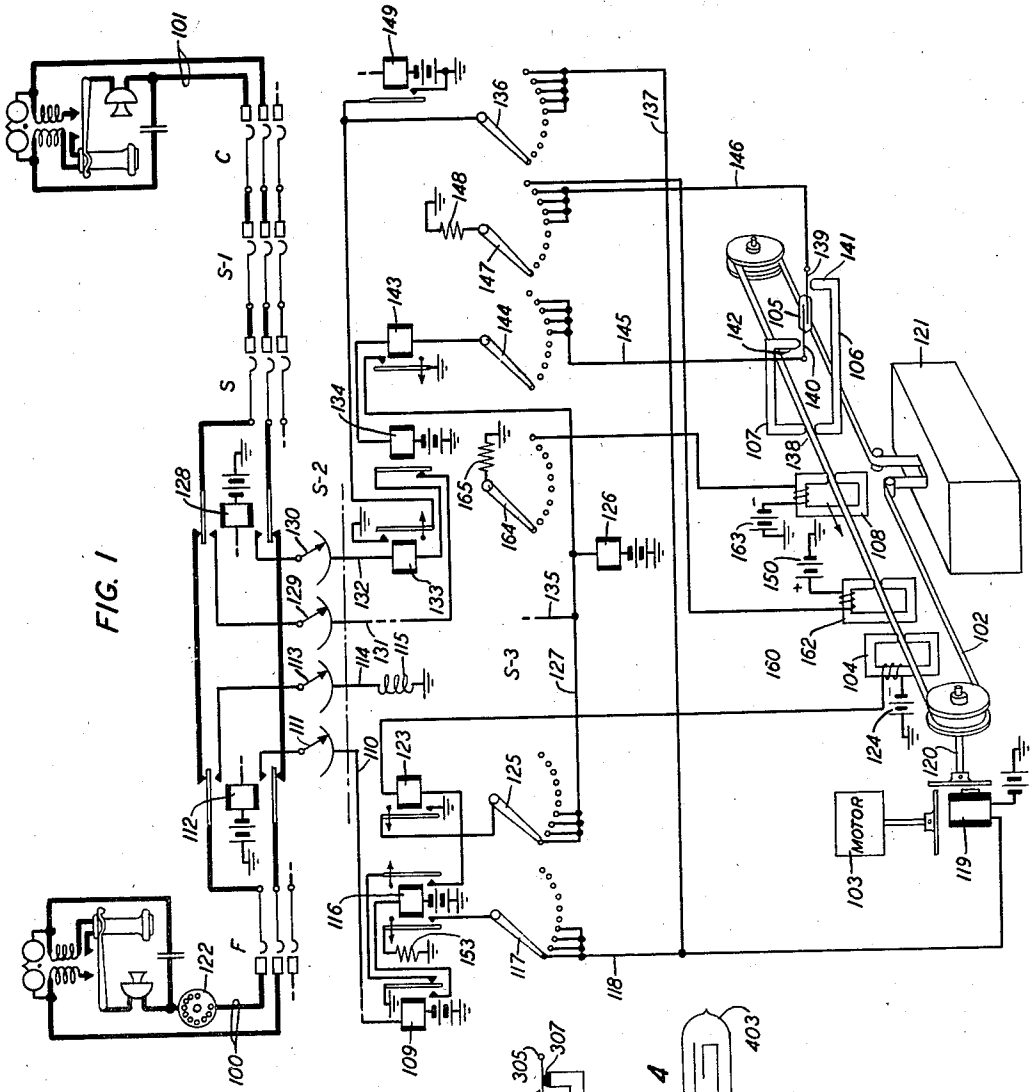
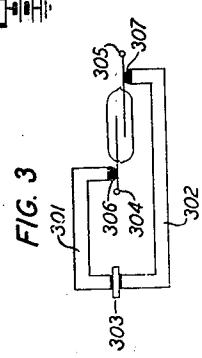
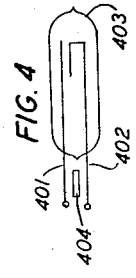
Oct. 13, 1942. R. J. TILLMAN 2,298,519

