Sept. 29, 1964 R. L. JEPSEN ETAL 3,150,817

HIGH VACUUM SYSTEM

Filed April 3, 1961

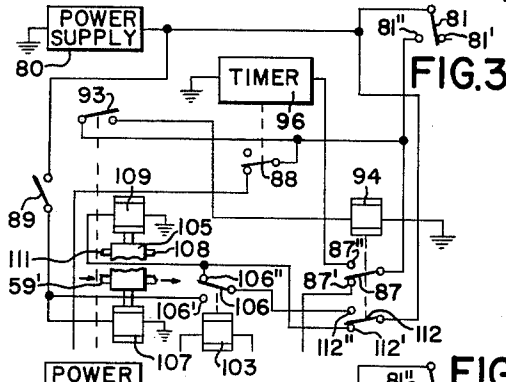


FIG.3

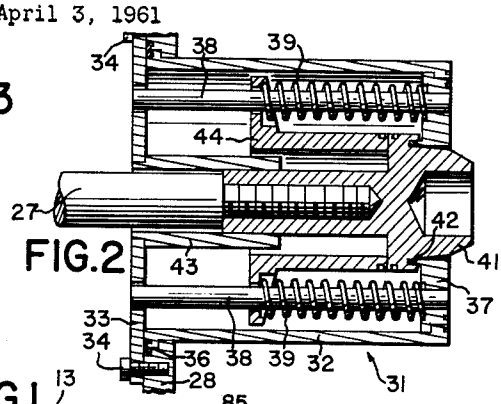
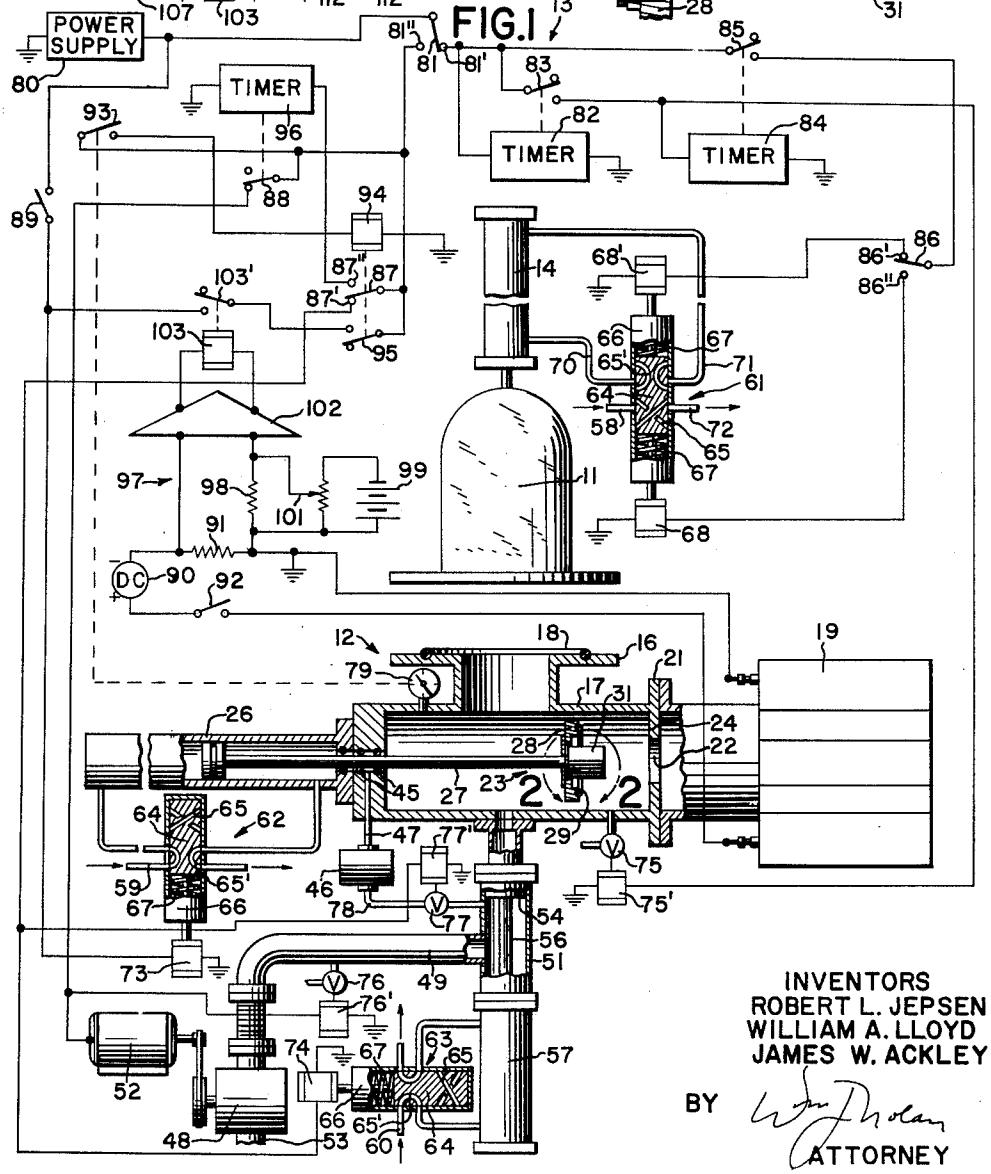


