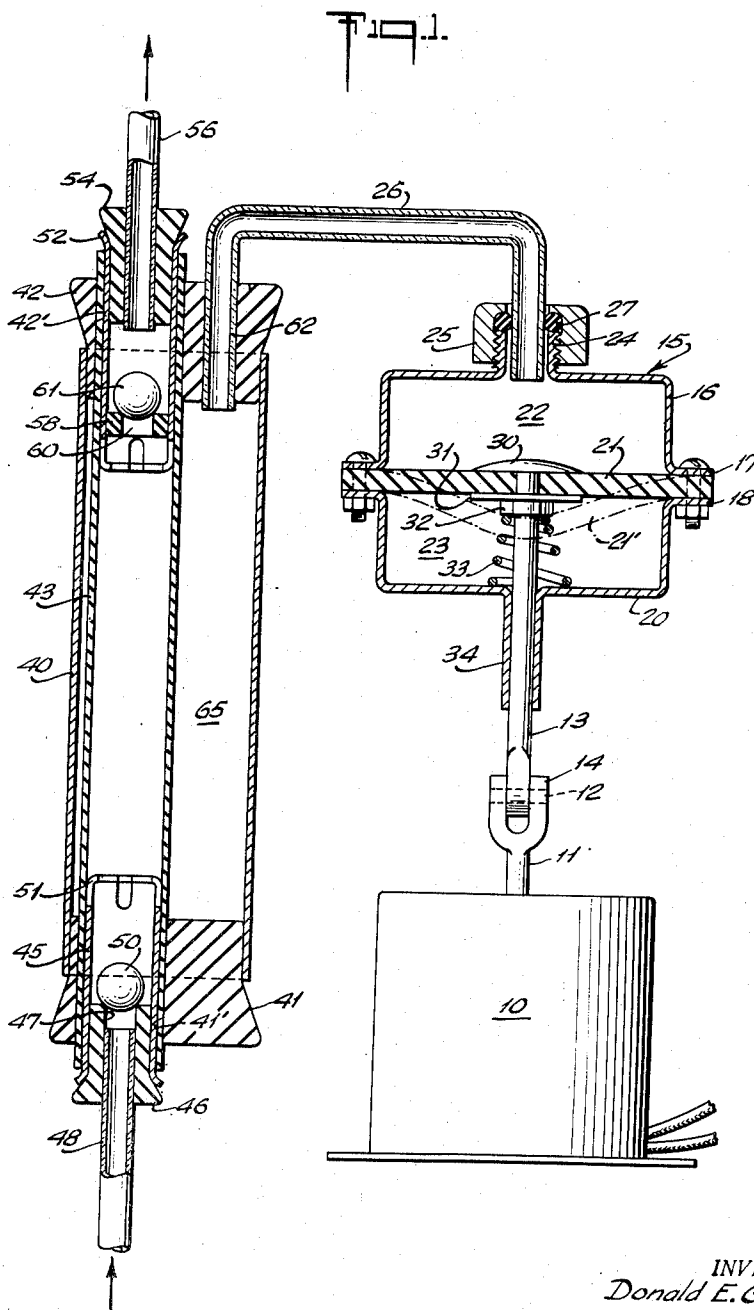


Filed Dec. 4, 1952

PUMPING DEVICE

3 Sheets-Sheet 1



