

Sept. 14, 1943.

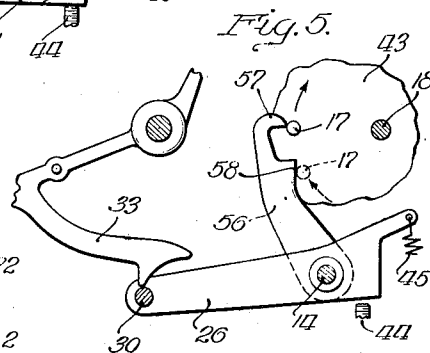
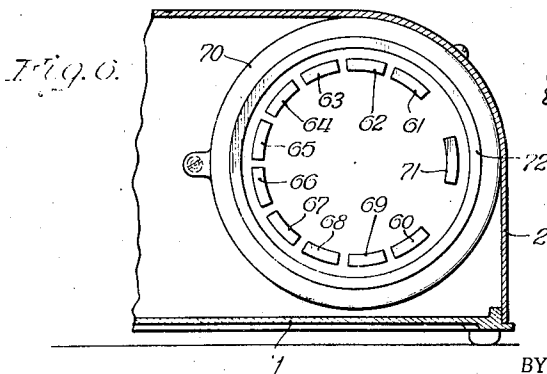
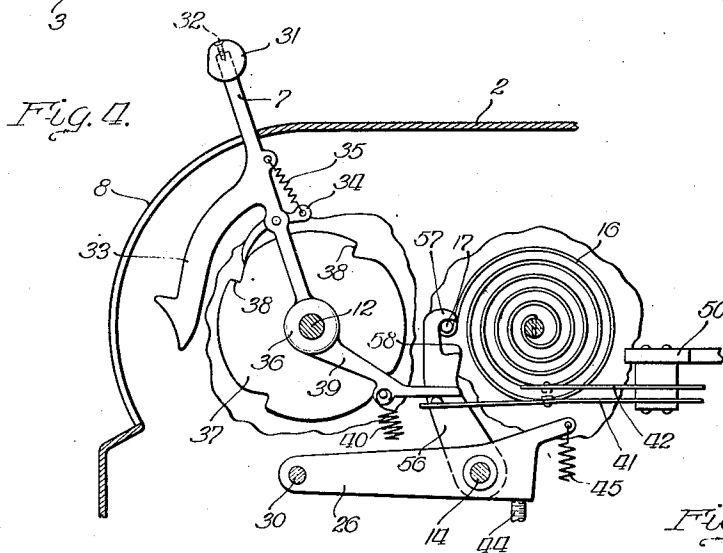
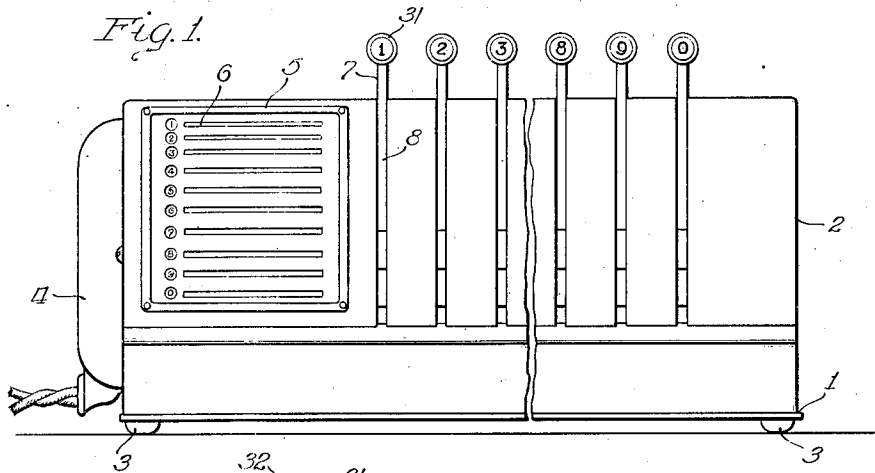
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2,329,234

AUTOMATIC SWITCHING SYSTEM

Filed Feb. 10, 1941

5 Sheets-Sheet 1



INVENTOR.

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Sept. 14, 1943.

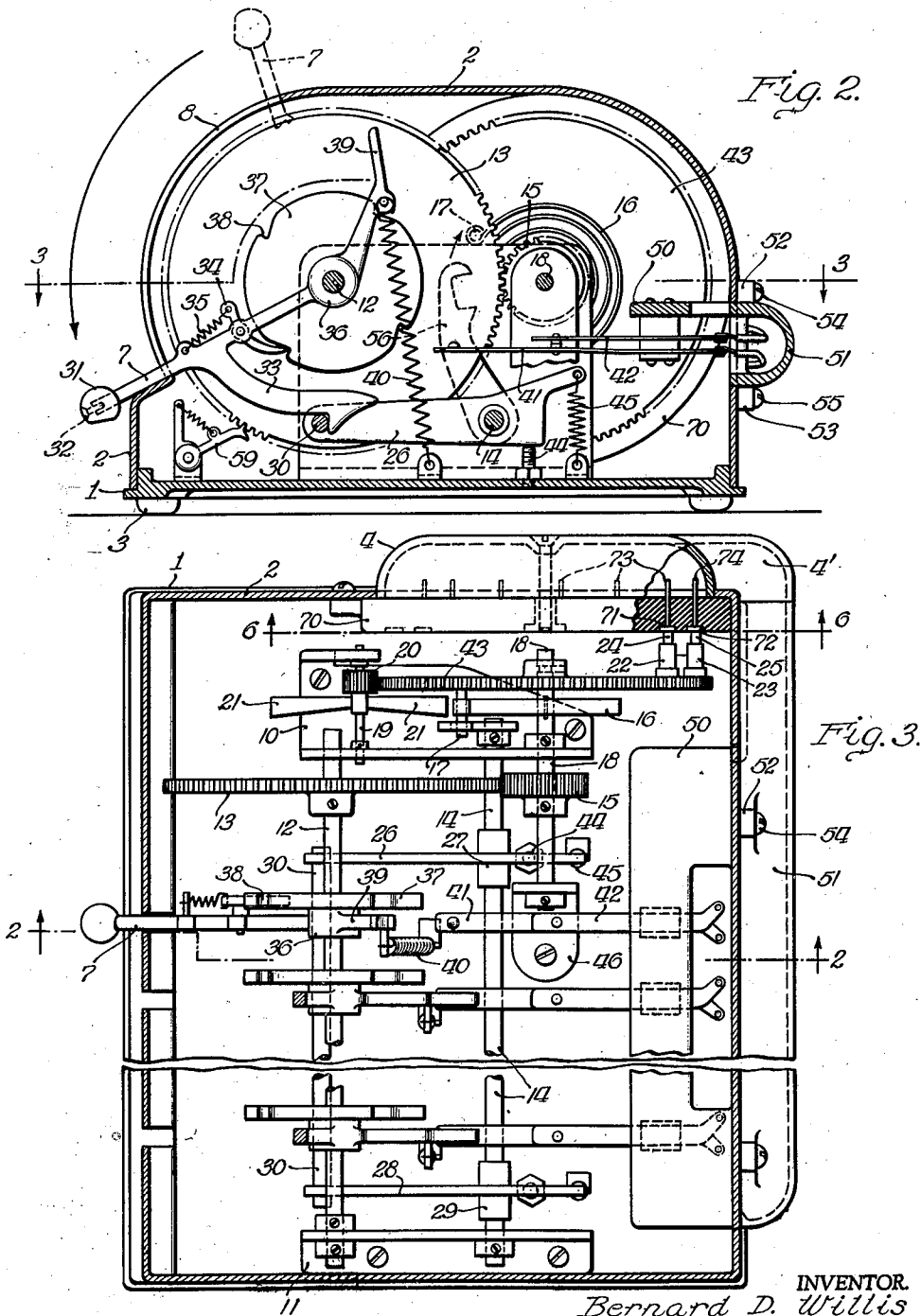
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2,329,234

AUTOMATIC SWITCHING SYSTEM

Filed Feb. 10, 1941

5 Sheets-Sheet 2



Sept. 14, 1943.

