United States Patent [19]
Kauer, Jr. et al.

[11] 3,768,500
[45] Oct. 30, 1973

[54] SELECTOR VALVE AND USE THEREOF IN A FRACTIONATION SYSTEM

[75] Inventors: George C. Kauer, Jr., Plainview, L.I.; Louis E. Brooks, Great Neck, L.I., both of N.Y.

[73] Assignee: Air Techniques Incorporated, New Hyde Park, N.Y.

[22] Filed: Apr. 1, 1971

[21] Appl. No.: 130,271

[52] U.S. Cl. .... 137/119, 235/201 ME
[51] Int. Cl. G06m 1/12, G05d 11/02
[58] Field of Search .... 137/119, 118, 112, 137/110; 235/201 ME

[56] References Cited

UNITED STATES PATENTS

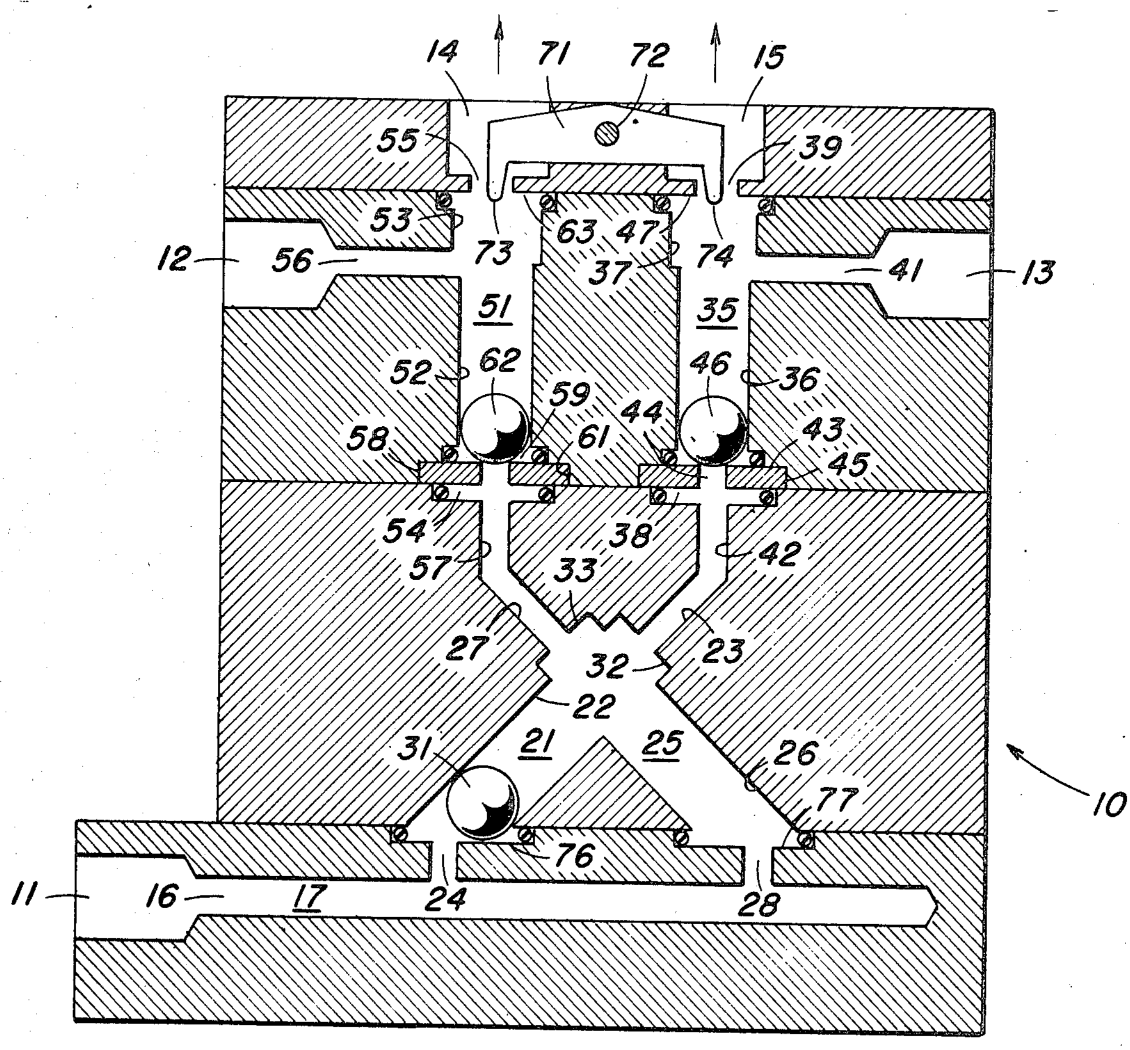
2,024,548	12/1935	Struve	137/112
3,299,661	1/1967	Harnish et al.	137/112 X
3,447,556	6/1969	Howeth	137/112
3,463,389	8/1969	Mott	137/119 X
3,614,965	10/1971	Metivier	137/119

Primary Examiner—Alan Cohan
Attorney—Marn & Hangarathis

[57] ABSTRACT

A five ported selector valve having an inlet, two outlet and two vent ports in which a ball is moved therein to alternately place the inlet port in fluid flow communication with each of the outlet ports in response to stopping and restarting of fluid flow through the inlet port. The outlet port not connected to the inlet port is in fluid flow communication with its respective vent port. The valve is particularly suited for reversing flow in a dual tower adsorption system. A three ported valve in which fluid is alternately directed from an inlet port to one of two outlet ports is also disclosed.

