Sept. 10, 1963 R. E. THOMPSON 3,103,178

HIGH-CAPACITY PUMP OF TUBE-COMPRESSION TYPE

Filed Aug. 11, 1961 2 Sheets-Sheet 1

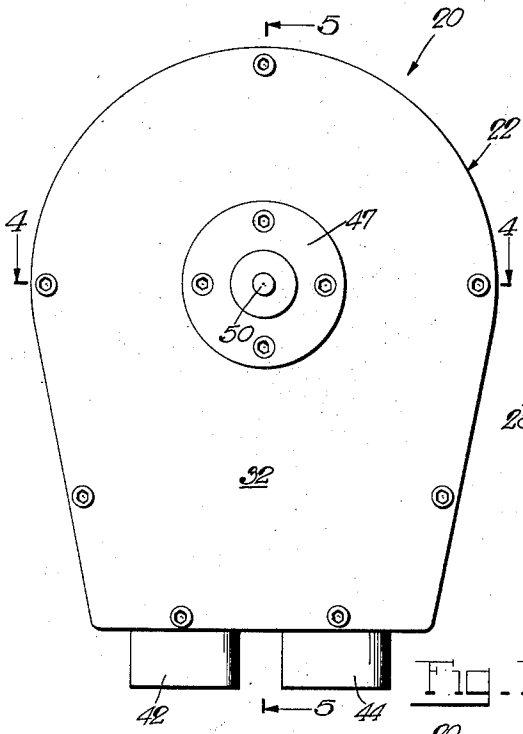


Fig. 1

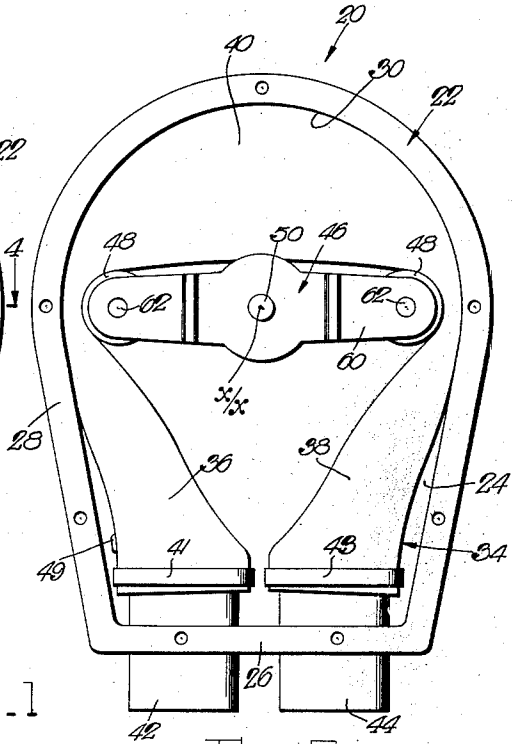


Fig. 2

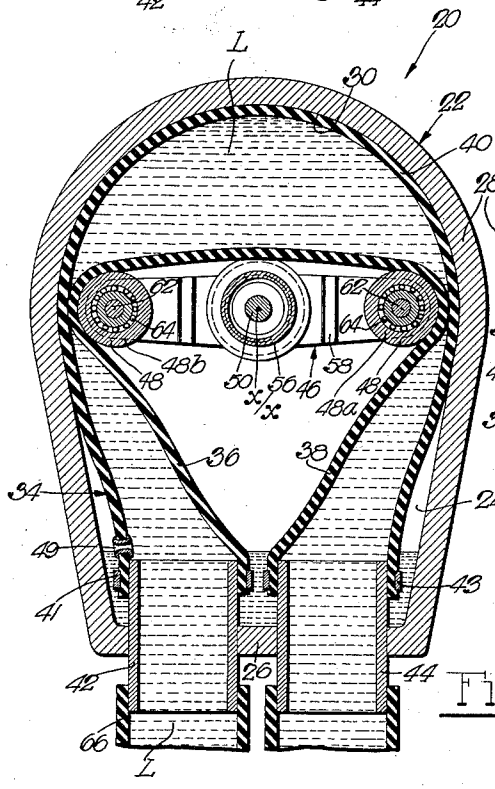


Fig. 3

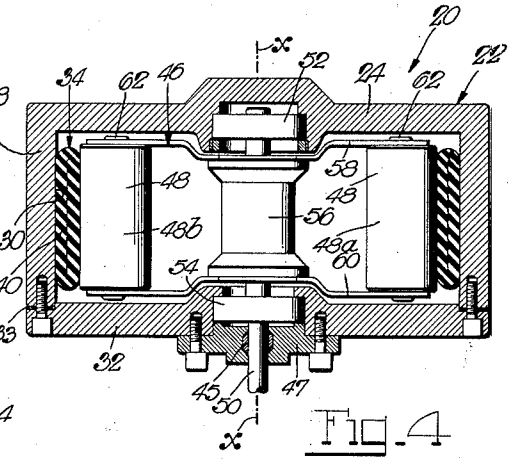


Fig. 4

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Sept. 10, 1963 R. E. THOMPSON 3,103,178

