

July 13, 1965

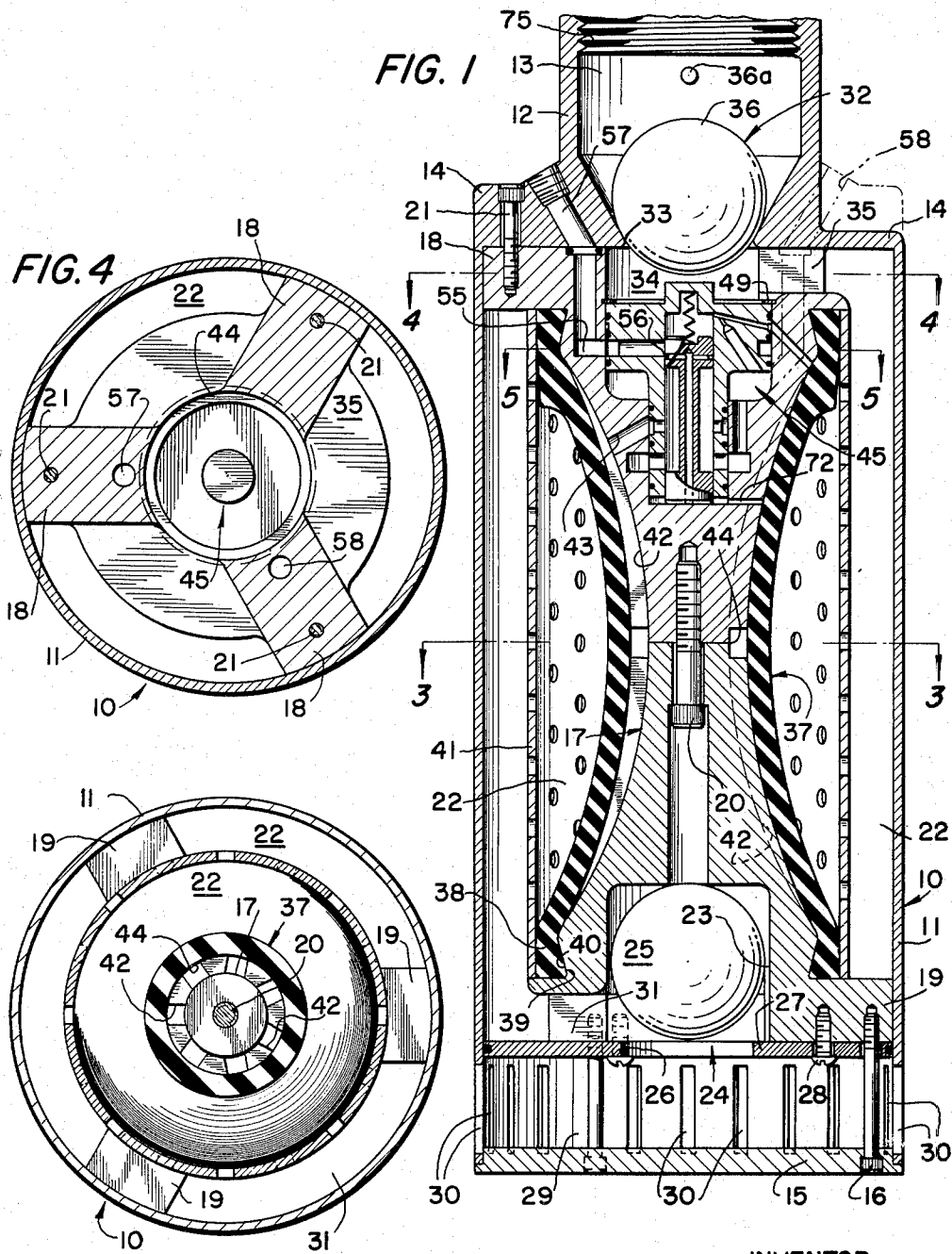
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3,194,170

DIAPHRAGM PUMP

Filed Feb. 25, 1964

6 Sheets-Sheet 1



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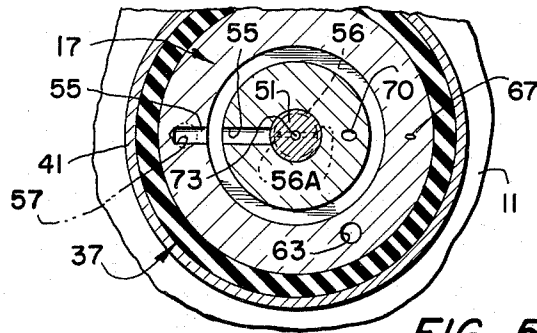