5 Claims, 5 Drawing Figures



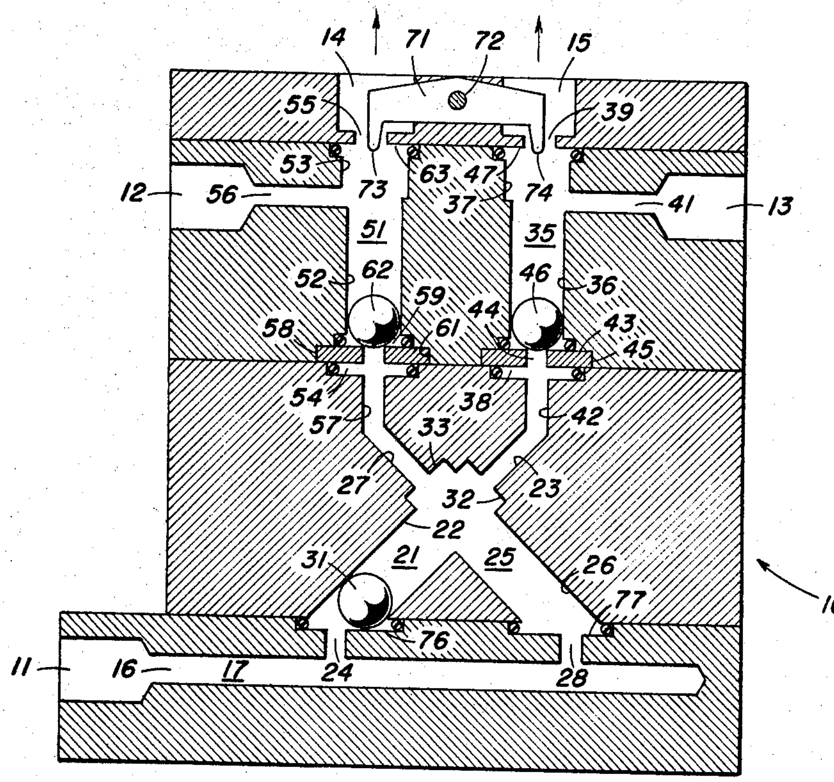


Fig. 1.

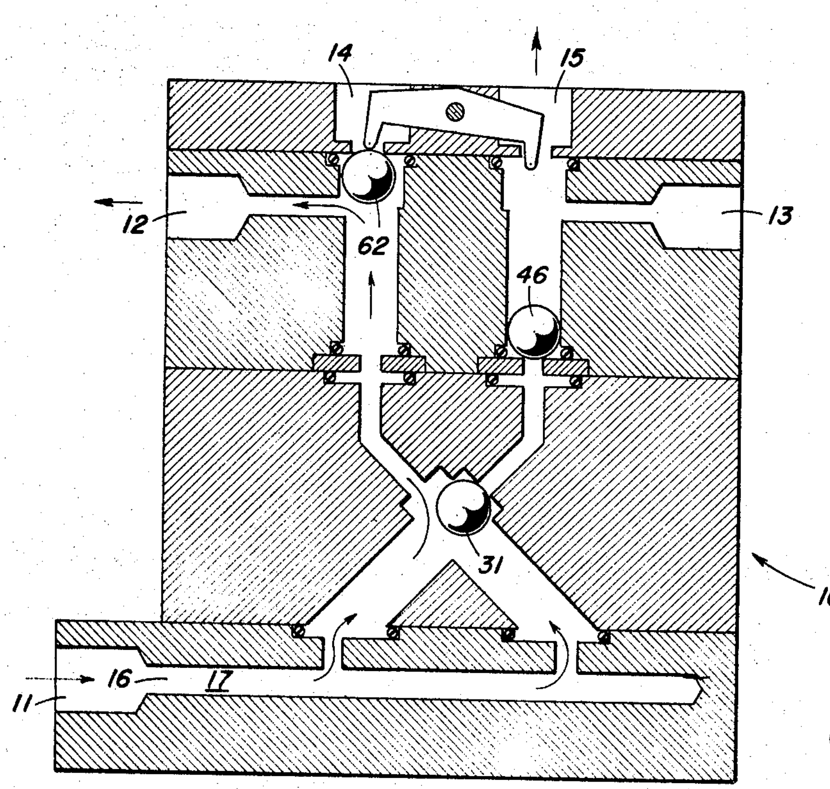


Fig. 2.

INVENTORS
George C. Kauer, Jr.
Louis E. Brooks
BY Marn & Jangarathis
ATTORNEYS

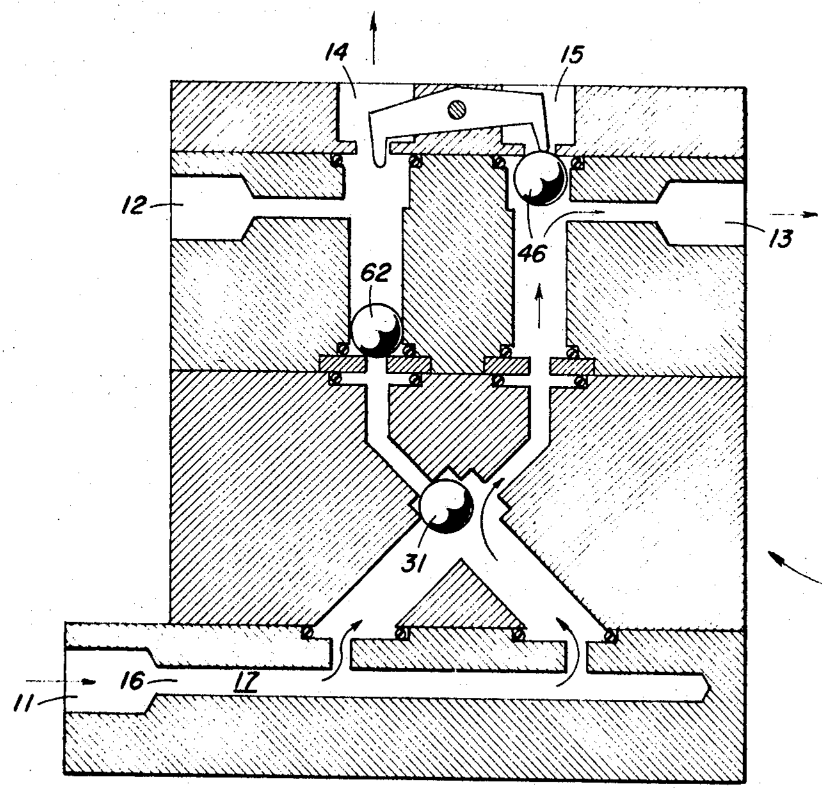


Fig. 3.

