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(54) **RETAINING ELEMENT FOR A MECHANICAL COMPONENT**

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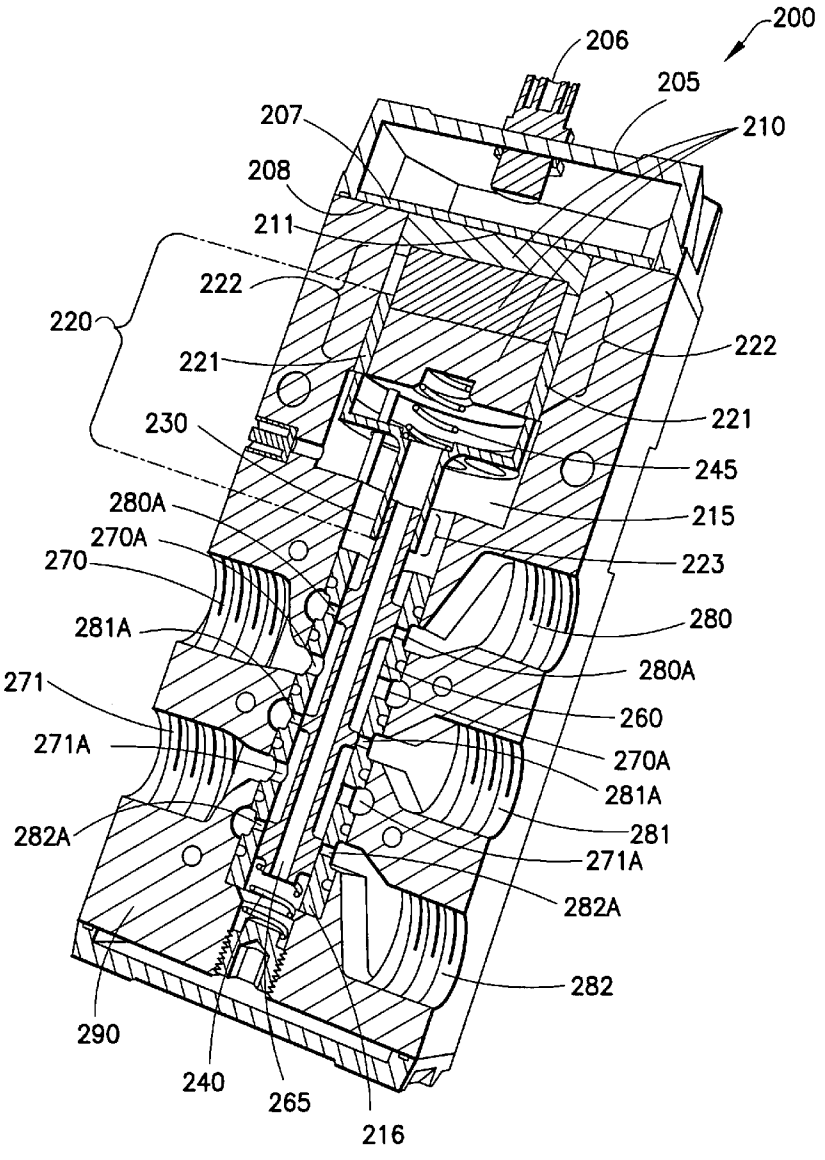
*F16K 31/02* (2006.01)

(52) **U.S. Cl.** ..... **251/129.01**

(57) **ABSTRACT**

A retaining element which retains a mechanical element within the cavity of a body is described. Specifically, an electronically controlled valve and a motor housing retainer are described. The motor housing retainer comprises a printed circuit board, which may provide a connection to the motor.



