

Nov. 19, 1940.

B. D. WILLIS

2,222,131

AUTOMATIC SWITCHING SYSTEM

Filed July 5, 1938

Fig. 1.

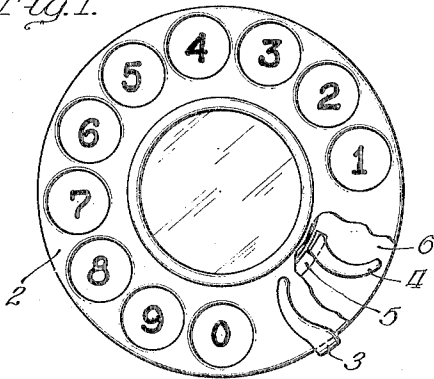


Fig. 2.

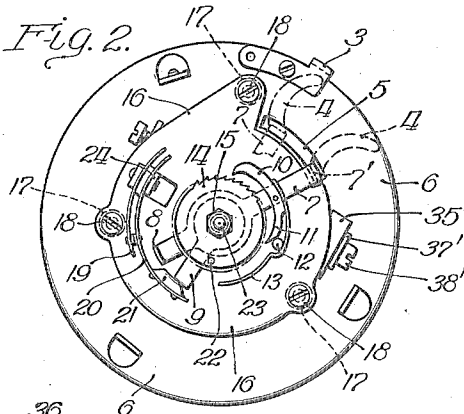


Fig. 3.

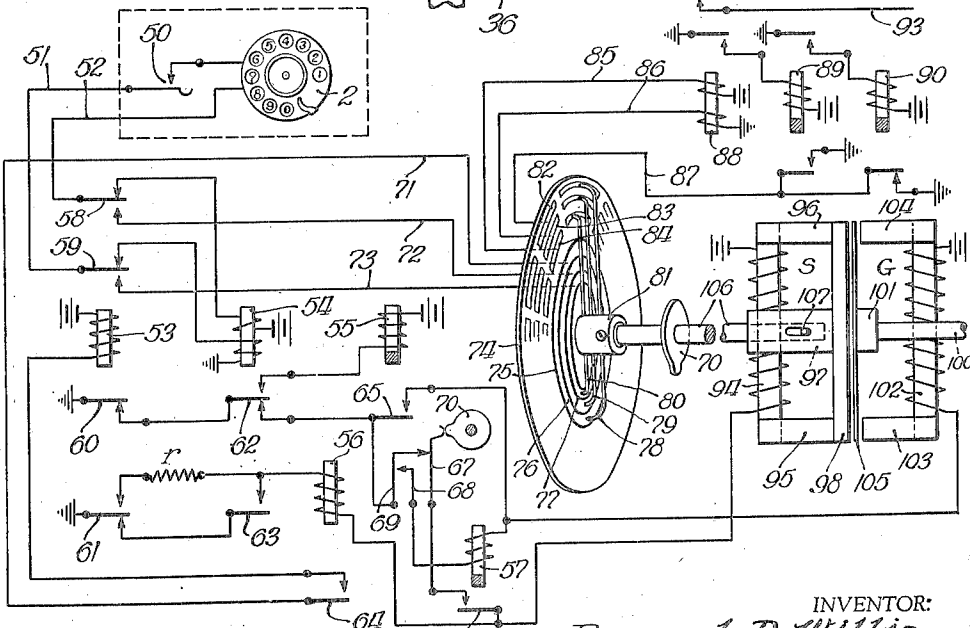
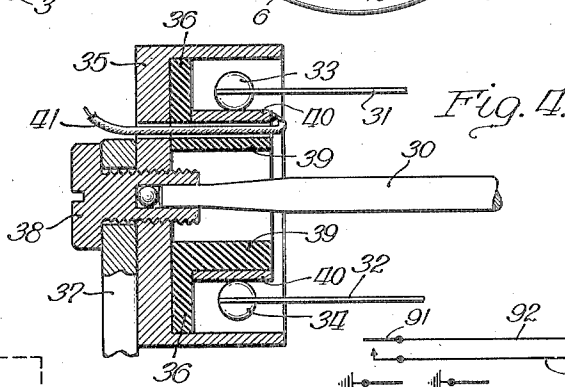
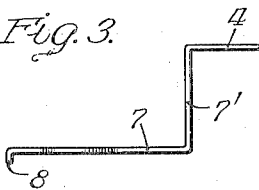


Fig. 5.

INVENTOR:
Bernard D. Willis
BY Richardson & Quer

ATTORNEYS. 287

UNITED STATES PATENT OFFICE

2,222,131

AUTOMATIC SWITCHING SYSTEM

Bernard D. Willis, Oak Park, Ill., assignor to Associated Electric Laboratories, Inc., Chicago, Ill., a corporation of Delaware

Application July 5, 1938, Serial No. 217,335

32 Claims. (Cl. 179-16)

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

10 An example of such a switching system is an automatic telephone system, in which each subscriber's line is equipped with a calling device at the subscriber's telephone, and in which automatic switches are provided at the exchange for the purpose of establishing connections under subscriber control. The invention is not, however, limited to use in an automatic telephone system, but may be used in a variety of situations—in fact, in practically any situation where it is desired to effect selective action under remote control.

The invention is mainly characterized by the novel principle which is employed for exercising control over the selecting operation. In systems which are in common use, such as automatic telephone systems, control is exercised by the transmission of a variable series of impulses of equal length which are generated by the calling device. The number of impulses in a series depends on the digit in accordance with which the dial of the calling device is operated. In my improved system, however, I prefer to use a single impulse of variable length or duration. The total impulse period, corresponding to the maximum capacity of the calling device, is divided into time units and each impulse transmitted lasts for a variable number of time units depending on the digit dialled. For instance, if the digit 1 is called, the transmitted impulse is of minimum length and has a duration of a single time unit. If the digit 2 is called, then the impulse produced lasts for two time units, while if the digit 5 is called, five time units are involved.

