

Sept. 11, 1962

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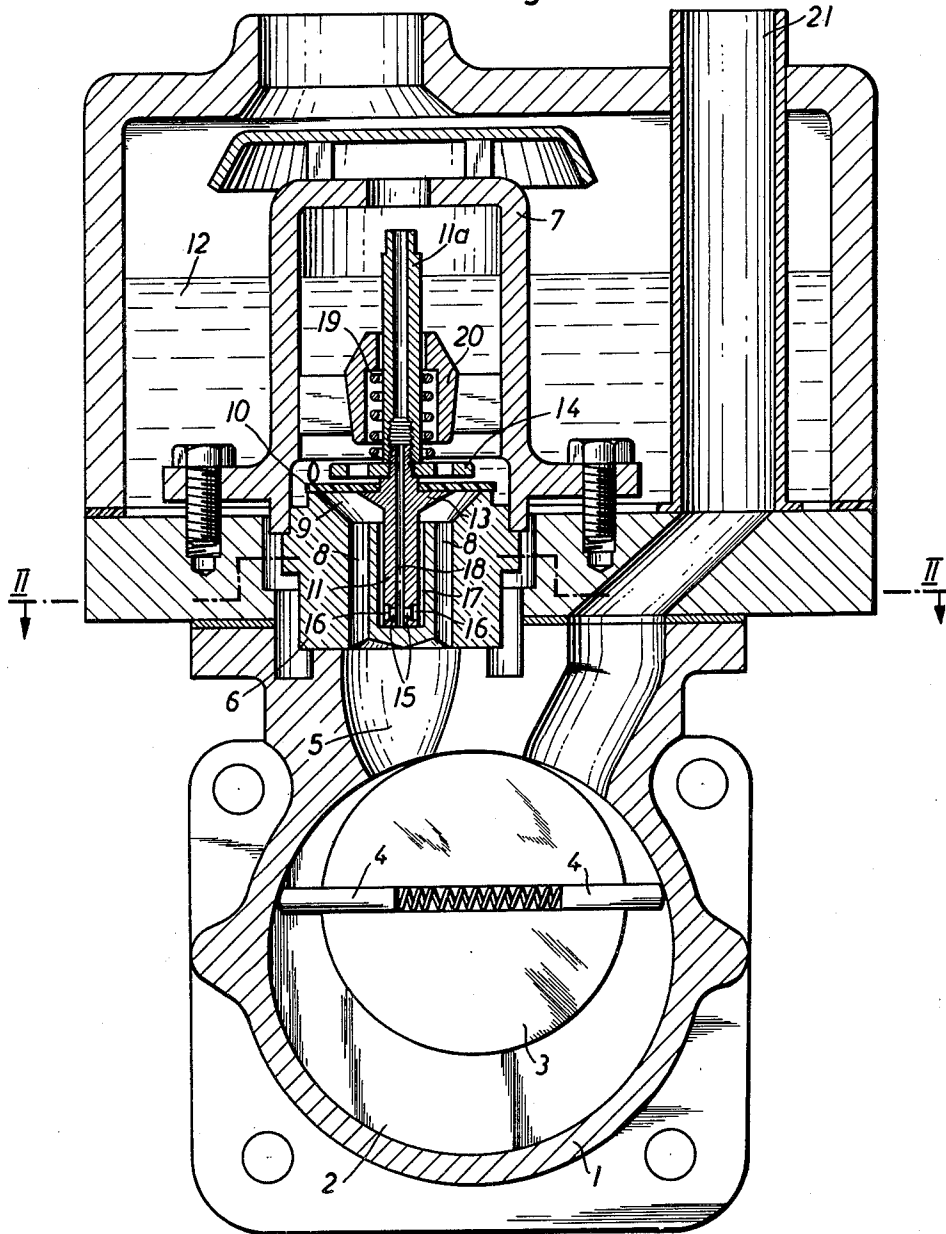
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ROTARY VACUUM PUMP

