April 29, 1941. C. N. HICKMAN 2,240,039

SELECTOR SWITCH

Filed July 9, 1938 3 Sheets-Sheet 1

FIG. 1

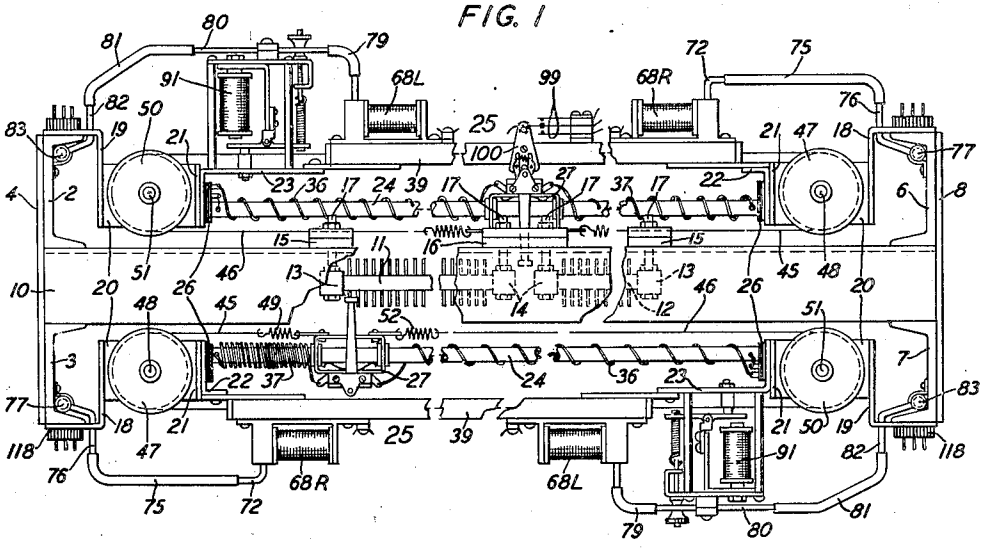

FIG. 2

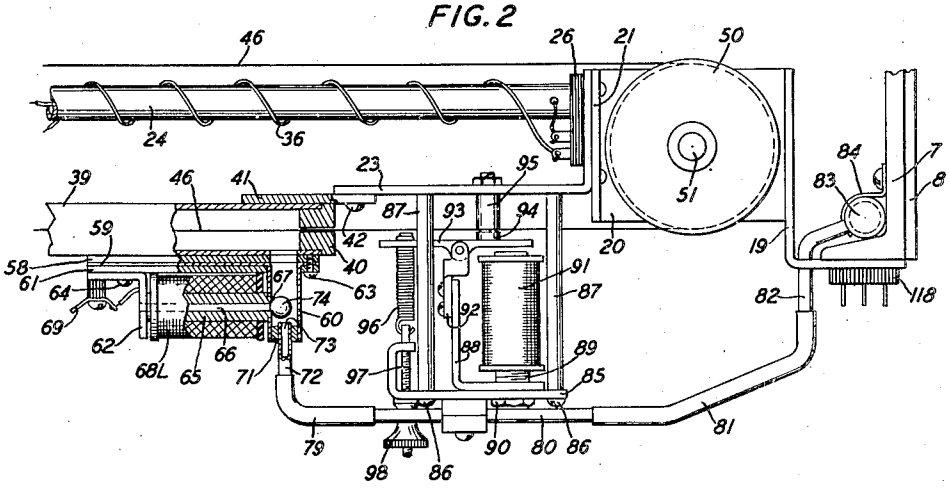

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FIG. 3

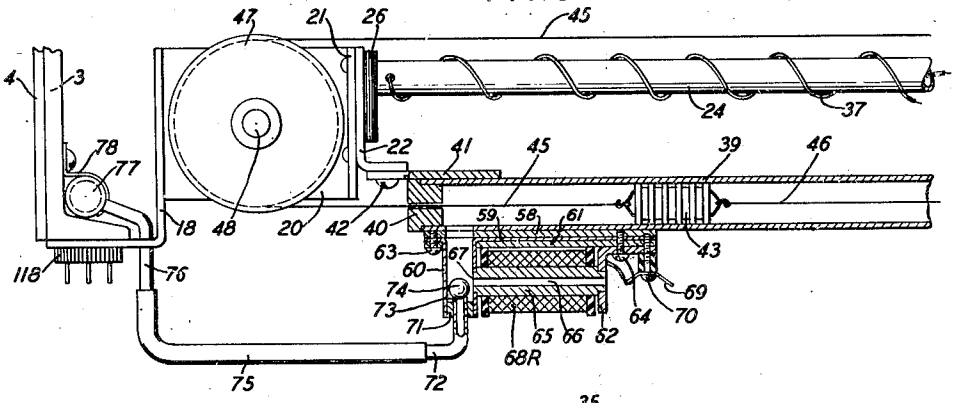

FIG. 4

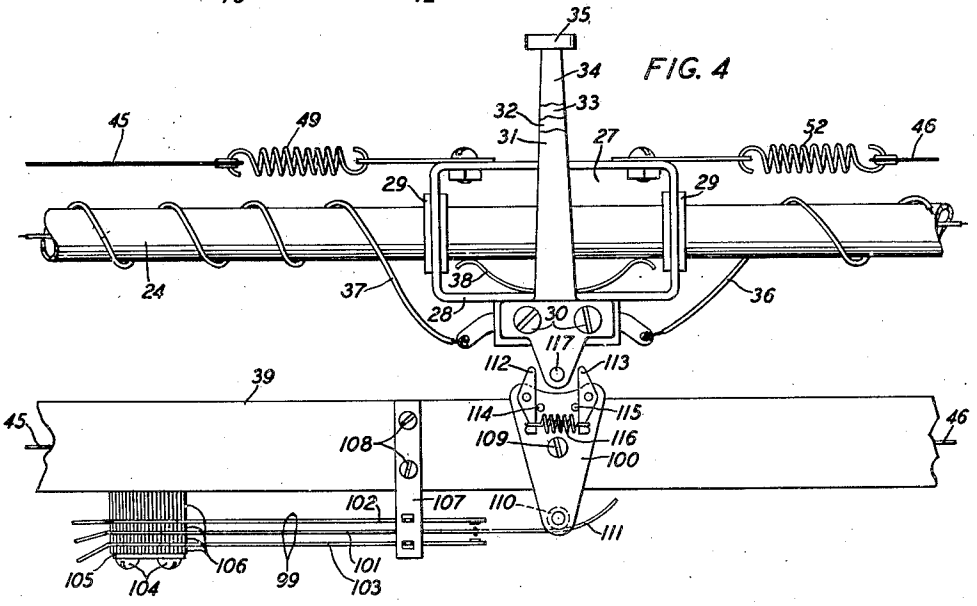

FIG. 5

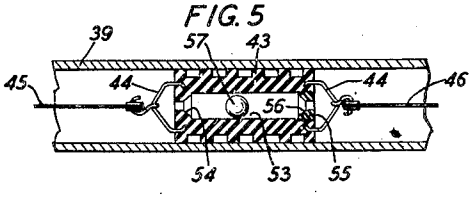

FIG. 6

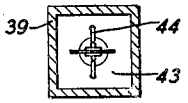

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FIG. 7

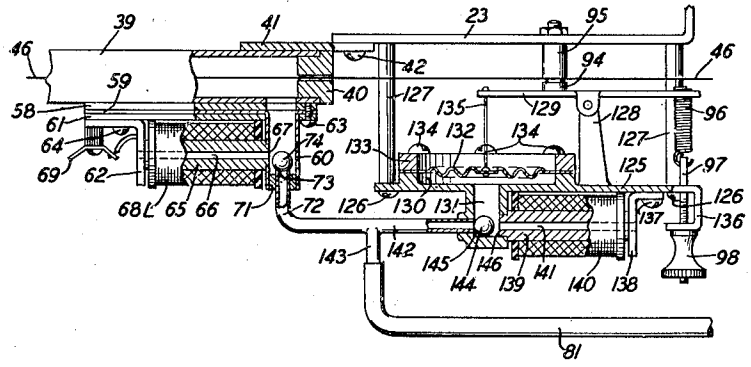


FIG. 8

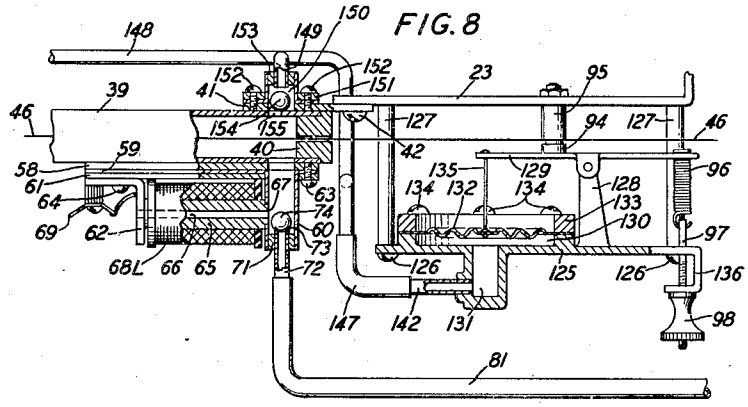


FIG. 9

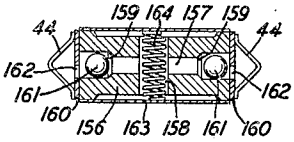
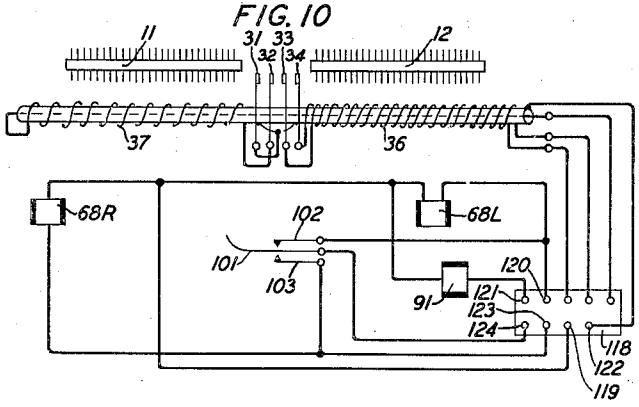


FIG. 10



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Patented Apr. 29, 1941 2,240,039

UNITED STATES PATENT OFFICE

2,240,039

SELECTOR SWITCH

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Application July 9, 1938, Serial No. 218,335

11 Claims. (Cl. 179—27.53)

This invention relates to selector switches applicable for use in machine switching telephone systems and more particularly to switches of the terminal hunting type having access to large groups of line or trunk terminals.

In machine switching telephone systems due to the cost of the switching equipment, it is essential that all equipment be used with the utmost efficiency since if the equipment is slow in operation a larger amount of equipment must be installed to handle peak loads than would be the case if equipment of a faster operating type were available. Heretofore, selector switches have been proposed which are capable of operation at very high terminal hunting speeds. Such switches have been provided with brush sets which are traversed in either of two directions over the terminals of panel banks by tape belts, one switch of this general type, disclosed in Patent 2,123,228, granted July 12, 1938, to W. W. Carpenter, is provided with two pulleys for driving the tape belt which may be clutched to two oppositely rotating power shafts by magnetic clutches associated with the driving pulleys. A further switch of this type is disclosed in Patent 2,123,229, granted July 12, 1938, to W. W. Carpenter and R. F. Mallina, in which the belt is driven by a reversible alternating current motor individual to the switch and geared to one of the pulleys over which the belt runs. For arresting the movement of the brush carriage when a marked set of bank terminals is encountered by the brush set each of these switches has been provided with a magnetically operated brake which cooperates with the tape belt.

