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(54) **Speed control switch device.**

(57) A speed control switch device includes a retractable trigger and a swingable reversing lever to control the power to, the speed of, and the direction of rotation of a motor in a hand-held electric tool, such as a drill. A single printed circuit board mounts the elements of the solid state speed control circuit and also mounts a first set of contacts, a second set of contacts, and a resistance strip which comprise integral parts of a reversing switch, an on/off switch, and a rheostat, respectively.

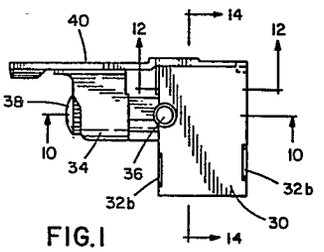

FIG.1

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# SPEED CONTROL SWITCH DEVICE

## Background of the Invention

This invention relates to speed control switches used to apply power to and control the speed of an electric motor. More specifically, the present invention relates to speed control trigger switches capable of reversing the direction of rotation as well as controlling the power and speed of an electric motor of a portable electric tool, such as an electric drill.

Trigger operated speed control devices have been known heretofore. One such device is disclosed in Robertson U.S. Patent No. 3,543,120. This device includes a pair of colinear resistance strips, each having a movable contact finger cooperating therewith to form a rheostat. The resistance strips are mounted to a circuit board containing the components of the speed control circuit.

Another type of speed control device is disclosed in Opalenik U.S. Patent No. 3,484,632, wherein a trigger slides a contact shoe and a separate brush contact along fixed contacts and a resistance strip, respectively. The brush contact and resistance strip comprise a potentiometer used in

combination with an SCR to control the speed of an associated electric motor. The contact shoe and fixed contact members comprise a switch mechanism which acts as an on/off and bypass switch.

Speed control devices having associated therewith switches for reversing the direction of rotation of an associated electric motor are also known. By reversing the flow of current in the field winding in relation to the armature winding of an electric motor, the direction of rotation may be reversed. A conventional double-pole double-throw switch can be utilized to provide such a reversing feature. In Frenzel U.S. Patent No. 3,260,827 such a conventional switch is utilized to control the direction of rotation of an electric motor.

A reversing switch which is contained within a trigger housing is disclosed in Piber U.S. Patent No. 3,632, 936. This reversing switch consists of a pair of contacts which engage a plurality of contact strips on a printed circuit board.

In Piber U.S. Patent No. 4,097,704 an on/off switch is disclosed consisting of a slidable metal contactor which engages fixed tubular contacts which are mounted to a printed circuit board carrying the electronic speed control circuitry. This patent also discloses a reversing switch which consists of a separate slidable printed circuit board having contact portions which engage a plurality of fixed contacts.

The present invention constitutes an improvement over the speed control and reversing switches of the prior art in providing a single printed circuit board mounting: all of the components of the speed control circuit including a

resistance strip engaged by a wiper contact defining a rheostat, a first set of contacts integral with the circuit board engaged by a slidable first contact means to comprise a reversing switch, and a second set of contacts integral with the circuit board cooperating with a slidable second contact means to comprise an on/off and by-pass switch. A unique slidable support carries the movable contacts of the on/off and by-pass switch, and the wiper (shorting) contact which cooperates with the resistance strip to comprise a rheostat.

Summary of the Invention

The present invention provides an improved control device suitable for controlling the power to, the speed of, and the direction of rotation of an electric motor, such as in a hand-held electric drill. A single printed circuit board has mounted thereto a first set of contacts, a second set of contacts, and a resistance strip which comprise integral parts of a reversing switch, an on/off switch, and a rheostat, respectively. The printed circuit board also carries all the components of the electronic (solid state) speed control circuit. A unique movable support carries contacts which engage the second set of contacts to comprise an on/off switch, and carries a wiper contact which slides along the resistance strip to comprise a rheostat.

A primary object of the present invention is to provide an improved speed control switch device having a single printed circuit board mounting the elements of the speed control circuit and also mounting elements of the reversing switch, the on/off switch and the rheostat for the speed control circuit.

Another object of the present invention is to provide an improved speed control device where all

external connections to a common printed circuit board are made by plug-in receptacles which include contacts integral with the circuit board.

A further object of the present invention is to provide an improved speed control device having a movable contactor support mounting contacts comprising a part of an on/off switch and a rheostat wherein these contacts are electrically connected.

Another object of the present invention is to provide a speed control switch device of increased reliability.

A more specific object of the invention is to provide a speed control switch device which utilizes printed circuit board screen printing techniques.

Another specific object of the present invention is to provide a speed control switch device having a single printed circuit and a reduced number of other parts thereby facilitating manufacture of such a switch and minimizing the cost thereof.

Another object of the present invention is to provide a speed control switch device which is economical to manufacture and may be substantially assembled using automated means.

Brief Description of the Drawings

Figure 1 is a left-side elevational view of one embodiment of a speed control switch device of the present invention;

Figure 2 is a rear elevational view of the embodiment of the present invention;

Figure 3 is a top view illustrating the two positions of the reversing lever;

Figure 4 is a right-side elevational side view of the embodiment of the present invention;

Figure 5 is a front view of the speed control switch device of the present invention;

Figure 6 is an enlarged partial rear view illustrating the reversing lever in an intermediate position;

Figure 7 is a right-side elevational view illustrating the cover removed from the main casing and turned over thereby displaying the internal components;

Figure 8 is a side view of the movable contactor support;

Figure 9 is a top view of the contactor support;

Figure 10 is a horizontal cross-sectional view taken along line 10-10 of Figure 1 illustrating the trigger mechanism fully extended;

Figure 11 is similar to Figure 10 except that the trigger mechanism is illustrated in an intermediate retracted position;

Figure 12 is a partial horizontal cross-sectional view taken about line 12-12 of Figure 1, illustrating a pair of bridging contacts positioned to provide rotation of the motor in the forward direction;

Figure 13 is similar to Figure 12 except that the bridging contacts are shown in an alternate position corresponding to reversed rotation of the electric motor;

Figure 14 is a vertical cross-sectional view taken about line 14-14 of Figure 1;

Figure 15 is a fragmentary, horizontal cross-sectional view illustrating the connection of a wire to the printed circuit board;

Figure 16 illustrates the component side of the printed circuit board with connections to the electric motor and power source shown schematically;

Figure 17 is a schematic diagram of the electrical circuitry of one embodiment of the present invention;

Figure 18 is an exploded, isometric view of the embodiment of the present invention; and

Figure 19 is an exploded, isometric view showing the printed circuit board removed from the casing cover.

Description of the Preferred Embodiment

Referring particularly to Figures 1-6 and 18, the embodiment of the present invention shown for purposes of illustration includes a casing 30 and a casing 32. Casing 30 has bosses 31 received in holes 32a in resilient side flanges 32b of casing cover 32 permitting the casing and cover to snap-lock together. Casing 30, cover 32, and a trigger 34 are preferably constructed of a material which does not conduct electricity, i.e. an insulating material, such as plastic. Openings 33 in cover 32 allow connection of the present device to an associated electric motor and power source by wires inserted therethrough as will be explained below.

Trigger 34 contains a knurled knob 38 which varies the permissible stroke of the trigger allowing repetitive operation at a predetermined speed. Push button 36 provides a means for locking the trigger mechanism while in a retracted position. A spring 39 constantly urges the trigger mechanism forward to the off position, i.e. to the position where no power is applied to an associated electric motor (not shown). Although the present invention is illustrated with a trigger mechanism capable of having an adjustable stroke, this particular type of trigger mechanism is not a necessary part of the present invention. Complete details of such a mechanism are disclosed in

Frenzel U.S. Patent Re. 26,781, entitled "Trigger Actuated Switch Device", which is assigned to the assignee of the present invention.