45 As in other switching systems, the so-called impulses may actually be electrical impulses transmitted over an open circuit, or they may be interruptions of a closed circuit. The latter arrangement has a wider range of usefulness and is employed in the illustrative embodiment of the invention shown herein. It will be appreciated then that in such a closed circuit system operating in accordance with my invention, the circuit will be opened or interrupted, a single time for each operation of the calling device and that the

length of each interruption will correspond to a number of time units equal to the digit dialled.

There are other features forming part of the invention which, however, will be pointed out in the course of the ensuing explanation, reference being had to the accompanying drawing, in which—

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

Fig. 2 is a rear view of the same;

Fig. 3 is a side view of the movable finger lever forming part of the calling device;

Fig. 4 is a section through a portion of a calling device governor, and shows an alternative arrangement for generating a variable length impulse; while

Fig. 5 is a diagrammatic circuit drawing of a complete switching system constructed in accordance with the invention.

Referring to Figs. 1, 2, and 3 of the drawing, 20 the calling device there shown will first be described. In certain respects this calling device is similar to the well known impulse transmitting calling devices which are in common use in automatic telephone systems throughout the country. An example of such a calling device is the one shown in the patent to Obergfell, No. 1,642,822, granted September 20, 1927. The construction of these calling devices has varied somewhat from time to time, but they all include a base or frame plate and a reciprocating finger hole dial rotatably mounted thereon, together with impulse sending mechanism which is actuated upon the return movement of the dial. The dial is supported on a central shaft which has bearings in the frame plate and which is connected to the frame through a helical coil spring in which tension is stored when the dial is rotated. The impulse sending mechanism comprises a main gear wheel freely rotatable about the axis of the shaft and in engagement with a small pinion. There is a ratchet connection between the dial and the main gear wheel. The pinion shaft carries a worm wheel for driving the governor and also an impulse cam for actuating the impulse springs to produce interruptions in the line circuit. When the dial is rotated by hand in accordance with some digit, tension is stored in the helical spring, as previously mentioned. When the dial is released, the ratchet mechanism immediately engages the main gear wheel so that the gear wheel is driven on the return movement of the dial. The main gear wheel drives the pinion shaft and rotates the cam to generate impulses. The governor

is also driven at the same time and insures that the dial will return to normal at a constant speed.

In the calling device illustrated in Figs. 1, 2, and 3, the parts above described are all utilized in substantially their usual form, with the exception of the impulse cam and the impulse transmitting springs, which are omitted. In lieu thereof there is provided a special impulse transmitting unit which is mounted on the frame plate of the calling device and which accomplishes the purpose of opening the line circuit once for each actuation of the calling device dial, the duration of the opening depending on the digit in accordance with which the dial is operated.

The finger hole dial is seen clearly in Fig. 1, where it is indicated at 2. The usual finger stop is shown at 3. In Fig. 2, which shows the rear view of the calling device, the base or frame plate on which the dial and other parts are supported is indicated at 6. This figure also shows the finger stop 3 and the manner in which it is attached to the frame plate. The remainder of the apparatus, including the helical power spring and the gear and pinion wheels, is not shown in the drawing. A small portion of the governor mechanism may, however, be seen, and includes the cup 35' which is mounted on the upturned member 37' of the frame by means of the bearing screw 38'. The complete governor mechanism is illustrated in the Obergfell patent hereinbefore referred to.

The impulse sending mechanism provided in accordance with the invention is mounted on a flat plate 16 which is generally circular in shape and which is supported on the frame plate 6 of the calling device in spaced relation thereto, by means of three hollow studs 17 and three machine screws 18. The distance between the plate 16 and the frame plate 6 may be approximately three-fourths of an inch, or just sufficient to provide room for the power spring and the governor mechanism. The shaft 23 on which the dial is mounted extends up through a central opening in the plate 16, and a short distance above the plate is reduced in diameter to form a shoulder. This reduced portion of the shaft is threaded to receive the nut 15. It will be understood, of course, that the shaft 23 is modified from standard construction to the extent indicated.

The impulse springs are indicated by the reference characters 19 and 20 and are supported on an upturned portion 24 of the plate 16 by suitable screws and insulators, as indicated in the drawing. These impulse springs are of curved shape, and the longer spring 20 has affixed to it a small block of insulating material 21. The line circuit is connected to the impulse springs at the stationary ends thereof beyond the insulators.

The finger lever 7 lies flat against the upper surface of the plate 16 and is freely rotatable on the shaft 23. At one end the finger lever has a short upturned portion 8 which extends into the plane of the insulator 21. At the other end the finger lever has an offset curved portion 4 which lies just underneath the dial 2 of the calling device. The shape of the complete finger lever can best be seen in Fig. 3. From this figure and from Figs. 1 and 2 it will be seen that the main part of the finger lever 7 is connected to the offset curved portion 4 by means of a section 7', extending perpendicular to both of the foregoing portions. This section 7' lies in a slot 5 which is cut in the frame plate 6. The slot is large enough to

permit free movement of the finger lever to the position in which it is shown in dotted lines in Fig. 2.

Just above the finger lever 7 there is provided a control member 9, which is also freely pivoted on the shaft 23, and which extends out radially therefrom with its end abutting against the insulating member 21 mounted on the spring 20. The function of the control member 9 is to maintain the impulse springs 19 and 20 in closed position. In explanation of this, it may be stated that the spring 20 is tensioned away from spring 19, so that it tends to open the line whenever permitted to do so. When the control member 9 is in the position in which it is shown in Fig. 2, however, the spring 20 is held in engagement with the spring 19.

Just above the control member 9 there is mounted on the shaft the toothed disk 14. This disk rests on the shoulder with which the shaft is provided and is securely held in place by means of the nut 15. The disk 14 therefore rotates with the shaft 23. A pin 22 is rigidly secured to the disk 14 and extends beneath it into the plane of the control member 9.