Filed July 23, 1958

4 Sheets-Sheet 1

Fig. 1



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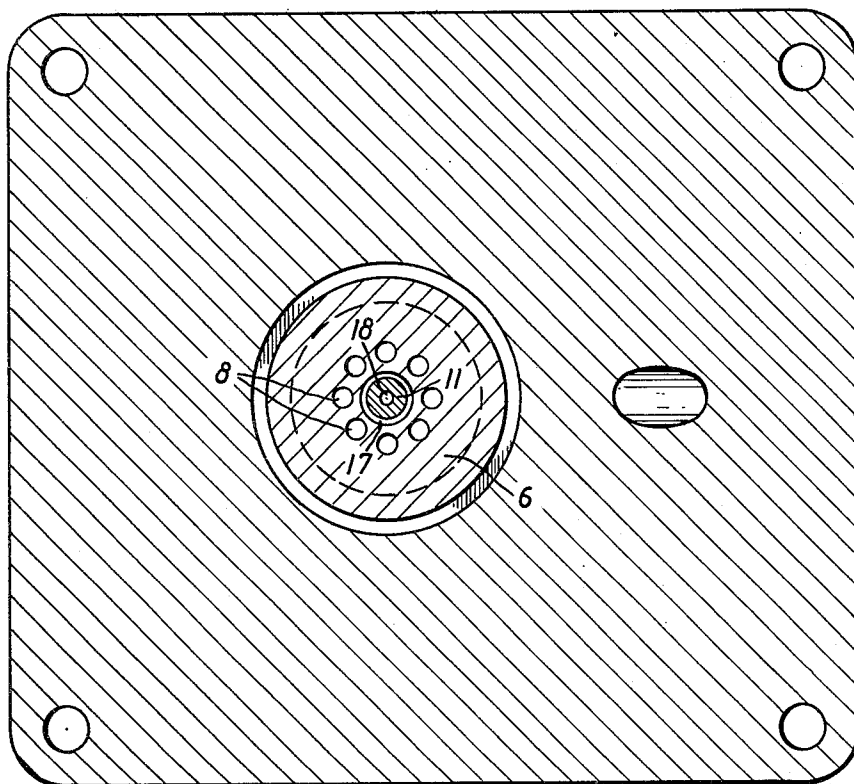
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ROTARY VACUUM PUMP

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Fig. 2



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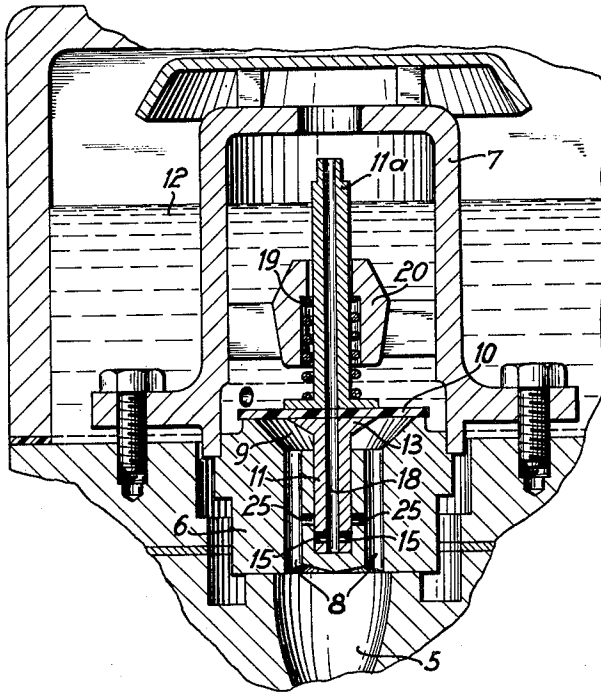
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FIG. 3



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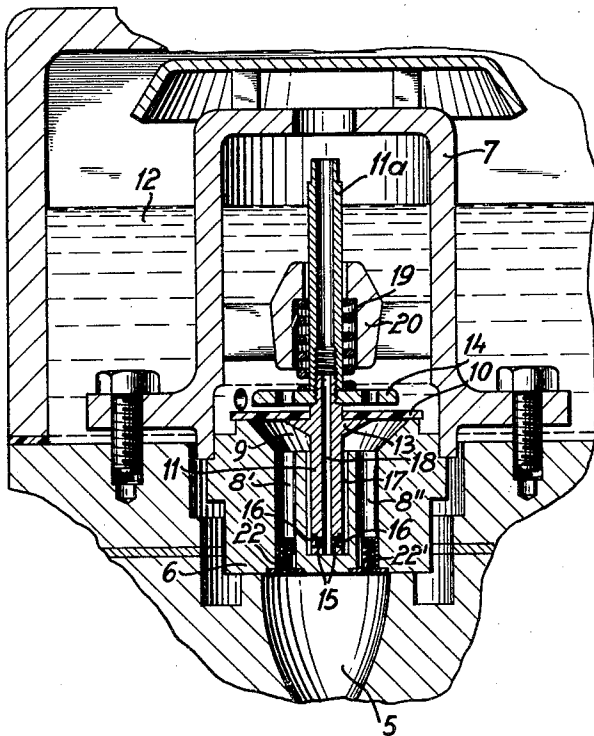
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FIG. 4