Since a switch of this type travels at a very high terminal hunting speed, the brush set may overrun a marked terminal set and therefore provision has been made for returning the brush set to the marked terminal set in that case. However, if the return movement should be too rapid, the brush set may overrun the terminal set in its return movement. It is, therefore, the object of the present invention to provide a driving means for the tape belt which is capable of smoothly accelerating the movement of the brush carriage at a relatively slow speed but also capable of driving the brush carriage at a high speed when once the period of acceleration has been passed and to provide efficient means for arresting the movement of the brush carriage.

In accordance with the present invention, this object is attained by providing a pneumatically operated motor for driving the tape belt of each switch unit of the sixty units mounted on the two sides of a switch frame. The switch unit cooperates with two panel type banks of terminals mounted on the frame side by side, each bank being provided with one hundred sets of vertically disposed multiple terminal strips, each of which strips has multiples for accessibility from thirty switch units on each side of the banks. By the provision of the two banks of one hundred terminal sets, two hundred lines, trunks or links may be terminated thereon.

Each switch unit is mounted horizontally on the frame in front of a horizontal row of two hundred terminal sets of the two banks and comprises a single brush set of three or more brushes mounted on a light carriage slidable on a tubular guide rod secured at its ends to brackets attached to the vertical end uprights of the frame. The brush set is traversed along the guide rod by two steel tapes which run over two pulleys or flanged drums mounted for free rotation on the end brackets. One end of each tape is secured to the brush carriage by a coiled spring which springs function to tension the tapes and to act as shock absorbers when the movement of the tapes is abruptly arrested. The other ends of the tapes are threaded through slots in the ends of a cylinder extending parallel to the guide rod and are attached to a piston slidable within the cylinder.

For controlling the movement of the piston within the cylinder in either direction whereby the brush set may be traversed by the tapes in either direction over the sets of bank terminals with which the brush set is associated, the cylinder is provided at each end with a magnetically controlled air valve. Each air valve comprises an electromagnet having an air duct extending axially through its core, a valve chamber communicating with the air duct, with the end of the motor cylinder and with a second duct connected with a reservoir in which air is maintained at a pressure below atmospheric pressure. Within the valve chamber is a steel ball which is normally held by suction over the reservoir duct and which upon the energization of the magnet coil is attracted to the end of the magnet core thus opening the second or reservoir duct and closing the duct through the magnet core.

