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(71) Applicant: VARIAN ASSOCIATES, INC. [US/US]; 3050 Hansen Way, Palo Alto, CA 94304 (US).

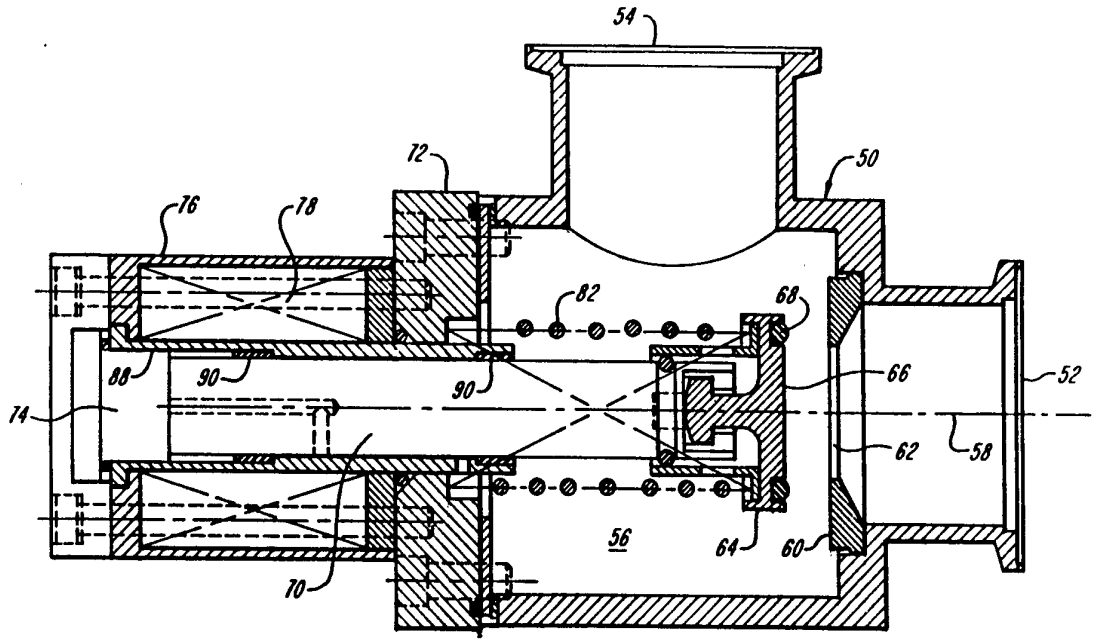
(72) Inventors: HABLANIAN, Marsbed ; 42 Longfellow Road, Wellesley, MA 02181 (US). NUZZI, Frank, J. ; 169 Berkeley Street, Methuen, MA 01844 (US).

(74) Agents: BERKOWITZ, Edward, H. et al.; Varian Associates, Inc., 3100 Hansen Way, Palo Alto, CA 94304-1030 (US).

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(54) Title: ELECTROMECHANICAL VACUUM VALVE WITH OPTIMIZED CONDUCTANCE



(57) Abstract

An electromechanical vacuum valve includes an orifice plate sealed in an internal conduit between the ports of the valve. The orifice plate has an orifice that is smaller in diameter than the ports. A relatively small diameter seal plate is used to seal the orifice. The seal plate is moved between open and closed positions by a solenoid. As a result of the small diameter orifice, the solenoid power is relatively low, and a bellows is not required. The geometry of the internal conduit between the ports is adjusted such that the total conductance between the ports is not substantially reduced by the orifice plate.

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ELECTROMECHANICAL VACUUM VALVE WITH OPTIMIZED CONDUCTANCE

Field of the Invention

This invention relates to electromechanical vacuum valves and, more particularly, to electromechanical vacuum valves having a longer operating life and lower cost than prior art valves.

Background of the Invention

An electromechanical vacuum valve includes a valve housing having first and second ports interconnected by an internal passage or conduit. A seal plate actuated by electromagnet moves between an open position and a closed position. The electromagnet includes a solenoid coil that is energized with an electrical signal. In the closed position, the seal plate seals the internal conduit between the first and second ports. In the open position, the seal plate is retracted, thereby permitting flow of gas between the first and second ports.