TELEPHONE SYSTEM

Filed June 21, 1940 2 Sheets-Sheet 1

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TELEPHONE SYSTEM

Filed June 21, 1940 2 Sheets-Sheet 2

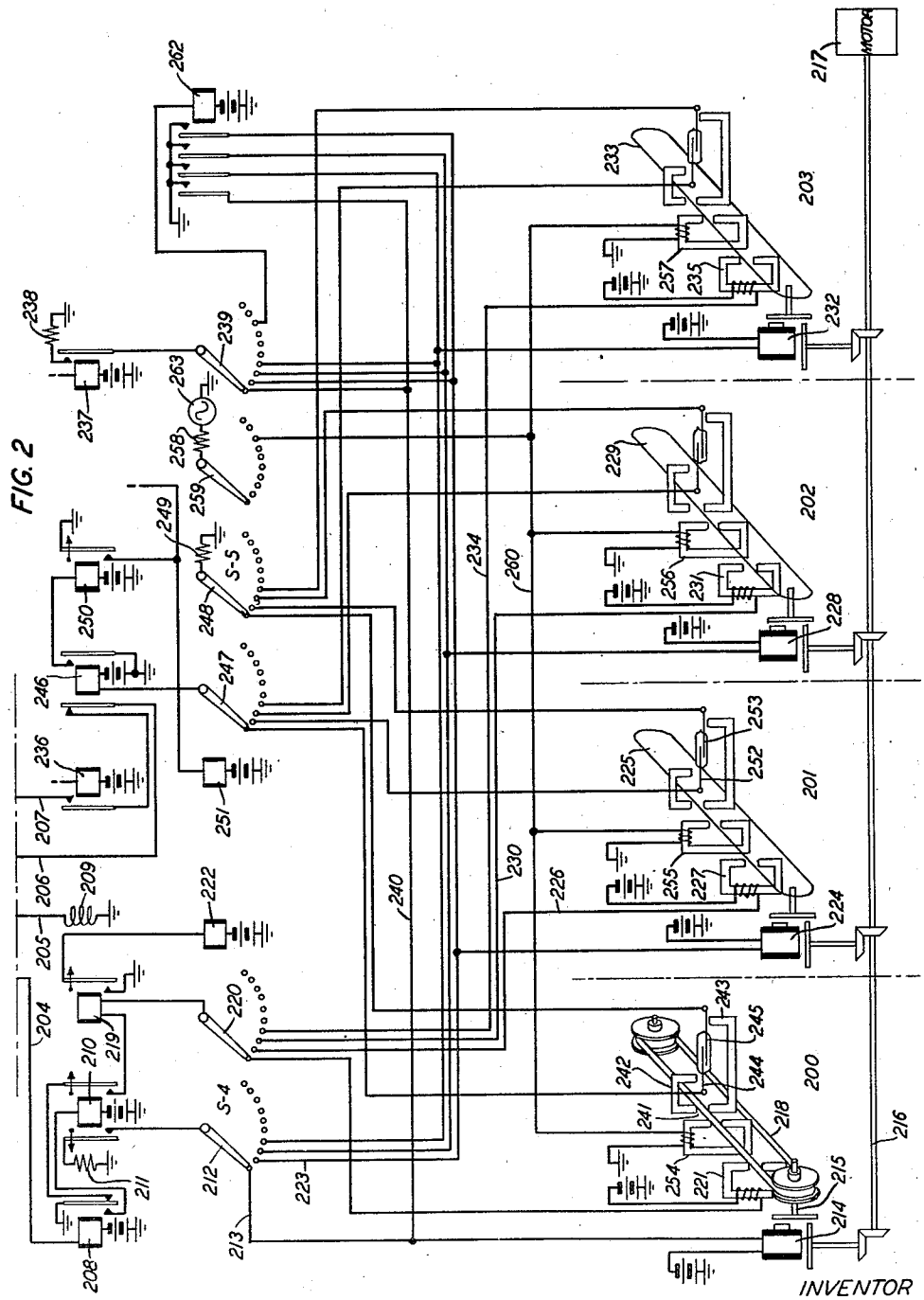


FIG. 2

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Patented Oct. 13, 1942

2,298,519

# UNITED STATES PATENT OFFICE

2,298,519

## TELEPHONE SYSTEM

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Application June 21, 1940, Serial No. 341,634

9 Claims. (Cl. 179—18)

This invention relates to telephone systems and particularly to systems in which connections are established by automatic switches.

The objects of the invention are to simplify the registration of telephone designations; to facilitate the use of these registered designations to control the selective operation of the automatic switches; and to obtain other improvements in systems of this character.

Telephone systems that require the called line designation to be stored at the central office before it is used to control the selective switches are generally provided with mechanisms known as register senders for this purpose. The registers of these senders play the important part of receiving the dial pulses from the subscriber's station and utilizing these pulses to register the different characters of a wanted designation. Since each designation character may have several values, usually ten, the register which receives and stores the character must be capable of assuming as many as ten different settings. To accomplish this requirement it has been the practice to provide either a plurality of relays for each separate register or a movable switch of some kind, such as a stepping switch having ten or more points.

According to the present invention advantages are obtained over these prior mechanisms by the use of magnetic recording means for receiving and recording the designation signal currents sent from the calling station. More specifically a simple magnetic medium in the form of a wire or tape is provided for recording the characters in each of the digital places of the designation. The incoming impulses, varying in numbers according to the values of the digits, cause the energization of the magnetizing element associated with the tape, and this element produces in the moving tape a number of magnetized areas corresponding to the digits. Having thus effectively stored the several digits of the