Normally with the valve magnet associated with each end of the cylinder deenergized, the reservoir duct at each end of the cylinder is closed and air under atmospheric pressure is admitted through the core ducts to the cylinder on either side of the piston thereby holding the piston stationary. If, however, one valve mag-

net, for example the magnet associated with the right end of the cylinder is energized, the pressure on the right side of the piston is reduced by suction through the reservoir duct and atmospheric pressure applied to the left side of the piston through the core duct of the magnet valve associated with the left end of the cylinder will drive the piston toward the right end of the cylinder thereby moving the brush set secured to the tape toward the left. If, however, the valve magnet associated with the left end of the cylinder were energized, a reverse movement of the piston toward the left and a movement of the brush set toward the right would result.

In order to delay the return movement of the brush set should it overrun a marked terminal set in its hunting movement, the piston is made hollow and is provided with an interior valve seat in each end thereof with which a valve ball cooperates. When for example suction is applied to the left side of the piston to move the brush set toward the right in its initial hunting movement, the ball is first sucked against the left valve seat in the piston and until it engages the valve seat the force exerted on the right side of the piston is small due to the passage of air around the ball. As soon, however, as the ball seats, the piston will accelerate rapidly. When the brush set overruns the marked terminal set and the control circuit of the switch causes the deenergization of the left valve magnet and the energization of the right valve magnet to remove suction from the left side of the piston and to apply suction to the right side of the piston, the ball in the piston must first be sucked to the right valve seat before the piston will become effective to start the return movement of the brush set toward the left thereby keeping the acceleration of the return movement low until the brush set has stopped on the marked terminal set.

The movement of the brush set may be arrested when the brush set encounters a marked terminal set by a magnetically operated brake cooperating with the tape or the brake may be pneumatically operated. In accordance with one embodiment of the invention, the brake shoe for engagement with the tape is attached to a pivoted brake lever one end of which is attached to a spring which normally forces the brake shoe against the tape and the other end of which is attached to a flexible diaphragm. The diaphragm closes one end of a valve chamber which is connected by one duct extending through the core of a valve magnet to the atmosphere and by a suction duct to the main air reservoir. A steel ball is positioned in the chamber which normally closes the suction duct and opens the core duct whereby atmospheric pressure is applied to both surfaces of the diaphragm. To release the brake the valve magnet is energized to attract the ball, thereby closing the core duct and opening the suction duct whereby the pressure against the inner surface of the diaphragm is lowered permitting the atmospheric pressure on the outer surface of the diaphram to flex the diaphram inwardly and move the brake lever against spring tension thereby removing the brake shoe from the tape.

In accordance with a further embodiment of the invention, the magnetically controlled brake valve is eliminated by connecting the diaphragm chamber by a duct connected to both ends of the motor cylinder through ball valves. When suction is applied to either end of the cylinder, the suction closes the ball valve at the other end of the cylinder and suction is applied to the diaphragm chamber and atmospheric pressure then flexes the diaphragm to remove the brake shoe from the tape.

The brake shoe acting on the tape and the operating mechanism therefor may, in accordance with a further embodiment of the invention be entirely eliminated by incorporating a brake mechanism in the piston of the motor. To accomplish this the piston is provided with a duct extending longitudinally therethrough and with a flexible tubular outer wall which is normally pressed into engagement with the inner wall of the cylinder by a coiled spring positioned within the piston. The flexible tube thus serves as a friction brake. Each end of the duct through the piston is provided with a valve seat with which a valve ball cooperates. When suction is applied to either end of the piston, the balls both move toward the end of the piston to which suction is applied, one ball opening the valve at that end and the other ball closing the valve at the other end whereby the suction is effective to collapse the thin side walls of the flexible tube against the pressure of the spring sufficiently to remove the braking action thereof with the wall of the cylinder.

For a more complete understanding of the invention and the mode of its operation, reference may be had to the following detailed description taken in connection with the accompanying drawings in which:

Fig. 1 is a partial top plan view of a switch frame showing two switch units embodying the invention mounted thereon;

Fig. 2 shows the brake mechanism and a partial cross-sectional view of one end of the motor cylinder and the magnetically operated valve associated therewith;

Fig. 3 is a cross-sectional view of the other end of the motor cylinder and the magnetically operated valve associated therewith;

Fig. 4 is an enlarged detail view of the brush carriage and normalling switch;

Fig. 5 is a detailed cross-sectional view of the motor piston;

Fig. 6 is an end view of the motor piston shown in Fig. 5;

Fig. 7 shows in partial cross-section a pneumatically operated brake mechanism;

Fig. 8 shows in partial cross-section a further embodiment of a pneumatically operated brake mechanism;

Fig. 9 is a cross-sectional disclosure of a pneumatically controlled brake mechanism incorporated in the motor piston; and

Fig. 10 is a circuit diagram showing the manner in which the magnetically operated valves of the switch, brushes and normallying switch are electrically connected.

Referring now to the drawings, the invention will be described in more detail. The switch frame on which the switch units are mounted may be of the general type disclosed in the patent of W. W. Carpenter et al. hereinbefore referred to and comprises two channel shaped uprights 2 and 3 joined at their upper ends by the strap 4 welded or otherwise secured thereto and similar uprights 6 and 7 also joined by a strap 8. The upper ends of the uprights 2 and 3 are joined to the upper ends of uprights 6 and 7 by the angle bar 10 which is welded or otherwise secured to the flanges of the uprights,

the lower ends of the uprights 2 and 3 are joined by an angle iron (not shown) and the lower ends of the uprights 6 and 7 are jointed by an angle iron (not shown) by means of which the frame may be secured to the switch room floor. The two pairs of uprights are further connected near their lower ends by an angle bar (not shown).

Secured side by side between the upright end members of the frame are two panel banks of terminals 11 and 12. Each bank is of the general type disclosed for example in Patent 1,127,741, granted February 9, 1915, to A. F. Dixon and comprises two vertical side members 13 and 14 between which one hundred sets of multiple terminal strips and separator strips are clamped. The banks are secured to the upper angle bar 10 and to the lower angle bar of the frame by straps 15 and 16 which are attached to the angle bars by screws and to the side members 13 and 14 of the banks by bolts 17. Each terminal strip is provided with thirty multiple terminals extending outwardly on each side thereof and with a soldering terminal at each end whereby accessibility is afforded to sixty selector switch units thirty on each side of the banks. The terminal strips are arranged in sets of four to which the tip, ring, sleeve and metering leads of a subscriber's line may be connected, although in some instances, as for example when the switch frame is to be used for other purposes, each set might comprise three terminal strips. The corresponding sets of multiple terminals on the several sets of strips in both banks are aligned horizontally and individualized to different selector switch units.