FIG. 5

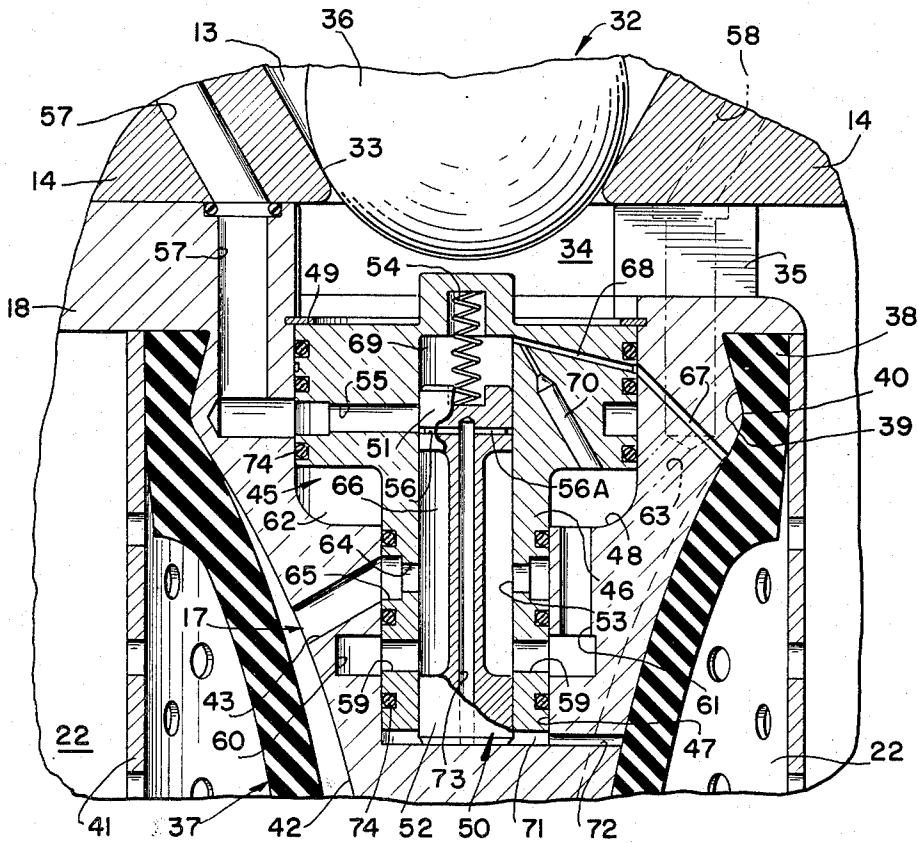


FIG. 2

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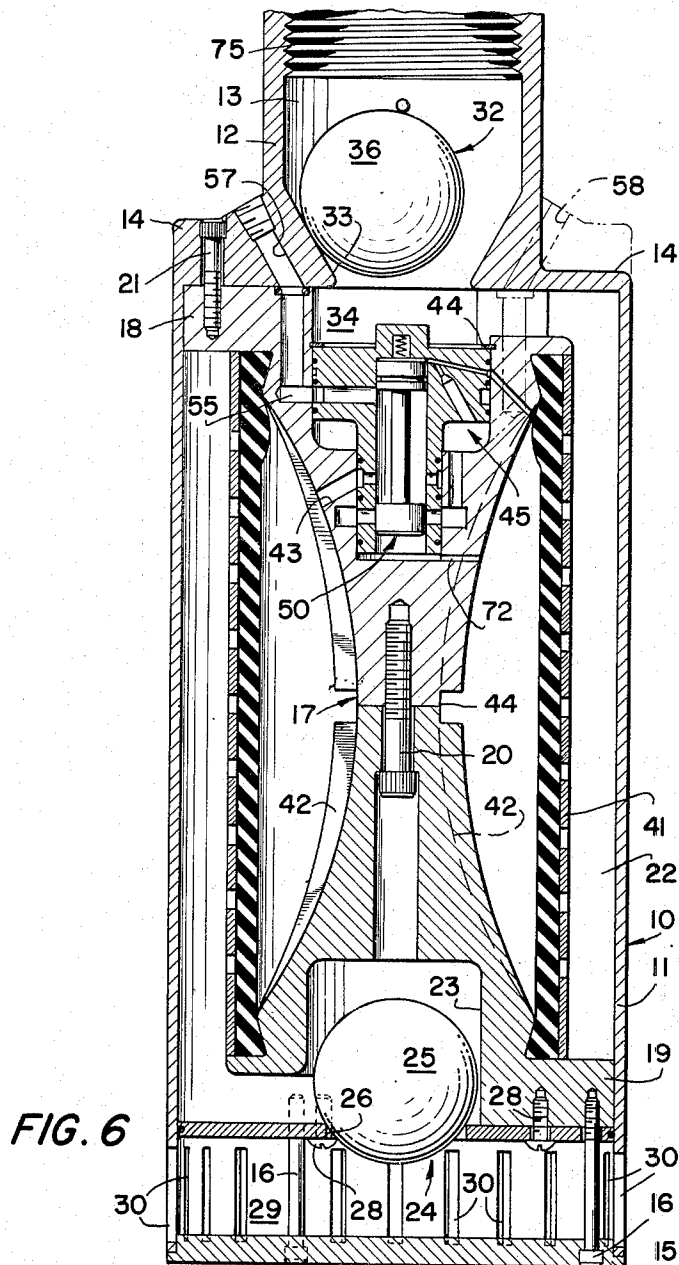


FIG. 6

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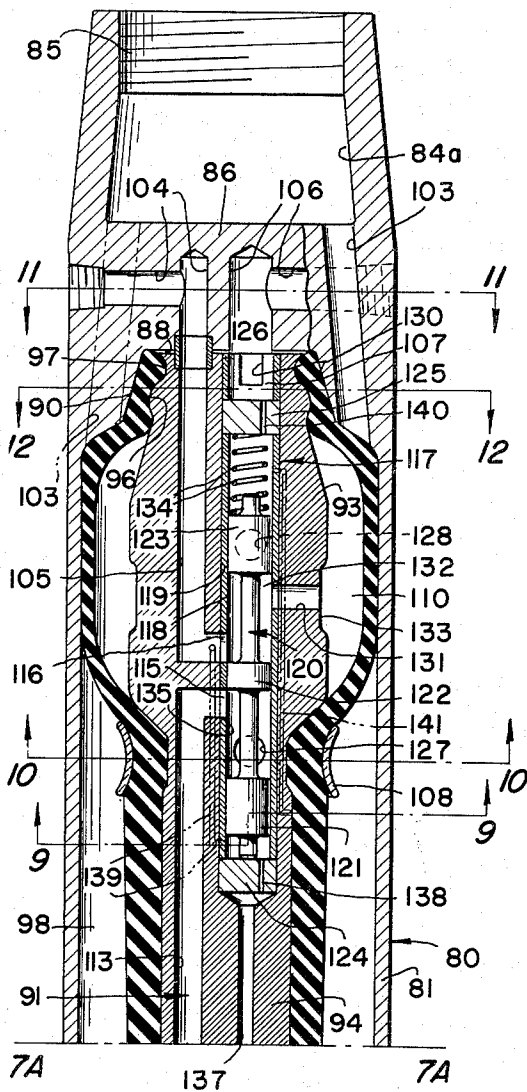