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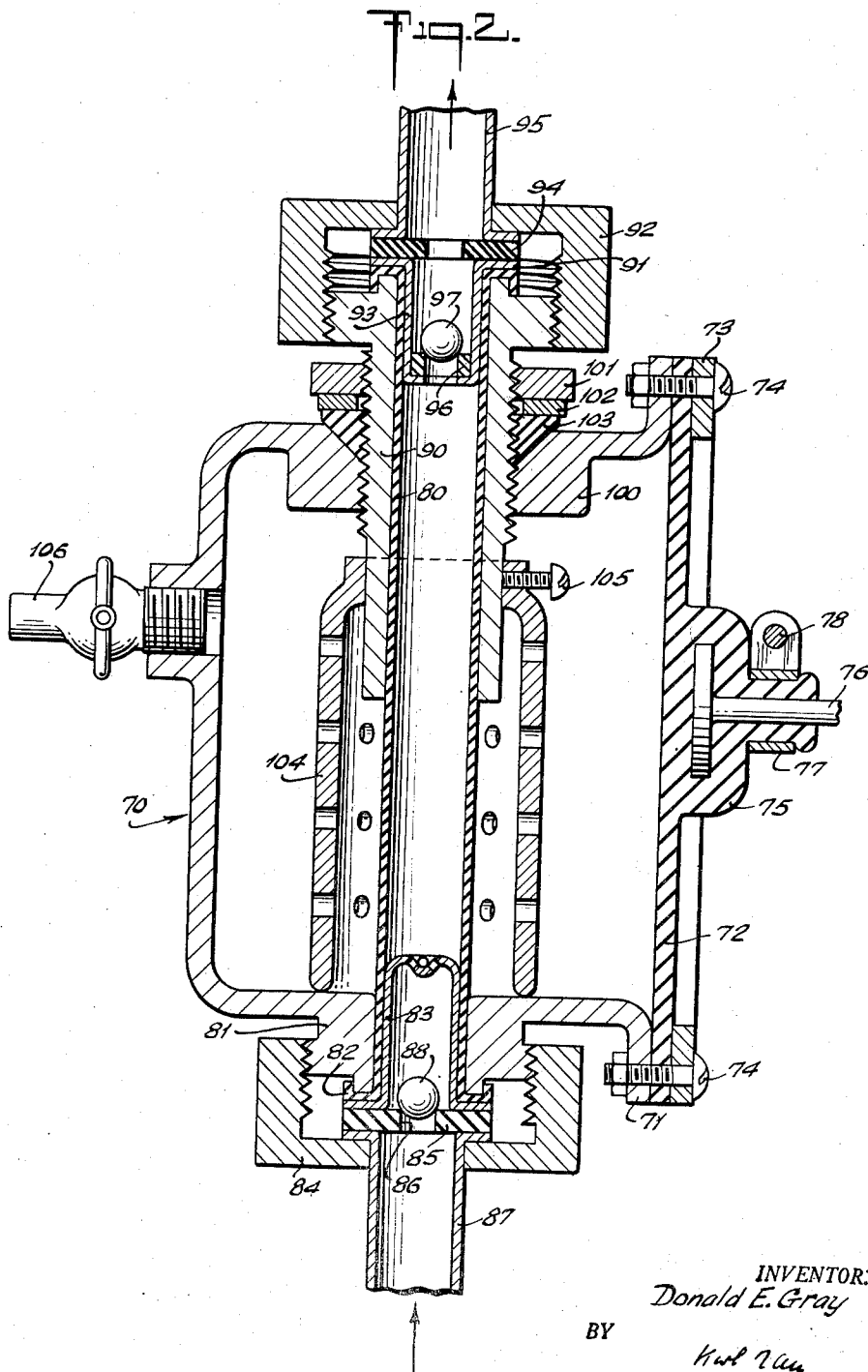
Nov. 12, 1957

