Nov. 8, 1966 D. L. PETTIT ETAL 3,284,742

ELECTROMAGNETIC CONTACTOR

Filed Aug. 17, 1964 2 Sheets-Sheet 1

Fig. 1.

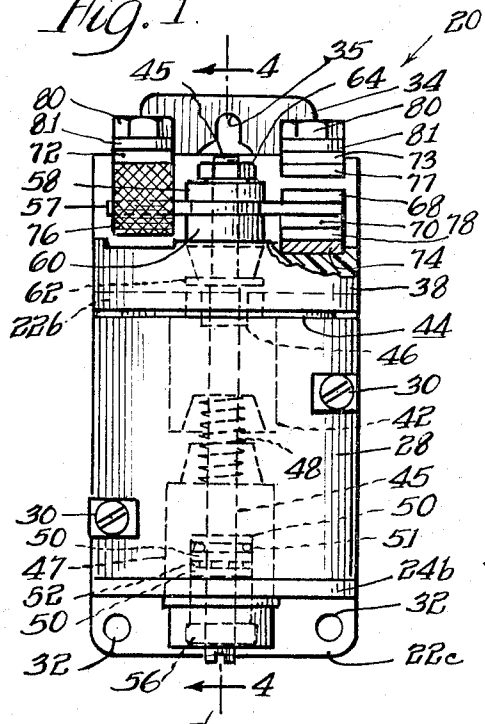

Fig. 2.

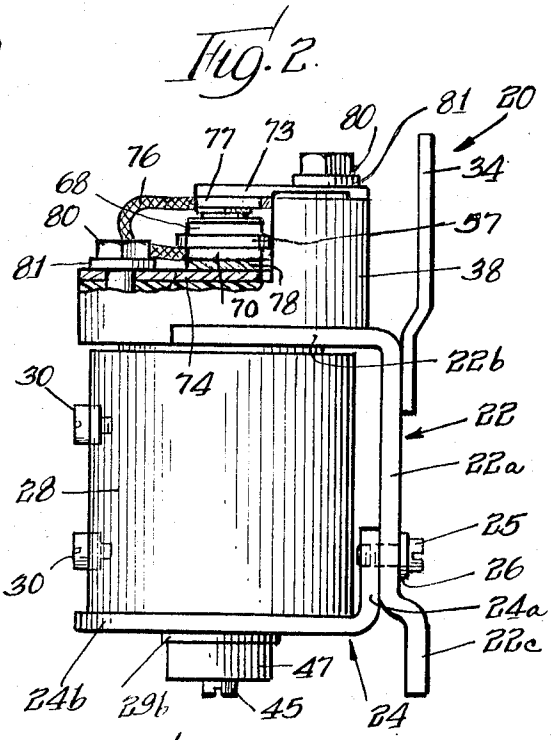

Fig. 3.

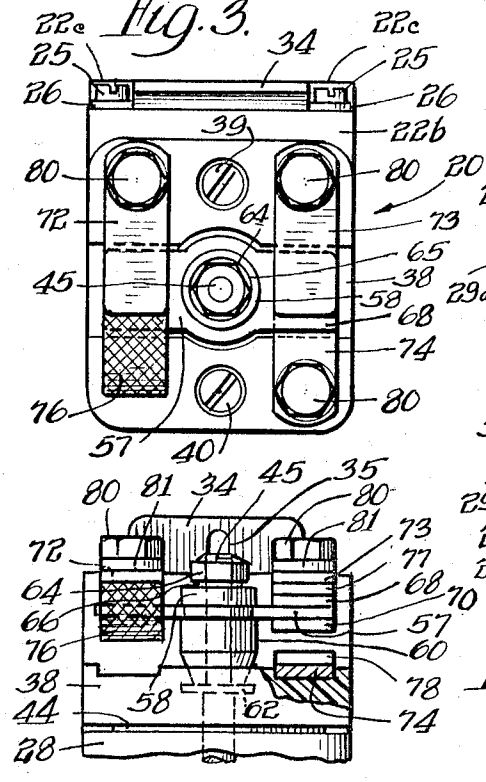

Fig. 4.

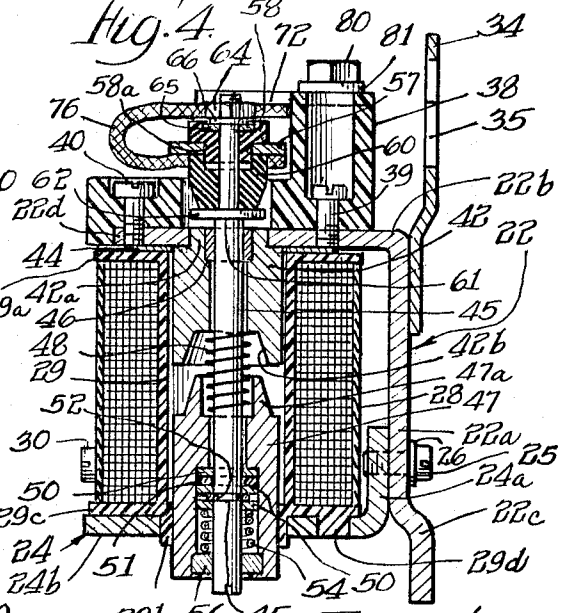

Fig. 5.

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Fig. 6.

