

As best seen in FIG. 3, a second or outer cap 62 is positioned over the inner cap 46. Outer cap 62 comprises a hollow cylindrical body portion 64 having means 66 (i.e., threads) disposed on its interior surface adapted to secure the outer cap 62 to the exterior surface of the upper portion of the body 48 of inner cap 46. The bottom of body 64 is located above the points where lateral passageway means 60 exit from the inner cap 46. Attached to the bottom of body 64 is an outwardly directed rim 68 paralleling the rim 52 of the first cap 46 but spaced therefrom. A cylindrical, vertically depending flange 70 is connected to the end of the rim 68 away from the inlet cap body 64. Flange 70 parallels flange 58 of inner cap 46, but is spaced therefrom, and extends substantially below the flange 58. The flange 70 forms the skirt of a second or outer jet 72 which comprises an inlet formed by the lateral passageways 60 in the first cap 46, and an outlet defined by the space between the rims 52 and 68 of the inner and outer caps, respectively. Skirt 70 is adapted to deflect the vapor jet issuing from the second nozzle 72 inwardly toward the axis of the jet assembly 26, thereby creating a velocity vector in that direction represented by the arrow A in FIG. 3.

It will be seen that the arrangement of the inner and outer caps 46 and 62, on the topmost jet assembly section provides two vapor jets at this point, each adapted to impart an inwardly directed velocity vector to the vapor jet stream issuing therefrom which will serve to substantially eliminate a principal cause of backstreaming. Moreover, the jets formed by the inner and outer caps are adapted so that the respective vapor jet streams issuing therefrom will interact in such a manner that the possibility of the migration of vapor molecules forming either of the jets toward the pump inlet will be minimized.

A further aspect of the present invention involves the provision of a heating arrangement 76 in the vapor chute 28 in order to further minimize backstreaming and startup problems and to promote pump efficiency. Advantageously, this heating arrangement is employed to heat the inner and outer caps as hereinafter described.

Heating arrangement 76 comprises a unitary, replaceable, cylindrical cartridge heater 78 which extends along the axis of the vapor chute 28 substantially throughout the length thereof. The lower end of the heater 78 extends through the pump bottom 14 and is connected to electrical leads 80 at a point beneath the bottom of the pump. The upper end of the cylindrical cartridge heater 78 extends into the hollow interior of the inner cap 46 and is in a heat conducting relationship therewith. It will be seen that the heater, which is of the resistance variety, is adapted to supply heat along the entire length of the vapor chute and directly to the inner and outer caps, 46 and 62, forming inner and outer topmost vapor jets in the jet assembly 26. The lower portion of the cartridge heater 78 is located in the oil sump 24 and is adapted to vaporize the liquid pumping fluid for the pumping operation.

Surrounding the entire length of the unitary cartridge heater 78 is a hollow tubular casing 82. The tubular casing 82 is formed of a suitable heat-conducting material and has a plurality of radial fins 84 attached to its exterior surface at intervals about its circumference. The radial fins 84 are also constructed of a suitable heat-conducting material and are maintained in a vertical plane between the pump bottom and the bottom of the topmost section of the jet assembly 26. The radial fins 84 extend outwardly from casing 82 to a point adjacent the interior surfaces of the sections 30 of the jet assembly 26, and the outer vertical edges of the radial fins 84 are connected by a heating cylinder 86. The height of the heating cylinder 86 is the same as that of the radial fins 84, and together, the fins and cylinder provide a means for conducting the heat supplied by the cartridge heater 78 to the sections 30 forming the nozzle assembly 26.

Because of the dimensions of the elements of heater 78 heat is distributed throughout the interior of vapor chute 28 in a manner such that undesirable vapor condensation is minimized. More particularly, because of the substantially

larger diameter and surface area provided in the lower portion of chute 28, and because of the larger diameter of this portion of the chute, relatively smaller amounts of heat per unit volume are radiated in this area, whereas relatively larger amounts are given off in the upper reaches of chute 28 where condensation problems and backstreaming are a particular problem. Furthermore, because of the direct connection of the heater 78 to the caps 46, 62, condensation and backstreaming are minimized and pump efficiency is promoted.

