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Wieloch et al.

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[54] **ELECTROMAGNETIC CONTACTOR WITH OVERLOAD RELAY**

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[51] **Int. Cl.**[7] **H01H 67/02**

[52] **U.S. Cl.** **335/132**; 335/10; 335/18; 335/202; 335/8

[58] **Field of Search** 335/6, 8, 10, 18, 335/132, 202

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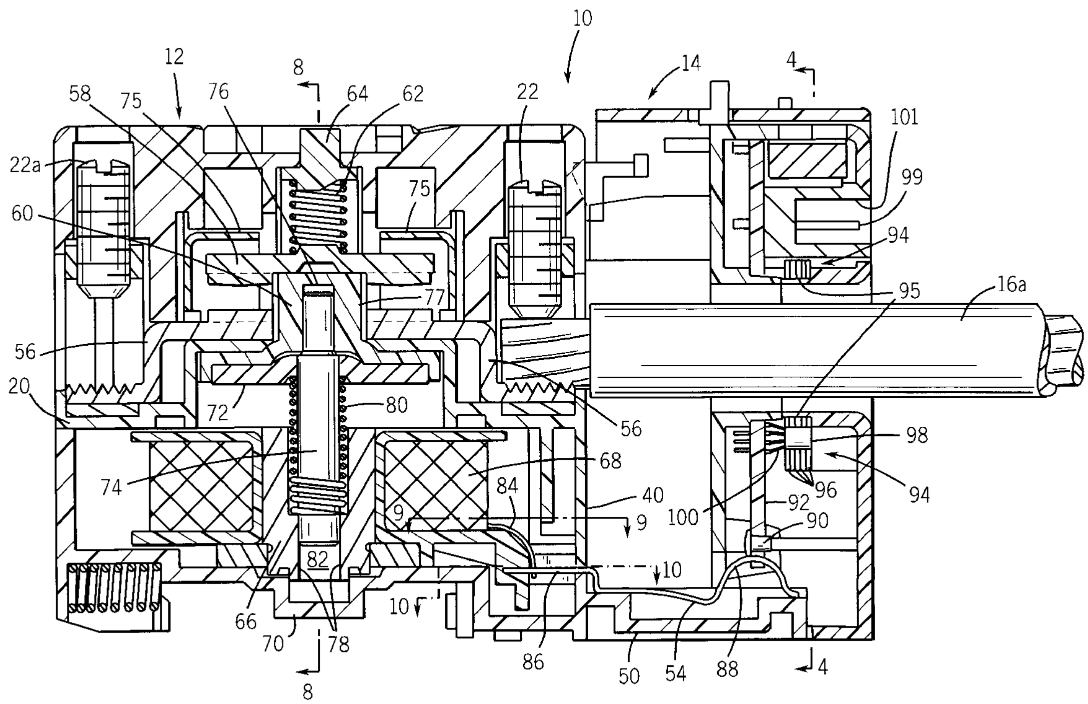
Attorney, Agent, or Firm—Boyle Fredrickson Ziolkowski S.C.; Timothy J. Ziolkowski; Larry Vande Zande

[57] **ABSTRACT**

An electromagnetic starter with an overload relay having magnetic flux shielding is disclosed for use in industrial contactor applications. The starter includes a multi-pole DC controlled contactor which is interlockingly coupled to an overload relay. The overload relay has a simplified interlocking connection to the contactor, which when made, corresponds to an abutting electrical connection between the contactor and the overload relay also being made. The contactor further has a guiding pin that promotes even contact closure within the contactor.

25 Claims, 6 Drawing Sheets



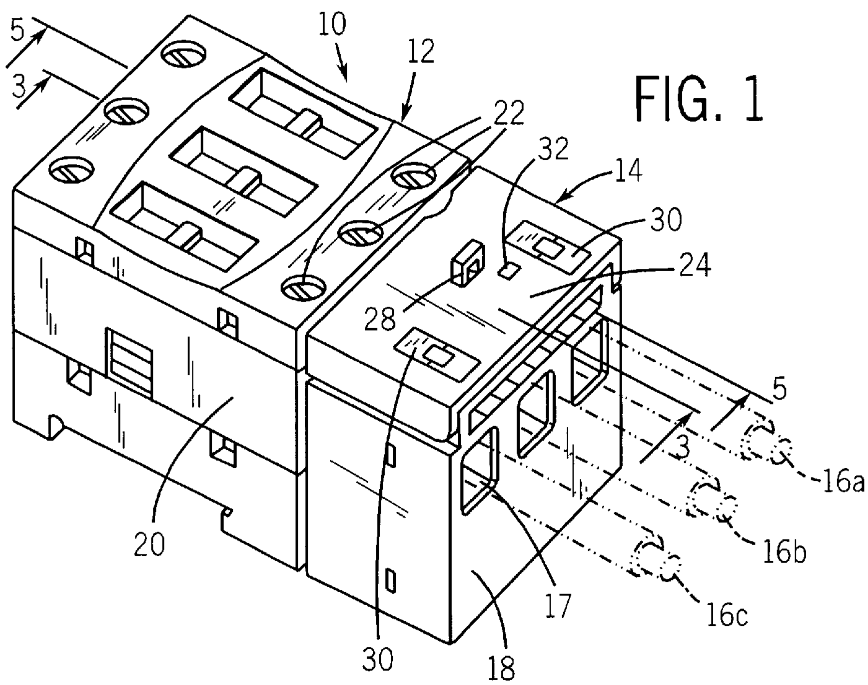
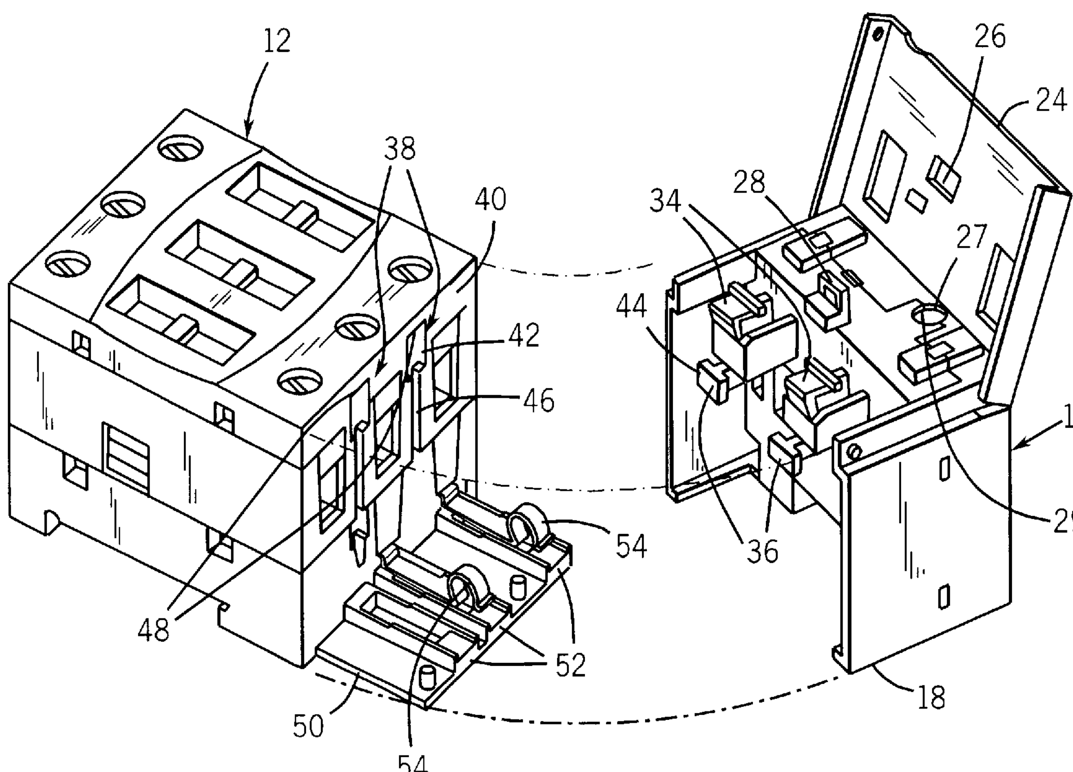