D. E. GRAY
PUMPING DEVICE

2,812,716

Filed Dec. 4, 1952

3 Sheets-Sheet 2



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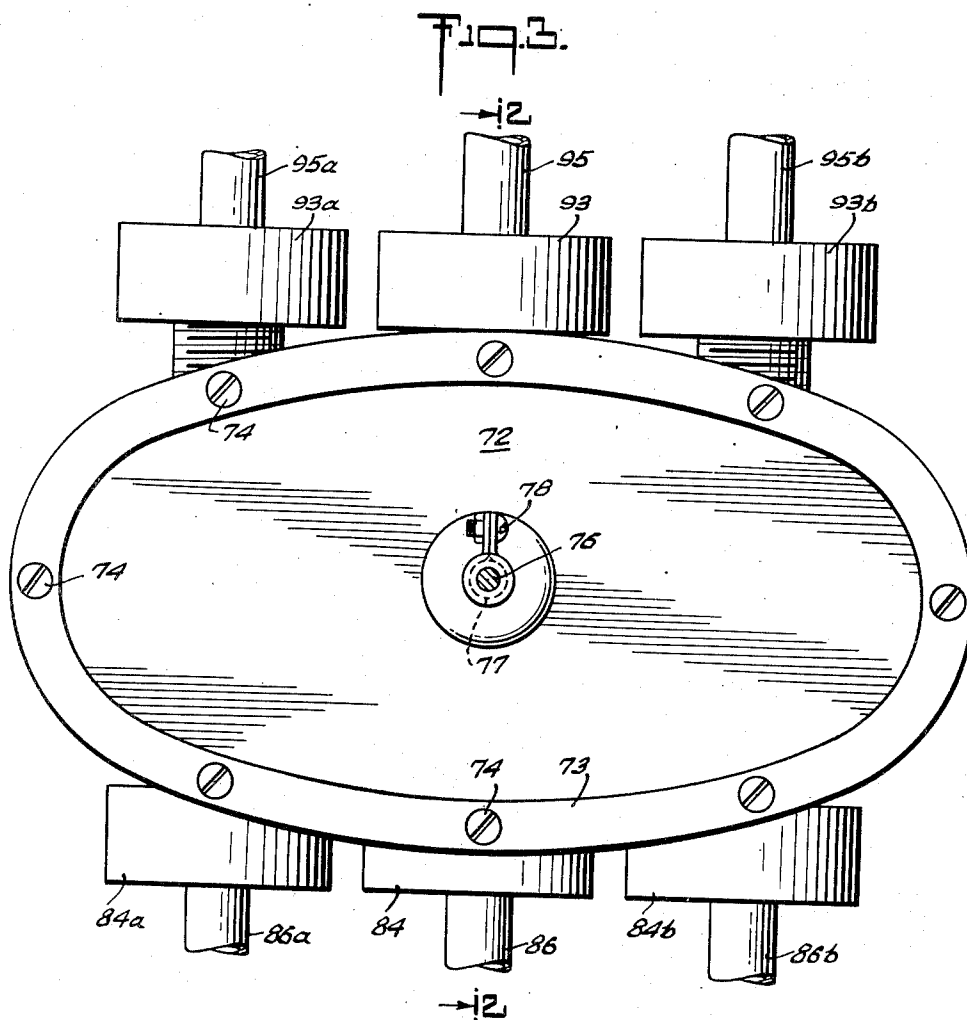
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PUMPING DEVICE

3 Sheets-Sheet 3



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2,812,716

PUMPING DEVICE

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5 Claims. (Cl. 103—37)

The present invention relates to an expansion or squeeze pump for conveying or transporting fluid material, such as gases or liquids, or for boosting the pressure of a moving fluid to compensate for the losses due to friction, impact, turbulence, or the like in passing through a conduit or transmission pipe line.

An object of the invention is the provision of an improved pumping device, wherein the fluid being conveyed or transported is substantially free from contact with the ambient atmosphere, to prevent contamination and other interference.

Other objects of the invention are the provision of a novel type of expansion or squeeze pump which is both simple in design and easy to operate; in which a relatively small primary pump or pressure control device is enabled to operate or control a relatively larger pump conveying the fluid to be transported; which can be adjusted or controlled in a simple manner to vary the pressure or pumping capacity thereof; and which can be associated with other pumping devices for simultaneously conveying and/or mixing, in any desired ratio, different fluids by means of a single control device.

The above and further objects as well as novel aspects of the invention will become more apparent from the following detailed description considered in conjunction with the accompanying drawings, forming part of this specification, and wherein:

Figure 1 is a cross-section through a pump assembly constructed in accordance with the principles of the invention; and

Figures 2 and 3 are cross-section and side views, respectively, of a composite or multiple pump structure embodying the invention.

Like reference characters denote like parts in the several views of the drawings.