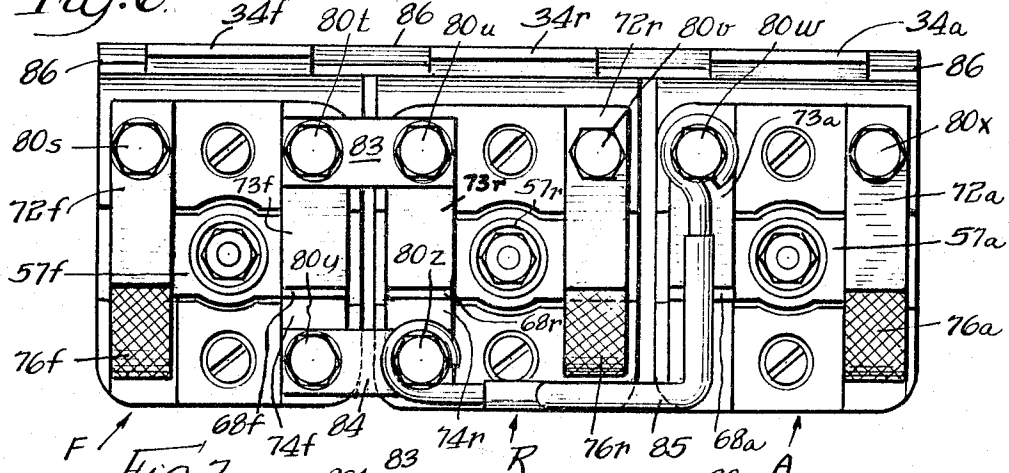


Fig. 7.

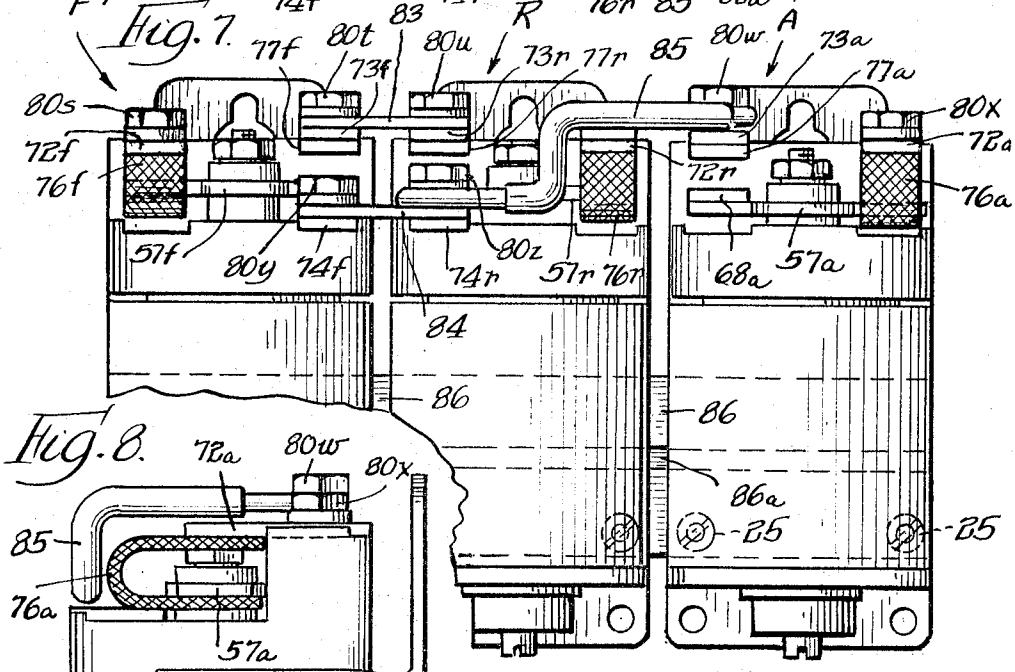
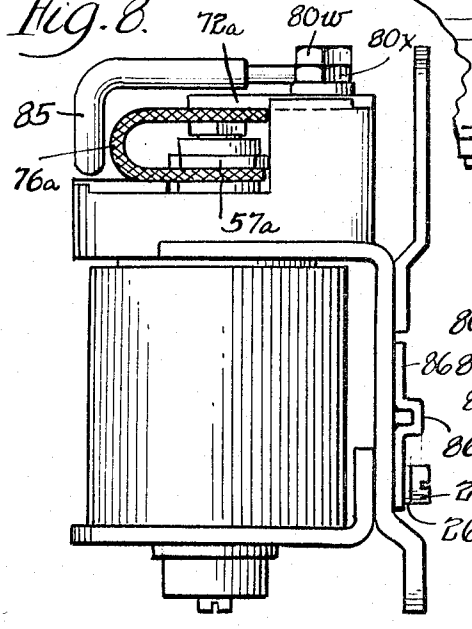


Fig. 8.