10
12
5
3
22
32
14
30
24
28
5
3
16a
16b
16c
17
20
30
18

FIG. 1


12
38
40
42
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50
52
54
54
26
24
28
34
27
44
14
36
29
18

FIG. 2

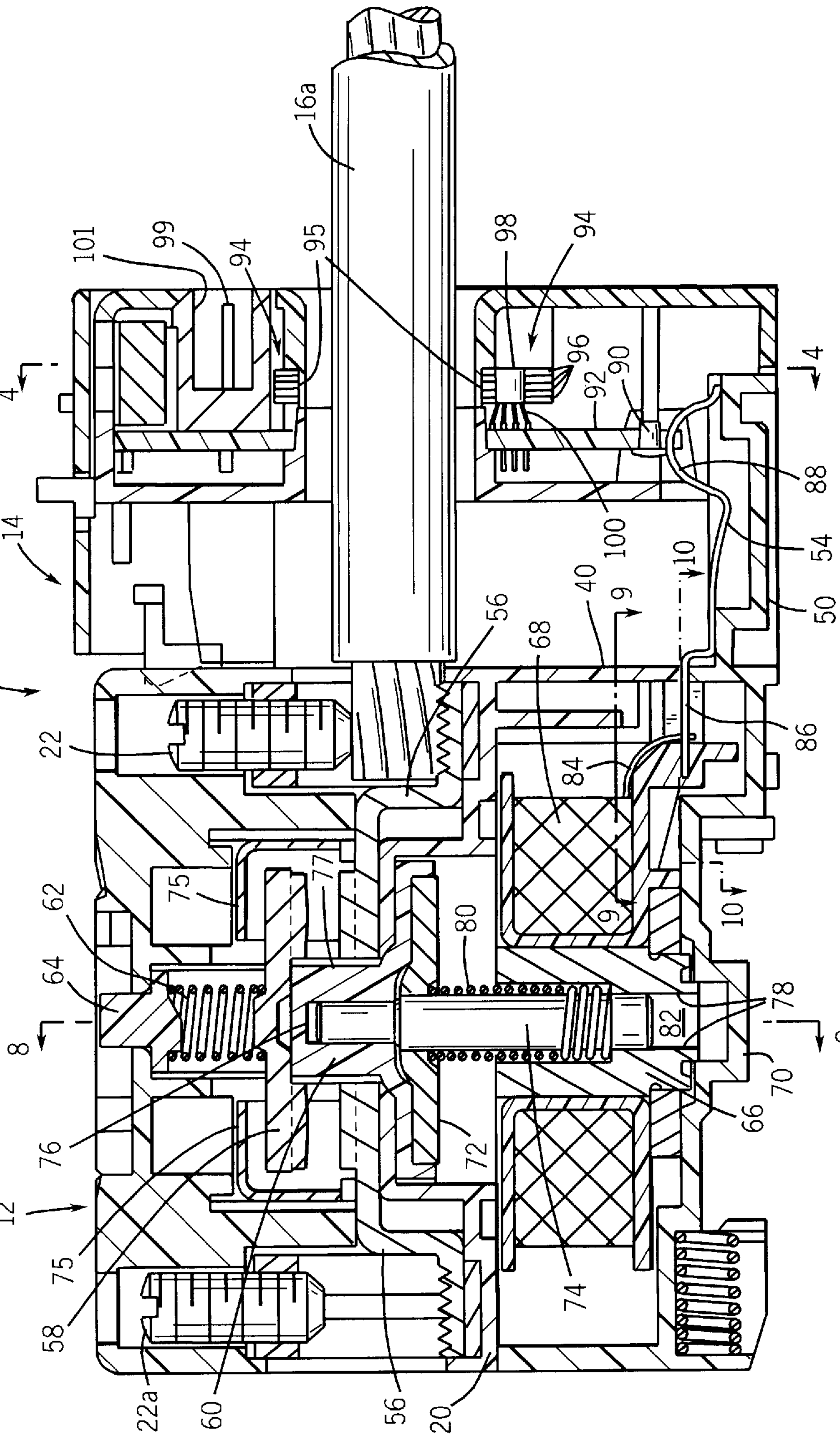

16a
101
99
94
95
98
94
96
90
92
88
100
54
14
4
4
10
40
9
10
50
56
68
86
84
22
10
75
77
9
10
62
80
64
78
82
8
8
70
66
76
72
12
75
74
58
22a
60
56
20