FIG. 7A

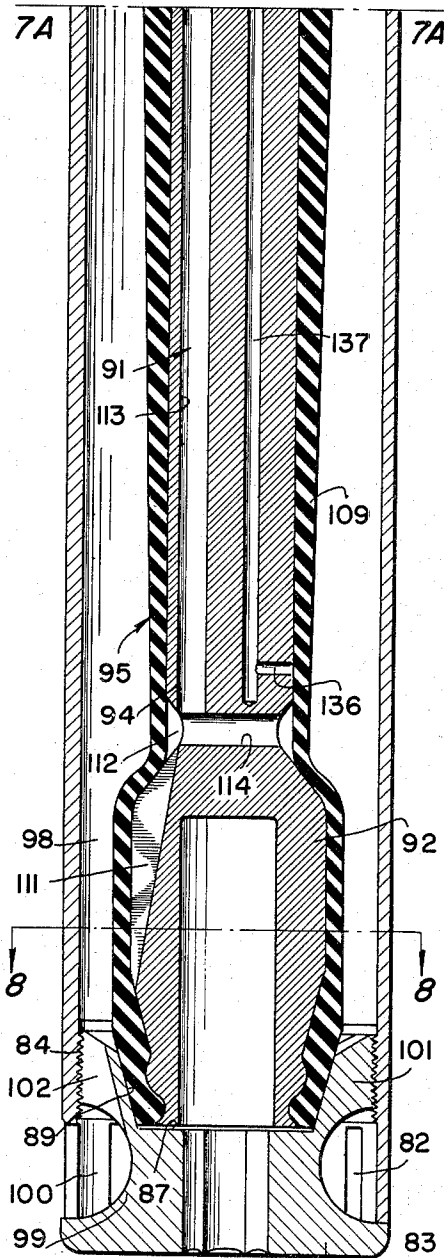


FIG. 7

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6 Sheets-Sheet 5

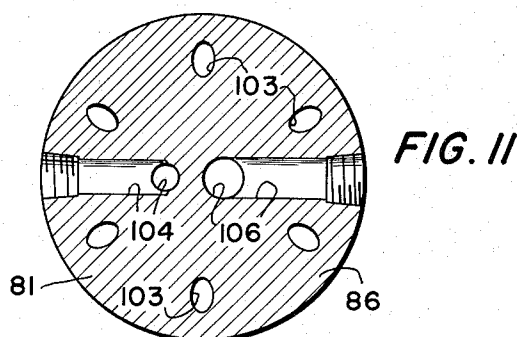


FIG. 11

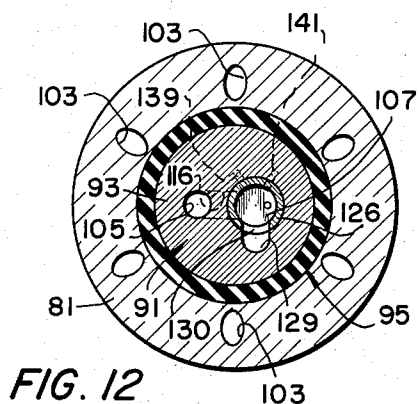


FIG. 12

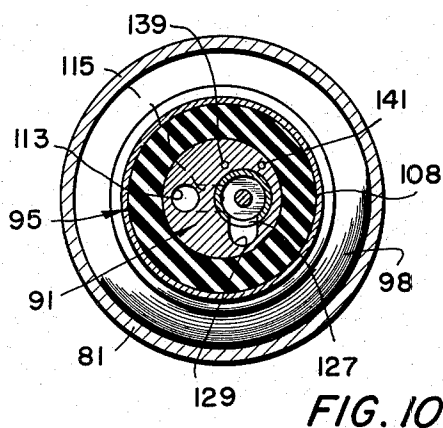


FIG. 10

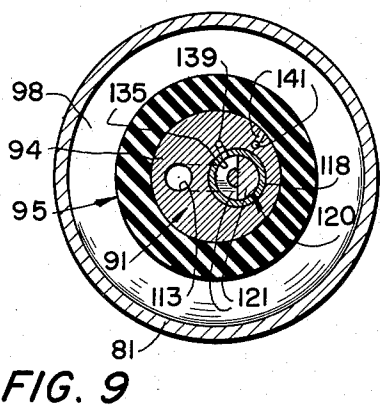


FIG. 9

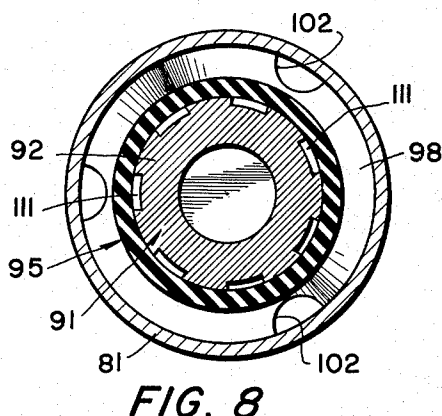


FIG. 8

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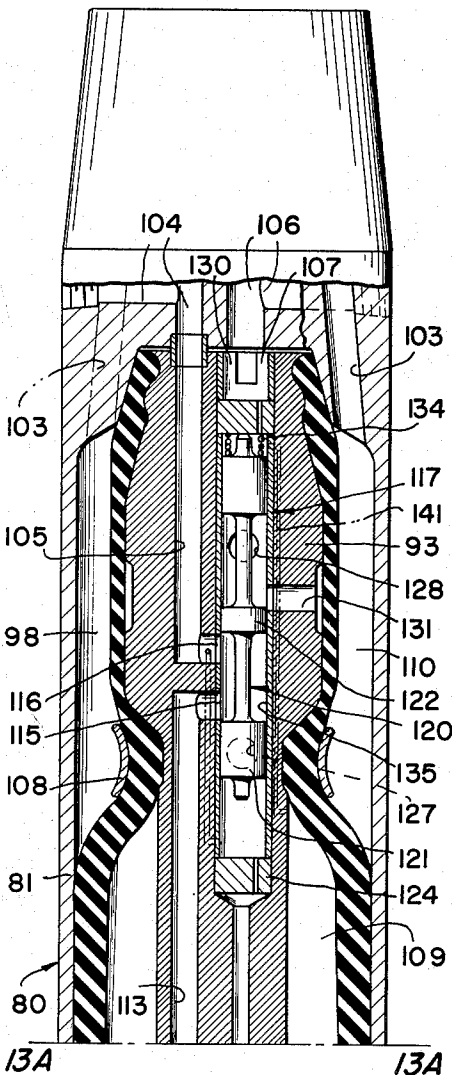