HIGH-CAPACITY PUMP OF TUBE-COMPRESSION TYPE

Filed Aug. 11, 1961 2 Sheets-Sheet 2

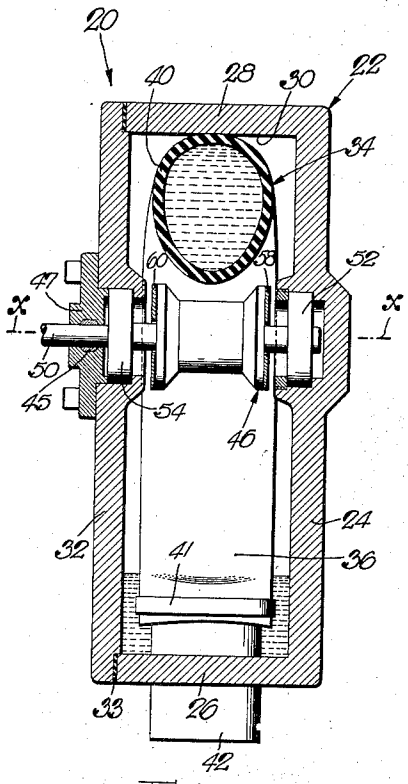


Fig. 5

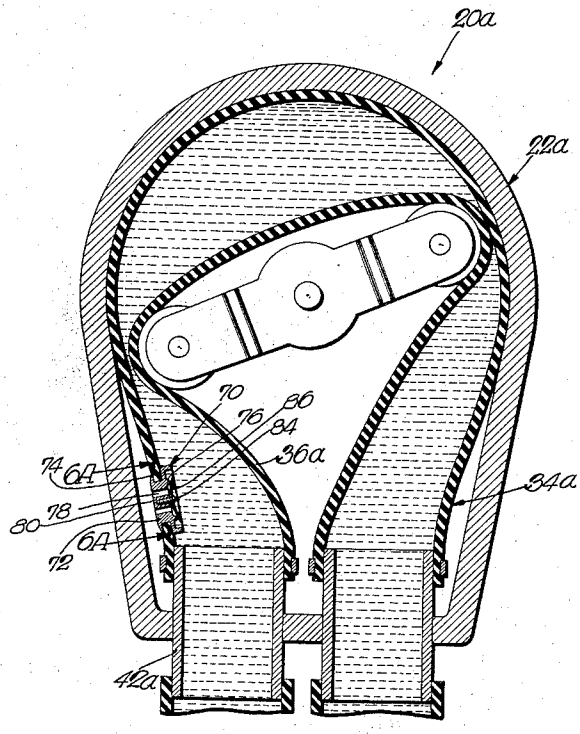


Fig. 6

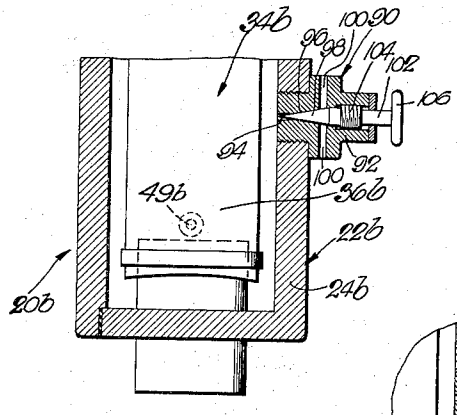


Fig. 7

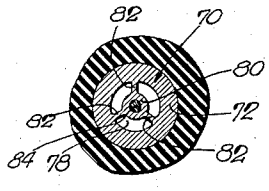


Fig. 6A

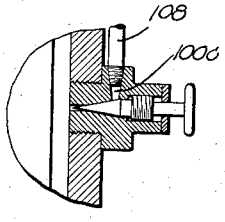


Fig. 8

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3,103,178

HIGH-CAPACITY PUMP OF TUBE-COMPRESSION TYPE

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Filed Aug. 11, 1961, Ser. No. 130,870
4 Claims. (Cl. 103—149)

This invention relates to rotary pumps in general, and to liquid pumps of tube-compression type in particular.

Pumps of this type are customarily provided with a resiliently flexible tube having inlet and outlet legs and an intermediate liquid-displacing section resting against a fixed surrounding track of arcuate extent, and spaced rollers turnable as a unit about the center axis of the track for cyclically compressing the tube section progressively into complete collapse or closure against the track. With the rollers being thus turned in the proper direction, the liquid in the tube section immediately ahead of the roller-compressed part thereof is displaced therefrom and discharged through the outlet leg of the tube, while the tube section immediately behind the roller-compressed part thereof resiliently recovers from its collapsed state and the ensuing partial vacuum therein draws liquid thereinto through the inlet leg of the tube. Since proper functioning of pumps of this type depends on resilient recovery of the displacement sections of the tubes thereof against external atmospheric pressure, it stands to reason that their maximum operating speeds and, hence, output capacities and also the maximum liquid lift to their suction sides are rather limited.

