact elements in the drum and brush 9. This reduces the energy level of the harmonics to a practically negligible value. It is by combinations of these various harmonic outputs that digits may be built up and it will now be described how this is effective in register 68.

It should now be observed that normally there may be applied a positive potential by the amplifier-detector and gain control devices 70 in any manner well known in the art to the grids 96 and 97 over the conductor 98 and individual resistances 99 and 100. This normal potential is effective to operate the two tubes 71 and 72 as soon as relay 90 is operated as described by the removal of ground on lead 98 at the outer right-hand armature and back contact of this relay. The cathodes of the two tubes are biased at different negative potentials by being connected at different points as shown on the potentiometer circuit at 101, so that tubes 71 and 72 will operate depending on different values of the potential existing on the conductor 98. Such values are first the normal positive potential from the amplifier-detector and gain control devices 70 which causes the tubes to become active, and second a medium negative potential and third the maximum negative potential. The three values of the potentials which, of course, are caused by a direct current source in the devices 70 are modified normally by the harmonics of the highest energy level harmonic, harmonics of a lower intermediate energy level and harmonics of negligible value. It should be stated here that the filter 69 is such that only the harmonics are transmitted to the devices 70 and the fundamental hundred cycle current is eliminated from these devices and also that the ground connection at contacts of relay 90 when released causes the normal potential applied to conductor 98 to be such that both tubes 71 and 72 are actuated. Hence when as stated above, relay 90 is operated and the harmonics transmitted from the subscriber's station when the non-linear element 65 is not shunted by either of the circuits through the brushes 9 or 10, these harmonics are of the highest energy level. Thus devices 70 will change its positive potential to become of a maximum negative potential so that both tubes will become inactive or extinguished whereas if the harmonics of a lower intermediate value are transmitted through the shunt circuit over brush 10 and due to the potentiometer 101 the potential will be changed to an intermediate negative potential so only tube 71 will remain active and tube 72 become inactive. However, when the element 65 is completely shunted by the circuit over brush 9, the harmonics transmitted will not be of sufficient strength to materially change the positive potential on lead 98 and thus both tubes will again become active. These various conditions are brought about due to the travel of the brush 44 over the drums and thus as a result of these various potentials on conductor 98, the tubes will either be both inactive, that is, when

full strength harmonics are transmitted and tube 71 remain active when harmonics of a lower intermediate level are transmitted or both tubes will be active when practically no harmonics are transmitted. With this in mind, it is evident that combinations of such various harmonics may be produced to compose digits so that before the brush engages the first row of segments on any drum, both tubes will become inactive and when the brush engages the succeeding four rows of segments on any drum either one or both tubes will become active, and when the brush engages the insulation between the rows of segments on any drum both tubes will become inactive. As for example if the digit JKL or 5, referring to Fig. 7, is the one that the brush 44 will engage, it is evident that when the brush engages the first segment a connection will be established through brush 10; when it engages the corresponding segment in the second row, a circuit will be established through brush 9; when the brush 44 engages the segment in the third row, a circuit will be completed through brush 9 and when the brush 44 engages the segment in the fourth row a circuit will be completed through brush 10. Thus, for the first segment in the first row only tube 71 will be active; for the second row both tubes will be active; for the third row both tubes will be active and for the fourth row only tube 71 will be active, whereas when the brush passes between these rows of segments, both of the tubes will become inactive.