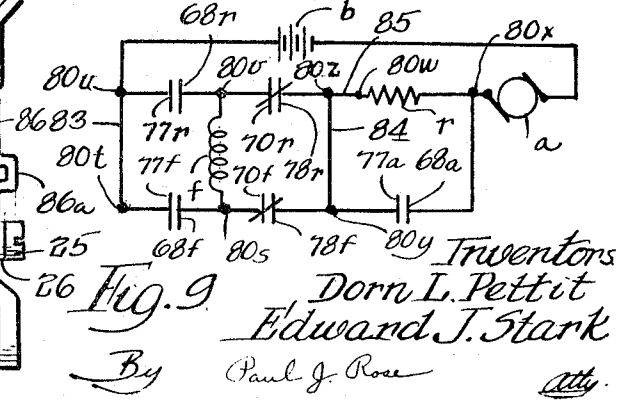


Fig. 9

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ELECTROMAGNETIC CONTACTOR

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15 Claims. (Cl. 335—193)

This invention relates to an improved direct-current electromagnetic contactor which is extremely compact and low in cost relative to its current carrying ability and is thus suitable for use on industrial electric trucks, electrically-powered golf carts, and the like. The small size of the improved contactor permits it to replace the automotive type contactors, sometimes referred to as "canned" contactors, heretofore used for such applications, and to provide many advantages thereover.

The improved contactor has both front and back (i.e., both normally open and normally closed) contacts and has its movable contacts at the free end of a cantilever. The resulting displacement of the path of movement of the contacts from the axis of a reciprocable actuating rod causes frictional engagement of the rod with its guide bearings thereby to reduce contact bounce of both the normally open and the normally closed contacts.

Bus bars or terminal straps carrying the stationary contacts of the improved contactor and a bus bar or terminal strap to which a flexible lead is attached are arranged with respect to the mounting surfaces of the contactor so that electrical connections to the contactors are easily made when two or more of the contactors are connected in a reversing and accelerating circuit for a direct-current series motor.

Another feature of the invention is that any arcing at the contacts upon separation thereof occurs at selected areas as a result of a blow-out effect in a direction away from insulating supports. The blow-out effect results from current paths through the bus and contact structure of the contactor.

FIG. 1 is a front elevational view of a contactor constructed in accordance with the invention;

FIG. 2 is a side elevational view of the contactor of FIG. 1;

FIG. 3 is a top plan view of the contactor of FIG. 1;

FIG. 4 is a sectional view taken substantially along the line 4—4 of FIG. 1;

FIG. 5 is a fragmentary view similar to the upper portion of FIG. 1, but showing the movable contacts shifted to a position corresponding with the energized condition of the coil of the contactor;

FIG. 6 is a top plan view of an assembly of three contactors similar to the contactor of FIGS. 1–5;

FIG. 7 is a front elevational view of the assembly of FIG. 6, with a portion broken away;

FIG. 8 is a side elevational view of the assembly of FIGS. 6 and 7; and

FIG. 9 is a circuit diagram for which the contactor assembly of FIGS. 6 and 7 is particularly adapted in the control of an electric truck or other electric battery powered vehicle.

FIGS. 1–5 disclose a contactor **20** constructed in accordance with the invention. The contactor **20** is provided with a magnet frame including a first generally L-shaped bracket **22** and a second generally L-shaped bracket **24**, a leg portion **22***a* of the bracket **22** serving as a back plate and having a leg portion **24***a* of the

bracket **24** secured thereto as by a pair of screws **25** provided with lock washers **26**. A leg portion **22***b* of the bracket **22** serves as a top plate and is spaced from a leg portion **24***b* of the bracket **24** serving as a bottom plate to define a space which receives a coil **28** wound on a spool **29** and having a pair of terminals **30**. The bracket **22** is provided with an offset extension **22***c* adjacent the end of the leg portion **22***a* opposite the leg portion **22***b*, a pair of mounting holes **32** being provided in the extension **22***c*. Welded or otherwise secured adjacent the end of the leg portion **22***a* opposite the extension **22***c* is a mounting plate **34** provided with a key-hole-shaped mounting aperture **35**.

A stepped terminal and stationary contact support block **38** formed of insulating material is secured to the upper surface of the leg portion **22***b* by a pair of screws **39** and **40**, the screws **39** being threaded into the leg portion **22***b* and the screw **40** being threaded into a tongue extension **22***d* extending from the leg portion **22***b* and recessed within the contact support block. The leg portion **22***b* is apertured to receive a reduced diameter end portion **42***a* of a generally cylindrical stationary magnetic core **42** which is welded or otherwise secured to the leg portion **22***b* on the opposite side thereof from the contact support block **38** and is received in a central aperture of the spool **29** adjacent one end thereof. An annular spring member **44** is disposed on the reduced diameter end portion **42***a* of the core **42** between the leg portion **22***b* and an upper flange **29***a* of the spool **29** to bias the spool **29** and the coil **28** thereon firmly against the leg portion **24***b* and prevent axial movement thereof relatively thereto. The core **42** is centrally apertured to receive an operating rod **45** mounted for reciprocal movement in a bushing **46** staked in the core at the reduced diameter end portion **42***a*.

The leg portion **24***b* is apertured to receive an annular portion **29***b* depending from a lower flange **29***c* of the spool **29**, which is thus held in assembled relationship with the brackets **22** and **24** respectively by the core **42** and the annular depending portion **29***b*. Further, to prevent the spool **29** and the coil **28** thereon from rotating with respect to the brackets and thus maintain the terminals **30** in proper position, the leg portion **24***b* is also apertured to receive a boss **29***d* depending from the flange **29***c* of the spool.

