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Turnbull

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[54] **ELECTROMAGNETIC CONTACTOR FOR BATTERY POWERED VEHICLES**

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[52] **U.S. Cl.** **335/133,** 335/131

[51] **Int. Cl.** **H01h 50/20**

[58] **Field of Search** 335/133, 132, 202, 255, 335/126, 131

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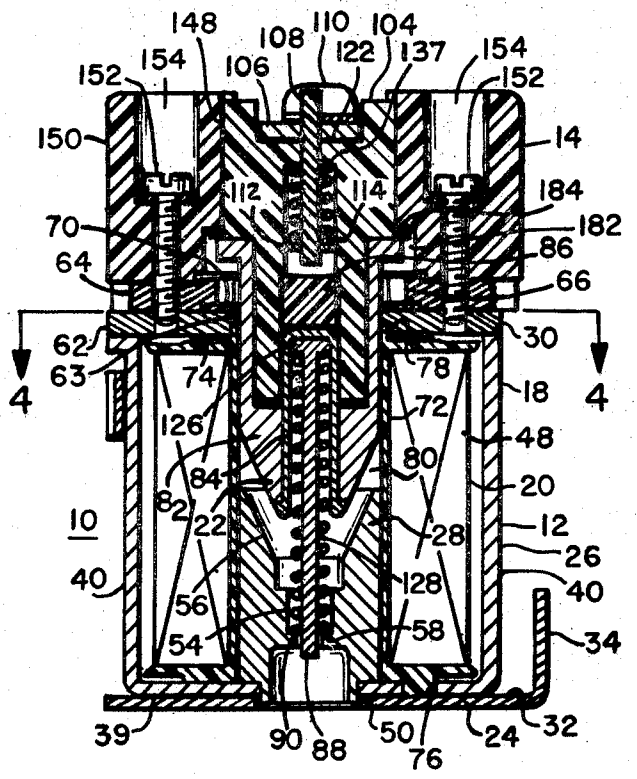
[57] **ABSTRACT**

A compact contactor for a battery operated lift truck. The contactor may be mounted in either of two positions and has its terminals arranged so it can be easily connected in a reversing circuit for a motor. The contactor includes a novel movable contact support which is molded in situ with a magnet plunger. The movable contact support completely isolates the springs for the movable contacts from the switching areas of the contactor and provides a guide for the movements of the plunger. The support for the stationary contact is arranged to position the terminals of the contactor so the contactor is easy to wire and permit a range of different sized contacts to be mounted on the support and electrically connected by a pair of metal members.