FIG.2

FIG.1



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HIGH VACUUM SYSTEM

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17 Claims. (Cl. 230—69)

This invention relates in general to high vacuum systems and more particularly to a novel method and apparatus for automatically controlling the operation of such system.

U.S. patent application Serial No. 673,816, filed July 24, 1957, by Lewis D. Hall, John C. Helmer and Robert L. Jepsen, entitled "Electrical Vacuum Pump Apparatus and Method," now U.S. Patent 2,993,638 discloses an electrical getter ion vacuum pump of the general type utilized in the present vacuum system. In systems of this type, a roughing pump is used to initially decrease the pressure in the system to less than 20 microns of mercury at which time voltage is applied to the getter ion pump. Unless the getter ion pump is extremely clean, it will heat up and the occluded gases therein will be driven off causing the pressure in the system to rise slightly. Since the pumping speed of the getter ion pump is very low at this time the roughing pump is left on to help the getter ion pump reduce the system pressure. When the operator observes that the pressure in the system again is less than 20 microns or at the pressure which corresponds to the lower pumping limit of the roughing pump, he isolates the roughing pump from the system.

A typical getter ion pump absorbs molecules at a low rate or, as commonly known, at low throughput (throughput being the rate the molecules are absorbed or pumped per unit time by the getter ion pump) when the pressure in the system is relatively high such as, for example, 10–20 microns. Therefore, in the above described system, the getter ion pump operates at a low throughput initially after the roughing pump is isolated from the system. As a result, it requires a considerable period to reduce the pressure in the system to the much lower pressure at which the getter ion pump operates at a maximum throughput, for example, $\frac{1}{10}$ micron.

Another problem associated with the operation of such a getter ion pump vacuum system is the possibility that a sudden release of gas in a low pressure system will raise the pressure to above the getter ion pump's starting pressure, i.e., the maximum pressure at which the pump will maintain a confined glow discharge. Because of the getter ion pump's low pumping speed in this pressure region a considerable time will be required to again reduce the system pressure and in some cases it may even be necessary to again utilize the roughing pump to aid the getter ion pump in the high pressure region. It is also possible that a major leak in the vacuum system will raise the pressure to such a high value that damaging arcing will occur in the getter ion pump.

The principal object of this invention is to provide an improved method and apparatus for obtaining high vacuum which is automatic in operation and which safely and efficiently utilizes an electrical getter ion pump.

One feature of this invention is the provision of an improved method and apparatus utilizing an electrical getter ion pump in which the ion pump is operated at a pressure at or near it point of optimum throughput while system pressure is at a higher value whereby the above noted disadvantages are substantially reduced or eliminated.

Another feature of the present invention is the provision of a method and apparatus for maintaining a low pressure in the getter ion pump while a vessel to be evacuated is at much higher pressures by the use of a throttling valve between the getter ion pump and the vessel.