A generally cylindrical armature **47** is resiliently mounted on a lower end portion of the operating rod **45** for limited reciprocal movement relatively thereto and is also loosely guided for reciprocal movement in the spool **29**. In order to improve the flux pattern in the magnetic circuit when the coil **28** is energized to cause the armature **47** to be attracted toward the core **42**, the core **42** is conically recessed at its lower end as indicated at **42***b* and the armature **47** is provided at its upper end with a conical portion **47***a* complementary to and receivable in the recess **42***b*. The armature **47** is biased away from the core **42** by a return spring **48** encircling the operating rod **45**, seated at one end on the core within the recess **42***b*, and seated at the other end on the armature within an enlarged inner diameter portion provided in the conical portion **47***a*. The spring **48** is also a contact pressure spring for a pair of normally closed contacts hereinafter described. The armature is provided at its lower end with an enlarged inner diameter portion for receiving a plurality of washers **50**, an O-ring **51** formed of rubber or other elastic material, a collar **52**, a contact pressure spring **54** for a pair of normally open contacts

hereinafter described, and an annular bushing **56** staked or otherwise secured in place in the lower end of the armature and serving both as a seat for the spring **54** and a bushing for the operating rod **45**. The collar **52** is secured against movement axially of the operating rod and may be in the form of a snap ring snapped into a groove **45***a* in the operating rod. The O-ring **51** serves as a shock-absorber when the coil **28** is deenergized, as hereinafter explained.

A generally flat movable contact arm **57** is secured to but insulated from the operating rod **45** adjacent the other end thereof from the armature **47**. The contact arm is centrally apertured to receive a reduced end portion **58***a* of an upper insulator **58**, the end portion **58***a* extending through the contact arm into telescoping relationship with a lower insulator **60**. The upper end portion of the operating rod is reduced in diameter to provide a shoulder **61** against which a washer **62** seats. The extreme upper end portion of the operating rod **45** is threaded to receive a nut **64** which holds a washer **65**, a lock washer **66**, the insulator **58**, the contact arm **57**, the insulator **60**, and the washer **62** in position on the rod **45**. The lower end of the operating rod is slotted to receive a screwdriver while the nut **64** is tightened. Adjacent one end and on opposite sides, the movable contact arm is provided with a pair of movable contacts **68** and **70** brazed or otherwise secured thereto.

The stepped terminal and stationary contact support block **38** supports three bus bars or terminal straps **72**, **73**, and **74**, the terminal strap **72** being secured adjacent one end to an upper rear portion or step of the block **38** and extending forwardly to dispose the free other end portion thereof over the opposite end portion of the movable contact arm **57** from the contacts **68** and **70**, the terminal strap **73** being secured adjacent one end to the upper rear portion or step of the block **38** and extending forwardly in parallel, spaced and coplanar relationship with the terminal strap **72** to dispose the free other end portion thereof over the movable contact **68**, and the terminal strap **74** being secured adjacent one end to a lower front portion or step of the block **38** and extending rearwardly in parallel, spaced, and non-coplanar relationship with the terminal straps **72** and **73** to dispose the free other end portion thereof under the movable contact **70**.

A braided wire cable **76** is provided to electrically connect the terminal strap **72** and the contact arm **57**, opposite end portions of the cable being brazed or otherwise secured respectively to the lower surface of the free end portion of the terminal strap **72** and the lower surface of the end portion of the contact arm opposite the contact **70**. A stationary contact **77** is brazed or otherwise secured to the lower surface of the free end portion of the terminal strap **73** in normally open contact relationship with the movable contact **68**. The contacts **68** and **77** thus form the pair of normally open contacts having the contact pressure spring **54**. A stationary contact **78** is brazed or otherwise secured to the upper surface of the free end portion of the terminal strap **74** in normally closed relationship with the movable contact **70**. The contacts **70** and **78** thus form the pair of normally closed contacts having the contact pressure spring **48**. The terminal straps are respectively secured in place on the block **38** by three bolts **80** provided respectively with lock washers **81** and threaded into metal inserts (not shown) in the block **38**.

When the coil **28** is energized, the armature **47** is attracted upwardly into engagement with the core **42**, moving as a unit with the operating rod **45** during the first portion of its upward stroke and moving relatively to the operating rod during the latter portion of its upward stroke to compress the spring **54** after the connect **68** has engaged the contact **77** and thus establish pressure between the contacts **68** and **77**. When the coil **28** is deenergized, the spring **54** expands and pushes the bushing **56** and armature **47** downwardly relatively to the operating rod **45**, and the spring **48** expands to move the armature **47** and operating rod **45** downwardly to engage the contact **70** with the contact **78** and establish pressure therebetween, the O-ring **51** acting as a shock absorber.

In the deenergized condition of the coil **28**, the spring **48** acts through the armature **47** and collar **52** to exert a downward force resultant on the operating rod **45** collinear with the axis thereof, while an equal and opposite upward force resultant is exerted by the contact **78** on the contact **70** at a point spaced from the axis of the operating rod. The couple thus formed has a counterclockwise (FIG. 1) moment effect on the operating rod **45**, contact arm **57**, and armature **47** considered as a unit and increases the friction between the operating rod **45** and bushing **46** and between the armature **47** and spool **29** to reduce contact bounce upon deenergization of the coil **28**.

In the energized condition of the coil **28**, the spring **54** acts through the collar **52** to exert an upward force resultant on the operating rod **45** collinear with the axis thereof, while an equal and opposite downward force resultant is exerted by the contact **77** on the contact **68** at a point spaced from the axis of the operating rod. The couple thus formed has a clockwise (FIG. 5) moment effect on the operating rod **45** and contact arm **57** considered as a unit and increases the friction between the operating rod **45** and bushing **46** and between the operating rod **45** and bushing **56** to reduce contact bounce upon energization of the coil **28**.