My prior Patent No. 2,982,225, dated May 2, 1961, shows a pump of this type which in its permissible maximum operating speed and, hence, output capacity, and in the maximum liquid lift to its suction side, is superior to the other prior pumps of this type. This is achieved by cyclic resilient stretching of the displacement section of the tube beyond its normal full volume in non-stretched condition, and to a larger extent by the ensuing reenforcement of this section and of the inlet leg of the tube against collapse under external atmospheric pressure. However, even my prior pump falls short of meeting the latest most exacting requirements of pumps of this type in the aforementioned respects for many applications.

It is among the objects of the present invention to provide a pump of this type the performance of which in point of permissible maximum operating speed and, hence, output capacity and also in the maximum liquid lift to the suction side thereof, is such as to meet even the latest exacting requirements of pumps of this type.

It is another object of the present invention to provide a pump of this type in which the primary obstacle to its optimum performance, namely exposure of the tube thereof to external atmospheric pressure, is largely overcome, by constantly subjecting the tube externally to a partial vacuum in the pump during operation of the same.

It is a further object of the present invention to provide a pump of this type in which the partial vacuum to which the tube is subjected during operation of the pump, as aforementioned, is created and maintained solely by the operating vacuum in the tube, by enclosing the tube in a sealed pump casing and providing between them a communicating passage through which to permit the operating vacuum in the tube to evacuate the casing without permitting liquid in the tube to fill the evacuated space in the casing at any time.