In using a vacuum diffusion pump comprising the heating arrangement described above, electricity is supplied through leads 80 to the resistance cartridge heater 78. The cartridge heater immediately begins to supply heat 1 to the liquid pumping fluid maintained in the oil sump 24, 2 to the jet assembly 26, by conductance through the radial fins 84 and heating ring 86, and 3 directly to the inner and outer caps, 46 and 62, forming the first and second topmost jets in the jet assembly. By the time sufficient heat is transferred to the pumping fluid in the sump 24 to initiate the evaporation thereof, all the nozzles of the assembly 26 have been sufficiently heated by the heater arrangement 76 to insure proper pump operation, and evacuation of the region connected to the pump inlet can begin. Moreover during the pumping operation, any heat loss by radiation, from the nozzle assembly 26, or from the caps comprising the topmost nozzles thereof will be offset by heat supplied by the heating arrangement 76 in accordance with the subject invention.

The heating means of the present invention thus eliminate the problems heretofore encountered in prior art vacuum diffusion pumps with regard to heat loss from the jet assembly and the cooling of oil vapor as it rises therein. As in the case of the prior art pumps, the heating means of the subject invention are adapted to evaporate the normally liquid pumping fluid maintained in the oil sump. However, in contrast to the teachings of the prior art, the unitary cartridge heater 78 and its associated radial fins 84, and heating ring 86, supply heat to the jet assembly to offset any radiation losses encountered thereby during the pumping operation and therefore ensure efficient pump operation. That is, the heat supplied by the cartridge heater is conducted from the heater casing outwardly, through the radial fins to the heating ring adjacent the interior surface of the jet assembly, and maintains the assembly at a temperature where condensation of oil vapor will not occur in the jets of assembly. Thus, the present invention does not rely on heat transfer from the oil vapor, itself, to initially bring the nozzle assembly to its operating temperature or to make up the heat loss suffered by the assembly during the pump's operation. Moreover, the heating arrangement of the present invention serves to superheat the vapor chute 28, ensuring that the vapor supplied to the various nozzles will not cool while travelling thereto and will be of the quality necessary for efficient pump operation.

At the topmost jet wherein the problems of backstreaming are most pronounced in the pumps of the prior art, the heating arrangement of the present invention, in combination with the inner and outer caps 46, 62, of the present invention, provides an arrangement designed to substantially eliminate this backstreaming problem. Heat is directly conducted from the cartridge heater to the inner cap and, in turn, to the outer cap which is in contact therewith. This arrangement ensures that the two topmost nozzles formed by the first and second caps will be maintained at a temperature sufficient to prevent condensation of oil vapor therein, and therefore to prevent one of the recognized causes of backstreaming. In the pumps of the prior art, the topmost nozzle is the most difficult to bring to, and maintain at, a suitable operating temperature because it is farthest removed from the heater positioned in the oil sump at the bottom of the pump, and this difficulty is obviated in accordance with the arrangement of the present invention.