Another feature of the present invention is the provision of a method and apparatus of the above featured type wherein said throttling valve is automatically controlled in accordance with the pressure in the getter ion pump to insure pump operation at optimum throughput pressure or other desired pressure of pump operation.

Still another feature of the present invention is the provision, in a system of immediately preceding featured type, of a method and apparatus for controlling said valve in accordance with the electrical current drawn by the getter ion pump.

Still another feature of the present invention is the provision of a method and apparatus of the above featured type wherein a roughing pump is utilized to initially evacuate the system and wherein the roughing pump is automatically isolated from the system at the proper intermediate pressure value.

Another feature of the present invention is the provision of a novel method and apparatus for raising and lowering the bell jar on a vacuum system.

These and other features and advantages of the present invention will be more apparent after a perusal of the following specification taken in connection with the accompanying drawings, wherein:

FIG. 1 shows a combination schematic and block diagram of an automatically controlled vacuum system embodying the present invention,

FIG. 2 is an enlarged cross-sectional detail enclosed by circle 2 of FIG. 1 when the valve is in the closed position, and,

FIG. 3 is an alternate embodiment of the control circuitry.

Referring to FIG. 1 of the drawing, a vessel in the form of a bell jar 11 is to be evacuated by a vacuum pump apparatus 12 which is controlled by a control circuit 13. The bell jar 11 is moved up and down by a hydraulic piston assembly 14 and is made to cooperate with a flange 16 disposed on a conduit 17. A suitable gasket 18 on the flange 16 provides a vacuum seal between the bell jar and the flange. A getter ion pump 19 is attached to an apertured plate 21 on conduit 17 and communicates with the conduit through an aperture 22. A valve assembly 23 is disposed within the conduit 17 which seals against an internal flange 24 on plate 21. A hydraulic piston assembly 26 is connected to the valve assembly 23 by a connecting rod 27 which positions the valve assembly 23 within the conduit 17 for maximum throughput to the pump 19.

The valve assembly 23 includes an apertured cover plate 28 with a sealing gasket 29 to provide a suitable outer vacuum seal between the internal flange 24 and the periphery of the cover plate 28. A cup-shaped assembly 31 which is shown in detail in FIG. 2 is fixed vacuum tight to the plate 28. The assembly 31 consists of a sleeve 32 which is held at one end within the aperture of plate 28 by a mounting plate 33 and bolts 34. A gasket 36 forms a suitable vacuum seal between the sleeve and the plate 28. At the other end of the sleeve 32 is brazed an apertured plate 37 which has a plurality of spring retaining dowels 38 disposed in a circular array around the aperture. A compression spring 39 is placed on each dowel 38.

The rod 27 has disposed on its end a sealing member 41 which has a ring gasket 42 fixed in a circumferential groove and seals against the inner periphery of the apertured plate 37. The gasket 42 forms an inner seal which closes a much smaller area than the outer seal 29

closes. To ensure that the member 41 is always aligned with the aperture in plate 37 when rod 27 is retracted by the piston assembly, mounting plate 33 has a coaxial sleeve 43 within which the member 41 is in sliding journal relationship. A collar 44 on member 41 is mounted coaxially and cooperates with springs 39 so that when rod 27 is slightly retracted by the piston assembly the outer seal 29 remains bearing against the internal flange 24 while the inner seal 42 is open to allow small amounts of gas into the getter ion pump 19.

A valve assembly of the kind just described is claimed in Divisional Application Serial No. 376,971, filed June 22, 1964.

An efficient high vacuum seal 45 is provided between the rod 27 and the conduit 17. The seal for convenience consists of two spaced gaskets disposed in the wall of the conduit 17 with the space between the two gaskets communicating with a vacuum ballast tank 46 through a pipe 47 and a duct formed in the wall of the conduit 17. The seal 45 and ballast tank 46 can be replaced by a metal bellows disposed concentrically around the rod 27 which bellows is sealed at its ends to rod 27 and conduit 17.