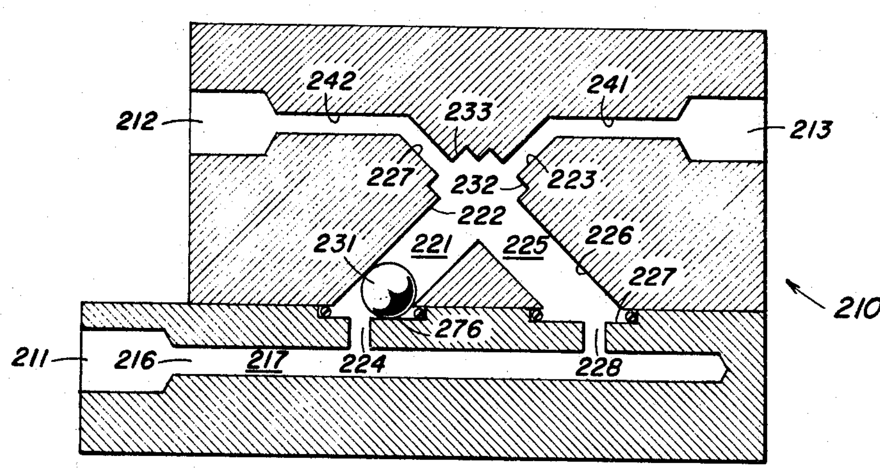


Fig. 5.

INVENTORS
George C. Kauer, Jr.
Louis E. Brooks
BY Marn & Jangarathis
ATTORNEYS

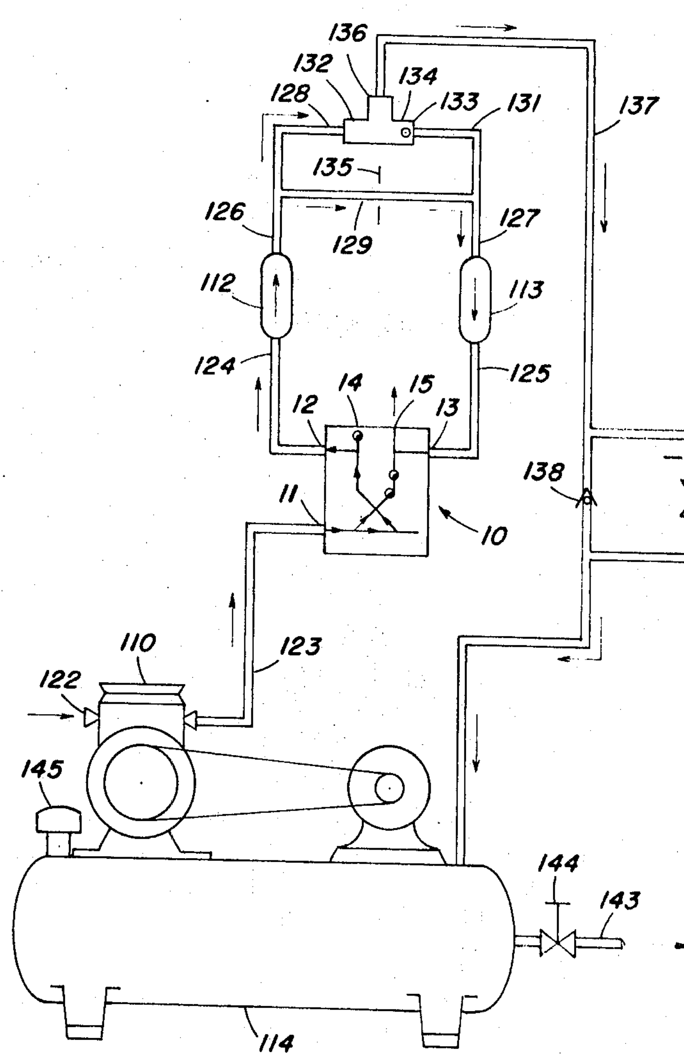


Fig. 4.

INVENTORS
George C. Kauer, Jr.
Louis E. Brooks
BY Marn & Jangarathis
ATTORNEYS

SELECTOR VALVE AND USE THEREOF IN A FRACTIONATION SYSTEM

This invention relates to the fractionation, by adsorption, of a compressed gas, and in particular, to the fractionation of a compressed gas by the use of dual adsorption chambers. This invention also relates to a new and improved valve for alternately directing flow from an inlet port to one of two outlet ports. This invention further relates to a new and improved valve which may be employed in a system effecting adsorption in dual chambers.

The use of two adsorption chambers for fractionating a gas in which one adsorption chamber is employed for adsorbing a component of a gaseous mixture while the other chamber is regenerated by passing a portion of the unadsorbed gas therethrough at a reduced pressure, is known in the art, and is exemplified by U.S. Pat. No. 2,944,627, granted July 12, 1960. In such a system, compressed gas is directed through one adsorption chamber to effect adsorption of a component thereof, with a major portion of the unadsorbed gas being passed directly to utilization equipment and a minor portion of the unadsorbed gas being passed through a pressure reducing flow controller to a second chamber which has previously been employed for adsorption. The unadsorbed portion of the gas is passed through the adsorbent in the second chamber to effect desorption of the adsorbed component and the gas containing the desorbed component is then vented to atmosphere.

The apparatus is provided with piping and valves to alternately connect the two chambers to adsorption and desorption and the valves are generally solenoid operated valves which are activated by a cycle timing device which maintains each chamber, on each portion of the cycle, for a short period of time; for example, from 30–80 seconds.

The prior art dual tower systems have numerous disadvantages. Thus, for example, the desorption operation is continuous, even if the system is not using the unadsorbed portion of the gas, with the compressor running to meet desorption demands. In addition, such systems do not include a storage tank and in order to keep such systems operating under all probable load conditions, the regeneration must be designed for the maximum probable load condition, resulting in considerable waste in that flow required for regeneration is excessive at all conditions, except maximum load. Furthermore, such systems depend on a combination of a valve and timer to change the cycle which is not generally reliable.

Accordingly, an object of this invention is to provide for desorbing of a component of a gas in a manner which avoids the aforementioned disadvantages.

Another object of this invention is to provide for effecting improved adsorption and desorption in dual adsorption chambers.

A further object of the invention is to provide for improved switching from adsorption to desorption in a dual adsorption chamber operation.

Still another object of this invention is to provide for a new and improved valve.

Still another object of the invention is to provide a new and improved valve for alternating flow from an inlet port to one of two outlet ports.

Yet a further object of this invention is to provide for a new and improved valve which is particularly suitable for changing the adsorption and regeneration cycles in a dual tower adsorption system.