FIG. 3

FIG. 4

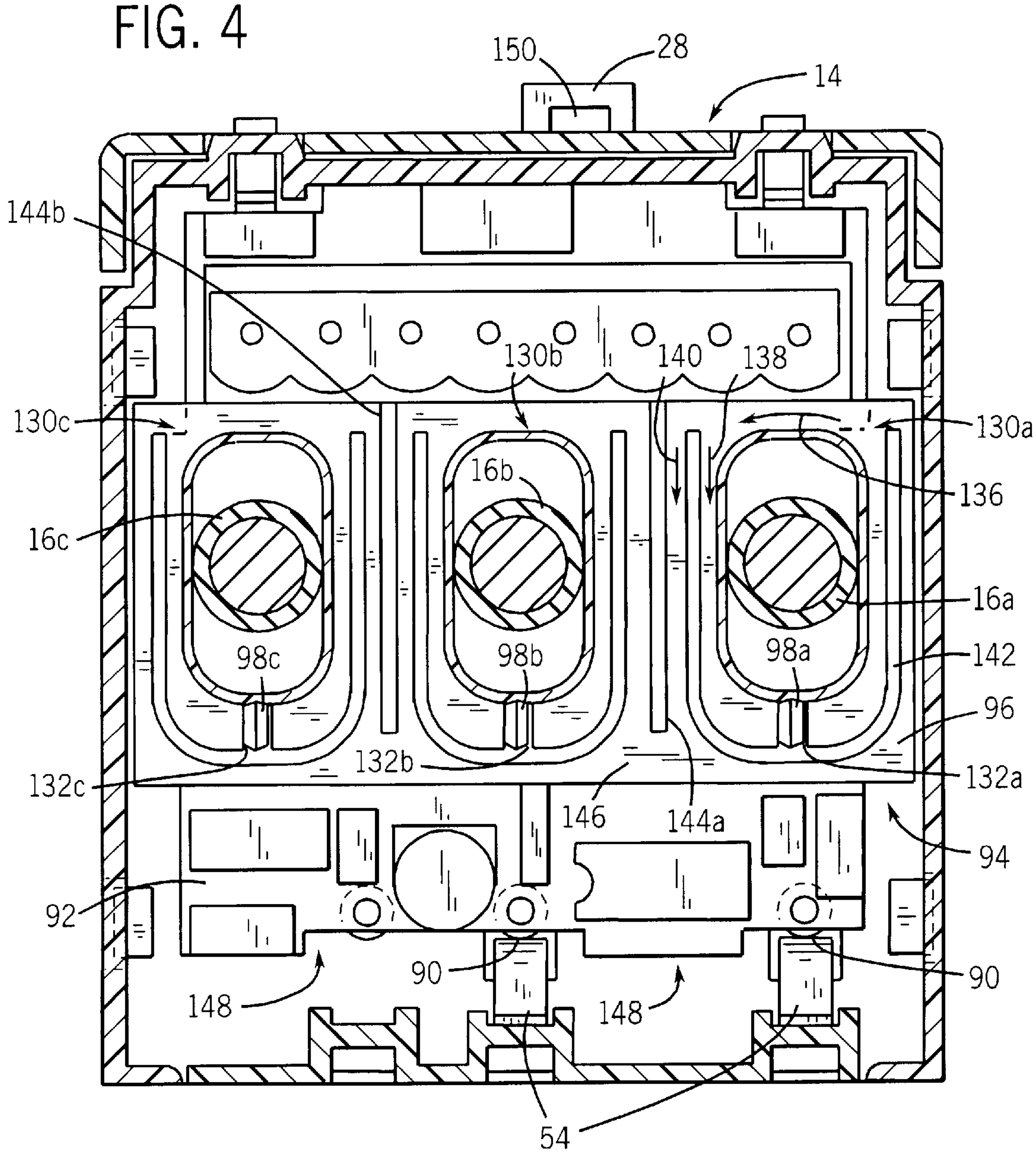
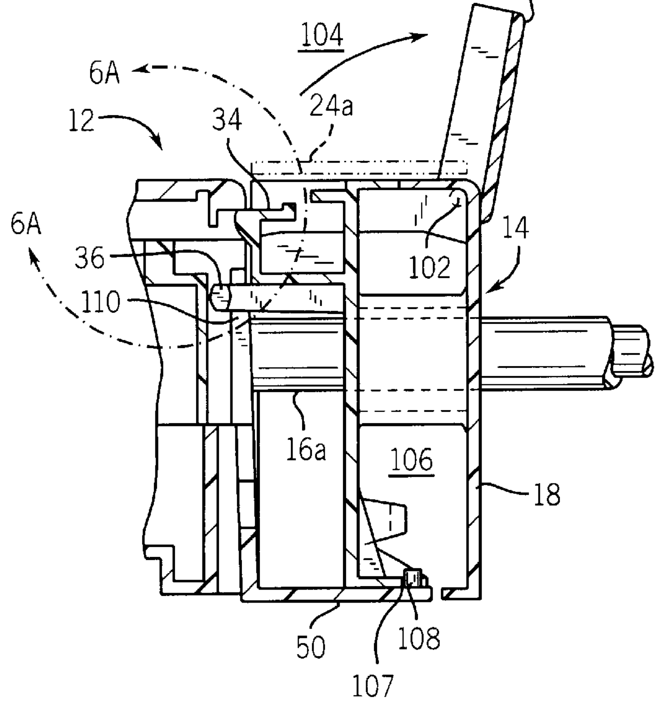

150
28
14
144b
130b
140
138
130c
130a
16b
136
16c
16a
98c
98b
98a
142
96
132c
132b
132a
146
144a
94
92
90
90
148
148
54