10 Claims, 9 Drawing Figures



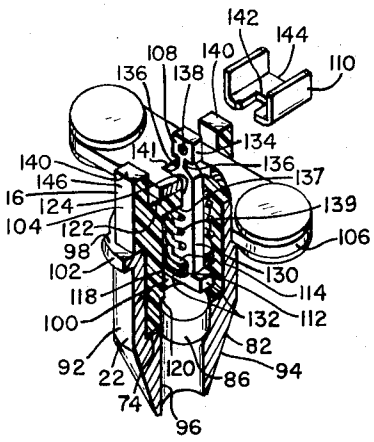


FIG.5

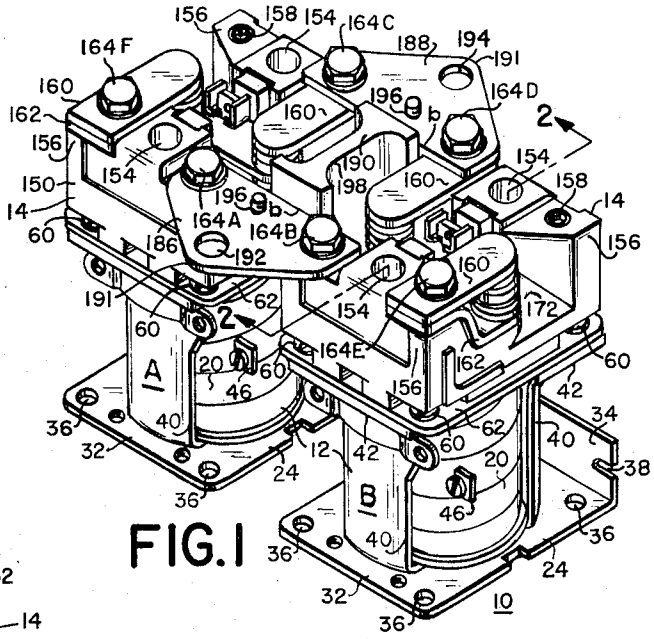


FIG.1

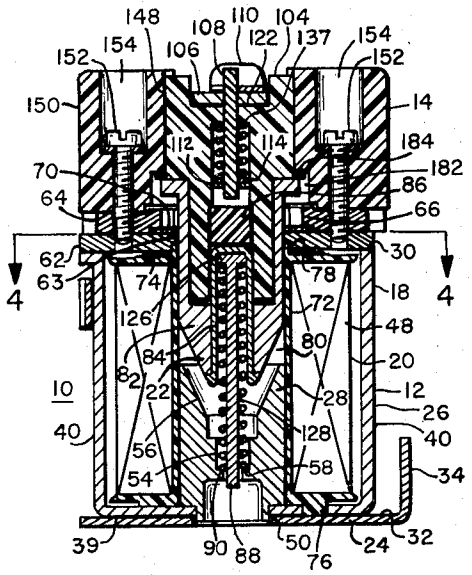


FIG.2

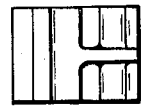


FIG.8

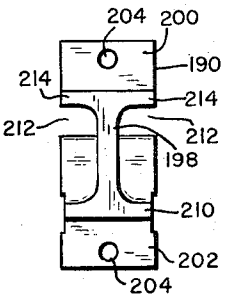


FIG.6

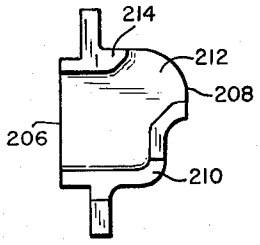


FIG.7

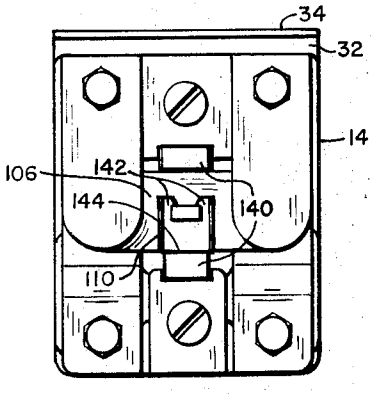


FIG.3

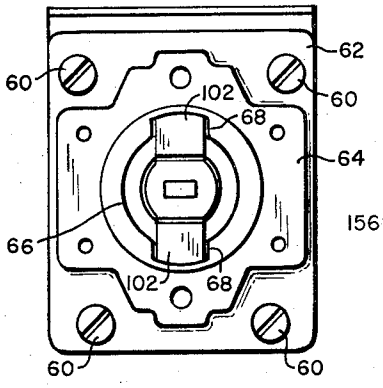


FIG.4

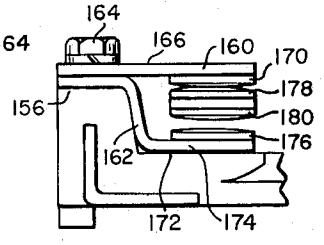


FIG.9

ELECTROMAGNETIC CONTACTOR FOR BATTERY POWERED VEHICLES

This invention relates to electromagnetic switches and is more particularly concerned with a contactor which is particularly suited for use in a battery operated lift truck and the like, its use being readily apparent from the illustrated example and the objects.

Electromagnetic contactors are conventionally designed so the size of their current carrying parts corresponds to the magnitude of the current the parts are expected to carry. The size of the current carrying parts, e.g., the terminals, the movable contacts and the stationary contacts of a contactor, together with the required spacing between the parts, not only dictates the forces which the movable contact springs must exert, but also dictates the forces the magnet motor must deliver if the contactor is to provide an acceptable number of switching operations without failure. Contactors designed for service in battery operated lift trucks are subject to vibration and shock, which requires that the force exerted by the movable contact springs be sufficient to maintain the movable contacts in tight engagement with the stationary contacts to prevent erosion of the contacts by small arcs that develop when the movable contacts bounce upon the stationary contacts. Thus in contactors designed for truck service, the forces of the contact springs and the magnet motor is not dictated by the size of the contacts but rather by the magnitude of the shocks which the contactor can be expected to endure so that the same size magnet motor in a contactor for electric trucks may be used with a range of different contacts.

The fact that the same magnet motor may be used with a range of different sized truck contactors results in a reduction in the cost of manufacture and inventories. The size of the contactor according to the present invention is considerably smaller than contactors heretofore known that have comparable current carrying capabilities. This result is partly accomplished by incorporating a novel plunger and movable contact support structure in the contactor as well as other features which will be apparent from the illustrated embodiment of the present invention and following objects.

It is an object of the present invention to provide a contactor with a novel movable contact support and armature wherein the contact support is molded in situ with the armature.

Another object is to provide a compactor contactor for a battery operated lift truck and the like which has a structure which will permit the contactor to be mounted on a panel so the axis of movement of a magnet plunger operator extends either perpendicular or parallel to the panel.

A further object is to provide a contactor with a support for the stationary contacts which includes an opening which provides a guide for a support carrying the movable contacts of the contactor.

An additional object is to provide a contactor with a support for the stationary contacts which includes an opening which provides a guide for a support carrying the movable contacts of the contactor and to provide the contactor with a magnet structure whereon the stationary contact support is mounted.

A still further object is to provide a contactor with a support for the stationary contacts which includes an opening which provides a guide for a support carrying

the movable contacts of the contactor and to provide the contactor with a magnet structure whereon the stationary contact support is mounted and wherein the movable contacted support is molded in situ with the plunger.

An additional object is to provide a contactor with a molded stationary contact support which is arranged so the contactor is easy to wire and a range of different sizes of stationary contacts may be mounted on the support.

A further object is to provide a movable plunger and a movable contact support in a contactor with bores that are axially aligned and arranged to receive a piston for reducing the contact bounce of the contactor and a movable contact guide and spring so that the spring is isolated from the arc generating portions of the contactor.