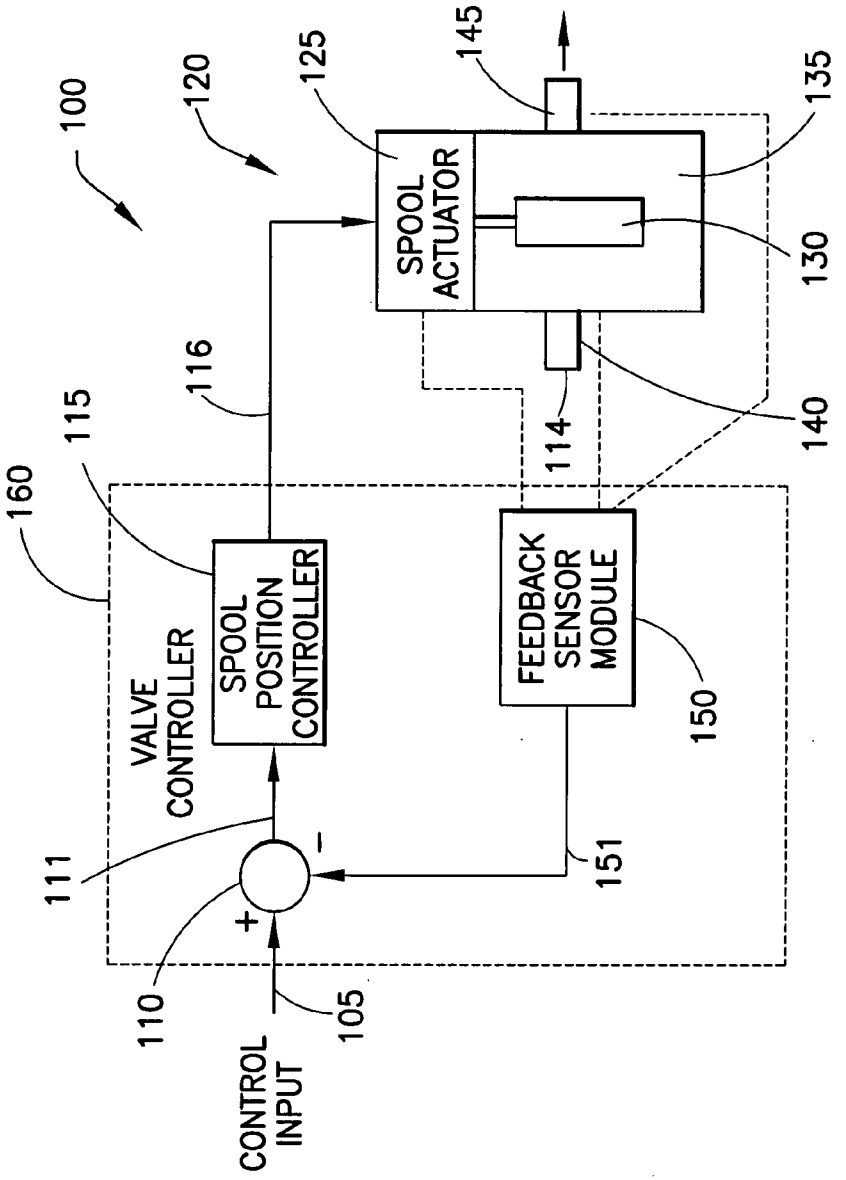

100
120
125
145
135
SPOOL ACTUATOR
130
116
115
114
140
160
VALVE CONTROLLER
SPOOL POSITION CONTROLLER
FEEDBACK SENSOR MODULE
150
111
151
110
105
CONTROL INPUT
+
-

FIG. 1

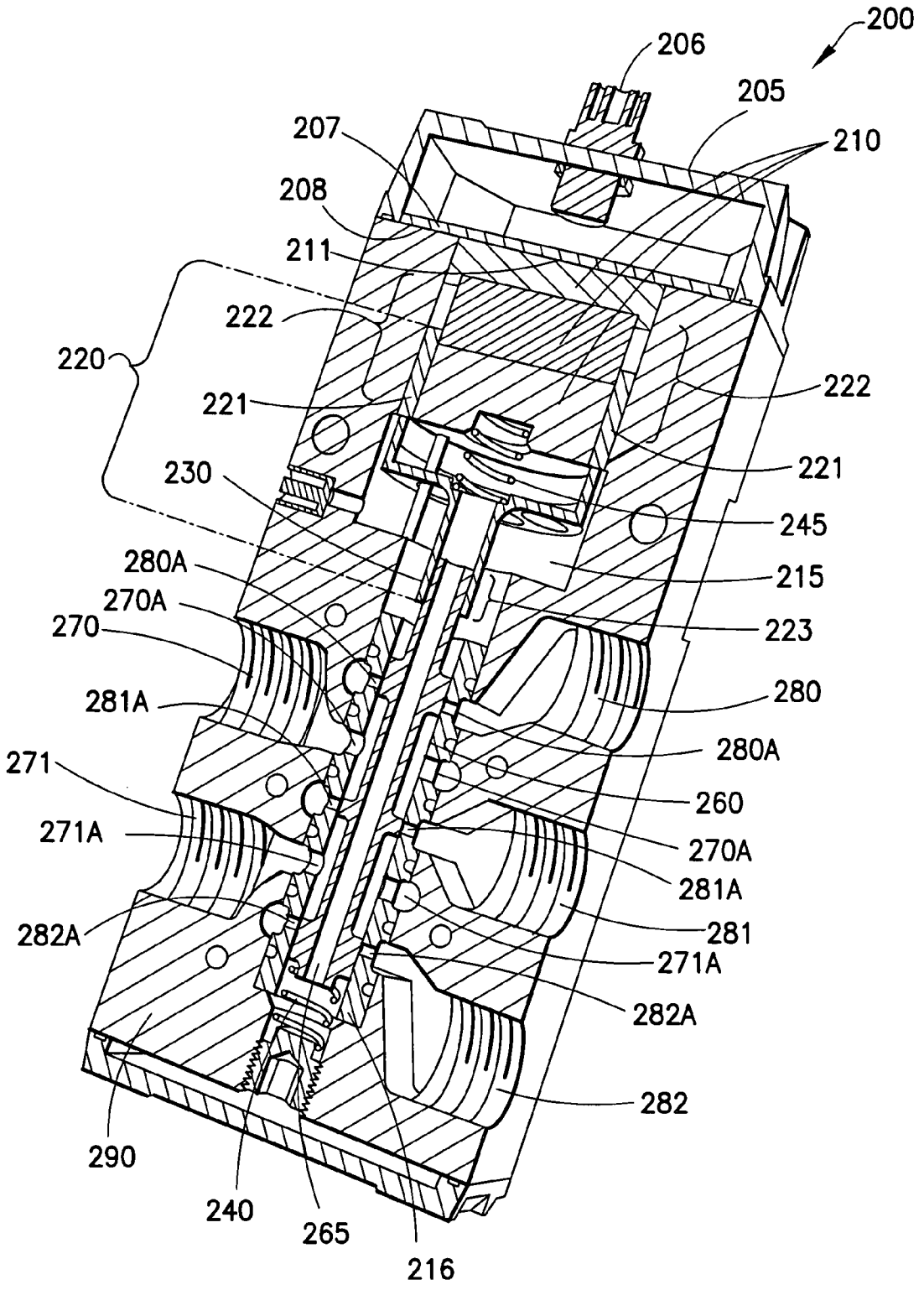

200
206
205
207
210
208
211
222
220
222
221
221
230
245
280A
215
270A
223
270
281A
280
280A
271
260
271A
270A
281A
282A
281
271A
282A
282
290
240
265
216