Another object of the present invention is to provide a pump of this type in which the aforementioned communicating passage between the tube and sealed pump casing may be in the simple form of an open vent in the tube, with the vent being provided in the tube advantageously at or near the lowest level of the operating vacuum therein to limit seepage of liquid from the tube to this level in the pump casing and preserve the space thereabove for subjection to the partial vacuum therein of as much of the tube as possible. Accordingly, continuous performance of this pump requires operation of the pump in more or less of a fixed position in which to maintain the specified location of the open vent in the tube and pump casing.

A further object of the present invention is to provide a pump of this type in which the aforementioned communicating passage between the tube and sealed pump casing is, alternatively, in the form of a check valve in the tube which opens only in response to a predominant operating vacuum in the tube for evacuation of the pump casing and, hence, prevents any seepage of liquid from the tube into the pump casing. Accordingly, the check valve may be located on the inlet leg of the tube at any place most convenient for the purpose, and the pump will in any and all positions perform satisfactorily.

It is a further object of the present invention to provide a pump of this type the output rate of which may be regulated independently of the drive of the roller unit, by providing the pump casing with a valve which may be manipulated from the outside either not to admit atmospheric air, or to admit atmospheric air at variable rate, into the evacuated interior of the pump casing. Thus, the pump will for a given drive rate of the roller unit have a maximum output rate when no air is admitted through this valve into the pump casing, and will have a reduced output rate depending on the rate of admission of air through this valve into the pump casing.

Other objects and advantages will appear to those skilled in the art from the following, considered in conjunction with the accompanying drawings.

In the accompanying drawings, in which certain modes of carrying out the present invention are shown for illustrative purposes:

FIG. 1 is a front view of a pump embodying the present invention;

FIG. 2 is a view of the pump with the cover removed to show the interior thereof;

FIG. 3 is a longitudinal section through the pump;

FIGS. 4 and 5 are transverse sections through the pump taken substantially on the lines **4—4** and **5—5**, respectively, of FIG. 1;

FIG. 6 is a longitudinal section through a pump embodying the present invention in a modified manner;

FIG. 6A is an enlarged fragmentary section taken on the line 6A—6A of FIG. 6;

FIG. 7 is a fragmentary section through a pump embodying another feature of the present invention; and

FIG. 8 is a fragmentary section through a pump embodying still another feature of the present invention.

Referring to the drawings, and more particularly to FIGS. 1 to 5 thereof, the reference numeral **20** designates a pump having a casing **22** with rear, bottom and side walls **24**, **26** and **28**, respectively, of which the side wall **28** forms an inner arcuate track **30** which presently is substantially semi-circular about a center axis *x—x*. The casing **22** is open at its front and is closed thereat by a removable cover **32**. Interposed between the casing **22** and cover **32** is a gasket **33** to seal the closed casing from the outside in accordance with one aspect of the present invention. Located in the casing **22** is a resiliently flexible tube **34** which presently is U-shaped, having opposite fluid-conducting legs **36** and **38** and an intermediate fluid displacement length or section **40**. The tube **34** rests with its displacement section **40** against the track **30**, and its legs **36** and **38** are with their ends fixed to the casing **22**, in this instance being slipped over

and clamped at 41 and 43 to the inner ends of conduits 42 and 44, respectively, which are suitably secured in the bottom wall 26 of the casing 22 and constitute inlet and outlet ports in the casing for the tube 34.

Also provided in the casing 22 is a rotor unit 46 carrying rollers 48 and being turnable about the center or track axis x—x. To this end, a drive or rotor shaft 50, which is journalled in antifriction bearings 52 and 54 in the casing 22 and cover 32, respectively, carries a hub 56 to the ends of which are suitably secured arms 58 and 60. Connecting the adjacent ends of these arms 58 and 60 are cross-pins 62 on which the rollers 48 are journalled, preferably through intermediation of antifriction bearings 64 (FIG. 3). The rollers 48, which in this instance number two and are diametrically opposite each other, are so spaced from the track axis x—x that their peripheries will compress to full closure any adjacent part of the displacement tube section 40 on the track 30 against the latter. To maintain the interior of the casing 22 sealed from the outside, the drive shaft 50 of the rotor unit 46 extends to the outside of the casing through a packing 45 in a bearing retainer 47 on the cover 32 (FIGS. 4 and 5).