The positional and directional terms such as "upper," "front," "downwardly," etc., as used herein are purely relative, it being possible to mount the contactor in various positions.

In the contactor **20** shown in FIGS. 1–5, the braided cable **76** and its associated terminal strap **72** are disposed toward the left end of the movable contact arm **57** in FIG. 1, while the movable contacts **68** and **70** and the associated stationary contacts **77** and **78** and terminal straps **73** and **74** are disposed toward the right end of the movable contact arm **57** in FIG. 1. Other arrangements are possible, and an assembly of contactors with varying arrangements of cables, contacts, and terminal straps is shown in FIGS. 6 and 7, the assembly of contactors being particularly adapted for use in a reversing and accelerating control circuit for a direct-current series motor and the arrangement of the cables, contacts, and terminal straps in the separate contactors and the arrangement of the contactors with each other being particularly adapted to permit easy connections to power source and motor terminals. The assembly of FIGS. 6 and 7 includes a contactor F identical to the contactor **20** of FIGS. 1–5, a contactor R identical to the contactor F except that the braided cable **76***r* and its associated terminal strap **72***r* are disposed toward the right end of the movable contact arm **57***r* and the movable contacts **68***r* and **70***r* (not shown) and the associated stationary contacts **77***r* and **78***r* (not shown) and and terminal straps **73***r* and **74***r* are disposed toward the left end of the movable contact arm **57***r*, and a contactor A identical to the contactor R except that the movable contact **70***a*, stationary contact **78***a*, and terminal strap **74***a* corresponding respectively to the movable contact **70***r*, stationary contact **78***r*, and terminal strap **74***r* have been omitted.

A bus bar **83** is provided to electrically connect the terminal strap **73***f* of the contactor F and the terminal strap **73***r* of the contactor R. A bus bar **84** is provided to electrically connect the terminal strap **74***f* of the contactor F and the terminal strap **74***r* of the contactor R. In addition, a solid wire conductor **85** is provided to electrically connect the bus bar **84** and the terminal strap **73***a* of the contactor A. The contactors F, R, and A are secured together by a tie bar **86** having a stiffening rib **86***a* and having appropriate apertures (not shown) for receiving the screws **25** which hold the brackets **22** and **24** of the respective contactors together.

The F, R, and A designations of the contactors indicate "Forward," "Reverse," and "Accelerate" in the control of

a direct-current series motor. In FIGS. 6 and 7, the bolts **80** of the contactors have been distinguished respectively by letter additions *s, t, u, v, w, x, y,* and *z*. The bolts **80***s*, **80***t*, **80***u*, **80***v*, **80***w*, **80***x*, **80***y*, and **80***z* serve as terminal connectors. As shown in the diagram of FIG. 9, the positive terminal of a battery *b* of an electric truck may be electrically connected to either of connectors or bolts **80***t* and **80***u*, which are joined by the bus bar **83**. A field winding *f* of a direct-current series motor of an electric truck may be electrically connected at opposite ends respectively to the connectors **80***s* and **80***v*. An armature winding *a* of the direct-current series motor may be electrically connected at opposite ends respectively to the connector **80***x* and the negative terminal of the battery *b*. A resistor *r* may be electrically connected at one end to any of the connectors **80***y*, **80***z*, and **80***w*, and at the other end to the connector **80***x*, the connectors **80***y* and **80***z* being joined by the bus bar **84** and the connectors **80***z* and **80***w* being joined by the conductor **85**.

When neither the contactor F nor the contactor R is energized, there is no circuit completed through the battery, because the circuit is open at the normally open contacts **68***f* and **77***f* of the contactor F and at the normally open contacts **68***r* and **77***r* of the contactor R. If the coil of the contactor F is then energized to cause the motor to rotate in the forward direction, the normally open contacts **68***f* and **77***f* are closed and the normally closed contacts **70***f* and **78***f* are opened. A circuit is then completed from the positive terminal of the battery *b* through the contacts **77***f* and **68***f*, through the field winding *f* in the direction from connector **80***s* to connector **80***v*, through the contacts **70***r* and **78***r*, the resistor *r*, and the armature winding *a* to the negative terminal of the battery *b*. If, while the contactor F is energized, the coil of the contactor A is then energized, the normally open contacts **68***a* and **77***a* are closed to by-pass the resistor *r* and cause the motor to rotate faster in the forward direction.

If, instead of the coil of the contactor F, the coil of the contactor R is energized to cause the motor to rotate in the reverse direction, the normally open contacts **68***r* and **77***r* are closed and the normally closed contacts **70***r* and **78***r* are opened. A circuit is then completed from the positive terminal of the battery *b* through the contacts **77***r* and **68***r*, through the field winding *f* in the direction from connector **80***v* to connector **80***s*, through the contacts **70***f* and **78***f*, the resistor *r*, and the armature winding *a* to the negative terminal of the battery *b*. If, while the contactor R is energized, the coil of the contactor A is then energized, the normally open contacts **68***a* and **77***a* are closed to by-pass the resistor *r* and cause the motor to rotate faster in the reverse direction.