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**ROTARY VACUUM PUMP**

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 Claims priority, application Germany July 24, 1957  
 13 Claims. (Cl. 230—205)

The present invention relates to rotary vacuum pumps. It relates more particularly to an improvement in rotary vacuum pumps of the type operated with an amount of liquid, and preferably oil, present in the pump casing and equipped with an exhaust valve arranged to operate submersed in a pool of said liquid or oil, a portion of the liquid being expelled and drawn in alternately through the valve during operation of the pump. Presence of the liquid in the pump minimizes dead space in the pump casing.

In pumps of the afore-described type a mixture of oil and air is expelled through the exhaust valve during the exhaust stroke. When the container to which the pump is connected reaches a very low air pressure, the fluid expelled from the pump contains decreasing amounts of air until practically oil alone is expelled when a high vacuum is reached.

The exhaust valve in pumps of this type is actuated by the liquid coming forth from the pump casing substantially in the manner of a check valve, the energy for operating the valve being derived from the kinetic energy of the streaming fluid. When this fluid is practically entirely oil or any other liquid which is substantially incompressible, the valve is subject to a sudden accelerating energy shock and the valve is propelled by a shock wave from its closed towards its open position. This shock wave is distinctly audible, and the noise generated by the pump may be such as to make use of this particular type of pump inconvenient under many conditions.

It has already been proposed to avoid such noises by providing a cushion of air in a valve space subjacent the exhaust valve. In order to provide such an air cushion it was suggested to admit a small amount of air from the atmosphere into the pump casing the air being then supplied to the space subjacent the valve by the normal operation of the pump. While such an arrangement is quite effective in reducing the operating noise of the pump, it limits the vacuum which can be achieved.

It is, therefore, the primary object of the present invention to provide an air cushion in the valve space subjacent the movable member of the exhaust valve assembly of a rotary vacuum pump of the type described above which does not interfere with the maximum vacuum obtainable by the pump.

With this object in view, the invention provides air supply means for supplying a limited amount of air directly to the valve space subjacent the movable valve member during operation of the pump, the supply means comprising essentially a capillary conduit communicating with the valve space and having an end open to the atmosphere. The invention furthermore contemplates interposing throttling means in the duct connecting the pump casing with the exhaust valve assembly and communicating at one end with the valve space subjacent the movable valve member.

The limited amount of air introduced by the arrangement of the invention into the valve space subjacent the exhaust valve sufficiently increases the compressibility of the mixture of liquid and gas present in the space to permit gradual build-up of pressure without a shock wave

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and the concomitant noises. The throttling means interposed between the valve space and the pump casing permits only a very small fraction of the supplied air to reach the pump casing. The backflow of the mixture of oil and air from the exhaust valve into the casing is sufficiently slowed down by the throttling arrangement to permit closing of the movable valve member before a major amount of the mixture reaches the pump casing.

It furthermore appears that the slight delay during backward travel of the oil-air mixture through the throttling arrangement enhances separation of oil and air sufficiently to cause the air substantially to be retained in the valve space and the oil to flow downward into the pump casing.

The novel arrangement of the air supply means of the invention, together with the throttling means provided between the valve space and pump casing reduces the amount of air introduced into the pump casing to such an extent as to avoid any significant deterioration of the vacuum attainable by the pump.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

FIG. 1 is an elevational section of a preferred embodiment of a rotary vacuum pump of the invention, the section being taken through the axis of the exhaust valve assembly;

FIG. 2 is a section of the pump of FIG. 1 taken along the line II—II looking in the direction of the arrows; and

FIGS. 3 and 4 are fragmentary elevational sections through rotary pumps of the invention, taken in analogy with FIG. 1.