In accordance with an important aspect of the present invention, the tube 34 is in the interior of the sealed casing 22 subjected to a partial vacuum in order to permit the pump to operate at considerably higher speed and, hence, output capacity, and also at a considerably higher liquid column to its suction side, than is possible with pumps in which the tubes are exposed to atmospheric pressure and, hence, subject to partial or full collapse on considerably lower pump speed and liquid lift. While it would be feasible, but rather impractical and prohibitive in cost, to connect to this end the sealed interior of the casing 22 with a vacuum source separate from the pump, it is incomparably preferable to evacuate the interior of the casing by means of the operating vacuum in the tube 34 during operation of the pump. To this end, there is provided between the suction side of the tube 34 and the interior of the casing 22 a communicating passage which in this instance is a vent 49 in the exemplary inlet leg 36 of the tube.

Assuming now that the inlet leg 36 of the tube 34 is through the conduit 42 and a hose connection 66 in communication with a fluid, and in the present example with a supply of liquid L to be pumped (FIG. 3), the rotor unit 46 will, for proper performance of the pump, be driven by hand or power clockwise as viewed in FIGS. 2 and 3. Thus, with the rotor unit 46 passing in its clockwise drive through the momentary angular position of FIG. 3, the presently trailing roller 48*b* has already started its present tube-compression cycle, while the presently leading roller 48*a* has not quite finished its present tube-compression cycle, this by virtue of the fact that the circular extent of the track 30 is in the present instance somewhat in excess of a semicircle. Each roller 48 thus performs a tube-compression or operating cycle while progressively compressing the displacement tube section 40 once against the track 30 throughout. With both rollers 48 thus compressing the adjacent parts of the displacement tube section 40 against the track 30 (FIG. 3), the space in this tube section between the compressed parts thereof and the previously admitted liquid L therein are fully sealed from the remainder of the tube until the leading roller 48*a* on continued clockwise rotation of the unit 46 reaches the end of its present operating cycle. When the leading roller 48*a* reaches and moves beyond the end of its present operating cycle, the sealed space in this tube section will open to the outlet leg 38 and the trapped liquid in this tube space will on continued clockwise rotation of the unit 46 be displaced therefrom and discharged through the outlet leg 38, the discharge of this liquid being completed when the trailing roller 48*b* reaches the end of its presently started operating cycle. Of course, as the trailing roller 48*b* continues its present operating cycle (FIG. 3), the part of the tube immediately therebehind will more and more resiliently recover from its roller-induced distortion and the ensuing partial vacuum therein will draw liquid thereinto. Thus, the presently trailing roller 48*b* will during its present operating cycle not only cause liquid to be drawn steadily into the part of the tube immediately therebehind, but it will also discharge the liquid ahead of it in this tube section from the latter and through the outlet leg 38 of the tube. The rollers 48 of the present arrangement thus have alternating operating cycles, with the operating cycle of either roller starting at least simultaneously with, and in no event subsequent to, the end of an operating cycle of the other roller in order to render the pump at all operative.