Referring more particularly to Figure 1, the numeral 10 indicates an actuating device, such as a solenoid, rotary cam or the like, to provide an alternating drive for operating a control device or periodic pressure generator, in the form of a diaphragm pump as shown in the drawing, which in turn serves to control or operate the main pumping device in the form of a squeeze or expansion pump, through either a liquid or gaseous transmission medium.

The solenoid 10 may be of any well known construction, comprising a plunger 11 adapted for reciprocating movement within the solenoid coil or winding (not shown) by means of alternating or periodic electric current pulses applied to the coil, in a manner well understood. The plunger 11, in the example shown, is provided with a yoke 14 which is in turn attached to the actuating rod 13 by a pin 12 or in any other suitable manner.

The diaphragm or control pump 15 comprises a first shell or upper housing half 16 having a flange 17 engaging the flange 18 of a similar lower housing shell 20. Secured between the flanges 17 and 18 is a diaphragm 21 of resilient or flexible material, such as rubber, whereby to

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provide two separate spaces 22 and 23 within the pump housing. The shell 16 is provided with an outwardly threaded extension or neck 24 adapted for engagement with an internally threaded screw cap 25. The neck 24 accommodates the end of a tube 26, a rubber sealing ring 27 surrounding the tube and being forced into a hermetic seal between neck 24 and the tube 26 by tightening of the cap 25, in a manner readily understood.

The actuating rod 13 is provided with a head 30 secured to the center of the diaphragm 21 by means of a washer 31 and a clamping nut 32, or in any other suitable manner.

Surrounding the rod 13 there is provided a conically shaped helicoid spring 33 having one end engaging the shell 20 and having its opposite end engaging the nut 32, in such a manner as to be compressed and expanded by the movement of the rod so as to assist the action of the diaphragm in a manner as will be understood from the following. The shell 20 is further provided with a neck or sleeve 34 serving as a guide for the rod 13 in slidable engagement therewith.

In operation, electric current pulses are supplied from any suitable source to the solenoid, thus periodically urging the plunger 11 and actuating rod 13 in a downward direction against the resiliency of the spring 33 and pulling or expanding the diaphragm 21 into a downward position, as indicated by dot-dash lines 21' in the drawing. As a result, a partial vacuum will be created within the space 22. During disconnection or reversal of the operating current of the solenoid, the diaphragm 21 return to or is moved upwardly beyond its normal position.

As will be understood, the solenoid may be energized either intermittently by a series of current pulses supplied by a suitable pulse generator or by an alternating current of suitable frequency, such as supplied by a suitable alternating current source. Alternatively, the rod 13 may be actuated by a cam or the like driven by a motor or by any other suitable means providing a reciprocating drive of suitable frequency. Furthermore, the periodic compression of the medium within the space 22, such as air or liquid, may be effected by any other suitable means, such as a rotary pump adapted to periodically increase and decrease the inclosed volume thereof, in the manner readily understood.

The main or squeeze pump consists, in the example shown, of an elongated tubular housing 40 and a pair of closure members 41 and 42 in the form of resilient plugs or stoppers of rubber or equivalent material hermetically closing the opposite ends of the tube. A flexible or resilient thin-walled tube 43, preferably of rubber, traverses the tube or housing 40, passing through or being mounted in an opening or hole 41' in the closure plug 41, on the one hand, and in an opening or hole 42' in the closure plug 42, on the other hand. The lower end of tube 43 is urged into a hermetic seal with the plug 41 by a rigid tubular retainer 45. The latter is, in turn, provided at its outer end with a closure member or stopper 46 which may consist of rubber or the like and is provided with a hole 47 adapted to accommodate an inlet tube or conduit 48. The inner open end of the stopper cooperates with a valve ball 50, to provide an inlet or suction check valve for the pump. The upper end of the member 45 is bent inwardly as at 51, to retain the ball 50 when not in the checking or closing position shown in the drawing.