A manually operated member such as lever 40 enables the user to reverse the direction of the electric motor by moving the lever from the position illustrated in solid lines to the phantom position, as shown in Figure 3. An opening 42 in lever 40 receives a cylindrical pin 43 extending from casing 30; this pin acts as a pivot point for the reversing lever. As best seen in Figures 2, 6 and 18, the rear portion of lever 40 contains a protrusion 44 which is normally seated in casing recess 46 or recess 48, depending upon the position of the lever. This protrusion and the recesses function as a detent for lever 40. In Figure 6, lever 40 is shown in an intermediate position as the lever is being moved between its forward and reverse positions; it is noted that protrusion 44 rides upon surface 47 between recesses 46 and 48 until lever 40 reaches its final left of right position.

A pin 52 mounted on block 60 (Figure 18) is disposed within U-shaped recess 50 in lever 40. Block 60 is restricted to back and forth movement within compartment 30a. Since pin 52 is free to move within U-shaped recess 50, the arcuate movement of lever 40 is translated into back and forth motion of block 60. The position of block 60 determines the direction of rotation of the electric motor as will be explained below.

Specifically referring to Figures 3 and 18, lever 40 contains pin 54 which functions as a stop to prevent reversal of the direction of rotation of the electric motor while the motor is in operation. The front portion of trigger 34 contains a longitudinal

recess or opening 56 which is divided into halves by center ridge partition 58. Pin 54 is received within either half of recess 56 as the trigger mechanism is retracted during operaton of the motor. However, ridge partition 58 will prevent lever 40 from being moved while the trigger is retracted because of interference between pin 54 and ridge partition 58. With trigger fully extended (off position), ridge 58 stops short of pin 54 allowing the position of lever 40 to be changed thereby changing the direction of rotation of the electric motor.

Now referring in particular to Figure 18, casing 30 is comprised of three compartments: the upper compartment 30a, already mentioned, a middle compartment 30b and a lower compartment 30c. Block 60 is disposed within upper compartment 30a for sliding movement about an axis parallel to the axis of movement of trigger 34. Bridging contacts 62 and 64 are carried by recesses 70 and 72 of block 60 and are spring-loaded by springs 66 and 68, respectively, so as to be constantly urged outwardly of the block.

Compartment 30b slidably receives the rear portion of trigger 34 allowing the trigger to be reciprocated therein. Two opposing ridges 30d (only one is seen in Figure 18) of compartment 30b serve as guides for the trigger. Spring 39 constantly urges the trigger forward from the rear wall 30e of compartment 30b.

A contactor support 74 is carried by the rear portion of trigger 34. A resilient means, i.e. spring 76, having one end disposed within opening 78 of the trigger and the other end receiving a pin 80 of contactor support 74, serves constantly to urge the contactor support away from wall 34a of the trigger. Flange 82 of contactor support 74 is received

within a generally rectangular recess 84 of the trigger. Contactor support 74 contains a forward contact 74a, and rearward contacts 74b and 74c. Contacts 74a and 74b cooperate with certain elements of a printed circuit board 84 to comprise on/off switch 105 shown schematically in Figure 17. A wiper contact means such as contact 74c cooperates with a resistance strip 106 carried by printed circuit board 84 to comprise a rheostat 107, also shown schematically in Figure 17. Further details of operation concerning contacts of contactor support 74 are provided below.

Face 86 of circuit board 84 (Figure 18) is blank, that is, it carries no components. The opposite face 88 of the circuit board carries the electronic components constituting the speed control circuit, which components are received in compartment 30c. Face 88 abuts edges of casing 30 so as to substantially enclose compartments 30a-30c. The circuit board is captivated between casing 30 and cover 32, as indicated in Figures 18 and 19. Circuit board 84 fits within cover 32, as indicated in Figures 18 and 19. Circuit board 84 fits within cover 32 so that face 86 is in substantial co-extensive engagement with face 32c of this casing section.

Now referring to Figure 7, the cover 32 containing circuit board 84 is shown rotated 180° for purposes of illustration. Bridging contacts 62, 64 and contacts 74a-74c are disposed within compartments 30a and 30b respectively for engagement with printed circuit board elements. Bridging contacts 62 and 64 cooperate with contacts 90, 92, 94, 96 and 98 of the printed circuit board 84 to comprise reversing switch 99 shown schematically in Figure 17. With respect to

contactor support 74, contact 74b cooperates with contact strip 100 and contact 74a cooperates with contact strips 102 and 104 to comprise on/off switch 105. Contact 74c cooperates with resistance strip 106 to comprise rheostat 107.

The contactor support 74, illustrated in detail in Figures 8 and 9, is made from an electrical conducting material. Pin 80 and contacts 74a-74c may be either stamped from support 74 or may be attached to the support by conventional means. Contacts 74a, 74b and 74c all extend from the same generally planar face of contactor support 74 and have generally convex ends to facilitate sliding engagement with their respective elements on printed circuit board 84. Contacts 74a, 74b and 74c are all electrically connected by support 74 whereby each of these contacts is electrically common with each of the other contacts. Therefore, the same potential will appear at each of these contacts.

Figure 16 illustrates face 88 of printed circuit board 84 with the electronic components comprising the electric speed control circuit mounted thereto. Printed circuit board 84 comprises a substrate made of a suitable insulating material upon which conductive "ink" is deposited, preferably using a screen printing technique well known in the art. The conductive ink preferably consists of a silver bearing paste which, after screen printed on to the substrate, is heated in an oven causing the ink to harden forming electrical conductors indicated by the crosshatched portion in Figure 16. Such conductors are used to interconnect electronic speed circuit components and are used as contacts 90, 92, 94, 96 and 98 which comprise part of reversing switch 99.

Thus, contacts 90-98 and the printed circuit board conductors can be formed in a single step. Contact strips 100, 102 and 104 are preferably formed of copper strips attached to the substrate of the printed circuit board by conventional means. Copper strips, or other suitable conductive material, are employed for these strips because they will be subjected to greater mechanical and electrical wear than "ink" contacts 90-98.

External connections made with printed circuit board 84 are shown in Figure 16 in schematic form. An electric motor (not shown) has its armature winding 108 and field winding 110 each connected by a pair of wires to conductors on printed circuit board 84 as shown. Similarly, commercially available 110 VAC line power is shown connected by a pair of wires to the printed circuit board conductors at points as illustrated. Electronic circuit components 118-120, and 124 are described below with respect to their schematic representations in Figure 17.

Figure 17 is a schematic representation of the components constituting the speed control switch device of the present invention including reversing switch 99, trigger activated on/off switch 105, rheostat 107, and electronic components utilized in a conventional speed control circuit. An electric motor (not shown) has armature winding 108 and a field winding 110. One side of the armature winding 108 is connected to one side of the 120 VAC line by wires 114 and 115. The other side of armature winding 108 is connected by wire 113 to a printed circuit board conductor having portions thereof which serve as contacts 90 and 98. The field winding 110 of electric motor is connected by wire 111 to printed

circuit board conductor 97 of which contact 96 is a part. The other side of the field widing is connected by wire 112 to a conductor of which contact 92 is a part. Bridging contacts 62 and 64 are shown schematically in Figure 17 as contacts 62' and 64' respectively. (Numerals having primes in Figure 17 denote schematic representations of components designated by corresponding numerals shown in other figures.)

For purposes of explaining the operation of reversing switch 99, assume that current is flowing from the 120 VAC line into wire 115 and returning by wire 116. Further, for purposes of explanation, assume that contact strips 100 and 104 are connected as is the case for full power (bypass) operation. As shown in Figure 17, reversing switch 99 connects contacts 90 and 92 by bridging contact 64' and connects contacts 94 and 96 by bridging contact 62'. Accordingly, current will flow through the following path: wire 115, wire 114, armature winding 108, wire 113, contact 90, bridging contact 64', contact 92, wire 112, field winding 110, wire 111, contact 96, bridging contact 62', contact 94, strip contact 100, strip contact 104 and finally returning by wire 116. From this description of the path of current flow, it is obvious that current flows through field winding 100 from left to right. The block 60 carrying bridging contacts 62 and 64 is shown schematically by a dotted line 60' connecting contacts 62' and 64'.