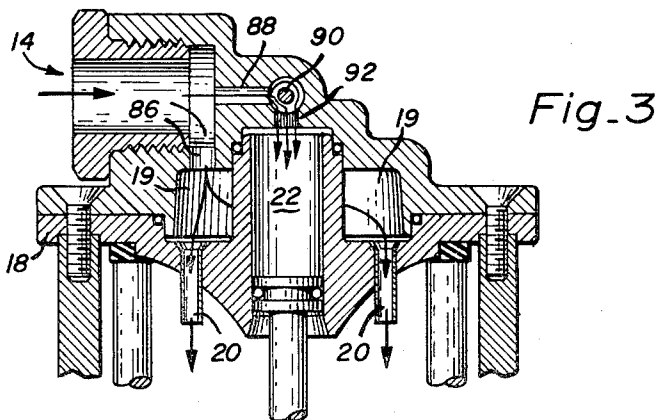
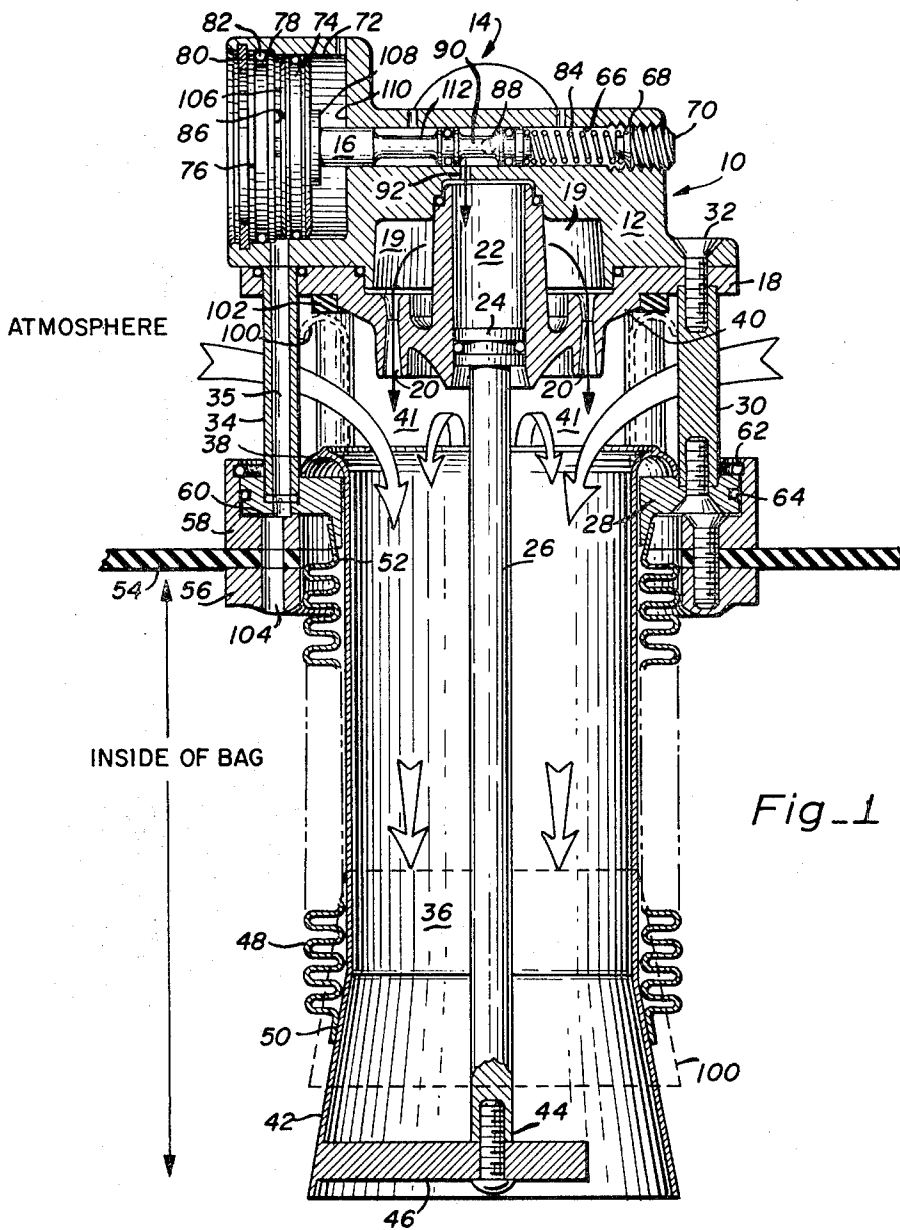
I claim:

1. In a vacuum diffusion pump including a jet assembly comprising a series of staged vapor jets and a vapor chute, a

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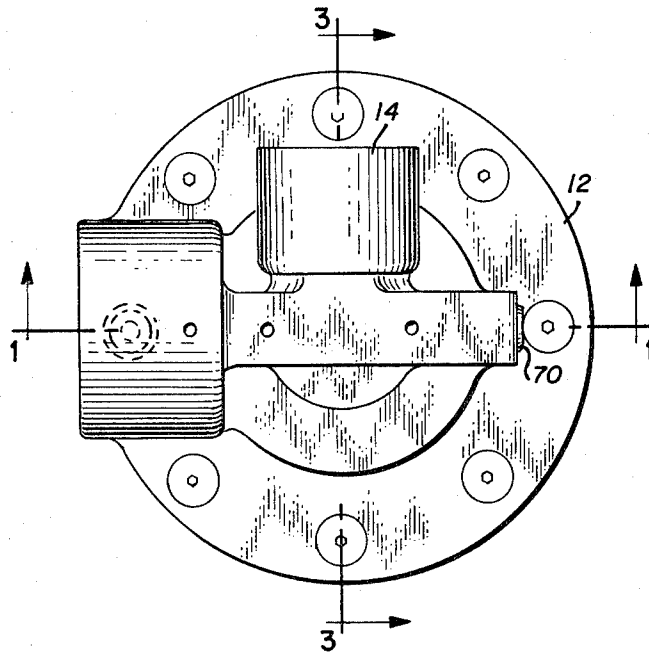


Fig. 2

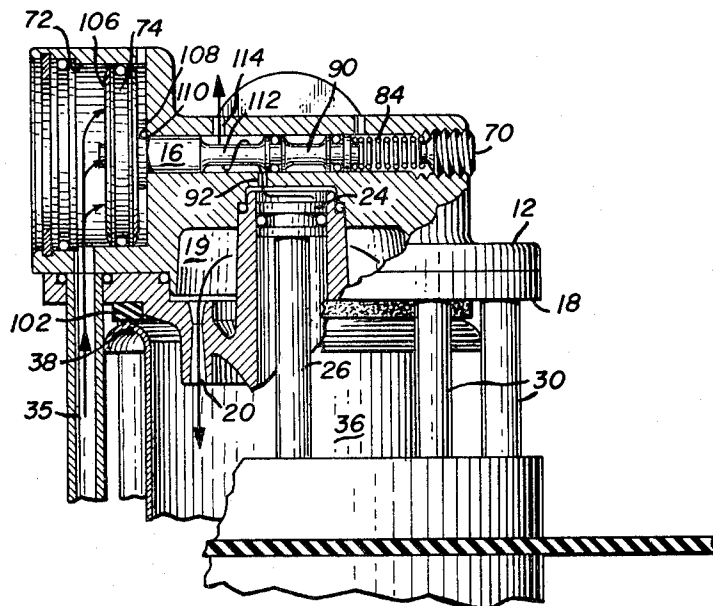


Fig. 4

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ASPIRATOR APPARATUS FOR BAG INFLATION SYSTEMS

BACKGROUND OF THE INVENTION

The present invention relates generally to aspirator devices and, more particularly, to a novel aspirator structure for use in compressed gas bag inflation systems.

This application is a continuation-in-part of U.S. Pat. application Ser. No. 803,178 filed Feb. 28, 1969 and assigned to the assignee of the present invention.

It is our intent that the entire specification and drawing of the aforementioned copending application be expressly incorporated by reference into this disclosure.

OBJECTS OF THE INVENTION

A principal object of the present invention is to provide a novel aspirator unit which is simple in mechanical structure, has a high aspirating efficiency and includes means for terminating the aspirating function upon sensing a predetermined bag inflation pressure.

Another object of the present invention is to provide an aspirating apparatus for bag inflation systems wherein the flow path of the aspirated gas is unimpeded by flow-directional changes or flapper valves within the aspirating flow path and which include means for terminating entrainment of aspirated gases in response to the attainment of a predetermined bag inflation pressure.