Pivoted to the finger lever 7 is a pawl 10, which is adapted to engage the teeth in disk 14. This pawl is provided with a tail piece normally in engagement with a stud 12 mounted on plate 16, and is also provided with a spring 13 which is shaped as shown in the drawing. The spring 13 may be spot-welded to the pawl.

The parts of the calling device just described can best be understood from an explanation of the operation in calling a digit. It will be assumed for this purpose that the dial 2 is actuated in accordance with the digit 1. The dial is rotated in clockwise direction, as shown in Fig. 1, and since the disk 14 is fixed to the shaft on which the dial is mounted, this disk will be rotated in a counter clockwise direction, as seen in Fig. 2. At the first movement of the dial, therefore, the pin 22 will pass out of engagement with the control member 9, the latter remaining in the position in which it is shown in the drawing. As the finger of the operator approaches the finger stop 3, it will engage the curved portion 4 of the movable finger lever 7, carrying it along with the dial during the further movement thereof. The finger lever is therefore rotated about its pivot on the shaft 23, and when the dial becomes fully set, with the finger of the operator in engagement with the finger stop 3, the curved portion 4 of the finger lever will be in the position in which it is shown in dotted lines in Fig. 2. During this movement of the finger lever, the upturned end portion 8 moves in a counter clockwise direction and passes into engagement with the insulating member 21 on impulse spring 20. Shortly before movement of the finger lever is completed, the upturned portion 8 engages the control member 9 and rotates it out of engagement with the insulation 21. With the finger lever fully operated, the upturned portion 8 thereof will be in approximately the same position as that normally occupied by the control member 9, the latter having been rotated far enough so that it is entirely clear of the insulation 21. It should be pointed out also that, at the first movement of the finger lever, the tail piece 11 of the pawl 10 will pass out of engagement with the stud 12, while an instant later the offset curved portion of spring 13 will come into engagement with this stud and will force the

pawl into engagement with one of the teeth of the disk 14.

The operation of the dial as described in the foregoing tensions the power spring in known manner, and when the dial is released by removal of the finger of the operator, the dial is rotated back to its normal position. When the dial returns to normal, the disk 14 secured to shaft 23 rotates in a clockwise direction, and since the pawl 10 is now in engagement with one of the teeth on the disk, the finger lever 4 is returned to its normal position along with the dial. As the finger lever reaches the position in which it is shown in Fig. 2, the tail piece of pawl 10 engages the stud 12 which rotates the pawl sufficiently to disengage it from the tooth on disk 14. The finger lever therefore stops in the position where it appears in Fig. 2, while the return movement of the dial continues unimpeded.

The restoration of the finger lever has the effect of opening the line circuit including contact springs 19 and 20, as will be appreciated from the fact that the control member 9 was previously rotated out of engagement with the insulator 21. Under its normal tension, therefore, the impulse spring 20 takes up a position in which it is out of engagement with contact spring 19, and the circuit is opened as stated. This condition continues until, as the dial approaches its normal position, the pin 22 fixed to the disk 14 engages the control member 9 and returns it to the position in which it appears in Fig. 2. In moving to this position the control member engages the sloping end of the insulator 21 and restores the impulse spring 20 to its normal position.

In the operation of the dial as just described, the return movement of the dial includes a period in which the finger lever 7 is being restored and in which the impulse spring 20 is held in engagement with the impulse spring 19 by the finger lever, and a period during which the impulse springs are separated, which lasts from the time at which the finger lever is restored until the control member 9 is restored just as the dial reaches normal position. This latter period is equal in length to one time unit. If the calling device is operated in accordance with the digit 2, the same restoration period for the finger lever is involved, but the subsequent period during which the impulse springs are separated is just twice as long as in the case where the digit 1 is dialed. That is, the period during which the impulse springs are separated comprises two time units. Similarly, if the dial is operated in accordance with the digit 3, the impulse springs will be separated for a period equal to three time units, and so on.

The governor of the calling device is accurately adjusted to run at a predetermined speed, which bears a definite relation to the speed of the switching mechanism, as will be subsequently explained. The arrangement which includes the movable finger lever 4 has the advantage that it prevents any false operation which might otherwise take place due to failure to rotate the dial to the full extent each time; that is, a careless operator might rotate the dial only part way and release it, which would produce an interruption having less than the required number of time units, were it not for the provision of the movable finger stop and the control exercised thereby. This arrangement insures that the im-

pulse springs cannot be opened at all unless the dial is rotated sufficiently so that the finger of the operator is brought substantially into engagement with the fixed finger stop 3, as unless this is done, the control member 9 cannot be moved out of engagement with the insulator 21.

The modification shown in Fig. 4 will now be briefly described. In this modification an ordinary calling device of standard construction is used except that it should be of the general type of calling device disclosed on pages 33, 34, and 35 of the book entitled "Automatic Telephony," by Smith and Campbell, first edition, published by McGraw-Hill Book Company in 1914. This calling device differs essentially from the calling device disclosed in the Obergfell patent by the angular distance between the first finger hole of the dial and the finger stop. In the calling device disclosed in the Obergfell patent this distance is sufficient so that, if the digit 1 is called, the impulse sending mechanism is rotated far enough on the return movement of the dial to transmit two impulses, the last impulse being canceled by a special contact mechanism associated with the impulse springs. In the dial disclosed by Smith and Campbell, however, the angular distance between the first finger hole of the dial and the finger stop is such that if the digit 1 is called, only a single impulse will be transmitted.

In accordance with the invention, a calling device of the type disclosed by Smith and Campbell is modified in order to produce a single variable length impulse at each dial actuation by omitting the impulse springs and by changing the governor as shown in Fig. 4. The modification of the governor which is necessary will now be briefly explained.