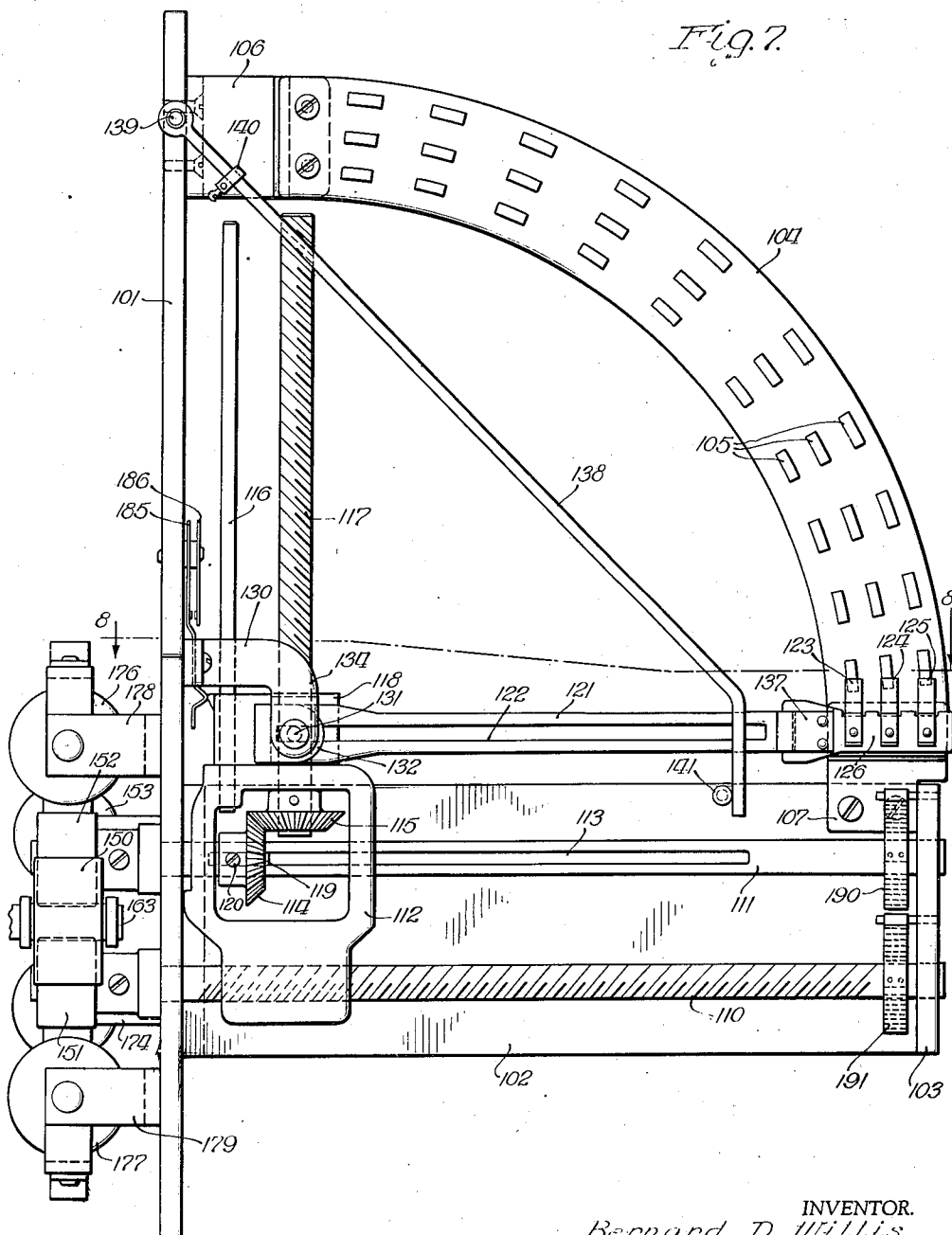
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AUTOMATIC SWITCHING SYSTEM

Filed Feb. 10, 1941

5 Sheets-Sheet 3



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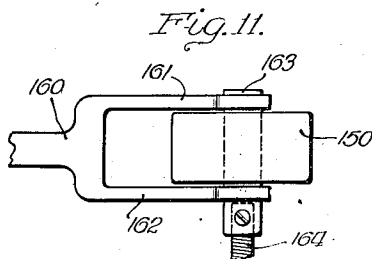
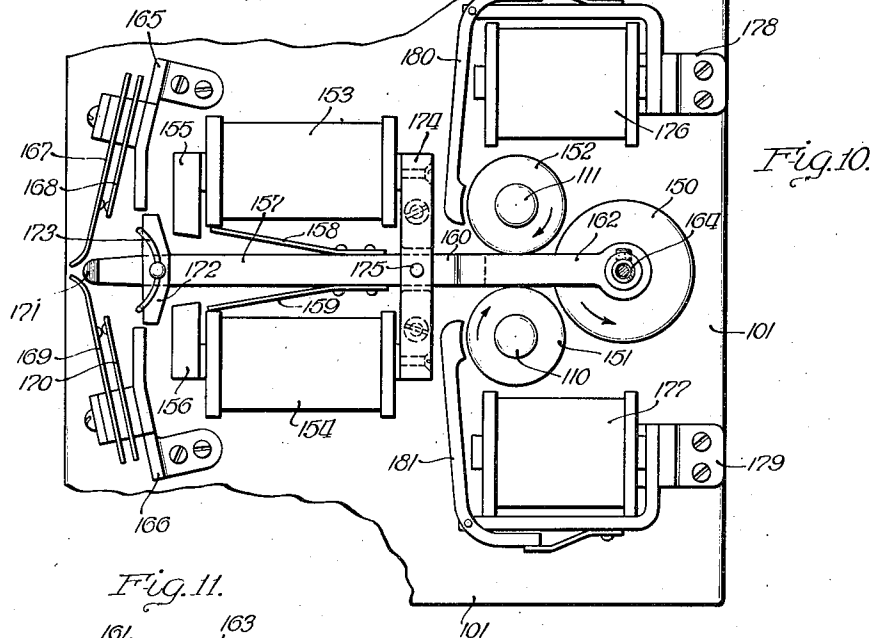
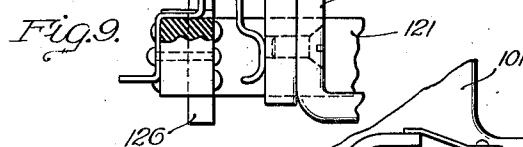
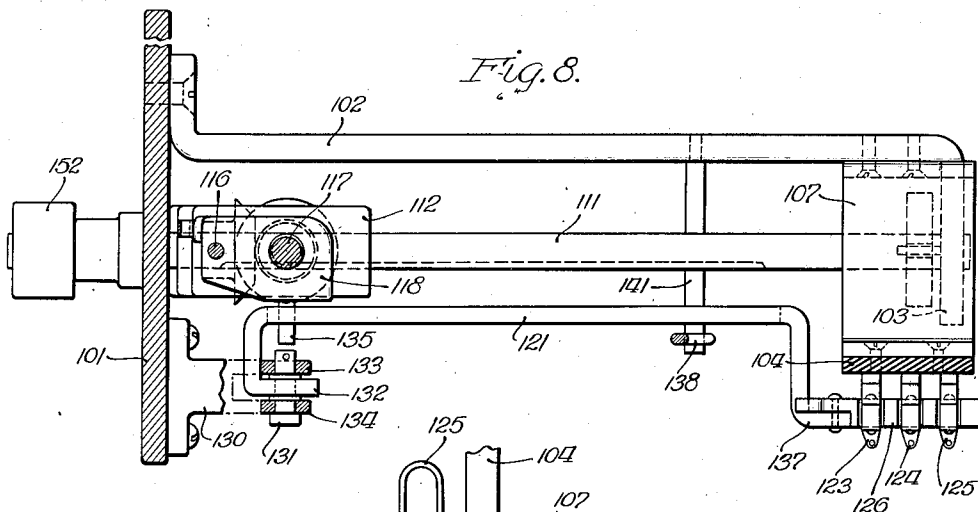
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AUTOMATIC SWITCHING SYSTEM