Still another object of the present invention is to provide a highly efficient aspirating device which enables the use of optimum aspirating jet configurations and flow conditions.

SUMMARY OF THE INVENTION

In accordance with the present invention, a novel aspirator structure is provided the atmospheric entrance ports and aspirating chamber of which are rotationally symmetric about the axis of the effluent orifice and includes an annular venturi path which is aligned with a plurality of aspirating jets. The exterior wall of the aspirating chamber is formed by a displaceable cylinder, one end of which serves as a closure means for closing the atmospheric entrance ports. The cylinder is normally biased into a closed position by an appropriate spring means but is actuated into its open position in response to gas pressure applied to the end of an actuating plunger coupled thereto. The spring means causes the cylinder to be returned to its closed position when the gas pressure applied to the top of the actuating plunger is removed by actuation of a bag pressure responsive valving apparatus.

An important advantage of the present invention is that it includes means for closing the atmospheric entrance ports upon attainment of a predetermined bag pressure so that the remaining high-pressure gas may be utilized to inflate the bag to a pressure in excess of atmospheric pressure.

Another advantage of the present invention is that the atmospheric entrance closure apparatus is closed in response to a predetermined bag pressure and is independent of the aspirating gas flow rate or pressure.

Still other advantages of the present invention will become apparent to those skilled in the art after having read the following disclosure of a preferred embodiment which is illustrated in the several FIGS. of the drawing.

IN THE DRAWING

FIG. 1 is an axial cross section taken through an aspirator device in accordance with the present invention.

FIG. 2 is a top view of the aspirator illustrated in FIG. 1.

FIG. 3 is a cross section of the upper portion of the aspirator illustrated in FIG. 1 taken along the lines 3-3 of FIG. 2.

FIG. 4 is a partial cross section of the upper portion of the aspirator shown in FIG. 1 taken along the lines 1-1 illustrating operation of the bag pressure responsive valve means.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1 of the drawing, there is shown an axial cross section of an aspirating structure 10 in accordance with a preferred embodiment of the present invention. This embodiment includes an upper cap member 12 having a high pressure gas inlet 14 (better illustrated in FIG. 3) and a transverse passageway extending therethrough which serves as a housing for the poppet valve 16. The lower side of the cap member 12 is adapted to mate with the high pressure jet supporting flange member 18 and an annular cavity 19 formed therebetween serves as a high-pressure gas conduit from the inlet 14 to the high-pressure jets 20 which are circularly arrayed around the passageway 19. In the center of the member 18, there is a cylindrical passageway 22 extending through the member 18 from the top to the bottom thereof to form a cylinder for receiving the head 24 of a pneumatic actuating member 26.

The cap member 12 and jet supporting flange 18 are mounted to an annular base flange 28 and spaced therefrom by a plurality of cylindrical spacer rods 30. The members 12 and 18 are fastened to the upper ends 32 of the spacer rods 30 by means of suitable fastening means 32 and the base flange 28 is likewise secured to the bottom end of the spacer rods 30. The spacer rod 34, however, is tubular and provides a gas communicating flow path between the interior of the inflated bag and one end of the poppet 16 as will be more specifically described below.

Telescopically received within the central aperture of the flange 28 is a cylindrical barrel member 36, the upper end 38 of which is rolled outwardly so that when in the open position, illustrated in FIG. 1, it serves to cooperate with the lower surface 40 of the flange 18 to produce a venturi passage 41 through which the atmospheric gases may be drawn. The lower end 42 of the barrel member 36 may be suitably flared to provide an aerodynamically suitable exhaust port for the aspirated gases. The lower end of the barrel 36 is attached to the end 44 of the piston 26 by spider members 46 of suitable design so as to provide minimum flow impedance to the aspirated gases. To provide an upwardly biasing force to the barrel member 36, an accordion like spring member 48 is secured at one end 50 to the lower portion of the barrel 36 and at the other end 52 to the base flange 28.