The current path through any of the contactors F, R, and A when the coil of the respective contactor is energized is such that upon deenergization of the coil and separation of the normally open contacts **68***f* and **77***f*, **68***r* and **77***r*, or **68***a* and **77***a*, any arcing that occurs is subject to a desirable blow-out effect due to the tendency of the current loop to expand away from the insulators supporting the respective movable contact arm and away from the upper rear portion of the respective stationary contact block.

It will be seen that an improved contactor has been provided having a novel means of reducing contact bounce, and that a compact contactor assembly has been provided which affords easy connection of leads from a battery, a field winding, and an armature winding of a direct-current series motor.

Various modifications may be made in the structure shown and described without departing from the spirit and scope of the invention, as set forth in the claims appended hereto.

We claim:

1. An electromagnetic contactor comprising a magnet frame, an energizable coil magnetically associated with said magnet frame, an armature magnetically associated with said magnet frame and coil and reciprocable upon energization and deenergization of said coil, an operating rod having an end portion connected to said armature for reciprocation therewith, an elongated movable contact arm extending generally perpendicularly to and centrally supported by the other end portion of said operating rod, a bushing disposed between said armature and movable contact arm and reciprocally guiding said operating rod, a pair of terminal members respectively disposed adjacent opposite end portions of said movable contact arm, a flexible electrical conductor electrically connecting one of said terminal members and one end portion of said movable contact arm, said movable contact arm having a movable contact portion on the other end portion thereof, and the other of said terminal members having a stationary contact portion engageable by said movable contact portion of said movable contact arm upon energization of said coil, the reaction force of said stationary contact portion against said movable contact arm tending to tilt said operating rod and increasing friction between said operating rod and said bushing to reduce contact bounce upon energization of said coil.

2. An electromagnetic contactor comprising a magnet frame, an energizable coil magnetically associated with said magnet frame, an armature magnetically associated with said magnet frame and coil and reciprocable upon energization and deenergization of said coil, an operating rod having an end portion extending through said armature for reciprocal movement relatively thereto, a first bushing disposed in said armature and reciprocally guiding said operating rod, an elongated movable contact arm extending generally perpendicularly to and centrally supported by the other end portion of said operating rod, a spring in said armature biasing said armature with respect to said operating rod in a direction away from said movable contact arm, a second bushing disposed between said armature and movable contact arm and reciprocally guiding said operating rod, a pair of terminal members respectively disposed adjacent opposite end portions of said movable contact arm, a flexible electrical conductor electrically connecting one of said terminal members and one end portion of said movable contact arm, said movable contact arm having a movable contact portion on the other end portion thereof, and the other of said terminal members having a stationary contact portion engageable by said movable contact portion of said movable contact arm upon energization of said coil, the reaction force of said stationary contact portion against said movable contact arm tending to tilt said operating rod and increasing friction between said operating rod and said first and second bushings to reduce contact bounce upon energization of said coil.

3. An electromagnetic contactor comprising a magnet frame, an energizable coil magnetically associated with said magnet frame, an armature magnetically associated with said magnet frame and coil and reciprocable upon energization and deenergization of said coil, said armature having a portion reciprocally guided by said coil, an operating rod having an end portion connected to said armature for reciprocation therewith, an elongated movable contact arm extending generally perpendicularly to and centrally supported by the other end portion of said operating rod, a bushing disposed between said armature and movable contact arm and reciprocally guiding said operating rod, a first terminal member disposed adjacent an end portion of said movable contact arm, a flexible electrical conductor electrically connecting said first terminal member and said end portion of said movable contact arm, a second terminal member and a third terminal member disposed adjacent the other end portion of said movable contact arm on opposite sides thereof, said other end portion of said movable contact arm having a pair of movable contact portions respectively on opposite sides thereof, said second terminal

member having a stationary contact portion engageable by one of said movable contact portions of said movable contact arm upon energization of said coil, and said third terminal member having a stationary contact portion engageable by the other of said movable contact portions of said movable contact arm upon deenergization of said coil, the reaction force of said stationary contact portion of said third terminal member against said movable contact arm tending to tilt said operating rod and armature and increasing friction between said operating rod and said bushing and between said armature and said coil to reduce contact bounce upon deenergization of said coil.

4. An electromagnetic contactor comprising a magnet frame, an energizable coil magnetically associated with said magnet frame, an armature magnetically associated with said magnet frame and coil and reciprocable upon energization and deenergization of said coil, said armature having a portion reciprocally guided by said coil, an operating rod having an end portion extending through said armature for reciprocal movement relatively thereto, a first bushing disposed in said armature and reciprocally guiding said operating rod, an elongated movable contact arm extending generally perpendicularly to and centrally supported by the other end portion of said operating rod, a spring in said armature biasing said armature with respect to said operating rod in a direction away from said movable contact arm, a second bushing disposed between said armature and movable contact arm and reciprocally guiding said operating rod, a first terminal member disposed adjacent an end portion of said movable contact arm, a flexible electrical conductor electrically connecting said first terminal member and said end portion of said movable contact arm, a second terminal member and a third terminal member disposed adjacent the other end portion of said movable contact arm on opposite sides thereof, said other end portion of said movable contact arm having a pair of movable contact portions respectively on opposite sides thereof, said second terminal member having a stationary cotnact portion engageable by one of said movable contact portions of said movable contact arm upon energization of said coil, and said third terminal member having a stationary contact portion engageable by the other of said movable contact portions of said movable contact arm upon deenergization of said coil, the reaction force of said stationary contact portion of said second terminal member against said movable contact arm tending to tilt said operating rod in one direction and increasing friction between said operating rod and said first and second bushings to reduce contact bounce upon energization of said coil, and the reaction force of said stationary contact portion of said third terminal member against said movable contact arm tending to tilt said operating rod and armature in the other direction and increasing friction between said operating rod and said second bushing and between said armature and said coil to reduce contact bounce upon deenergization of said coil.

