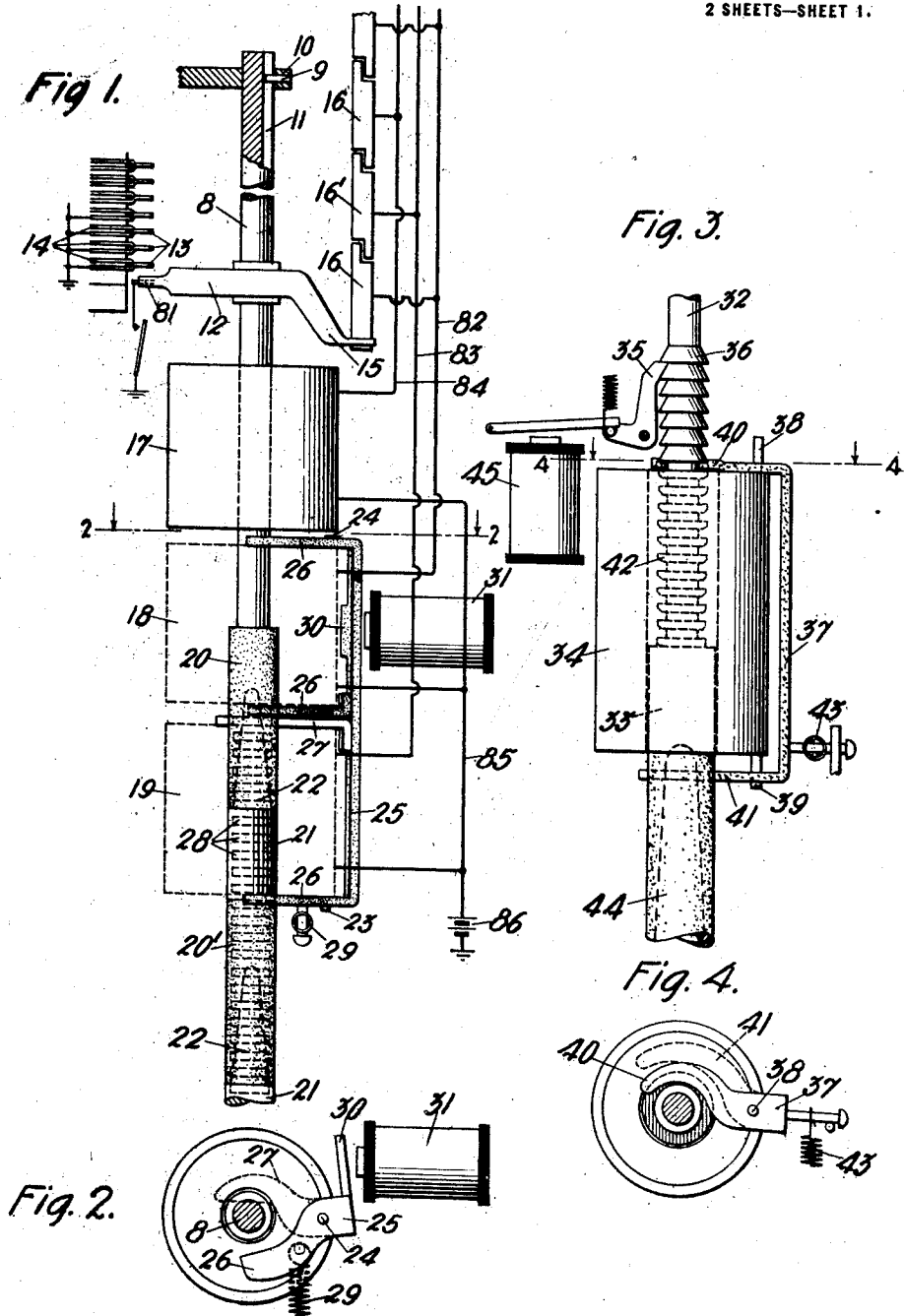


C. J. HENDRICKSON,
SOLENOID OPERATED SWITCH.
APPLICATION FILED JUNE 23, 1916.

1,247,399.