Referring now to the drawing and particularly to FIG. 1, there is shown a pump casing 1 enclosing a cylindrical pump space 2 in which a cylindrical impeller 3 is arranged for rotation about its axis eccentrically of pump space 2 and in tangential contact with pump casing 1. Two vanes 4 are slidable in a diametrical slot in impeller 3 and are urged outwardly of the impeller by a spring in a well-known manner so as to make sealing contact with the pump casing with their outer ends as they sweep over the walls of pump space 2 during rotation of impeller 3.

The pump impeller 3 with its vanes 4 operates in a well-known manner to draw air or any other gas through the intake pipe 21 and to expel it through a duct 5 towards an exhaust valve. The exhaust valve operates under a body of oil 12, some of which is drawn into the pump through the exhaust valve when the pump space communicating with the exhaust valve is at sub-atmospheric pressure during a portion of the pump cycle. The space between the impeller and the pump casing ahead of a vane 4 approaching duct 5 is thus filled with oil and dead spaces in the pump casing and exhaust duct are avoided.

Duct 5 communicates with a plurality of throttling bores 8 of reduced cross-sectional area in the valve body 6 arranged in a circular pattern as best seen from FIG. 2 and leading upward into a valve space 9 arranged subjacent to and closable by movable valve member 10 which in the embodiment illustrated consists of a disc seated on a flat surface of valve body 6.

Valve body 6 is provided with a central bore 17 in which a cylindrical tubular air supply means 11 is mounted

with circumferential clearance. The upper end 11a of air supply means 11 projects upward into the atmosphere above the pool of oil 12. A shoulder member 13 on tubular element 11 has the shape of an inverted cone and is arranged with the conical surface in valve space 9. Its base is flush with the flat surface of valve body 6 forming the seat for movable valve member 10. Air supply element 11 passes through an axial opening in valve member 10 which is slidable on element 11. A flange 14 fixedly and adjustably fastened on element 11 limits the upward movement of valve member 10 on tubular element 11.

A baffle arrangement 7 is mounted over the valve body 6 so as to catch the stream of oil ejected through the valve during the compression stroke of the pump. A yoke 20 is mounted on baffle assembly 7 transversely of air supply means 11. Element 11 is slidable in a bore of yoke 20 and is urged downward into a central bore 17 of valve body 6 by a spring 19 abutting against yoke 20 and flange 14. Upward movement of air supply element 11 against the restraint of spring 19 is limited by abutment of flange 14 against a cooperating surface of yoke 20.

Air supply means 11 is provided with an axial cavity 18 communicating at the upper end 11a of element 11 with the atmosphere and closed at the lower end by abutment of element 11 against valve body 6 at the bottom end of central bore 17. Near its lower end, the axial cavity 18 communicates with an annular recess 16 arranged in the periphery of element 11 adjacent bore 17 by two channels 15. A continuous passageway of very small cross-section is thus provided between valve space 9 and the atmosphere. Fluid flow through this channel is severely limited by relatively long portions of small cross-sectional area and by a plurality of changes in the direction of flow.

The afore-described device operates as follows:

As a vane 4 approaches discharge duct 5, positive pressure is built up in the valve space 9 subjacent disc 10. The disc slides upward on air supply element 11 until it abuts against flange 14. An annular opening is formed between disc 10 and valve body 6 and the mixture of oil and air propelled by vane 4 is ejected.

As vane 4 passes discharge duct 5, the duct communicates with pump space 2 behind the passing vane 4 which is under negative pressure. Oil is thus sucked-in from pool 12 through valve space 9 until the disc 10 is returned into seating engagement with valve body 6 and the flat base of conical shoulder 13 by gravity and the energy of the flowing fluid. The stroke of valve disc 10 is only small in order to limit the amount of oil drawn into pump space 2 by the negative pressure therein.

When the pump is started, the pump space 2 is almost completely filled with oil and the fluid expelled through the exhaust valve is of such quantity as not to escape safely through the annular space formed between disc 10 and valve body 6 during normal operation of the pump. When the pressure exerted by the liquid on disc 10 in the open position exceeds a predetermined value, the disc 10 together with tubular element 11 is moved upward against the restraint of spring 19 until the opening between disc 10 and valve 6 is sufficiently large so that the liquid pressure drops to a safe value. Such occasional relative displacement of tubular element 11 and valve body 6 also serves to dislodge and flush out any foreign bodies that might become wedged in the narrow spaces forming the connection between valve space 9 and the opening to the atmosphere in upper end 11a of air supply element 11.