FIG. 13A

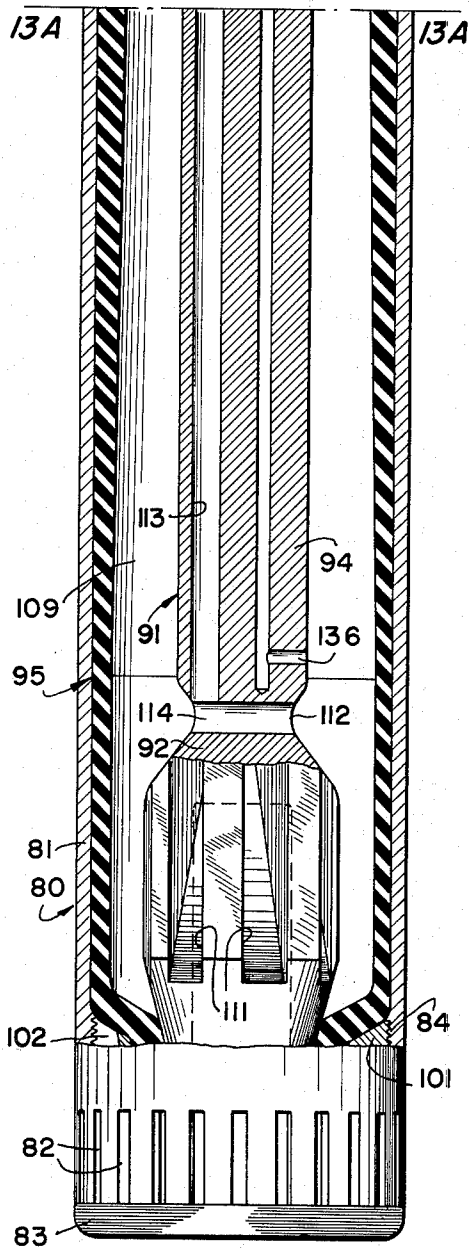


FIG. 13

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DIAPHRAGM PUMP

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Filed Feb. 25, 1964, Ser. No. 347,297

14 Claims. (Cl. 103—152)

This invention relates to diaphragm pumps and more particularly to a pumping apparatus of the type in which a diaphragm is alternately expanded and contracted under the urging of a pulsating flow of pressure fluid to pump another fluid.

An object of the present invention is to provide a diaphragm pump of the character described wherein pressure fluid, hereinafter referred to as the actuating fluid, such as compressed air, is positively controlled.

Another object of this invention is to provide a diaphragm pump which is capable of efficient operation when the fluid to be pumped has entrained solids therein.

A further object of this invention is to provide a diaphragm pump of compact construction and of relatively light weight so that it can be suspended from the pumped fluid discharge conduit and can be used in very confined areas.

A still further object of the present invention is to provide a diaphragm pump wherein the stresses in the diaphragm are minimal so that the diaphragm has a relatively long operative life.

An additional object of the invention is to provide a diaphragm pump which is submersible in the fluid to be pumped to thereby eliminate the need for priming the pump.

Accordingly, the present invention contemplates a novel diaphragm pump comprising a cylindrical housing having at one end an inlet port for the fluid to be pumped and a fluid outlet port at the opposite end for discharging the pumped fluid. A diaphragm supporting core is disposed coaxially in the housing to define with the inner surfaces of the housing an annular pumping working chamber. A tubular diaphragm is superimposed on the supporting core and attached at spaced points to the latter. The diaphragm is constructed of an elastomeric material which is capable of expanding and contracting within the working chamber to effect the pumping of the fluid introduced therein through the housing inlet port. Inlet passage means is provided in the housing and the supporting core for conducting the actuating fluid (pressurized fluid such as compressed air) from a source thereof into the interior of the tubular diaphragm to cause the latter to expand within the working chamber. The outlet passage means in the housing and the supporting core for conducting the actuating fluid from the interior of the diaphragm is provided to pass the spent actuating fluid from the pump and thereby permit the contraction of the diaphragm. A fluid-actuated control valve is disposed within the supporting core for controlling the flow of actuating fluid through the inlet and the outlet passage means to provide alternate expansion and contraction of the diaphragm. Actuation of the control valve in proper timed sequence to the expansion and contraction of the diaphragm is achieved by the restricted passages extending from the interior of the tubular diaphragm to the valve and through which the flow of actuating fluid is controlled by the diaphragm. A pressure-responsive valve means is disposed at the inlet port and the outlet port of the housing so that upon the expansion of the diaphragm the inlet port closes and the outlet port opens and upon the contraction or the collapse of the diaphragm the inlet port opens and the outlet port closes.

A feature of one embodiment of this invention is a

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tubular screen disposed in the working chamber in coaxial relation to the diaphragm to prevent solid material, such as pebbles, wood particles, and/or the like, entrained in the fluid to be pumped from contacting the diaphragm.

A feature of another embodiment of the present invention is the cooperative relationship of the diaphragm with the inlet port and the outlet port in the pump housing to control the flow of the fluid to be pumped into and out of the working chamber whereby the need for check valves at the inlet port and the outlet port is obviated.

The invention will be more fully understood from the following detailed description thereof when considered in connection with the accompanying drawings wherein two embodiments of the invention are illustrated by way of example and in which:

FIG. 1 is a longitudinal sectional view of a diaphragm pump according to one embodiment of this invention;

FIG. 2 is a fragmentary view, on an enlarged scale, showing the control valve of the embodiment shown in FIG. 1;

FIG. 3 is a transverse cross-sectional view taken along line 3—3 of FIG. 1;

FIG. 4 is a cross-sectional view taken along line 4—4 of FIG. 1;

FIG. 5 is a cross-sectional view taken along line 5—5 of FIG. 1;

FIG. 6 is a view, similar to FIG. 1, showing another operative position of the pump;

FIG. 7 is a longitudinal cross-sectional view of part of a diaphragm pump according to another embodiment of this invention;

FIG. 7A is a longitudinal cross-sectional view of another part of the diaphragm pump of FIG. 7, the view being joined to FIG. 7 along line 7A—7A of FIGS. 7 and 7A;

FIG. 8 is a transverse sectional view taken along line 8—8 of FIG. 7;

FIG. 9 is a transverse sectional view taken along line 9—9 of FIG. 7A;

FIG. 10 is a view in cross section taken along line 10—10 of FIG. 7A;

FIG. 11 is a cross-sectional view taken along line 11—11 of FIG. 7A;

FIG. 12 is a view in cross section taken along line 12—12 of FIG. 7A;

FIG. 13 is a view, similar to FIG. 7, showing another operative position of that part of the pump shown in FIG. 7; and

FIG. 13A is a view, similar to FIG. 7A, showing another operative position of that part of the pump shown in FIG. 7A, the view being joined to FIG. 13 along line 13A—13A of FIGS. 13 and 13A.