Patented Nov. 20, 1917.
2 SHEETS—SHEET 1.



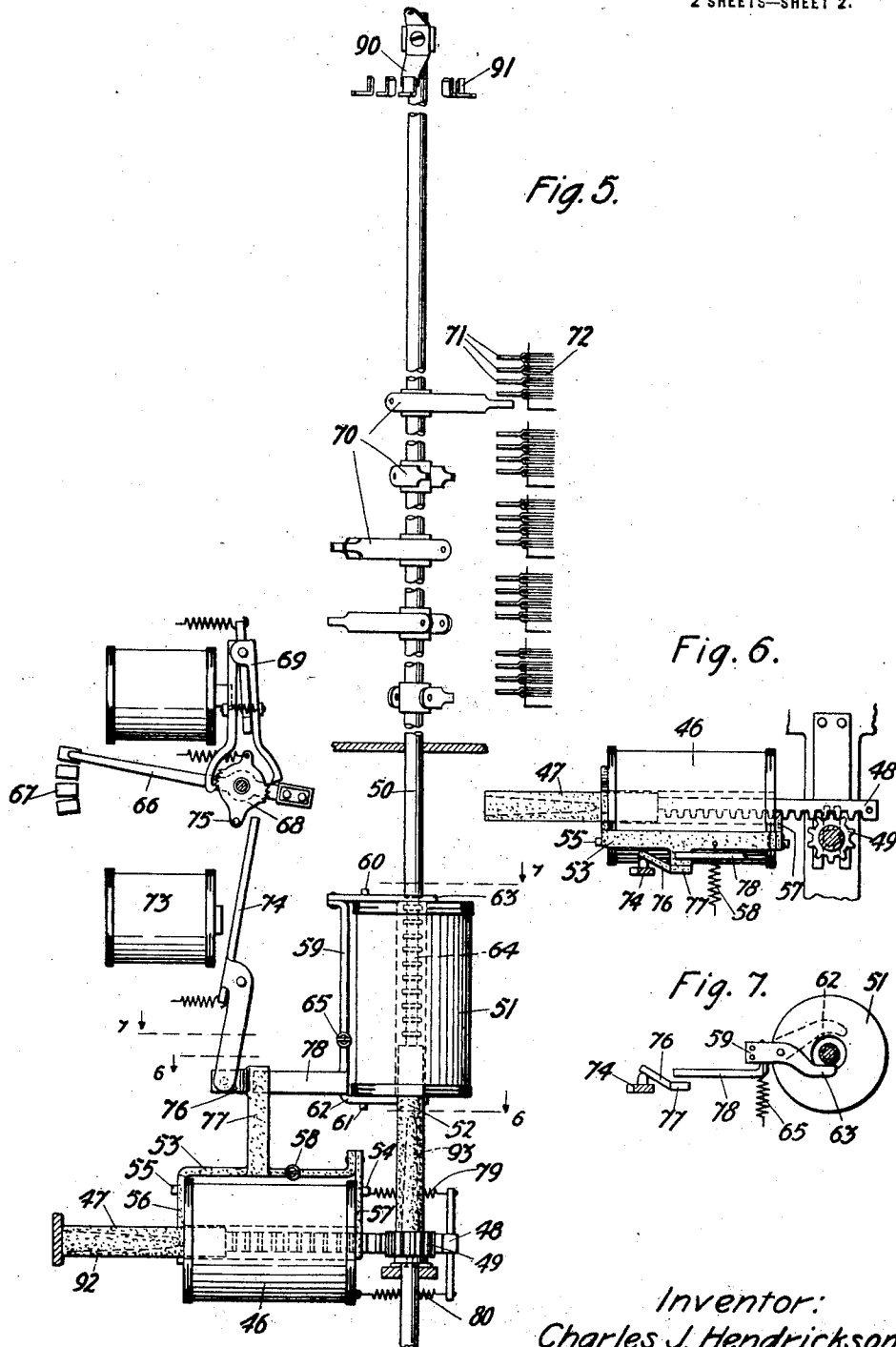
Inventor:
Charles J. Hendrickson.
by *A. C. Chandler*. Atty

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UNITED STATES PATENT OFFICE.