FIG. 5



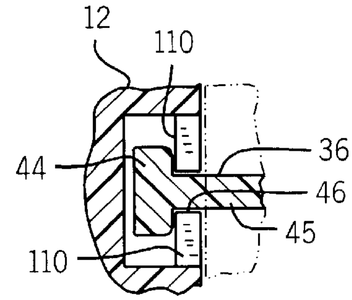


FIG. 6C

FIG. 6A

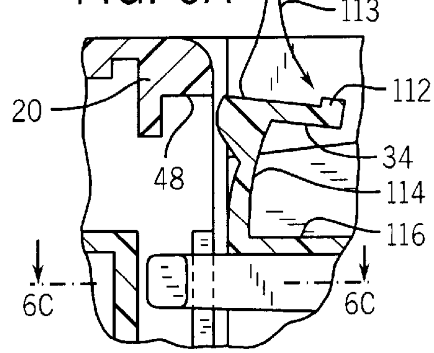


FIG. 7

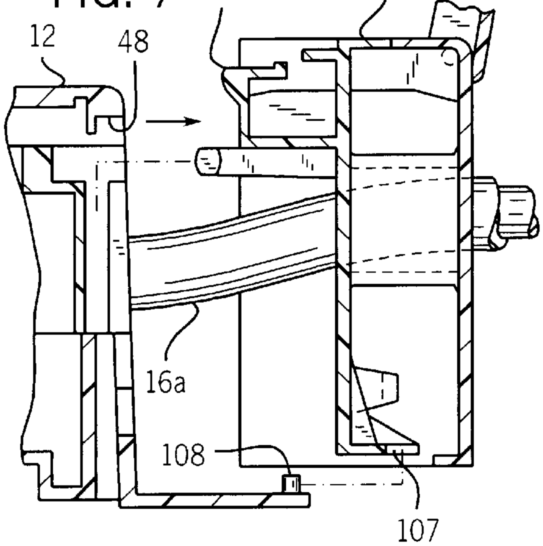


FIG. 6B

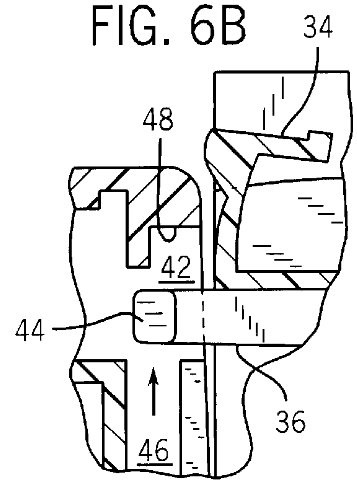


FIG. 8

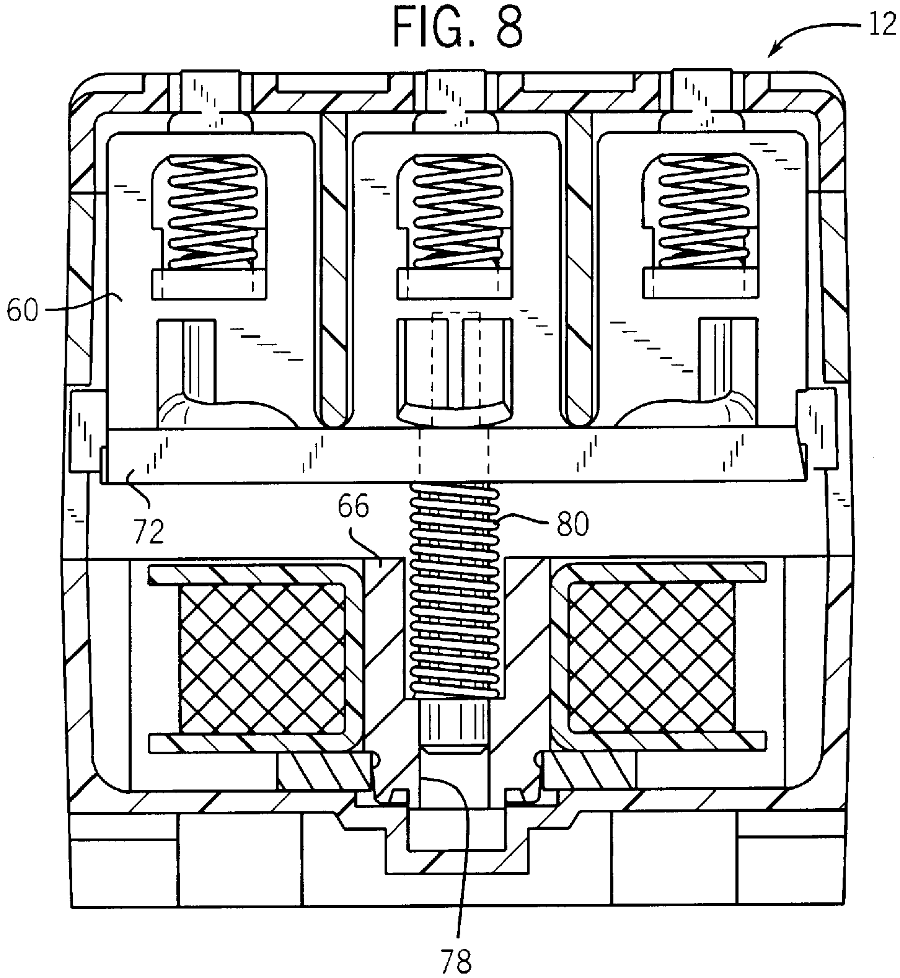


FIG. 9

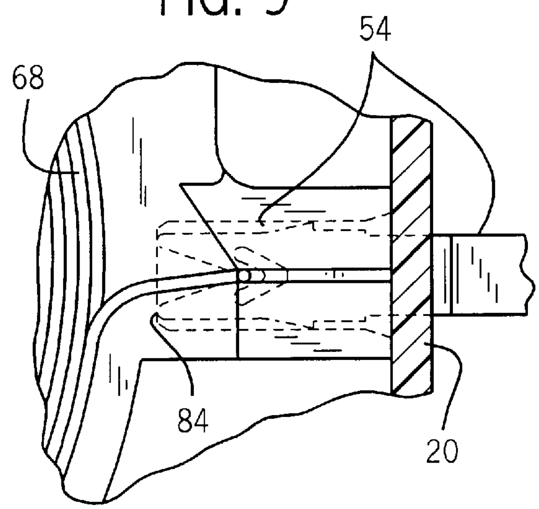


FIG. 10

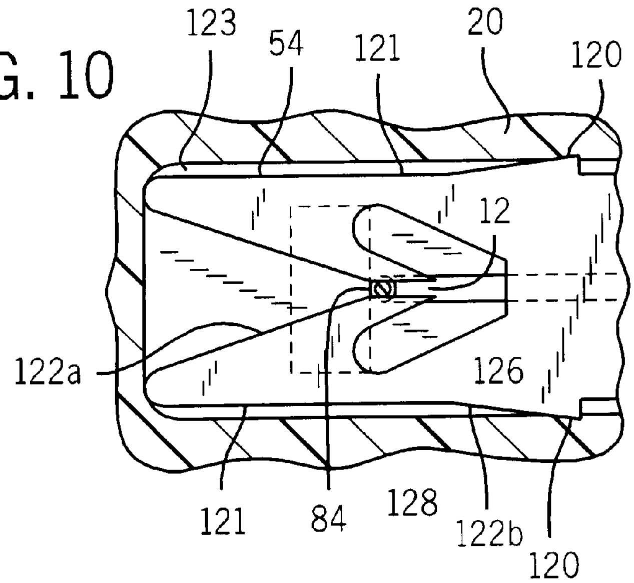
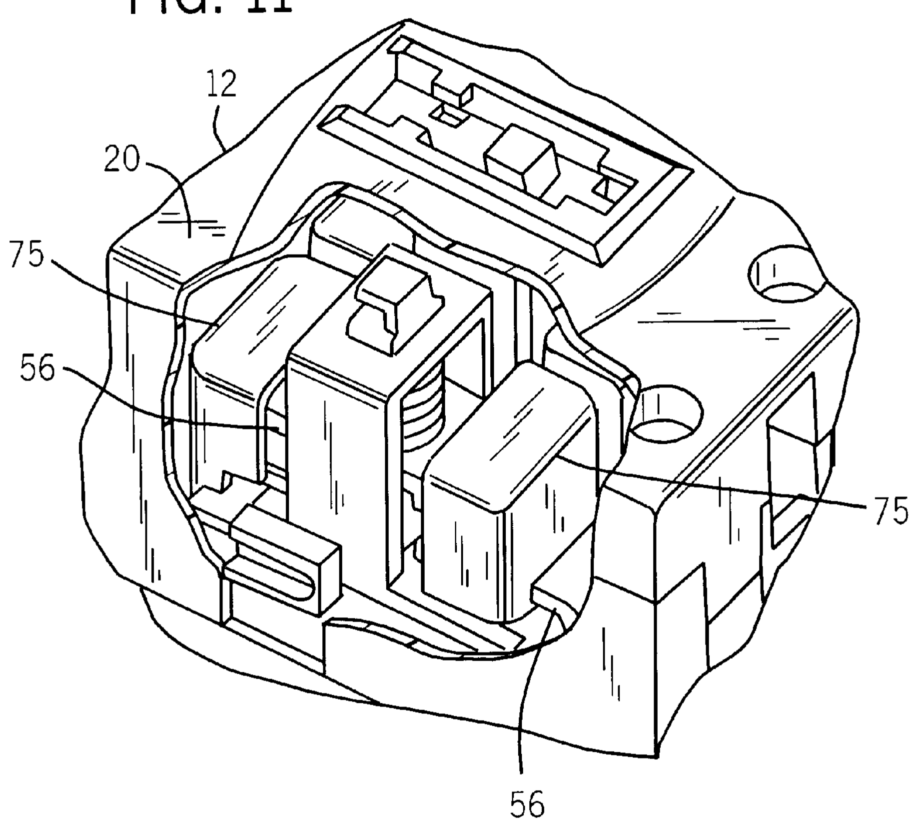


FIG. 11



ELECTROMAGNETIC CONTACTOR WITH OVERLOAD RELAY

BACKGROUND OF THE INVENTION

The present invention relates generally to electromagnetic contactors, and more particularly to a contactor which is coupled to an overload relay to form an electric motor starter that provides overcurrent protection in order to prevent current overloading to a load, i.e. a motor.

In electromagnetic starter applications, an overload relay is used to protect a particular load, such as a motor, from excessive currents. Known overload relays incorporate bi-metal switches and heaters in the overload relay connected in series with contacts of the contactor. However, these devices require separate invasive connections between the contactor and overload relay, and their presence increases the cost and size of the starter. Therefore, it would be desirable to have a smaller, lower cost overload relay having a simplified non-invasive connection to the contactor that eliminates the necessity for other devices connected to the contactor.

Another problem associated with the operation of a electromagnetic contactor is a tendency for a moveable contact carrier to lock during travel to and from an energized electromagnetic core. The random locking of the moveable contact carrier prevents the precise control of contactor timing required in industrial contacts.

Therefore, it would be desirable to have an electromagnetic contactor with an overload relay having a simplified non-invasive electrical connection through the overload relay to a contactor, that prevents cross-pole magnetic flux transfer and provides a smooth travel path for a moveable contact carrier in the contactor as it travels to and from an electromagnetic coil.

SUMMARY OF THE INVENTION

The present invention provides an electromagnetic starter that provides a simplified connection between a contactor and an overload relay which provides a simplified non-invasive connection to the contactor, provides more accurate magnetic field sensor readings within the overload relay, and maintains smooth operation of the contactor by providing even contact closure and opening.