These and other objects of the invention should be more readily apparent from reading the following detailed description thereof with reference to the accompanying drawings, wherein:

FIG. 1 is an elevational view, in cross-section, of a preferred embodiment of the valve of the invention in a first operating position;

FIG. 2 is an elevational view, in cross-section, of the embodiment of FIG. 1 in a second operating position;

FIG. 3 is an elevational view, in cross-section, of the embodiment of FIG. 1 in a third operating position;

FIG. 4 is a simplified schematic representation of a dual tower adsoption system incorporating the valve embodiment illustrated in FIG. 1; and

FIG. 5 is an elevational view, in cross-section, of another preferred embodiment of the valve of the present invention.

The objects of this invention are broadly accomplished, in one aspect, by providing for adsorbing of a component of a compressed gas by means of a suitable adsorbent in which adsorption of the component by the adsorbent, and subsequent regeneration of the adsorbent by desorption of the component, is effected when the compressor is in operation and the switching of the adsorbent from the adsorption of an overall cycle to the desorption portion of the overall cycle and vice versa, is controlled by a selector valve which changes flow in response to deactivation and activation of the compressor.

More particularly, a compressed gaseous mixture is passed through a selector valve to a first adsorbent bed to effect adsorption of one component thereof and a first unadsorbed portion of the gas is passed to a storage tank for subsequent utilization. A second unadsorbed portion of the gas is passed, at a lower pressure, through a second adsorbent bed in which the one component has previously been adsorbed to desorb the one component therefrom and thereby regenerate the bed for subsequent adsorption and the gas, containing the desorbed component is passed through the selector valve to the atmosphere. The adsorption in the first bed and the desorption in the second bed is continued until a predetermined maximum pressure is obtained in the storage tank, at which time, the compressor is deactivated, and the elements of the selector valve are automatically moved in response to the deactivation of the compressor to a position in which upon reactivation of the compressor the valve elements are moved to a position in which the flow path is reversed to effect adsorption in the second bed and desorption in the first bed. The compressor is reactivated upon the pressure in the storage tank reaching a predetermined minimum, and adsorption is effected in the second bed and desorption in the first bed until the pressure in the storage tank again rises to a predetermined maximum, thereby deactivating the compressor and resetting the valve elements of the selector valve to a position in which reactivation of the compressor moves the valve elements to direct the gas flow to effect adsorption in the first bed and desorption in the second bed. Thus, the adsorption and desorption is effected only when the compressor is in operation and the frequency and length of the overall cycle is a function of the amount of desorbed gas required by the utilization system.

The selector valve is a five ported valve having an inlet port, two outlet ports and two vent ports. The inlet port is in fluid flow communication with each of the outlet ports and each of the outlet ports is in fluid flow communication with a respective vent port. The valve is provided with a flow control means which alternately directs flow through the valve from the inlet port to one of the outlet ports while simultaneously directing flow from the other outlet port through its respective vent port. The flow control means alternates the flow from the inlet port to the two outlet ports in response to stopping and restarting of flow through the inlet port.

Still more particularly, a pair of flow passages, each connected at one end to the inlet port and intersecting at their other ends, are connected, at their intersecting ends, to one vent port and one outlet port through a third flow passage and to the other vent port and the other outlet port through a fourth flow passage. The one vent port and the one outlet port are connected to each other through the third flow passage and the other vent port and the other outlet port are connected to each other through the fourth flow passage.

A first closure means, preferably in the form of a ball, is movably positioned in the intersecting flow passages, and is moved in response to and by fluid introduced into the inlet port to alternately close communication between the intersecting passages and the third flow passage and the intersecting passages and the fourth flow passage. The third and fourth flow passages are each provided with a closure member, preferably in the form of a ball, which is movable in the passage in response to and by fluid flowing therethrough from the inlet port. In the absence of fluid flow through the inlet port, the closure members are positioned in each of the third and fourth flow passages at a position whereby fluid can flow therethrough between the vent and outlet ports. In response to fluid flow through the inlet port, the first closure member prevents fluid flow to either the third or fourth flow passage from the intersecting flow passages and the fluid flow through one of the third and fourth flow passages moves its closure member to a position which closes the vent port and opens fluid flow communication between the outlet port and the intersecting passages, whereby fluid flows from the inlet port to one of the outlet ports. The closure member in the one of the third or fourth flow passages which does not experience fluid flow from the intersecting passages remains in its previous position, thereby maintaining the fluid flow communication between the vent and outlet ports.

The selector valve, hereinabove described, is employed in a dual tower adsorption system by connecting the inlet port to a compressor, one outlet port to one adsorption tower and the other outlet port to a second adsorption tower. During periods when the compressor is deactivated both towers are connected to the atmosphere through the respective outlet and vent ports of the valve. Upon activation of the compressor, the introduction of fluid into the inlet port of the valve opens fluid flow communication between the inlet port and one outlet port, whereby compressed gas is passed to one adsorption tower and maintains fluid flow communication between the second outlet port and its respective vent port, whereby regeneration gas can flow from the other adsoprtion tower to the atmosphere. Upon stopping and reactivation of the compressor, the fluid flow is reversed in that the inlet port is now in fluid flow communication with the second outlet port, whereby compressed gas flows to the other adsorption tower and the one outlet port is in fluid flow communication with its respective vent port, whereby regeneration gas can flow from the one tower to the atmosphere.

The objects of this invention are also accomplished by providing a three ported valve having an inlet port and two outlet ports each connected to the inlet port. The valve is provided with a flow control means which is movable by and in response to fluid introduced into the inlet port, said flow control means alternately directing the flow from the inlet port to the first outlet port and from the inlet port to the second outlet port in response to stopping and restarting of flow through the inlet port. More particularly, the valve is provided with a first flow passage having a first end connected to the inlet port and the second end to the first outlet port, and a second flow passage having a first end connected to the inlet port and the second end to the second outlet port, the flow passages intersecting adjacent their second ends. A movable closure member, preferably in the form of a ball is movable within and between the intersecting flow passages. Upon being positioned in the first flow passage, the closure member is moved by fluid introduced into the inlet port to the second end of the first flow passage to close the first outlet port, whereby fluid flows from the inlet port to the second outlet port. Upon stopping of fluid introduction into the inlet port, the closure member falls by gravity into the second flow passage, and upon restarting introduction of fluid into the inlet port, the closure member is moved to the second end of the second flow passage to close the second outlet port, whereby fluid flows from the inlet port to the first outlet port. Upon stopping the introduction of fluid into the inlet port, the closure member falls by gravity into the first flow passage.