CHARLES J. HENDRICKSON, OF NEW YORK, N. Y., ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

SOLENOID-OPERATED SWITCH.

1,247,399.

Specification of Letters Patent.

Patented Nov. 20, 1917.

Application filed June 23, 1916. Serial No. 105,355.

To all whom it may concern:

Be it known that I, CHARLES J. HENDRICKSON, a citizen of the United States, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Solenoid-Operated Switches, of which the following is a full, clear, concise, and exact description.

10 This invention relates to switches for use in automatic telephone systems, and more especially to switches in which the power for imparting motion to the brushes is supplied by the action of a plunger in a solenoid.

15 The object of the present invention is to provide an automatic switch which shall be simple in structure, and rapid and accurate in operation.

20 In the well-known types of step-by-step switch, either rotary or vertical motion, or a combination of both motions, may be applied to a brush-carrying shaft by means of ratchet and pawl devices electromagnetically operated. In the present invention, the magnetism set up in the winding of a coil is able to exert a pull directly on either the brush-carrying mechanism itself, or on a plunger carrying a toothed rack arranged to engage a pinion mounted on such brush-carrying shaft. This arrangement admits of fewer and simpler parts, as well as being capable of greater speed of action.

30 A further feature of the invention is an arrangement by which a rectilinear motion of any desired length may be given to a brush carrier by the successive use of a plurality of solenoids acting in a fixed sequence.

40 Another feature of the invention is the provision of means whereby the motion of the plunger within the solenoid is made to take place at a uniform rate.

45 The various features of the invention will be better understood from the following description, taken in connection with the accompanying drawings.

Referring to the drawings, Figure 1 is a side elevation of a line finder switch in which motion is rectilinear only. Fig. 2 is a plan view of the same switch, partly in section, on the line 2—2 of Fig. 1. Fig. 3 is a side elevation of an arrangement by which a shaft may be given motion in the direction

of its axis under the control of impulses. 55 Fig. 4 is a plan view of the same arrangement, partly in section, on the line 4—4 of Fig. 3. Fig. 5 is a side elevation of an "around-and-up" switch, embodying the idea of this invention. Fig. 6 is a plan view, 60 partly in section, on the line 6—6 of Fig. 5 and shows the solenoid and rack and pinion by which rotary motion is imparted to the shaft of the switch. Fig. 7 is a plan view, partly in section, on the line 7—7 of Fig. 5, 65 and illustrates the means for releasing the switch.

In Fig. 1, the invention is shown applied to a line finder switch, motion being rectilinear and continuous, that is, the brush is 70 not advanced step by step, but is carried in one continuous movement to the desired contact. The range of the brush may be over any desired number of contacts.

A shaft 8 of non-magnetic material is 75 slidably mounted in suitable bearings, not shown, and is locked from rotation on its axis by a pin 9 set in a fixed support 10 and engaging a slot 11 in the shaft 8. A test brush 12, which may be one of a set, is 80 rigidly and insulatively mounted on said shaft and is arranged to make contact successively with test contacts 13. In electrical connection with brush 12 is a tail-piece 15, which is arranged to slide over and make 85 contact with a series of commutator strips 16, for a purpose to be explained later.