For supporting each selector switch unit on the switch frame in proper relationship to the horizontal row of bank terminal sets to which it is individualized, two brackets 18 and 19 are provided, the supporting brackets of the switch units on the front of the frame being secured to the outside flanges of the upright channel members 3 and 7 and the switch units on the rear of the frame being secured to the outside flanges of the upright channel members 2 and 6. Each bracket is in general channel shaped having a horizontal web 20, an outer flange by which it is attached to a vertical upright of the switch frame and an upwardly extending flange 21.

Secured to the flange 21 of bracket 18 as by screws or welding is an L-shaped member 22 and similarly secured to the flange 21 of bracket 19 is an L-shaped member 23, said members 22 and 23 serving to support the tubular guide rod 24 and the pneumatic driving motor 25 of the switch unit in parallel relation to the face of the terminal banks. The ends of the tubular guide rod 24 are seated in bushings 26 of insulating material which are secured to the members 22 and 23 in any desired manner whereby the guide rod is electrically insulated from the switch frame.

Slidable on the guide rod 24 of each switch unit is a brush carriage 27 having a rectangular frame 28 as most clearly disclosed in Fig. 4, the ends of which are provided with bushings 29 which slidably embrace the guide rod. Insulatedly secured to the frame 28 by screws 30 are brush springs 31 to 34, inclusive, each provided with a contact shoe 35. These brushes serve as sleeve, tip, ring and metering brushes, respectively, for cooperation with sets of terminals on the terminal banks or if no meter control is necessary and the bank terminal sets having only tip, ring and sleeve terminals, the outer two of the brushes may be electrically connected together. For connecting the brush springs to external circuits, the ring brush 33 is connected to a terminal positioned on the bushing 26 attached to the member 23 by a flexible insulated conductor 36 coiled around the guide rod 24 on one side of the brush carriage, the tip brush 32 is connected by a second flexible conductor 37 coiled around the guide rod 24 on the other side of the brush carriage and extending through the tubular guide rod to a second terminal positioned on the bushing 26, the sleeve brush 31 is electrically connected through the brush carriage frame 28 and the spring 38 attached thereto which slides on the guide rod to an external conductor connected to the end of the guide rod, and when a metering control is necessary the fourth or metering brush 34 is connected by a third flexible conductor coiled around the guide rod 24 in the same manner as conductor 36.

For traversing the brush carriage 27 along the guide rod 24 a pneumatic motor 25 is provided. This motor comprises a cylinder 39 preferably made of thin square tubing having its ends closed by plugs 40 of hard rubber or other suitable material. To support the cylinder parallel to the guide rod a plate 41 is brazed or otherwise secured to a side wall of the cylinder at each end thereof which plates are secured to the members 22 and 23 by screws 42. Slidably positioned in the cylinder is a piston 43 preferably of molded hard rubber, each end of which is provided with a bail 44 molded therein to which the ends of two driving tapes 45 and 46 are connected.

The tape 45 extends through a slot in the plug 40 in the left end of the cylinder, thence over an idler pulley or flanged drum 47 journaled on stub shaft 48 secured on the web 20 of the end bracket 18 and is secured at its other end through a coiled spring 49 to one end of the brush carriage 27. The tape 46 similarly extends through a slot in the plug 40 in the right end of the cylinder over an idler pulley 50 journaled on a stub shaft 51 secured on the web 20 of end bracket 19 and is secured at its other end through a coiled spring 52 to the other end of the brush carriage. The coiled springs 49 and 52 serve the dual purpose of tensioning the tapes and absorbing the shock incident to starting and stopping the brush carriage.

The piston 43 is provided as shown in Fig. 5 with a bore 53 extending axially therethrough one end of the bore being reduced in diameter at its point of emergence through the end wall of the piston to form a valve seat 54. The other end of the bore is threaded to receive a plug 55 having an opening therethrough and formed on its inner end with a valve seat 56. Freely movable within the central bore is a valve ball 57 which cooperates with the ball seats for a purpose to be later described.

Each end of the cylinder 39 is provided with a valve assembly. The valve assembly on the left end of the cylinder, as disclosed in Fig. 3, comprises a base plate 58 soldered or otherwise secured to the outer front wall of the cylinder and having an opening therein aligned with an opening in the wall of the cylinder, a plate 59 having a tubular valve chamber 60 struck up therefrom or secured thereto by solder or other suitable means, a clamping plate 61 having a hole therein through which the valve chamber 60 extends and an L-shaped heel-piece 62. The valve chamber plate 59 is clamped to the base plate 58 with the valve chamber aligned with the openings through the plate 58 and the wall of the cylinder

by screws 63 and 64, the screw 64 also serving to secure the heel-piece 62 to the base plate. When thus clamped an air-tight joint is provided between the valve chamber 60 and the end of the cylinder. Secured to the heel-piece 62 and extending parallel to the base plate 58 is a core 65, the outer end of which is seated in an opening in a side wall of the valve chamber 60. The core has an air duct 66 extending therethrough which is provided on the end communicating with the valve chamber with a valve seat 67. An electromagnet coil 68R is positioned on the core between the valve chamber 60 and the heel-piece 62, the terminals of which are connected to terminal lugs 69 insulatedly secured to the heel-piece 62 by screws 70. The screws 70 also serve to aid in securing the heel-piece 62 in position. The outer end of the valve chamber 60 is closed by a plug 71 through which an exhaust air duct 72 having a valve seat 73 on its inner end extends. Positioned within the valve chamber and cooperating with the valve seats 67 and 73, is a steel valve ball 74 which upon the energization of the magnet coil 68 is attracted from a position in which it normally rests on the valve seat 73 closing the air duct 72 into a position on the valve seat 67 for closing the air duct 66 through the magnet core. The air duct 72 is connected by flexible rubber tube 75 with a branch 76 of the supply pipe 77. The supply pipe 77 is supported by clamps 78 on the upright 3 and is connected to an air reservoir (not shown) which is connected to a suitable exhaust pump.

The valve assembly associated with the right end of the cylinder 39 is similarly constructed, the exhaust air duct 72 thereof being connected by rubber tubing 79, pipe 80, and rubber tubing 81 to a branch 82 of the supply pipe 83. The supply pipe 83 is supported by clamps 84 on the upright 7 and is connected to the air reservoir.

Associated with each switch unit adjacent to the right end of the driving motor cylinder is a magnetically controlled brake which cooperates with the driving tape 46. The brake mechanism comprises an end support 85 which is secured to the member 23 by screws 86 which extend through the support 85 and spacing sleeves 87 and engage in threaded openings in the member 23. Secured to the inner face of the support 85 is an L-shaped return pole-piece 88 through which and through the support 85 the magnet core 89 is threaded. The threaded end of the core is provided with a hexagonal nut portion by means of which the core may be turned in the threaded opening of the support 85 for adjusting the air gap between the free end of the core and the magnet armature. For clamping the core in its adjusted position, the lock-nut 90 is provided. A magnet coil 91 is supported on the free end of the core 89.