Referring to Fig. 4, the reference character 37 indicates the upturned ear on the frame plate of the calling device on which the governor cup 35 is mounted by means of the bearing screw 38. Inside the governor cup 35 is securely fixed a disk 36 of insulating material which is provided with a hub portion 39. This latter is surrounded by a metal band 40. The conductor 41 passes through a hole drilled through the base of the cup 35 and through the hub 39 and has one end secured to the metal band 40 by soldering. The reference character 30 indicates a portion of the governor shaft, the end of which has a thrust bearing in the bearing screw 38. The end of this bearing screw is drilled out slightly larger than the end of the shaft, and there is a small steel ball inserted against which the end of the shaft bears when it is rotated. The governor also includes the springs 31 and 32, the extremities of which are equipped with weights 33 and 34, respectively. The springs 31 and 32 are normally tensioned toward the shaft 30 so that the weights 33 and 34 press against the metal band 40 at all times when the governor is stationary.

One of the line conductors incoming to the calling device is connected to the frame at some suitable point, while the other line conductor is connected to the conductor 41. Suitable binding posts or terminals (not shown) may be provided for this purpose if desired. The circuit will then extend from one line conductor to the frame, thence to the governor through the shaft bearings, and thence by way of springs 31 and 32, weights 33 and 34, the metal band 40, and conductor 41 to the other line conductor.

Describing the operation of this modification briefly, and assuming that the calling device is actuated in accordance with the digit 1, when the

dial is pulled around by the operator tension is stored in the power spring in the usual way, but the other parts, including the governor, remain stationary. When the dial is released, the ratchet mechanism connecting the dial with the main gear wheel becomes effective and the governor mechanism starts to rotate. Instantly the governor springs 31 and 32 separate due to centrifugal force acting on the weights 33 and 34, and these weights leave the metal band 40 and engage the inner wall of the cup 35, whereby they operate to regulate the speed at which the dial returns to normal. The separation of weights 33 and 34 from the band 40 breaks the line circuit, and it remains open until the dial has been restored, at which time the governor ceases its rotation and the springs 31 and 32 again resume their normal position. The result is therefore that the line circuit is opened for a predetermined length of time equal to one time unit. If the dial is operated in accordance with the digit 2, the distance which the dial has to travel in restoring to normal is just twice as far and the governor is operated for an interval which is exactly twice as long, and the line circuit is held open for a period of two time units. Thus, it will be appreciated that by making use of the governor mechanism modified as shown and described, the line circuit can be opened at each operation of the dial for a variable period which contains a number of time units corresponding to the digit dialed.

The modification shown in Fig. 4 is considerably less expensive to manufacture than the arrangement shown in Figs. 1, 2, and 3, but it is open to the possible objection that it is not fool-proof in the sense that the latter arrangement is. That is, a false operation may occur through careless operation of the dial. This objection, however, may be obviated by instructing the persons using the calling device as to the necessity for fully setting the dial each time; and at any rate it is not serious under ordinary conditions for the standard calling devices in common use are subject to the same possibility of false operation.

Attention may now be directed to the complete switching system which is disclosed in Fig. 5. This system includes a control station which is indicated by the dotted rectangle enclosing the calling device. This control station may also be provided with a switch 50 of any suitable type for closing the line circuit.

From the control station a line comprising conductors 51 and 52 extends to the switching station and there terminates in an automatic switch. This switch comprises a number of relays and certain mechanical parts which will now be explained briefly.

The relays 53-57, inclusive, may be ordinary telephone type relays of well known construction. Relays 55 and 57 are what is known as slow acting relays; that is, each of these relays is provided with a copper slug which makes it slow to deenergize. The function of these relays will be explained fully during the description of the circuit operation.

The mechanical portion of the switch includes a contact disk 74, a wiper or brush shaft 106, a continuously operating power shaft 100, and a clutch comprising disks 98 and 105 and stop and go clutch magnets indicated, respectively, by the reference characters S and G.

The contact disk 74 may be made of Bakelite or other suitable insulating material and carries

11 sets of contacts such as the set comprising contacts 82, 83, and 84. Each of these contacts may be a curved strip of metal which lies flat on the face of the disk and which is provided with ears at the ends which pass through perforations in the disk and are bent or riveted over on the back side. Inside the circular row of contact sets there are three continuous conducting rings 76, 76, and 77, which are secured to the face of the disk in any suitable manner; preferably by means of countersunk rivets which pass through the disk and afford means for establishing conductive connection to the rings on the rear. The wiper shaft 106 is supported on suitable bearings (not shown) in axial alignment with the disk 74, and supports at the left a wiper holder 81, to which the wipers 78, 79, 80 are securely fixed. This wiper holder may be constructed in any suitable manner, but, as indicated in the drawing, it comprises a molded cylinder in one end of which the wipers are embedded. The other end is drilled out to fit the shaft 106 to which it is adjustably secured by means of a set screw. The wipers extend out farther from the holder 81 on one side than on the other, so that at one end the wipers are in engagement with the contact rings, while at the other end the wipers are adapted to engage the contact sets.

There is also mounted on the wiper shaft 106 a cam 70, which is provided for the purpose of controlling the off-normal springs 67, 68, and 69. In order to simplify the drawing, these off-normal springs are shown in association with the relays, and the cam 70 is also included in the relay circuit. This simplifies the drawing somewhat, and the departure from the actual construction will not cause any confusion.