Three solenoids 17, 18 and 19 are placed in alignment in tandem as shown, and are mounted in any well-known manner. Cylindrical sections 20, 20', etc., of magnetic material are mounted on the shaft 8, the number of such cores being determined by the extent of motion required by the brush 12. Each magnetic section is approximately 95 equal in length to the length of the operating solenoids. The magnetic sections are separated by cylindrical non-magnetic sections 21, the spacing of the magnetic sections being such that after one section has 100 reached the limit of its motion under the control of a particular solenoid, another section will be in operative relation to the solenoid next to be actuated. In the drawing, the magnetic sections are indicated by finely 105 dotted portions, this convention being assumed in order that greater clearness may be given to the drawing. A cone-like por-

tion is hollowed out from the lower parts of the magnetic sections 20, as indicated at 22 by broken lines.

Pivotaly mounted on pins 23 and 24 is a swinging frame 25 carrying three armatures 26 and a pawl 27, the pawl being of non-magnetic material, their relative positions being more clearly shown in Fig. 2. The pawl 27 is arranged to engage notches 28 under the tension of a spring 29. The frame 25 carries in addition an armature 30 in operative relation to a release magnet 31.

In Figs. 3 and 4, an arrangement is shown by which the motion of a shaft may be controlled in accordance with impulses sent by making and breaking the circuit of an operating solenoid. A brush-carrying shaft 32 of non-magnetic material is mounted so as to be free to move in either a rotary or a longitudinal direction, and carries, at its lower end, a cylinder 33 of magnetic material arranged to be acted on by solenoid 34. A spring-pressed pawl 35 engages ratchet teeth 36 to prevent return movement of the shaft.

A frame 37 is pivotaly and slidably mounted on studs 38 and 39, and carries a pawl 40 and a stop arm 41 of magnetic material, as best shown in Fig. 4. The pawl 40 is arranged to engage notches 42, but is normally held from such engagement by the action of a spring 43. There are as many notches 42 and ratchet teeth 36 as the desired number of steps, and the distance over which the bracket 37 slides is equal to the distance traversed by the shaft in making one step. A cone-like portion 44 is hollowed out of the plunger 33, as shown, for a purpose to be described.

A release magnet 45 is provided to withdraw pawl 35 from engagement with the ratchet teeth 36 and allow of the return of the shaft.

Figs. 5, 6 and 7 show the invention applied to a switch of the "around-and-up" type. A solenoid 46 is arranged to operate a plunger 47, such plunger carrying a strip of toothed rack 48. This toothed rack is in engagement with a pinion 49 mounted on a rotatable shaft 50. The action of this solenoid imparts rotary motion to the shaft. Vertical motion is given to the shaft by a second solenoid 51, which is arranged to operate a plunger 52 mounted on said shaft 50.

A frame 53, pivotaly mounted on studs 54 and 55, carries at one end an armature 56 and at the other end a pawl 57, which is arranged to engage the teeth of rack 48 and is normally held from engagement therewith by the action of spring 58.

A similar frame 59 is provided for solenoid 51 and is mounted on studs 60 and 61. It carries an armature 62 and a pawl 63 of non-magnetic material, such pawl being

arranged to engage notches 64, and normally held in engagement therewith by the action of a spring 65.

A side-switch wiper 66 is arranged to swing over contacts 67, a ratchet wheel 68 and hinged escapement 69 supplying the means for electromagnetic control.

Spirally disposed brushes 70 are arranged about the shaft 50, and may be brought into an operative position, with respect to their respective groups of terminal sets 71-72, by rotation of said shaft.

At 90 is shown a group finding brush and contacts 91 with which it may be brought into connection.

The arrangement of brushes 70, brush 90 and the structure of the side switch is substantially the same as shown for the corresponding parts in an application by O. F. Forsberg, Serial No. 6302, filed Feb. 5, 1915.