It follows from the preceding description that it is a partial vacuum which draws liquid into the inlet leg 36 and the ever increasing communicating part of the displacement tube section 40 during each operating cycle of each roller 48. This partial vacuum is during pump operation constantly maintained in the inlet leg 36 of the tube, and is in fact restricted to the inlet leg part 36 of the suction side of the tube at the start of each operating cycle of each roller 48, with the suction side of the tube being understood to be the inlet leg and the therewith communicating ever increasing part of the displacement section 40 of the tube during each operating cycle of each roller 48. As already mentioned, it is the function of the vent 49 to subject the interior of the casing 22 for its evacuation to the operating vacuum in the suction side of the tube 34. Since constant evacuation of the interior of the casing 22 during operation of the pump is imperative for non-collapse of the tube 34 at peak performance of the pump in point of operating speed and, hence, output capacity and also in point of height of liquid column to its suction side, the vent 49 must necessarily be arranged on the suction side of the tube 34 below the section 40 thereof and, hence, in the inlet leg 36 as described. The interior of the casing 22 is thus constantly subjected to the operating vacuum in the inlet leg 36 and, hence, kept evacuated, during operation of the pump. However, liquid from the inlet leg 36 will inevitably seep through the open vent 49 into the interior of the casing 22, but will in no event rise therein above the level of the vent 49 through which the part of the casing thereabove is kept evacuated. It is, therefore, advantageous to locate the vent 49 as low as possible in the inlet leg 36 of the tube, i.e., in close proximity to its connection with the inlet conduit 42 (FIG. 3), so as to subject as much as possible of the tube, and more particularly its suction side, to the partial vacuum in the casing 22. Of course, in order that the pump may operate for any length of time, the same must be fixed in the position shown in FIG. 3 or in any other position in which at least most of the suction side of the tube is above the level of the vent 49 and, hence, subjected to the partial vacuum in the casing 22. Also, while the vent 49 is, in the present example, provided in the inlet leg 36 of the tube 34, it is fully within the purview of the present invention to provide the vent, instead, in the inlet conduit 42 anywhere within the interior of the casing 22, and preferably in close proximity to the bottom wall 26 of the casing.

Subjection of the tube 34 to a partial vacuum in the interior of the casing 22 is further advantageous in that a rupture in the tube will in many cases not interfere with the normal performance of the pump or merely reduce its output rate, whereas a rupture anywhere in the suction side of a tube subjected to external atmospheric pressure will almost always lead to immediate and complete failure of the pump. Thus, if a comparatively small rupture should occur in the present tube 34 anywhere in its inlet leg 36, or for that matter anywhere in its entire suction side, the pump will continue to perform normally since the operating vacuum in the tube will be constantly maintained. If the rupture should be fairly

large, the pump will in most cases nevertheless continue to perform for emergency purposes until the tube can be replaced, though the liquid level in the casing **22** may rise above the vent **49** toward or even to the level of the rupture and reduce the capacity of the pump accordingly. On the other hand, if a rupture should occur in the tube **34** anywhere in its displacement section **40** or in its outlet leg **38**, the pump will also continue to perform so long as the rupture is not excessively large or the head of liquid above the rupture is not such as to force excessive liquid through the rupture into the casing **22** or burst the tube at the rupture.

The primary objective of subjecting the tube **34** to the partial vacuum in the interior of the casing **22** is, of course, permissible higher operating speed and, hence, output capacity and also permissible greater height of a liquid column to the suction side, of the pump than could be achieved heretofore. Tests conducted with the present pump revealed startling performance results in these respects. Thus, just to mention one test which indicates the vast superiority in performance of the present pump over that of previous pumps with their tubes exposed to atmospheric pressure, one and the same pump was operated at a fixed speed of 150 r.p.m. first with a ventless tube and then with a replaced vent-equipped tube which was in all other respects identical with the first tube. The height of the liquid column to the suction side of the pump was maintained at 6 feet during each operation. Operation of the pump under these circumstances showed that with the ventless tube the output rate was .138 gallons per minute, while with the vent-equipped tube the output rate was 4.13 gallons per minute, i.e., 30 times greater than the output rate with the ventless tube. These data indicate specifically that the ventless tube collapsed quite badly, and the vent-equipped tube collapsed not at all or at the most inappreciably, at the indicated operating speed of the pump and the indicated liquid column to the suction side thereof. These same data indicate more generally that the performance of the pump with the vent-equipped tube is, in point of permissible maximum operating speed and, hence, output capacity or in point of permissible maximum height of liquid column to the suction side of the pump, or both, vastly superior to the performance in these respects of the pump with the ventless tube.