When lever 40 of reversing switch 99 is moved to its alternate position, bridging contacts 62' and 64' will each move, from left to right, a distance corresponding to the distance separating contact 90 from contact 92. Thus, bridging contact

64' will connect contacts 92, 94 and bridging contact 62' with connect contacts 96, 98. With the reversing switch 99 in the alternate position, the current flow path will be as follows: wire 115, wire 114, armature winding 108, wire 113, contact 98, bridging contact 62', contact 96, wire 111, field winding 110, wire 112, contact 92, bridging contact 64', contact 94, strip contacts 100 and 104 and finally returning through wire 116. Current flows through armature winding 108 in the same direction as previously but flows through the field winding 110 in the opposite direction. This change in polarity of current flowing through the field winding 110 will cause the electric motor to rotate in the opposite direction.

As shown in Figure 17, the on/off switch 105 comprises contactor support 74' having contacts 74a' and 74b', and contact strips 100, 102 and 104. The specific on/off switch disclosed herein has three different electrical conditions: OFF, ON, and BYPASS. In the OFF condition, an open circuit in series with the electric motor prevents any current flow; this occurs with the trigger fully extended as urged by spring 39. In the ON condition, the circuit to the motor is closed and the current flows through the motor as regulated by the electronic speed control circuit. This ON condition is brought about when the trigger is located intermediate its fully extended and fully retracted positions with the speed of the motor increasing with increasing trigger retraction. In the BYPASS condition, the electronic speed control circuit is bypassed or shorted thus placing 120 VAC power directly across the electric motor producing maximum motor speed. The BYPASS condition corresponds with the trigger in its fully retracted position. Of course, the BYPASS feature could be omitted if not desired.

Referring to Figure 17, in the OFF position of the trigger, only contact 74a' of the contacts carried by contactor support 74' makes contact with its respective engagement member, contact strip 102. In the ON position, contact 74b' makes contact with strip contact 100, contact 74a' maintains contact with strip contact 102, and contact 74c' makes contact with resistance strip 106 depicted as resistor 106'. In this condition, contactor support 74' and its associated contacts provide electrical continuity between strip contacts 100 and 102 with resistor 106'. Current flowing at this time must flow through the armature and field windings of the electric motor to contactor strips 100 and 102 and return through the electronic speed control circuit to strip contactor 104 and wire 116.

The specific electronic speed control circuit shown in Figure 17 consists of a solid state switching device, such as SCR 118, a potentiometer 107 comprised of resistor 106' and shorting contact 74c', a fixed resistance 120', a trim resistor 122' and a capacitor 124'. While switch 105 is in the ON position, the flow of current, and hence power to the motor, is controlled by SCR 118. The voltage at the gate 119' of the SCR controls the SCR and is determined by the equivalent RC time constant determined by capacitor 124' and the equivalent resistance of resistors 120', 122' and potentiometer 107 of which resistor 106' is a part. Resistance strip 106 (see Figure 16) has a value of resistance which is proportional to the effective length of the resistance strip. As trigger 34' is retracted, shorting contact 74c', which connects resistor 106' with contact strips 100 and 102, slides along 106' reducing the effective length, and hence resistance, of resistance strip 106.

Retracting the trigger 34' reduces the RC time constant causing SCR 118 to conduct earlier during the AC voltage cycle thereby allowing a larger average current to flow through armature winding 108 and field winding 110 of the electric motor, increasing the motor speed. Further retracting of trigger 34' causes the motor speed to continually increase until contact 74a' makes initial contact with contact strip 104. At this time, contact 74b' is still in contact with contact strip 100, thereby effectively bypasing the speed control circuit. In this condition, full line voltage from the 120 VAC power source is placed directly across the electric motor allowing the electric motor to reach its maximum speed. Further electronic circuitry details are disclosed in Gawron U.S. Paatent No. 3,209,228 which is assigned to the assignee of the present invention.

Upon a gradual release of trigger 34', contact 74a' slides from contact strip 104 to stop 102. When contact 74a' ceases making contact with contract strip 104, the electric motor will once again be subject to the control of SCR 118, which is in turn controlled by the position of contact 74c' in relation to resistor 106'. As trigger 34' reaches its fully extended (OFF) position, contactor support 74' pivots so as to remove contact 74b' and 74c' from engagement with contact strip 100 and resistor 106', respectively. The physical aspects of reversing switch 99, on/off switch 105, and rheostat 107 are explained below.

Now referring to Figure 10, on/off switch 105 is illustrated in the OFF position; this condition occurs when the trigger 34 is fully outwardly extended. This position of the trigger is maintained by force exerted by spring 39 acting against the rear wall 30e of casing 30 which has a protrusion around

which one end of spring 39 is seated. Front surface 34b and rearward surface 34c of trigger 34 define the forward and rearward extent respectively of recess 84 in which is disposed flange 82 of contactor support 74. The rearward face of flange 82 abuts surface 34c while simultaneously a portion of the forward face of flange 82 abuts inside wall 32c of cover 32. A force due to compressed spring 39 is exerted against the rearward face of flange 82 causing the contact carrying portion of contactor support 74 to pivot about contact 74a as the forward face of flange 82 contacts inside wall 32c. The force exerted by spring 39 overcomes the force exerted by spring 76 which urges the contact carrying portion of the contactor support 74 towards printed circuit board 84. (Contact strips 100, 102 and 104 are shown in Figure 10 as having an exaggerated thickness for purposes of illustration.) Contact 74a is illustrated as making contact with contact strip 102 while contact 74b is pivoted away from engagement with contact strip 100. Contact 74b and contact 74c quickly engage and disengage their respective elements on printed circuit board 84 due to the pivoting action of contactor support 74 about contact 74a; this feature minimizes arcing during initiation and termination of power to the motor.

Now referring to Figure 11, trigger 34 is shown in an intermediate retracted (ON) position as indicated by the arrow. The force exerted upon contactor support 74 by spring 76 maintains contact 74a and contact 74b in firm engagement with contact strips 102 and 100, respectively. Although not seen in Figure 11, contact 74c is simultaneously engaging resistance strip 106. The distance between forward surface 34b and rearward surface 34c of recess 84 is sufficient to accommodate the angularly disposed

flange 82 allowing the contact carrying portion of contactor support 74 to remain in parallel relationship with printed circuit board 84. As trigger 34 is moved rearwardly, as indicated by the arrow, contactor support 74 is urged rearwardly due to force exerted upon the front face of flange 82 by the abutting forward surface 34b. The contacts carried by contactor support 74 slide along their respective elements. Since contact 74a is engaging contact strip 102, as illustrated in Figure 11, the speed of the electric motor will be controlled by the speed control circuit.

As trigger mechanism 34 is continued to be retracted, contact 74a will engage contact strip 104. The engagement of contact 74a with contact strip 104 will occur just prior to or simultaneously with the maximum permitted travel of the trigger. While contact 74a engages contact strip 104, the electronic speed control circuit is bypassed and full AC voltage is applied to the electric motor.

Figures 12 and 13 best illustrate the bridging action of reversing switch 99. Now referring specifically to Figure 12, bridging contacts 62 and 64 carried by block 60 are shown urged against printed circuit board 84 by springs 66 and 68 respectively. The corners of bridging contacts 62 and 64 adjacent printed circuit board 84 are rounded to facilitate sliding of the bridging contacts along the mating fixed contacts of circuit board 84. Bridging contact 62 electrically connects contacts 94 and 96 while simultaneously bridging contact 64 connects contacts 90 and 92. This corresponds with the electrical connections indicated schematically in Figure 17. Block 60 abuts partition wall 138 of casing 30.