Filed Feb. 10, 1941

5 Sheets-Sheet 4



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2,329,234

AUTOMATIC SWITCHING SYSTEM

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5 Sheets-Sheet 5

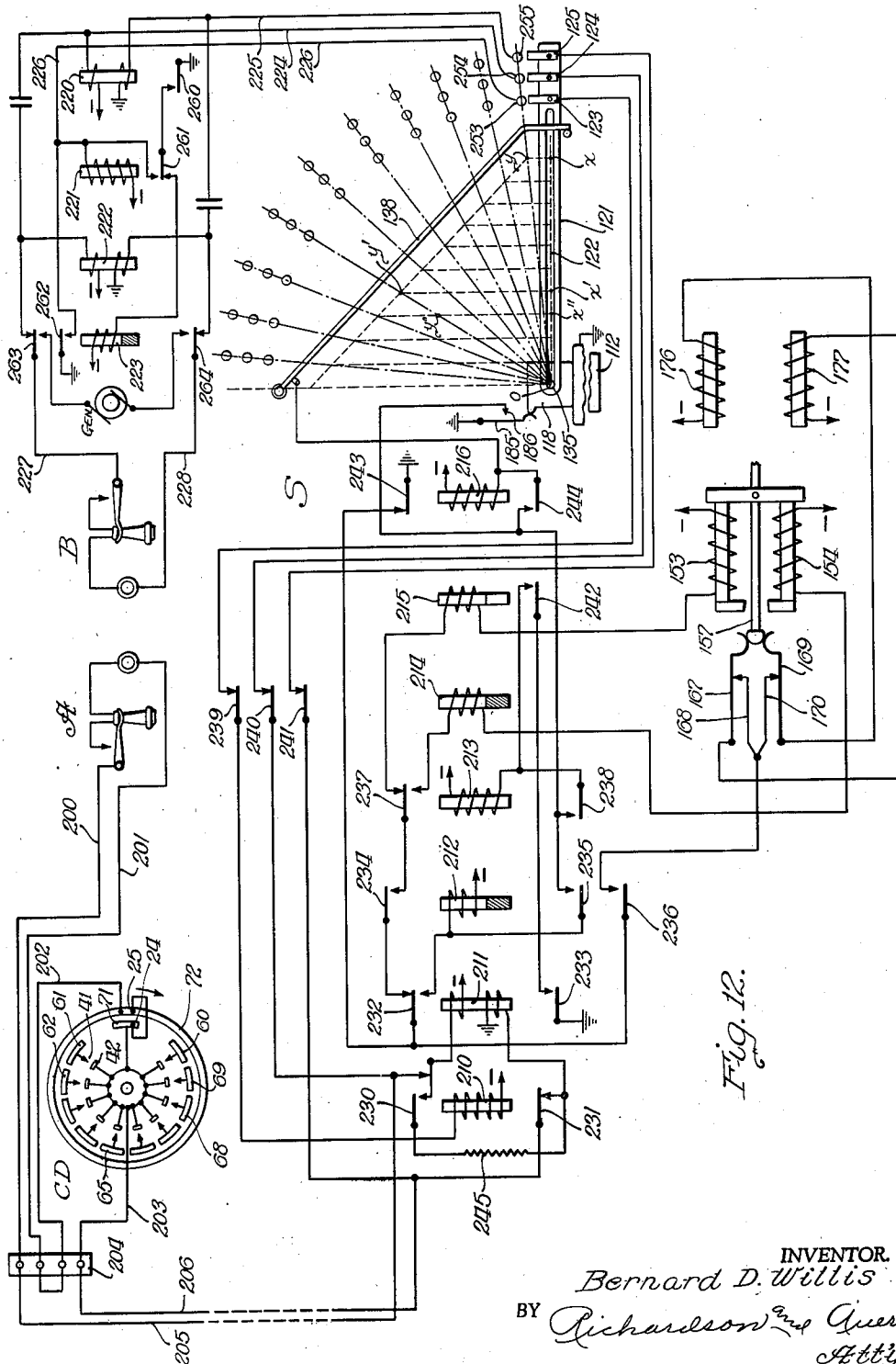


Fig. 12.

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UNITED STATES PATENT OFFICE

2,329,234

AUTOMATIC SWITCHING SYSTEM

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Application February 10, 1941, Serial No. 378,151

18 Claims. (Cl. 179—18)

The present invention relates in general to automatic switching systems, and more in particular to such switching systems as include an impulse sender or calling device at a control station, a line extending to a distant switching station or exchange, and one or more automatic switches at the latter point which are selectively controlled over the line by the calling device at the control station.

An example of such a switching system is an automatic telephone system, in which each subscriber's line is provided with a calling device at the subscriber's telephone, and in which automatic switches are provided at the exchange for the purpose of establishing telephone connections under subscriber control. For convenience, therefore, the invention is illustrated and described herein as a simple form of automatic telephone system. It is not limited to such use, however, but may be employed in a variety of situations where it is desired to effect selective action under remote control.

The main feature of the invention is the novel principle in accordance with which the selecting operation is controlled. In automatic telephone systems which are in common use, the control is exercised by the transmission of a variable series of impulses which are generated by a calling device. The number of impulses in a series depends on the digit in accordance with which the calling device is operated, and the selecting operation resulting from the transmission of a series of impulses is in accordance with the number of impulses in the series. This principle of operation requires absolute accuracy in the registration of a series of impulses and since the impulses must be transmitted at rather high speed, and frequently over lines ill adapted to high speed impulse transmission, certain difficulties have been encountered which render it more or less unsatisfactory.

In my Patent No. 2,222,131, granted November 19, 1940, I have described a system of selective control for use in automatic telephone systems or other automatic switching systems, which employs a single impulse of variable length or duration, and in which the selecting operation performed in response to the calling of a digit is in accordance with the length of the single impulse generated by such calling operation. A continuous motion switch is used, which is started at the beginning of the impulse and is stopped at the end thereof. The switch runs at predetermined speed for the duration of the impulse, and the extent of its motion, or the selecting oper-

ation performed, is therefore in accordance with the length of the impulse. In this system of control the duration of each impulse is determined by the digit called, but is also dependent upon the speed of the calling device, which accordingly must be coordinated with the speed of the automatic switches in order to insure accurate selection. The necessary speed relation between the calling device and switches is not particularly difficult of attainment, but this requirement nevertheless introduces a difficulty under certain circumstances, which renders the system less satisfactory than it otherwise would be.

My improved system of selective control resembles the system disclosed in my above mentioned patent to some extent; that is, it dispenses with the use of a variable series of impulses. At each operation of the calling device a fixed number of impulses is generated. Two impulses instead of one are generated, however, and although these two impulses are of variable length the selection effected does not depend directly upon the length of the impulses, but upon the ratio of the length of the first impulse to that of the second. Thus the speed of the calling device, within reasonable limits, is entirely immaterial. For the digit 1, for example, the ratio of the duration of the first impulse to that of the second may be as 10 is to 1. A given calling device may operate at such a speed that the duration of the first impulse is one second, while the duration of the second impulse is one-tenth second. Another calling device may have a faster speed such that the duration of the first impulse is only one-half second, but the duration of the second impulse in this case will only be one-twentieth second, and the ratio between the two impulses will be the same.

It will be understood that in my improved system the calling device and likewise the switch under control thereof must run at some constant speed, but the two speeds do not have a fixed relation to each other and accordingly these requirements are easily met. For instance, the switch may be operated by a synchronous motor running on commercial power, which has a substantially constant frequency. The calling device, on the other hand, may be provided with a speed governor, of which several reliable types are known. Since the calling device speed is not rigidly associated with the switch speed, either speed may be varied within quite wide limits without affecting the selection control.