Now referring to the drawing and more particularly to FIGS. 1 to 6, 10 generally designates a diaphragm pump according to one embodiment of this invention. Diaphragm pump 10 comprises a cylindrical housing or casing 11 which has a reduced diameter portion 12 at one end to define a discharge or outlet passageway 13 and an end wall 14. A base plate 15 is secured to the opposite end of casing 11 by means of a plurality of screws 16 (only two of which are shown in FIG. 1).

A diaphragm supporting core 17 is disposed coaxially within casing 11. Supporting core 17 has a "wasp"-shaped body portion and webbed end flanges 18 and 19. For ease of manufacture and assembly, supporting core 17 may be constructed, as shown, of two parts secured together by a screw 20. Supporting core 17 is secured in casing 11 by a plurality of circumferentially spaced screws 21 (only one of which is shown in FIG. 1) extending through end wall 14 of casing 11 and into threaded bores

in webbed end flange 18 of supporting core 17. The opposite end of supporting core 17 is secured in casing 11 by screws 16 which extend through base plate 15 and are turned into the threaded bores in webbed end flange 19 of the supporting core. The diaphragm supporting core 17 defines with the interior surface of casing 11 an annular pumping or working chamber 22.

Adjacent webbed flange 19, supporting core 17 is provided with an axial recess 23 which serves to house a ball check valve 24. The ball 25 of check valve 24 is adapted to seat within an inlet opening or port 26 formed in valve plate 27 which fits within casing 11 and in abutment against webbed flange 19 of supporting core 17. Valve plate 27 is secured to webbed flange 19 by a plurality of screws 28 (only two of which are shown in FIG. 1). Opening 26 communicates with an inlet chamber 29 formed in casing 11 by valve plate 27 and base plate 15. Inlet chamber 29 communicates with the exterior of casing 11 through a plurality of strainer slots 30 disposed in casing 11. Opening 26 also communicates, when ball 25 is unseated, with working chamber 22, via recess 23 and the flow passages 31 formed between the webs of webbed flange 19.

An outlet check valve 32 is housed within reduced diameter portion 12 of casing end wall 14. An axial recess 34 is provided in supporting core 17 adjacent webbed flange 18 and in registry with outlet port 33. Recess 34 serves to communicate outlet port 33 with the flow passages 35 formed by the adjacent webs of webbed flange 18 so that the fluid can pass from working chamber 22, through port 33, into outlet passageway 13 when the ball 36 of check valve 32 is unseated from within outlet port 33. A diametrically extending pin 36a is provided in reduced diameter portion 12 to limit the movement of ball 36.

Superimposed over the "wasp"-shaped portion of supporting core 17 is a resilient boot or tubular diaphragm 37. The diaphragm is composed of elastomeric material, such as rubber, resilient plastic, or the like, which, when relaxed or in the contracted position, hugs the outer peripheral surface of supporting core 17. Each of the end portions 38 of the diaphragm is shaped to provide a tapered, annular inner surface 39 which is complementary to and abuts an annular surface 40 on supporting core 17. This interlocking, complementary surface engagement between diaphragm 37 and supporting core 17 serves to anchor end portions 38 to supporting core 17.

Pump 10 may also be provided with a tubular screen 41, such as a perforated cylinder, a wire-mesh screening, or the like, coaxial with the supporting core and engaging end portions 38 of the diaphragm. The tubular screen functions to prevent relatively large solid matter, which enters working chamber 22 and is entrained in the fluid to be pumped, from directly contacting the diaphragm, thus minimizing the wear and/or the damage to diaphragm 37. Tubular screen 41 also secures end portions 28 of diaphragm 37 to supporting core 17. If screen 41 is not employed, retaining rings (not shown) would have to be employed for retaining the ends of the diaphragm to supporting core 17.

To provide for the conductance of actuating fluid (pressurized fluid), such as compressed air, to the interior of the diaphragm and the interior surface thereof, the outer surface of supporting core 17 is provided with a plurality of circumferentially spaced, longitudinally extending flutes or grooves 42 (see FIG. 3). One of the grooves 42 communicates with a passage 43 in the supporting core to alternately receive the actuating fluid from and to pass the actuating fluid to a distribution-groove 44. Grooves 42 all communicate with annular distribution-groove 44 in the surface of supporting core 17 so that each of the grooves 42 receives the actuating fluid.

To conduct and control the flow of actuating fluid to and from the interior of diaphragm 37, a fluid-responsive control valve 45 is housed within supporting core 17.

As best shown in FIG. 2, control valve 45 comprises a T-shaped valve housing 46 which is disposed in an axial bore 47 and a counterbore 48. Valve housing 46 is secured in place by a retaining ring 49. A spool type valve 5 having two spaced lands 51 and 52 is disposed for slidable movement within an axial recess 53 formed in valve housing 46. Spool valve 50 is held in a downward position, as viewed in FIGS. 1 and 2, by a spring 54. Land 51 of spool valve 50 controls the flow through an inlet port 55, which port communicates with a supply passageway 57. Supply and discharge passageways 57 and 58 extend through wall 14 and webbed flange 18. Supply passageway 57 is suitably connected through a conduit (not shown) to a source of actuating fluid, such as an air compressor (not shown), while discharge passageway 58 communicates with the atmosphere. Land 52 of spool valve 50 is adapted to control the flow of fluid into exhaust ports 59. Exhaust ports 59 communicate with an annular groove 60 in supporting core 17 which, in turn, communicates with an exhaust passage 61 in supporting core 17. The exhaust passage communicates with a chamber 62 formed between counterbore 48 and valve housing 46. Chamber 62 is in communication with discharge passageway 58 via a passage 63. The valve housing is also provided with ports 64 and an annulus 65 to communicate the chamber 66, formed in recess 53 between lands 51 and 52 of the spool valve, with passage 43.