In order to accommodate the mounting of the aspirating device to the inflatable bag 54, an aperture is provided therein which is formed by a pair of annular members 56 and 58 which sandwich the apertured edge of the flexible bag 54 therebetween. An annular seat 60 is provided in the upper ring 58 for receiving the base flange 28 as the barrel and spring assembly of the aspirator 10 is inserted into the opening formed by the rings 56 and 58. The aspirator 10 is securely fastened to the bag 54 and maintained in engagement with the seat 60 by a snapping 62. An annular O-ring 64 insures an airtight seal therebetween.

The cap member 12 has a bore 66 passing transversely therethrough for receiving the valve poppet 16. The end portion 68 thereof is threaded to receive an adjustable end plug 70. At the other end of the bore 66, there is formed an enlarged cylindrical bore 72 for receiving the pressure head 74 of the poppet 16, the operative portion of which extends into the bore 66. A sealing member 76 is positioned within the bore 72 and is secured against the shoulder 78 by a snapping 80. The member 76 includes an annular O-ring 82 which provides an airtight seal at the end of the chamber. The poppet 16 is normally biased leftwardly by a spring means 84 in the position shown, high-pressure gas entering the inlet 14 (see FIG. 3) will flow through the passage 86 into the chamber 19 to be distributed to a plurality of jets 20 positioned in one or more circular arrays around the axis of the flange 18. However, some of the high-pressure gas will enter the passageway 88 and flow around the spool 90, through the passages 92 and into chamber 22.

It will be noted that whereas in the FIG. 1 embodiment, the flange 18 and jets 20 are integrally formed into a single member, the FIG. 3 embodiment shows the alternative use of individual inserts passed through apertures in the flange 18 to form the jets 20. This obviously enables the dimensions of the inserts 20 to be chosen to fit a particular application.

When the aspirator 10 is installed in the deflated bag 54, the barrel 36 is retracted into the position shown by the dotted lines 100 and the rolled edge 38 of the barrel 36 sealingly engages the annular sealing ring 102 which is mounted to the lower surface of the flange 18. Prior to actuation the barrel 36 is maintained in this closed position by the spring means 48 so as to prevent the entry of moisture or foreign matter into the bag 54. The poppet 16 is biased leftwardly into the position shown in FIG. 1 by the spring means 84 with a force which is determined by the position of the threaded plug 70, i.e., the bag pressure required to drive the poppet 16 rightwardly is selectable by varying the position of the plug 70.

Upon triggering the regulator means of the inflation system including the aspirator 10 (one such system is illustrated in the aforementioned compending application), high-pressure gas from the storage container is caused to flow into the inlet 14 and thence to the chamber 19 to be distributed to the jets 20 to produce a plurality of high-pressure jet streams within the cylinder 36. At the same time the high-pressure gas flows through the passage 88, around the spool 90 and through the passages 92 into the chamber 22 to apply a force to the piston head 24. This causes the member 26 to be driven downwardly against the force of the spring means 48 causing the cylinder 36 to be displaced into the aspirating position shown in FIG. 1.

With the cylinder 36 in this position, atmospheric gases are entrained within the venturi passage 41 formed by the cylinder 36 and the lower side 40 of the flange 18. The high-pressure gases escaping through the jets 20, which are radially spaced in one or more concentric rows about the axis of the device, cause a low-pressure condition to be produced within the throat of the aspirating device which, as a result, causes large quantities of atmospheric air to be drawn in through the aspirator openings to be entrained by the jet streams and forced into the inflatable device through the lower end of the barrel 36.