The practical application of the new principle of selection control described in the foregoing

involves the production of a new and improved calling device and a new and improved automatic switch mechanism, together with suitable new circuit arrangements for controlling the operations of the switch in response to the operation of the calling device. These may be regarded as additional features of the invention.

The foregoing and other features of the invention will be fully explained in the course of the following detailed description, reference being had to the accompanying drawings, in which—

Fig. 1 is a front view of the calling device;

Figs. 2 and 3 are additional views of the calling device, Fig. 2 being a section on the line 2—2, Fig. 3, and Fig. 3 being a section on the line 3—3, Fig. 2;

Figs. 4 and 5 are fragmentary views showing details of the calling device;

Fig. 6 is a partial section on the line 6—6, Fig. 3, showing the commutator;

Fig. 7 is a side view of the switch mechanism;

Fig. 8 is a section on the line 8—8, Fig. 7;

Fig. 9 is a view showing details of the switch brush construction;

Fig. 10 is a partial end view of the switch showing the electromagnetic operating mechanism;

Fig. 11 is a view showing details of the main drive roller; and

Fig. 12 is a diagrammatic circuit drawing of an automatic telephone system in accordance with the invention.

Referring to Figs. 1 to 6, inclusive, the calling device will first be described. Fig. 1 shows the general appearance of the calling device when installed and ready for use. As seen in this figure, there is a base 1, which may be a metal casting, and which is provided with rubber supports 3 at the corners. There is also a cover 2, of heavy sheet metal, and shaped as shown in Figs. 1 and 2. It will also be seen that a number of digit keys such as key 7 are provided, which project through slots such as 8 in the curved front of the cover 2. There may be ten of these keys, numbered from 1 to 0, inclusive. At the left of the row of keys there is an escutcheon 5, which holds the directory card 6. At the right hand end the cover is completely closed, but at the left hand end there is a circular opening (see Fig. 3), which is provided in order to afford access to the rear of the commutator 10 for wiring purposes. This opening is closed by a detachable shallow cup-shaped closure member 4.

Most of the parts of the calling device are mounted on the base 1. To this end a U-shaped bracket 10 is provided at one end of the calling device and an L-shaped bracket 11 at the other end. There is also an L-shaped bracket 46. These brackets may be fastened to the base 1 by means of screws, as indicated in Fig. 3. The shaft 12 is supported in bearings in the two brackets 10 and 11 and supports the gear wheel 13. The ten digit keys such as key 7 are also mounted on the shaft 12.

The arrangement of key 7 may be described in detail in connection with Fig. 4. Reference may also be made to Fig. 2, which shows the key in operated position. At the projecting extremity of the key there is a knob or ball 31, secured to the shank of the key by a screw 32. At the other end the key is provided with a hub 35, which is rotatable on the shaft 12. Projecting downwardly and to the right from the hub 36 there is an arm 39, provided for the purpose of controlling the contact spring 41, which is

maintained normally separated from contact spring 42. A coil spring 40, better seen in Fig. 2, is attached to arm 39 and tends to rotate the key in a clockwise direction on shaft 12, thereby normally maintaining it in the position in which it appears in Fig. 4. The key 7 is also provided with a locking hook 33, the purpose of which will be described subsequently.

Associated with the key 7 there is a disk 37, which is keyed or otherwise rigidly secured on shaft 12. The disk 37 has four notches spaced ninety degrees apart around its periphery, whereby it may be rotated by the key 7 through the medium of the pawl 34, the latter being held against the disk by the spring 35. The slot 8 is long enough so that when the key 7 is operated (see Fig. 2), it moves through an arc of somewhat more than ninety degrees. Each time the key is operated, therefore, the pawl 34 engages in one of the notches 38 and rotates the disk 37 through an angular distance of ninety degrees. The rotation of the disk of course rotates the shaft 12, since the disk is fixed to the shaft.

Each of the other keys is arranged the same as key 7, and each of these other keys has associated with it a notched disk similar to the disk 37. When any key is operated, therefore, the shaft 12 is rotated through an angular distance of ninety degrees.

The key locking mechanism will now be described. It comprises a shaft 14, rotatable in bearings in the brackets 10 and 11, two arms 26 and 28, which are rigidly secured to shaft 14 by keyed hubs 27 and 29, and a cross rod 30 which extends between the ends of arms 26 and 28 and is rigidly secured thereto. Associated with the arm 26 there is a coil spring 45, which tends to rotate the arm 26 and shaft 14 in a clockwise direction, such rotation being limited, however, by a stop screw 44 which prevents rotation of the arm 26 beyond the position in which it is shown in Figs. 2 and 4. There may be a similar stop screw and spring associated with the arm 28, as indicated in Fig. 3. With this locking arrangement, it will be seen that when any key such as 7 is operated, its locking hook such as 33 will depress the cross rod 30, rotating the shaft 14 through the medium of arms 26 and 28. When the hook passes the cross rod, the latter is raised again by the springs such as 45 and the key is locked, as shown in Fig. 2.

The contact springs 41 and 42 associated with key 7 have already been referred to. There is a similar set of contact springs associated with each of the other keys. These sets of contact springs are all mounted by suitable screws and insulators on a flat metal bar 50 which may be formed integrally with the channel member 51. The latter extends lengthwise along the rear of the cover 2 on the outside thereof and forms a conduit for the conductors which lead from the sets of contact springs to the commutator 10. The channel member 51, bar 50, and the sets of contact springs constitute a demountable unit which may be assembled and wired outside the calling device. When this unit is to be assembled in the calling device the bar 50 and associated sets of contact springs are passed through an opening which is provided in the rear wall of the cover 2. This opening is closed by the channel member 51, the ears such as 52 and 53 of which now rest against the rear wall of the cover. The unit is held in position by means of screws

such as 54 and 55. It will be understood that each set of contact springs is controlled by its associated key in such a manner that the springs are normally open, being allowed to close, however, whenever the key is operated. The open and closed positions of the set of contact springs 41-42 are shown in Figs. 4 and 2, respectively.

Supported in bearings on the brackets 10 and 46 there is a short shaft 18. The shaft 18 is adapted to be rotated by a pinion 15, which is in mesh with the gear wheel 13. The gear ratio is four to one, from which it follows that the pinion 15 and shaft 18 are rotated three hundred and sixty degrees, or one complete rotation, each time a key such as key 7 is operated. This follows from the fact that the operation of a key rotates shaft 12 and gear wheel 13 ninety degrees and from the four to one ratio between gear wheel 13 and pinion 15. The gear wheel 43 is rotatable on shaft 18 and is connected thereto by means of a helical spring 16, one end of which is secured to the shaft 18 and the other end of which is secured to a pin 17. This pin is rigidly fixed to the gear wheel 43 and projects from the side thereof, as shown in Fig. 3. The spring 16 is normally under tension, tending to rotate the gear wheel 43 in a clockwise direction, as seen in Fig. 2. Rotation of the gear wheel cannot normally take place, however, due to the fact that the pin 17 is held by the hook 57 on the end of arm 56, as shown in Fig. 4. The arm 56 is rigidly supported on shaft 14. Since the spring 16 is under tension, it also tends to rotate the shaft 18 and pinion 15 in a counter-clockwise direction, but such rotation is prevented by the dog 59, Fig. 2, which engages with the teeth of the gear wheel 13.

The gear wheel 43 is in engagement with a pinion 20, which is fixed on the shaft 19, the latter having bearings in the bracket 10. On this shaft there is mounted the wind governor comprising vanes 21. Any other known form of governor could be used here, such as a centrifugal governor, for example.

The commutator 70 may be of molded insulating material and has a row of contacts 61 to 60 and 71 embedded therein, as seen in Figs. 3 and 6. There is also a ring 72 of conducting material. The commutator may be secured to the cover 2 by means of screws, as shown in Fig. 6.