Figure 13 shows the reversing switch 99 in

its alternate position. In this alternate position, bridging contact 62 connects contacts 96 and 98 while bridging contact 64 connects contacts 92 and 94. The purpose of the alternate interconnection is to reverse the flow of current through field winding 100 of the electric motor thereby changing the direction of rotation. Block 60 now abuts partition wall 136 of casing 30.

The cross-sectional view in Figure 14 discloses contacts 74a, 74b and 74c of contactor support 74 engaging contact strips 102, 100, and resistance strip 106 respectively. (The thickness of contact strips 100 and 102 are shown exaggerated to illustrate that these strips are thicker than resistance strip 106.) Contact 74c protrudes further from support 74 than the other contacts in order to compensate for the difference in thickness between resistance strip 106 and contact strips 100 and 102. Accordingly, the contact carrying portion of contactor 74 remains in parallel relationship with printed circuit board 84 in the ON and BYPASS positions of the trigger.

The retention means utilized for connecting external wiring to the printed circuit board 84 is illustrated in Figures 12, 13 and 15; it will be understood that the construction shown in these two figures is typical for all six lead-wire connections to the trigger speed control switch of the present invention. Referring momentarily to Figure 16, it is seen that six insulated external wires 111-116 are connected with printed circuit board 84 in order to make connections with field winding 110, armature winding 108, and the 110 VAC power line.

Returning to Figures 12, 13 and 15, an internal casing wall member, generally designated 132,

has first and second portions 133 and 134 respectively joining the rear wall 30e and a partitional wall 136. The wall portion 133 cooperates with the rear wall 30e to form a V-shaped formation or pocket 135. A resilient strip 130 is held at one of its ends in the pocket 135 by frictional engagement; the other end of this trip is held in yieldable engagement with contact elements on printed circuit board 84. Each strip 130 is disposed behind an associated opening 33 in the casing.

A length of the insulating cover is removed from the ends of each of the six lead wires exposing inner metal conductors which are preferably tinned. The ends of these wires are inserted through their respective openings 33 in cover 32 which are adjacent points on printed circuit board conductors indicated in Figure 16. In the specific example of one of the six connections, as shown in Figure 15, end 111a of wire 111 is inserted into opening 33. The end of strip 130 adjacent circuit board 84 is flexed or bent inwardly by end 111a allowing the same to slide between conductor 97 and the end of the strip. Strip 130 is sufficiently resilient so as to maintain substantial pressure against wire end 111a, thereby ensuring good electrical contact. Strip 130 also has sufficient stiffness to prevent wire 111 from being removed from opening 33 unless an extraordinary pulling force is applied to the wire. It will be noted that inner partition 136 functions as a stop to prevent end 111a from being inserted beyond that partition.

It is noted that the mass of the contactor support 74 is rather substantial compared to the aggregate masses of the contacts 74a, 74b and 74c. The mass of the contactor support cooperates with the

spring constant of the spring 76 to minimize the possibility of contact bounce between the contact 74a, 74b and 74c and the associated contact strips on the printed circuit board. This feature is particularly important when the speed control device of the present invention is incorporated within a tool of the impact type, as such a tool is subjected to rather severe vibration. The contactor support also serves as a heat sink thereby conducting heat away from its associated contacts.

From the foregoing, it will be apparent that this invention provides a speed control switch device having a reversing switch, on/off switch, and a speed control rheostat integrally fabricated as a part of a single printed circuit board which also mounts the speed control circuit elements. A unique slidable support carries a plurality of contacts, each electrically common with each other, which comprise movable contacts of the on/off switch and a wiper contact which cooperates with a resistance strip to comprise a rheostat. The device of the present invention requires a minimal number of component parts making the device economical to manufacture and enhancing reliability.

While it will be apparent to those skilled in the art that the preferred embodiment of the present invention heretofore described and illustrated may be modified and changed in various ways, it is to be understood that the invention is not intended to be confined to the particular embodiment disclosed herein but is limited in scope only by the appended claims.

Claims:

1. In a speed control switch device for a power tool of the type including a housing enclosing a reversible electric motor, the switch device including a casing enclosing the components of a solid state speed control circuit and mounting a trigger for actuating an on/off switch and for controlling such circuit in response to the amount of trigger movement thereby to vary the speed of the associated motor, the casing also containing a reversing switch and mounting a manually operated member movable between two positions to control the direction of rotation of the associated electrical motor, the improvement comprising:

(a) a printed circuit board in the casing and mounting,

(i) the components of said speed control circuit including a resistance strip,

(ii) a first set of contacts, and

(iii) a second set of contacts;

(b) first contact means mounted within said casing adjacent said first set of contacts for movement back and forth for alternately bridging certain ones of the contacts of said first set of contacts so as to establish forward and reverse circuit paths, said manually operated member being connected with said first contact means for moving the same between two positions corresponding with said two positions of said member, said first set of contacts along with said first contact means defining said reversing switch;

(c) wiper contact means within said casing and connected to said trigger for movement therewith, the wiper contact means sliding along said resistance strip during movement of the trigger thereby defining a rheostat for controlling said solid state circuit; and

(d) second contact means in said casing and connected to said trigger for movement therewith, which second contact means engage said second set of contacts during movement of the trigger thereby defining said on/off switch.

2. The improvement according to Claim 1 wherein said first contact means comprise a pair of reversing contacts carried by a block of non-conductive material.

3. The improvement according to Claim 1 wherein all components comprising said speed control circuit are in engagement with said printed circuit board.

4. The improvement according to Claim 1 wherein said resistance strip and the first set of contacts are printed on the printed circuit board.

5. The improvement according to Claim 1 wherein said resistance strip, the first set of contacts and the second set of contacts are all integrally mounted on the same face of the printed circuit board.

6. The improvement according to Claim 1 wherein said wiper contact means and said second contact means are mounted on a common movable contactor support.

7. The improvement according to Claim 6 wherein said contactor support is electrically conductive thereby establishing continuity between said wiper contact means and said second contact means.

8. The improvement according to Claim 1 wherein the casing has at least two compartments defined therein including a first compartment containing said first contact means aligned so as to engage said first set of contacts, and a second compartment having the wiper contact means and the second contact

means disposed therein for engagement with the resistance strip and the second set of contacts, respectively.

9. The improvement according to Claim 1 or Claim 8 wherein said casing is comprised of two sections which snap together to captivate the printed circuit board therebetween.

10. The improvement according to Claim 6 wherein said contactor support includes a flange by which the reciprocal movement of the trigger is transmitted to the contactor support.

11. The improvement according to Claim 6 wherein the contactor support is pivotally carried by the trigger and wherein a portion of said contactor support is pivoted away from the printed circuit board when the trigger is in its fully extended position.

12. The improvement according to Claim 11 wherein said portion of the contactor support which pivots away from the printed circuit board carries at least one contact of said second contact means thereby disengaging same from the second set of contacts.

13. The improvement according to Claim 11 or Claim 12 wherein said portion of the contactor support which pivots away from the printed circuit board carries said wiper contact means thereby disengaging the shorting contact from the resistance strip.

14. The improvement according to Claim 1 further including a detent means for maintaining said manually operated member in one of two positions.

15. The improvement according to Claim 8 wherein said second compartment further comprises a means for guidig the trigger during reciprocal movement within said second compartment.

16. The improvement according to Claim 8 wherein said casing is comprised of three compartments including a third compartment which receives said electronic circuit mounted to the printed circuit board.

17. In a speed control switch device for a power tool including an electric motor, electronic circuit means for controlling the speed of the motor, and a spring-loaded trigger for reciprocal movement, wherein said switch device includes a resistance strip and a wiper contact for engagement with said resistance strip for sliding movement therealong defining a rheostat, and on/off means in series with the electric motor for applying power to the motor during retraction of the trigger and for removing power to the motor with the trigger fully extended, said on/off means having at least one sliding contact for engagement with at least one fixed contact, the improvement comprising:

(a) an integral support mounting said wiper contact and said sliding contact, said support providing electrical continuity between said wiper contact and said sliding contact, and

(b) means responsive to movement of the trigger for sliding said support so that said sliding contact engages said fixed contact during retraction of the trigger.