The invention will be further described with reference to preferred embodiments thereof illustrated in the accompanying drawings, but it is to be understood that the scope of the invention is not to be limited thereby.

Referring to FIG. 1, a valve body **10** includes an inlet port **11**, a first outlet port **12**, a second outlet port **13**, a first vent port **14** and a second vent port **15**. An inlet passage **16**, defined by horizontal bore **17**, extends inwardly through through valve body **10** from the inlet port **11** and terminates within the valve body **10**.

A flow passage **21**, defined by angular cylindrical bore **22** having an upper reduced portion **23**, connected at its lower end to inlet passage **16** through a vertical cylindrical bore **24**, extends angularly upwardly away from the inlet port **11**, and a flow passage **25**, defined by angular cylindrical bore **26** having an upper reduced portion **27**, connected at its lower end to inlet passage **16** through a vertical cylindrical bore **28**, longitudinally spaced from vertical bore **24**, extends angularly upwardly toward the inlet port **11**, with the bores **22** and **26** intersecting at the upper ends thereof. The bores **22** and **26** have identical diameters and a movable closure member, in the form of a ball **31**, having a diameter approximating, but slightly less than the diameter of the cylindrical bores **22** and **26**, is movably positioned for movement within the bores **22** and **26** in response to fluid flow therethrough to alternately seat against the shoulder **32** formed between bore **22** and its reduced portion **23**, and the shoulder **33** formed between bore **26** and its reduced portion **27**.

The various dimensions of the bores 22 and 26 and the ball 31 are coordinated in a manner such that the center of gravity of the ball 31, in the position in which ball 31 is seated against shoulder 32, is positioned so that gravity causes the ball 31 to fall into bore 26 upon stopping of fluid flow through the inlet port 11, and the center of gravity of the ball 31, in the position in which the ball 31 is seated against shoulder 33, is positioned so that gravity causes the ball 31 to fall into bore 22 upon stopping of fluid flow through the inlet port 11.

A flow passage 35 defined by a vertical cylindrical bore 36 having an unaligned enlarged upper portion 37 and an aligned enlarged lower portion 38 is connected at its upper portion with the vent port 15 through reduced aligned bore 39. A horizontal cylindrical bore 41 connects the outlet port 13 to the flow passage 35 at the intersection of the bore 36 with its unaligned upper portion 37. A reduced cylindrical vertical bore 42, aligned with enlarged portion 38 of bore 36, connects the flow passage 35 with the reduced bore portion 23 of bore 26. An annular member 43, which defines a restricted flow port 44 between the enlarged portion 38 and bore 36, is positioned in a circular groove 45 in the enlarged portion 38, and the annular member 43 also functions as a seat for a movable closure member, in the form of a ball 46, having a diameter approximating, but slightly less than the diameter of the bore 36. The ball 46 is axially movable within bore 36 and closes port 15 when seated against the shoulder 47 between the enlarged portion 37 of bore 36, and reduced bore 39, with the dimensions of the various bores and the ball being coordinated so that horizontal bore 41 is not closed by ball 46 when the ball 46 is seated against shoulder 47. The ball 46 may or may not be sealingly seated against the annular member 43.

A flow passage 51 defined by a vertical cylindrical bore 52 having an unaligned enlarged upper portion 53 and an aligned enlarged lower portion 54 is connected at its upper portion 53, with the vent port 14 through reduced aligned bore 55. A horiztonal cylindrical bore 56 connects the outlet port 12 to the flow passage 51 at the intersection of the bore 52 with its unaligned upper portion 53. A cylindrical vertical bore 57, aligned with enlarged portion 54 of bore 52, connects the flow passage 51 with the reduced bore portion 27 of bore 26. An annular member 58, which defines a restricted flow port 59 between the enlarged portion 54 and bore 52, is positioned in a circular groove 61 in the enlarged portion 54, and the annular member 58 also functions as a seat for a movable closure member, in the form of a ball 62, having a diameter approximating but slightly less than the diameter of the bore 52. The ball 62 is axially movable within bore 52 and closes port 14 when seated against the shoulder 63 between the enlarged portion 53 of bore 52 and reduced bore 55, with the dimensions of the various bores and the ball being coordinated so that horizontal bore 56 is not closed by ball 62 when the ball 62 is seated against shoulder 63. The ball 62 may or may not be sealingly seated against the annular member 58.

A rocker arm 71 is pivotally mounted to the valve body 10 adjacent the ports 14 and 15 by a pivot pin 72, and the rocker arm 71 has downwardly extending portions 73 and 74 which extend through the reduced bores 55 and 39, respectively, into the enlarged portions 53 and 37 of bores 52 and 36 respectively. The rocker arm 71 functions to prevent the balls 46 and 63 from both being seated against their respective shoulders, as hereinafter described.

In operation, FIG. 1 depicts the valve without any flow of fluid through the inlet port 11 in which case the ball 31 is at rest seated against a shoulder 76 between bore 24 and bore 22; ball 46 is at rest in bore 36 against annular member 43 placing ports 13 and 15 in fluid flow communication with each other through passage 35 and ball 62 ia at rest in bore 52 against annular member 58 connecting ports 12 and 14 through passage 51. Upon the introduction of fluid into inlet port 11 (FIG. 2), the fluid flowing from inlet passage 16 through vertical bore 24 into bore 22 causes ball 31 to move upwardly in bore 22 and become seated against shoulder 32 thereby preventing fluid from flowing to port 44, whereby the ball 46 in bore 36 remains at rest against annular port 43, maintaining fluid flow communication between outlet port 13 and vent port 15 through passage 35.

The fluid introduced through inlet port 11 flow through the bores 22 and 26 and reduced bore 27 into the bore 52 through port 59 causing the ball 62 positioned in bore 52 to move upwardly therein and become seated against shoulder 63, thereby closing fluid flow communication between the passage 51 and the port 14, and opening fluid flow communication between the port 59 and port 12 through the passage 51. Thus, there is a continuous passage of fluid from inlet port 11 to only outlet port 12. The seating of ball 62 against shoulder 63 pivots the rocker arm 71 causing the portion 74 thereof to move further into the enlarged portion 37 of bore 36 and thereby preventing the ball 46 from becoming seated against shoulder 47. Thus, in the event that leakage of fluid past ball 31 into reduced bore 23 and through port 44 causes ball 46 to move upwardly in bore 36, the ball 46 can not close fluid flow communication between ports 13 and 15 in that the ball 46 is not seated against shoulder 47, and fluid can flow from port 13 between the ball 46 and the wall of the enlarged portion 37 to the vent port 15. Thus, as shown in FIG. 2, fluid flows through the valve from the inlet port 11 to the outlet port 12, and fluid also flows between ports 13 and 15.