Further objects and features of the invention will be readily apparent to those skilled in the art from the following specification and from the appended drawings illustrating certain preferred embodiments, in which:

FIG. **1** is a perspective view of a pair of contactors according to the present invention interconnected in a reversing circuit configuration;

FIG. **2** is a cross-sectional view taken along line **2—2** in FIG. **1**;

FIG. **3** is a top plan view of one of the contactors in FIG. **1**;

FIG. **4** is a top plan view of the contactor in FIG. **3** taken generally along line **4—4** in FIG. **2**;

FIG. **5** is a perspective view partly showing in cross-section a movable contact and magnet plunger structure as used in the contactor in FIG. **2**;

FIGS. **6, 7** and **8** respectively are top, side and end views of an arc suppressing and directing member which is positioned between the pair of contactors in FIG. **1**; and

FIG. **9** is a side view of a normally open and a normally close stationary contact which are selectively mounted on the contactors in FIG. **1.**

Referring to the drawing, an electromagnetically operated switch or contactor **10** includes an electromagnet assembly **12,** a stationary contact assembly **14** and a movable contact and plunger assembly **22.** The electromagnet assembly **12** includes a magnet frame assembly **18** and a coil assembly **20.** The magnet frame assembly **18** is fabricated from a low carbon steel with reasonable high permeability at low flux densities and includes a mounting plate **24,** a magnet frame **26,** a cylindrical rear magnet pole or core **28** and a front magnet pole assembly **30.** The mounting plate **24** has a base portion **32** and a flange **34** extending along a marginal edge of the base portion **32.** The base portion **32** is provided with openings **36** at each of its four corners and the flange **34** has openings **38** in its opposite ends. The openings **36** and **38** are provided so that the contactor **10** may be mounted in either of two positions on a panel, not shown, by suitable screws which are selectively received in the openings **36** or **38** and threaded into the panel. When the openings **36** are used to secure the contactor to the panel, the contactor will be oriented so that the axis of the plunger assembly **22** will extend normal to the panel. When the openings **38** are utilized to secure the flange **34** to the panel, another mounting part, not shown, is provided at the front end of the contactor so the axis of the plunger assembly **22** will be parallel to the mounting panel. For purposes of

description, the components of the contactor **10** will be described when the base portion **32** is secured to the mounting panel by screws extending through the openings **36.**

The magnet frame **26** is cup-shaped and has a rear wall **39** secured to the mounting plate **24** and side walls **40** extending forwardly from the rear wall **39** to outwardly extending flanges **42** at the front ends of the wall **40.** The side walls **40** of the cup-shaped frame **26** are slotted to make the part easier to manufacture and to provide clearance and access to a pair of terminals **46** of a coil winding **48** which is part of the coil assembly **20.** The rear wall **39** and the mounting plate **24** are provided with circular openings **50** that are centered on the axis of the plunger assembly **22.**

The core **28** has an end secured in the openings **50** and includes a bore **54** which extends through the core **28** along the axis of the plunger assembly **22.** The front end of the bore **54** is provided with a counterbored portion **56** that has conically tapered side walls. The diameter of the rear end of the bore **54** is slightly reduced to provide an annular spring seat **58.** The portion of the bore **54** extending rearwardly of the spring seat **58** is also counterbored to provide clearance for the operator of a mechanical interlock, not shown or described herein, which may be positioned at the rear end of the contactor **10.**

The front magnet pole assembly **30** is secured to the front side of the flanges **42** by screws **60** which extend through openings in a front pole plate **62** into threaded openings in the flanges **42.** The front pole plate **62** is generally rectangular in shape and has a circular central opening **63** centered on the axis of the plunger assembly **22.** Secured on the front side of the pole plate **62,** as with projection welds, is a pole plate **64.** The pole plate **64** has a central circular opening **66** centered along the axis of the plunger assembly **22** and a pair of notches **68** extending outwardly from opposite side walls of the opening **66.** The notches **68** are arcuate in shape and are centered in a plane defined by the axis of the plunger assembly **22** that extends perpendicular to the panel on which the contactor **10** is mounted. A rear side of the pole plate **64** is provided with a circular depression wherein a non-magnetic stainless steel annular shim **70** is held captive between the pole plates **62** and **64** when the pole plates are secured together. The arcuate notches **68** are arranged to expose portions of the shim **70** to the front end of the magnet frame assembly **18.**

The coil assembly **20** includes a molded plastic bobbin **72,** a wave washer **74,** and the coil winding **48** which is random wound on the bobbin **72** and covered with a suitable tape. The coil assembly **20** is accurately positioned between the rear wall **39** and the pole plate **62** by projections **76** which extend from a rear end of the bobbin **72** into suitably located openings in the rear wall **39** and an annular flange **78** which extends forwardly from the front end of the bobbin **72** into the opening **63.** The bobbin **72** has a cylindrical bore **80** extending therethrough that is centered on the axis of the plunger assembly **22.** The magnet core **28** extends forwardly in the bore **80** and the plunger assembly **22** is movable and guided along its axis of movement by the walls of the bore **80.** The plunger assembly **22** includes a cylindrical plunger **82,** a spring guide **84,** an insulator **86,** a guide pin **88** and a spring **90.** Additionally, a movable contact assembly **16** may be considered as part of the plunger assembly **22** in view of the manner in which they are connected and cooperate, as will be later described. As shown in FIG. **5,** the cylindrical plunger **82** has a body portion **92** which is guided in the bore **80** and a conically tapered rear end **94** with a bore **96** extending between the rear end **94** and a front end **98** of the plunger **82.** The front end of the bore **96** is provided with a counterbored portion which provides a cavity **100** that has an appreciable depth and extends rearwardly into the plunger **82.** Extending outwardly at the front end of the plunger **82** are a pair of arcuately shaped ears **102,** most clearly illustrated in FIG. **5.** The ears **102** are sized to be received in the notches **68** without engaging any side wall portion of the notches **68.**