The gear wheel 43 carries a pair of brushes 24 and 25 which cooperate, respectively, with the contacts such as 61 and the ring 72. These brushes are supported in brush holders 22 and 23, which are insulated from the gear wheel, but are conductively connected together. The brush 24 is normally in engagement with contact 71, and this contact is therefore normally connected through the two brushes to ring 72. When the gear 43 is rotated, the brush 24 leaves contact 71 and engages successively with contacts 60, 69, etc., which are thus connected successively to ring 72, since brush 25 maintains continuous contact with the ring.

The contacts such as 71 are each provided with a pin or stud such as 73, these pins extending through the commutator and projecting from the back thereof. There is also a pin 74 associated with the ring 72. These pins enable suitable circuit connections to be made to the commutator.

The wiring is shown in Fig. 12, where the calling device is shown diagrammatically and is indicated by the reference character CD. As shown, there are only two conductors leading in

to the calling device, these conductors being indicated at 202 and 203. These conductors extend through a suitable opening in the closure member 4 (see Fig. 1), to the rear of the commutator 70, where conductor 202 is connected to the ring 72 by means of the pin 74. Conductor 203 is connected to contact 71 by means of its pin 73. This pin 73 is also connected to all of the contact springs such as 42 of the sets of contact springs which are associated with the keys. The other contact springs such as 41 of these sets of contact springs are wired individually to the pins such as 73 which are associated with the commutator contacts 61 to 60. That is, contact spring 41 associated with the first key 7 corresponding to the digit 1 is wired to contact 61, the contact spring corresponding to spring 41 but associated with the digit 2 key is wired to contact 62, and so on. There being ten keys, there will be ten conductors connected as described. These conductors, together with the additional conductor for connecting the contact springs such as 42 with the contact 71, extend from the key contact springs by way of the conduit 51 and the extension 4' of the closure member 4 to the rear of the commutator, where they are connected as described.

Reference may now be made to Figs. 7 to 11, inclusive, which show a complete switch constructed in accordance with the invention.

The various parts of the switch are mounted on a frame which comprises a flat metal plate 101 and a second metal plate 102 which is bent as shown in Fig. 8 and secured to plate 101 by means of screws.

The switch bank comprises an arcuate-shaped member 104 having on the face thereof a plurality of contact sets such as 105. The member 104 is preferably of molded insulating material, with the contacts such as 105 embedded therein, each contact having a pin which projects at the rear of the member 104 for the attachment of a conductor. The bank may, however, be constructed in other ways, as is well known in the art.

The switch bank is secured to the frame by means of two brackets 106 and 107, as seen in Fig. 7. The bracket 106 includes a part which rests against the frame plate 101 and which is secured to plate 101 by screws, a second part extending at right angles to the first part and parallel to the plane of the paper, a third part extending forward perpendicular to the plane of the paper, and a fourth part extending parallel to the plane of the paper to which the end of the bank 104 is secured by screws. The bracket 107 includes a part secured to the frame plate 102 by means of screws and a forwardly offset part to which the lower end of the bank is secured by screws.

The end of frame plate 102 is bent forward at right angles to form a bearing member 103. The shafts 110 and 111 extend through bearings in the frame plate 101 and parallel to the frame plate 102, and are provided with bearings in the member 103. These two shafts support a movable carriage 112 which is threaded on the shaft 110 and which is slidable on the shaft 111. It will be understood that shafts 110 and 111 pass through openings in the carriage, and that the threaded opening provided for the threaded shaft 110 affords means for moving the carriage to the right upon rotation of shaft 110, the carriage sliding on shaft 111 in the course of such movement. The bevel gear 114 is also slidable on

shaft 111. The shaft 111 is adapted to rotate the gear 114 in any position of the carriage through the medium of a square spline 113 which lies partly in the groove 113 and partly in a corresponding recess in the gear, to which it is secured by a screw 120.

Extending vertically upward from the carriage 142 there is a shaft or rod 116 which is rigidly fixed to the carriage. The block 118 is slidable vertically on the rod 116. There is also a vertical rotatable shaft 117, which is threaded in the block 118 and which has a bearing in the carriage 142. The shaft 117 is rotated by means of a bevel gear 115, in mesh with gear 114, and such rotation is effective to raise the block 118, sliding it along the rod 116.

The reference character 121 indicates a pivoted wiper or brush arm. At the left this wiper arm is bent in a U shape, forming a short section 132 which is parallel to but offset from the main part of the wiper arm, as seen clearly in Fig. 8. The support 130 is secured to the frame plate 101 as shown, and is bifurcated, whereby two downwardly extending members 133 and 134 are formed, which lie on opposite sides of the section 132 of the wiper arm. The pivot pin 131 passes through these parts and affords a bearing or pivot about which the wiper arm 121 is rotatable.

The wiper arm 121 has a slot 122, as clearly shown in Fig. 7. The pin 135, Fig. 8, is rigidly fixed to the block 118 and projects through the slot 122 in the wiper arm. When the carriage 142 is moved to the right, the pin 135 slides along the slot 122, and when the block 118 slides vertically on the rod 116 the pin 135 rotates the wiper arm 121 on its pivot 131.

The three wipers or brushes are indicated at 123, 124, and 125. At the right hand end the wiper arm 121 includes an offset portion 131, to which there is secured a block of insulating material 126. The wipers 123-125 are secured to this block, as shown clearly in Fig. 9.

The rod 138 extends diagonally across the switch, as shown in Fig. 7, and is pivoted on frame plate 101 at 139. The lower end of the rod rests normally against the insulated support 141. The pivot 139 is also insulated, so that the rod is electrically insulated from the frame and other parts of the switch. A terminal member 140 is clamped to the rod near the pivoted end thereof and provides means for attaching a conductor.

The arrangement for rotating the shafts 110 and 144 may now be described, with reference particularly to Figs. 10 and 11. Briefly stated, this arrangement comprises a power driven roller 150 which is adapted to be brought into engagement successively with rollers 151 and 152, which are mounted on shafts 110 and 144, respectively.

The roller 150 is supported on a pivoted armature 157. The armature 157 is operated by two electromagnets 153 and 154, the cores of which are attached to the plate 174. The latter is set edgewise against the frame plate 101 and is fastened thereto by screws. The armature 157 lies in a slot in the plate 174 and is provided with a pivot 175. The armature 157 includes an extension 160, which is bifurcated as shown in Fig. 11, the extension thus comprising the two members 161 and 162 which are provided with bearings for the shaft 163 on which the roller 150 is mounted. The shaft 163 is connected to a short flexible shaft 164, which is continuously rotated at a constant speed by any suitable means provided for that purpose. The shaft 164 may, for instance, be driven by a small motor, or a plurality of such shafts associated with a plurality of switches may be geared to a common motor driven shaft. Such arrangements for driving switches of the power operated type are well known and accordingly are not shown herein.

From the foregoing it will be understood that the roller 150 is continuously rotated at the desired speed by the shaft 164. The rotation of roller 150 is normally ineffective, however, for it is normally out of engagement with both of the rollers 151 and 152, being maintained in a central position by means of springs 158 and 159 which are attached to the armature 157. To guard against accidental movement of the armature 157 on its pivot, by shock or other cause, such as might bring about a momentary engagement between roller 150 and roller 151 or roller 152, a light auxiliary armature 172 may be provided.

This armature is pivoted on the main armature 157 and is normally maintained at right angles thereto by a spring 173, whereby the ends of the auxiliary armature are adapted to engage the ends of the brackets 165 and 166 and positively prevent any undesirable movement of the main armature on its pivot. When the electromagnet 153 is energized, the pole piece 155 first operatively attracts the adjacent end of the auxiliary armature 172, which is thus rendered ineffective to prevent the movement of the main armature 157 toward the pole piece. The operation of the main armature by electromagnet 153 brings roller 150 into engagement with roller 151 and thereby causes the rotation of shaft 110. In a similar manner the energization of electromagnet 154 causes the rotation of shaft 144, by bringing roller 150 into engagement with roller 152.