Upon stopping fluid flow through inlet port 11, the ball 31, seated against shoulder 32, falls by gravity into bore 26 and rests therein against a shoulder 77 formed between bores 26 and 28. The stopping of flow through port 59 causes ball 62 in bore 52 which was seated against shoulder 63 to fall by gravity and come to rest against member 58. Thus, ports 12 and 14 are interconnected through passage 51 and ports 13 and 15 are interconnected through passage 35, with balls 62 and 46 being at rest on annular members 58 and 43, respectively. Upon restarting introduction of fluid into inlet port 11 (FIG. 3), the fluid flowing from inlet passage 16 through vertical bore 28 into bore 26 causes ball 31 to move upwardly in bore 26 and become seated against shoulder 33, thereby preventing fluid from flowing through the reduced bore 27 to port 59, whereby the ball 62 in bore 52 remains at rest against annular member 58, maintaining fluid flow communication between outlet port 12 and vent port 14 through passage 51.

The fluid introduced through inlet port 11 flows through the bores 22 and 26 and reduced bore 23 into the bore 36 through port 44 causing the ball 46 positioned in bore 36 to move upwardly therein and become seated against shoulder 47, thereby closing fluid flow communication between the passage 35 and the port 15, and opening fluid flow communication between the port 44 and the port 13. The seating of ball 46 against shoulder 47 pivots the rocker arm 71 causing the portion 73 thereof to move further into the enlarged portion 53 of bore 52 and thereby preventing the ball 62 from becoming seated against shoulder 63. Thus, in the event that leakage of fluid past ball 31 into reduced bore 27 and through port 59 causes ball 62 to move upwardly in bore 52, the ball 62 can not close fluid flow communication between ports 12 and 14 in that the ball 62 is not seated against shoulder 63, and can flow from port 15 between the ball 62 and the wall of the enlarged portion 53 to the vent port 14. Thus, as shown in FIG. 3, fluid flows through the valve from the inlet port 11 to the port 13, and fluid also flows between ports 12 and 14 through passage 51.

Upon stopping fluid flow through inlet port 11 (FIG. 1), the ball 31, seated against shoulder 33, falls by gravity into bore 22 and rests therein against the shoulder 76 formed between bores 22 and 24. The stopping of flow through port 44 causes ball 46 in bore 36 which was seated against shoulder 47 to fall by gravity and come to rest against member 43. Thus, ports 12 and 14 are interconnected through passage 51 and ports 13 and 15 are interconnected through passage 35, with balls 46 and 62 being at rest on annular members 43 and 58, respectively.

The valve of the present invention is particularly suitable for controlling flow in a dual tower adsorption system and the use thereof in such a system is described with reference to an embodiment of such a system illustrated in FIG. 4. The embodiment is particularly described with reference to the de-hydration of air, but it is to be understood that the invention is equally applicable to fractionation, by adsorption, of other gaseous mixtures, as disclosed, for example, in U.S. Pat. No. 2,944,627.

Referring to FIG. 4, the system for dehydrating a compressed gas includes, as principal elements, a compressor 110, two drying chambers 112 and 113 containing a suitable adsorbent, a storage tank or reservoir 114, and the four-way, five-ported valve 10 of the present invention, having ports 11, 12, 13, 14 and 15, the ports 14 and 15 functioning as exhaust ports and port 11 as an inlet port for a compressed gas. The system, as illustrated in the drawing, is operating with drying being effected in chamber 112, and regeneration being effected in chamber 113, as represented by solid flow lines through valve 10. The broken flow lines through valve 10 is representative of the operation of the system with drying being effected in chamber 113 and regeneration being effected in chamber 112.

The compressor 110 is provided with a gas inlet conduit 122 for introducing a gas to be compressed and dehydrated, and an outlet conduit 123 connected to port 11 of valve 10. The lower portion of drying chambers 112 and 113 are connected to ports 12 and 13, respectively, of valve 10 through conduits 124 and 125, respectively, the conduits 124 and 125 functioning as an inlet for compressed wet gas during a drying portion of the cycle, and as an outlet for regenerating gas during a regeneration portion of the cycle. The upper portion of the drying chambers 112 and 113 are connected through conduits 126 and 127, respectively, to the junction of conduits 128 and 129 and conduits 131 and 129, respectively, the conduits 128 and 131 being connected to inlet ports 132 and 133, respectively, of a three ported, two position selector valve 134, and the conduit 129 including a suitable pressure reducing flow controller, preferably a fixed orifice, represented as 135. The conduits 126 and 127 function as an outlet for dehydrated compressed gas during the drying portion of a cycle and as an inlet for regeneration gas during the regeneration portion of the cycle, with the conduit 129 providing for the passage, as a regeneration gas, of a controlled amount of dehydrated gas from the drying chamber operating on the drying portion of the cycle to the drying chamber operating on the regeneration portion of the cycle.

The outlet port 136 of the selector valve 134, which is preferably, as shown, a ball type valve in which pressure at inlet port 132 moves the ball thereof over to port 133 to cover and close same, and pressure at inlet port 133 moves the ball over to port 132 to cover and close same, is connected to the inlet of a reservoir or storage tank 114 through conduit 137, including a check valve 138, and which is further provided with a by-pass conduit 139 around check valve 138, the by-pass conduit 139 including a pressue reducing flow controller 141, preferably a fixed orifice as shown, and a valve 142. The reservoir or storage tank 114 is provided with an outlet conduit 143, including a normally open valve 144, to provide dehydrated compressed gas to a system or appratus (not shown) employing dehydrated compressed gas and is further provided with a pressure sensitive switch, schematically represented as 145, of a type known in the art, which shuts the compressor 110 on and off in response to preset minimum and maximum pressures, respectively, in storage tank 114.