As mentioned above, when a vessel is to be evacuated by a getter ion pump, the vessel is first pumped down to an intermediate low pressure by a roughing pump. Roughing pumps can be of any convenient type, such as mechanical, sorption, or diffusion pumps. In the embodiment shown, a mechanical pump 48 is used as a roughing pump which has its inlet port communicating with the conduit 17 through a conduit 49 and a valve assembly 51. The mechanical pump 48 is operated by an electric motor 52. Outlet port 53 of the pump 48 may be connected for speed and efficiency to another mechanical pump (not shown). A valve 54 in the valve assembly 51 which valves off the roughing system from conduit 17 is connected by a connecting rod 56 to a hydraulic piston assembly 57.

The hydraulic piston assemblies 14, 26 and 57 preferably are operated by a common hydraulic pressure system (not shown). The high pressure fluid from the system flows by way of pipes 58, 59 and 60 into four-way-valves 61, 62 and 63 which operate piston assemblies 14, 26 and 57 respectively. Valves 61, 62 and 63 are shown schematically in order to clearly show their operative function and the invention is not limited to the particular valves shown. Valve 61 illustrates a three-position valve wherein a slide 64 having two pairs of suitable ports 65 and 65' is enclosed in a closed-end tubular casing 66 with compression springs 67 disposed at each end of the slide and within the casing. The slide 64 is operated by two solenoids 68 and 68' connected at each end of the slide 64 by connecting rods. When neither solenoid is energized, the slide 64 moves to its center position (first position) due to the action of the compression springs 67 and thus none of the ports 65 or 65' are aligned with any of the four pipes 58, 70, 71 and 72, which are connected to the casing 66. When solenoid 68 is energized the slide 64 is attracted to it (the second position) and the ports 65' are aligned with the pipes attached to the casing so that high pressure fluid enters the valve 61 through pipe 58 and one of the ports 65' guides the fluid into pipe 70, and into the connecting rod end of the piston assembly 14 thus raising the bell jar. The fluid from the head end is guided into the valve 61 by pipe 71, within the valve by one of the ducts 65' and out of the valve by pipe 72 and back into the hydraulic system. The third position of valve 61 is achieved by energizing solenoid 68' wherein ducts 65 are now aligned with the pipes 58, 70, 71 and 72 and high pressure fluid in pipe 58 is guided across the slide 64 through the duct 65 to pipe 71 and into the head end of the piston assembly 14 thus lowering the bell jar.

Valves 62 and 63 are two-position valves and are illustrated as having also a slide 64 including a pair of ports 65 and 65' within a casing 66. But these valves 62 and 63 require only one spring 67 and one solenoid 73 and 74 each, respectively. Thus when solenoid 73 and 74 are energized ducts 65 are aligned with the four pipes in the casing and when the solenoids are de-energized the spring 67 moves the slides so that ducts 65' are aligned with the four pipes in the casing. One understands that the valves as illustrated are only schematic arrangements in order to illustrate more clearly the operation of the system and the invention is not limited thereby. There are many commercially available four-way-solenoid valves which can be used to operate the hydraulic system and a typical commercially available valve is an "All-Purpose Four-Way Solenoid Valve, V9 series" as manufactured by Skinner Electric Valve, New Britain, Conn. A three position valve such as valve 61 may be used in combination with either or both piston assemblies 26 and 57, and a two position valve such as valve 62 may be used in combination with piston assembly 14.

In order to increase the efficiency and shorten the time required to cyclically evacuate the system and return the system back to atmospheric pressure, two valves 75 and 76 which open the system to the atmosphere are provided in conduit 17, the high vacuum system, and in conduit 49, the roughing system. Valves 75 and 76 are, preferably, operated by solenoids 75' and 76' respectively with valve 76 being normally open, and valve 75 being normally closed. Therefore since the roughing system can be at atmospheric pressure when there is a high vacuum in conduit 17 a solenoid 77' operated, normally closed valve 77 is placed in a pipe 78 which communicates the ballast tank 46 with the roughing system. If a bellows is used to provide motion and sealing between the rod 27 and conduit 17, as mentioned above, then valve 77 is not required. The pipe 78 allows the tank 46 to be repeatedly evacuated by the system to ensure that the space between seals 45 is at some intermediate vacuum than the vacuum in conduit 17. A pressure sensing switch 79 which is operated by the pressure in high vacuum system is provided in the apparatus and conduit 17 whereby automatic control of the circuit 13 is obtained during automatic operation of the apparatus 12.