A magnet 73 controls the release of the entire switch. A pivoted armature lever 74 is actuated when magnet 73 is energized, and restores the side switch by engaging a lug 75 on the toothed segment 68. The other end of the lever 74 is arranged to engage an offset 76 and push down a lever 77 attached to frame 53, thereby withdrawing pawl 57 from engagement with toothed rack 48. The lever 77, in going down, carries with it a lever 78 attached to frame 59, causing the withdrawal of pawl 63 from a slot 64. The switch is now free to return to normal, being restored vertically by the action of gravity, and in a rotary direction by the retraction of the toothed rack 48 by the action of springs 79 and 80.

The various structures having been detailed, a description of their respective modes of operation follows.

The operation of the line finder switch shown in Figs. 1 and 2 will first be described. Upon the initiation of a call, ground is put, in any well-known manner, upon the contact on which the brush 12 normally rests. A circuit for solenoid 18 is completed from ground, contact 81, brush 12, tail-piece 15, commutator strip 16, wire 82, winding of solenoid 18, wire 85 to battery 86 and ground. Solenoid 18 attracts its armature 26, moving pivoted frame 25 and causing the withdrawal of pawl 27 from notch 28, thereby allowing core 20 to be attracted and the brush carrying shaft to be advanced. Assuming now that the normal condition of a line is indicated by a ground on test contact 13, and a calling condition by the absence of such ground, the switch will be kept in continuous motion until the calling line is picked up, current now being supplied to solenoid 18 from ground, successive test contacts 13, brush 12, tail-piece 15, commutator strip 16, wire 82, winding of solenoid 18, wire 85 to battery and ground. The brush 12 engages a succeeding test con-

tact just before breaking connection with the one it is leaving, and thus, the circuit just described remains complete until the calling line is found.

5 At the time the core reaches the limit of its range of movement under the attraction of solenoid 18, the piece 15 will have engaged a new commutator segment 16', and a core 20' will be in a position to be attracted
10 by solenoid 19. The circuit of solenoid 19 is completed from ground to one of test contacts 13, brush 12, tail-piece 15, commutator strip 16', conductor 83, winding of solenoid 19, conductor 85, to battery and
15 ground. The action of solenoid 19 maintains pawl 27 out of engagement with notches 28 and pulls up core 20'.

When core 20' reaches the limit of its range of movement, the piece 15 will be engaging commutator strip 16'', and core 20
20 will be in a position to be advanced upon the energization of solenoid 17.

It may thus be readily seen that the brush 12 may be advanced over any desired range
25 by simply providing enough cores 20 and segments 16, the multiple connections for solenoid 18 being indicated in Fig. 1.

As soon as the terminal set of the calling line is reached, the circuit of the operating
30 solenoid is broken, since brush 12 fails to find a ground, and the solenoid is deenergized, armature 26 is retracted and pawl 27 drops into engagement with some slot 28, and the brush set is held on the terminals
35 of the calling line.

The switch is released when current is supplied to magnet 31. Armature 31 is attracted and withdraws holding pawl 27,
40 whereupon the brush carrier falls back to normal by gravity.

The operation of the control mechanism shown in Figs. 3 and 4 will next be described. On the first closure of circuit, a
45 current flows through the windings of solenoid 34, energizing same and causing the attraction of armature 41. The resultant movement of bracket 37 moves pawl 40 into engagement with the first of the slots 42. The solenoid also attracts core 33, thus moving
50 the brush-carrying shaft in a vertical direction. During the vertical movement, the bracket 37 is carried with the shaft, due to the engagement of pawl 40 with slot 42. The extent of this movement is limited by
55 the stop arm 41, which holds the bracket and shaft from further motion when it strikes the solenoid 34. When a break in the circuit occurs, solenoid 34 is deenergized and bracket 37 is actuated by spring 43 to withdraw
60 pawl 40 from the first slot and allow the bracket to fall back to normal position by gravity. This brings the pawl 40 into the plane of the second slot, so that on a second energization of the solenoid, it will engage
65 such second slot and the shaft will make

the second step. In this way, the shaft may be advanced step by step in response to makes and breaks in the circuit, and is held from return motion by the pawl 35, arranged to engage notches 36, as previously
70 described.