Secured to the free end of the pole-piece 88 by screws is a bracket 92 provided with ears between which the magnet armature 93 is pivoted. One end of the armature overlies the end of pole-piece 88 and the end of magnet core 89 and is provided near its pivot with a brake shoe 94 which cooperates with the brake shoe 95 attached to the member 23. The coiled spring 96, one end of which is secured to the outer end of the armature 93 and the other end of which is secured to the tensioning screw 97 is provided for normally retracting the armature 93 and for forcing the brake shoe 94 carried thereby toward the stationary brake shoe 95 to clamp the tape 46 therebetween. The position of the brake shoe 94 with respect to the pivot point of the armature, to the point of attachment of spring 96 to the armature and to the end of the armature which overlies the end of core 89 is so chosen that the motion of the brake shoe is very slight in the order of a few thousandths of an inch but that the braking effect applied thereto by the spring 96 is quite large. Since, however, the end of the armature which overlies the magnet core has considerable leverage, the magnet coil 91 when energized is quickly able to overcome the spring 96 to disengage the brake shoe 94 from the tape 46. To enable the adjustment of the tension in spring 96, the screw 97 to which the outer end of the spring is connected is caused to slide in the U-shaped extension of the supporting plate 85 by the rotation of the knurled nut 98 threaded upon the outer end of the screw.

Each switch unit is also provided with a normalling switch disclosed most clearly in Fig. 4, comprising a spring pile-up 99 insulatedly secured to the front wall of the motor cylinder 39 and an operating member 100 pivotally secured to the upper wall of the cylinder at a point opposite the mid-point between the terminal banks 11 and 12 of the switch frame. The spring pile-up comprises a middle or active spring 101 and passive springs 102 and 103 mounted on either side thereof. The springs are all provided at one end with soldering lug extensions and are clamped near that end to the front wall of the cylinder 39 by screws 104 which extend through the outer clamping plate 105 through the springs and the insulating separators 106 into threaded openings in the cylinder wall. The springs are insulated from each other and from the cylinder 39 by the insulating separators 106 and from the screws 104 by any suitable means such as fibre sleeves surrounding the screws 104.

The passive springs 102 and 103 are held in such a position as to be normally out of engagement with the middle spring 101 by tangs extending upwardly therefrom which are seated in holes in the comb bar 107 of insulating material, secured to the upper wall of the cylinder 39 by screws 108.

The operating member 100 is triangular in shape and is pivoted to the upper face of the cylinder 39 by a screw 109. The tip of the member is provided with a roller 110 of insulating material which cooperates with the cam extension 111 of the spring 101. Pivoted to the wide end of the member 100 are two fingers 112 and 113, the outer ends of which are normally engaged against stop pins 114 and 115, secured to the member 100, by the coiled spring 116 the ends of which are secured to the ends of the fingers. When the brush carriage 27 is in its normal position at the mid-point between the terminal banks as disclosed in the upper portion of Fig. 1 and also in Fig. 4, the insulated stud 117 attached to the brush carriage is engaged between the ends of fingers 112 and 113 and the member 100 is held in its neutral position.

Should the brush carriage move toward the right as viewed in Fig. 4 and engage the stud 117 with the finger 113, due to the engagement of the outer end of the finger with the stop pin 115, the movement of the brush carriage will rotate the member 100 in a clockwise direction, thereby moving the roller 110 away from the extension 111 on spring 101 thereby permitting the spring to move into engagement with spring 102 preparatory to restoring the brush carriage toward the left into its normal position following

the termination of the connection. When thereafter the brush carriage is returned toward the left, the stud 117 will engage the end of finger 113 and snap over it since the finger will at this time pivot away from its stop pin 115. The stud 117 as it continues its movement toward the left will then engage the inner edge of finger 112 and since this finger is held from pivoting by its stop pin 114, the pressure of stud 117 against the end of finger 112, will cause the member 100 to rotate around its pivot 109 in a counter-clockwise direction thereby causing the disengagement of spring 101 from spring 102 to arrest the return movement of the brush carriage.

Should the brush carriage be moved initially toward the left and engage stud 117 with the inner edge of finger 112, due to the engagement of the outer end of the finger with the stop pin 114, the member 100 will be rotated in a counter-clockwise direction, thereby moving the roller 110 into engagement with the cam section 111 of spring 101 to engage the spring with spring 103 preparatory to restoring the brush carriage towards the right into its normal position. When thereafter the brush carriage is returned toward the right, the stud 117 will engage the end of finger 112 and snap over it into engagement with the inner edge of finger 113 and since this finger is held from pivoting by its stop pin 115, the member 100 will be rotated in a clockwise direction thereby causing the disengagement of the spring 101 from spring 103 to arrest the return movement of the brush carriage.

For enabling the connection of control conductors to various elements of the switch unit connecting blocks 118 are provided individual to the switch unit which are attached by screws to the end brackets 18 and 19.

Considering now the manner in which the switch unit functions and referring particularly to the diagram of Fig. 10, it will be assumed that a line or trunk terminating in the left bank 11 on the switch frame is placed in a calling condition and that a control circuit (not shown) but of the type disclosed in the patent of W. W. Carpenter hereinbefore referred to, connects operating battery to terminal 119 of connecting block 118 and ground to terminals 120 and 121. The magnet coil 68L of the valve at the right end of the motor cylinder 39 and the brake magnet coil 91 are thereby energized, the coil 68L causing the attraction of the steel ball 74 associated therewith against the valve seat 67, as shown in Fig. 2, to close the air duct 66 extending through the core 65 and away from the valve seat 73 to open the duct 72 connected to the evacuated air reservoir. At this time the ball 74 of the valve at the left end of the motor cylinder 39, as most clearly disclosed in Fig. 3, is held by suction from the air reservoir against the valve seat 73 thereby closing the suction duct 72 and opening the duct 66 through the core 65 since the magnet coil 68R is at the time unenergized. Brake magnet coil 91 upon energizing removes the brake shoe 94 from engagement with the tape 46, thereby freeing the tape and the brush carriage 27 to which it is attached for movement.

With the suction duct at the right end of the cylinder opened and the core duct 66 closed and the core duct 66 at the left end of the cylinder open, suction is applied to the right end of the cylinder 39 and to the right end of the piston 43 therein and air under atmospheric pressure enters through the duct 66 at the left end of the cylinder into the left end of the cylinder against the left end of piston 43. In response to the difference of air pressure applied to the ends of the piston, air at first passes through the duct 53 in the piston, disclosed in Fig. 5, around the valve ball 57 but almost immediately thereafter forces the valve ball 57 into engagement with the valve seat 56 in the right end wall of the piston, whereby the air pressure then becomes fully effective to move the piston 43 toward the right and by the tape 45 attached to the left end of the piston to move the brush carriage 27 toward the left along its guide rod 24 thereby moving the brushes of the brush set over the horizontal rows of terminals of the left terminal bank 11 allocated to the switch unit.