FIG.2

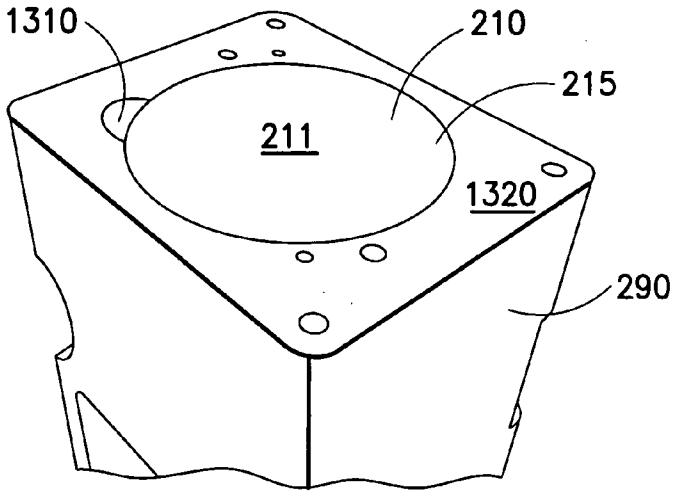

1310
210
215
211
1320
290

FIG.3

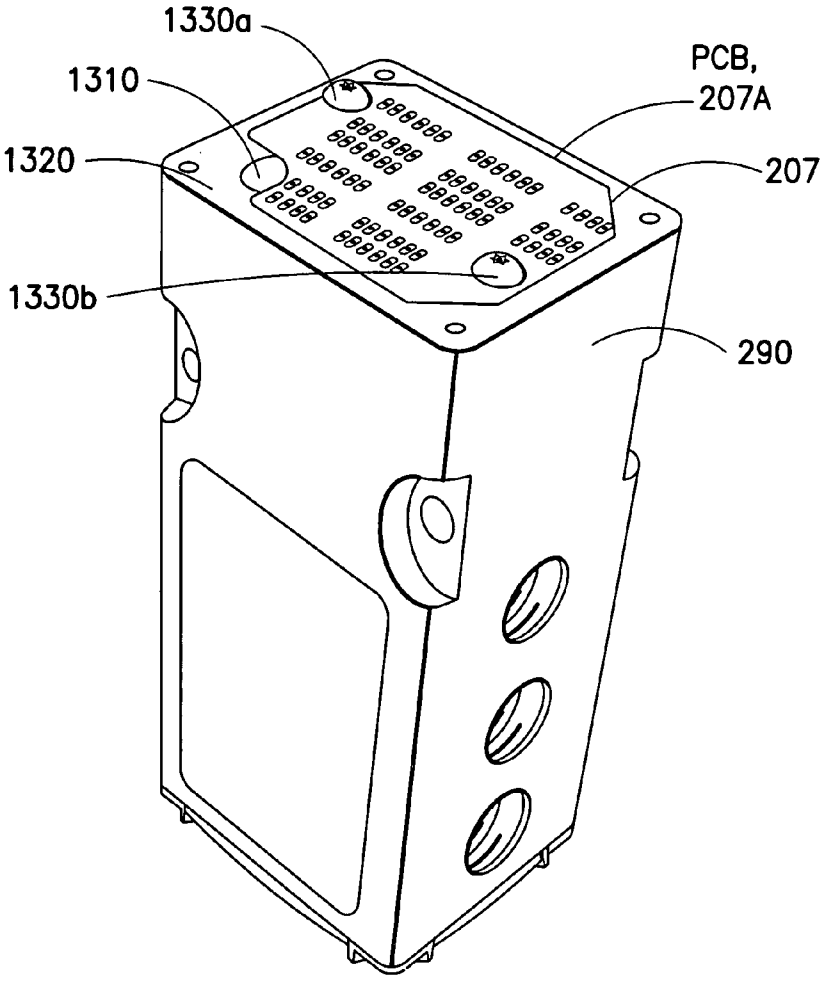

1330a
1310
PCB,
207A
1320
207
1330b
290

FIG.4

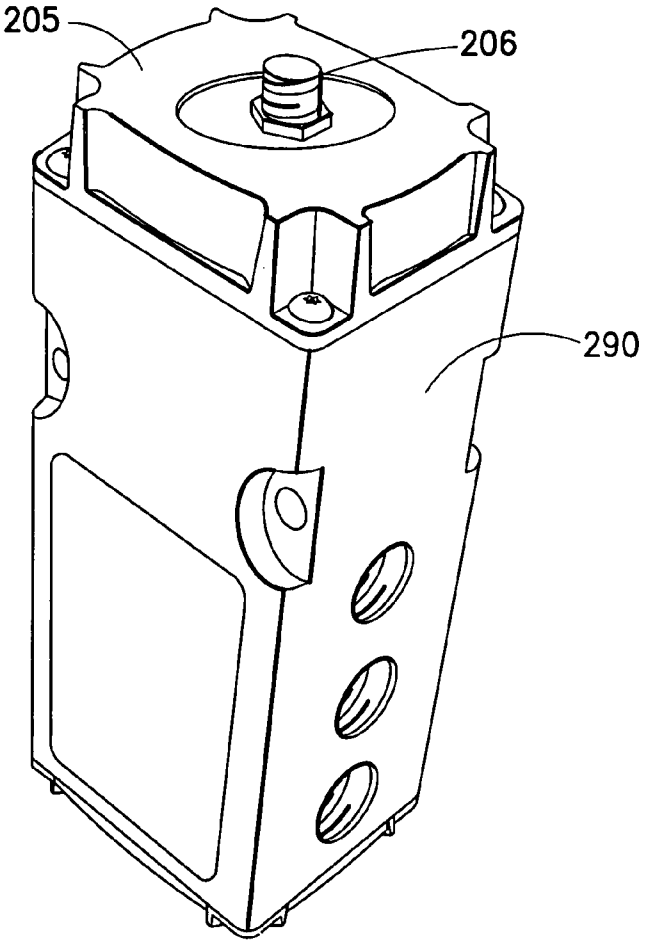



FIG.5

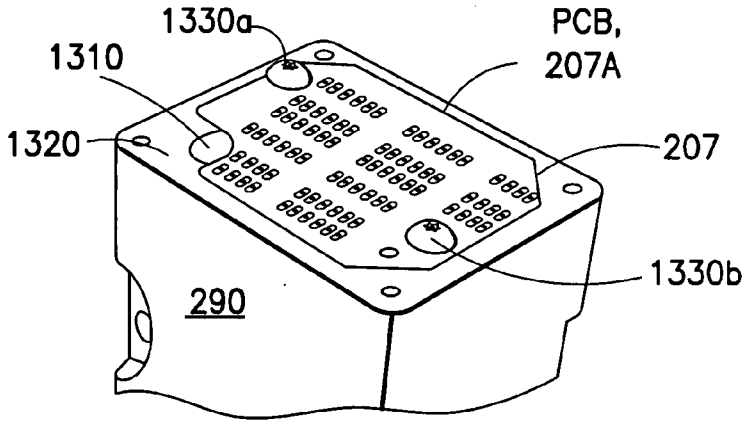



FIG.6