The control circuit 13 includes a power supply 80, which, when initially energized, closes a circuit through a manually-operated double throw switch 81 and contacts 81' to energize a timer 82. After a predetermined time delay the timer 82 closes a switch 83 which closes a circuit to energize a second timer 84 and also a parallel circuit to solenoid 75' of valve 75 which operates but performs no necessary function at this stage. After another predetermined time delay, timer 84 operates to close a switch 85 and thereby close a circuit through manually-operated double throw switch 86 and its contact 86' to the solenoid 68' which operates, as explained above, to lower the bell jar.

With the bell jar 11 lowered onto the flange 16, contacts 81 and 81' are manually opened to release timers 82 and 84 and solenoids 68' and 75' and contacts 81 and 81'' are closed. The resultant de-energization of solenoid 68' causes valve 61 to return to its midposition to thus lock the bell jar in place. Contacts 81 and 81'', on closing, complete a circuit through contacts 87 and 87' to solenoids 77' and 74 which operate to open valve 77 to the ballast ank 46 and to open valve 54 between the closed vacuum system and the roughing pump 48, respectively. Contacts 81 and 81'' also complete a circuit through switch 88 to motor 52 and to solenoid 76'. Solenoid 76' operates to close valve 76 and motor 52 starts the mechanical pump 48. At this time a manual switch 89 is also closed to energize solenoid 73 and thus open valve 23 to the getter ion pump 19.

The mechanical pump 48 now operates to evacuate the closed vacuum system including the bell jar 11, ballast tank 46, conduit 17 and getter ion pump 19. When the pressure in the system is lowered to about 20 microns, as indicated by a gauge (not shown), a circuit including a

high voltage power supply 90 and a resistor 91 is closed to the getter ion pump 19 by a manual switch 92. This causes the getter ion pump 19 to heat up and initially outgas to slightly raise the pressure in the system.

When the roughing pump reduces the pressure in the system to less than 20 microns, the pressure sensitive switch 79 closes a switch 93 to energize a solenoid 94 which operates to open contacts 87 and 87', close contacts 87 and 87", and close contacts 95. The opening of contacts 87 and 87' releases solenoids 77' and 74 to close valves 77 and 54, respectively, and thus seal off the ballast tank 46 and the vacuum system from the roughing pump 48. Contacts 87 and 87", on closing, energize a timer 96 which, after a predetermined time long enough to ensure that valve 54 is closed, opens the switch 88 to turn off motor 52 and de-energizes solenoid 76' to allow atmospheric pressure into the roughing pump system and prevent lubricating oils from backing up therein.

At this time, switch 89 is preferably opened to de-energize relay 73 and allow valve 23 to close. The getter ion pump 19 is therefore only required at this time to lower the pressure within its own volume. This volume being small, the getter ion pump quickly lowers the pressure to a desired pump operating pressure while the pressure within the bell jar 11 and conduit 17 remains about 20 microns. The throttle valve 23 serves the purpose of maintaining this desired pressure within the getter ion pump regardless of the bell jar system pressure (so long as system pressure is greater than the desired pressure), i.e., by selectively opening and closing the gas access path between the pump 19 and jar 11. Thus, for example, the pump 19 may be operated at its maximum throughput pressure. A throttle valve of a type similar to valve 23 may be manually operated to achieve this result or automatic operation as hereinafter described may be utilized.

The flow of current to an electrical getter ion pump decreases with decreasing pump operating pressure. This relationship of current and pressure is utilized by an automation circuit 97 which operates in response to the current drawn by the pump 19 to control the closing and opening of valve 23.