5. An electromagnetic contactor comprising a stepped terminal and stationary contact block formed of insulating material and having upper and lower step portions, a pair of spaced terminal straps respectively mounted on said upper step portion adjacent opposite ends thereof and having end portions extending over said lower step portion in spaced relationship thereto, a reciprocably mounted operating rod extending through said lower step portion between said terminal straps, an elongated generally flat movable contact arm centrally supported by said operating rod in insulated relationship thereto and disposed between said end portions of said terminal straps and said lower step portion, a flexible electrical conductor electrically connecting said end portion of one of said terminal straps and one end portion of said movable contact arm, a movable contact on the other end portion of said movable contact arm on the side thereof facing the other of said terminal straps, energizable and deenergizable electromagnetic means for reciprocably moving said terminal straps and one end portion of said movable portion of said other terminal strap engageable by said movable contact upon energization of said electromagnetic means.

6. An electromagnetic contactor as claimed in claim 5, including a third terminal strap mounted on said lower step portion and having an end portion adjacent said other end portion of said movable contact arm, a second movable contact on said other end portion of said movable contact arm on the side thereof facing said third terminal strap, and a stationary contact on said end portion of said third terminal strap engageable by said second movable contact upon deenergization of said electromagnetic means.

7. An electromagnetic contactor comprising a generally U-shaped magnet frame, an energizable coil supported within said magnet frame between a pair of leg portions thereof, a stationary core in said coil adjacent one end thereof, a movable armature in said coil adjacent the other end thereof and adapted to be attracted toward said core upon energization of said coil, a stepped terminal and stationary contact block formed of insulating material and supported on the one of said leg portions adjacent said core on the other side of said one leg portion from said coil, an operating rod connected to said armature and extending through said core, magnet frame, and block, an elongated generally flat movable contact arm supported centrally thereof on and in insulated relationship to an end portion of said operating rod extending outwardly of said block, a spring between said core and armature biasing said armature, operating rod, and movable contact arm in a direction tending to move said movable contact arm toward said block, a movable contact mounted on one end portion of said movable contact arm on the opposite side thereof from said coil, a first terminal strap having one end portion mounted on a step of said block remote from said coil and extending in spaced relationship to a step of said block adjacent said coil and having its other end portion disposed in overlapping spaced relationship to said movable contact, a stationary contact mounted on said other end portion of said first terminal strap on the side thereof facing said coil and adapted to be engaged by said movable contact upon energization of said coil, a second terminal strap having one end portion mounted on said step of said block remote from said coil and extending in spaced relationship to said step of said block adjacent said coil and having its other end portion disposed in overlapping spaced relationship to the other end portion of said movable contact arm, and a flexible electrical conductor electrically connecting said other end portion of said second terminal strap and said other end portion of said movable contact arm.

8. An electromagnetic contactor as claimed in claim 7, including a second movable contact mounted on said one end portion of said movable contact arm on the side thereof facing said coil, a third terminal strap having one end portion mounted on said step of said block adjacent said coil and extending therealong and having its other end portion disposed in overlapping spaced relationship to said second movable contact, and a stationary contact mounted on said other end portion of said third terminal strap on the opposite side thereof from said coil and adapted to be engaged by said second movable contact when said coil is deenergized.

9. An electromagnetic contactor as claimed in claim 7, wherein said armature is reciprocably mounted on said operating rod and a spring is provided in said armature, said spring biasing said armature toward the end of said operating rod opposite said movable contact arm.

10. An electromagnetic contactor as claimed in claim 8, wherein said armature is reciprocably mounted on said operating rod and a spring is provided in said armature.

said spring biasing said armature toward the end of said operating rod opposite said movable contact arm.

11. An assembly of electromagnetic contactors particularly adapted to control the operation of a direct-current motor having a field winding in series with an armature winding, said assembly comprising first and second electromagnetic contactors mounted side by side, each of said contactors including a stepped terminal and stationary contact block formed of insulating material and having upper and lower step portions, a pair of spaced terminal straps respectively mounted on said upper step portion adjacent opposite ends thereof and having ends portions extending over said lower step portion in spaced relationship thereto, a reciprocably mounted operating rod extending through said lower step portion between said terminal straps, an elongated generally flat movable contact arm centrally supported by said operating rod in insulated relationship thereto and disposed between said end portions of said terminal straps and said lower step portion, and energizable and deenergizable electromagnetic means for reciprocably moving said operating rod, said first contactor including a flexible electrical conductor electrically connecting the terminal strap on the respective upper step portion and remote from said second contactor and the end portion of the respective movable contact arm remote from said second contactor, a pair of movable contacts on the end portion of the respective movable contact arm adjacent said second contactor and respectively disposed on opposite sides of the respective movable contact arm, a stationary contact disposed on the other terminal strap on the respective upper step portion adjacent said second contactor and engageable by one of the respective movable contacts upon energization of the respective electromagnetic means, a terminal strap mounted on the respective lower step portion adjacent the end thereof adjacent said second contactor, and a stationary contact disposed on the terminal strap on the respective lower step portion and engageable by the other of the respective movable contacts upon deenergization of the respective electromagnetic means, said second contactor including a flexible electrical conductor electrically connecting the terminal strap on the respective upper step portion and remote from said first contactor and the end portion of the respective movable contact arm remote from said first contactor, a pair of movable contacts on the end portion of the respective movable contact arm adjacent said first contactor and respectively disposed on opposite sides of the respective movable contact arm, a stationary contact disposed on the terminal strap on the respective upper step portion adjacent said first contactor and engageable by one of the respective movable contacts upon energization of the respective electromagnetic means, a terminal strap mounted on the respective lower step portion adjacent the end thereof adjacent said first contactor, and a stationary contact disposed on the terminal strap on the respective lower step portion and engageable by the other of the respective movable contacts upon deenergization of the respective electromagnetic means, a first electrical conductor electrically connecting the terminal strap on the upper step portion of said first contactor adjacent said second contactor and the terminal strap on the upper step portion of said second contactor adjacent said first contactor, and a second electrical conductor electrically connecting the terminal strap on the lower step portion of said first contactor and the terminal strap on the lower step portion of said second contactor.