During a major portion of the pump cycle, valve space 9 is under negative pressure. Air is therefore sucked in through air supply means 11. It passes through the two openings 15 into recess 16 and then along the annular slot between element 11 and valve body 6 into valve space 9. The dimensions of the various portions of this passageway are selected such that the amount of air admitted is sufficient to increase the compressibility of

the oil-air mixture in valve space 9 so as to permit gradual pressure build-up and to avoid a shock wave and concomitant noises. The dimensions of the passageway, however, must be adequate so that the column of oil building up in the axial cavity 18 of air supply means 11 during the exhaust stroke of the pump is completely sucked into the valve space during the period of negative pressure.

During this period, a mixture of oil and air is drawn from the valve space 9 into the pump space 2 through throttling passages 8. Because of the restricted cross-sectional area of passages 8 a pressure differential is maintained between pump space 2 and valve space 9, and the amount of oil-air mixture drawn into the pump casing 1 is limited.

When the pump has produced a high vacuum, very little air enters the casing space 2 so that almost only liquid is pumped into duct means 5, 8 and 9. This would cause very hard shocks on valve 10 and noisy operation. However, since a small amount of air enters valve space 9 through air supply means 11, 16, 18, the mixture of liquid and air in valve space 9 is compressible and the shocks are reduced.

There is also a certain amount of liquid-gas separation taking place in the throttling passages 8 which contributes to reducing the amount of air drawn into the pump space 2 where it would reduce the maximum vacuum attainable by the pump.

The embodiment of the pump of the invention illustrated in FIGS. 3 and 4 is largely identical with that of FIG. 1. The pump of FIG. 3 differs from the pump of FIG. 1 in that the valve disc 10 is fixedly connected with the tubular air supply element 11, element 11 reciprocating in valve body 6 together with disc 10 during the pump cycle. Tubular element 11 is provided with openings 15 which are adapted to register with corresponding openings 25 in valve body 6 so that during registry of corresponding openings 15 and 25 air can pass through element 11 into valve space 9.

The pump of FIG. 4 is equipped with ball valves 22 and 22' arranged in the ducts 8' and 8'' respectively connecting valve space 9 with pump space 2 for throttling the flow of fluid from the valve space into the pump space.

The example of an embodiment of the invention illustrated in FIG. 3 operates substantially in the same manner as described above in connection with the description of the pump of FIG. 1, the amount of air drawn into valve space 9 being limited by the period of registry between openings 15 and 25, respectively. In FIG. 4, the flow of fluid is throttled by ball valve 22 in very much the same manner and with substantially the same effects as by the throttling passages 8 of the embodiment of FIG. 1.

The embodiment of FIG. 4 operates in the same manner as the embodiment of FIG. 1. A small amount of air is drawn through air supply means 11, 18, 16 into duct means 9, 16, 8, 8'. The compressible air liquid mixture in valve space 9 prevents noisy operation of the valve 10. The throttling means 22, 22' limits the amount of air drawn into the space 2 during operation of the pump.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of vacuum pumps differing from the types described above.

While the invention has been illustrated and described as embodied in vacuum pumps, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the stand-

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point of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. In a vacuum pump, a pumping chamber; a container; conduit means connecting said container with said pumping chamber; an amount of liquid in said container and in said conduit and entering also said pumping chamber; valve means arranged in said conduit means so as to permit passage of liquid and air from said pumping chamber into said container but to prevent such passage from said container into said pumping chamber; a valve chamber arranged in said conduit means adjacent said valve means and located between the latter and said pumping chamber; air supply means connected to said valve chamber for admitting thereto a relatively small amount of a gaseous substance adapted to mix within said valve chamber with liquid filling the same so as to form a compressible liquid-gas mixture adapted to be pumped during the compression period of the pump from said valve chamber through said valve means into said container without causing knocking of the valve means; and throttling means arranged in said conduit means between said valve chamber and said pumping chamber preventing sucking of said liquid-gas mixture from said valve chamber into said pumping chamber during the suction period of the pump.