called designation, the tape is driven through an associated reproducing element at the proper time, and this element converts the magnetized areas of the tape into corresponding trains of impulses which then serve to control the selective operation of the switches. When the stored digits have been used to set the switches, the records on the tape are erased magnetically, thus preparing it for recording the next designation.

A feature of the invention is a magnetic reproducing mechanism for reproducing the stored impulses in which the magnetized tape and a set of magnetic impulse contacts are included in the magnetic circuit. The magnetic circuit, which is formed by members of relatively high permeability has a narrow gap through which the moving tape passes to produce flux changes therein. The magnetic spring contacts of a relay form another gap in the magnetic circuit. The magnetized areas in the tape produces in the magnetic circuit a flux which flows through the relay contact springs and attracts them into engagement with each other. The closures of these springs produce impulses which are transmitted to the switches.

Among the advantages of this digit storing mechanism are simplicity of its construction and operation and the effectiveness with which it records the incoming impulses and reproduces them when they are needed to operate the switches.

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

In the drawings accompanying the specification Fig. 1 illustrates an automatic telephone system incorporating the features of this invention. This figure illustrates diagrammatically the automatic switches used in establishing a connection between subscribers, and a designation recording device for controlling the switches;

Fig. 2 shows an alternative form of the recording mechanism; and

Figs. 3 and 4 show alternative forms of the reproducing unit.

Referring particularly to the drawings, a calling subscriber's line **100** appears in the terminal bank of a line-finder switch F which is joined by a link circuit to a first selector switch S. The selector switch S has access through a suitable number of succeeding switches, such as selector S—1 and connector C, to called subscribers' lines, including the line **101**. The link interconnecting the finder F and selector S is provided with a sender selector switch S—2 having access to common recording senders, one of which is shown.