In a typical operation, the pressure switch 145 is set to activate the compressor 110 upon sensing a predetermined minimum pressure in reservoir 114 (for example 25 psig), and to deactivate compressor 110 upon sensing a predetermined maximum pressure in reservoir 114 (for example 35 psig). Thus, for example, with a pressure of 30 lbs. in reservoir 114, the pressure control switch 145 has compressor 110 turned off and the air pressure in the system upstream of check valve 138 in conduit 137 is at about 0 psig, as a result of the upstream portion being open to the atmosphere by the direct connection of ports 12 and 13 with vent ports 14 and 15, respectively.

Upon the pressure in reservoir 114 reaching the predetermined minimum, e.g., 25 psig, pressure switch 145 starts up compressor 110 whereby compressed air flows from compressor 110 through conduit 122 into the inlet port 11 of valve 10 (the ball 31 being positioned as shown in FIG. 1) resulting in the valve being positioned as shown in FIG. 2. Accordingly, compressed gas flows from the inlet port 11 of valve 10 to the outlet port 12 thereof and through conduit 124 into drying chamber 112. The compressed gas passes through the absorbent in drying chamber 112 thereby effecting drying of the compressed gas, and a major portion of the compressed gas withdrawn from drying chamber 112 flows through conduits 126 and 128, ports 132 and 136 of selector valve 134 and conduit 137 into the reservoir 114. A minor portion of the air, the amount of which is determined by the sizing of orifice 135 and the operating pressure, flows through conduit 129 and is expanded through the orifice 135 for introduction into the drying chamber 113 through conduit 127. The dry expanded gas flows through the adsorbent in drying chamber 113 and readsorbs the water vapor adsorbed by the adsorbent during a previous drying cycle. The gas, containing readsorbed water, is withdrawn from chamber 113 through conduit 125 and is exhausted through ports 13 and 15 of valve 10 (the valve being postioned as shown in FIG. 2).

The compressor 110 compresses more air than is withdrawn from reservoir 114, and eventually the pressure in reservoir 114 is built-up to a pressure above the predetermined maximum, i.e., 35 psig, at which pressure, the pressure switch 145 shuts off compressor 110. The shutting off of the compressor 110 stops the flow of gas through inlet port 11 of valve 10, and as hereinabove described, the valve elements are positioned so that the conduits 124 and 125 are connected to the atmosphere through ports 12 and 14 and ports 13 and 15, respectively, of valve 10. The pressure in the reservoir 114 is locked in by closing of the check valve 138 in conduit 137.

The cycle is again initiated upon the pressure reaching a predetermined minimum in reservoir 114 with the flow of compressed air from compressor 110 to inlet port 11 of valve 10 resulting in the valve elements being positioned as shown in FIG. 3. Accordingly, compressed gas flows from the inlet port 11 of valve 10 to the outlet port 13 thereof and through conduit 125 into drying chamber 113. A major portion of the dried compressed air is passed to the storage tank 114 and a minor portion thereof is employed for regenerating the adsorbent in chamber 112 which is connected to the atmoshpere through conduit 124 and the ports 12 and 14 of valve 10. Upon the pressure again reaching the predetermined maximum in reservoir 114, the pressure switch 145 shuts off compressor 110 and as hereinabove described the stopping of flow of gas to inlet port 11 of valve 10 results in the valve elements thereof being positioned as illustrated in FIG. 1. A restarting of the compressor 110 restarts the cycle, as hereinabove described.

In some cases, in order to establish a desired dessicant dryness, over reactivation of the dessicant may be required. An excess regeneration of the dessicant may be achieved by opening valve 142 in by-pass conduit 139 after the compressor 110 is shutdown, whereby a small amount of air, as controlled by orifice 141 in by-pass conduit 139, is passed from reservoir 114 through by-pass conduit 139 and selector valve 134 to the chamber which has just completed the drying cycle and is now connected for the regeneration cycle upon reactivation of compressor 110. If desired total regeneration or reactivation may be achieved by closing the valve 144 in outlet conduit 143 whereby all of the air in reservoir 114 may be returned through the drying chamber.

As should be apparent from the hereinabove description of a preferred embodiment of the invention illustrated in FIG. 4 , each time the compressor is activated, one drying chamber is adsorbing water and the other is being desorbed of water, and each time the compressor is deactivated, the selector valve is automatically moved to a position in which upon reactivation of the compressor the other drying chamber is in the drying portion of the cycle and the one drying chamber is in the reactivation portion of the cycle.

The present invention is an improvement over prior art dual tower systems in that a storage tank is provided downstream of the adsorption towers and the regeneration and adsorption cycles are controlled in response to compressor on-time. In this manner, regeneration is effected only during compressor on-time which is a function of the demand of the utilization system, resulting in the volume of gas employed for regeneration being proportional to the demand requirements of the utilization system. Moreover, the compressor operates at a fixed output volume of air, with the demands of the utilization system being controlled by the on-time of the compressor and, therefore, the volume of gas required for regeneration of the adsorbent is adjusted and fixed in relation to this volume, thereby eliminating the considerable waste of gas which results in the prior art systems in which the regeneration gas requirements must be adjusted and fixed for the maximum load demands of the utilization system. In addition, the use of the valve of the invention alters the adsorption and desorption cycle by starting and stopping of fluid flow thereby eliminating the combination of timer and solenoid valves employed in prior art systems.

These and other advantages should be apparent to those skilled in the art from the teachings herein.

The present invention may be modified in numerous ways within the spirit and scope of the invention. Thus, for example, although a five ported valve has been particularly described, the present invention also contemplates a three ported valve in which fluid is alternately directed from an inlet port to one of two outlet ports. A three ported valve which incorporates the teachings of the present invention is illustrated in FIG. 5.

Referring to FIG. 5, a valve body 210 includes an inlet port 211, a first outlet port 212 and a second outlet port 213. An inlet passage 216, defined by horizontal bore 217, extends inwardly through the valve body 210 from the inlet port 211 and terminates within the valve body 210.