To provide for proper-timed actuation of spool valve 50 within recess 53, a passage 67 is formed in the supporting core to extend from the outer surface of the supporting core adjacent end portion 38 of diaphragm 37 to an annulus in the surface of valve housing 46, the annulus being in communication with a passage 68 extending in the valve housing from the annulus to a chamber 69 defined in recess 53 by the bottom of the recess and land 51 of the spool valve. Chamber 69 is also in communication with chamber 62 through a restricted passage 70 extending from chamber 62 to passage 68. A chamber 71 defined by land 52 of spool valve 50 and the bottom of bore 47 is in communication with the interior of diaphragm 37 by way of a passage 72. Land 52 of spool valve 50 is provided with an annular groove 56 in the peripheral surface thereof and two holes 56A (see FIG. 5) which extend radially from annular groove 56 inwardly to a blind axial bore 73 in spool valve 50. With diaphragm 37 expanded so that passage 72 is open and with spool valve 50 in the position shown in FIGS. 1 and 2, the actuating fluid will flow from inlet port 55, through annular groove 56, holes 56A, and axial bore 73, to chamber 71, and thence through passage 72 to the interior of the diaphragm and the atmosphere. When diaphragm 37 collapses sufficiently to close passage 72, the actuating fluid flowing through the spool valve, from inlet port 55 into chamber 71, builds up in chamber 71 until the pressure exerted on land 51 is sufficient to overcome the force of spring 54 and spool valve 50 is moved to the position shown in FIG. 6.

Suitable seals 74 are disposed in valve housing 46 to seal the interstices between the valve housing and bore 47 and counterbore 48 to prevent the fluid from by-passing the various ports in the valve housing.

In the position of the control valve 45 as shown in FIG. 2, land 51 closes inlet port 55, thereby preventing the flow of actuating fluid into chamber 66, ports 64, annulus 65, passage 43, grooves 42, and the interior of diaphragm 37. With the cessation of the flow of the actuating fluid into the interior of diaphragm 37, the actuating fluid is forced from the interior of the diaphragm through passage 43, annulus 65, ports 64, chamber 66, exhaust ports 59, annular groove 60, exhaust passage 61, and thence into chamber 62. From chamber 62 the actuating fluid flows through passage 63 and discharge passageway 58 to the atmosphere. With the diaphragm in the fully expanded position as shown in FIG. 6, the pressure forces acting on

spool valve 50 are balanced by the flow of the actuating fluid into chamber 69 via passages 68 and 67 and into chamber 71 through passage 72. With the pressure forces acting on spool valve 50 balanced, spring 54 moves the spool valve to the position as shown in FIGS. 1 and 2. As the actuating fluid exhausts from the interior of diaphragm 37, as was previously described, and the diaphragm contracts, the diaphragm first closes passage 67 so that the pressure acting on the spool valve remains balanced since passage 72 is still open. When diaphragm 37 collapses sufficiently to close passage 72, the unbalanced pressure acting on spool valve 50, by reason of the build-up of the actuating fluid pressure in chamber 71, forces the spool valve to move upwardly, as viewed in FIGS. 1 and 2, toward the position shown in FIG. 6. The fluid in chamber 69 is relieved through passages 68 and 70 to exhaust chamber 62 (see FIG. 2).

With the spool valve in the position shown in FIG. 6, the actuating fluid flows from inlet port 55 into chamber 66 and thence into ports 64 and annulus 65. From annulus 65 the fluid flows into passage 43, groove 42, and into distribution-groove 44. From groove 44 the fluid flows into all the grooves 42 and thereby forces the diaphragm to expand outwardly away from supporting core 17. When the diaphragm is expanded sufficiently to uncover passage 67, passage 67 permits the fluid to flow into chamber 69 and thereby balance the pressures acting on spool valve 50. With the pressures acting on spool valve 50 balanced, spring 54 forces the spool valve to slide to the position shown in FIGS. 1 and 2. With the spool valve in the position shown in FIGS. 1 and 2, the actuating fluid supply is cut off to the interior of the diaphragm and the latter is brought into communication with the atmosphere so that the diaphragm collapses, as hereinbefore described.

In the operation of diaphragm pump 10, the fluid to be pumped is sucked into working chamber 22, as diaphragm 37 is collapsing, through strainer slots 30, chamber 29, inlet port 26, and passages 31. After this, check valve 32 moves to a closed position. With spool valve 50 of control valve 45 in the position shown in FIG. 6, the actuating fluid, such as compressed air or the like, is conducted, as heretofore described, into the interior of diaphragm 37 to cause the expansion of the latter in working chamber 22. The expansion of the diaphragm forces the fluid in the working chamber from the working chamber via passages 35, recess 34, outlet port 33, and discharge passageway 13. Ball 36 of check valve 32 is unseated by the fluid being forced from the working chamber, while ball 25 of check valve 24 is seated by the fluid being pumped. As heretofore described, spool valve 50 is moved from the position shown in FIG. 6 to the position shown in FIGS. 1 and 2 when the diaphragm has been fully expanded so as to expose passage 67. When the diaphragm contracts, outlet check valve 32 closes and inlet ball check valve 24 opens to admit additional fluid to be pumped into working chamber 22. Thereafter the above-described cycle of operation is repeated.

The reduced diameter portion 12 of casing 11 is internally threaded at 75 to receive a threaded coupling (not shown) by which a discharge conduit (not shown) is attached to diaphragm pump 10. The pump, by virtue of its compact lightweight construction, can be suspended from the discharge conduit.

The "hourglass" configuration of diaphragm 37 prevents undue strains on the diaphragm at end portions 38 thereof where the diaphragm is anchored to supporting core 17 because radial expansion of the diaphragm is accompanied by axial contraction of the diaphragm, thereby minimizing the stresses in the diaphragm.

Alternative Embodiment

In FIGS. 7 to 13A is illustrated another embodiment of the present invention. The diaphragm pump 80 comprises an elongated, cylindrical housing or casing 81. The inlet end of the casing is provided with a plurality

of circumferentially spaced, longitudinally extending slots 82 which define with a closure member 83 threadably secured at 84 to casing 81 a plurality of inlet ports. The opposite or outlet end of casing 81 is provided with an axial recess 84a which is internally threaded at 85 to receive a coupling member (not shown) of a discharge conduit (not shown). Closure member 83 and casing end wall 86 are provided with coaxially disposed recesses 87 and 88, respectively, which recesses have tapered side walls 89 and 90, respectively. The recesses 87 and 88 serve to support the opposite ends of a diaphragm supporting core 91 coaxially within casing 81.