As soon as the brush carriage leaves its normal position, the springs 101 and 103 of the normalling switch are engaged as previously described preparatory to returning the brush carriage to its normal position and when the sleeve brush 31 of the brush set engages the sleeve terminal of the calling line, a test circuit is established therefrom over terminal 122 of the connecting block 118 to the control circuit (not shown) which is effective to cause the deenergization of magnets 68L and 91. Magnet 91 upon deenergizing reapplies the brake shoe 94 to the tape 46 to arrest further movement of the brush carriage and magnet 68L upon deenergizing releases the ball 74 from the valve seat 67 of the valve at the right end of the cylinder whereupon the ball is sucked against the valve seat 73 of the suction duct 72. With the balls of both valves now closing the suction ducts 72 and opening the core ducts 66, the pressure on both sides of the piston 43 becomes equalized at atmospheric pressure and the piston has no further tendency to move within the cylinder.

If due to its speed the brush carriage has moved in its hunting movement to carry the sleeve brush 31 beyond the marked bank terminal, the control circuit will become effective as described in the patent of W. W. Carpenter to cause the brush carriage to be moved toward the right to return the sleeve brush 31 to the marked terminal. To accomplish this, the operating circuits of valve magnets 68R and brake magnet 91 are established over terminals 123 and 121 of the connecting block 118. With magnet 91 energized, the brake shoe 94 is withdrawn from the tape 46 to free the brush carriage for movement and with valve magnet 68R energized and valve magnet 68L deenergized, suction is applied to the left end of the cylinder 39 and air under atmospheric pressure is admitted to the right end of the cylinder.

Due to the difference in pressure applied to the opposite ends of the piston 43, air at first passes through the duct 53 in the piston around the valve ball 57 but the piston is, however, forced slowly towards the left and by the tape 46 connected to the right end thereof moves the brush carriage towards the right. As soon as the ball 57 becomes seated on the ball seat 54 in the left end wall of the piston, the full difference of pressure applied to the opposite ends of the piston becomes effective to accelerate the movement of the piston toward the left. The valve ball 57 is thus effective to retard the acceleration of the brush set so that it will not cause the sleeve brush 31 to overrun the marked terminal on its return movement. When the marked terminal is again encountered, the test circuit from brush 31 over terminal 122 is reestablished resulting in the

deenergization of magnets 68R and 91 to arrest the movement of the brush set.

When the established connection is no longer required, the control circuit completes the circuit of magnet 91 over terminals 119 and 121 and with the springs 101 and 103 of the normalling switch now engaged, completes the circuit of valve magnet 68R over terminals 119 and 124, whereupon the brush carriage is returned toward the right to its normal position, in which position the springs 101 and 103 disengage to open the circuit of magnet 68R. The circuit of magnet 91 is also opened at this time whereupon the return movement of the brush carriage is arrested.

If the calling line had been located in the right terminal bank 12, the control circuit would have established the circuits of brake magnet 91 and of valve magnet 68R to advance the brush set in an initial hunting movement over the right terminal bank, the brush carriage being returned toward the left in the event the sleeve brush 31 overran the marked terminal by the deenergization of magnets 68R and 91 and the subsequent energization of magnet 91 and valve magnet 68L. In this case, the initial movement of the brush carriage to the right operates the normalling switch to engage contact springs 101 and 102 preparatory to controlling the reoperation of magnets 91 and 68L for returning the brush carriage to its normal position upon the release of the connection.

To reduce the amount of current required to move the brake shoe 94 from the tape at the time the brush carriage is being advanced, the modified brake mechanism disclosed in Fig. 7 may be used in place of the mechanism shown in Fig. 2. In accordance with this modification, a support 125 of magnetic material is provided which is secured to the member 23 by screws 126 extending through the support 125 and through spacing sleeves 127 into threaded holes in member 23. This support is provided on its inner face with a pedestal 128 on the outer end of which the brake lever 129 is pivoted and with a cylindrical portion 130 serving as a diaphragm chamber and on its outer face with a cylindrical valve chamber 131 communicating with the diaphragm chamber 130. The diaphragm chamber 130 is closed by a concentrically corrugated diaphragm 132 which is held in position by a clamping ring 133 secured to the edge of the chamber 130 by screws 134. The diaphragm is connected to one end of the brake lever 129 by a link 135 which is riveted or otherwise secured to the center of the diaphragm. Secured to the lever 129 between the end connected to the diaphragm and the pivot point of the lever and near the pivot point is a brake shoe 94 which cooperates with the brake shoe 95 attached to the member 23. The coiled spring 96, one end of which is secured to the other end of lever 129 and the other end of which is secured to the tensioning screw 97, is provided for normally holding the brake lever 129 in such a position as to force the brake shoe 94 toward the shoe 95 to clamp the tape 46 therebetween. To enable the adjustment of the tension of spring 96, the screw 97 to which the outer end of the spring is connected is caused to slide in the U-shaped extension 136 of support 125 by the rotation of the knurled nut 98 threaded upon the outer end of the screw.

Secured to the outer face of the support 125 by screws 137 is an L-shaped heel-piece 138 between one arm of which and the valve chamber 131 the magnet core 139 is positioned. The core extends parallel to the face of the support 125 and is attached at one of its ends to the heel-piece and is provided at its other end with a shouldered portion which is seated in an opening in the side wall of the valve chamber 131. The core is surrounded by a magnet coil 140 and is provided with an air duct 141 extending axially therethrough. In the side wall of the valve chamber opposite the core duct 141 and aligned therewith is an opening in which is secured a branch 142 of an air duct, the second branch 72 of which is connected to the valve chamber 60 of the motor cylinder and a third branch 143 of which is connected by the rubber tubing 81 to a branch 82 of the supply pipe 83 as shown in Fig. 2. Positioned within the valve chamber 131 and supported on the end wall thereof is a steel valve ball 144 which is normally held by suction against the valve seat 145 formed on the end of the duct 142 but which is attractable to the end of the core 139 against the valve seat 146 formed in the end of the core duct when the magnet coil 140 is energized.

This brake mechanism functions in the following manner: With the magnet coil 140 deenergized the ball 144 is held by suction on the valve seat 145 thereby closing the suction duct and opening the core duct, whereby air under atmospheric pressure is applied through the core duct, valve chamber and diaphragm chamber to one face of the diaphragm 132, and since the other face of the diaphragm is exposed to the atmosphere, the diaphragm remains unflexed and the spring 96 holds the brake shoe 94 against the tape 46. When, however, the brake magnet coil 140 is energized together with one of the motor valve magnets 68R or 68L to initiate the operation of the brush carriage, magnet 140 upon energizing attracts the ball 144 to the valve seat 146 in the core duct 141 to close the core duct and to open the suction duct 142 whereby the air pressure in the diaphragm chamber is reduced below atmospheric pressure. The pressure on the outside of the diaphragm now being greater than the pressure on the inside thereof flexes the diaphragm into the chamber 130 and through the link 135 swings the brake lever 129 against the tension of spring 96 to remove the brake shoe 94 from the tape 46 whereby the tape and the brush carriage to which it is attached may be moved by the motor in either of its directions of movement dependent upon which one of the valve magnets 68R or 68L is at the time energized.