As previously stated, the shaft 100 is a power shaft and is driven at a predetermined constant speed by any suitable means such as a synchronous motor. For the purpose of temporarily connecting the wiper shaft 106 to the power shaft 100, the clutch mechanism previously referred to is provided. At the left hand end of the power shaft 100 is fixed a hub 101 to which is secured the disk 105, which is made of non-magnetic material. The go magnet G comprises a core portion 102 which lies behind the shaft 100, and two offset pole pieces 103 and 104. These pole pieces are connected to the core 102 by short sections perpendicular to the plane of the drawing, so that the pole pieces lie in the plane of the shaft 100. The ends of the pole pieces 103 and 104 approach closely to the disk 105 but are not in contact with it at any time. On the wiper shaft 106 is slidably mounted a hub 97 to which is secured the disk 98, constructed of magnetic material such as soft iron. While the hub 97 is slidable on the shaft 106, it is not rotatable on the shaft but drives the latter through the medium of a pin 107, which lies in a slot cut in the hub 97. This slot provides for a limited longitudinal movement of the hub on the shaft. The stop magnet is of a construction similar to the go magnet G and comprises a core 94 and two offset pole pieces 95 and 96. In normal position the disk 98 rests against these pole pieces. The operation of the switch will be fully explained in the course of the description of the operation in effecting a desired selection.

Each of the contact sets with which the contact disk 74 is provided constitutes a terminal of a line adapted for selection through the medium of the switch. One of these lines is shown in the drawing as leading from the set of contacts 82,

83, and 84, and comprises the conductors 85, 86, 87. The two former conductors terminate in the line relay 88, which controls relays 89 and 90, while conductor 87 leads to contacts on the two latter relays. Relay 88 is equipped with contacts 91 for closing a circuit over conductors 92 and 93. The relays 88, 89, 90 are representative of any suitable or desired line circuit.

The operation of the system shown in Fig. 5 will now be explained. For this purpose it will be assumed that it is desired to select the line comprising conductors 85, 86, 87 which terminates in the tenth set of contacts comprising contacts 82, 83, 84. It will be understood, therefore, that in order to select this line the calling device must be operated in accordance with the digit 0. In addition to operating the dial, the switch 50 must first be closed.

When the switch 50 is closed, a circuit is completed over the line conductors 51 and 52 for the line relay 54 in an obvious manner. The line relay 54 accordingly energizes and at the front contact of armature 62 completes a circuit for the slow acting relay 55, which energizes and prepares a circuit for the go magnet G at the front contact of armature 65. The line relay 54 on energizing also completes a circuit for the stop magnet S at armature 63, this circuit including also the relay 56. Relay 55 and stop magnet S are accordingly energized, but these operations are of no importance at the moment.

When the dial 2 is operated in accordance with the digit 0, the line circuit is interrupted in the manner previously explained, for a period equal to ten time units. At the beginning of this interruption in the line circuit the line relay 54 deenergizes and breaks the circuit of relay 55, which, however, is slightly slow to fall back and remains in energized position long enough for a circuit to be established through the back contact of armature 62 and the front contact of armature 65 to the go magnet G. On energization of the go magnet, the disk 98 is instantly attracted and moves to the right into engagement with the disk 105, thus coupling the wiper shaft 106 to the power shaft 100. The wipers 78, 79, 80 now start to rotate in a clockwise direction and at a speed which carries them past one set of contacts per time unit. Relay 55 falls back after an instant and breaks the circuit of the go magnet G at armature 65, but before this takes place a new circuit is established through the off-normal springs 68 and 69. When the wiper shaft starts to rotate the cam 70 rotates with it, with the result that off-normal spring 67 is allowed to separate from spring 69, and the latter comes into engagement with spring 68. The circuit for the go magnet then extends from ground by way of armatures 60 and 62, off-normal springs 69 and 68, and the winding of relay 57 to the go magnet. Relay 57 is energized, but its operation at this time performs no function.

At the end of the interruption in the line circuit, ten time units will have elapsed and the wipers 78, 79, 80 will have been rotated into engagement with the tenth set of contacts, or the contact set comprising contacts 82, 83, 84 in which the desired line is terminated. The closure of the line circuit at the end of the interruption brings about the re-energization of the line relay 54, which breaks the circuit of the go magnet G at armature 62 and closes the circuit of the stop magnet S at armature 63. The latter circuit extends from ground by way of armatures 61 and 63, and winding of relay 56, to the stop magnet,

and is instantly effective to move the disk 98 out of engagement with the disk 105 and to bring it against the pole pieces 95 and 96, with the result that the movement of the wiper shaft 106 is stopped with the wipers in engagement with the tenth set of contacts.

Relay 56 is energized in the circuit of the stop magnet S and now closes a circuit for the switching relay 53, which extends from ground at the normally closed contact of relay 90 by way of conductor 87, contact 82, wiper 78 in engagement therewith, contact ring 75, conductor 71, armature 64 and its front contact, and the winding of relay 53 to battery. Relay 53 is energized over this circuit, and at armatures 60 and 61 breaks the circuit of relay 55 and also the original circuit for the stop magnet. At the front contact of armature 61, however, an alternative circuit is established for relay 56 and for the stop magnet which includes the resistance r. This resistance permits enough current to flow over the circuit to maintain relay 56 energized. In addition to the foregoing operations, relay 53 disconnects the incoming line comprising conductors 51 and 52 from the winding of relay 54, which deenergizes, and extends it to the line conductors 72 and 73. A circuit is accordingly established over the line and over the conductors 72 and 73, contact rings 76 and 77, wipers 79 and 80, contacts 83 and 84, and conductors 85 and 86, to the windings of relay 88. Relay 88 is accordingly energized and completes a circuit for the slow acting relay 89, which energizes also and closes a circuit for slow acting relay 90. Relay 89, on energizing, places ground on conductor 87 before the original ground connection through which the circuit was first established is opened at the armature of relay 90. Relay 88 also closes a circuit over conductors 92 and 93 at armature 91.

The desired selection has now been effected, and line 51-52 has been connected to line 85-86. It will be understood that the connection may be used for any desired purpose, depending on the situation in which the selecting system is used. The details of the operations which are performed after the connection is established, however, form no part of the invention and are not shown herein.