The present invention includes a starter having a multi-phase DC controlled contactor. The contactor includes a pair of stationary contacts mounted within a contactor housing. A moveable contact is mounted in operable association with the stationary contacts, and is carried by a moveable contact carrier slidably mounted to the contactor housing. The contactor includes an electromagnetic coil mounted to the contactor housing for attracting the moveable contact carrier. Extending out from the contactor housing is at least one flexible coil terminal attached at one end to the electromagnetic coil. The starter also includes an overload relay interlockingly coupled to the contactor. In a preferred embodiment, the overload relay includes at least one retaining projection which extends from the overload relay and a flexing lock tab integral with each retaining projection. The contactor has a receiving channel to receive the retaining projection and a retaining channel which is narrower than the receiving channel. When the contactor is coupled to the overload relay, the retaining projection enters the receiving channel and proceeds downwardly through the retaining channel until the flexing lock tab snaps into a lip of the contactor. The overload relay is then prevented from being removed from the contactor. The flexible coil terminal abuts

an electrical conductor on the printed circuit board to provide the electrical connection between the contactor and the overload relay. A printed circuit board resides within the overload relay housing for controlling power to the contactor.

Various other features, objects and advantages of the present invention will be made apparent from the following detailed description and the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings illustrate the best mode presently contemplated for carrying out the invention.

In the drawings:

FIG. **1** is a perspective view of a contactor with an overload relay connected thereto to form a motor starter in accordance with the present invention.

FIG. **2** is a perspective view of the starter of FIG. **1** with the contactor and the overload relay separated.

FIG. **3** is a cross-sectional view taken along line **3**—**3** of FIG. **1**. with the contactor and the overload relay connected.

FIG. **4** is a lateral cross-sectional view of the overload relay taken along line **4**—**4** of FIG. **3**.

FIG. **5** is a partial cross-sectional view taken along line **5**—**5** of FIG. **1**

FIG. **6**A is an enlarged partial view of section **6**A of FIG. **5** showing the initial disengagement of the overload relay from the contactor.

FIG. **6**B is a view similar to that of FIG. **6**A but with the overload relay further disengaged from the contactor.

FIG. **6**C is a partial cross-sectional view taken along line **6**C of FIG. **6**A showing the retention of the retaining projection of the overload relay by the contactor housing.

FIG. **7** is a view similar to that of FIG. **5**, but with the overload relay disconnected from the contactor.

FIG. **8** is a lateral cross-sectional view of the contactor taken along line **8**—**8** of FIG. **3**.

FIG. **9** is a partial cross-sectional view taken along line **9**—**9** of FIG. **3**.

FIG. **10** is a partial cross-sectional view taken along line **10**—**10** of FIG. **3**.

FIG. **11** is a partial perspective view of the contactor of FIG. **1** with the contactor housing partially removed to show the arc shields in accordance with one aspect of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **1**, a starter **10** is shown in perspective view. Starter **10** is a multi-phase DC starter as is used in industrial control applications, such as motor control, and includes contactor **12** and overload relay **14**. Contactor **12** is an electromagnetic contactor for switching supply current to a motor (not shown), while the overload relay **14** senses and measures the current to the motor, and shuts off or de-energizes the contactor **12** if too much current (overload) is flowing to the motor, thus protecting the motor. Overload relay **14** is shown connected with the contactor **12**. Overload relay **14** accepts a series of conductors **16***a*, **16***b* and **16***c* (shown partially in phantom) through overload relay housing **18**, to contactor housing **20** to be secured by lugs **22**. Overload relay **14** includes a pivotable cover **24** shown in a cover closed position. Overload relay cover **24** further includes an aperture (**26** of FIG. **2**) such that when cover **24** is in the cover closed position, a locking hasp **28** extends through cover **24** via aperture **26**. Other items such as switches **30** and LED indicator **32** may also show through or extend through cover **24** in a similar manner.

Referring to FIG. **2**, the cover **24** of the overload relay **14** is shown in a cover open position. The cover **24** in the cover open position permits visualization of conductors **16***a*, **16***b* and **16***c* (of FIG. **1**) as inserted through openings **17** in the overload relay **14** and into the contactor **12** during installation. Overload relay housing **18** includes a circular opening through which the rotary knob of a potentiometer **27** connected to a printed circuit board is disposed. Potentiometer **27** includes a screwdriver type slot **29** for adjustment of the full load amperage of the particular motor with which the starter **10** is to be used. Potentiometer **27** is covered when cover **24** is in the cover closed position, and a seal inserted through locking hasp **28** prevents unknown later adjustment of potentiometer **27**.

Contactor **12** is shown separated from overload relay **14** to better show the connection therebetween. In order to make the connection, the overload relay **14** includes flexing lock tabs **34**, which are each connected to a retaining projection **36**. Preferably, retaining projection **36** is T shaped as will be described in further detail with respect to FIGS. **6**A–**6**C. Retainer projections **36** are insertable into connecting slots **38** within housing wall **40** of contactor **12**. Each connecting slot **38** preferably has a general T shape with a receiving channel **42** for initially receiving the head **44** of retaining projection **36**. Receiving channel **42** terminates at one end in a retaining channel **46** which is narrower than the receiving channel **42**. During connection, the retaining projection **36** enters the receiving channel **42** and proceeds downwardly through the retaining channel **46**. Preferably, the head **44** of retaining projection **36** is wider than the retaining channel **46**, thereby preventing removal of retaining projection **36** through retaining channel **46**. The retaining projection **36** proceeds downwardly through retaining channel **46** until flexing lock tabs **34** snap under lip **48** of contactor housing wall **40**. One of ordinary skill will recognize that a different number of retaining projections **36** and connecting slots **38** may be utilized to accomplish a similar connection.

The contactor **12** includes a platform **50** which is integral with and extends substantially transversely to the plane of contactor wall **40**. Platform **50** includes supports **52** for supporting flexible coil terminals **54** which extend outwardly from within the contactor **12**. Although two flexible coil terminals are shown, it is contemplated that other numbers and arrangements of flexible coil terminals may be utilized. When coupled, the overload relay **14** is placed over the platform **50** to make an electrical connection with flexible coil terminals **54**.

Referring to FIG. **3**, the starter **10** is shown with contactor **12** connected to the overload relay **14**. The overload relay **14** has a simplified connection to the contactor **12** that includes a snap fit physical connection and an abutting electrical connection, which occur at substantially the same time.

Contactor **12** includes stationary contacts **56** mounted to the contactor housing **20**. A moveable contact **58** is mounted **5** to a moveable contact carrier **60**. The moveable contact **58** is biased toward the stationary contacts **56** by a moveable contact biasing mechanism **62** which is located between the upper enclosure **64** of the moveable contact carrier **60** and the moveable contact **58**.

A magnetic core **66** surrounded by electromagnetic coil **68** in a conventional manner is located on a base portion **70** of contactor housing **20**. The magnetic core **66** is preferably a solid iron member. Electromagnetic coil **68** preferably runs on direct current and is controlled to limit current after device pick-up. As a result, magnetic core **66** need not be as large as alternating current electromagnet counterparts having similar power capabilities. The overall size of contactor **12** is therefore reduced. When energized, magnetic core **66** attracts armature **72** which is connected to **20** moveable contact carrier **60**. Moveable contact carrier **60** along with armature **72** are guided towards the magnetic core **66** with guide pin **74**.