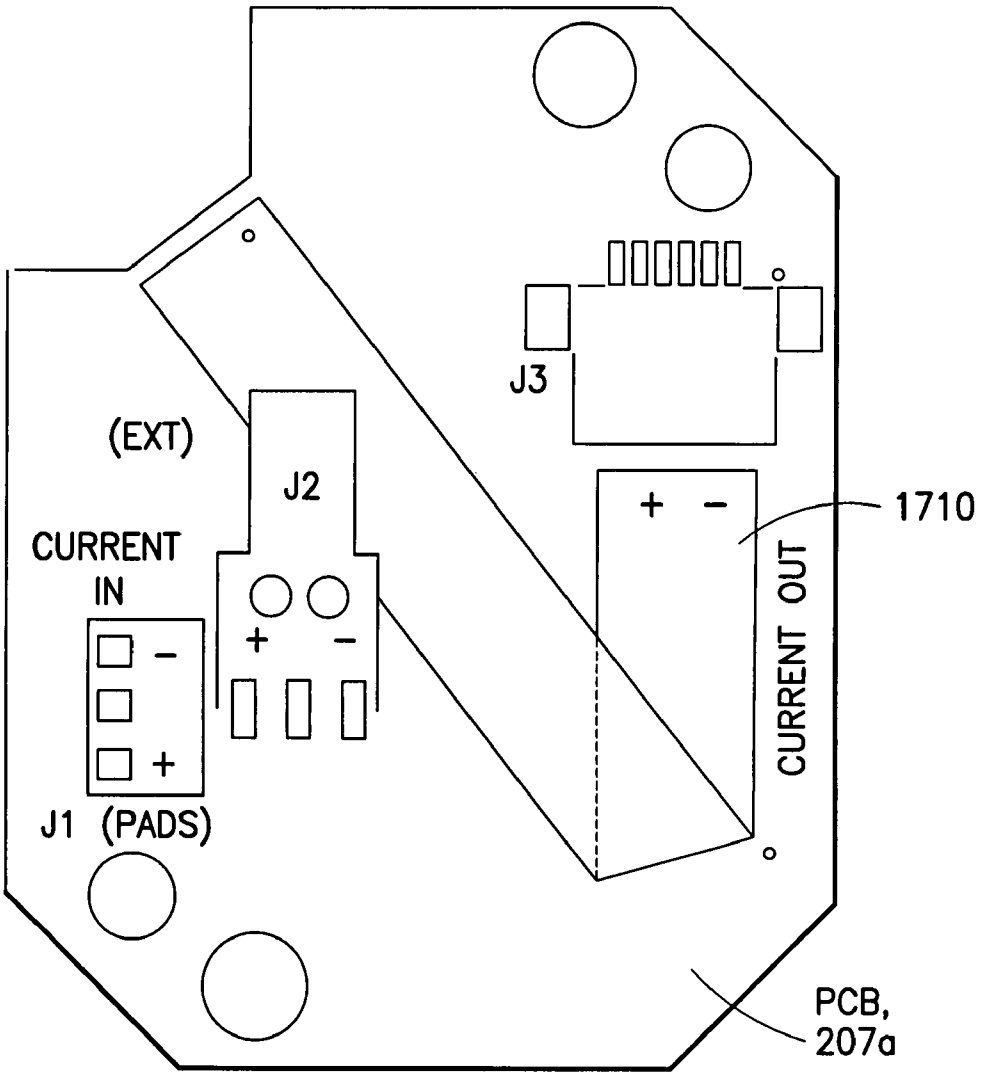



FIG.7

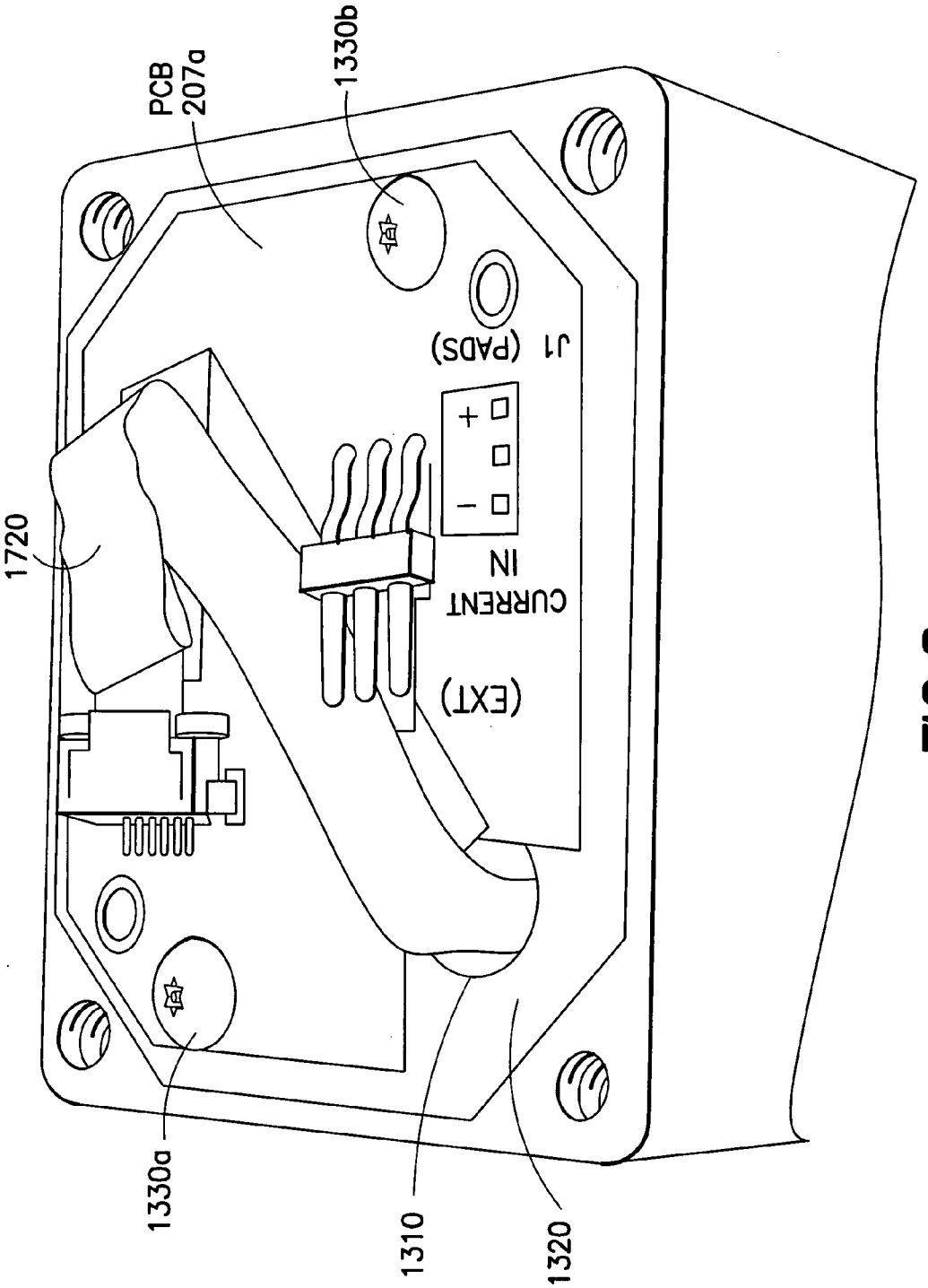



FIG.8

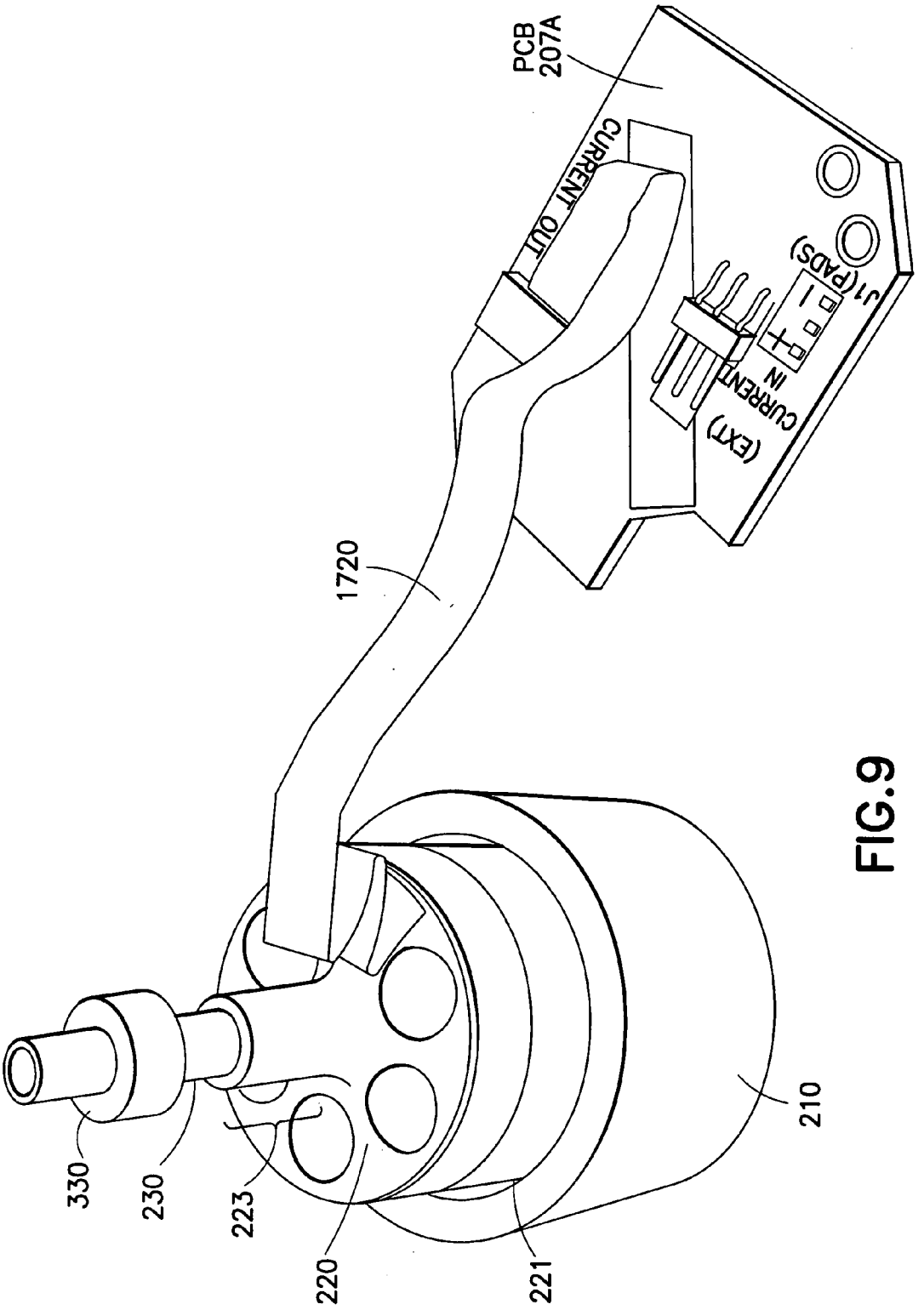

PCB
207A
CURRENT OUT
J1 (PADS)
CURRENT IN (EXT)
1720
210
330
230
223
220
221

FIG.9

# RETAINING ELEMENT FOR A MECHANICAL COMPONENT

## CROSS-REFERENCE TO RELATED APPLICATIONS:

**[0001]** This patent application claims priority under 35 U.S.C. §119(e) from Provisional Patent Application No. 60/854,562, filed Oct. 25, 2006, the disclosure of which is incorporated by reference herein in its entirety.