The movable contact assembly **16** includes a molded movable contact carrier **104,** a movable contact **106,** a movable contact guide **108,** a keeper **110,** a washer **112** and a damper **114.**

The carrier **104** is molded of insulating material in situ with the plunger **82** and has a portion filling the cavity **100** in intimate contact with the walls of the cavity **100** to provide a firm bond therebetween. The carrier **104** has a bore extending forwardly from its rear end which forms a continuation of the bore **96.** A forward end portion of the bore is slightly reduce in diameter to provide a cylindrical bore **118** and an annular ridge **120** at the rear end of the bore **118.** Extending forwardly between the front end of the bore **118** and a front end **122** of the carrier **104** is a rectangular slot **124** which extends lengthwise along an axis that is parallel to the panel on which the contactor **10** is mounted. The front end **122** extends in a plane that is perpendicular to the axis of movement of the plunger assembly **22.**

The insulator **86** has a cylindrical shape and is positioned in the front end of the bore **96** against the ridge **120** to electrically isolate the metal parts in the bore **96** from the metal parts in the bore **118.** The spring guide **84** is tubular in shape and is positioned in the bore **96.** The spring guide **84** has a closed front end positioned against the insulator **86** and an outwardly flared rear end which overlays the rear end of the tapered end **94.** The guide pin **88** has a head portion **126** positioned against the closed front end of the spring guide **84** and a stem **128** extending from the head portion **126** rearwardly through the bore **54** to the external rear of the contactor **10.** The spring **90** surrounds a portion of the stem **128** and is positioned between the head portion **126** and the spring seat **58** to constantly bias the plunger **82** forwardly in the bore **80.**

The contact guide **108** is formed from a flat metal part to have a stem portion **130** and a pair of feet **132** extending in opposite directions at the rear end of the stem portion **130.** The stem portion **130** extends from the bore **118** through the rectangular slot **124** to provide a portion **134** at its front end that extends forwardly of the front end **122** of the carrier **104.** The portion **134** has a pair of notches **136** in its opposite sides and an opening **138** adjacent its front end. The washer **112** has a rectangular central opening which receives the stem portion **130** while its rear surfaces rest upon the feet **132.** The damper **114** also has a rectangular central opening and a rear surface which rests upon the front surface of the washer **112.** The damper **114** is formed of resilient material and is disc-shaped and has a diameter which will cause the peripheral edges of the

damper 114 to frictionally engage the wall portions of the bore 118 and move in the bore 118 with a piston-like action. A spring 139 is positioned between the ridge 137 and the front side of the damper 114 to constantly bias the contact guide 108 rearwardly in the carrier 104.

The movable contact 106 is formed as a rectangular part of a highly conductive metal, e.g., copper, and has noble metal contact areas at its opposite ends. The movable contact 106 has a central portion positioned on the end 122 and extends along an axis parallel to the panel on which the contactor 10 is mounted. The central portion of the contact 106 is provided with a rectangular slot 141 through which the portion 134 of the contact guide 108 extends. Also, the end 122 is provided with a pair of spaced abutments 140 which are located on opposite sides of the central portion of the movable contact 106 to prevent the movable contact from rotating on the end 104. The movable contact 106 is maintained assembled on the end 104 of the contact guide by the keeper 110 which is formed as a channel part to have a notch 142 extending in its bight portion which receives a portion of the contact guide while portions of the keeper 110 surrounding the notch 142 are received in the notches 136. The keeper 110 has a length so an edge 144 engages a wall on one of the abutments 140 when the portions of the keeper 110 are received in the notches 136.

The portion 146 of the contact carrier 104 that extends forwardly of the plunger 82 is substantially rectangular in shape and is centered along a plane perpendicular to the panel on which the contactor 10 is mounted. The portion 146 is movable in a rectangular bore 148 that extends through a molded insulating support 150. The support 150 is part of the stationary contact assembly 14 and has a rear side mounted on the front end of the magnet frame assembly 18 by a pair of screws 152 which are received in bores 154 in the support 150. The support 150 is generally rectangular in shape and has a raised abutment 156 extending forwardly at each of its four corners of its front surface. Each abutment has a threaded metal insert 158 embedded therein.

Two different types of stationary contacts may be mounted on any of the four abutments 156 to selectively cooperate with the movable contact 106 to provide a normally open or normally close contact function. As shown in FIG. 9, one of the types of stationary contacts designated by a numeral 160 is shaped to provide a normally closed contact function and the other type, designated by a numeral 162, is shaped to provide a normally open contact function.