The upper end of the flexible or squeeze tube 43 extends through the hole or opening 42' in the closure plug 42 and is held in hermetic engagement therewith by a rigid tube or retainer 52. The latter is similar in its construction to the retainer 45 and is in turn provided with a closure member or stopper 54 having a central hole to accommodate a connecting tube or outlet conduit 56. There is further provided a rubber ring 58 hermetically mounted in the

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lower part of the tube 52 and having a central hole or opening 60 to serve as a seat for the valve ball 61, to act as the delivery or output valve of the pump.

The closure member 42 is provided with a further hole 62 having mounted therein in hermetic engagement the opposite end of tube 26, to connect the inside or space 65 of the tube 40 with the chamber 22 of the pilot pump or equivalent periodic pressure generator.

In operation, the ball 50 and closure plug 46, providing an inlet or suction valve, and the ball 61 and seal ring 58, providing an outlet or delivery valve, cooperate with the flexible or squeeze tube 43, the latter being alternately expanded and contracted by the control device, in such a manner as to effect pumping of a fluid to be transported from the inlet 48 to the outlet 56, as indicated by the arrows in the drawing.

From the foregoing it will be apparent that any fluid being conveyed, i. e. either gas or liquid, through the inlet 48, retainer 45, squeeze tube 43, retainer 52 and the outlet 56, will not come in contact with the outside atmosphere or any exterior contaminating material.

More specifically, in operation, as the solenoid 10 or other control device is actuated to pull the rod 13 in a downward direction, the diaphragm 21 will be deformed downwardly, as shown at 21', thereby creating a partial vacuum in the space 22 as well as within the space 65 of the main pump tube 43. The partial vacuum thus created within the space 65, in turn, causes the tube 43 to expand and thus to exert a downward force on the delivery valve ball 61, thereby closing the opening in the rubber ring 58. Furthermore, the partial vacuum created within the tube 43 by its extension into the space 65 will pull or force the fluid material to be pumped or conveyed into the inlet tube 48 by unseating the suction valve ball 50 and allowing the fluid material to enter the tube 43.

When the current to the solenoid is disconnected or the actuating rod 13 operated in the opposite direction, the diaphragm 21 will be urged upwardly by the spring 33 to or beyond its normal position, thus creating a pressure within the space 22 as well as within the space 65. The pressure in the space 65 contracts the tube 43, thus urging the fluid material through the hole 60 and the ring 58 by unseating the ball 61. At the same time, the increased pressure within the tube 43 acts to reseat the ball 50 on the opening in the plug 46, thus stopping any backward flow of the fluid. During the next operating cycle of the solenoid or other control means, the same suction and delivery cycle will be repeated.

In other words, excess and underpressure is applied alternately to the space 65, expanding and contracting thereby the tube 43 and opening and closing the suction and delivery valves, respectively. As a result, fluid material may be pumped from a reservoir connected to the inlet 48 or the pressure of an existing fluid stream may be boosted by connecting the inlets or outlets 48 and 56 in an existing pipe or transmission line.

It will be evident that the diaphragm pump or pressure generator may be activated by a double acting solenoid or by a crank and motor arrangement, in such a way that the diaphragm 21 can be deformed in both upward and downward directions. Thus, the pressure exerted on the space 65 can be increased over that supplied by the spring 33, or the spring 33 can be provided on the top surface of the diaphragm 21 so that the spring will control the vacuum or underpressure during an operating cycle and the solenoid will supply the pressure during the succeeding cycle. Thus, by proper choice of the operating mechanism, the squeeze pump can be made to work in any ambient pressure or atmosphere and can also act as a booster pump or velocity increasing pump, in a manner readily understood.

From the operation of the squeeze pump, as described by creating a partial vacuum and pressure, respectively, it will be obvious to those skilled in the art that the spaces

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22 and 65 may be filled with a liquid transmission medium in place of a gas such as air. In this case, the pump will operate hydraulically instead of pneumatically and extreme pressures and velocities may be imparted to the fluid stream being pumped through the tube 43.