Subjection of the tube to a partial vacuum in the interior of the pump casing in accordance with the present invention also permits the use of a tube of minimum wall-thickness for a given performance of the pump and, hence, requires minimum torque for the drive of the pump, as will be readily understood.

Reference is now had to FIG. 6, which shows a pump **20***a* that differs from the described pump **20** by having in its tube **34***a* a check valve **70** in lieu of an open vent. The exemplary check valve **70**, which in the present instance is provided in the inlet leg **36***a* of the tube, comprises a valve body **72** which at **74** is permanently secured to the tube wall and has an annular seat **76** of V-shaped cross-section and a passage **78** that leads from the seat **76** to the interior of the casing **22***a* (see also FIG. 6A). Provided in the valve passage **78** is a hub **80** which by means of spider arms **82** across the passage **78** is joined to the rest of the valve body **72**. Secured at **84** to the hub **80** of the valve body **72** is a resilient valve disc **86** of rubber or the like which in the present instance is resiliently flexed into normal closing engagement with the valve seat **76**.

The operation of the present pump **20***a* is quite similar to that of the earlier described pump **20**, with the important exception that no liquid is permitted to seep from the inlet leg **36***a* of the tube **34***a* into the interior of the casing **22***a*. Thus, the check valve **70** will open only if the partial vacuum in the inlet leg **36***a* is sufficiently higher than that in the evacuated interior of the casing **22***a* to overcome the resilient force of the valve disc **86** with which the same is normally urged into closing engagement with the valve seat **76**, wherefore there is at no time a condition in the check valve **70** which would permit the flow therethrough of any liquid from the inlet leg **36***a* into the interior of the casing **22***a*. Of course, while the check valve is biased into its closed position for its described leakproof performance liquidwise, the force with which it is so biased into closed position may be, and preferably is, exceedingly small so that to all intents and purposes the interior of the casing is evacuated by the full operating vacuum in the tube. Leakproof performance, liquidwise, of the check valve **70** secures the important advantage that the present pump will perform in any position whatsoever, as will be readily understood. Also, in view of its leakproof performance, the check valve may be mounted in the inlet leg **36***a* of the tube **34***a* at any convenient place thereof and not necessarily in close proximity to the inlet conduit **42***a*, but its mount somewhere in the inlet leg is imperative for proper performance of the pump since it is only the inlet leg of the tube in which an operating vacuum is constantly maintained during operation of the pump. Further, while the check valve **70** is in the present example mounted in the tube **34***a*, i.e., in the inlet leg **36***a* thereof, it is fully within the purview of the present invention to mount the check valve anywhere in the inlet conduit **42***a* within the interior of the casing **22***a*.

Reference is now had to FIG. 7 which shows a pump **20***b* that may in all respects be like either of the described pumps **20** or **20***a*, except that the present pump **20***b* has in its casing **22***b* a valve **90** for either admitting no atmospheric air, or admitting atmospheric air at variable flow rate, into the interior of the casing **22***b* for regulation of the output rate of the pump independently of its operating speed. Thus, when the valve **90** is closed so that no atmospheric air is admitted into the casing **22***b*, the latter is evacuated to the optimum extent by the operating vacuum in the inlet leg **36***b* of the tube **34***b*, with the result that the pump will at a given operating speed have a maximum output rate. Conversely, if the valve **90** is manipulated to admit atmospheric air into the casing **22***b* at a rate at which the operating vacuum in the tube will remain sufficiently high constantly to evacuate the interior of the casing so as to maintain a partial vacuum therein, the output rate of the pump will at the same operating speed be reduced in inverse proportoin to the flow rate of the admitted atmospheric air into the casing. Thus, as long as the pump functions to displace liquid, all atmospheric air admitted through the valve **90** passes inevitably into the inlet leg of the tube and reduces the operating vacuum therein for a reduced output rate of the pump. Also, the valve **90** may be opened so wide as to stop performance of the pump altogether despite its continuous drive. It follows, therefore, that the valve **90** affords wide and minute regulation of the output rate of the pump, and even temporary or permanent non-performance of the same, at continuous and even non-varying drive of the same, for many purposes, general or special. If the present pump **20***b* is, with the exception of its valve **90**, like the described pump **20** and in its normal operating position like or similar to that shown in FIG. 3, i.e., with its inlet and outlet legs lowermost, the valve **90** is preferably at a level vertically above that of the vent **49***b* in the inlet leg **36***b* of the tube **34***b* (FIG. 7), so that no liquid that may be in the interior of the casing **22***b* up to the vent **49***b* may leak to the outside of the pump through the open valve **90**.