Supporting core 91 has a somewhat "dumbbell" configuration with two enlarged diameter end portions 92 and 93 connected together by a reduced diameter portion 94 formed integral with the end portions. A tubular diaphragm 95 having an internal surface configuration mating with the outer surface configuration of supporting core 91 is superimposed on supporting core 91. Each of the end portions of the supporting core is provided with an annular projection 96 and an adjacent annular depression 97, while each of the end portions of diaphragm 95 has internal surfaces complementary to projection 96 and depression 97. The external surfaces of the end portions of the diaphragm are tapered so that, when closure member 83 is turned into casing 81, the end portions of the diaphragm are securely clamped between tapered side walls 89 and 90 and the end portions of supporting core 91. The supporting core is also thereby supported within casing 81 to define with the casing a pumping or working chamber 98.

To provide for the flow of the fluid to be pumped into working chamber 98, closure member 83 has a reduced diameter portion 99 which defines with the slotted end portion of casing 81 an inlet chamber 100. Closure member 83 is also provided with a plurality of spaced radial webs 101 which define therebetween inlet ports 102 which communicate inlet chamber 100 with working chamber 98.

To provide for the flow of pumped fluid from working chamber 98, end wall 86 of the casing is provided with a plurality of circumferentially spaced outlet ports 103. End wall 86 is also provided with an actuating fluid supply passage 104 which communicates through a supply conduit (not shown) with a source (not shown) of actuating fluid, such as an air compressor or the like, and a longitudinally extending inlet passage 105 in supporting core 91. An actuating fluid exhaust passage 106 is provided in end wall 86 to communicate an exhaust chamber 107 in supporting core 91 with the atmosphere.

A clamping ring 108 surrounds diaphragm 95 adjacent enlarged diameter end portion 93 of the supporting core so that the diaphragm is divided into a pumping section 109 and a valving section 110. The pumping section 109 of diaphragm 95 has a wall thickness which progressively diminishes from clamping ring 108 to the inlet end portion thereof. This construction of diaphragm 95 provides for the peristaltic expansion of pumping section 109 from inlet ports 102 toward outlet ports 103.

To provide for the introduction of actuating fluid into the interior of the diaphragm to cause the expansion of the latter, the peripheral surface of the enlarged end portion 92 of supporting core 91 is provided with a plurality of longitudinal flutes or grooves 111, each of which communicates with an annular depression 112 formed at the junction of enlarged end portion 92 and reduced diameter portion 94 of supporting core 91. A longitudinally extending passageway 113 is provided in supporting core 91 to communicate at one end with depression 112 and an equalizing passage 114 and at the opposite end with inlet passage 105 via ports 115 and 116 in a control valve assembly 117.

Control valve assembly 117 comprises a sleeve 118 disposed in a bore 119 in supporting core 91. A spool valve 120 having spaced land portions 121, 122, and 123 is disposed for slidable movement within sleeve 118. The

opposite ends of sleeve 118 are closed by plugs 124 and 125 disposed in bore 119. Plug 125 is spaced from end wall 86 by a spacer sleeve 126 to define chamber 107. Land 121 and land 123 control the fluid flow through two exhaust ports 127 and 128 which communicate with an exhaust passage 129 (see FIG. 10). Exhaust passage 129 also communicates with exhaust chamber 107 through an exhaust port 130. Land 122 controls the communication between ports 115 and 116. A fluid passage 131 is provided in supporting core 91 to communicate at one end with a chamber 132 formed between lands 122 and 123 and an annulus 133 formed in the outer peripheral surface of supporting core 91. Spool valve 120 is biased in a downward direction, as viewed in FIG. 7A, by a spring 134 which bears at one end against land 123 and at the other end against plug 125.

In the position of spool valve 120 shown in FIG. 13A, the actuating fluid flows through supply passage 104, inlet passage 105, port 116, and into a chamber 135 defined by lands 121 and 122. From chamber 135 the actuating fluid flows through passageway 113 to annular depression 112 and thence into grooves 111. The fluid introduced into grooves 111 passes into the interior of pumping section 109 thereby causing the latter to expand. Since the wall of the diaphragm adjacent inlet ports 102 is relatively thin and of larger diameter than the other part of pumping section 109, the initial expansion occurs in that area so that inlet ports 102 are closed by the expansion of the diaphragm as is shown in FIGS. 13 and 13A. In a peristaltic manner, pumping section 109 is expanded along its length from inlet ports 102 to clamping ring 103. At this time, since the interior of valving section 110 is in communication with the atmosphere through annulus 133, passage 131, chamber 132, exhaust port 128, passage 129, port 130, exhaust chamber 107, and exhaust passage 106, pumping section 109 is not inflated and, therefore, outlet ports 103 are open. Thus, as pumping section 109 inflates, the fluid in working chamber 98 is forced therefrom through outlet ports 103.

When pumping section 109 is fully expanded, a restricted line 141 is opened to the actuating fluid (see FIG. 13A). Line 141 conducts the actuating fluid to a valve chamber in which spring 134 is disposed. This balances the fluid pressure acting on land 121 of spool valve 120, which fluid is conducted to act against land 121 by way of a port 136, a passage 137, and a hole 138 in plug 124. With the pressures acting against spool valve 120 balanced, spring 134 is capable of sliding spool valve 120 upwardly as viewed in FIG. 13A and to the position shown in FIG. 7A.

When spool valve 120 is in the position shown in FIG. 7A, the interior of pumping section 109 is brought into communication with the atmosphere through depression 112, passage 114, passageway 113, port 115, chamber 135, exhaust port 127, exhaust passage 129 (FIG. 10), exhaust chamber 107, exhaust port 130, and exhaust passage 106 so that pumping section 109 contracts. Simultaneously, exhaust port 128 is closed by land 123, and passage 131 is brought into communication with port 116 through chamber 132 so that the actuating fluid flows into annulus 133 and to the inner surface of valving section 110, thereby causing the latter to expand and seal outlet ports 103 as shown in FIG. 7A. With inlet ports 102 open, the fluid to be pumped enters working chamber 98 through slots 82, chamber 100, and ports 102.

To force the spool valve in an upward direction as viewed in FIG. 13A to the position shown in FIG. 7A against the force of spring 134, the inlet actuating fluid is conducted from port 116 by way of a restricted line 139 to the chamber defined between land 121 and plug 124. The fluid in the chamber where spring 134 is located is vented to exhaust chamber 107 through a restricted line 140 in plug 125.