With this in mind it is evident that the output circuit of the tubes 71 and 72 will when current flows through these circuits cause the operation of relays 102 and 103. As stated normally these output circuits are active and consequently relays 102 and 103 will be energized and when the full harmonics are first applied both tubes will become inactive. Consequently these two relays 102 and 103 will release. The release of these relays closes circuits for the two windings of the magnet 74 which causes the brushes of the switches 73 to take one step. The next action will be that only tube 71 will remain active and relay 102 will release. This produces no effect. That is, the first register relay in group 75 will not be operated as there is no circuit closed through the brush and first contact of switch 73 to this relay. Then, both tubes will become inactive and relays 102 and 103 will be both released, causing the magnet 74 to energize the switches 73 to take a second step. Then, both tubes will become active and relays 102 and 103 will be operated. In this case the second register relay of the group 75 will operate over a circuit from battery, winding of this relay, the second contact and brush of switch 73 to ground at relay 103. Then both tubes will become inactive causing the switch to take a third step. Then both tubes will become active, causing relays 102 and 103 to be operated. The operation of relay 103 in this case closes a circuit for a third register relay over the brush and the third contact of switch 73. Then tubes 71 and 72 will become inactive causing the switch to take a fourth step. Then tube 71 only remains active and at this time no register relay will be actuated as there will be no circuit to this relay through the brush in the fourth contact of switch 73. Hence by sending this digit 5 the second and third register relays only will be operated. These register relays will lock in operated position by a ground applied at relay 80. In the same manner seven other digits may be registered by the setting of the other combination, as hereafter shown. It will be noted that in this register there would be thirty-two relays, four relays for each digit and these relays will be operated in various combinations to represent the various digits. When the brush 44 has returned completely to normal, contacts 50, 51 and 52 will be restored to normal position and the circuit at the substation will then be ready for talking. It should be understood that the register relays when they have all been set in accordance with the eight digits suitable apparatus will be provided whereby the settings of the register will be employed for selecting connections beyond to the called subscriber's line and when the register has performed its functions, the relay 80 will be released and the register relays restore to normal and also the relays 84, 90, 89, 87 and 88 and the register circuit itself will be removed from the connection leading to the first selector in any manner well known in the art.

What is claimed is:

1. In a telephone system, a line, means for transmitting over said line groups of signals, each group representing a telephone digit and each signal comprising a number of harmonics of a fundamental frequency modified as to their energy levels to identify the digits, and means responsive to said groups of signals for recording the digits represented thereby.

2. In a telephone system, a line, a source of alternating current connected to said line, means for producing harmonics of alternating current from said source at fixed energy levels, means for transmitting signals representative of telephone designations over said line comprising combinations of impulses of said harmonics at said fixed energy levels and at other modified energy levels, and means responsive to said combinations of impulses for making records representing corresponding telephone designations.

3. In a telephone system, a line, means for transmitting over said line groups of signals each group representing a telephone digit and each signal comprising a number of harmonics of a fundamental frequency modified as to their energy levels to identify the digits, thermionic tubes associated with said line operated in response to the succeeding signals in each group in corresponding combinations, and means responsive to current through said tube when operated to make a record representing a telephone digit as determined by said groups of signals.

4. In a telephone system, a line, a source of alternating current connected to said line, means for producing in said line signals comprising harmonics of said alternating current, means for changing the energy levels of the harmonics in said signals from a normal level to two succeeding lower levels, means for combining signals of harmonics of these various energy levels into codes, each representative of a telephone designation, and means responsive to said combinations of signals for recording the corresponding telephone designations.

5. In a telephone system, a line, a source of alternating current connected to said line, means for producing in said line signals comprising harmonics of said alternating current, means for changing the energy levels of the harmonics in said signals from a normal level to two succeeding lower levels, means for combining signals of harmonics of these various energy levels into codes, each representative of a telephone designation, recording means, and means for sup-

pressing current from said alternating current source and for transmitting the code signals to said recording means to record the telephone designations represented by them.

6. In a telephone system, a line and means for transmitting over said line groups of signals, each group representing a telephone digit and each signal comprising a number of harmonics of a fundamental frequency modified as to their energy levels to identify the digit, and a plurality of three-element thermionic tubes, means for transmitting said signals to the control elements of said tubes, and means associated with the cathode and anode elements of said tubes for controlling the discharges thereof to cause said tubes to discharge at different potentials on their respective control elements as established thereon by said harmonics of different energy levels, and recording means responsive to discharges from said tubes to record said signals as digit designations.

7. In a telephone system, a line, a source of alternating current connected to said line, means for producing in said line signals comprising harmonics of said alternating current, means for changing the energy levels of the harmonics in said signals from a normal level to two succeeding lower levels, means for combining signals of harmonics of these various levels into codes, each representative of a telephone digit designation, a plurality of three-element thermionic discharge devices, means for transmitting said codes in succession to the control elements of said devices and preventing current from said alternating current source from being transmitted to said control elements, and means associated with a cathode and anode elements of said devices for controlling the discharges thereof to cause said devices to discharge at different potentials on their respective control elements as established thereon by said harmonics of different energy levels, and means responsive to discharges from said devices for recording said codes as digit designations.

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