2. In combination with a vacuum pump having a pump chamber, a container, a conduit means connecting said container with said pump chamber and including a valve chamber adjacent said container and throttling means connecting said valve chamber with said pump chamber; an amount of liquid in said container and said conduit means also entering said pump chamber; valve means located between said valve chamber and said container and being movable for opening and closing said conduit means; and air supply means communicating with said valve chamber for supplying a limited amount of air to said valve chamber to produce a compressible mixture of liquid and air in said valve chamber for reducing the shock acting on said valve means when said pump pumps liquid into said valve space and container, said throttling means preventing the mixture of liquid and air from entering said pump chamber when negative pressure prevails in said pump chamber.

3. A pump arrangement as set forth in claim 2, wherein said throttling means includes at least one throttling duct.

4. A pump arrangement as set forth in claim 2, wherein said throttling means includes a plurality of throttling ducts connected in parallel and having ends opening in said valve chamber.

5. A pump arrangement as set forth in claim 4, and including ball valves located in said throttling ducts.

6. In combination with a vacuum pump having a pump chamber, a container, a conduit means connecting said container with said pump chamber and including a valve chamber adjacent said container and throttling means connecting said valve chamber with said pump chamber; an amount of liquid in said container and said conduit means also entering said pump chamber; valve means located between said valve chamber and said container and being movable for opening and closing said conduit means; a body located adjacent said valve chamber and having a cavity opening into the same; and air supply means mounted on said valve means and being movable with the same during at least part of the movement of said valve means, said air supply means having one portion located in said cavity, and another portion projecting into said container and above the level of the liquid in the same, said air supply means being forced with a passage passing through said portions and com-

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municating with said valve space at least when said valve means opens said conduit and moves said air supply means in said cavity for supplying a limited amount of air to said valve chamber to provide a compressible mixture of liquid and air in said valve space for reducing the shock acting on said valve means when said pump pumps liquid into said valve chamber and container, said throttling means preventing the mixture of liquid and air from entering said pump chamber when negative pressure prevails in said pump chamber.

7. A pump arrangement as set forth in claim 6, wherein said one portion of said air supply means forms an annular passage in said cavity opening into said valve space and communicating with said passage in said air supply means when the same is moved by said valve means.

8. A pump arrangement as set forth in claim 7, wherein said one portion has transverse ducts connecting said passage with said annular space.

9. A pump arrangement as set forth in claim 6, wherein said body is formed with transverse ducts connecting said cavity with said throttling means and wherein said one portion slidably engages the surface of said cavity, and is formed with transverse ducts connecting said passage with said transverse ducts in said body when said valve means moves said air supply means.

10. A pump arrangement as set forth in claim 6, wherein said air supply means is fixedly connected to said valve means for movement therewith, said valve means being a plate.

11. A pump arrangement as set forth in claim 6, wherein said air supply means has two flanges and wherein said valve means is a valve plate located between said flanges of said air supply means so that said air supply means is moved by said valve plate during the last part of the movement of the same when said valve plate opens said conduit means.

12. In combination with a vacuum pump having a pump chamber, a container, a conduit means connecting said container with said pump chamber and including a valve chamber adjacent said container and throttling means connecting said valve chamber with said pump chamber; an amount of liquid in said container and said conduit means also entering said pump chamber; valve means located between said valve chamber and said container and being movable for opening and closing said conduit means; a body formed with a cylindrical cavity having a bottom and opening into said valve space; an air supply means having a first tubular portion located in said cavity resting on said bottom and forming an annular space in said cavity communicating with said valve space, said air supply means having a second tubular portion projecting through said liquid into the air, and an intermediate portion passing through said valve means, said air supply means having two projecting portions located on opposite sides of said valve means and being spaced a greater distance than the thickness of said valve means so that air supply means is moved by said valve means during the second part of the opening movement of the same whereby said first tubular portion is raised from said bottom, said air supply means being formed with a passage connecting the ends of said tubular portions so that air passes through the passage and along said bottom and through said annular space into said valve chamber when said valve means moves said air supply means, whereby a limited amount of air is supplied to said valve chamber to provide a compressible mixture of the liquid and air in said valve chamber for reducing the shock acting on said valve means when said pump pumps liquid into said valve chamber and container, said throttling means preventing the mixture of liquid and air from entering said pump chamber when negative pressure prevails in said pump chamber.

13. A pump arrangement as set forth in claim 12, wherein said valve means is a circular plate, wherein said valve chamber is a frusto-conical chamber, and wherein

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said throttling means includes a plurality of parallel ducts surrounding said body.

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