The aspirating action will continue until the pressure in the bag 54 builds up to a predetermined pressure level at which time the barrel 36 is caused to return to its upper position to seal off the atmospheric flow passage. This predetermined pressure level is determined by the position of the threaded plug 70 which by acting on spring 84 causes a selected biasing force to be applied to the end of the poppet 16. As the pressure in the bag 54 builds up, this pressure is communicated through the passages 104 and 35 to the face 106 of the piston 74. When the pressure within the bag 54 has built up to a level capable of overcoming the spring force of spring 84, the poppet 16 will be driven rightwardly until the stop 108 abuts the end wall 110 of the bore 72, as is more clearly shown in FIG. 4.

With the poppet 16 in this position, the spool portion 112 provides a flow passage to atmosphere from the chamber 22 through opening 92, around the spool 112, and out through the atmospheric opening 114. With the pressure thus eliminated from the top of the piston head 24, the spring 48 causes the barrel 36 to be again retracted into the its upward position so that the lip 38 engages the sealing member 102 blocking the entrance of further atmospheric air as well as the exit of any gases from the bag 54. The remaining gas within the storage container will then be dumped directly into the bag 54 to cause the bag 54 to be inflated to a pressure somewhat above atmospheric pressure.

Although now shown in this embodiment of the invention, it is contemplated that the poppet valve 16 could also be adapted to shut off the high-pressure gas flow to the jets 20 upon sensing a second predetermined pressure level, or, a second poppet valve structure could be provided for this purpose.

Whereas, in prior art structures the throat-to-jet area ration required to build up the desired working pressure in the bag 54 was approximately 40—60 to 1, the present invention allows the throat-to-jet area ratio to be increased to 80—120 to 1, or higher, and is thus much more efficient. Other advantages of this particular structure over those of the prior art should likewise be apparent to those of skill in the art. For example, the inlet area of the present invention for receiving atmospheric gases is substantially larger than that possible in prior art structures, thus allowing larger quantities of atmospheric gases to be drawn into the device per unit time. In addition, because of the rotationally symmetric nature of the aspirating chamber, this structure enables the use of a considerably higher number of high-pressure jets than is possible with other structures known in the prior art thus enabling a greater speed of aspiration.

Still further, it is of material importance that the axes of the high-pressure jet stream substantially coincide with the atmospheric flow stream and the two are exhausted directly into the inflatable device 54 with neither a change in flow direction, nor the presence of a material flow disturbing structure downstream of the aspirating region. This feature alone provides a substantial increase in the aspirating efficiency of the apparatus over any known prior art device. Moreover, the improved pressure-sensing feature of this particular embodiment enables the most favorable aspirating ratio and high-pressure gas conditions to be utilized since the atmospheric entrance closure member, once opened, is not dependent upon the dieoff of the high-pressure gases as a means by which to cause the atmospheric inlet to be closed. The closure is automatically facilitated upon the attainment of a predetermined bag pressure and is completely independent of the pressure remaining in the high-pressure gas source.

While only a single preferred embodiment of the improved aspirator of the present invention has been set forth in detail hereinabove, it is contemplated that after having read the above disclosure certain other modifications will be apparent to those skilled in the art. It is therefore to be understood that the above disclosure is to be taken as merely illustrative of a preferred embodiment and not as limiting the invention to the particular structure illustrated. Furthermore, it is intended that the appended claims be interpreted as covering all such modifications which fall within the true spirit and scope of the invention.

I claim:

1. An aspirating device of the type disclosed comprising: means forming a generally cylindrical body member which is intended to be mounted substantially external of an inflatable device, said body member having external openings passing through the sides thereof for admitting atmospheric air into said body member; flow diverting means disposed axially concentric with said body member and forming the inner wall of an annular flow path for atmospheric gases entering said external openings, said annular flow path being generally concentric with said body member; high-pressure jet means passing through said flow diverting means for directing a plurality of streams of high-pressure gas into said annular flow path in a direction generally parallel to the axis of said body member; closure means normally closing said external openings, said closure means being opened by closure opening means outside of said atmospheric flow path and in response to the application of said high-pressure gas flow to the aspirating device; and

valve means responsive to the pressure produced in said inflatable device for interrupting the high-pressure gas flow to said closure opening means so as to cause said closure means to return to its normally closed position.