Guide pin **74** is press-fit or molded securely into moveable contact carrier **60** at one end in an inner surface **76**. Guide pin **74** is slidable along guide surface **78** within magnetic core **66**. The single guide pin **74** is centrally disposed and is utilized in providing a smooth and even path for the armature **72** and moveable contactor **60** as it travels to and from the magnetic core **66**, preventing the side to side motion during movement caused by uneven movement and partial locking of the moveable contact carrier **60**. Moveable contact carrier **60** is guided at its upper end **77** by surfaces on the contactor housing **20**. Guide pin **74** is partially enclosed by a resilient armature return spring **80**, which is compressed as the moveable contact carrier **60** moves toward the magnetic core **66**. Armature return spring **80** biases the moveable contact carrier **60** and armature **72** away from magnetic core **66**. The combination of the guide pin **74** and the armature return spring **80** helps to provide even downward motion of the moveable contact carrier **60** and helps prevent tilting or locking that may occur during contact closure. The moveable contact carrier **60** is guided along guide surface **78** to help provide a more level path to the magnetic core **66**. Additionally, lower end **82** of guide pin **74** may be used to cushion or dampen the downward movement at the end of its downward movement, such as in a dash-pot capacity, to help reduce bounce and cushion the closure of the armature **72** with magnetic core **66**. Appropriate tolerancing of the guide pin **74** surfaces **78** and housing **20** promotes its use in this capacity.

Turning now to the electrical connection between the contactor **12** and the overload relay **14**, a coil extension **84** extends from electromagnetic coil **68**. As will be further described in FIGS. **9**–**10**, coil extension **84** is connected to a flexible coil terminal **54**. The flexible coil terminal **54** extends outwardly from wall **40** of contactor **12**. Flexible coil terminal **54** extends onto and rests upon platform **50** so as to position itself to abuttingly engage an electrical conductor or rivet **90** which is part of printed circuit board **92** of the overload relay **14**. In operation, power is supplied to the printed circuit board **92** through a connector **99**, which is sized to receive, for example, a JP1 eight pin connector that plugs into the opening **101** of the overload relay **14**. Electrical power is directed through the printed circuit board **92** so as to be available through rivet **90** to establish an electrical connection to the coil **68** when the flexible coil terminal **54** contacts rivet **90**, as occurs when the overload relay **14** is snap fit onto contactor **12**. By this means the coil power can be modulated to reduce quiescent power in the device.

Conductor **16***a*, as is the case with conductors **16***b* and **16***c*, extends through the overload relay **14** into contactor **12** and secured by lugs **22**. It is understood that similar connections are made on the opposite side of contactor **12** such that other conductors may be inserted therein and secured by lug **22***a* to complete a current path to contactor **12**.

As will be discussed in greater detail in the discussion of FIG. **4**, overload relay **14** includes a magnetic flux concentrating shield **94**. Preferably, because of the desirability of manufacturing the magnetic flux concentrating shield **94** by a stamping process, it is made up of thin layers of laminated members **96** secured together. A magnetic field sensor, such as a Hall sensor **98**, is inserted in the air gaps surrounding each Hall sensor **98**. The Hall sensor **98** is connected to printed circuit board **92** by leads **100** and is soldered to the printed circuit board **92**, such that it stands off from the printed circuit board **92**. The magnetic flux concentrating shield **94** is precisely positioned in the overload relay housing **20** about wall **95** so as to preserve the alignment of Hall sensor **98**. Hall sensor **98** and magnetic flux concentrating shield **94**, in combination with printed circuit board **92**, provide the necessary current measuring circuitry such that the contactor **12** is protected from and can be disabled during overload currents.

FIG. **4** is a cross-sectional view of the overload relay **14**, and as previously described, includes a magnetic flux concentrating shield **94**, which is preferably made up of layers of laminated members **96**. Each laminated member **96** includes a pole section **130*a***, **130*b*** and **130*c*** for the reception of conductors **16*a***, **16*b*** and **16*c*** therethrough respectively. Each pole section **130*a***, **130*b*** and **130*c*** includes an air gap **132*a***, **132*b***, and **132*c*** into which resides a magnetic field sensor, such as Hall sensors **98*a***, **98*b*** and **98*c***. Hall sensors are utilized because they are small and fit easily within the space available in the overload relay. Because of the reduced available area, the spacing between individual poles can cause the Hall sensor in one pole to sense (additional) stray flux from an adjacent pole. The Hall sensors **98*a*–98*c*** stand off from the surface of the printed circuit board **92** so as to be self aligning within the air gaps **132*a*–132*c***. The printed circuit board **92** and the magnetic flux concentrating shield **94** are both secured within the overload relay housing **20**, FIGS. **3** and **4**, so as not to disturb the precise placement and orientation of the Hall sensors, which must be positioned with their sensitive faces perpendicular to the direction of flux. During operation, current flows through conductor **16*a*** in a direction passing transversely through the laminated member **96** upwardly from the plane of FIG. **4**. Such a current creates a magnetic flux path in a counter clockwise direction as indicated by arrow **136**. Flux path **136**, for example, is divided between primary flux path **138** and secondary flux path **140** which are divided by U shaped channel **142**. Outer flux path **140**, which provides an avenue for stray magnetic flux, is substantially prevented by pole shielding slot **144*a*** from traveling directly to pole section **130*b***. The magnetic flux to be measured is concentrated into primary flux path **138**, where it must jump through the air gap **132*a***, and ultimately through Hall sensor **98*a***. The elongated path created by pole shielding slots **144*a*** and similarly **144*b*** not only concentrates the magnetic flux for a particular pole into the Hall sensor for that pole, but also prevents the magnetic flux from taking the elongated path, thereby shielding the adjacent poles with their Hall sensors **98*a***, **98*b*** and **98*c*** from the effects of cross pole magnetic flux interference. U-shaped channels **142**, it will be recognized, also prevent magnetic flux from influencing Hall sensors **98*a***, **98*b*** and **98*c***, and therefore are considered pole shielding slots as well. Additionally, it will be recognized that more pole shielding slots such as **144*a*** and **144*b***, and additional channels **142**, in various configurations and shapes, may also be utilized to prevent the cross-pole magnetic flux interference.

Although two pole shielding slots **144*a*** and **144*b*** and three U-shaped channels such as **142** are shown, any number, configuration and placement of the pole shielding slots and U-shaped channels that prevent flux transfer between pole sections is contemplated by the present invention.

As previously described, Hall sensors **98*a*–98*c*** are electrically connected to printed circuit board **92**. Printed circuit board **92** includes various control circuitry and microprocessors (collectively **148**). The control circuitry **148** provides DC control utilizing pulse width modulation. The pulse width is adjustable such that the magnetic coil is overpowered at start-up and then cut back during continued running. The adjustable pulse width modulation utilized by the control circuitry **148** promotes lower inertia and shorter length strokes of the moveable contact carrier **(60)**, which reduces contact bounce and extends the mechanical life of the contacts.

Locking hasp **28** is shown extending from overload relay **14**. The locking hasp includes a securing hole **150**, in which a tamper resistant seal, such as a wire or lead seal, to prevent unauthorized opening of the cover **24**.

As previously described, the conductor rivets **90** are shown abutting the flexible coil terminal **54**.