The bracket 165 not only acts as a stop in co-operation with the auxiliary armature 172 but also serves to support a pair of contact springs 167 and 168. These contact springs are normally in engagement but are separated by a knob of insulating material 171 whenever the armature 157 is operated by the electromagnet 153. A similar set of contact springs 169 and 170 is supported on bracket 166. These springs also are normally closed and are separated by knob 171 whenever the armature 157 is operated by electromagnet 154.

The electromagnets 176 and 177 are brake magnets and are provided with armatures 180 and 181 which are adapted to engage the rollers 152 and 151, respectively, to prevent rotation thereof, as will be subsequently explained more in detail. The magnets 176 and 177 are mounted on the frame plate 101 by means of brackets 178 and 179, respectively.

The carriage 142 is normally maintained in its extreme position to the left, where it bears against the frame plate 101, by a clock spring 191, which tends to rotate the shaft 110 in a clockwise direction as viewed from the right hand end of the shaft in Fig. 7. A similar clock spring 192 tends to rotate the shaft 144 in the same direction, which maintains the block 118 in a position where it bears against the top of the carriage 142. A pair of off normal springs, comprising the contact springs 185 and 186, are normally maintained open by the block 118. These springs may be mounted on the frame plate 101, as shown in Fig. 7.

Reference may now be made to the circuit drawing, Fig. 12, which shows the electrical connections of the system.

The reference character A indicates a tele-

phone, which may be of any suitable common battery type. The conductors 200 and 201 extend from the telephone to a terminal strip 204, where the conductors 202 and 203 coming from the calling device CD are also terminated. At this terminal strip conductor 200 is connected directly to the line conductor 205, while conductor 201 is connected to the line conductor 206 by way of the calling device CD. In other words, the calling device is connected in series with one side of the line.

The line conductors 205 and 206 extend to a switching station or exchange where they terminate in an automatic switch indicated by the reference character S. This switch comprises a switch mechanism such as is shown in Figs. 7 to 11, inclusive, and the control relays 210 to 216, inclusive. The functions of these relays will be explained shortly.

The switch S may have access to ten lines, one of which is shown, and comprises the line conductors 227 and 228. These conductors may extend to a telephone station B, which may be a common battery telephone similar to the telephone A. The relays 220 to 223, inclusive, are at the exchange and are individual to the line of station B.

A suitable source of current is provided for operating the switch, such as a storage battery, for example. In the circuit drawing connections to the negative pole of the battery are indicated by arrows accompanied by negative signs, while connections to the positive or grounded pole of the battery are indicated by the usual ground symbols.

The operation of the system will now be described, it being assumed for this purpose that a call is to be made from the station A to the station B. The line of station B is connected to the first set of bank contacts in the switch S and accordingly is selected by calling the digit 1.

When the receiver is removed at station A, a circuit is completed for the line relay 211, said circuit extending from ground by way of the lower winding of the line relay, contact 231, line conductor 206, conductor 203, contact 71, brushes 24 and 25, ring 72, conductor 202, conductor 201, telephone at station A, conductor 200, line conductor 205, contacts controlled at 230, and the upper winding of relay 211 to negative battery. Upon energizing, the line relay 211 closes a circuit for the slow-acting relay 212 at contact 232, said circuit also including contact 243. Upon energizing in turn, relay 212 prepares certain circuits at contacts 234 and 235, and at contact 236 closes circuits for the brake magnets 176 and 177. These circuits include the sets of contact springs controlled by the armature 157 and will be apparent upon inspection. The brake magnets energize when their circuits are closed and their armatures grip the rollers 152 and 151.

The calling party at station A may now operate the calling device key corresponding to the digit 1, rotating this key forward from its normal position as shown in Fig. 4 to the fully operated position in which it appears in Fig. 2. The operation of the key rotates the shaft 12 through an angular distance of ninety degrees, and gear 13 and pinion 15 cause one full rotation of shaft 18, thereby winding spring 16. As the key approaches its fully operated position the hook 33 depresses the locking bar 30, as shown in Fig. 5, thereby rotating shaft 14 and arm 56 and moving the hook 57 far enough to the left so that it can no longer hold the pin 17. This operation

releases the gear 43, which starts to rotate in a clockwise direction from power supplied by spring 16 and under the control of the governor 21. When the key reaches its fully operated position, the shaft 14 is restored by spring 45 and the key becomes locked by bar 30, as shown in Fig. 2. The operation of the key permits contact spring 41 to engage contact spring 42, thereby connecting contact 61 to the conductor 203.

When the gear 43 is released as described in the foregoing, it makes one complete rotation and then becomes locked in normal position, the operated key 7 being released just before the gear wheel has fully returned to normal. The manner in which these operations take place will be readily understood from the drawings, particularly Fig. 5. When the gear wheel approaches normal position and shortly before the pin 17 reaches its dotted line position, the said pin engages the cam surface 58 on arm 56, whereupon the further rotation of the gear wheel rotates shaft 14 and depresses the locking bar 30. This operation releases the operated key, which is restored to normal position by the spring 40. As soon as the pin 17 passes off the cam surface 58, the shaft 14 is restored instantly, the arm 56 is moved to the right, and the pin 17 passes into the notch behind hook 57. The gear wheel 43 thus becomes locked again, as shown in Fig. 4. After the key has been released, reverse rotation of the shaft 12 and gear 13 is prevented by the dog 59. The slight retrograde movement that may occur before the dog engages a tooth of gear 13 does no harm because of the fact that the keys move through an arc which is greater than ninety degrees.

During the rotation of the gear wheel 43 the brushes 24 and 25 cooperate with the commutator contacts to transmit two impulses over the line to effect the desired control over the switch S, whereby the said switch is caused to select the line of station B. These so-called impulses are actually interruptions of the line circuit. When the brush 24 leaves contact 71 the line circuit is opened, starting the first impulse. As the brush 24 engages contact 60, 69, etc., the line circuit remains open, for these contacts correspond to the tenth, ninth, etc., digit keys, which are in normal position. When brush 24 reaches contact 61, however, corresponding to the first digit key, the line circuit is again closed, for contacts 41 and 42 have been closed by the operation of the key. The engagement of brush 24 with contact 61 thus terminates the first impulse. The line circuit is again opened when the brush 24 leaves contact 61, which thus starts the second impulse. This impulse is terminated when the brush 24 reaches contact 71, where it comes to rest.

When the calling device is operated in accordance with the digit 1, that is, when the first digit key is operated, the two impulses resulting from the operation bear a ratio to each other which is as ten is to one. Explaining this more in detail, the path of the brush 24 is divided into thirteen equal spaces. One of these spaces is occupied by the normal position contact 71, leaving twelve spaces in which the line circuit may be interrupted when such spaces are traversed by brush 24. Ten of these spaces are occupied by the contacts 61 to 60, inclusive, there being a blank space on either side of the contact 71. These spaces correspond to time units, since the brush moves at constant speed. Thus it will be

seen that during one complete rotation of the brush 24 the line circuit will be opened at contact 41 for a total period of twelve time units. The line circuit is not actually open for this whole period, however, for in the rotation of the brush it will pass over an active contact such as 61, thereby closing the line circuit for an interval of one time unit and dividing the total period of twelve time units into two complementary impulse periods, the sum of which is equal to eleven time units. In case the digit 1 is called, contact 61 is rendered active, and the first impulse comprises ten time units corresponding to the angular distance from contact 41 to contact 31 in a clockwise direction, while the second impulse comprises one time unit, corresponding to the angular distance from contact 61 to contact 71 in a clockwise direction. If the digit 5 is called, the contact 65 is made active, the first impulse will be six time units in duration, and the second impulse will have a duration of five time units. The impulse ratio in this case is six to five. The impulse ratios corresponding to the other digits will be apparent from the foregoing and are seen to range from ten to one (digit 1) to one to ten (digit 10).

Proceeding now to a consideration of the operation of the switch S in response to the impulses, the first impulse or interruption of the line circuit causes the line relay 211 to deenergize and the circuit of relay 212 is broken. Since the latter relay is slow acting, however, it does not fall back immediately, and a circuit is closed for the magnet 153, said circuit extending from ground by way of contact 243, contact 232, contact 234, contact 237, winding of relay 215, and winding of magnet 153 to negative battery. Relay 215 is energized over this circuit and prepares a circuit for the change-over relay 213 at contact 242.