Each of the stationary contacts 160 and 162 includes a mounting portion which is secured to a front face of one of the abutments 156 by a terminal screw designated as 164 in FIG. 9. The terminal screw 164 extends through an opening in the mounting portion of the contacts 160 and 162 and is threaded into the threaded insert 158 embedded within the raised abutment 156 whereon the associated stationary contact 160 and/or 162 is positioned. The stationary contact 160 includes a portion 166 that has a noble metal contact 170 secured thereon. The portion 166 extends from the abutment 156 whereon the contact 160 is secured to position the contact 170 so that the contact 170 is centered along an axis that extends perpendicular to the axis of movement of the plunger 82 and is spaced equidistantly between a pair of adjacent abutments 156 at the upper corners of the support 150 and a pair of adjacent abutments 156 at the lower front corners of the support 150. The portion 166 extends from its associated abutment 156 to position the contact 170 so that the contact faces and is spaced from a front surface portion 172 that extends on the front side of the support 150 between the pair of adjacent abutments 156 at the top edge of the support 150 and the pair of adjacent abutments 156 at the bottom edge of the support 150. The normally open stationary contact 162 includes a portion 174 that has a noble metal contact 176 secured thereon. The portion 174 extends from its associated abutment 156 so that the contact 176 is positioned adjacent the front surface portion 172 and faces forwardly with the contact 176 centered along an axis which is parallel to the axis which passes through the center of the contacts 170 and equidistantly spaced between the abutments 156 at the upper and lower corners of the support 150.

The stationary contacts 160 and 162 are selectively positionable on the front surface of the support 150 to provide a normally open contact function, a normally close contact function, or a normally open and a normally close contact function, providing a pair of the same type of closed contacts, e.g., a pair of contacts 160 or a pair of contacts 162, are selectively positioned on an adjacent pair of abutments at either the top or the bottom edges of the support 150. This arrangement will permit the movable contact 106, which is rectangular in shape and movable in a plane passing through the axes which passes through the centers of the contacts 170 and the contacts 176, the present noble metal contact portions 178 which are engageable with the contacts 170 and noble metal contact portions 180 which are engageable with the contacts 176, respectively, when the coil assembly 20 is respectively deenergized and energized.

The contactor 10 is assembled by securing the mounting plate 24, the magnet frame 26 and the magnet core 28 together and positioning the coil assembly 20 within the mounting frame 26 so that the core 28 extends forwardly in the rear end of the bore 80 and the terminals 46 are exposed through openings in the frame 26. The wave washer 74 is then positioned on the front end of the coil assembly 20 and an assembly consisting of pole plate 62, the pole plate 64, and the shim 70 is secured to the front end of the magnet frame assembly 18 by the screws 60. The plunger assembly 22 is then positioned within the bore 80 so that the ears 102 are aligned to be received within the notches 68. The stationary contact support 150 when secured to the front end of the pole plate 64 by screws 152 will be in a position which will cause the rectangularly shaped portion 146 of the contact carrier 104 to be received in the rectangular bore 148 in the support 150. The rectangular bore 148 provides a guide for the movement of the contact carrier 104 and prevents the contact carrier 104 and the plunger 82 from rotating. If the contactor 10 is to provide a normally open type contact switching function, the contacts 162 are secured on the abutment 156 as previously described before the movable contact 106 is assembled on the front end 122 of the movable contact carrier 104. If the contactor 10 is to provide a normally closed type of contact switching function, the movable contact 106 is positioned on the

front end 122 before the contacts 160 are secured on the support 150 as described.

The movable contact 106 is installed on the front end 122 of the carrier 104 by positioning the movable contact between the abutments 140 on the front end 122 with the portion 134 on the movable contact guide 108 extending through the rectangular slot 141 in the movable contact 106. The keeper 110 then is assembled on the portion 134 with the aid of a pointed tool, such as a punch, which has its point installed in the opening 138 and its shank fulcrummed on one of the abutments 140 so the tool can be pivoted on the abutment and cause the contact guide 108 to move against the force of the spring 139 so that the notches 136 will be exposed at the front side of the movable contact 106. The exposed notches 136 will permit the keeper 110 to be moved into a position where it will maintain the movable contact 106 in its position on the end 122. It is readily apparent that the movable contact 106 may be readily removed from the end 122 by merely lifting the side of the keeper 110 that is remote from the notch 142 and sliding the keeper 110 out of engagement with the portion 134.

As shown in FIG. 2, the rear side of the support 150 is provided with a recess 182 which receives the front end of the plunger 82, including the ears 102. The front end of the recess 182 is provided with stop surfaces 184 which are engaged by portions of the ears 102 to limit the forward movement of the plunger assembly 22 when the contactor 10 is de-energized and the contactor 10 is not provided with normally closed stationary contacts 160. When the contactor 10 is furnished with a pair of normally closed type stationary contacts 160 and the contactor 10 is de-energized, the movable contact assembly 16 will be urged forwardly by the spring 90 so that the contacts 178 will be pressed into tight engagement with the contact 170 and cause a slight spacing to be present between the ears 102 and the stop surface 184.