12. An assembly as claimed in claim 11, wherein said first and second electrical conductors are generally flat bus bars.

13. An assembly of electromagnetic contactors particularly adapted to control the operation of a direct-current motor having a field winding in series with an armature winding, said assembly comprising first, second, and third electromagnetic contactors mounted side by side in a row, each of said contactors including a stepped terminal and stationary contact block formed of insulating material and having upper and lower step portions, a pair of spaced terminal straps respectively mounted on said upper step portion adjacent opposite ends thereof and having end portions extending over said lower step portion in spaced relationship thereto, a reciprocably mounted operating rod extending through said lower step portion between said terminal straps, an elongated generally flat movable contact arm centrally supported by said operating rod in insulated relationship thereto and disposed between said end portions of said terminal straps and said lower step portion, and energizable and deenergizable electromagnetic means for reciprocably moving said operating rod, said first contactor being disposed adjacent said second contactor and including a flexible electrical conductor electrically connecting the terminal strap on the respective upper step portion and remote from said second contactor and the end portion of the respective movable contact arm remote from said second contactor, a pair of movable contacts on the end portion of the respective movable contact arm adjacent said second contactor and respectively disposed on opposite sides of the respective movable contact arm, a stationary contact disposed on the other terminal strap on the respective upper step portion adjacent said second contactor and engageable by one of the respective movable contacts upon energization of the respective electromagnetic means, a terminal strap mounted on the respective lower step portion adjacent the end thereof adjacent said second contactor, and a stationary contact disposed on the terminal strap on the respective lower step portion and engageable by the other of the respective movable contacts upon deenergization of the respective electromagnetic means, said second contactor including a flexible electrical conductor electrically connecting the terminal strap on the respective upper step portion and remote from said first contactor and the end portion of the respective movable contact arm remote from said first contactor, a pair of movable contacts on the end portion of the respective movable contact arm adjacent said first contactor and respectively disposed on opposite sides of the respective movable contact arm, a stationary contact disposed on the terminal strap on the respective upper step portion adjacent said first contactor and engageable by one of the respective movable contacts upon energization of the respective electromagnetic means, a terminal strap mounted on the respective lower step portion adjacent the end thereof adjacent said first contactor, and a stationary contact disposed on the terminal strap on the respective lower step portion and engageable by the other of the respective movable contacts upon deenergization of the respective electromagnetic means, said third contactor being disposed adjacent one of said first and second contactors and including a flexible electrical conductor electrically connecting one of the terminal straps on the respective upper step portion and one of the end portions of the respective movable contact arm, a movable contact on the other end portion of the respective movable contact arm and disposed on the side of the respective movable contact arm facing the other of the terminal straps on the respective upper step portion, and a stationary contact disposed on said other terminal strap on the respective upper step portion and engageable by the respective movable contact upon energization of the respective electromagnetic means, a first electrical conductor electrically connecting the terminal strap on the upper step portion of said first contactor adjacent said second contactor and the terminal strap on the upper step portion of said second contactor adjacent said first contactor, a second electrical conductor electrically connecting the terminal strap on the lower step portion of said first contactor and the terminal strap on the lower step portion of said second contactor, and a third electrical conductor electrically connecting

said second electrical conductor and said other terminal strap of said third contactor.

14. An assembly as claimed in claim **13**, wherein said first and second electrical conductors are generally flat bus bars.

15. An assembly as claimed in claim **13**, wherein the end portion of said movable contact arm of said third contactor having said movable contact mounted thereon is disposed adjacent said one of said first and second contactors and the end portion of said movable contact arm of said third contactor having said flexible electrical conductor connected thereto is disposed remote from said one of said first and second contactors.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,284,742 November 8, 1966

Dorn L. Pettit et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 17, for "screws" read -- screw --; column 3, line 70, for "connect" read -- contact --; column 4, line 55, for "and and" read -- and --; column 7, line 39, for "cotnact" read -- contact --; column 8, line 2, strike out "terminal straps and one end portion of said movable" and insert instead -- operating rod, and a stationary contact on said end --; column 9, line 12, for "ends" read -- end --.

Signed and sealed this 12th day of September 1967.

(SEAL)
Attest:

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