A flow passage 221, defined by angular cylindrical bore 222 having an upper reduced portion 223, connected at its lower end to inlet passagd 216 through a vertical cylindrical bore 224, extends angularly upwardly away from the inlet port 211, and a flow passage 225, defined by angular cylindrical bore 226 having an upper reduced portion 227, connected at its lower end to inlet passage 216 through a vertical cylindrical bore 228, longitudinally spaced from vertical bore 224, extends angularly upwardly toward the inlet port 211, with the bores 222 and 226 intersecting at the upper ends thereof. The bores 222 and 226 have identical diameters and a movable closure member, in the form of a ball 231, having a diameter approximating, but slightly less than the diameter of the cylindrical bores 222 and 226, is movably positioned for movement within the bores 222 and 226 in response to fluid flow therethrough to alternately seat against the shoulder 232 formed between bore 222 and its reduced portion 223, and the shoulder 233 formed between bore 226 and its reduced portion 227. The various dimensions of the bores 222 and 226 and the ball 231 are coordinated in a manner such that the center of gravity of the ball 231, in the position in which ball 231 is seated against shoulder 232, is positioned so that gravity causes the ball 231 to fall into bore 226 upon stopping of fluid flow through the inlet port 211, and the center of gravity of the ball 231, in the position in which the ball 231 is seated against shoulder 233, is positioned so that gravity causes the ball 231 to fall into bore 222 upon stopping of fluid flow through the inlet port 211.

A flow passage in the form of horizontal cylindrical bore 241 connects reduced bore 223 to the outlet port 213, and a flow passage in the form of horizontal cylindrical bore 242 connects reduced bore 227 to the outlet port 212.

The operation of the embodiment of FIG. 5 is similar to that of the embodiment of FIGS. 1 – 3. In operation, upon the introduction of fluid into inlet port 221, the fluid flowing from the inlet passage 216 through vertical bore 224 into bore 222 causes ball 231 to move upwardly in bore 222 and become seated against shoulder 232 thereby preventing fluid from flowing to outlet port 213 and whereby fluid flows through the bores 222 and 226 and reduced bore 227 into the bore 242 and outlet port 212.

Upon stopping fluid flow through inlet port 211, the ball 231, seated against shoulder 232, falls by gravity into bore 226 and rests therein against a shoulder 227 formed between bores 226 and 228. Upon restarting introduction of fluid into inlet port 211, the fluid flowing from inlet passage 216 through vertical bore 228 into bore 226 causes ball 231 to move upwardly in bore 226 and become seated against shoulder 233, thereby preventing fluid from flowing through the reduced bore 227 to outlet port 212 whereby fluid flow through the bores 222 and 226 and reduced bore 223 into the bore 241 and outlet port 213.

Upon stopping fluid flow through inlet port 211, the ball 231, seated against shoulder 233, falls by gravity into bore 222 and rests therein against the shoulder 276 formed between bores 222 and 224.

The hereinabove described embodiments and other embodiments are deemed to be within the scope of those skilled in the art from the teachings herein.

Numerous modifications and variations of the present invention are possible in light of the above teachings and, therefore, within the scope of the appended claims, the invention may be practiced in a manner other than as particularly described.

What is claimed is:

1. A valve comprising:

a valve body including an inlet port, a first outlet port, a second outlet port, a first vent port, a second vent port;

first passage means within the valve body connected to said inlet port; second passage means within the valve body interconnecting the first outlet port and the first vent port, said second passage means being connected to the first passage means, said first and second passage means providing fluid flow communication between the inlet port and the first outlet port and between the first outlet port and the first vent port; third passage means within the valve body interconnecting the second passage means within the valve body intersecting the second outlet port and the second vent port, said third passage means being connected to the first passage means to provide fluid flow communication between the second vent port and the second outlet port and the inlet port and the second outlet port; said flow control means comprising first, second and third closure means; said first closure means being within the first passage means movable by fluid introduced through said inlet port to alternately close communication between the first passage means and the second passage means and the first passage means and the third passage means in response to alternate starting of fluid introduction into the inlet port; said second closure means being positioned in said second passage means movable by and in response to flow of fluid from the first passage means to the second passage means, said second closure means closing fluid flow communication between the first outlet port and the first vent port in response to fluid flow from the first passage means to the second passage means, whereby fluid is passed from the inlet port to the first outlet port, said second closure means in response to no fluid flow from the first passage means to the second passage means permitting fluid flow between the first outlet port and the first vent port; said third closure means being positioned in said third passage means movable by and in response to flow of fluid from the first passage means to the third passage means, said third closure means closing fluid flow communication between the second outlet port and the second vent port in response to fluid flow from the first passage means to the third passage means, whereby fluid is passed from the inlet port to the second outlet port, said third closure means in response to no fluid flow from the first passage means to the third passage means permitting fluid flow between the second outlet port and the second vent port.

2. The valve as defined in claim 1 wherein said first passage means comprises: a first bore having one end thereof connected to the inlet port and the second end thereof connected to the second passage means, said second end of the first bore including a first seat; a second bore having one end thereof connected to the inlet port and the second end thereof connected to the third passage means said second end of the second bore including a second seat, said first and second bores intersecting with each other adjacent their respective second ends; said first closure means comprising a ball which is movable within and between the first and second bores, said ball when positioned within the first bore being moved into engagement with the first seat upon introduction of fluid into the inlet port, said ball when positioned within the second bore being moved into engagement with the second seat upon introduction of fluid into the inlet port, the center of gravity of the ball when seated against the first seat causing the ball to fall into the second bore upon stopping introduction of fluid into the inlet port and the center of gravity of the ball when seated against the second seat causing the ball to fall into the first bore upon stopping of introduction of fluid into the inlet port.

3. The valve as defined in claim 1 wherein said second closure means comprises a second ball movable within said second passage means, said second passage means including a third seat for the second ball adjacent the connection between the second passage means and the first bore, and a fourth seat for the second ball adjacent the connection between the second passage means and the first vent port, said second ball being seated against the third seat upon stopping of fluid flow from the first bore to the second passage means and said second ball being seated against said fourth seat when fluid flows from the first bore to the second passage means.

4. The valve as defined in claim 3 wherein said third closure means comprises a third ball movable within said third passage means, said third passage means including a fifth seat for the third ball adjacent the connection between the third passage means and the second bore, and a sixth seat for the third ball adjacent the connection between the third passage means and the second vent port, said third ball being seated against the fifth seat upon stopping of fluid flow from the second bore to the third passage means and said third ball being seated against said sixth seat when fluid flows from the second bore to the third passage means.

5. The valve as defined in claim 4 and further comprising means for preventing the second ball and the third ball from simultaneously being seated against the fourth and sixth seat, respectively.

* * * * *