The coil winding 48, when energized by direct current, will cause the contactor 10 to be energized and the plunger 82 and the contact carrier 104 to move rearwardly toward the core 28 against the force provided by the spring 90. The movement of the plunger 82 is guided by the bore 80 and limited by the engagement between the rear side of the ears 102 and the front exposed surface portions of the non-magnetic shim 70. The rectangular bore 148 and the portion 146 are arranged so that the ears 102 are prevented from engaging any portions of the notches 68. The movement of the contact carrier 104 will cause the movable contact 106 to move out of engagement with the stationary contacts 160 and into engagement with the stationary contacts 162. The movement of the contact carrier 104 rearwardly toward the energized position where the ears 102 engage the shim 70 will cause the contact portions 180 to engage the contacts 176 prior to the engagement between the ears 102 and the shim 70 so that the movable contact 106 moves out of its engagement with the end 122. The movement of the movable contact 106 from the end 122 is opposed by the spring 139 which provides a force through the contact guide 108 and causes the contact portions 180 to be pressed firmly against the contacts 176.

Any contact bounce which normally would occur when the contact portions 180 engage the contacts 176 is reduced to a minimum by the friction between the peripheral edges of the damper 114 and the walls of the bore 118 as the damper 114 moves in the bore 118.

The de-energization of the coil winding 48 will cause the contactor 10 to be de-energized and the plunger 82 and the movable contact carrier 104 to move to the de-energized position previously described. The engagement between the ears 102 and the shim 70 prevents the plunger 82 from being maintained in its energized position by residual magnetism which would normally occur if the shim 70 was made of magnetic metal. The force provided by the spring 90 on the plunger 82 causes the plunger 82 and the movable contact carrier 104 to move from an energized position to a de-energized position where the contact portions 178 engage and are firmly pressed against the contacts 170 by the force exerted by the spring 90.

An advantage provided by the construction of the movable contact assembly 16 is that the spring 139 is isolated and shielded from high temperature exposure which is generated by arcs during the operation of the contactor 10. The springs 139 thus will suffer no loss in elastic modulus and will not require replacement when the movable contacts 106 are replaced. The insulator 86 is included in the contactor 10 to electrically isolate the movable contact structure that includes the guide 108 from the panel on which the contactor 10 is mounted.

A pair of contactors 10, designated as A and B, are shown in FIG. 1 as connected to control the energization of a series field direct current motor reversing circuit. The connection between the pair of contactors A and B is accomplished by a pair of identical triangularly shaped metal conductor members 186 and 188 which properly space the pair of contactors A and B and cause the arcs generated by the switching contacts of the contactors A and B to be properly directed. The members 186 and 188 also provide a support for an arc directing chute member 190 as will be later described.

The members 186 and 188 generally have an isosceles triangle shape and each has a base *b* spaced and parallel to a plane passing through the axis of movement of the plunger assemblies 22 of a pair of contactors A and B. The sides of each member 186 and 188 extend from the base *b* of the members to an apex 191 which is located in a plane perpendicular to the base *b* and parallel and equidistant to the axis of movement of the plunger assemblies 22 of the pair of contactors A and B. The members 186 and 188 have openings 192 and 194 located adjacent their respective apices 191 with the openings 192 and 194 centered along an axis through the apices 191 of the members 186 and 188. The members 186 and 188 also have a pair of openings at the opposite ends of their respective bases b which are arranged to receive screws which are threaded into the abutments of the contactors A and B. Each member 186 and 188 is also provided with a threaded opening 196. The openings 196 in the respective members 186 and 188 are centered along an axis through the center of the openings 192 and 194 and are located adjacent the base *b* of the respective members 186 and 188.

The member 186 is secured to the contactors A and B by terminal screws which also mount the contacts 160 and/or 162 on the abutments 156 and on the contactors A and B respectively designated as 164A and 164B. Similarly, the member 188 is secured to the contactors A and B by terminal screws designated as 164C

and 164D. The members 186 and 188, when secured to the contactors A and B by the terminal screws 164A–D, space the contactors equidistantly a predetermined distance on opposite sides of a plane passing through the centers of the openings 192 and 194 so that a space is provided between the confronting adjacent side walls of the supports 150 of the contactors A and B.

The member 190 is positioned between the contactors A and B by the members 186 and 188. The member 190 is formed of a cold-molded, non-tracking, arc-suppressing and quenching material as is well known to those skilled in the art. The member 190 has a web portion 198 extending in the plane which is equidistant from the contactors A and B. As shown in FIGS. 6–8, the web portion 198 interconnects a pair of mounting portions 200 and 202. The mounting portions 200 and 202 are positioned adjacent the rear sides of the members 186 and 188 and are secured to the members 186 and 188 by screws which pass through suitably located openings 204 in the mounting portions 200 and 202 and are threaded into the openings 196 in the members 186 and 188 respectively. The web portion 198 extends from a front end 206 rearwardly to a rear end 208 and preferably is tapered so that front end 206 has a greater thickness than the rear end 208. Extending rearwardly from opposite sides of an upper end of the web portion 198 is a rib 210. The rib 210 extends from the front end of the web portion 198 rearwardly to provide openings 212 on opposite sides of rear bottom edge of the web portion 198. Extending rearwardly from opposite sides of a lower end from the front end to the openings 212 in a rib 214. All of the corners between the ribs 210 and 214 and the web portion 198 are rounded in a manner most clearly seen in FIG. 6.