18. The improvement according to Claim 17 wherein said support is made of metal.

19. The improvement according to Claim 18 wherein said wiper contact and said sliding contact comprise bosses formed on the metal support.

20. The improvement according to Claim 17 further comprising a means for pivoting said support so that said sliding contact does not engage said fixed contact while the trigger is fully extended.

21. In a speed control switch device for a power tool of the type including a housing enclosing a reversible electric motor, the switch device including a casing enclosing the components of a solid state speed control circuit and mounting a trigger for actuating an on/off switch and for controlling such circuit in response to the amount of trigger movement thereby to vary the speed of the associated motor, the casing also containing a reversing switch and mounting a manually operated member movable between two positions to control the direction of rotation of the associated electrical motor, the improvement comprising:

(a) a unitary printed circuit board within said casing;

(b) a first and second contact means connected with said manually operated member and said trigger, respectively, for independent movement thereby, said first and second contact means engaging said circuit board and cooperating with the latter to define the speed control circuit, the on/off switch and the reversing switch; and

(c) contact elements on said circuit board and arranged to be engaged by conductors to establish electrical communication externally of the casing with the associated electric motor and a source of line current.

22. The improvement according to Claim 21 wherein said casing includes an aperture adjacent each of said contact elements for receiving an external conductor and allowing the same to make electrical contact with the associated contact element.

23. The improvement according to Claim 22 wherein said casing includes a retention means adjacent each of said contact elements, such retention means and such contact elements cooperating to define plug-in receptacles for said conductors.

24. In a speed control switch device for a power tool of the type including a housing enclosing a reversible electric motor, the switch device including a casing enclosing the components of a solid state speed control circuit and mounting a trigger for actuating an on/off switch and for controlling such circuit in response to the amount of trigger movement thereby to vary the speed of the associated motor, the improvement comprising:

(a) a contactor support member in said casing and connected to said trigger for movement thereby;

(b) said contactor support mounting at least first and second contact elements associated respectively with said on/off switch and said speed control circuit, the mass of said contactor support being substantially in excess of the aggregate masses of said first and second contact elements;

(c) third and fourth fixed contacts mounted in said casing for respective engagement with said first and second contact elements, said third and fourth fixed contacts being associated with said on/off switch and said speed control circuit, respectively; and

(d) resilient means in the casing engaged with said contactor support for urging said first and second contact elements into respective engagement with said third and fourth fixed contacts, the mass of said contactor support cooperating with said resilient means to minimize bounce of said first and second contact elements.

25. The improvement according to Claim 24 wherein said first and second contact elements are integral with said contactor support.