A vacuum valve is typically required to operate between atmospheric pressure and vacuum. Thus, a pressure of approximately 15 pounds per square inch is applied to the seal plate when the valve is closed. In order to ensure fail-safe operation in the event of a power failure, a spring is typically used to hold the seal plate in the closed position. As a result of the pressure differential across the vacuum valve and the use of a spring to hold the valve in a closed position, a relatively large solenoid is required for operation of the valve. Furthermore, the solenoid can overheat when the valve is operated frequently or when the valve is required to remain in the open position for extended periods. Since solenoid power requirements increase in proportion to the square of the valve diameter, prior art vacuum valves have been limited to relatively small diameters.

One prior art technique to overcome the above problems is to provide one or more holes in the seal plate to equalize the pressure on the two sides of the plate. In this configuration, one side of the seal plate is isolated with a bellows. This configuration has provided satisfactory operation in terms of reducing the size and power requirements of the solenoid. However, the bellows is a relatively unreliable component and significantly reduces the operating life of the vacuum valve. Furthermore, since the stroke of the bellows is limited, the travel of the seal plate between open and closed

positions is likewise limited. As a result, the seal plate in the open position partially blocks the internal passage between the first and second ports of the valve and reduces the conductance of the valve. Finally, the bellows adds to the cost of the vacuum valve.

It is a general object of the present invention to provide improved electromechanical vacuum valves.

It is another object of the present invention to provide improved methods for making electromechanical vacuum valves.

It is a further object of the present invention to provide electromechanical vacuum valves which do not require a bellows.

It is yet another object of the present invention to provide electromechanical vacuum valves which have a long operating life.

It is still another object of the present invention to provide electromechanical vacuum valves which have a relatively large conductance when in the open position.

It is a further object of the present invention to provide electromechanical vacuum valves which are low in cost and easy to manufacture.

Summary of the Invention

According to the present invention, these and other objects and advantages are achieved in an electromechanical vacuum valve comprising a valve housing having a first port and second port

interconnected by an internal conduit, an orifice plate sealed in the internal conduit, the orifice plate having an orifice with a diameter that is less than the diameter of the first and second ports, a seal plate movable between a closed position in which the seal plate seals the orifice and an open position in which the seal plate is retracted from the orifice, and electromechanical means for moving the seal plate between the open position and the closed position in response to an electrical control signal.

The orifice has a relatively small seal area, and a bellows is not required to equalize the pressure on opposite sides of the seal plate. By eliminating a bellows from the vacuum valve, the operating life of the valve is extended.

The geometry of the internal conduit between the first and second ports in the vacuum valve is selected to provide a desired total conductance between the first and second ports. Thus, the bellows is eliminated from the vacuum valve without a significant change in conductance.

The vacuum valve of the present invention is typically a right-angle valve having a port diameter in the range of about 1.0 inch to 2.0 inches. The diameter of the orifice in the orifice plate is typically in the range of about 60% to 90% of the port diameter.

Brief Description of the Drawings

For a better understanding of the present invention, together with other further objects, advantages and capabilities thereof, reference is made to the accompanying drawings which are incorporated herein by reference and in which:

Fig. 1 is a cross sectional view of an electromechanical vacuum valve in accordance with the prior art;

Fig. 2 is a partially cut away view of a vacuum valve in accordance with the present invention; and

Fig. 3 is a cross sectional view of an electromechanical vacuum valve in accordance with the present invention.

Description of the Prior Art

An electromechanical vacuum valve in accordance with the prior art is shown in Fig. 1. A valve housing 10 defines a first port 12, a second port 14 and an internal passage 16 interconnecting ports 12 and 14. A seal ring 20 is mounted in the passage 16 between ports 12 and 14. The seal ring 20 includes an orifice 22 having approximately the same diameter as ports 12 and 14. A seal plate 24 is mounted within internal passage 16 and is attached to a plunger 26. The plunger 26 extends through a wall 30 of valve housing 10 and through a bore of a solenoid 32. The plunger 26 is a magnetic material. The solenoid 32 and the plunger 26 comprise an electromagnet that is energized by an electrical signal. The electromagnet moves the seal

plate 24 between an open position as shown in Fig. 1 and a closed position (not shown) where the seal plate 24 seals orifice 22. The seal plate 24 is held in a closed position when the solenoid 32 is not energized by a spring 34. In order to reduce the force required to move the seal plate 24 between the open and closed positions, a bellows 36 is attached between seal plate 24 and housing wall 30, and the seal plate 24 is provided with openings 38 for pressure equalization.