In order to release the connection, the switch 50 is opened, causing relay 88 to deenergize. Relay 88, on deenergizing, opens the circuit of relay 89, which deenergizes after an instant and opens the circuit of relay 90. When relay 89 deenergizes, it also disconnects ground from conductor 87, and this conductor is therefore ungrounded for an instant until relay 90 deenergizes. Relay 53 accordingly deenergizes and opens the circuit including relay 56 and the stop magnet S, whereupon relay 56 deenergizes and opens the circuit of relay 53 at armature 64. Relay 53 therefore cannot again energize when ground is applied to conductor 87 by the deenergization of relay 90.

On deenergizing, relay 53 also closes a circuit for the go magnet G, the circuit including off-normal springs 69 and 68 and the relay 57. The go magnet G is accordingly energized to couple the wiper shaft 106 to the power shaft 100 and the wipers are rotated toward their normal position. Relay 57 is energized in series with the go magnet and prepares a circuit for the stop magnet S at armature 66. When the wipers reach their normal position, where they are shown in the drawing, the cam 70 engages off-normal spring 67 and said spring is shifted into engagement with spring 69, the latter spring being dis-

engaged from spring 68 at the same time. The circuit of the go magnet G is broken by this restoration of the off-normal springs, and a circuit is established for the stop magnet S, the circuit including off-normal springs 69 and 67 and armature 66 of relay 57. The circuit of relay 57 has already been broken, but the relay is slow acting and remains in operated position long enough to provide for a momentary energization of the stop magnet as described, which prevents overrun of the wipers due to inertia of the moving parts, and insures that the wipers will be brought to rest in normal position. The switch is now fully restored and ready for use in a second selecting operation, which may be the same as the first or in accordance with any other digit.

Attention may now be directed to certain features of the system which it was not convenient to discuss in detail in the course of the general explanation. It has already been stated that the speed of the power shaft 100 bears a predetermined relation to the speed of the calling device dial and is such that the switch wipers are moved past one set of contacts per time unit. The length of a time unit therefore determines the speed of shaft 100 in revolutions per minute. While the speed may be varied between fairly wide limits, I propose for convenience to so regulate the governor of the calling device that the dial illustrated in Fig. 1 will return to normal in exactly one second, when the dial is operated in accordance with the digit 0. Of this period of one second, one-eleventh is consumed in restoring the finger lever and the remainder, ten-elevenths, is divided into ten time units corresponding to the ten digits. Each time unit, therefore, is equal to one-eleventh of a second. Now, since there are eleven sets of contacts on the contact disk 74, and since the switch wipers are required to pass over one set of contacts per time unit, the wipers require eleven time units to make a complete rotation, or exactly one second. The shaft 100 therefore rotates at a speed of 60 R. P. M.

As mentioned hereinbefore, the shaft 100 may be driven by a synchronous motor which can be operated from any current source of constant frequency. An ordinary 60-cycle commercial power supply will be found to have the necessary constant frequency characteristic, as is demonstrated by the fact that commercial power is universally used in recent years for the operation of clocks. The driving of the power shaft 100 at the proper speed therefore presents no difficulty.

The maintenance of the dial speed at the proper value is a somewhat more difficult problem, but the satisfactory operation of the system is insured nevertheless by an accurate regulation of the governor, and by the contact arrangement at the switch which permits variations in dial speed within certain limits without resulting in any error in selection. As regards the governor, it is well known that very accurate regulation is possible, and that when once properly adjusted the speed will be maintained constant for long periods. As to the switch, it will be appreciated that if the dial runs too fast, the switch wipers will lag and will fail to reach the exact centers of the contacts, while if the dial is too slow, the wipers will advance farther than they should. This result is due to the decrease and increase in the time units caused by fast and slow dials, respectively. The error thus introduced is cumulative and becomes increasingly serious as the numerical value of the digits dialed increases. That

is, the total error is greatest when the digit 0 is dialed. The danger of a false selection which is thus introduced is eliminated (assuming that the dial speed is regulated within prescribed limits) by restricting the number of contact sets to eleven and by distributing the contact sets over a complete circle. With this arrangement each contact set has an angular length of about 30°, and the wipers may lag or lead by about 15° without causing a wrong selection. It is entirely feasible, therefore, to provide for the full number of ten digits as required in the decimal system. Of course, if less than ten digits are employed, the number of contact sets is correspondingly reduced, and as they will still be distributed over a complete circle, the factor of safety will be increased.

The invention having been described, that which is considered to be new and for which it is desired to secure the protection of Letters Patent will be pointed out in the appended claims.

What I claim is:

1. In an automatic switching system, a calling device having a reciprocating dial, a line circuit including said calling device, means included in said calling device for altering said line circuit at the beginning of the return movement of the dial and for maintaining the altered condition until the return movement is completed, an automatic switch, and means controlled over said line circuit for continuously advancing said switch during the time said line circuit is in altered condition at a speed bearing a predetermined relation to the speed of the return movement of said dial.

2. In an automatic switching system, a calling device, an automatic switch, a rotating power shaft, a line circuit extending between said calling device and switch, means included in said calling device for continuously holding the line circuit open for a variable period of time depending on the digit dialed, and means responsive to the opening of the line and reclosing of the same for coupling and uncoupling said switch to and from said shaft.

3. In an automatic switching system, a calling device, an automatic power driven switch, a line circuit extending between said calling device and switch, means included in said calling device for opening the line circuit for a period comprising a number of time units equal to the digit dialed, means controlled over said line circuit responsive to the opening thereof for continuously operating said switch throughout the period during which the line circuit is open and for stopping it when the circuit is closed, and wipers in said switch having different selective positions equal in number to the capacity of said calling device in time units.

4. In an automatic switching system, a calling device, an automatic switch, a line circuit extending from said calling device to said switch, means included in said calling device for continuously opening the line circuit for a period comprising a variable number of time units, wipers and contact sets included in said switch, a shaft associated with said switch and rotating at a speed which will drive the said wipers past one contact set per time unit, and means controlled over said line circuit responsive to opening thereof at said calling device for coupling the switch wipers to said shaft.

5. In an automatic switching system, a calling device provided with a reciprocating dial, means in said calling device for producing a single im-

pulse at each actuation of the dial, said impulse having a variable length depending on the digit dialed, an automatic switch, and means including a line circuit extending between said calling device and switch for advancing the switch a distance proportionate to the length of said impulse.

6. In an automatic switching system, a calling device provided with a reciprocating dial, normally closed impulse springs, means for opening said springs during each return movement of said dial and for closing them only at the end of such return movement, whereby said springs are opened for a variable time interval depending on the digit dialed, means including a movable finger lever for insuring a complete setting operation of the dial in order to effect opening of said springs upon the return movement, an automatic switch, and means including a line circuit extending between said calling device and switch for advancing said switch throughout the time said impulse springs are open.

7. In an automatic switching system, a calling device provided with a reciprocating dial, an automatic switch, a line circuit connecting said calling device and switch, a governor for regulating the speed at which said dial returns to normal after each setting thereof, means included in the governor mechanism for opening said line circuit throughout the return movement of the dial, and means responsive throughout the time the line is open for advancing said switch.

8. In an automatic switching system, a calling device provided with a reciprocating dial, an automatic switch, a line circuit connecting said calling device and switch, a centrifugal device operated only during the return movement of the dial and effective to open said line circuit when the return movement attains a certain speed and to close the line circuit again when the return movement is completed, and means responsive throughout the time the line is open for advancing said switch.

9. In an automatic switching system, an automatic switch including a wiper shaft, a constantly rotating shaft, an electromagnetic clutch for connecting said shafts, a line incoming to said switch, control means for closing said line and for opening it for a predetermined variable time interval, said line remaining open throughout said interval, means including fast and slow relays energized responsive to closing the line and deenergized responsive to opening thereof to close a circuit for said clutch, and an alternative circuit for the clutch closed upon the initial movement of said wiper shaft and opened responsive to the reenergization of the said fast relay at the end of said time interval.

10. In an automatic switching system, an automatic switch including a wiper shaft, a constantly rotating shaft, a go magnet for coupling said shafts, a stop magnet for stopping said wiper shaft, an incoming line, means for placing a control condition on said line and for maintaining it throughout a variable time interval, and means responsive to said control condition and effective at the beginning of the said time interval to energize said go magnet and at the end of the time interval to energize said stop magnet.

11. In an automatic switching system, an automatic switch, a line circuit over which said switch is controlled, means for continuously driving said switch to a variable set position responsive to a single change in the line circuit of variable duration, means also controlled over the

line circuit for continuously driving said switch to normal position, and electromagnet means for positively stopping the switch in any set position and also in its home position to prevent overrun when the driving means ceases to function.

12. In an automatic switching system, a calling device having a reciprocating dial, means for regulating the return movement of the dial to a predetermined speed, a line circuit, means in said calling device for interrupting said line circuit during the return movement of the dial and for maintaining it in interrupted condition for a variable time interval which depends on the digit dialed and upon the speed to which the return movement is regulated, an automatic switch, wipers in said switch and means for advancing them while the line circuit is interrupted, and contact sets in said switch distributed in a complete circle, the contacts in each set being extended as far as possible around the circle in both directions from the points at which they are normally engaged by said wipers so as to allow for a maximum variation in the speed of the dial without causing said wipers to be positioned on the wrong set of contacts.

13. In an automatic switching system, a first line, a plurality of other lines, means responsive to the closing of said first line and the subsequent single opening thereof for a predetermined variable time interval for selecting one of said other lines, and means for connecting the first line to the selected other line responsive to the completion of the selection.

14. In an automatic switching system, a first line, a plurality of other lines, means responsive to the closing of said first line and the subsequent single opening thereof for a predetermined variable time interval for selecting one of said other lines, means for connecting the first line to the selected other line responsive to the completion of the selection, and a relay energized over the said first line and the selected other line for controlling the maintenance of said connection.

15. In an automatic switching system, a first line, a plurality of other lines, switching mechanism responsive to closing of said first line and subsequent single opening thereof for a variable predetermined time interval for selecting one of said other lines, a control relay for said mechanism normally connected to said line, and means effective upon the completion of the said selection for disconnecting said first line from said relay and for connecting it to the selected other line.

16. In an automatic switching system, a first line, a plurality of other lines, switching mechanism for selecting any one of said other lines and for connecting said first line thereto, and control means for said mechanism responsive to the establishment of current flow over the first line and the subsequent interruption of said current flow for a variable predetermined time interval during which the interrupted condition is maintained.

17. In an automatic switching system, a first line, a plurality of other lines, a device for selecting one of said other lines, means for supplying current to said first line, means responsive to a single predetermined variable length interruption of the current flow over said first line for selectively operating said device, and means for conductively connecting said first line to the line selected by said device.

18. In an automatic switching system, a first

line, a plurality of other lines, a device for selecting one of said other lines, means for supplying current to said first line, means responsive to a single predetermined variable length interruption of the current flow over said first line for selectively operating said device, means for conductively connecting said first line to the line selected by said device, means for supplying current to said first line over the selecting line connected therewith, and means for disconnecting said first current supplying means.

19. In an automatic switching system, a first line, means for supplying current to said line, a switch means for continuously driving said switch responsive to a single variable length interruption of the current flow over said line, a plurality of other lines, means for connecting said first line with one of said other lines, the line connected to depending on the length of said interruption and the consequent advance of said switch, means including a relay energized over said first line and deenergized by interruption of current flow therein for controlling said switch, and a second relay energized over said first line and the other line connected thereto for controlling the maintenance of the connection.

20. In an automatic switching system, a line extending to a switching station, said line being normally open at the distant end, means at said distant end for closing and opening said line at will, a device also at said distant end effective while the line is closed by said first means for opening it and holding it open at another point for a variable predetermined time interval, switching mechanism at said station prepared for operation responsive to closure of said line, means responsive to opening of said line for selectively operating said mechanism in accordance with the duration of said time interval, a connection established between said line and one of a plurality of other lines responsive to operation of said mechanism, and means for maintaining said connection until said first line is opened by said first means.

21. In an automatic switching system, a two-conductor metallic line circuit extending from a control station to a switching station and there terminating in an automatic switch, means at said control station for closing the line and for thereafter opening it and holding it open for a variable predetermined time, a line relay included in said switch and energized over the line when the same is closed, means prepared for operation responsive to energization of said line relay and rendered effective upon deenergization thereof to advance the switch a variable distance depending on the duration of the open period, a line selected by operation of said switch, and means for connecting the conductors of the said first line, respectively, with the conductors of the selected line through the contacts of said switch.

22. In an automatic switching system, an automatic switch provided with a line relay and having access to called lines, a calling line terminating in said switch, a control station on the calling line, means at said station for closing an energizing circuit for said line relay over the calling line, means at the control station for opening said circuit and holding it open for a variable predetermined time, thereby deenergizing said line relay while the circuit is open, means in said switch controlled by said line relay for advancing the switch while the line relay is deenergized to select a called line, the line selected depending on the length of time the line relay is deenergized, and

means in said switch for disconnecting the calling line from said line relay and for connecting the calling line to the selected called line.

23. In an automatic switching system, an automatic switch provided with a line relay and having access to called lines, a calling line terminating in said switch, a control station on the calling line, means at said station for closing an energizing circuit for said line relay over the calling line, means at the control station for opening said circuit and holding it open for a variable predetermined time, thereby deenergizing said line relay while the circuit is open, means in said switch controlled by said line relay for advancing the switch while the line relay is deenergized to select a called line, the line selected depending on the length of time the line relay is deenergized, means in said switch for disconnecting the calling line from said line relay and for connecting the calling line to the selected called line, and means controlled over the connected calling and called lines for maintaining the established connection.

24. In an automatic switching system, an automatic switch provided with a line relay and having access to called lines, a calling line terminating in said switch, a control station on the calling line, means at said station for closing an energizing circuit for said line relay over the calling line, means at the control station for opening said circuit and holding it open for a variable predetermined time, thereby deenergizing said line relay while the circuit is open, means in said switch controlled by said line relay for advancing the switch while the line relay is deenergized to select a called line, the line selected depending on the length of time the line relay is deenergized, means in said switch for disconnecting the calling line from said line relay and for connecting the calling line to the selected called line, a relay reenergized over the connected calling and called lines in series, and means for restoring said switch when said last mentioned relay is deenergized by opening the calling line at said control station.

25. 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 closing the same and for then opening the line a single time for a predetermined period depending on the number of the called line, means in the switch responsive to opening of the line for advancing the switch to select the called line, and means in said switch for connecting said lines.

26. In an automatic telephone system, an automatic switch having a bank in which terminate a plurality of called lines, a calling line, means on the calling line for closing the line and for opening it and maintaining the open condition for a variable length of time depending on the position of a desired called line in the bank of said switch, means in said switch responsive to the closing and subsequent opening of the calling line for advancing the switch to select the desired called line and connect the calling line thereto, and means responsive to reclosure of the line upon expiration of said variable time for maintaining said switch in operated position.

27. In an automatic telephone system, a calling line extending from a subscriber's station to an exchange, a switch at the exchange having access to a plurality of called lines, a calling device at the said station for effecting a change in the calling line circuit and for maintaining it for a variable predetermined time interval, means

controlled over said line for continuously advancing said switch during the period in which the line circuit is in changed condition to cause said switch to select a desired called line, and means effective upon the completion of the operation of said switch for extending the calling line into connection with the called line.

28. In an automatic telephone system, a calling line extending from a subscriber's station to an exchange, a switch at the exchange having access to a plurality of called lines, a calling device at the said station for effecting a change in the calling line circuit and for maintaining it for a variable predetermined time interval, means controlled over said line for continuously advancing said switch during the period in which the line circuit is in changed condition to cause said switch to select a desired called line, means effective upon the completion of the operation of said switch for extending the calling line into connection with the called line, and means dependent upon restoration of the calling line circuit at the end of said time interval for maintaining the connection between the calling and called line.

29. In an automatic telephone system, a calling line extending to a switching station, means for closing said line, switching mechanism at the said station prepared for operation responsive to closure of said line, means for opening said line and for maintaining it in open condition for a variable predetermined time interval, means responsive to the opening of said line for selectively operating said switching mechanism in accordance

with the length of said time interval, another line selected and connected with the calling line responsive to the operation of said mechanism, and means controlled over the calling line for maintaining said connection.

30. In a automatic switching system, a line, an automatic switch, means responsive to the establishment of current flow over said line and the subsequent interruption thereof for starting said switch, and means for continuing the advance of said switch for a variable time depending on the duration of the interruption.

31. In an automatic switching system, a line, an automatic switch, means responsive to the establishment of current flow over said line and the subsequent interruption thereof for starting said switch, means for continuing the advance of said switch for a variable time depending on the duration of the interruption, and means for stopping the switch if the interruption is longer than a predetermined time interval.

32. In an automatic switching system, a line, an automatic switch, means responsive to the establishment of current flow over said line and the subsequent interruption thereof for starting said switch, means for continuing the advance of said switch for a variable time depending on the duration of the interruption, means for stopping the switch at the end of the interruption, and means for restoring the switch responsive to a second interruption of current flow over said line.

BERNARD D. WILLIS.