When the magnet 153 is energized, it operates the armature 157, thereby bringing the continuously rotating roller 150 (see Fig. 10) into engagement with the roller 151. At the same time the armature 157 separates the contacts 157 and 158, thus deenergizing the brake magnet 177, and freeing the roller 151. The roller 151 accordingly starts to rotate the shaft 110, winding spring 191, and the carriage 112 starts to move to the right. As soon as the carriage has moved off normal the contact springs 185 and 186 are closed, thereby completing a locking circuit for relay 212. This relay accordingly remains energized throughout the first impulse, regardless of its duration.

At the end of the first impulse the line circuit is closed and the line relay is again energized, breaking the circuit of relay 215 and magnet 153. Relay 215 is slow acting and holds contact 242 closed long enough so that the line relay can close a circuit for relay 213 at contact 233. Upon energizing, relay 213 locks itself at contact 238. The magnet 153 deenergizes when its circuit is broken, whereupon the armature 157 is retracted and the roller 150 is disengaged from roller 151. At the same time the contact springs 157 and 158 are allowed to close, thus again energizing the brake magnet 177. The brake magnet 177 now prevents reverse rotation of the shaft 110 by the spring 191.

During the first impulse the carriage 112 is moved continuously to the right by the rotation of the shaft 110, and the pin 135 in the block 118 travels along the slot 122 in the wiper arm 121. The distance traversed, of course, depends on the speed of the switch drive, which should

bear such a relation to the calling device speed that the pin 135 will travel the greater part of the length of the slot, the exact distance being immaterial within a considerable range. It may be assumed that when the first impulse is terminated the pin 135 has reached the point X; that is, it traverses the distance O—X, the point O representing the initial position of pin 135.

When the second impulse is received the line relay 211 is again deenergized, and opens the circuit of relay 212, also the circuit of relay 213, but these relays remain energized over their locking circuits. The line relay also closes a circuit for the magnet 154, extending from ground by way of contact 243, contact 232, contact 234, contact 237, winding of relay 214, and winding of magnet 154 to negative battery. Relay 214 energizes over the above circuit and at contacts 239, 240, and 241 disconnects the switch wipers 123, 124, and 125.

The magnet 154 is also energized, and operates armature 157, thereby causing the roller 150 to engage the roller 152, and at the same time separating the contact springs 169 and 170. The brake magnet 176 is thus deenergized and the rollers 150 and 152 start to rotate the shaft 111. The shaft 111 rotates the shaft 117 by means of gears 114 and 115, thereby raising the block 118 and pin 135 and rotating the wiper arm 121 about its pivot 131. This pivot does not appear in the circuit drawing, Fig. 12, but is in alignment with the pin 135 when the latter is in normal position, as will be recalled from Fig. 8.

At the end of the second impulse the line relay again energizes, breaking the circuit of relay 214 and magnet 154. Upon deenergizing, relay 214 connects up the wipers 123, 124, and 125. When the magnet 154 deenergizes, the armature 157 is retracted, disengaging the roller 150 from roller 152 and closing the contact springs 169 and 170. The rotation of shafts 111 and 117 is thus terminated and the shafts are held in their advanced positions against the tension of spring 190 by the brake magnet 176, which energizes again as soon as contact springs 169 and 170 are closed.

The second impulse is only one-tenth as long as the first impulse, and consequently the vertical distance traversed by the pin 135 is only one-tenth of the horizontal distance. This vertical distance is represented by the distance X—Y, which is one-tenth the distance O—X. The final position of the pin 135 is therefore at the point Y, and the wiper arm is positioned along the line O—Y, bringing the wipers 123, 124, and 125 into engagement with the first set of contacts in the bank of the switch.

The relay 214 does not fall back until after the switch wipers have been brought to their final selective position. The contacts 239, 240, and 241 then close, and the line conductors 205 and 206 are extended by way of contacts 240 and 241, wipers 124 and 125, bank contacts 254 and 255, and conductors 224 and 225 to the windings of the line relay 220. Relay 220 is accordingly energized over the calling line in parallel with the line relay 211 and closes a circuit for the ringing relay 223 at contact 260. Upon energizing, relay 223 connects a source of ringing current Gen to the conductor 227 and 228 of the line extending to station B, said connection being made at contacts 263 and 264, and at contact 262 connects ground to the holding conductor 226. The grounding of conductor 226 operates relay 221, which locks itself to ground at contact 260 of relay 220 and breaks the circuit of relay 223. The latter relay is slow acting and holds the

ringing circuit closed for an interval after its circuit is broken. After relay 223 has deenergized the holding conductor 226 is maintained grounded by way of contact 260 of relay 229 and contact 261 of relay 221.

The grounding of the holding conductor 226 completes a circuit for relay 210, extending from ground on said conductor by way of bank contact 253, wiper 123, contact 239, and winding of relay 210 to negative battery. Upon energizing, relay 210 disconnects the line relay 211 from line conductors 205 and 206 at contacts controlled at 230 and at contact 231, and at contact 230 closes a local circuit for the line relay including the resistance 245. The line relay 211 is thus held energized.

When the call is answered at station B, the calling and called parties may carry on a conversation in known manner. Current for the transmitter at station B is supplied through the windings of the impedance coil 222, while current for the transmitter at station A is supplied through the windings of the line relay 220.

The release of the connection is brought about by the replacement of the receiver at the calling station A. When the receiver is replaced, the line circuit is interrupted and the line relay 220 is deenergized, opening the circuit of relay 221 and removing ground from the holding conductor 226. Relay 210 accordingly deenergizes and breaks the circuit of the line relay 211. Upon deenergizing, the line relay closes the previously described circuit including relay 214 and magnet 154, the said relay energizing and disconnecting the switch wipers as before. Magnet 154, upon energizing, brings rollers 150 and 152 into engagement and also opens contact springs 169 and 170 to deenergize the brake magnet 176. Rotation of shafts 111 and 117 now ensues, which raises the block 118 and pin 135 in the manner previously described. The movement of the block and pin continues until the latter engages the rod 138, whereupon a circuit is closed for relay 216, extending from the grounded frame of the switch by way of pin 135, rod 138, and winding of relay 216 to battery. Upon energizing, relay 216 locks itself at contact 244, and at contact 243 it breaks the circuit of relay 214 and magnet 154 and also the circuits of the brake magnets 176 and 177. The deenergization of magnet 154 disengages the roller 150 from roller 152 and stops further upward movement of the block 118. The deenergization of the brake magnets leaves the shafts 110 and 111 free, with the result that they are rotated in the reverse direction by the springs 191 and 190. Thus the block 118 is lowered until it again rests on top of the carriage 112, while the latter is moved to the left until it engages the frame plate 101. The wiper arm rotates on its pivot in response to the movement of block 118 and assumes a horizontal position.

The restoration of the mechanical parts as described in the foregoing separates the off normal springs 185 and 186, thereby breaking the locking circuits of relays 212, 213, and 216. These relays therefore deenergize and the switch is completely restored to normal, ready for another call.

The manner in which the switch is operated in response to the calling of other digits will be readily understood. When the digit 7 is called, for instance, by operation of the digit key corresponding to the digit 7, the calling device CD transmits two impulses having an impulse ratio of four to seven. In response to the first of these impulses the carriage 112 moves to the right during an interval of four time units and the pin 135

reaches the point X'. In response to the second impulse the block 118 moves vertically during an interval of seven time units and carries the pin 135 to the point Y'. The wiper arm is rotated during the movement of block 118 and takes up a position along the line O—Y', thereby positioning the wipers on the seventh set of bank contacts. The other digits are called in the same way. It may be stated generally that the impulse ratio is different for each digit and that when any digit is called the pin 135 of the switch is moved along the two sides of a right triangle in which the lengths of the sides bear the same ratio to each other as the impulse ratio. The wiper arm is in any case positioned along the hypotenuse of the triangle, a line the slope of which is determined by the relative lengths of the sides and not by their absolute lengths.