The vacuum valve shown in Fig. 1 has several disadvantages. The bellows 36 is prone to early failure and reduces the operating life of the valve. In addition, the bellows 36 adds to the cost of the valve. Furthermore, the length of the stroke between open and closed positions is usually small in order to reduce the stress on the bellows and extend its operating life. However, when the stroke is relatively small, the seal plate 24 partially blocks the orifice 22 in the open position and the conductance of the valve is reduced. In addition, the conductance of the valve is reduced because the presence of the bellows 36 reduces the volume of the internal passage 16 that is available for gas flow.

Detailed Description of the Invention

An electromechanical vacuum valve in accordance with the present invention is shown in Figs. 2 and 3. A valve housing 50 defines a first port 52 and a second port 54 interconnected by an internal passage

or conduit 56. In the example of FIGS. 2 and 3, the valve housing 50 has a generally cylindrical configuration about an axis 58. Port 52 is located on axis 58, and port 54 is formed in a side wall of the cylindrical housing 50. Ports 52 and 54 are oriented at 90° relative to each other in the present example.

An orifice plate 60 is sealed within internal passage 56 adjacent to first port 52. The orifice plate 60 includes an orifice 62 having a diameter that is smaller than the diameter of ports 52 and 54. Typically, the diameter of orifice 62 is in the range of about 60% to 90% of the diameter of port 52. The orifice plate 60 is typically fabricated of stainless steel or other hard metal and can be sealed to housing 50 using a known expansion technique. The orifice plate 60 is first immersed in liquid nitrogen, thereby causing it to contract. The cooled orifice plate is then installed in housing 50 and allowed to return to room temperature and thereby expand into an opening in valve housing 50. The outer periphery of the orifice plate 60 is provided with a circumferential ridge that reliably seals the orifice plate to the valve housing upon expansion of the orifice plate.

A seal plate 64 positioned within internal passage 56 includes a seal surface 66 having an elastomer ring 68 mounted thereon. The seal plate 64 is attached to a plunger 70 which extends through a housing wall 72 into a bore 74 in a solenoid 76.

The solenoid 76 includes a solenoid coil 78 and an electrical connector 80. A coil spring 82 is attached between seal plate 64 and housing wall 72. The coil spring 82 is concentric with and surrounds plunger 70. The plunger 70 is a magnetic material. The plunger 70 and the solenoid 76 constitute an electromagnet which moves the seal plate 64 between an open position as shown in Fig. 2 and a closed position (not shown) where seal plate 64 seals orifice 62. The plunger 70 typically moves within a sleeve 88 provided with a linear bearing 90. The seal surface 66 is larger than orifice 62 so that when the valve is closed, elastomer ring 68 contacts and seals the periphery of orifice 62. In the closed position the internal passage 56 between ports 52 and 54 is sealed, and the valve is closed.

The spring 82 maintains the seal plate 64 in the closed position when the solenoid 76 is not energized. This ensures fail-safe operation such that the valve remains closed when power is lost. When the solenoid coil 78 is energized by an electrical signal, the seal plate 64 is retracted by plunger 70 to the open position.

The area that must be sealed in order to close the vacuum valve is the area of orifice 62. The seal area in the valve of the present invention is reduced in comparison with prior art vacuum valves, thereby permitting a reduction in the size of seal plate 64 and a reduction in the power required to operate the solenoid 76. Since the power required

to operate solenoid coil 78 increases in proportion to the square of the diameter of orifice 62, it is clear that a reduction in orifice diameter is significant. More importantly, the relatively small orifice 62 permits the vacuum valve to be operated without requiring a bellows. The elimination of the bellows extends the operating life of the vacuum valve and reduces its cost. As discussed below, the conductance of the vacuum valve is increased by the elimination of the bellows.

As indicated above, the diameter of orifice 62 is preferably in a range of about 60% to 90% of the diameter of ports 52 and 54. In one example of the present invention, the ports 52 and 54 have a diameter of 1.56 cm, and the orifice 62 has a diameter of 0.94 cm. The orifice plate 60 produces an undesirable reduction in conductance between ports 52 and 54. However, in accordance with the present invention, the decrease in conductance produced by orifice plate 60 is offset, or compensated for, by adjusting the conductance of the internal passage 56. The total conductance between ports 52 and 54 can be viewed as the sum of the conductance of orifice 62 and the conductance of internal passage 56. By increasing the conductance of internal passage 56 to offset the decrease in conductance resulting from orifice plate 60, the total conductance between ports 52 and 54 can be maintained at a desired value.