It will further be apparent to those skilled in the art that, in place of the particular valve structure shown, any other type of valve may be substituted to act as suction and delivery valves for the fluid being conveyed. It will further be evident that any equivalent operating device, such as a piston pump, rotary pump, or the like, may be substituted for the diaphragm pump shown for illustration, to apply periodic pressure pulses to the transmission medium in the pump chamber 65. Thus a device similar to a rotary pump arranged to periodically increase and decrease the total space may be advantageously employed for the purpose of the invention.

The squeeze pump, as described, can also be used as a flow control device, in that the cross-section of the tube 43 can be reduced by contraction by the normal or steady pressure in the space 65, especially when using compressible fluid, such as air, as a control medium. In other words, the normal fluid pressure within the space 22, the connecting tube 26 and space 65 may be preadjusted to provide a substantially constant or steady pressure or bias upon the tube 43, upon which steady pressure are superimposed the alternating pressure pulses produced by the diaphragm 21 or an equivalent pressure generator.

The squeeze pump as described, among many other uses, is particularly suitable for use in connection with an artificial heart as used in heart operations. As previously stated, all seals internal to the tube 43 are hermetic seals and, consequently, no contamination by outside agents may occur during the operation of the pump. Furthermore, sterilization of the pump is readily effected by pumping therethrough, prior to its use, a hot saline or equivalent sterilizing solution.

Referring to Figures 2 and 3, there is shown a composite or multiple pump assembly constructed in accordance with the principles of the invention and comprising a casing 70 of circular, oval or any other suitable cross-section and serving to house a plurality of main pump devices all operated or controlled by a single primary pump or variable pressure device.

The housing 70 is provided, for this purpose, with a lateral flanged and preferably oval-shaped extension 71 to which is secured in hermetic engagement a rubber diaphragm 72 by means of a retaining ring 73 and clamping screws or bolts 74. The diaphragm 72, in the example shown, has an integral central projection or protuberance 75 in which is mounted, such as by direct molding therein, the T-shaped end of a reciprocating actuating rod by means of a clamping ring 77 and screw 78, or in any other suitable manner. The rod 76 is operated by a suitable actuating device, such as a solenoid, rotary cam, etc. (not shown), to periodically deflect the diaphragm 72 in the inward and outward direction, in a manner readily understood from the above.

The main pump or squeeze tube 80 has its lower end secured to a projecting flange 81 of the casing 70 by reversely bending the end 82 of the tube around the edge of the flange. A cylindrical retainer 83 is placed inside the end of the tube 80 having a flange clamped into liquid tight engagement with the portion 82 of tube 80 by means of a screw cap 84 engaging the outside of the flange 81, a centrally perforated rubber disc 85 having a central opening 86, as well as the flange of an inlet tube or conduit 87, being further interposed between the cap 84 and the flange 81, to effect a hermetic seal or connection of the elements with the housing 70. A valve ball 88 which may be of metal on account of the resilient washer 85 arranged within the retainer 83 cooperates with the opening 86 in the disc or washer 85 to serve as an inlet or suction valve, in a manner similar as described in connection with Figure 1.

The other end of the squeeze tube 80 is mounted, in the example shown, in a separate adjusting sleeve 90 and has its end 91 bent over the outer edge of said sleeve and hermetically connected thereto by means of screw cap 92 engaging a threaded annular flange of the sleeve. There are again interposed between the sleeve 90 and cap 92 the flanged end of a cylindrical retainer 93 inserted in the end of the tube 80, a rubber washer 94 and the inner flange of an outlet tube or conduit 95, all being clamped into rigid and liquid-tight engagement with each other and the sleeve 90, in the manner shown and readily understood. Mounted near the inner end of the retainer 93 is a perforated rubber disc 96 cooperating with a valve ball 97, to provide a delivery valve, in a manner readily understood from the foregoing.