When the spool valve is in the position shown in FIG. 7

13A, the interior of valving section 110 is brought into communication with the atmosphere through annulus 133, passage 131, chamber 132, exhaust port 128, exhaust passage 129 (see FIG. 12), exhaust port 130, exhaust chamber 107, and exhaust passage 106 so that valving section 110 contracts. Simultaneously, pumping section 109 inflates, as previously described, to force the fluid in working chamber 98 through outlet ports 103.

It is believed now readily apparent that a novel diaphragm pump which is compact and, therefore, useful in confined spaces has been described. It is a pump of lightweight construction so that it may be suspended from the discharge line. It is a pump in which the stresses on the diaphragm are minimal. In one embodiment it is a pump wherein relatively large particles of entrained solids cannot contact and damage the diaphragm. In another embodiment it is a pump wherein check valves have been eliminated and the diaphragm controls the flow through the inlet and the outlet ports of the pump.

Although two embodiments of the invention have been illustrated and described in detail, it is to be expressly understood that the invention is not limited thereto. Various changes can be made in the arrangement of parts without departing from the spirit and scope of the invention as the same will now be understood by those skilled in the art.

I claim:

1. A diaphragm pump comprising

- (a) a housing having an inlet port at one end to receive the fluid to be pumped and an outlet port at the opposite end to discharge the pumped fluid,
- (b) a supporting core disposed within said housing to define a working chamber,
- (c) a tubular flexible diaphragm superimposed over the supporting core and secured at longitudinally spaced points,
- (d) inlet passage means in said supporting core and said housing for communicating a source of actuating fluid with the interior of the tubular diaphragm to effect the expansion of the diaphragm in said working chamber and thereby force the fluid in the latter through said outlet port,
- (e) exhaust passage means in said supporting core and said housing for discharging the actuating fluid from the interior of the diaphragm to permit the latter to contract, and
- (f) fluid-actuated valve control means in said supporting core for providing alternate flow of actuating fluid through said inlet passage means and said exhaust passage means to provide alternate expansion and contraction of said diaphragm.

2. The apparatus of claim 1 wherein said fluid-actuated valve control means includes a spool valve disposed for axial slidable movement in a valve housing.

3. The apparatus of claim 1 wherein the diaphragm coacts with the inlet port and the outlet port upon expansion and contraction of the diaphragm to control the flow of the fluid through the inlet port and the outlet port.

4. The apparatus of claim 1 wherein a screen means is disposed within the working chamber and around the diaphragm and in spaced relationship with the latter to shield the diaphragm from direct contact with relatively large solid particles entrained in the fluid to be pumped.

5. The apparatus of claim 1 wherein said fluid-actuated valve control means includes a spool valve biased in one position by a spring and wherein the pressure passage means controlled by the diaphragm conducts actuating fluid to unbalance the spool valve to another position.

6. The apparatus of claim 1 wherein said supporting core and said diaphragm have an "hourglass" configuration.

7. A diaphragm pump comprising

- (a) a cylindrical casing,
- (b) said cylindrical casing having an inlet port at one end to receive the fluid to be pumped and an outlet port at the opposite end to discharge the pumped fluid,
- (c) a supporting core disposed coaxially within said casing to define with the casing an annular working chamber,
- (d) valve means at said inlet port and said outlet port to control the flow of the fluid to be pumped into and from the working chamber,
- (e) a tubular diaphragm of elastomeric material secured over said core at longitudinally spaced points,
- (f) inlet passage means in said supporting core and said casing for conducting pressurized fluid from a source thereof into the interior of the diaphragm to cause the latter to expand within the working chamber between said spaced points,
- (g) exhaust passage means in said supporting core and said casing for conducting pressurized fluid from the interior of the diaphragm so that the latter will contract into engagement with said supporting core, and
- (h) a fluid-actuated control valve having a spring-biased, slidable spool valve disposed in said supporting core to control the flow of pressurized fluid through said inlet passage means and said exhaust passage means to provide alternate expansion and contraction of said diaphragm within said expansion chamber.

8. The apparatus of claim 7 wherein said valve means are check valves.

9. The apparatus of claim 7 wherein said valve means are portions of the diaphragm which cooperate with the inlet and the outlet ports upon expansion and contraction to seal and unseal said ports.

10. A diaphragm pump comprising

- (a) a cylindrical casing,
- (b) said cylindrical casing having an inlet port at one end to receive the fluid to be pumped and an outlet port at the opposite end to discharge the pumped fluid,
- (c) a supporting core disposed coaxially within said casing to define with the casing an annular working chamber,
- (d) a tubular diaphragm of elastomeric material secured over said core at longitudinally spaced points,

(e) inlet passage means in said supporting core and said casing for conducting pressurized fluid from a source thereof into the interior of the diaphragm to cause the latter to expand within the working chamber between said spaced points,

(f) said tubular diaphragm having a wall thickness gradually diminishing in a direction from the outlet port to the inlet port so that the diaphragm expansion is peristaltic in nature,

(g) exhaust passage means in said supporting core and said casing for conducting pressurized fluid from the interior of the diaphragm so that the latter will contract into engagement with said supporting core, and

(h) a fluid-actuated control valve disposed in said supporting core to control the flow of pressurized fluid through said inlet passage means and said exhaust passage means to provide alternate expansion and contraction of said diaphragm within said expansion chamber.

11. The apparatus of claim 10 wherein the diaphragm portions adjacent the inlet port and the outlet port cooperate with the ports upon expansion and contraction to seal and unseal said inlet and outlet ports.

12. The apparatus of claim 10 wherein the diaphragm and the core have a substantially "dumbbell" configuration.

13. The apparatus of claim 10 wherein a securing means for holding the diaphragm to the supporting core is disposed intermediate the ends of the diaphragm to divide the diaphragm into a pumping section and a valving section.

14. The apparatus of claim 10 wherein said fluid-actuated control valve has a spool valve and a spring to bias the spool valve in one position and pressure ports to provide a pressure imbalance on said spool valve to effect the movement of the latter against the force of said spring.

References Cited by the Examiner

UNITED STATES PATENTS

2,653,552	9/53	Geeraert	103—152
3,007,416	11/61	Childs	103—44

DONLEY J. STOCKING, *Primary Examiner*.

ROBERT M. WALKER, *Examiner*.