It will be easily seen now why the speed of the calling device can be varied independent of the switch drive speed without affecting the accuracy of selection. Suppose, for example, that the calling device speed increases, which will decrease the length of the impulses, although maintaining the same ratio between them. It may be assumed that the increase in speed is so great that when the digit 7 is called the length of the first impulse is only sufficient to advance the pin 135 to the point X' instead of to the point X'. The second impulse is correspondingly shortened, however, so that in its vertical movement the pin 135 is raised only to the point Y''. The point Y'' lies on the line O—Y', from which it will be seen that the final position of the wiper arm is the same regardless of the change in the speed of the calling device.

It will be appreciated that, while a comparatively simple telephone system has been shown herein, the principle of selection disclosed may be used in larger systems, following known methods employed in expanding the capacity of automatic telephone systems in common use. It will be understood also that this new principle of selection may be employed to advantage in various other automatic switching or indicating systems, and in such cases the number of selections or the number of calling device keys may be increased beyond the number shown herein. Nor is the invention limited to the precise impulse ratios explained herein, which have been selected merely as a convenient illustration of the principle involved.

Various other modifications may be made within the spirit of the invention, and I do not therefore wish to be restricted to the exact form of the invention which is shown and described herein, but desire to include and have protected by Letters Patent all forms and modifications of my invention which come within the scope of the appended claims.

I claim:

1. In an automatic telephone system, means for connecting a calling and called line, comprising an automatic progressively movable switch, means on the calling line for impressing two variable length but continuous control conditions on the line for each number called, the ratio of the duration of one condition to that of the other varying in accordance with the number of the called line, means for operating said switch by means of said control conditions in accordance with said ratio to select the particular called line, and means in said switch for connecting said lines.

2. In an automatic telephone system, an auto-

automatic switch having a bank in which a plurality of called lines are terminated, a calling line associated with said switch, a controller in said switch, means on the calling line for operating said controller in two stages, the ratio of the distance traveled by said controller in one stage to the distance traveled in the other stage being dependent on the position of the called line terminals in the bank of said switch, and a progressively movable brush carrier maintained in stationary position during the first stage of operation of said controller and advanced over said bank by the controller in the second stage of its operation to select the called line.

3. In an automatic switching system, a first line, a plurality of other lines, means for closing the first line and for producing two variable length interruptions therein, switching means for selecting one of said other lines, said switching means including a controller movable in two directions at right angles to each other in response to said interruptions, respectively, together with contact means positioned by said controller, and means for connecting said first line to the selected other line responsive to the completion of the selection.

4. In an automatic switching system, a first line, a plurality of other lines, means for closing the first line and for producing two variable length interruptions therein, an automatic switch for selecting one of said other lines, means for moving said switch to selecting position in accordance with the relative lengths of said interruptions, and means for connecting said first line to the selected other line.

5. In an automatic switching system, a control circuit, means for closing said circuit, an automatic switch, means responsive to the closure of said circuit for preparing said switch for operation, means for producing two successive interruptions in said circuit, the duration of said interruptions bearing a predetermined ratio to each other, means for operating said switch responsive to said interruptions and to an extent determined by said ratio, and means for releasing said switch responsive to another interruption in said circuit.

6. In an automatic switching system, a control circuit, an automatic switch, means responsive to the closure of said circuit for preparing said switch for operation, a positioning device in said switch, means for continuously moving said device in two directions at right angles to each other in response to two successive interruptions in said circuit, the final position of said device depending on the relative duration of said interruptions, switching means in said switch selectively controlled by said device in its final position, and means responsive to another interruption in said circuit for restoring said device and said switching means.

7. In an automatic selecting system, a line, a controller, means responsive to two control conditions imposed on said line for moving said controller along the two sides, respectively, of a right triangle, and a pivoted selecting arm aligned with the hypotenuse of said triangle by said controller.

8. In an automatic selecting system, a control circuit, means for imposing a control condition on said circuit, said control condition comprising two parts of variable duration, and selecting mechanism positioned in accordance with the ratio between said parts and independent of their sum.

9. In an automatic selecting system, a control

circuit, means for imposing a control condition on said circuit, means for momentarily interrupting said control condition at a variable point between the beginning and end thereof, a selecting mechanism, and means for operating said mechanism responsive to said control condition to a position determined by the point at which said interruption occurs.

10. In a control system, a line, means for transmitting two impulses over said line, including means for varying the relative lengths of said impulses at will, a controller moved in two directions at right angles to each other through distances proportionate to the lengths of said impulses, respectively, and a responsive device including a member moved through an angle whose tangent is equal to the ratio of one said distance to the other.

11. In combination, means for transmitting pairs of variable length impulses, including means for varying the relative lengths of the impulses in each pair, mechanical means responsive to any pair of impulses for interpreting the same in terms of the tangent of an angle, a device including an angularly movable member, and means for moving said member through the angle determined by said tangent.

12. In combination, a line, means for placing a control condition on said line for two periods of variable length, a device including a part continuously movable in two directions at right angles to each other in response to said control conditions, respectively, a second part pivoted at the initial position of said first part, and means for moving said second part on its pivot to a position defined by the line which is determined by the initial and final positions of said first part.

13. In combination, a pivoted arm having a plurality of selective positions, each corresponding to a different angular movement of said arm, means for moving said arm to any selective position, and means for controlling said moving means by a pair of impulses of variable duration such that the ratio of one impulse to the other is equal to the tangent of the angle through which said arm is moved to reach the desired selective position.

14. In combination, a switch comprising an arcuate bank, a pivoted wiper arm carrying wipers adapted to engage the contacts of said bank, a controller normally located in alignment with the pivot of said arm and having a sliding connection with said arm, means for transmitting two impulses to said switch, means responsive to the first impulse for moving said controller parallel to said arm, and means responsive to the second impulse for moving said controller at right angles to its first direction of movement, thereby rotating said arm on its pivot.

15. In an automatic telephone system, called lines, an automatic progressively movable switch having access to said lines, a calling line connected to said switch for controlling the same to extend connections to certain of said called lines in accordance with the digits of the called numbers assigned thereto, means on the calling line for impressing two variable calling conditions on the line for each digit of the called number desired, said conditions having a predetermined ratio, one to the other, in accordance with the digit, and means in the switch operated responsive to said calling conditions of any digit to move the switch in accordance with the ratio of one condition to the other and independent of the

duration of the conditions to select a particular one of said called lines.

16. In an automatic telephone system, a calling line, an automatic progressively movable switch controlled over said line, a plurality of lines accessible to said switch at different points in the movement thereof, means on the calling line for impressing a calling condition on said line for a predetermined time for operating said switch to seize one of said lines, said means effective at will to divide the time of said calling condition into two separate parts, the ratio of one part to the other varying with different operations of said means, and means for operating said switch responsive to each calling condition to a particular point to select one of said lines, the line selected depending upon the ratio of one part of the calling condition to the other.

17. In an automatic telephone system, a calling line, an automatic progressively movable switch controlled over said line, a plurality of other lines accessible to said switch, means on said calling line for always transmitting a pair of impulses over said line for each digit of a

number called, each pair of impulses having a predetermined ratio of duration one to the other for a particular digit, and means in said switch operated in response to each pair of impulses to select a particular one of said lines, the line selected determined by the ratio of one impulse to the other.

18. In an automatic telephone system, a calling line, an automatic switch controlled over said line having a progressively movable wiper and contacts accessible thereto, means on the calling line for transmitting pairs of impulses over said line representing different digits, each impulse of a pair having a definite ratio of duration to the other impulse of the pair, and said ratio differing for each digit, means in the switch responsive to a particular pair of said impulses to move said wiper in one continuous movement into engagement with a particular one of said contacts, the contact connected with dependent only on the ratio of one impulse of the pair to the other.

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