When a pair of contactors A and B are constructed and interconnected by a pair of members 186 and 188 so the contactors A and B may be connected in reversing circuit for a series field direct current motor, not shown, one side of a D.C. source, not shown, is connected by a suitable terminal and screw, not shown, which is threaded into the opening 194 and the other side of the source is connected through the armature winding of the motor to a terminal and a screw which is threaded into the opening 192.

Secured on the abutment 156 at the lower right corner of the support 150 of the contactor B by a terminal screw designated as 164E is a normally closed stationary contact 160 and a normally open stationary contact 162. Similarly secured to the abutment at the lower left corner of the support 150 of the contactor A by a terminal screw 164F is a normally closed stationary contact 160 and a normally open stationary contact 162. A pair of normally closed stationary contacts 160 are secured to the upper right and upper left abutments 156 of contactors A and B respectively by the terminal screws 164C and 164D respectively, which also secure the member 188. Secured to the lower right and left abutments 156 of the contactors A and B respectively by terminal screws 164A and 164B are a pair of normally open stationary contacts 162, not shown.

Preferably, the contactors A and B are mechanically interlocked by a mechanism, not shown, which is mounted at the rear of the contactors A and B and actuated by the rear ends of the guide pins 88 so the contactors A and B are incapable of simultaneously being in their energized or de-energized states. When the contactors A and B are connected in the reversing circuit for a series field direct current motor, the terminal screws 164F and 164E are connected to opposite ends of the field winding.

When the contactor A is energized and the contactor B is de-energized, the movable contact 106 of contactor A will interrupt the circuit between the terminal screws 164C and 164F and complete the circuit between the terminal screws 164F and 164A while the movable contact 106 of the contactor B will cause the circuit between the terminal screws 164D and 164E to be completed and the circuit between the terminal screws 164E and 164B to be interrupted. The completed circuit between the terminal screws 164F and 164A will cause current to flow through the normally closed contacts 160 of the contactor B and the normally open contacts of the contactor A so that the motor field is energized by current flow in one direction. For example, current from a D.C. source which is connected by suitable conductors and screws which are threaded into the openings 194 and 192 in a direction which will casue current to flow from the opening 194 to the opening 192, will flow through a path that includes the opening 194, the terminal screw 164D, the normally closed contacts 160 of the contactor B, the terminal screw 164E, the field of the motor, the terminal screw 164F, the normally open contacts 162 of the energized contactor A, the terminal screw 164A and the opening 192.

A severe arc may be generated between the contacts 180 and 176 of the contactor A when the contactor A is initially deenergized. The hot gases generated by the arc are directed downwardly and outwardly by the arc chute 190.

The current interrupting capability of the contactors A and B is appreciably increased by the presence of the arc chute 190 and the members 186 and 188 in the assembly. It will be seen that the arc chute 190 provides a barrier between the contactors A and B reduces the possibility of hot ionized gases from being transferred from the contacts associated with the terminal screws 164A and 164C of the contactor A to the space between the contacts associated with the terminal screws 164B and 164D of the contactor B when the contactor A is initially de-energized. The presence of hot ionized gases in the space between the contacts associated with the terminal screws 164B and 164D may cause a line-to-line short circuit between the conductors which are connected to the openings 192 and 194. The members 186 and 188 aid in the effectiveness of the arc chute 190. In practices heretofore used, the members 186 and 188 would be in the form of a flat strip of conductive metal and the connections to the source would be made to one of the terminal screws, e.g., terminal screw 164D, with the strap providing the connection to the terminal screw 164C. When this arrangement is used, the magnetic field generated by the current flow when contactor A is interrupting current flow will cause the arcs generated between the movable contacts associated with the terminal screws 164A and 164C to strike the arc chute 190 at a 90° angle and thus reduce the effectiveness of the web portion 198 from directing the hot ionized gases away from the opening contacts. The same result will occur when the contactor B is initially de-energized to interrupt the circuit through its contacts and the connection from the source is made to the terminal screw 164C. The connections provided

by the openings **192** and **194** at a point equidistant between and remote from the terminal screws **164C–164D** and **164A–164B** respectively, causes the magnetic field generated by currents through the contactors A and B to be distributed so that arcs generated when the contacts of contactors A and B open will strike the web portion at an angle which aids the arc chute in directing the hot gases downwardly and forwardly through the openings **212.** The taper on the web portion **198** also increases the efficiency of the arc chute **190.**

The operation of the contactor B when the contactor B is energized and de-energized is believed obvious in view of the foregoing description of the operation and arcs generated when contactor A is energized and de-energized. The only difference between the operation of the contactor A and B is that the energization of the contactor B will cause the direction of current flow through the field of the motor to be in the opposite direction from the current flow when contactor A is energized.

While certain preferred embodiments of the invention have been specifically disclosed, it is understood that the invention is not limited thereto, as many variations will be readily apparent to those skilled in the art and the invention is to be given its broadest possible interpretation within the terms of the following claims.