26. The improvement according to Claim 24 wherein said resilient means is defined by a spring.

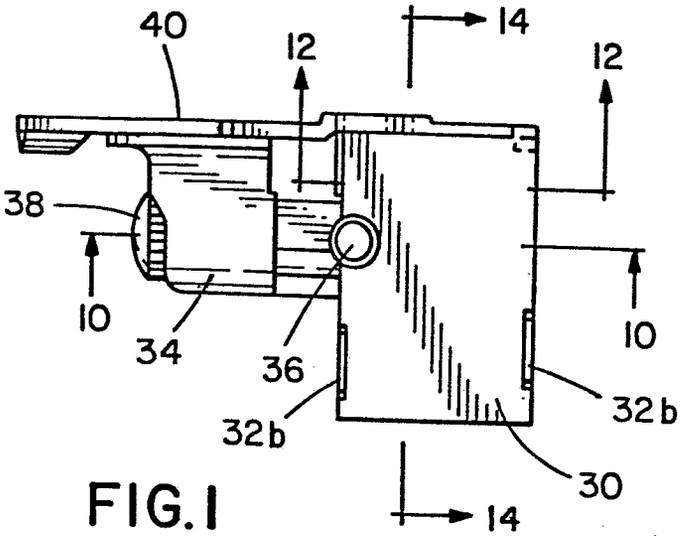



FIG.1

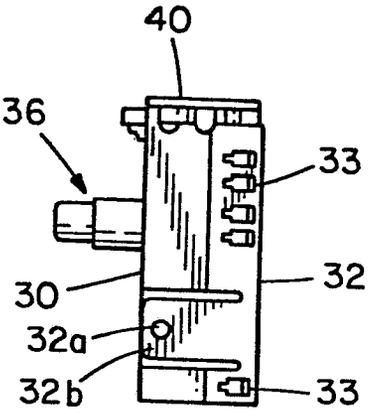



FIG.2

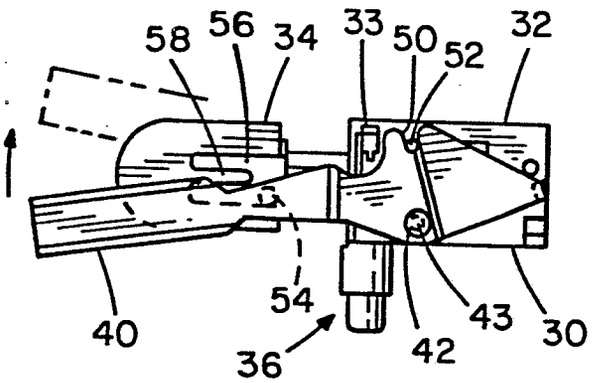



FIG.3

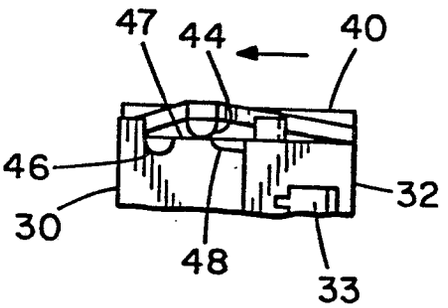



FIG.6

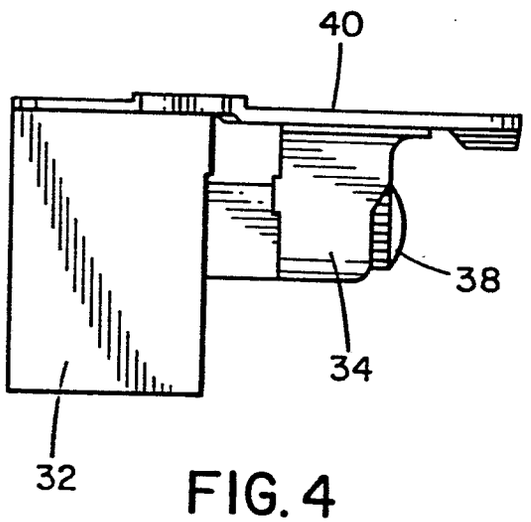



FIG.4

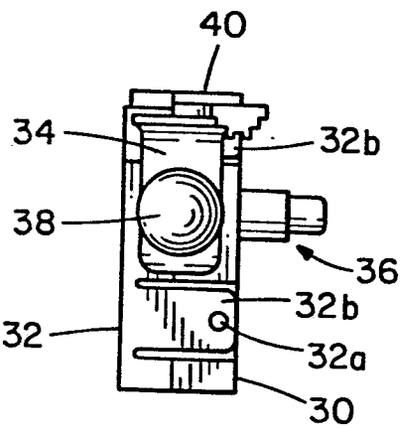



FIG.5

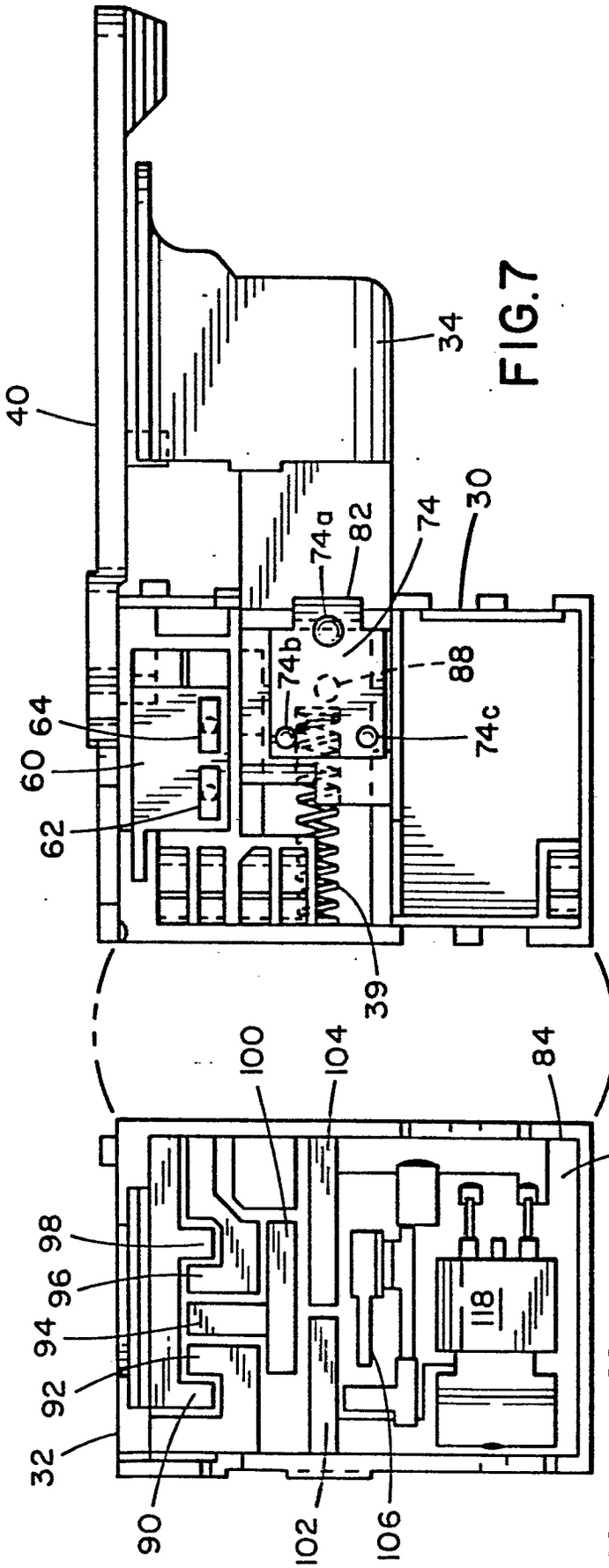



FIG.7

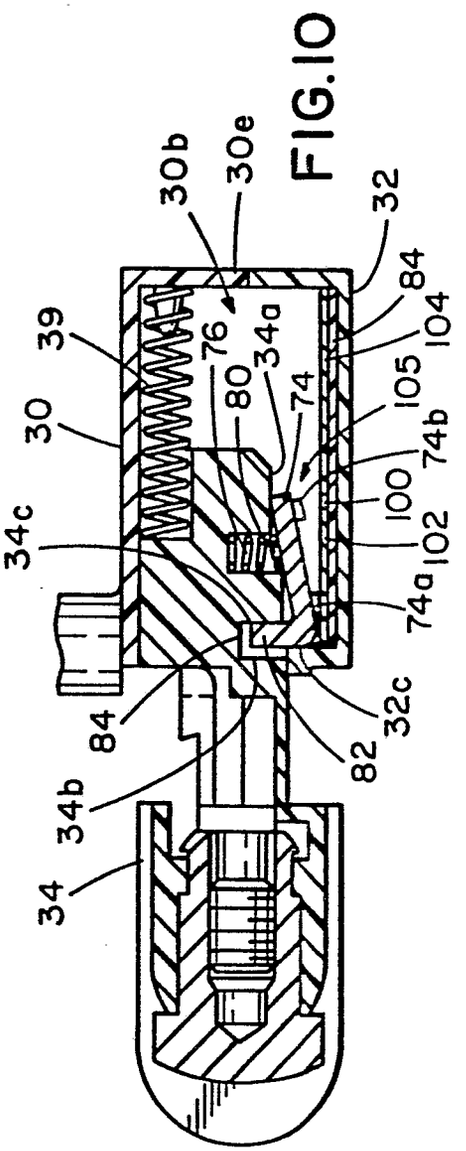



FIG.10

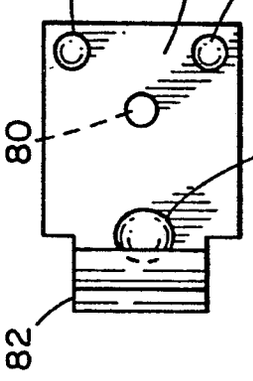



FIG.8