The sleeve 90 is provided with an outer threaded portion engaging a threaded opening in the reinforced wall portion 100 of the casing 70, whereby to enable a variable adjustment of the sleeve so as to cause its lower end to engage or overlap varying portions of the squeeze tube 80. As a result, the effective expansible or operative length of the tube 80 may be controlled in an effort to vary the capacity of the pump or pressure produced. After the sleeve 90 has been adjusted to a desired position, it is locked into hermetic engagement with the casing 70, by means of a tightening or clamping nut 101 against a pair of superposed rigid and resilient washers 102 and 103, respectively. In order to protect the squeeze tube 80, there is provided a further cylindrical perforate sleeve 104 concentric to and arranged at a suitable distance from the tube 80, said sleeve being adjustably mounted upon the sleeve 90 by means of a set screw 105 or in any other suitable manner.

There is further shown in Figure 2 a valve 106 connected to a suitable outlet of the housing 70 to serve as a means for introducing a suitable transmission medium, such as air or gas, at a desired pressure, to enable a further control of the pumping action, in the manner pointed out above. In the latter case, the fluid medium within the housing 70 is adjusted to exert a steady or normal pressure upon the tube 80, upon which steady pressure are superimposed alternating pressure pulses produced by the diaphragm 72. In this manner the operation of the device can be controlled and adjusted to closely exacting specifications and to suit various different requirements and operating conditions.

While a single pumping device or squeeze tube 80 may be mounted in the casing 70, in the manner shown, a plurality of juxtaposed pumps can be provided all mounted within the casing 70 and controlled and operated by the same primary pump or diaphragm 72. Thus, referring to Figure 3, there are indicated three pumping devices associated with or mounted in the casing 70 and having inlet tubes or conduits 86, 86a, 86b, outlet conduits 95, 95a, 95b and each being constructed in the manner shown in Figure 2. Such a device may advantageously be used for simultaneously transporting several different substances at a desired ratio by correspondingly adjusting each of the pumps of the device for mixing or any other purpose, in a manner readily understood.

In the foregoing, the invention has been described with reference to a specific illustrative device. It will be evident, however, that numerous variations and modifications as well as the substitution of equivalent elements for those shown and disclosed herein for illustration, may be made without departing from the broader scope and spirit of the invention defined in the appended claims. The speci-

fication and drawings are accordingly to be regarded in an illustrative rather than in a limiting sense.

What I claim is:

1. A pumping device comprising a casing providing a closed chamber filled with a fluid medium, an expansible and contractible tubular member disposed within said chamber and having inlet and outlet means fluid-tightly mounted in said casing, suction and delivery valve means operatively associated with said member, means to apply periodic pressure pulses to said medium to contract and expand said member and to pump a fluid therethrough, and means for adjusting the effective expansible portion of said member.

2. A pumping device comprising a casing providing a single closed chamber filled with gaseous medium at a predetermined pressure, a plurality of rubber tubes disposed within said chamber each having inlet and outlet means hermetically mounted in said casing, suction and delivery valve means operatively associated with each of said tubes, means to periodically increase and decrease said pressure to simultaneously contract and expand said tubes, to pump a plurality of fluids therethrough, and adjustable sleeve means closely surrounding said tubes for adjusting the effective expansible and contractible portions thereof.

3. A pumping device comprising a casing providing a single closed chamber filled with a fluid medium, a plurality of flexible pumping tubes passing through and hermetically mounted in said casing, suction and delivery valve means operatively associated with each of said tubes, a flexible diaphragm hermetically connected to and forming part of said casing, and reciprocating drive-means to deflect said diaphragm and to apply periodic pressure pulses to said medium.

4. A pumping device comprising a housing containing a fluid medium, a flexible pumping tube passing through and hermetically mounted in said housing, suction and delivery valve means operatively associated with said tube, means to apply periodic pressure pulses to said medium, to alternately contract and expand said tube, and an adjustable sleeve closely surrounding said tube for varying the effective expansible and contractible portion thereof.

5. A pumping device comprising a housing to provide a single closed chamber containing a gaseous medium at a predetermined pressure, a plurality of flexible pumping tubes passing through and hermetically mounted in said housing, suction and delivery valve means operatively associated with each of said tubes, a flexible diaphragm hermetically connected to and forming a part of said housing, and reciprocating drive means to deflect said diaphragm and to periodically increase and decrease the pressure of said medium.

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