2. An aspirating device as recited in claim 1 wherein said closure opening means is a pneumatic means responsive to said high-pressure gas flow and is formed in said flow directing means outside of said annular flow path, said pneumatic

means opening said closure means in response to the application of said high-pressure gas to said aspirating device.

3. An aspirating device as recited in claim 2 wherein said valve means includes a displaceable spool member which upon being displaced to a predetermined position causes said high-pressure gas flow to said pneumatic means to be interrupted disabling said pneumatic means.

4. An aspirating device as recited in claim 3 wherein said spool means is attached to a piston means having a force applying surface which is subjected to the fluid pressure within said inflatable device, said pressure being communicated through a fluid conduit which is provided between said force applying surface and said inflatable device.

5. An aspirating device as recited in claim 1 wherein said closure means is an open cylinder one end of which has an outwardly turned flange, the flanged end of said cylinder being telescopically received within said body member and forming the outer wall of said annular flow path, said flanged end being adapted to sealingly engage the lower side of said flow diverting means when displaced to one extreme closing said annular flow path, said flanged end providing a venturi action within said flow path when axially displaced from said sealing engagement.

6. An aspirating device as recited in claim 5 wherein spring means are provided for maintaining said closure means in its closed position when said aspirating device is not subjected to a high-pressure flow of gas and for causing said closure to be returned to its closed position in response to the actuation of said valve means.

7. An aspirating device as recited in claim 6 wherein said closure opening means is a pneumatic means responsive to said high-pressure gas flow and is formed in said flow directing means outside of said annular flow path, said pneumatic means opening said closure means in response to the application of said high-pressure gas to said aspirating device.

8. An aspirating device as recited in claim 7 wherein said valve means includes a displaceable spool member which upon being displaced to a predetermined position causes said high-pressure gas flow to said pneumatic means to be interrupted disabling said pneumatic means.

9. An aspirating device as recited in claim 8 wherein said spool means is attached to a piston means having a receiving surface which is subjected to the fluid pressure within said inflatable device, said pressure being communicated through a fluid conduit which is provided between said force applying surface and said inflatable device.

10. In an inflation system for inflating an inflatable device

including a source of compressed gas, means for regulating the flow of compressed gas caused to flow into said inflatable device, and an aspirating means for increasing the quantity of gas forced into said inflatable device beyond that contained within said source of compressed gas, an improved aspirator means comprising:

a generally cylindrical housing means mounted substantially external of said inflatable device and having openings in the sides thereof for communicating atmospheric air into said housing means;

Flow-directing means disposed within said housing means and defining a generally cylindrically shaped flow path between said openings and said inflatable device;

jet means for introducing into said flow path in a direction generally parallel with the axis of said housing means a plurality of streams of said compressed gas;

closure means for closing said openings; and

pneumatic means for openings said closure means when said aspirator device is subjected to said compressed gas and causing said closure means to be closed when the pressure in said inflatable device reaches a predetermined level, said pneumatic means including a piston means coupled to said closure means for opening said closure means when said pneumatic means is subjected to said compressed gas and a valve means responsive to the pressure in said inflatable device for interrupting the flow of compressed gas to said pneumatic means when the pressure in said inflatable device reaches said predetermined level.

11. In an inflation system as recited in claim 10 wherein said valve means includes a displaceable spool member which upon being displaced to a predetermined position causes the flow of said compressed gas to said piston means to be interrupted to disable said piston means.

12. In an inflation system as recited in claim 11 wherein said closure means is an open cylinder one end of which is telescopically received within said housing means and adapted to sealingly engage said flow directing means in one position to close said atmospheric openings and to form a venturi restriction in said flow path when in another position.

13. In an inflation system as recited in claim 12 wherein resilient biasing means are provided for biasing said closure means into its closed position when the flow of compressed gas to said aspirator means is interrupted in response to the actuation of said valve means by said predetermined level of pressure in said inflatable device.

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