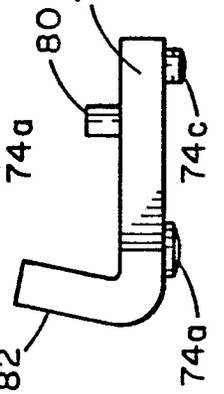



FIG.9

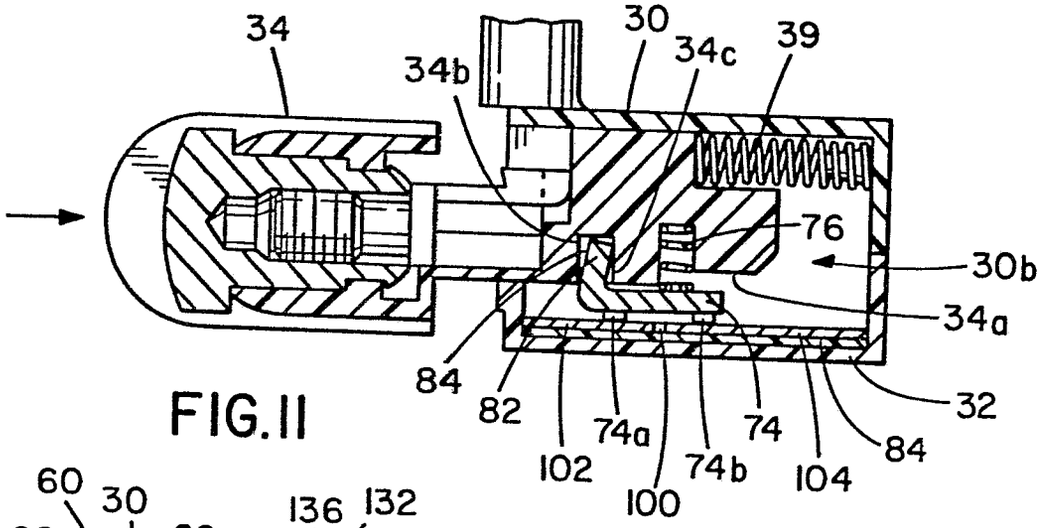



FIG.11

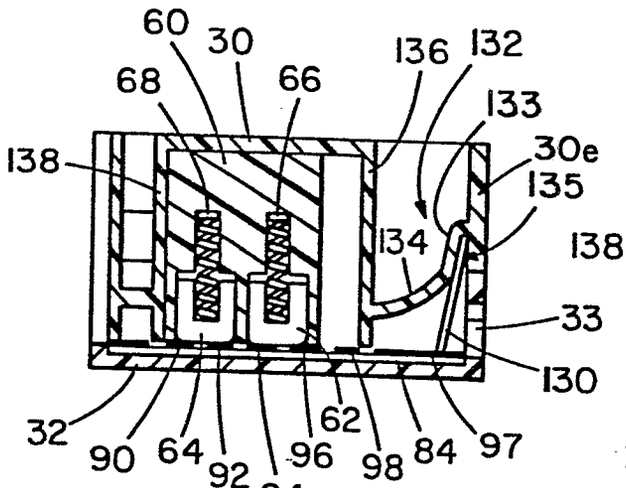



FIG.12

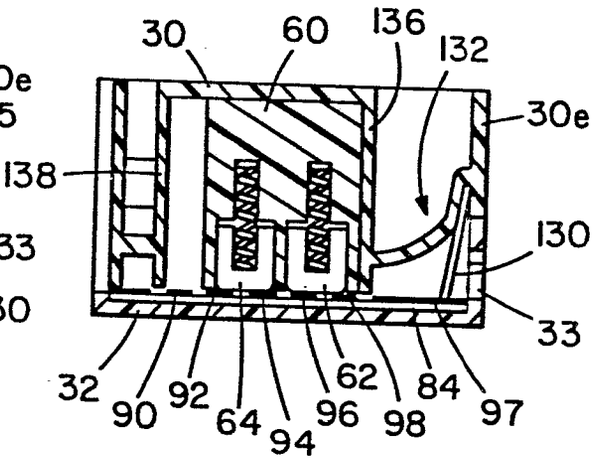



FIG.13

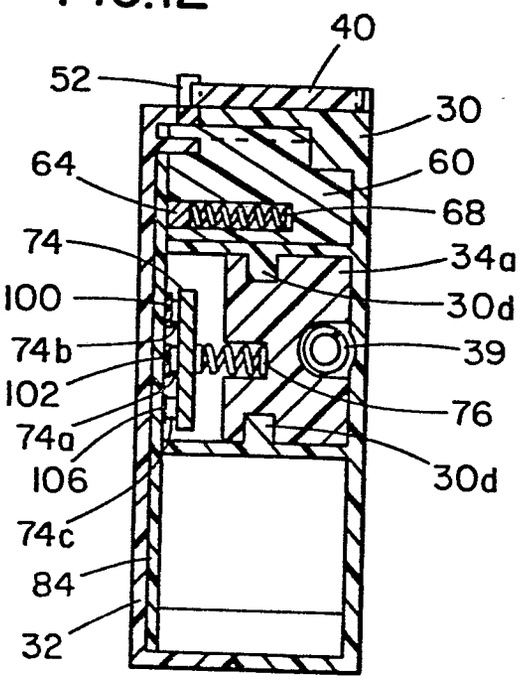



FIG.14

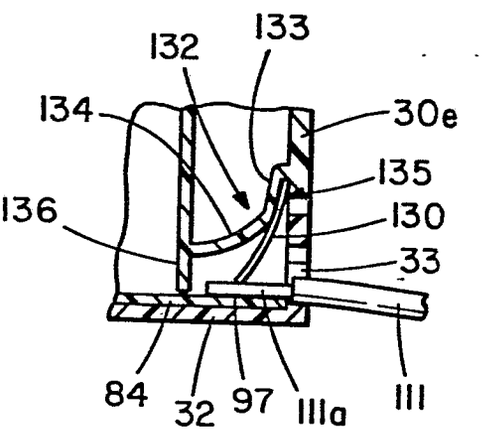
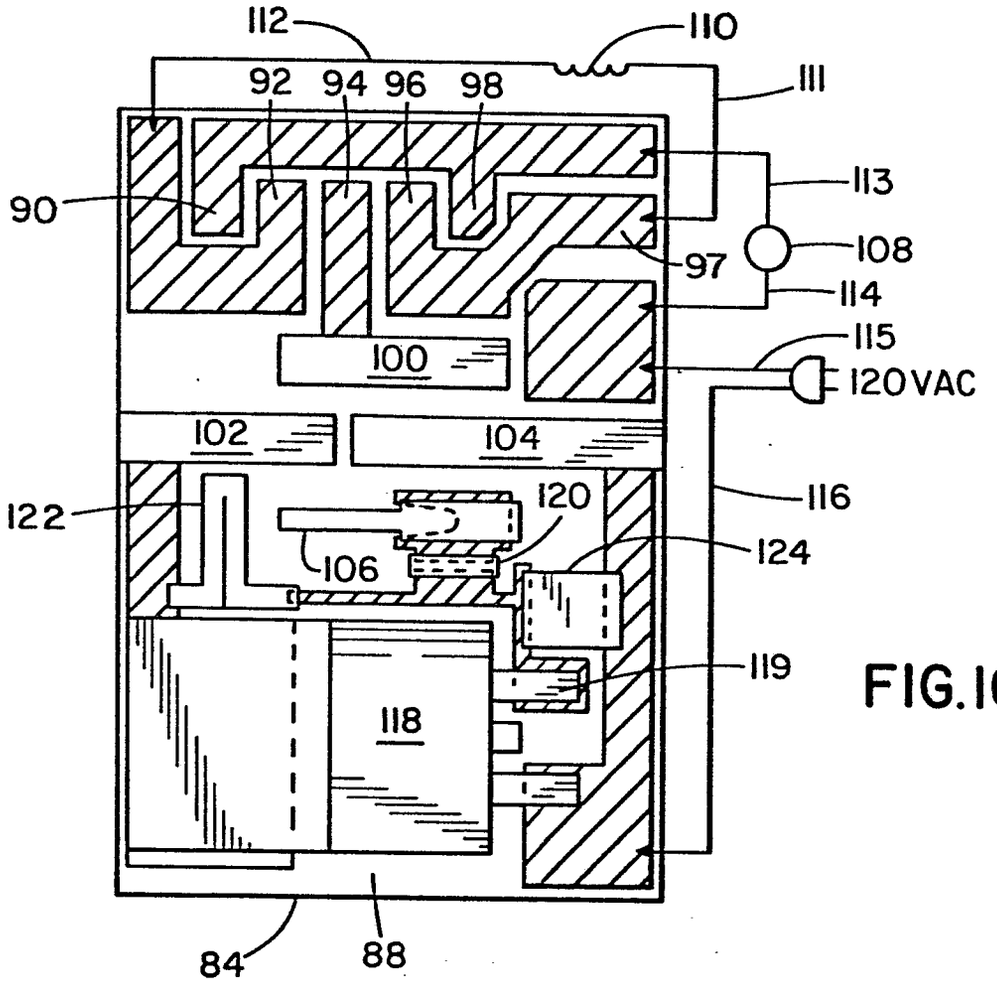



FIG.15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98
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116
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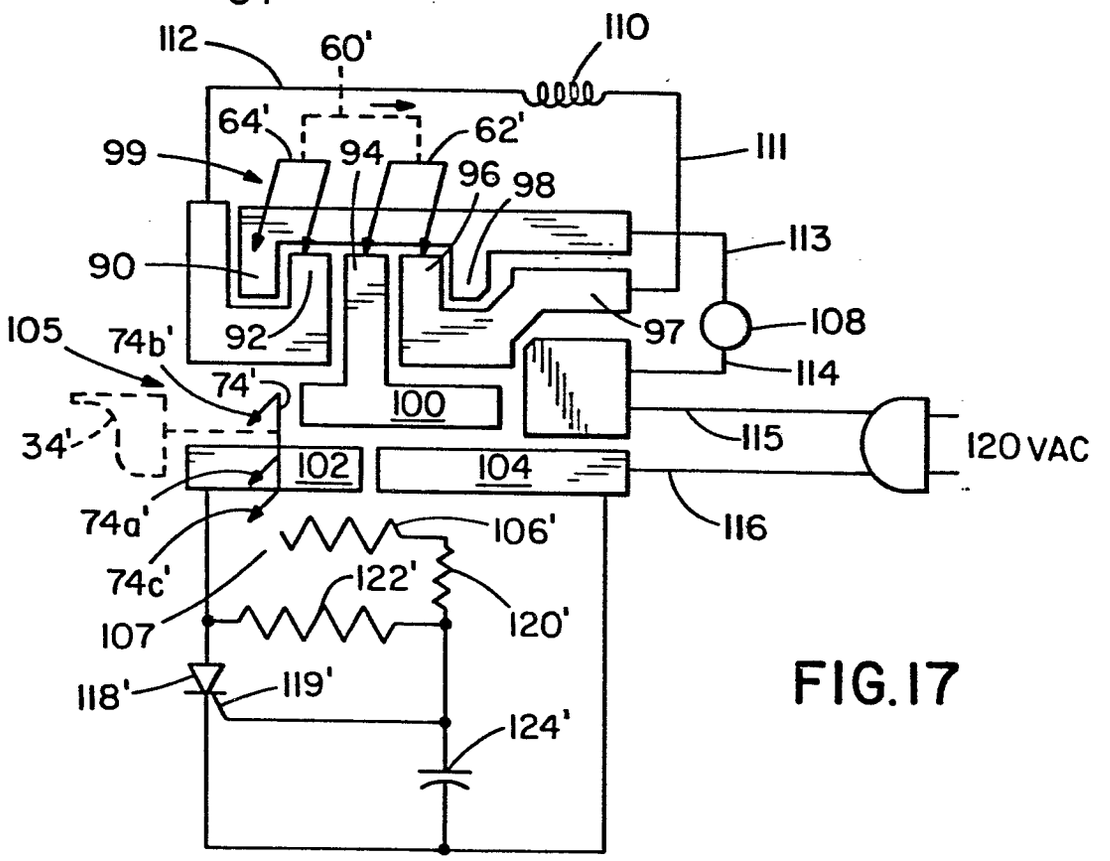
120
106
124
119
118
84
88