The conductance of internal passage 56 is

determined by its internal geometry. It has been found that the elimination of the bellows from the vacuum valve of the present invention approximately offsets the reduction in conductance caused by orifice plate 60. This can be understood with reference to Fig. 1. Although the interior of bellows 36 is connected to internal passage 16 through openings 38, the volume within bellows 36 contributes little to the conductance between ports 12 and 14 because of its relative isolation. Gas flowing through the vacuum valve must flow around bellows 36 in order to pass between ports 12 and 14. It can be seen that the volume outside bellows 36 is relatively small in the valve of FIG. 1.

By contrast, in the vacuum valve of the present invention as shown in Figs. 2 and 3, the volume of internal passage 56 that is available for gas flow between ports 52 and 54 is significantly larger. Measurements have shown that the conductance between ports 52 and 54 is substantially unchanged when the bellows is removed and an orifice plate is used. In the measurements, the ports 52 and 54 had a diameter of 1.56 inches, and the orifice 62 had a diameter of 0.94 inch. It will be understood that the total conductance of the vacuum valve can further be controlled by varying the geometry of internal passage 56, such as by increasing its volume.

In summary, the electromagnetic valve of the present invention provides longer operating life and lower cost in comparison with prior art vacuum

valves which utilize a bellows. These advantages are achieved by eliminating the bellows and without a substantial effect on the conductance of the vacuum valve. Although the vacuum valve shown and described above is a right angle valve wherein the longitudinal axis of port 52 is oriented at 90° with respect to the longitudinal axis of port 54, the invention is not limited to right-angle valves. It will be understood that the use of an orifice plate and control of the conductance of the internal passage to provide a predetermined conductance can be applied to any valve geometry.

While there have been shown and described what are at present considered the preferred embodiments of the present invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the invention as defined by the appended claims.

CLAIMS

What is claimed is:

1. An electromechanical vacuum valve comprising:

a valve housing having a first port and a second port interconnected by an internal conduit, said ports having a predetermined diameter;

an orifice plate sealed in said internal conduit, said orifice plate having an orifice with a diameter that is less than said predetermined diameter;

a seal plate movable between a closed position in which said seal plate seals said orifice and an open position in which said seal plate is retracted from said orifice; and

electromechanical means for moving said seal plate between said open position and said closed position in response to an electrical control signal.

2. An electromechanical vacuum valve as defined in claim 1 wherein said internal conduit has sufficient volume to provide a predetermined conductance between said first and second ports and wherein said orifice plate permits said internal conduit to be closed without requiring the use of a bellows.

3. An electromechanical vacuum valve as defined in claim 1 wherein the diameter of said

orifice is in a range of about 60% to 90% of said predetermined diameter.

4. An electromechanical vacuum valve as defined in claim 1 wherein said electromechanical means comprises an electromagnet including a solenoid and a plunger coupled to said seal plate, the position of said plunger and said seal plate being controlled by said solenoid in response to said control signal.

5. An electromechanical vacuum valve as defined in claim 1 wherein said first and second ports each have a central axis and wherein the central axes of said first and second ports are separated by 90°.

6. An electromechanical vacuum valve as defined in claim 1 wherein said internal conduit has a geometry that is selected to substantially compensate for a reduction in conductance between said first and second ports caused by said orifice plate.

7. An electromechanical vacuum valve as defined in claim 1 wherein the diameter of said orifice is no more than 90% of said predetermined diameter.

8. An electromechanical vacuum valve as defined in claim 1 further including spring means

for holding said seal plate in said closed position when said electromechanical means is not energized.

9. A method for making an electromechanical vacuum valve having a predetermined conductance, comprising the steps of:

providing a valve housing having a first port and a second port interconnected by an internal conduit, a seal plate movable between a closed position and an open position, and electromechanical means for moving said seal plate between said open position and said closed position in response to a control signal;

sealing an orifice plate in said internal conduit, said orifice plate having an orifice with a diameter that is less than the diameter of said first and second ports;

positioning said seal plate so as to seal said orifice in said closed position, said orifice plate permitting said seal plate to seal said orifice without requiring a bellows;

providing said internal conduit with sufficient conductance to substantially compensate for a reduction in conductance caused by said orifice plate and thereby provide said predetermined conductance.

10. An electromechanical vacuum valve comprising:

a valve housing having a first port and a

second port interconnected by an internal conduit, said ports having a predetermined diameter;

an orifice plate sealed in said internal conduit, said orifice plate having an orifice with a diameter that is not more than 90% of said predetermined diameter;

a seal plate positioned within said internal conduit and movable between a closed position in which said seal plate seals said orifice and an open position in which said seal plate is retracted from said orifice;

electromechanical means for moving said seal plate between said open position and said closed position in response to an electrical control signal, said electromechanical means including a solenoid and a plunger extending through a bore in said solenoid, said plunger being coupled to said seal plate, the position of said plunger and said seal plate being controlled by said solenoid in response to said control signal; and

spring means for holding said seal plate in said closed position when said solenoid is not energized, said internal conduit having sufficient conductance to provide a predetermined total conductance between said first and second ports.

11. An electromechancial vacuum valve as defined in claim 10 wherein the diameter of said orifice is in a range of about 60% to 90% of said predetermined diameter.

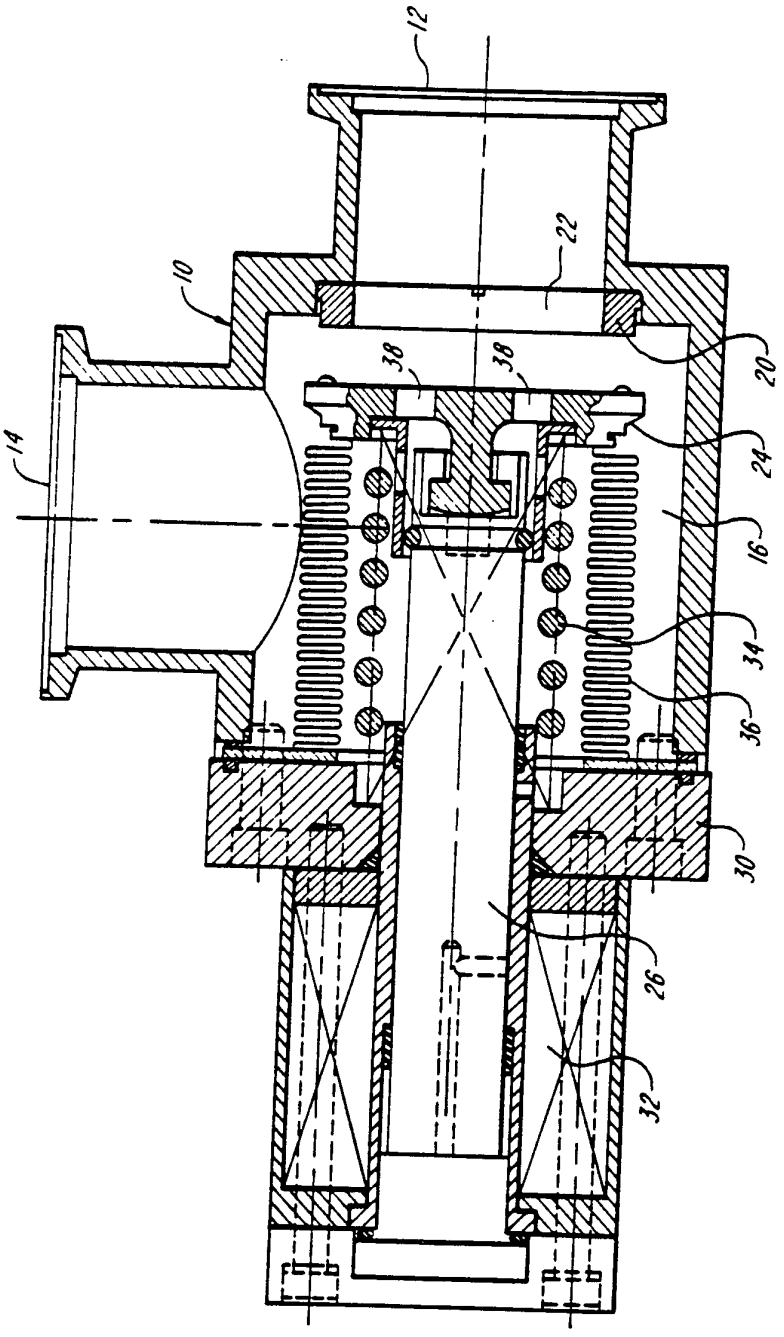


FIG. 1
(PRIOR ART)

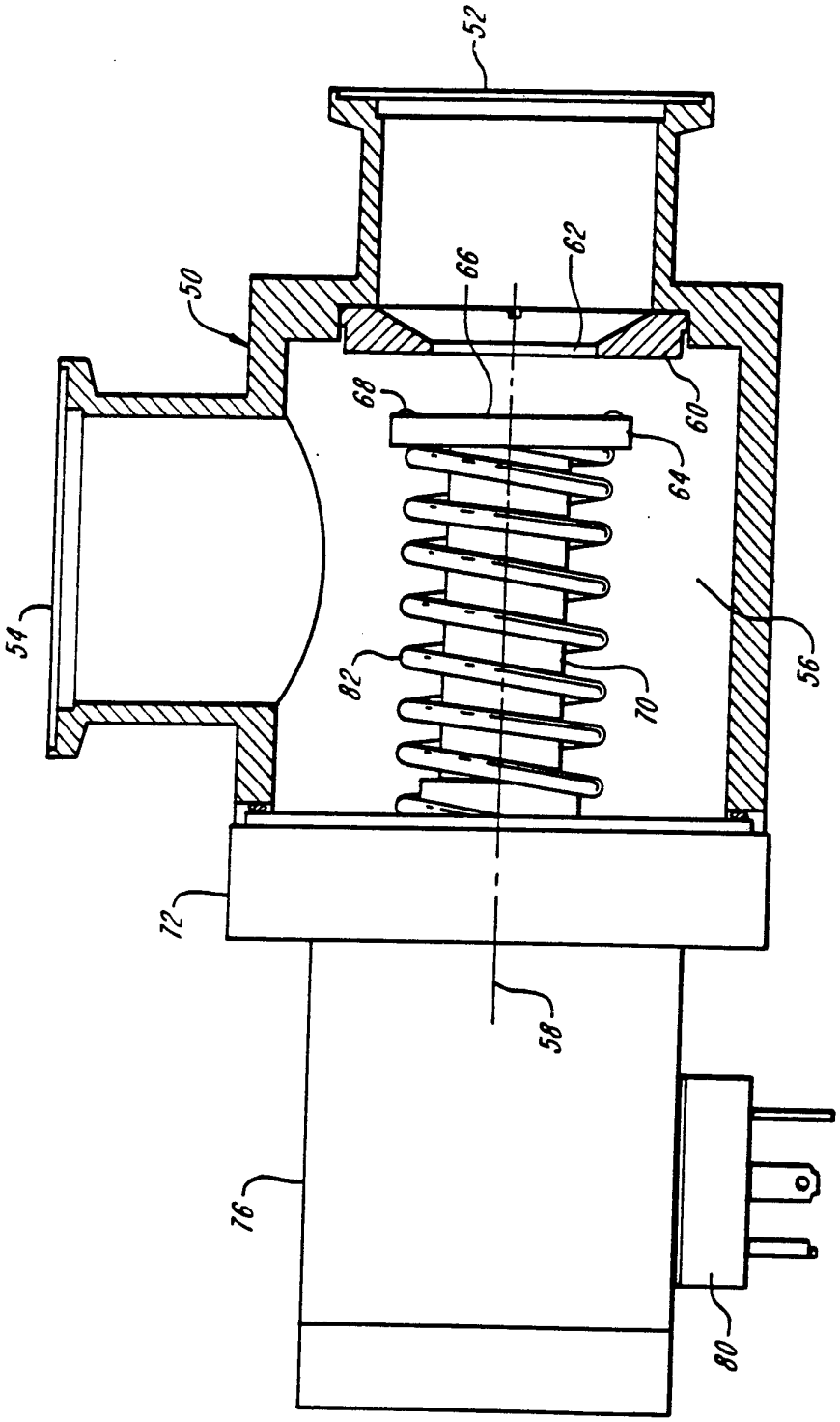


FIG. 2

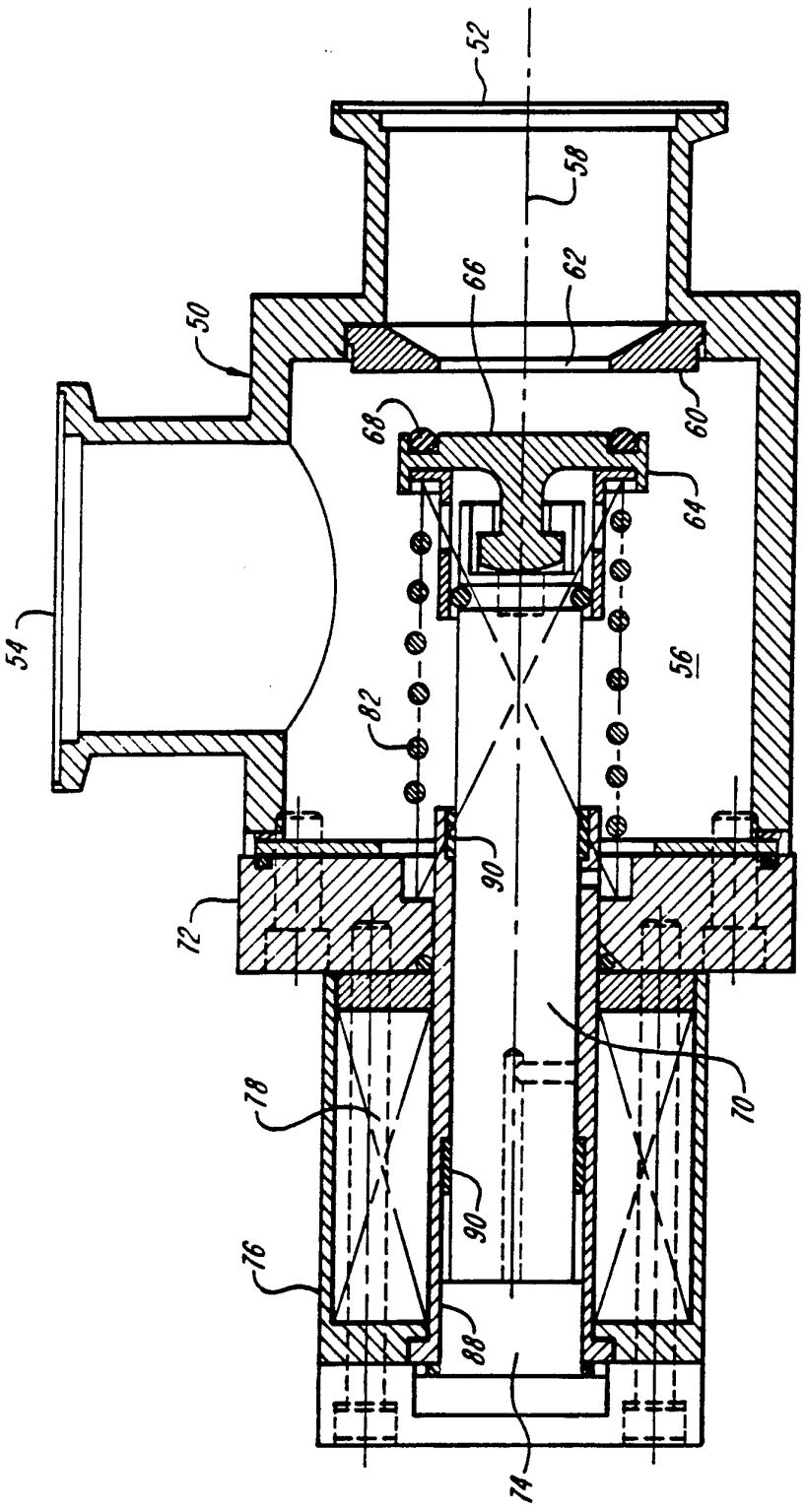


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 92/09383

A. CLASSIFICATION OF SUBJECT MATTER

IPC5: F16K 31/06
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC5: F16K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP, A1, 0219572 (LEYBOLD-HERAEUS GMBH), 29 April 1987 (29.04.87) --	1-8,9,10-11
A	EP, A3, 0173115 (LEYBOLD-HERAEUS GMBH), 5 March 1986 (05.03.86), figure 1 --	1,9,10
A	SE, B, 355056 (LUCIFER SA), 2 April 1973 (02.04.73), figure 1, claim 1 -- --------	1,9,10

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

Information on patent family members

28/05/93

International application No.
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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EP-A3- 0173115	05/03/86	DE-A- 3431037	06/03/86
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