Referring now to FIG. **5**, the contactor **12** is shown connected to the overload relay **14**. Cover **24** is shown in the cover open position. Cover **24** is pivotable about pivot point **102** (shown in phantom) to go from the phantomed closed position **24*a*** in a direction indicated by arrow **104**. Opening of the cover of **24** permits viewing of the conductors **16*a*–16*c*** (as for installation purposes) such that the interior **106** of the overload relay as well as any conductor wiring, is visible and accessible. For example, although not specifically shown here, a potentiometer adjustment screw **27** used to set operating current ranges may be covered by cover **24** in order to adjust circuit timing and delay functions. The opening of cover **34** also allows access to the interconnection of contactor **12** with the overload relay **14**.

Turning now to the physical connection between the contactor **12** and the overload relay **14**, the contactor platform **50** has at least one, and preferably two extensions **108** extending transversely therefrom, which are insertable into a recess **107** of the overload relay housing **18** in fitting engagement. To make the upper connection, and as previously described, the overload relay **14** includes flexing lock tab **34**, which is shown in its locked position. Flexing lock tab **34** is connected to retaining projection **36**, which is shown in its corresponding retained position against inner wall surface **110** of contactor **12**.

As best seen in FIG. **6**C, retaining projection **36** preferably is formed in a T shape having a head **44** and a narrower stem **45** which is sized to fit within retaining channel **46**. In the interlocked position as shown, the head **44** of the retaining projection **36** is prevented from being removed from the contactor **12** by the interior wall **110**, thereby maintaining, in combination with the flexing lock tab **34**, the interconnection of the contactor **12** with the overload relay **14**.

Referring now to FIG. **6**A, when it is desired to remove the overload relay **14** from the contactor **12**, a force applied near ridge **112** in the direction indicated by arrow **113** causes lock tab **34** to flex along stem **113** with respect to fixed lock tab base **116** permitting an edge at **118** of the flexing lock tab **34** to clear the lip **48** of the contactor housing **20**.

Referring now to FIG. **6**B, when flexing lock tab **34** clears lip **48**, retaining projection **36** may be lifted through retaining channel **46** until the head **44** is able to be withdrawn through and clear receiving channel **42**.

FIG. **7** shows the removal of the overload relay **14** from the contactor **12**. Extension **108** is removed from inner portion **107** contemporaneously with the removal of the flexing lock tab **34** from lip **48**. The overload relay **14** is free to slide along conductor **16***a* (as well as the other conductors) so that the overload relay **14** may be slid up to contactor **12** and then later physically connected thereto if so desired.

FIG. **8** shows a cross-sectional view of the contactor **12**. When the moveable contact carrier **60**, along with armature **72** are attracted towards the energized magnetic core **66**, the armature **72** exerts a compressive force against resilient armature return spring **80**. Together with guide pin **74**, the moveable contact carrier **60** and the armature **72**, along guide surface **78** in order to provide a substantially level and even travel path for the moveable contact carrier **60**.

Referring now to FIG. **9** a close-up is shown of the connection between the electromagnetic coil **68** and the flexible coil terminal **54**, shown partially in phantom. A piece of the coil wire, shown as coil extension **84**, extends from electromagnetic coil **68** and through contactor housing **20**. It is the connection between the flexible coil terminal **54** and the coil extension **84** that permits the selective energization of electromagnetic coil **68**.

As best seen in FIG. **10**, the flexible coil terminal **54** is inserted through contactor housing **20** into a slot **123** molded into insulation bobbin of coil **68**, and is prevented from being removed by a series of barbs **120** along the longitudinal edges **121** of the flexible coil terminal **54**. The direction of the coil extension **84** is substantially transverse to the direction of the flexible coil terminal **54**. Flexible coil terminal **54** includes V shaped sections **122***a* and **122***b*. During the connection process, the coil extension **84** is directed by sections **122***a* and **122***b* along striping channel **124**. The coil extension **84** initially has an insulation layer **126** surrounding the actual conducting portion **128**. As the flexible coil terminal **54** is inserted into the contactor housing **20**, the edges of the striping channel **124** cut into the installation layer **126**, in order to provide electrical contact between the coil extension **84** and the flexible coil terminal **54**.

Referring now to FIG. **11**, the contactor **12** is shown with the contactor housing **20** partially removed to reveal a pair of arc shields **75** which cover a portion of stationary contacts **56**. The purpose for the arc shields **75** is to contain any generated electrical arcs and gases as a result of arcing within the confines of the arc shields **75**. Therefore, it is important to minimize any gaps between the arc shield **75** and the stationary contacts **56**. To that end, it is preferred that the arc shields are deep drawn as opposed to fabrication by folding to eliminate any gaps to produce a contained environment about the stationary contacts **56**. The presence of the arc shields **75** prevents carbon build-up inside the contactor housing **20**. Preferably there are two arc shields per pole, for a total of 6 arc shields **75** in a three pole contactor.

The present invention has been described in terms of the preferred embodiment, and it is recognized that equivalents, alternatives, and modifications, aside from those expressly stated, are possible and within the scope of the appending claims.

For example, many types of interlocking connections are possible between the contactor **12** and the overload relay **14**.

Additionally, the magnetic flux concentrating shield **94** may have many combinations and sizes of pole shielding slots and channels to effectively prevent cross-pole magnetic flux sensor corruption.

Alternately, in another contemplated embodiment, the contactor **12** may be interlocked and snap-fit with a housing structure similar to overload relay **14** without the overload relay function. In such an embodiment, the housing structure would house the printed circuit board **92** without the overload relay circuitry and magnetic flux shielding (i.e., a de-populated board) but maintain the ability to make an abutting electrical connection to the contactor **12** via conducting rivet **90** (FIG. **3**). In such a structure, various snap-fit connections are possible, including the snap-fit flexing lock tabs extending from different points along the printed circuit board housing, to connect the printed circuit board housing to the contactor. The printed circuit board housing in such an embodiment would not be utilized for overload relay purposes. Therefore, the new embodiment of the contactor with the coupled printed circuit board housing would not be utilized as a starter, although a similar electrical connection between the contactor **12** and the printed circuit board housing is made, and pulse width modulation of the electromagnetic coil is maintained.

We claim:

1. A starter comprising:

a multi phase DC controlled contactor comprising:

at least one stationary contact mounted within a contactor housing;

a moveable contact mounted in operable association with the stationary contact;

a moveable contact carrier slidably mounted to the contactor housing;

an electromagnetic coil mounted to the contactor housing for attracting the moveable contact carrier;

at least one flexible coil terminal attached at one end to the electromagnetic coil and extending out through the contactor housing; and

an overload relay interlockingly coupled with the contactor and including a printed circuit board residing within a overload relay housing for controlling power to the contactor coil;

wherein an abutting electrical connection between the flexible coil terminal and the printed circuit board is made when the overload relay is coupled to the contactor.

2. The starter of claim **1** wherein the contactor further includes a reciprocating guide pin attached to the moveable contact carrier and moveable along at least one guide surface such that the moveable contact carrier and the guide pin have a substantially smooth path while traveling along the guide surface.

3. The starter of claim **1** wherein the contactor further includes an arc shield attached to the contactor housing at each stationary contact and wherein the arc shield is deep drawn to eliminate openings and facilitate electrical arc retention and gas containment within the arc shield, thereby avoiding carbon build-up within the contactor housing.

4. The starter of claim **1** wherein the electromagnetic coil is controlled by an electronic controller on the printed circuit board in the overload relay.