Each of these senders includes a magnetic recording mechanism **160** comprising a movable magnetic wire or tape **102** which is driven by a motor **103** through a recording element **104** to record the dial impulses transmitted over the calling subscriber's line to the recording mechanism. These impulses are delivered to the recording element **104** by means of impulse receiving relays, and the motor **103** is clutched to the shaft **120** for driving the tape **102** during the recording period under the control of a circuit closed through the contacts of a sequence switch

S—3. After the digits have been recorded on the magnetic tape 102, the tape is driven through an air-gap of a reproducing device comprising a relay 105 having magnetic contacts arranged in a second air-gap. The magnetic circuit including these two air-gaps is formed by the magnetic members 106 and 107. The relay 105 repeatedly closes its contacts in response to the movement of the tape through the air-gap and transmits impulses over a circuit extending through the contacts of the sequence switch S—3. These impulses serve to cause the selective operation of the switches S, S—1 and C to extend the desired connection to the subscriber's line 101. Thereafter the tape 102 is driven through erasing devices 108 and 162 to remove the magnetization and restore the tape to its neutral condition ready for the next use.

The alternate recording sender disclosed in Fig. 2 is similar to the one shown in Fig. 1 in that it utilizes the magnetic recording medium for recording the designation impulses transmitted from the calling subscriber's station. It differs, however, in that a separate recording tape or wire is provided for each of the successive digits involved in the designation. Assuming the designations have four digital places, there are provided a corresponding number of recorders 200, 201, 202 and 203 for recording these digits. The incoming impulse series from the subscriber's line are directed successively to the recorders 200, 201, 202, 203 by a sequence switch S—4. After the digits have all been recorded the outgoing impulse circuit is associated with the successive recorders by means of a second controlling sequence switch S—5. After all digits have been transmitted from the recorders the magnetized tapes are demagnetized by running them through erasing devices.

For the purpose of the present disclosure it is assumed that the switches F, S, S—1 and C are of the step-by-step type, the selectors S and S—1 and the connector C being operated by impulses transmitted directly to the operating magnets of these switches from the sender. It should be understood, however, that the invention is not limited to the use of step-by-step switches; instead it may be applied to systems in which any type of switch is used, such as the panel switch or the cross-bar switch or the relay switch. Also it has been assumed that the magnetic recording medium is a tape or wire commonly used for the purpose of recording signals magnetically. It will be obvious, however, that any form of magnetic medium, including magnetic discs or cylinders, may be used in the present system. Furthermore, it will be understood that the recording mechanism or sender is equipped with all the necessary relays and devices for performing the numerous functions usually required in the establishment of telephone connections.

For a better understanding of the invention a description will now be given of the manner in which the system operates, referring first to Fig. 1. Assume for this purpose that the subscriber of line 100 wishes to converse with the subscriber of line 101. When the calling subscriber initiates the call, the line finder F operates and seizes the line 100, and the sender selector S—2 operates at the same time to associate the line-finder-selector link with an idle recording sender. An impulse circuit may now be traced from battery through the winding of relay 109, conductor 110, brush 111 of switch S—2 thence over the front contact of the operated relay 112 in the link, through a brush of the line finder F over the loop of the calling line and returning through the line finder and over the front contact of relay 112, brush 113, conductor 114 through the reactance coil 115 to ground. Relay 109 operates and closes an obvious circuit for slow-release relay 116. Relay 116 closes a circuit from ground through resistance 153, armature and contact of relay 116, brush 117 of selector S—3, in position 1, conductor 118 through the winding of clutch magnet 119 to battery and ground. The magnet 119 clutches the shaft of motor 103 to the drive shaft 120, and the tape 102 is driven in the direction indicated by the arrow. The reservoir 121 is provided to hold a supply of the tape necessary for recording the several digits of the designation.