What is claimed is:

1. In a D.C. operated electromagnetic switch the combination comprising: a frame having a pair of spaced ends and portions interconnecting the ends providing a path for magnet flux passing through the ends, a magnet coil positioned between the ends, said magnet coil having a cylindrical passage axially aligned with an opening in a first of the pair of ends and a coil winding surrounding the passage, a plunger having a cylindrical portion movable in the passage and a portion extending through the opening to a free end and a cavity in the plunger extending from the free end axially into the cylindrical portion, an insulating support mounted on the first end, said insulating support having an opening extending therethrough axially aligned with passage, and a pair of spaced stationary contacts mounted on a front surface of the support on opposite sides of the opening, and an insulating movable contact carrier having a portion extending through the opening in the support and a portion molded in situ in the cavity

2. The combination as recited in claim **1** wherein portions of the contact carrier engage portions of the block surrounding the opening in the block for preventing rotation of the plunger in the passage.

3. The combination as recited in claim **1** wherein the carrier and plunger have axially aligned bores extending therethrough.

4. The combination as recited in claim **3** wherein the portion of the carrier extending through the opening has an end providing movable contact support surface that extends in a plane normal to the axis of the bore through the carrier and a movable contact is positioned on the contact support surface to provide a bridging engagement with the stationary contacts.

5. The combination as recited in claim **4** wherein the cross-sectional area of the bore at the end providing the movable contact surface is reduced to provide a spring seat and the movable contact is positioned on the contact surface by a member that has an end extending through the reduced portion of the bore and through an opening in a central portion of the movable contact.

6. The combination as recited in claim **4** wherein the member has an enlarged end movable in the bore in the contact carrier and a spring is positioned between the enlarged end and the spring seat.

7. The combination as recited in claim **6** wherein the enlarged end is movable along the walls forming the bore with a piston-like action.

8. The combination as recited in claim **7** wherein the portion of the plunger providing the free end includes a pair of ears extending from said portion normal to the axis of the passage and said first end includes a pair of non-magnet stop surfaces that are engaged by the ears to limit the movement of the plunger in one direction when the coil is energized by direct current.

9. A reversing direct current contactor assembly comprising: a pair of identical electromagnetically operated switches, each of said switches including: an electromagnet comprising a frame having a rear end, a front end, and portions connecting the rear end and the front end providing a path for magnet flux passing through said ends, a magnet coil positioned between the ends, said coil having a cylindrical bore extending along a first axis with a front end of the bore aligned with a circular opening in the front end of the frame and a coil winding surrounding the cylindrical bore, and a cylindrical plunger having a rear end portion movable in the bore and a front end portion extending through the opening in the front end of the frame, an insulating stationary contact support secured on the front end of the frame, said support having a passage extending therethrough aligned on the first axis, an insulating movable contact carrier extending through the passage, said carrier having a rear end secured to the front end of plunger and a movable contact support surface at a front end of the carrier disposed forwardly of a front surface of the support, an elongated movable contact mounted on the support surface, said movable contact having a central portion centered on the first axis and portions extending in opposite directions from the central portion along a second axis that is perpendicular to the first axis, means for positioning the pair of switches so the second axis of the respective switches are aligned in a plane through the first axis of both switches with the switches spaced equidistantly from a third axis that extends perpendicular to the plane so a side on the stationary contact support of a first of the pair of switches confronts a side on the stationary contact support of a second of the pair of switches with the confronting sides extending parallel and in spaced relation to the third axis, each of said switches including a pair of stationary contact assemblies mounted on a portion of the front surface of the support most proximate the third axis, a first of said pair of contact assemblies including a metal support having a mounting portion secured to portion of a corner of the front surfaces of the support adjacent the confronting sides and a side of the support that is spaced from a first side of the plane and a contact support portion extending from the mounting portion along an axis parallel to the third axis to a free end, a second of said pair of contact assemblies including a metal support having a mounting portion secured to a portion of a corner of the front surface of the support adjacent the confronting side and a side of the support that is spaced from a second side of the plane and a contact support portion extending

from the mounting portion along an axis parallel to the third axis to a free end, said means for positioning the switches including a first metal piece interconnecting the mounting portions of the first pair of contact assemblies and a second metal piece interconnecting the mounting portions of the second pair of contact assemblies, each of said metal pieces having a threaded opening and a means for connecting a bared end of a wire centered on the third axis and an insulating part formed of arc suppressing material, said part having a body portion centered along the third axis and extending in the space between the switches and a pair of ears extending from the body portion, each of said ears having an opening aligned with one of the openings in the metal pieces for mounting said insulating part on the metal pieces, said insulating part providing a means for directing hot gases generated upon the opening of the contacts of said switches.

10. The combination as recited in claim **9** wherein each of said switches includes a second pair of stationary contact assemblies mounted on a corner portion of the front surface remote from the confronting side and spaced from the first side of the plane, each of said second pair of stationary contact assemblies including a pair of metal stationary contact supports that are electrically connected together and spaced to be alternately engaged by a portion of the movable contact when the electromagnet is alternately energized and deenergized.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,815,060 Dated June 4, 1974

Inventor(s) Merlin Y. Turnbull

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 11, line 49, cancel "block" and insert --support--.
Col. 12, line 3, for the claim reference "4" read --5--.

Signed and Sealed this

fifteenth Day of *June 1976*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks

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