The exemplary valve **90**, which is of needle-type, has a body **92** which in this instance is screwed into the rear wall **24***b* of the casing **22***b*. The valve body **92** is provided with a discharge passage **94** that is in part formed as a tapered seat **96** for a needle valve **98**, and one or more inlet ports **100** that lead to the seat part **96** of the discharge passage **94**. The needle valve **98** has a rearward shank **102** a length **104** of which is threadedly received in the valve body **92** for movement of the valve into and from engagement with the seat **96** on turning the former

in opposite directions. For convenient manipulation of the needle valve **98**, the same carries at the end of its shank **102** a handwheel **106**.

The valve **90** may also be used to treat the liquid to-be-pumped, such as aerating the same with carbon dioxide, oxygen, or any other gas. To that end, the inlet ports **100** of the valve may simply be connected with a proper gas source. Such an arrangement is shown in FIG. 8, in which the inlet port **100***c* is through a conduit **108** connected with a proper gas source.

The invention may be carried out in other specific ways than those herein set forth without departing from the spirit and essential characteristics of the invention, and the present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

What is claimed is:

1. In a pump, the combination of a sealed casing having an inner arcuate track with a center axis and inlet and outlet port elements; a resiliently flexible tube in said casing having fluid inlet and outlet leg elements continuous with said inlet and outlet port elements, respectively, and an intermediate fluid displacement section surrounded by said track; a rotor unit turnable about said track axis and having a plurality of rollers spaced from said track axis to compress to full closure adjacent parts, respectively, of said intermediate tube section on said track against the latter and being so angularly spaced from each other that successive rollers will in at least one angular position of said unit compress to full closure the respective adjacent parts of said intermediate tube section against said track; passage means between one of said inlet elements and the interior of said casing to admit into the latter the operating vacuum in said tube; and a valve in said casing operable from the outside thereof either not to admit atmospheric air or to admit atmospheric air at variable rate into the interior of said casing for regulation of the output rate of the pump.

2. The combination in a pump as set forth in claim 1, in which said casing has a normal operating position in which said port elements are lowermost, said passage means is a vent in one of said inlet elements, and said valve is in said normal casing position at a level vertically above that of said vent.

3. The combination in a pump as set forth in claim 1, in which said passage means is a check valve in one of said inlet elements normally biased into closed position and opening only under a predominant operating vacuum in said tube.

4. In a pump, the combination of a sealed casing having an inner arcuate track with a center axis and inlet and outlet port elements; a resiliently flexible tube in said casing having fluid inlet and outlet leg elements continuous with said inlet and outlet port elements, respectively, and an intermediate fluid displacement section surrounded by said track; a rotor unit turnable about said track axis and having a plurality of rollers spaced from said track axis to compress to full closure adjacent parts, respectively, of said intermediate tube section on said track against the latter and being so angularly spaced from each other that successive rollers will in at least one angular position of said unit compress to full closure the respective adjacent parts of said intermediate tube section against said track; passage means between one of said inlet elements and the interior of said casing to admit into the latter the operating vacuum in said tube; a valve in said casing having a body with an inlet port and a discharge passage leading into the interior of said casing and a seat intermediate said port and passage, and a valve element operable from the outside of said casing to move into and from engagement with said seat; and a conduit providing communication between said inlet port and a gas source.

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