FIG.16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99
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74'
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100
34'
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74a'
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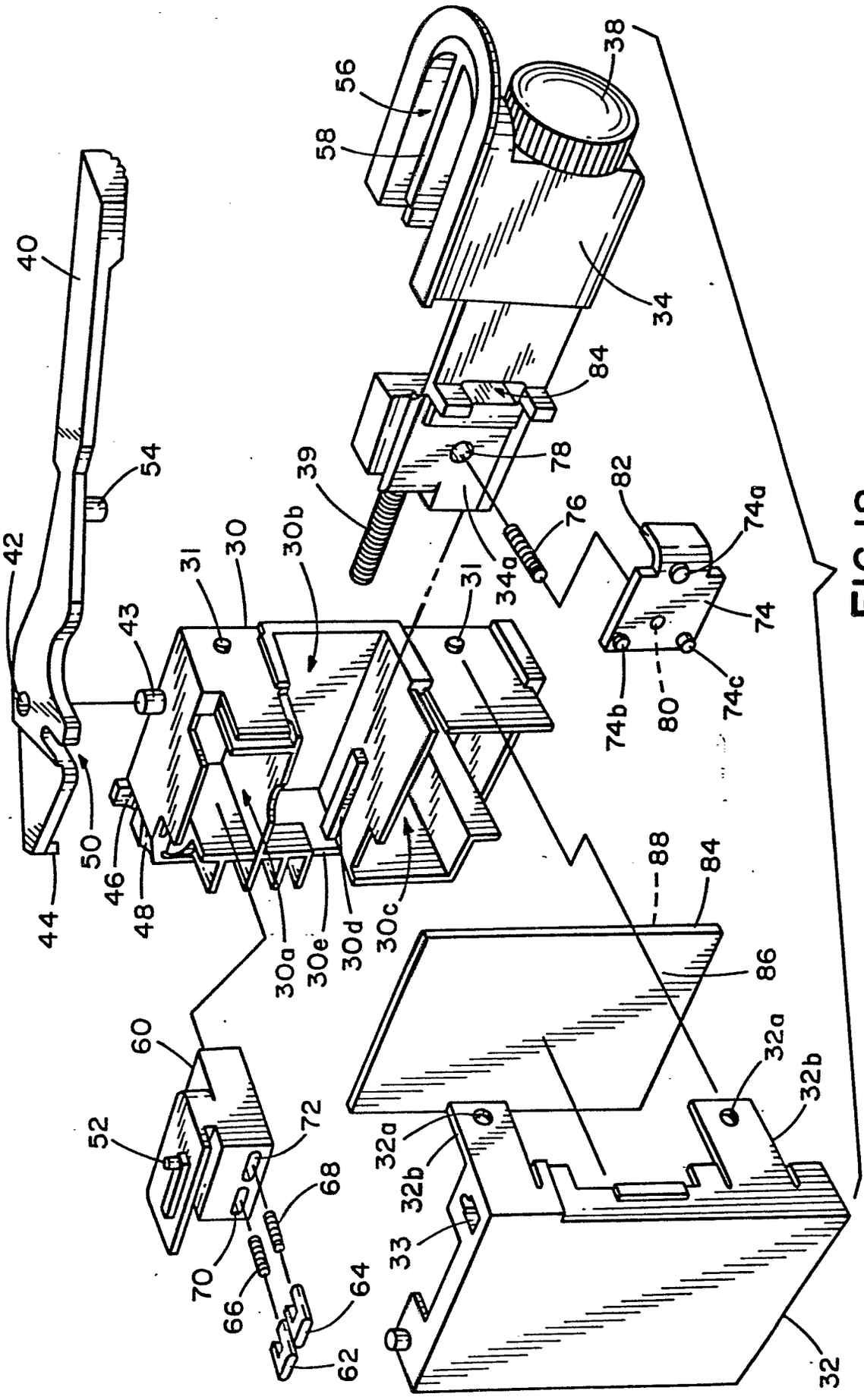
106'
74c'
122'
120'
107
118'
119'
124'

FIG.17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74c
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FIG. 18

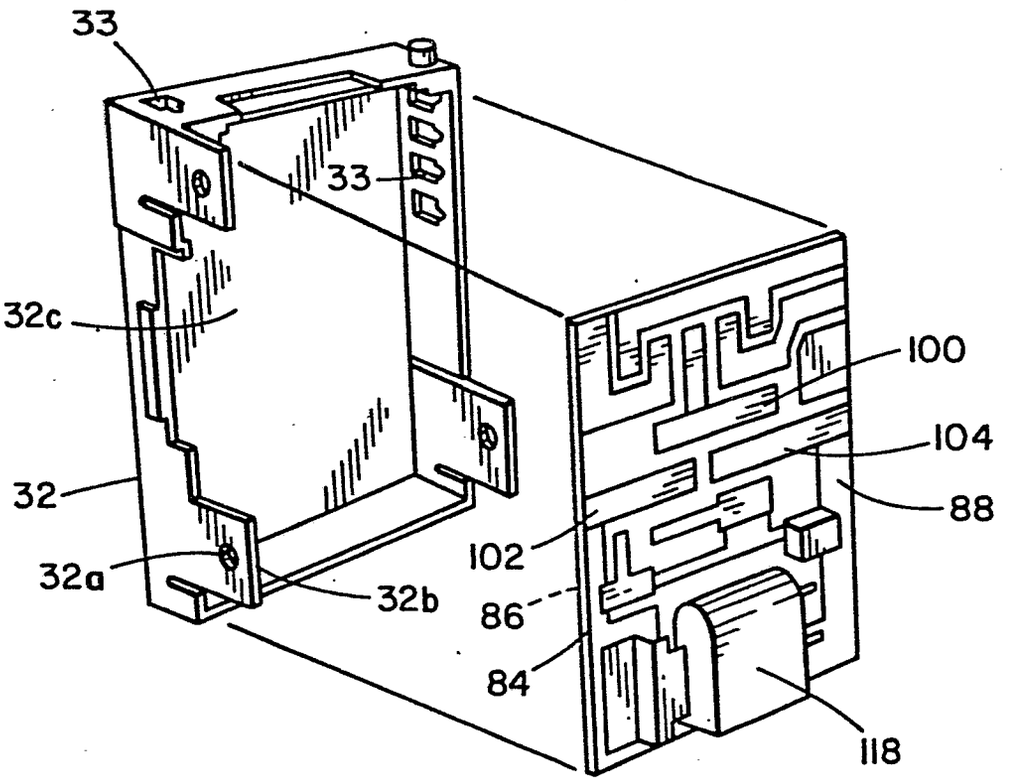


FIG. 19