A further modification of the pneumatically operated brake mechanism is disclosed in Fig. 8 which is similar to that disclosed in Fig. 7 except that the control magnet and associated valve ball are omitted. According to this modification the suction duct 142 connected to the chamber 131 is connected by rubber tubing 147 to a duct 148 having two branches 149, one of which is shown, connected to auxiliary valves associated with the two ends of the motor cylinder 39. Each auxiliary valve comprises a flanged tubular chamber 150, the flanged portion of which is clamped by screws 152 between the clamping ring 151 and the plate 41 which supports the end of the motor cylinder 39, plug 153 which serves to close the outer end of the chamber and through which the branch 149 of the duct 148 extends and a valve ball 154. The plate 41 is provided with an opening of the same diameter as the inside diameter of the chamber 150 and a small opening 155 is

provided in the wall of the cylinder 39 for permitting the passage of air between the chamber and the cylinder. Normally the ball 154 of the valve at each end of the cylinder rests in the position shown in Fig. 8, but not closing the openings 155 through the cylinder wall.

When, for example, the valve magnet 68L is energized for the purpose of moving the brush carriage to the left and the ball 74 is moved from the valve seat 73 on the end of the suction duct 72, to close the core duct 66, suction is applied to the right side of the motor piston and through the opening 155, chamber 150, ducts 148 and 142 to the diaphragm chamber 130 of the brake mechanism whereby the diaphragm 132 becomes flexed inwardly to move the brake shoe 94 from engagement with the tape. The suction applied to the duct 148 is also effective to suck the ball 154 in the valve chamber 150 at the left end of the motor cylinder into engagement with the valve seat on the end of branch 149 of the duct 148 to prevent suction from being applied to the left end of the cylinder. With air at atmospheric pressure applied to the cylinder on the left end of the piston, the piston is therefore drawn toward the right end of the cylinder in the manner previously described.

Should the valve magnet 68R at the left end of the cylinder be energized with the magnet 68L at the right end of the cylinder deenergized, suction will be applied to the left end of the cylinder and through the valve chamber 150 at the left end of the cylinder to the duct 148 thereby causing the brake shoe 94 to be disengaged from the tape as previously described and causing the ball 154 to close the branch 149 of the duct 148 at the right end of the cylinder to prevent suction from being applied to the right end of the cylinder. The piston will in this case be forced toward the left end of the cylinder thereby moving the brush set toward the right. It will thus be apparent that whenever either valve magnet is energized the brake shoe 94 will become disengaged from the tape to enable the tape and brush set to be advanced by the pneumatic motor.

As a further modification of this invention, the brake mechanism such as disclosed in Figs. 2, 7 and 8 may be entirely eliminated by incorporating a brake in the motor piston as shown in Fig. 9. In accordance with this modification the piston comprises a body portion 156 having flanged ends, an axial duct 157 extending through the body portion and an opening 158 through the body of the piston at right angles to the duct 157 and communicating therewith. Each end of the duct 157 is enlarged in diameter and provided with a valve seat 159. The ends of the piston are closed by discs 160 secured thereto in any desired manner to which bails 44 are secured and which also serve as a means for retaining the valve balls 161 within the enlarged portions of the duct 157. Each of the discs is provided with an aperture 162 for the admission of air to the inside of the piston. Surrounding the body portion 156 and making an air tight contact with the flanged ends thereof is a sleeve 163 of thin sheet metal or other suitable flexible material which is normally flexed outwardly by the coiled spring 164 located within the opening 158 in the body of the piston.

With the piston in position in the cylinder, the spring 164 normally flexes the sleeve 163 into engagement with the inside walls of the cylinder with sufficient pressure to frictionally hold the piston against movement in the cylinder. When, however, suction is applied to either end of the piston, the ball 161 at the opposite end of the piston will be forced against its seat 159 thereby closing the opposite end of the duct 157 whereby the suction will be effective to collapse the sleeve 163 sufficiently to reduce its frictional engagement with the inner walls of the cylinder, thus freeing the piston for movement within the cylinder. With suction thus applied to one end of the piston and atmospheric pressure applied to its opposite end now closed by the valve ball 161, the piston is forced along the cylinder 39. As soon, however, as the suction is removed, the spring 164 becomes effective to again flex the sleeve 163 into frictional engagement with the inner walls of the cylinder thereby serving as a brake to arrest the movement of the piston and the movement of the brush carriage controlled thereby.

What is claimed is:

1. In a selector switch having a bank of terminals and a brush set cooperating therewith, a brush carriage upon which said brush set is mounted, a belt traversible in either of two directions for moving said brush carriage to traverse said brush set in either direction across said bank, supporting pulleys for said belt, a pneumatic motor for traversing said belt operable by air at atmospheric pressure and a reservoir of air under less than atmospheric pressure, said motor comprising a cylinder through which said belt passes, a piston within said cylinder to which said belt is secured and a magnetically controlled valve associated with each end of said cylinder for connecting either end of said cylinder with the atmosphere or with said reservoir.

2. In a selector switch having a bank of terminals and a brush set cooperating therewith, a brush carriage upon which said brush set is mounted, a pneumatic motor operable by air at atmospheric pressure for moving said brush carriage to traverse said brush set in either direction across said bank and a reservoir of air under less than atmospheric pressure, said motor comprising a cylinder, a piston within said cylinder to which said brush carriage is connected and a magnetically controlled valve associated with each end of said cylinder, each of said valves comprising a valve chamber, a first valve seat in said chamber, a duct connecting said valve seat with the atmosphere, a second valve seat in said chamber, a second duct connecting said second valve seat with said reservoir, a valve ball for cooperating with said valve seats and normally resting on said second valve seat to close said reservoir duct, and an electromagnet operative upon its energization to move said ball to said first valve seat to open said second duct and to close said first duct.

3. In a selector switch having a bank of terminals and a brush set cooperating therewith, a brush carriage upon which said brush set is mounted, a pneumatic motor operable by air at atmospheric pressure for moving said brush carriage to traverse said brush set in either direction across said bank and a reservoir of air under less than atmospheric pressure, said motor comprising a cylinder, a piston within said cylinder to which said brush set is connected and a magnetically controlled valve associated with each end of said cylinder, each of said valves comprising a valve chamber, an electromagnet having its core extending into said chamber and formed with a first valve seat in the end thereof, a first duct connecting said valve seat with the atmos-

phere, a second valve seat in said chamber, a second duct connecting said second valve seat with said reservoir, a valve ball for cooperation with said valve seats and normally resting on said second valve seat to close said reservoir duct and attractable on the energization of said electromagnet to said first valve seat to open said second duct and to close said first duct.