5. The starter of claim **1** wherein the contactor further comprises a platform extending from the contactor housing and having a plurality of coil terminal supports attached thereto, and wherein the overload relay further comprises at least one retaining projection extending from the overload relay and a flexing lock tab integral with each retaining projection;

wherein the contactor has a receiving channel to receive the retaining projection and a retaining channel narrower than the receiving channel such that when the contactor is coupled to the overload relay the retaining projection enters the receiving channel and proceeds downwardly through the retaining channel until the flexing lock tab snaps into a lip of the contactor, thereby preventing removal of the overload relay from the contactor; and

wherein when the contactor is coupled to the overload relay the flexible coil terminal abuts an electrical conductor on the printed circuit board in the overload relay to provide the abutting electrical connection.

6. The starter of claim **5** wherein the at least one retaining projection is t-shaped to permit entry of the retaining projection into the receiving channel and prevent removal of the retaining projection through the retaining channel when the contactor is coupled with the overload relay.

7. The starter of claim **5** wherein the overload relay further includes a potentiometer secured therein and wherein the cover in the cover closed position covers the potentiometer.

8. The starter of claim **1** wherein the overload relay further includes a magnetic flux concentrating shield connected to and residing in the overload relay housing.

9. The starter of claim **8** wherein the magnetic flux concentrating shield comprises:

a plurality of pole sections, each pole section having an aperture to receive a conductor transversely therethrough and comprising:

a primary magnetic flux path having an air gap;

a secondary continuous magnetic flux path;

a magnetic flux sensor disposed within the air gap of the primary magnetic flux path; and

a plurality of pole shielding slots within the magnetic flux concentrating shield, such that when electrical current flows through the conductor of each pole section, a resultant magnetic flux flowing in the direction of each primary magnetic flux path is substantially prevented by the pole shielding slots from reaching the magnetic flux sensor of another of the plurality of pole sections, thereby minimizing cross-pole magnetic flux sensor interference.

10. The starter of claim **8** wherein the magnetic flux concentrating shield comprises a plurality of laminated members.

11. The starter of claim **1** wherein the contactor housing includes a conductor lug and the overload relay includes a cover mounted on an overload relay housing and pivotable between a cover open position and a cover closed position such that the cover can be pivoted from the cover closed position to permit viewing of a conductor extending into the conductor lug.

12. The starter of claim **11** wherein the cover has at least one aperture such that a locking hasp attached to the overload relay housing projects through the aperture in the cover may be sealed to lock the cover.

13. The starter of claim **11** wherein the cover open position permits viewing of a conductor inserted through the overload relay and into the conductor lug of the contactor housing during installation of the conductor.

14. The starter of claim **11** wherein the overload relay has a housing which includes a full load amperage adjustment potentiometer disposed thereon such that when the cover is in the cover closed position and the locking hasp is sealed, access to and adjustment of the full load amperage adjustment potentiometer is prevented.

15. A starter comprising:

a multi phase DC controlled contactor comprising:

at least one stationary contact mounted within a contactor housing having at least one connecting slot;

a moveable contact mounted in operable association with the stationary contact;

a moveable contact carrier slidably mounted to the contactor housing;

an electromagnetic coil attached to the contactor housing for attracting the moveable contact carrier;

a platform extending from the contactor housing and having a plurality of coil supports attached thereto;

at least one flexible coil terminal attached at one end to the electromagnetic coil and extending out from the contactor housing onto the coil supports;

an overload relay interlockingly coupled with the contactor comprising:

at least one retaining projection extending from the overload relay;

a flexing lock tab integral with each retaining projection;

a printed circuit board residing within an overload relay housing for controlling power to the contactor;

a magnetic flux concentrating shield connected to and residing in the overload relay housing comprising:

a plurality of pole sections, each pole section having an aperture to receive a conductor transversely therethrough and comprising:

a primary magnetic flux path section having an air gap;

a magnetic flux sensor disposed within the air gap of the primary magnetic flux path section and operatively associated with the printed circuit board; and

a plurality of pole shielding slots, such that when electrical current flows through the conductor of each pole section, a resultant magnetic flux flowing in the direction of each primary magnetic flux path is substantially prevented by the pole shielding slots from reaching the magnetic flux sensor of another of the plurality of pole sections, thereby minimizing cross-pole magnetic flux sensor interference;

wherein the connecting slot has a receiving channel to receive the retaining projection and a retaining channel narrower than the receiving channel such that when the contactor is coupled to the overload relay the retaining projection enters the receiving channel of the connecting slot and proceeds downwardly through the retaining channel until the flexing lock tab snaps into a lip of the contactor, thereby preventing removal of the overload relay from the contactor; and

wherein when the contactor is coupled to the overload relay the flexible coil terminal abuts an electrical conductor on the printed circuit board to provide an electrical connection between the contactor and the overload relay.

16. The starter of claim **15** wherein the magnetic flux concentrating shield comprises a plurality of laminated members.

17. The starter of claim **15** wherein the contactor further includes an arc shield attached to the contactor housing at each stationary contact and wherein the arc shield is deep drawn to eliminate openings and facilitate electrical arc retention and gas containment within the arc shield, thereby avoiding carbon build-up within the contactor housing.

18. The starter of claim **15** wherein the contactor housing includes a conductor lug and the overload relay includes a cover mounted on an overload relay housing and pivotable between a cover open position and a cover closed position such that the cover can be pivoted from the cover closed position to permit viewing of a conductor extending into the conductor lug.

19. The starter of claim **18** wherein the cover has at least one aperture such that a locking hasp attached to the overload relay housing projects through the aperture in the cover may be sealed to lock the cover.

20. The starter of claim **15** wherein the at least one retaining projection is t-shaped to permit entry of the retaining projection into the receiving channel and prevent removal of the retaining projection through the retaining channel when the contactor is coupled with the overload relay.

21. The starter of claim **18** wherein the overload relay further includes a potentiometer secured therein and wherein the cover in the cover closed position prevents access to the potentiometer.

22. The starter of claim **15** wherein the contactor further includes a reciprocating guide pin attached to the moveable contact carrier and moveable along at least one guide surface on the contactor housing such that the moveable contact carrier and the guide pin have a substantially smooth path while traveling along the guide surface.

23. The starter of claim **15** wherein there are three pole sections.

24. A contactor assembly comprising:

at least one stationary contact mounted within a contactor housing;

a moveable contact mounted in operable association with the stationary contact;

a moveable contact carrier slidably mounted to the contactor housing;

an electromagnetic coil mounted to the contactor housing for attracting the moveable contact carrier;

at least one flexible coil terminal attached at one end to the electromagnetic coil and extending out through the contactor housing; and

a circuit board housing interlockingly coupled with the contactor and including a printed circuit board residing within the circuit board housing;

wherein an abutting electrical connection between the flexible coil terminal and the printed circuit board is made when the circuit board housing is coupled to the contactor.

25. The contactor assembly of claim **24** wherein the contactor further comprises a platform extending from the contactor housing and having a plurality of coil terminal supports attached thereto, and wherein the circuit board housing further comprises at least one retaining projection extending from the circuit board housing and a flexing lock tab integral with the circuit board housing;

wherein the contactor has a receiving channel to receive the retaining projection and a retaining channel narrower than the receiving channel such that when the contactor is coupled to the circuit board housing the retaining projection enters the receiving channel and proceeds downwardly through the retaining channel until the flexing lock tab snaps into the contactor housing to achieve a snap lock connection between the circuit board housing and the contactor; and

wherein when the contactor is coupled to the circuit board housing the flexible coil terminal abuts an electrical conductor on the printed circuit board in the circuit board housing to provide the abutting electrical connection.

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