In response to each opening of the subscriber's line circuit during the first series of impulses transmitted by the subscriber's dial 122 impulse relay 109 releases and closes a circuit from ground through its back contact, closed contacts of relay 116, winding of slow-release relay 123, through the winding of the magnetizing element 104 to the negative pole of battery 124. Each energization of the element 104 produces a magnetized area in the moving tape 102, there being as many of these magnetized areas as there are impulses in the series. These magnetized areas are permanent and remain in the tape until they have served their purpose and are erased magnetically as will be explained more fully hereinafter. Relay 123 operates on the first impulse and remains energized throughout the series. This relay closes a circuit from ground through its front contacts, brush 125, conductor 127 through the winding of the stepping magnet 126 to battery. Magnet 126 energizes preparatory to advancing the brushes of switch S—3 to their second position terminals. In the interval between the last impulse of the first series and the beginning of the second impulse series relay 123 releases and magnet 126 deenergizes and steps the brushes of switch S—3 to position 2. The tape 102 continues to advance so that a space is introduced between the recording of the first digit and the recording of the next digit.

When the next series of impulses are received, relay 123 reoperates to energize the magnet 126, and the recording element 104 is successively energized to magnetize the moving tape a number of times corresponding to the number of impulses in the second series. This procedure continues for the remaining digits of the designation. Assuming the designation has four digital places, the magnet 126 steps the switch S—3 out of position 4 and into position 5 following the receipt and recording of the last digit. As the switch S—3 passes out of position 4 the circuit of the clutch magnet 119 is opened, and the magnetic tape 102 comes to rest.

When the sender is ready to operate the selective switches, an impulse circuit is established from battery and ground through the impulse relay (not shown) in the selector switch S, over the front contacts of operated relay 128, through the brushes 129 and 130 of switch S—2 thence over conductors 131 and 132 through the winding of slow-release relay 133 and the closed contacts of relay 134. Relay 133 operates but does not perform any function at this time. Having prepared the impulse circuit, the sender causes the operation of stepping magnet 126 by momentarily applying ground potential to conductor 135. Magnet 126 operates and releases, and the switch

S—3 advances into position 6. In this position a circuit is closed from ground through the front contacts of relay 133, brush 136, conductor 137 through the winding of magnet 119 to battery. The motor 103 is again clutched to the drive shaft 120, and the magnetized tape 102 resumes its forward motion.

When the first series of magnetized areas pass through the air-gap 138, a magnetic field is produced in the magnetic circuit, including the members 106 and 107, which may be of high permeability. Each magnetized area produces a magnetic field across the gap formed by the magnet contact springs 139 and 140 of the relay 105. These springs are enclosed in a glass vessel or other suitable container and are acted upon directly by the flux produced across the gap formed by the pole-pieces 141 and 142. Therefore, each magnetized area of the tape passing through the gap 138 sets up a magnetic field which attracts the flexible magnetic springs 139 and 140 into contact engagement with each other. A device of this type, in which magnetic spring contacts are acted upon directly by the magnetic field, is disclosed in the W. B. Ellwood Patent 2,289,830 of July 14, 1942.

Each time the springs 139 and 140 engage each other a circuit is completed from battery through the winding of impulse relay 134, winding of slow-release relay 143, brush 144 in position 6, conductor 145, contacts 140 and 139, conductor 146, brush 147, resistance 148 to ground. Relay 134 operates in response to each of these impulses and opens the impulse circuit extending to the selector switch S. Relay 143 operates in the circuit traced and closes a circuit for the stepping magnet 126. Relay 143, being slow to release, holds its armature attracted throughout the impulse series. Relay 133, being slow, also retains its armature during the intervals between the impulses of each series. The selector S responds to these impulses and advances to the desired level of contacts and then seizes an idle trunk in the level extending to the succeeding selector S—1.

At the end of the first outgoing impulse series the non-magnetized portion of the tape 102 passes through the gap 138 and slow-release relay 143 retracts its armature to open the circuit of magnet 126. Magnet 126 releases, and the brushes of switch S—3 advance to the seventh position.

The tape 102 continues to move, and presently the magnetized areas representing the second series of impulses pass through the air-gap 138. As above described, these magnetized areas cause the successive closures of the contacts 139 and 140 and the corresponding operation of impulse relay 134. Relay 134 transmits the impulse series to the selector S—1 which is operated to select the proper level of trunks and thereafter an idle trunk extending to the connector switch C. At the end of the second series the magnet 126 steps the switch S—3 to position 8. In like manner the last two series of impulses are transmitted to connector switch C, and the connection is established to the called subscriber's line 101.