4. In a selector switch having a bank of terminals and a brush set cooperating therewith, a brush carriage upon which said brush set is mounted, a pneumatic motor operable by air at atmospheric pressure for moving said brush carriage to traverse said brush set in either direction over said bank and a reservoir of air under less than atmospheric pressure, said motor comprising a cylinder, a piston within said cylinder connected to said brush carriage and a magnetically controlled valve associated with each end of said cylinder for connecting either end of said cylinder with the atmosphere or with said reservoir, said piston having a duct extending therethrough and a valve in said duct operable to close said duct when the air pressure on one side of said piston is reduced whereby until said duct is closed the acceleration of said piston is delayed.

5. In a selector switch having a bank of terminals and a brush set cooperating therewith, a brush carriage upon which said brush set is mounted, a pneumatic motor operable by air at atmospheric pressure for moving said brush carriage to traverse said brush set in either direction across said bank, and a reservoir of air under less than atmospheric pressure, said motor comprising a cylinder, a piston within said cylinder to which said brush carriage is connected and a magnetically controlled valve associated with each end of said cylinder for connecting either end of said cylinder with the atmosphere or with the reservoir, said piston having a valve chamber therein provided with a valve seat on each end thereof, ducts extending from said valve seats through the end walls of said piston and a valve ball within said chamber operable into engagement with either one of said valve seats whereby when a difference of air pressure is established on opposite ends of said piston air is first permitted to leak through said system to delay the acceleration thereof until the difference in air pressure causes said ball to become seated on one of said valve seats.

6. In a selector switch having a bank of terminals and a brush set cooperating therewith, a brush carriage upon which said brush set is mounted, a belt for moving said brush carriage to traverse said brush set in either direction over said bank, supporting pulleys for said belt, a motor for driving said belt and a brake mechanism for arresting the movement of said belt comprising a brake shoe, a spring for normally engaging said brake shoe with said belt, a pneumatic device for retracting said brake shoe and a reservoir of air under less than atmospheric pressure, said pneumatic device comprising a chamber associable with said reservoir, a diaphragm closing said chamber having one of its surfaces exposed to the atmosphere and connected to said brake shoe and a valve for controlling the connection of said chamber with said reservoir whereby atmospheric pressure acting upon said diaphragm causes the retraction of said brake shoe.

7. In a selector switch having a bank of terminals and a brush set cooperating therewith, a brush carriage upon which said brush set is mounted, a belt for moving said brush carriage to traverse said brush set in either direction across said bank, supporting pulleys for said belt, a motor for driving said belt and a brake mechanism for arresting the movement of said belt comprising a brake lever, a brake shoe secured to said lever, a spring for operating said lever to normally engage said brake shoe with said belt, a reservoir of air under less than atmospheric pressure and a pneumatic device for retracting said brake shoe, said device comprising a valve chamber, a diaphragm closing said chamber having the outer surface thereof exposed to atmospheric pressure and connected to said brake lever, an electromagnet having its core extending into said chamber and formed with a first valve seat in the end thereof, a first duct connecting said valve seat with the atmosphere, a second valve seat in said chamber, a second duct connecting said second valve seat with said reservoir, a valve ball for cooperation with said valve seats and normally resting on said second valve seat to close said reservoir duct and to open said first duct whereby both surfaces of said diaphragm are subjected to atmospheric pressure and attractable to said first valve seat to open said reservoir duct and to close said first duct whereby the pressure on the surfaces of said diaphragm is unequalized to cause said diaphragm to flex and operate said lever to disengage said brake shoe from said belt.

8. In a selector switch having a bank of terminals and a brush set cooperating therewith, a brush carriage upon which said brush set is mounted, a belt for moving said brush carriage to traverse said brush set in either direction over said bank, supporting pulleys for said belt, a pneumatic motor for driving said belt operable by air at atmospheric pressure, a reservoir of air under less than atmospheric pressure, said motor comprising a cylinder, a piston within said cylinder to which said belt is secured and a magnetically controlled valve associated with each end of said cylinder for connecting either end of said cylinder with the atmosphere or with said reservoir, a brake mechanism for arresting the movement of said belt comprising a brake shoe, a spring for normally engaging said brake shoe with said belt and a pneumatic device for retracting said brake shoe, a duct connecting said pneumatic device with each end of said cylinder and pneumatically operated valves interposed between said duct and the ends of said cylinder.

9. In a selector switch having a bank of terminals and a brush set cooperating therewith, a brush carriage upon which said brush set is mounted, a pneumatic motor operable by air at atmospheric pressure for moving said brush carriage to traverse said brush set in either direction across said bank and a reservoir of air under less than atmospheric pressure, said motor comprising a cylinder, a piston within said cylinder connected to said brush carriage and a magnetically controlled valve associated with each end of said cylinder for connecting either end of said cylinder with the atmosphere or with said reservoir, said piston having a duct extending therethrough, valves in said duct operable to close said duct at the end thereof opposite to that to which suction from said reservoir is applied, a flexible sleeve surrounding said piston and a spring within said piston normally effective to expand the sleeve into frictional engagement with the inner walls of said cylinder whereby said piston serves as a brake to arrest the movement of said brush carriage, said sleeve being collapsed to remove the

braking effect thereof when suction is applied to either end of said piston.

10. In a selector switch having a bank of terminals and a brush set cooperating therewith, a brush carriage upon which said brush set is mounted, a belt for moving said brush carriage to traverse said brush set in either direction over said bank, supporting pulleys for said belt, a pneumatic motor for driving said belt operable by air at atmospheric pressure, a reservoir of air under less than atmospheric pressure, said motor comprising a cylinder, a piston within said cylinder to which said belt is secured and a magnetically controlled valve associated with each end of said cylinder for connecting either end of said cylinder with the atmosphere or with said reservoir, said piston having a duct extending therethrough, valves in said duct operable to close said duct at the end thereof opposite to that to which suction from said reservoir is applied, a flexible sleeve surrounding said piston and a spring within said piston normally effective to expand said sleeve into frictional engagement with the inner walls of said cylinder whereby said piston serves as a brake to arrest the movement of said belt, said sleeve being collapsed to remove its braking effect when suction is applied to either end of said piston.

11. In a selector switch having a bank of terminals and a brush set cooperating therewith, a brush carriage upon which said brush set is mounted, a belt for moving said brush carriage to traverse said brush set in either direction across said bank, supporting pulleys for said belt, a pneumatic motor for driving said belt operable by air at atmospheric pressure and a reservoir of air under less than atmospheric pressure, said motor comprising a cylinder having substantially closed ends through which said belt passes, a piston within said cylinder to which said belt is secured and a magnetically controlled valve associated with each end of said cylinder for connecting either end of said cylinder with the atmosphere or with said reservoir, said piston having a duct extending therethrough and a valve in said duct operable to close said duct when the air pressure on one side of said piston is reduced to delay the acceleration of said piston.

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