## TECHNICAL FIELD

**[0002]** This invention relates generally to control systems and assemblies and, more specifically, relates to controllers and systems using electronically controlled valves, electronically controlled valves, and portions thereof, as well as to assemblies that include at least one valve.

## BACKGROUND

**[0003]** Control systems for electronically controlled valves are used with many different types of fluids and gases for many different purposes. While control systems, their controllers, and the associated electronically controlled valves have many benefits, these control systems, controllers, electronically controlled valves and portions thereof may still be improved.

## SUMMARY

**[0004]** An exemplary embodiment in accordance with this invention is a motor housing retainer that is a substrate composed of a dielectric material. The retaining element is configured to be affixed over a cavity in a valve body and prevents a motor housing from exiting the cavity in the valve body. Additionally the motor housing retainer provides one or more connection points for electrical connections.

**[0005]** In further exemplary embodiments, the motor housing retainer has an opening to allow access to the cavity. The motor housing retainer can be configured to fit within a recess on the valve body.

**[0006]** In additional exemplary embodiments, the motor housing retainer is a printed circuit board where at least two connectors are connected by a circuit on the printed circuit board.

**[0007]** In further exemplary embodiments, the motor housing retainer provides an electrical connection between the motor housing and the motor housing cover. The connection to the motor housing may be a Flexible Printed Circuit connector and uses a flat cable to connect to the voice coil. Such a connection may be used for coil current transfer.

**[0008]** Another exemplary embodiment in accordance with this invention is an electronically controlled valve. The valve includes a valve body with a cavity; a motor housing within the cavity; and a motor housing retainer. The retainer is a substrate composed of a dielectric material. The retaining element is configured to be affixed over a cavity in a valve body and prevents a motor housing from exiting the cavity in the valve body. Additionally the motor housing retainer provides one or more connection points for electrical connections.

**[0009]** In additional exemplary embodiments, the motor housing retainer has an opening to allow access to the cavity. The motor housing retainer can be configured to fit within a recess on the valve body.

**[0010]** In further exemplary embodiments, the motor housing retainer is a printed circuit board where at least two connectors are connected by a circuit on the printed circuit board.

**[0011]** In additional exemplary embodiments, the motor housing retainer provides an electrical connection between a voice coil, part of a coil header assembly, and a motor housing cover. The connection to the motor housing may be a Flexible Printed Circuit connector and uses a flat cable to connect to the voice coil. Such a connection may be used for coil current transfer.

**[0012]** A further exemplary embodiment in accordance with this invention is a valve retaining element. The element provides a means for preventing a motor housing from exiting a cavity in a valve body; and means for providing one or more electronic connections enabling coil current transfer.

**[0013]** In further exemplary embodiments, the valve retaining element provides an electrical connection between a voice coil, part of a coil header assembly, and a motor housing cover.

**[0014]** Another exemplary embodiment in accordance with this invention is a method which includes providing a valve body; inserting a spool actuator through an opening into a cavity within the valve body; and affixing a printed circuit board over the opening. The printed circuit board provides an electrical connection to the spool actuator and also mechanically preventing the spool actuator from passing through the opening.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0015]** The attached Drawing Figures include the following:

**[0016]** FIG. **1** is a block diagram of a system including a portion for controlling an electronically controlled valve and the electronically controlled valve;

**[0017]** FIG. **2** is a cutaway, perspective view of an exemplary pneumatic valve;

**[0018]** FIG. **3** is a top perspective view of the valve shown in FIG. **2**, without the electronics cover and the motor housing retainer;

**[0019]** FIG. **4** is a top perspective view of the valve shown in FIG. **2**, without the electronics cover but with the motor housing retainer;

**[0020]** FIG. **5** is a top perspective view of the valve shown in FIG. **2**, with the electronics cover (which covers the motor housing retainer);

**[0021]** FIG. **6** is a close-up top perspective view of the valve shown in FIG. **2**, without the electronics cover but with the motor housing retainer;

**[0022]** FIG. **7** is a top view of screening for the motor housing retainer;

**[0023]** FIG. **8** is another close-up top perspective view of the valve shown in FIG. **2**, without the electronics cover but with the motor housing retainer; and

**[0024]** FIG. **9** is a view of the motor housing retainer coupled to the motor housing and also of the coil header assembly and spool.

## DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

**[0025]** Referring to FIG. **1**, a block diagram is shown of an exemplary system **100** having a portion for controlling an

electronically controlled valve **120**. System **100** also includes in this example the electronically controlled valve **120**. FIG. **1** is a simplistic, high-level view of the system **100** that includes a control input **105**, an adder **110**, a spool position controller **115**, the electronically controlled valve **120**, and a feedback sensor module **150** that takes an input from one or more feedback sensors (not shown) and that produces one or more feedback signals **151**. A valve controller **160** includes the adder **110**, the spool position controller **115**, and the feedback sensor module **150**. The electronically controlled valve **120** includes a spool actuator **125**, such as a voice coil, a spool **130**, a body **135**, an input **140**, and an output **145**.

**[0026]** The electronically controlled valve **120** controls fluid (e.g., gas, water, oil) flow **141** through the electronically controlled valve **120** by operating the spool **130**. The spool actuator **125** controls movement of the spool **130** based on one or more control signals **116** from the spool position controller **115**. The spool position controller **115** modifies the one or more control signals **116** based on the one or more input signals **111**, which include addition of the control input signal **105** and the one or more feedback signals **151**. The feedback sensor module **150** can monitor the spool actuator **120** (e.g., current through the spool actuator), a sensor indicating the position of the spool **130**, or sensors indicating any number of other valve attributes (e.g., pressure or flow rate of the fluid flow **141**). Aspects of the present invention are related to a number of the elements shown in FIG. **1**.