When the last series of impulses has been transmitted from the tape 102, the switch S—3 advances to position 10, and the record on the tape is erased to prepare it for the next use. To this end the clutch magnet 119 is maintained in an energized condition over a circuit extending through the brush 136 in position 10 to ground through the contact of a control relay 149. As the tape passes through the erasing unit 108 the flux produced by source 163 is sufficient to magnetize all sections of the tape to substantially the same degree and in the same direction as the magnetization produced by recording unit 104. Thereafter the tape passes through the unit 162 which is energized in the opposite direction by a somewhat weaker source 150, thus neutralizing the entire tape. The units 108 and 162 are energized in circuits traceable, respectively, from the negative pole of battery 163 and the positive pole of battery 150 through the winding of units 108 and 162, brushes 164 and 147, through the resistances 165 and 148 to ground.

At the proper time the control relay 149 is released, and a ground potential is momentarily applied to conductor 135 to restore the switch S—3 to its normal position. All relays in the sender are released, and the connection between the calling and called lines is now in condition for conversation. At the end of conversation the established connection is released in the well-known manner.

In the alternate sender shown in Fig. 2 the conductors 204, 205, 206 and 207, corresponding respectively to conductors 110, 114, 131 and 132, also appear in the contact banks of a sender selector switch, such as the switch S—2. When a call is made and the sender is seized by the sender selector switch, an impulse circuit is completed from battery through the winding of impulse relay 208, thence over conductor 204 through the sender selector and over the subscriber's line, returning through the sender selector and over conductor 205 through reactance coil 209 to ground. Relay 208 closes an obvious operating circuit for slow-release relay 210. Relay 210 closes a circuit from ground through resistance 211, contacts of relay 210, brush 212 of sequence switch S—4, conductor 213, winding of clutch magnet 214 to battery. The magnet 214 clutches the drive shaft 215 of the first recorder 200 to the common shaft 216, which is driven by the motor 217, to start the magnetic tape 218.

For each impulse of the first series relay 208 releases and closes a circuit from ground through its armature and back contact, front contact of relay 210, winding of slow-release relay 219, brush 220 through the winding of the recording unit 221 to the negative pole of battery. The recording unit 221 magnetizes the moving tape 218, and relay 219 operates and closes an energizing circuit for the stepping magnet 222. Magnet 222 remains energized throughout the impulse series preparatory to advancing the brushes to the second position contacts. At the end of the series, relay 219 releases, releasing the magnet 222, and the brushes of switch S—4 move out of position 1 and into position 2. The circuit of clutch magnet 214 is opened when the switch advances, and the tape 218 comes to rest, having recorded thereon the first digit of the wanted designation.

With the switch S—4 in position 2 a circuit is closed from ground through the resistance 211, brush 212, conductor 223 through the winding of clutch magnet 224 to battery. Magnet 224 energizes and clutches the driving shaft of the recorder 201 to the main operating shaft 216, and the magnetic tape 225 is started in operation. When the impulses of the second series are received from the subscriber's dial, relay 208 re-

leases successively and closes a circuit from ground through its armature and back contact, front contact of relay 210, winding of relay 219, brush 220, conductor 226 through the winding of recording unit 227 to the negative pole of battery. The second series of impulses are recorded on the moving tape 225, following which the relay 219 releases and again the magnet 222 deenergizes to advance the brushes 212 and 220 into position 3. As the switch S—4 moves out of position 2 magnet 224 becomes deenergized, and the tape 225 comes to rest.