The automation circuit has a resistor 98 with a given voltage thereacross produced by a battery power supply 99 in conjunction with a rheostat 101. Resistor 91 also has produced thereacross a voltage due to the current demand of the getter pump 19. These two voltages buck each other so that, depending on which one of the two is greater, current will flow in one direction or the other through an amplifier 102 to a polar sensitive relay 103. Therefore, when the voltage across resistor 98 is greater than the voltage across resistor 91, the relay 103 will close its contacts 103' energizing solenoid 73 and opening valves 23 to permit the gas within bell jar 11 to flow into the pump 19 thus raising the pressure within the getter pump. As this pressure increases, the voltage across resistor 91 increases and when this voltage is greater than the voltage across resistor 98, contacts 103' are opened since the direction of current to the polar sensitive relay 103 is reversed. This cycle of operation will be continuously and automatically repeated until the pressure in the system has been reduced to the pressure within the pump 19. Rheostat 101 is used to conveniently adjust the voltage across resistor 98 so that valve 23 will be opened and closed at any desired operating pressure of the getter ion pump, for example, the maximum throughput pressure.

The above described control of pump operating pressure by the valve 23 will begin functioning at any time the system pressure again rises above the selected operating pressure of the getter ion pump. The present method and apparatus is therefore extremely useful in vacuum processing applications in which large bursts of gas are evolved at critical times during the process (for example, a tube processing which entails cathode conversion) since the large gas bursts can be pumped at the getter ion pumps optimum throughput pressure.

The valve 23 provides an extremely sensitive gas access control since each cycle of the above described automatic control operation will be accomplished within the inherent time delay between the initial breaking of the seal 42 and the later breaking of seal 29. Thus, all the getter ion pump pressure control is performed by the opening and closing of the more sensitive smaller seal 42 while the larger seal 29 is broken to provide maximum gas access only after pressure equilization between the system and pump has been realized. At this time, both of the seals 29 and 41 will remain open allowing the getter ion pump to further reduce the pressure within the entire system.

If a more sensitive amplifier 102 and quick-acting, precision hydraulic equipment are used in the system, valve 23 can be made whereby it only has the outer seal 29 and it can be opened to control the amount of gas entering the getter ion pump. The valve 23, as shown, is preferred when slow-acting, economical, commercially available components are incorporated in the system.

When access is required into the system, contacts 81 and 81" are manually opened to primarily de-energize solenoid 73 to close valve 23 isolating the getter pump from the bell jar system which allows continued low pressure operation of the getter pump. At the same time, contacts 81 and 81' are closed to operate timer 82, which, after a delay long enough to ensure that valve 23 has closed, closes switch 83 which energizes timer 84 and solenoid 75'. Solenoid 75' opens valve 75 allowing atmosphere pressure within conduit 17 and bell jar 11, and timer 84 closes switch 85, after allowing atmospheric pressure into the system, and now the bell jar 11 is ready for removal by manually closing contacts 86 and 86" to energize solenoid 68. It is thus noted that the bell jar cannot be raised during any period in which the bell jar is under vacuum.

The system thus provides for raising the bell jar system to atmospheric pressure while maintaining a low operating pressure in the getter ion pump. This prevents the adsorption of gas by the getter pump walls that occurs whenever pressure is increased within the pump. The time required to reduce system pressure on subsequent vacuum operations is thereby greatly reduced because the large amount of gas that would have been adsorbed does not now have to be pumped.

The second and subsequent times the bell jar 11 and the system are to be evacuated, the bell jar 11 is placed on flange 16 by manually closing contacts 86 and 86' and afterward contacts 81 and 81" are closed, as before, but switch 89 is not closed so that valve 23 remains closed to prevent atmospheric pressure from being admitted into the getter ion pump 19. The bell jar system is now automatically evacuated in the same manner as described above except switch 92 remains closed since the getter ion pump 19 is continuously operated. Since the system is initially roughed to an intermediate vacuum and the getter ion pump 19 then pumps at maximum throughput, a system was built having a ten liter bell jar which was reduced to a pressure of 10^{-2} microns within 6 minutes and a pressure of 10^{-3} microns within 16 minutes.

As an alternate method, the pressure sensing switch 79 and the roughing system can be eliminated and valve 23 may be used to throttle gas into the getter pump when the bell jar 11 and conduit 17 is initially at atmospheric pressure. This process requires a very accurate and precision valve 23 in order to control a slow leak through it so that extremely small amounts of gases are supplied to the getter pump.