**[0027]** Turning to FIG. **2** in addition to FIG. **1**, a cutaway, perspective view is shown of an exemplary and non-limiting embodiment of a pneumatic valve **200**. The pneumatic valve **200** includes an electronics cover **205**, a motor housing retainer **207**, a motor housing **210**, an upper cavity **215**, a lower cavity **216**, a coil header assembly **220**, a spool **230**, a sleeve **260**, a lower spring **240**, an upper spring **245**, external ports **270**, **271**, **280**, **281**, and **282**, circumferentially spaced internal ports **270***a*, **271***a*, **280***a*, **281***a*, and **282***a*, and a valve body **290**. Coil header assembly **220** includes a voice coil portion **222** having a voice coil **221** and an overlap portion that overlaps a portion of the spool **230** and connects the spool **230** to the coil header assembly **220**. The spool actuator **125** of FIG. **1** includes, in the example of FIG. **2**, motor housing **210**, coil header assembly **220**, upper spring **245**, and lower spring **240**. It is noted that a view of the motor housing **210** is also shown in FIG. **9** and that at least a portion of the motor housing **210** is magnetized in order to be responsive to the voice coil **221**.

**[0028]** In this example, a top surface **211** of the motor housing **210** contacts a bottom surface **208** of motor housing retainer **207** and is held in place by the motor housing retainer **207**. In accordance with the exemplary embodiments of this invention, the motor housing retainer **207** is a PCB (printed circuit board). The motor housing retainer **207** serves multiple purposes, as is disclosed in more detail below. It should be appreciated that the motor housing retainer may be attached using a number of techniques, including using hardware such as screws; and sliding or snapping into place.

**[0029]** The spool **230** includes in this example a passage **265**. The passage **265** has a number of purposes, including equalizing pressure between the upper cavity **215** and the lower cavity **216**. The spool **230** may also be manufactured without passage **265**.

**[0030]** As described below, the electronics cover **205** may include a connector **206** used to couple a spool position controller **115** to the voice coil **221** on voice coil portion **222**. The electronics cover **205** is one example of a cover used herein.

**[0031]** A description of exemplary operation of the valve **200** is included in U.S. Pat. No. 5,960,831, which is hereby incorporated by reference in its entirety. U.S. Pat. No. 5,960,831 describes, for instance, airflow through the external ports **270**, **271**, **280**, **281**, and **283** and the circumferentially spaced internal ports **270***a*, **271***a*, **280***a*, **281***a*, and **283***a*. It is noted that the springs **240**, **245** along with the coil header assembly **220**, motor housing **210**, and spool **230**, are configured such that the spool **230** blocks the ports **281**A when no power is applied to the voice coil **221**. Other portions of pneumatic valve **200** are also described in U.S. Pat. No. 5,960,831.

**[0032]** In FIG. **2**, it can be seen that the motor housing **210** in the pneumatic valve **200** has a compressive force applied by spring compression (e.g., by springs **240** and **245**). This force can cause the motor housing **210** to eject from the valve cavity (e.g., upper cavity **215**). The exemplary embodiments of this invention retain the motor housing without unnecessarily increasing envelope size, cost, weight, or by adding unnecessary parts to the assembly.

**[0033]** Other possible approaches to solving this problem of retaining the motor housing **2 10** may employ the use of an adhesive, such as epoxy, or the use of hardware to secure the motor housing **210** to the body **290**, manufacturing a cover plate that is attached with hardware, or by using a pressing or other bonding operation. However, each of these approaches adds additional parts and/or manufacturing steps to the assembly as well as making disassembly/maintenance more difficult. Another approach may be to thread the motor housing **210** (e.g., and a matching inner surface of the upper cavity **215** in the valve body **290**). However, this approach would add additional cost to the assembly.

**[0034]** The use of the exemplary embodiments of this invention avoid these and other problems by using a PCB to serve at least three purposes 1) as a mechanical element, 2) as a spring contact plate for coil current transfer, and 3) as a connector location. As shown in FIG. **2** (and FIGS. **4** and **6**), the motor housing retainer **207** is a PCB that acts as a mechanical element, a spring contact plate for coil current transfer, and a connector location for other product variants. This is explained in more detail below.

**[0035]** It is noted that the example described below specifically concerns retaining a spring loaded voice coil motor in a pneumatic valve. However, the techniques shown below are also applicable to retaining any mechanical element having static or dynamic forces thereon, and the use of the exemplary embodiments of this invention is not limited to retaining a spring loaded voice coil motor in a pneumatic valve.

**[0036]** Referring to FIG. **3** in addition to FIG. **2**, a top perspective view is shown of the valve in FIG. **2**, without the electronics cover **205** and the motor housing retainer **207**. The valve body **290** has a top surface **1320** and an opening **1310**. The top surface **211** of the motor housing **210** is shown in the upper cavity **215**. Note that because of the force of the springs **240** and **245**, the motor housing **210** as shown in FIG. **3** will eject from the valve body **290**.

**[0037]** In order to retain the motor housing **210** in the upper cavity **215** of the body **290**, the motor housing retainer

**207** is attached to the body **290**, show here attached with screws **1330***a* and **1330***b*, such as shown in FIG. **4**. FIG. **4** is a top perspective view of the valve of FIG. **2**, without the electronics cover **205** but with the motor housing retainer **207** (shown as the PCB **207**A). It is noted that these motor housing retainer **207** may also be used to hold the mechanical assembly together even if no springs are present (e.g., the motor must still be held in place).

**[0038]** FIG. **5** is a top perspective view of the valve shown in FIG. **2**, with the electronics cover **205** (which covers the motor housing retainer **207**). Note that the connector **206** would be coupled to, e.g., a valve controller **160** using a cable (not shown) carrying control signal(s) **116**. The connector **206** will also be coupled to the motor housing retainer **207**.