In position 3 of the switch S—4 the clutch magnet 228 is energized to start the recording tape 229, and the impulse circuit from relay 208 is extended over conductor 230 to the recording unit 231. After the third series of impulses has been recorded on tape 229 the switch S—4 advances to the fourth position, the tape 229 comes to rest, and the clutch magnet 232 is energized to start the tape 233. The final series of impulses are now received and the impulse circuit from relay 208 extends over conductor 234 to the recording unit 235. These impulses are recorded on the tape 233, whereupon the switch S—4 advances into position 5 and the tape 233 comes to rest.

At the proper time in the sequence of operations the relay 236 is operated to close the impulse circuit over conductors 206 and 207 to the first selector switch S, and relay 237 is operated to close a circuit from ground through resistance 238, contacts of said relay, brush 239 of switch S—5, standing in position 1, thence over conductors 240 and 213 through the winding of clutch magnet 214 to battery. The tape 218 resumes its movement, and the magnetized areas thereof pass through the air-gap 241 formed by the magnetic members 242 and 243. Each time a magnetized area passes through the gap 241 the magnetic contacts 244 and 245 move into engagement with each other, and a circuit is completed from battery through the winding of relay 246, brush 247, through the contacts 244 and 245, brush 248 and resistance 249 to ground. Each time relay 246 operates it opens its contacts to transmit an impulse to the selector S. Relay 246 also closes an obvious circuit for slow-release relay 250, and the latter relay closes an energizing circuit for the stepping magnet 251. At the end of the impulse series, when the last magnetized area has passed through the air-gap 241, relay 250 releases and opens the circuit of magnet 251. Thereupon the magnet 251 advances the brushes of switch S—5 into position 2, disconnecting the recorder 200 and associating the recorder 201 with the outgoing impulse circuit. The clutch magnet 224 is now energized in an obvious circuit, and the magnetic contacts 252 and 253 are included in circuit with the impulse relay 246. In the manner already described the second series of impulses are transmitted to the selector switch S—1 following which the switch S—5 advances to position 3 to disconnect the recorder 201 and to connect the recorder 202 with the outgoing impulse circuit. In like manner the last two series of impulses are transmitted successively from the recorders 202 and 203 to operate the connector switch C.

At some convenient time after the last series of impulses have been transmitted from the recorder 203 the sender advances the sequence switch S—5 to some subsequent position such as position 8. In this position a circuit is closed from ground through the resistance 238, contacts of relay 237, brush 239 through the winding of relay 262 to battery. Relay 262 closes obvious circuits through the windings of clutch magnets 214, 224, 228 and 232. While the respective magnetic tapes are being driven by the shaft 216 a circuit is closed for the erasing units 254, 255, 256 and 257. This circuit may be traced from the source of alternating current 263 through the resistance 258, brush 259, conductor 260 and thence in parallel through the windings of said erasing units to ground. The frequency of source 263 is sufficiently high to neutralize the magnetized areas of the respective tapes, thus restoring them to their normal condition ready for the next use.

After the other necessary functions have been completed by the sender it advances the switches S—4 and S—5 to their normal positions and releases.

In the alternative reproducing unit shown in Fig. 3 the gap between the magnetic members 301 and 302 is just wide enough to permit the free passage of the tape 303. This narrow gap serves to increase the efficiency of the magnetic circuit. Since, however, the tape touches the members 301 and 302, these members are separated from the magnetic contacts 304 and 305 by thin insulating pieces 306 and 307. If desirable the members 301 and 302 may engage contacts 304 and 305, in which case the tape 303 would need to be insulated from said members.

In Fig. 4 the magnetic contact springs 401 and 402 project from the same end of the glass tube 403, and the tape 404 passes through the gap formed by these springs as shown.

What is claimed is:

1. In a telephone system, a central office, telephone lines terminating therein, automatic switches, means for sending series of impulses over a calling line representing the telephone designation of a wanted line, a magnetizable medium in said central office, means responsive to said impulses for establishing a variable number of permanent magnetizations in said medium to record said telephone designation, and impulse generating contacts of magnetic material controlled by said medium in accordance with the record thereon for selectively operating said automatic switches to extend the calling line toward the called line.

2. In a telephone system, a central office, telephone lines terminating therein, automatic switches, means for sending series of impulses over a calling line representing the telephone designation of a wanted line, a movable magnetic tape, recording means responsive to said impulses for magnetizing said tape to store said impulse series, magnetic reproducing means including impulse contacts of magnetic material coacting with the magnetized tape to reproduce said impulse series, automatic switches responsive to said reproduced impulses for selectively extending the calling line toward the called line, and means for erasing the magnetizations on said tape.

3. In a telephone system, a central office, telephone lines terminating therein, automatic switches, means for sending a plurality of series of impulses representing the successive digits of a telephone designation, a magnetizable tape at the central office, a recording device responsive to said impulse series for magnetizing said tape to record the designation thereon, means for directing each series of impulses to said recording device, a reproducing device including impulse

contacts of magnetic material responsive to the magnetized tape to reproduce the recorded series of impulses, and an impulse circuit for delivering the reproduced impulses to said switches.

4. In a telephone system, a central office, telephone lines terminating therein, automatic switches, a common sender mechanism for controlling said switches, said sender mechanism including a recording medium, means for sending designation impulses over a calling line to the central office, means responsive to said impulses for setting up in said medium areas of permanent magnetism to record the telephone designation, impulse generating contacts magnetically responsive to the areas of magnetism in said medium for reproducing the recorded impulses, and means for utilizing said reproduced impulses to control the selective operation of said switches to establish a connection from the calling line to a called line.

5. In a telephone system, a telephone line, means for sending impulses over said line representing a telephone designation, a magnetic medium, means responsive to said impulses for variably magnetizing said medium to record said designation thereon, magnetic means for reproducing said impulses having a magnetic circuit with an air-gap therein, impulse generating contacts of magnetic material located in said air-gap and responsive to flux changes in said magnetic circuit, means for causing said magnetized medium to produce flux changes in said magnetic circuit, and selective means controlled by the impulses produced by said impulse contacts.

6. In a telephone system, a telephone line, means for sending impulses over said line representing a telephone designation, a magnetic tape, means responsive to said impulses for variably magnetizing said tape to record said designation thereon, magnetic means for reproducing said impulses having a plurality of air-gaps therein, impulse generating contacts of magnetic material located in one of said air-gaps and responsive to flux changes in said magnetic circuit, means for causing said magnetized tape to produce flux changes in said magnetic circuit by passing it through another of said air-gaps, and selective means controlled by the impulses produced by said impulse contacts.

7. In a telephone system, a telephone line, means for sending impulses over said line representing a telephone designation, a magnetic tape, means responsive to said impulses for variably magnetizing said tape to record said designation thereon, a magnetic reproducing mechanism having a magnetic circuit with two air-gaps therein, impulse generating contacts of magnetic material located in one of said air-gaps and responsive to flux changes in said magnetic circuit, means for moving the magnetized tape through the other of said air-gaps to produce flux changes in said magnetic circuit and in said first air-gap, and selective means controlled by the impulses produced by said impulse contacts.

8. The combination in an impulse mechanism of a magnetic medium, means responsive to incoming impulses for variably magnetizing said medium to record said impulses thereon, magnetic means for reproducing said impulses having a magnetic circuit with a gap therein, impulse generating contacts of magnetic material responsive to flux changes in said magnetic circuit, and means for moving said magnetized medium through said gap to produce flux changes in said magnetic circuit.

9. The combination in an impulse mechanism of a magnetic medium, means responsive to impulses for variably magnetizing said medium to record said impulses thereon, magnetic means for reproducing said impulses having a magnetic circuit with a gap therein, a pair of impulse generating contacts of magnetic material located in said magnetic circuit and forming a second gap, said contacts being responsive to flux changes in said magnetic circuit to generate impulses, and means for causing said magnetized medium to move through said first-mentioned gap to produce flux changes in said magnetic circuit.

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