For some applications, a three position valve 105 similar to valve 61 and the modified control circuit of FIG. 3 may be desirable for operating the piston assembly 26 for valve 23. The components in FIG. 3 which are identical to components in FIG. 1 bear the same numbers. A

double throw switch 106 is now operated by the polar sensing relay 103. When current flows through the relay 103 in one direction contacts 106 and 106' are closed to energize a solenoid 107 whereby high pressure fluid in pipe 59' is guided by the valve 105 in pipe 108 and into the connecting rod end of piston assembly 26 to create an opening force on valve 23. Conversely when current reverses through the relay 103 contacts 106 and 106'' close to energize solenoid 109 whereby high pressure fluid in pipe 59' is guided by the valve 105 into pipe 111 and into the head end of piston assembly 26 to create a closing force on valve 23. When no current passes through the relay 103 the contact arm 106 floats between contacts 106' and 106'' and neither solenoid 107 or 109 is energized. Since fluid cannot enter or exit from the piston assembly 26 the valve 23 is locked in position.

When access is desired into the system contacts 81 and 81'' are opened to de-energize solenoid 94 to open contacts 112 and 112'' and closing contacts 112 and 112' on a double throw switch 112. This opens the automatic control circuit to valve opening solenoid 107 and closes an energizing circuit to valve closing solenoid 109 to thereby close valve 23. Contacts 81, 81' and 81'' may then be operated to perform the same functions as described above.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A process for evacuating gases found in an envelope with a getter ion pump, said process comprising placing said envelope in communicating relationship with said ion pump, and throttling gases to a predetermined low pressure into said pump from said envelope, said throttling process controlled by the pressure within said pump.

2. A process for evacuating gases found in an envelope comprising first evacuating gases found in said envelope with a roughing vacuum pump, valving off said envelope from said roughing pump, and then placing said envelope in communicating relationship with a getter ion pump, and throttling gases to a pressure lower than atmospheric into said getter pump from said envelope.

3. An apparatus for evacuating an envelope comprising an envelope, a getter ion pump in communicating relation with said envelope, a valve between said ion pump and said envelope, an electrical power supply for said ion pump, and means in cooperation with the current from said power supply for opening said valve when said current is below a given value and closing said valve when said current increases over said given value.

4. The apparatus of claim 3 wherein said means comprises a resistor connected in series with said power supply and said ion pump, a relay means connected across said resistor, said relay functioning when the voltage across said resistor is over a given value, and electrical means for operating said valve, said relay means controlling said electrical means whereby said valve is closed when said current is over said given value and is opened when said current is below said given value.

5. The apparatus of claim 3 wherein said means comprises a resistor connected in series with said power supply and ion pump, an amplifier and low direct voltage supply connected in series with said resistor, electrical means for operating said valve, and solenoid means connected to said amplifier and disposed to operate in a given direction when the current in said amplifier is in a given direction, and, when the current in said amplifier reverses, the direction of operation also reverses, said solenoid means also disposed to control said electrical means and the position of said valve.

6. An apparatus for evacuating an envelope comprising an envelope, a getter ion pump in communicating relation with said envelope, a first valve between said ion pump and said envelope, a mechanical pump in communicating relation with said envelope, a second valve disposed between said mechanical pump and said envelope, pressure transducer means cooperating with said envelope for closing said first valve and opening said second valve when the pressure in said envelope is high and opening said first valve and for closing said second valve when the pressure in said envelope is low, an electrical power supply for said ion pump, and means in cooperation with the current from said power supply for opening said first valve when said current from said supply is below a given value and closing said valve when said current from said supply increases above said given value.

7. The apparatus of claim 6 wherein said means comprises a resistor connected in series with said power supply and said ion pump, a relay means connected across said resistor, and electrical means for operating said first valve, and said relay means control said electrical means whereby said first valve is closed when said current in said resistor is over said given value and is opened when said current is below said value.