**[0039]** FIG. **6** is a close-up top perspective view of the valve shown in FIG. **2**, without the electronics cover **205** but with the motor housing retainer **207**, embodied as the PCB **207**A. The opening **1310** is used to house a cable from the motor housing retainer **207** to the voice coil **221**, as described in more detail below.

**[0040]** Turning to FIGS. **7** and **8**, FIG. **7** is a top view of an exemplary screening for the PCB **207**A, while FIG. **8** is another close-up top perspective view of the valve shown in FIG. **2**, without the electronics cover **205** but with the motor housing retainer **207**. It is noted that, if desired, the motor housing retainer **207** can be mounted into a recess formed in top surface **1230** of the valve body **290**. However such a recess is optional.

**[0041]** The screening shown in FIG. **7** indicates locations for three different connectors. Reference **1710** indicates a route for a cable. Connector J**3** is used to attach cable **1720** from the motor housing retainer **207** to the voice coil **221**. In this exemplary embodiment, a Flexible Printed Circuit (FPC) connector J**3** is used to match the FPC cable **1720**. The FPC cable **1720** was chosen as a flat cable for superior assembly features and operation. Regular wire or other cables and connectors may also be used. The cable **1720** is routed through the opening **1310**. Connector J**2** is used to couple the motor housing retainer **207** to the connector **206**. The connector J**1** includes a number of pads which may be used to connect other product variants to the motor housing retainer **207**.

**[0042]** It should be appreciated that the PCB **207**A could also accommodate other components such as integrated circuits, resistors, capacitors, etc., as is known in the art. Such components may be passive or may transform a signal passing through the component.

**[0043]** FIG. **9** is a view of the motor housing retainer **207** coupled to the motor housing **210** and also of the coil header assembly **220** and spool **230**. It can be seen that the motor housing retainer **207** is coupled to the voice coil **221** using the cable **1720**.

**[0044]** In general, the PCB **207**A could be fabricated from any suitable substrate material, such as one or more layers of a glass-epoxy. In general, the thickness of the PCB **207**A is made sufficient to resist any force applied to it by the motor housing **210** without experiencing undue deformation or bending. Depending on whether the motor housing **210** is electrically conductive, it may be desirable in some embodiments to include a layer or sheet of a electric material between the top of the motor housing **210** and the bottom of the PCB **207**A, to prevent the shorting of electrical signal line.

**[0045]** The foregoing description has provided by way of exemplary and non-limiting examples a full and informative description of the best techniques presently contemplated by the inventors for carrying out embodiments of the invention. However, various modifications and adaptations may become apparent to those skilled in the relevant arts in view of the foregoing description, when read in conjunction with the accompanying drawings and the appended claims. All such and similar modifications of the teachings of this invention will still fall within the scope of this invention.

**[0046]** Furthermore, some of the features of exemplary embodiments of this invention could be used to advantage without the corresponding use of other features. As such, the foregoing description should be considered as merely illustrative of the principles of embodiments of the present invention, and not in limitation thereof.

What is claimed is:

**1**. A retaining element comprising:

a substrate composed of a dielectric material configured to be affixed over a cavity in a body,

where the affixed substrate prevents a mechanical element from exiting the cavity in the body and further where the affixed substrate provides one or more connection points for electrical connections.

**2**. The retaining element in claim **1**, where the body is a valve body.

**3**. The retaining element in claim **1**, where the mechanical element is a motor housing.

**4**. The retaining element in claim **1**, where the substrate has an opening to allow access to the cavity.

**5**. The retaining element in claim **1**, where the substrate is configured to fit within a recess on the valve body.

**6**. The retaining element in claim **1**, wherein the substrate is a printed circuit board where at least two connectors are connected via a circuit on the printed circuit board.

**7**. The retaining element in claim **1**, wherein a first connector is connected to the mechanical element and a second connector is connected to a cover and further where the first connector and the second connector are electrically connected.

**8**. The retaining element in claim **7**, where the first connector is a Flexible Printed Circuit connector and uses a flat cable to connect to a voice coil.

**9**. The retaining element in claim **7**, where the connection is used for coil current transfer.

**10**. An electronically controlled valve comprising:

a valve body;

a cavity within the body;

a motor housing within the cavity; and

a motor housing retainer, where the retainer comprises a substrate composed of a dielectric material configured to be affixed over a cavity in a valve body, where the affixed substrate prevents a motor housing from exiting the cavity in the valve body and further where the affixed substrate provides one or more connection points for electrical connections.

**11**. The electronically controlled valve in claim **10**, where the substrate has an opening to allow access to the cavity.

**12**. The electronically controlled valve in claim **10**, where the substrate configured to fit within a recess on the valve body.

**13**. The electronically controlled valve in claim **10**, wherein the substrate is a printed circuit board where at least two connectors are connected via a circuit on the printed circuit board.

**14**. The electronically controlled valve in claim **13**, further comprising a coil header assembly, which includes a voice coil, wherein a first connector is connected to the voice coil and a second connector is connected to a motor housing cover and further where the first connector and the second connector are electrically connected.

**15**. The electronically controlled valve in claim **14**, where the first connector is a Flexible Printed Circuit connector and uses a flat cable to connect to the voice coil.

**16**. The electronically controlled valve in claim **14**, where the connection is used for coil current transfer.

**17**. A retaining element comprising:

means for preventing a mechanical element from exiting a cavity in a body; and

means for providing one or more electronic connections enabling coil current transfer.

**18**. The retaining element in claim **17**, where the body is a valve body and the mechanical element is a motor housing.

**19**. The retaining element in claim **17**, where a first connection is used to connect to a voice coil and a second connection is used to connect to a connector on a cover and further where the first connector and the second connector are electrically connected.

**20**. A method, comprising:

providing a valve body;

inserting a spool actuator through an opening into a cavity within the valve body; and

affixing a printed circuit board over the opening, the printed circuit board providing an electrical connection to the spool actuator and also mechanically preventing the spool actuator from passing through the opening.

* * * * *