Release is accomplished by supplying current to magnet 45 in any well-known manner. The energization of magnet 45 withdraws holding pawl 35 and the shaft drops
75 to its normal position.

The structure shown in Figs. 5, 6 and 7 is arranged to be used as a line finder switch and is of the type in which both rotary and vertical motions are imparted to a brush-carrying shaft, the switch as shown being
80 arranged to have the rotary movement act first.

The invention is not restricted to use with a line finder switch, but may equally well be used with selector or connector switches, as
85 will be shown later. It is also immaterial whether the rotary or the vertical movement acts first.

No circuit arrangement is provided for
90 the structure shown in Figs. 5, 6 and 7, but such circuit arrangement would be of sufficient similarity to that used with the switch of the above mentioned Forsberg application No. 6302, in a two-wire step-by-step
95 system, as to be unnecessary of detailed description, the chief distinction being that in the present usage, solenoids would be substituted for stepping magnets, and no means would be necessary for causing makes and
100 breaks of their circuits. The circuits for a line finder switch of a two-wire system are shown in an application by C. L. Goodrum, Serial No. 872,743, filed November 18, 1914.

Upon the initiation of a call, ground is
105 put on the test contact 91 of the group to which the calling subscriber belongs and current is supplied to the rotary solenoid 46. When the group hunting brush 90 finds a test contact 91 having a connection to
110 ground, the side switch is moved into its second position, thereby opening the circuit of solenoid 46. During the energization of the solenoid, armature 56 is held attracted and actuates bracket 53 to hold pawl 57 from
115 engagement with toothed rack 48. As soon as the circuit of the solenoid is broken, spring 58 retracts bracket 53, and pawl 57 engages one of the teeth of strip 48 and stops the rotary motion of the brush rod.
120

In the second position of the side switch, current is led to the vertical solenoid 51, and the selected brush set 70 is made to travel
125 over the contacts 71—72 of the group in which the calling line is located. On finding the calling line, the side switch moves into its third position, thereby opening the circuit of solenoid 51 and completing the circuit of a cut-off relay (not shown), which clears the connection through to a first se-
130

lector. The controlling mechanism for solenoid 51 acts in a manner identical with that for a solenoid 46, and need not be described.

At the conclusion of the conversation, release magnet 73 is energized and restores the switch in the manner previously described.

If the switch is to be used as a selector, the brush 90 and contacts 91 are dispensed with, and the rotary solenoid must be provided with control means similar to those shown in Figs. 3 and 4, by which the rotary movement will take place in response to impulses.

If the switch is to be used as a connector, both vertical and rotary solenoids must be subject to impulse control.

The hollowed-out, cone-like portions shown at 22 in Fig. 1, at 44 in Fig. 3, and at 92 and 93 in Fig. 5, are intended to maintain motion at a uniform rate and prevent undue acceleration of the plunger. If the core were simply a cylinder of magnetic material, the result would be a constantly increasing speed as it enters the coil, since the metal would provide a path of constantly decreasing reluctance, allowing the magnetomotive force to be correspondingly increased. By hollowing out the cores as shown, a more nearly uniform pull is produced, and motion of the plunger takes place at a comparatively uniform rate.

The invention has been shown in connection with switches arranged for use with two-wire systems. It is not restricted to use with a two-wire system, however, since it may obviously be used with equal advantage in systems of other kinds.

What is claimed is:

1. In an automatic switch for use in telephone exchange systems, a series of terminal sets, a brush-carrying shaft, electromagnetic means for advancing said shaft in a continuous movement, a pivoted frame carrying a magnetic armature in operative relation to said operating electromagnetic means, a pawl arranged to engage notches in the brush shaft, said pawl being operated by said pivoted frame, and means including said pawl for immediately stopping said shaft upon the deenergization of said operating means.

2. In an automatic switch for use in telephone exchange systems, a series of terminal sets, a brush-carrying shaft, means for advancing the brush-carrying shaft in a continuous movement, such means consisting of a plurality of plungers mounted in tandem on said shaft and a plurality of operating solenoids therefor, and means for arresting said brush-carrying shaft in a desired relation to said series of terminal sets.

3. In an automatic switch for use in telephone exchange systems, a series of terminal sets, a brush-carrying shaft, a plurality of operating solenoids, a plurality of plungers mounted on said brush shaft in tandem,

means for supplying current to said solenoids successively, and means for arresting said brush-carrying shaft in a desired relation to said series of terminal sets.

4. In an automatic switch for use in telephone exchange systems, a series of terminal sets, a brush-carrying shaft, a plurality of plungers mounted in tandem on such brush shaft, a plurality of operating solenoids, means for successively energizing said solenoids, and means for immediately stopping said brush shaft upon the deenergization of whichever of said solenoids has been operating.

5. In an automatic switch for use in telephone exchange systems, a series of terminal sets, a brush-carrying shaft, a plurality of plungers mounted on said shaft, a plurality of operating solenoids, means for successively energizing said solenoids, a pivoted bracket carrying a plurality of magnetic armatures, one for each solenoid and in operative relation to said solenoids, a pawl arranged to engage notches in said brush shaft, said pawl being operated by said pivoted frame, and means including said pawl for immediately stopping said shaft upon the deenergization of the solenoid acting at that instant.

6. In an automatic switch for use in telephone exchange systems, a series of terminal sets, a shaft, a brush set, including a test brush, carried thereby, a plurality of plungers mounted in tandem on such shaft, a plurality of solenoids for operating said plungers, and means for supplying current to said solenoids successively, such means comprising a series of commutator strips and a contact piece slidable over said strips and in electrical connection with said test brush.

7. In an automatic switch for use in telephone exchange systems, a series of terminal sets, a brush-carrying shaft, a plurality of plungers mounted in tandem on such shaft, a plurality of solenoids for operating said plungers, the arrangement of said solenoids and plungers being such that the brush-carrying shaft may be advanced in a continuous movement of any desired length irrespective of the length of the individual solenoids, and means for arresting said brush-carrying shaft in a desired relation to said series of terminal sets.

8. In an automatic switch for use in telephone exchange systems, a series of terminal sets, a brush-carrying shaft, a plurality of plungers mounted in tandem on such shaft, three solenoids for operating such plungers, means for advancing the brush-carrying shaft in a continuous movement of any desired length irrespective of the length of the individual solenoids, means for supplying current to said solenoids successively,

and means for arresting said brush-carrying shaft in a desired relation to said series of terminal sets.

9. In an automatic switch for use in tele-
5 phone exchange systems, a series of terminal
sets mounted in a straight line, a brush-
carrying shaft, a plurality of plungers
mounted on said shaft, a plurality of oper-
ating solenoids therefor arranged to advance
10 said shaft in a continuous movement, electro-
magnetic means for maintaining such motion
at a substantially uniform rate, and means
for arresting said brush-carrying shaft in a
desired relation to said series of terminal
15 sets.

10. In an automatic switch for use in tele-

phone exchange systems, a series of terminal
sets, a brush-carrying shaft, a plurality of
plungers mounted in tandem on said shaft,
a plurality of operating solenoids for said 20
plungers to advance the shaft in a continu-
ous movement of any desired length irre-
spective of the length of the individual sole-
noids, electromagnetic means for maintain-
ing such motion at a substantially uniform 25
rate, and means for arresting said brush-
carrying shaft in a desired relation to said
series of terminal sets.

In witness whereof, I hereunto subscribe
my name this 22nd day of June, A. D. 1916. 30

CHARLES J. HENDRICKSON.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents,
Washington, D. C."