8. The apparatus of claim 6 wherein said means comprises a resistor connected in series with said power supply and ion pump, an amplifier and low direct voltage supply connected in series with said resistor, electrical means for operating said valve, and solenoid means connected to said amplifier and disposed to operate in a given direction when the current in said amplifier is in a given direction, and when current in said amplifier reverses the direction of operation reverses, said solenoid means also disposed to control said electrical means and the position of said valve.

9. An apparatus for evacuating an envelope comprising an envelope, a getter ion pump in communicating relation with said envelope, a valve between said ion pump and said envelope, said valve comprising a rod forming a seal at one end, said end cooperates with an apertured plate to form a throttle valve, said apertured plate having a seal around its periphery for sealing said ion pump from said envelope, and spring means cooperating between said rod and said plate for urging said plate to be sealed at its periphery while said throttle valve is open.

10. The apparatus of claim 9 wherein said spring means comprises a cup member having an axial aperture and is disposed on said apertured plate with the apertures aligned, said end of said rod seals against the periphery of said aperture in said cup-shaped member, a collar on said rod, and a compression spring cooperating between said collar and the bottom of said cup-shaped member.

11. An apparatus comprising an envelope having an access opening, a roughing vacuum pump for roughing a vacuum within said envelope, a high vacuum pump for forming a high vacuum within said envelope, first means for closing and opening said access opening, second means for communicating said roughing pump with said envelope and for roughing a vacuum within said envelope only when said access opening is closed, pressure sensing means for sealing off said roughing pump from said envelope when said pressure in said envelope is at a predetermined low value, third means for communicating said high vacuum pump with said envelope and forming a high vacuum within said envelope, and fourth means for sealing said high vacuum pump from said envelope, first timer means for allowing atmospheric pressure within said envelope after said high vacuum pump is sealed from said envelope, and second timer means for electrically energizing said first means so that said access opening may be opened by said first means.

12. The apparatus of claim 11 wherein said high vacuum pump is a getter ion pump, said fourth means comprises a valve between said getter pump and said envelope, and an automation circuit means in cooperation with said current demand of said getter pump for opening

and closing said valve as said current demand decreases and increases respectively.

13. The apparatus of claim 14 wherein said valve comprises an apertured plate, sealing means at the periphery of said plate, a cup-shaped member having an aperture in its bottom and sealed to said plate with said apertures coaxial, a rod having a seal at one end protruding through the aperture of said plate and sealing against the periphery of the aperture of said cup member, a collar disposed on said shaft, and spring means cooperating between said collar and said cup member for urging said seal at one end of said rod from the bottom of said cup member.

14. The valve of claim 13 wherein said spring means comprises a plurality of compression springs disposed within said cup member and around said rod, and a dowel disposed within each spring, said dowels fixed at one end to said cup member.

15. An apparatus comprising an envelope to be evacuated, a high vacuum pump and means for maintaining the pressure within said pump at a predetermined low pressure as said pump is pumping while the pressure in said envelope is above said predetermined low pressure,

said means comprising a throttle valve disposed between said envelope and said pump.

16. The apparatus of claim 15 wherein said valve means comprises a sensitive, small restriction valve and a coarse, larger restriction valve, and means for first opening and closing said sensitive valve until the pressure in said envelope is equal to said predetermined low pressure and then opening said coarse valve to provide a low conductance path between said envelope and said pump.

17. The apparatus of claim 15 wherein said high vacuum pump is a getter ion pump, and said valve means is automatically controlled by the current demand of the pump.

References Cited in the file of this patent

UNITED STATES PATENTS

1,802,897	Holden et al.	Apr. 28, 1931
2,403,777	Yonka	July 9, 1946
2,954,156	Meyer	Sept. 27, 1960
2,973,134	Von Aidenne	Feb. 28, 1961
3,050,622	Boyer et al.	Aug. 21, 1962

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,150,817 September 29, 1964

Robert L. Jepsen et al.

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

Column 4, line 63, for "ballast ank" read -- ballast tank --; column 5, line 53, for "valves" read -- valve --; column 6, lines 31 and 32, for "atmosphere" read -- atmospheric --; column 9, line 3, for the claim reference numeral "14" read -- 12 --.

Signed and sealed this 2nd day of March 1965.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents