Dec. 29, 1970 L. F. WILSON 3,551,076

TUBULAR DIAPHRAGM PUMP

Filed March 22, 1968 2 Sheets-Sheet 1

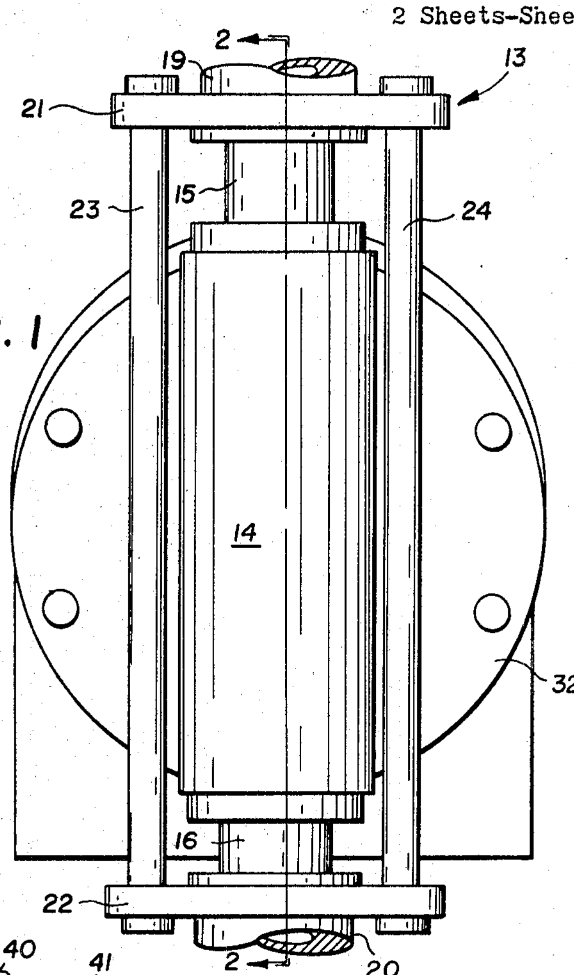

FIG. 1

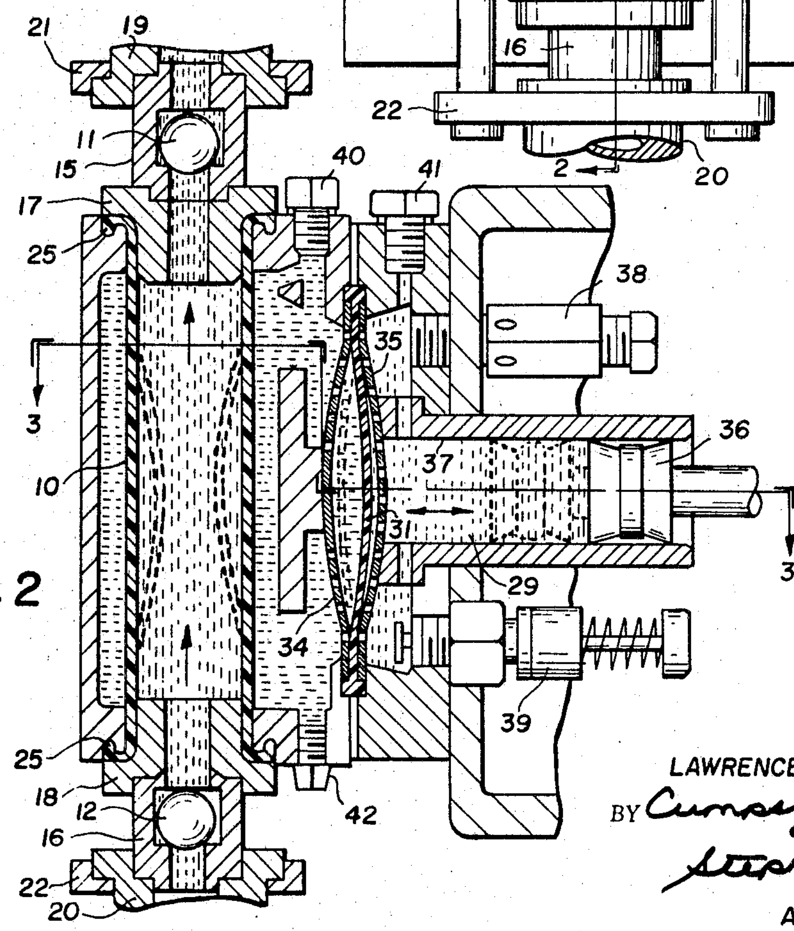

FIG. 2

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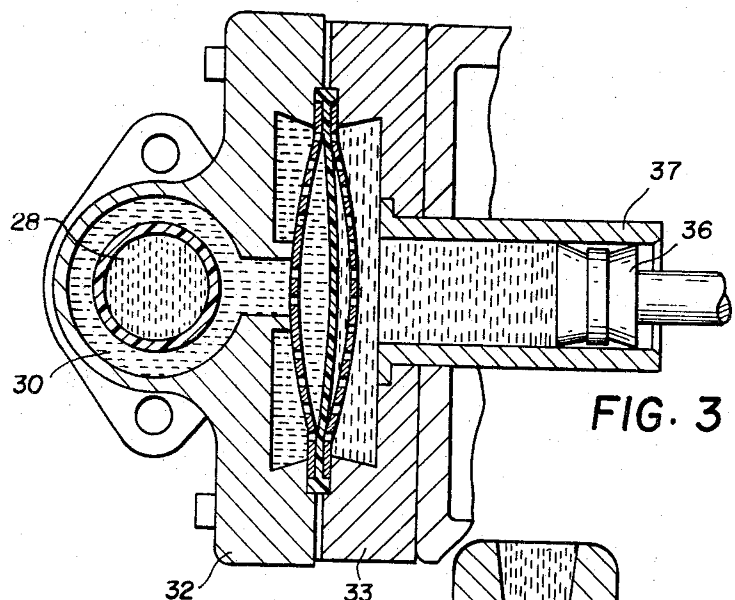

FIG. 3

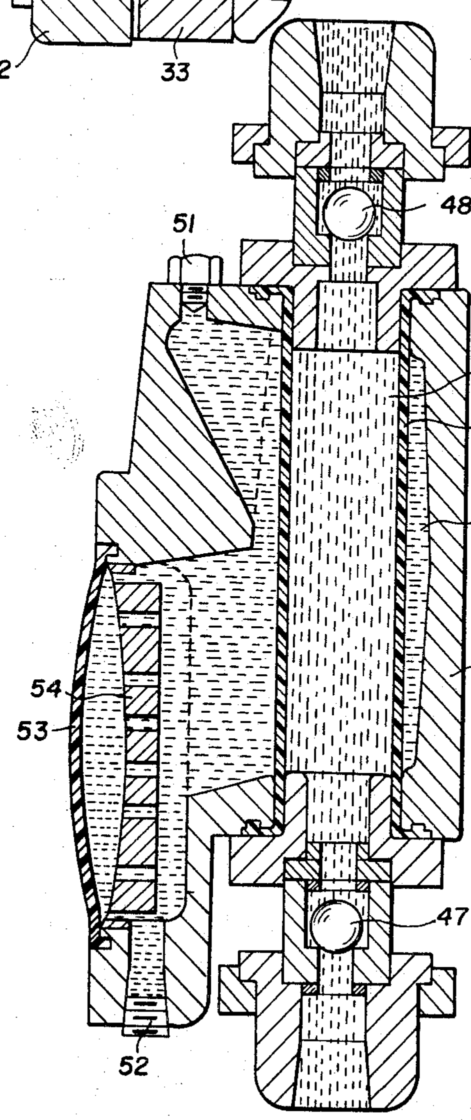

FIG. 4

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United States Patent Office 3,551,076
Patented Dec. 29, 1970

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3,551,076
TUBULAR DIAPHRAGM PUMP

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Filed Mar. 22, 1968, Ser. No. 715,242
Int. Cl. F04b *9/10*
U.S. Cl. 417—385 4 Claims

ABSTRACT OF THE DISCLOSURE

A hydraulically reciprocated diaphragm drives a tubular diaphragm through which material is pumped in positive displacements, and a predetermined volume of liquid couples the diaphragm and the tube and surrounds the tube. The diaphragm's excursion is limited, and the liquid volume is set to compress but not expand the tube relative to its normal cylindrical shape.

Diaphragm pumps are widely used in metering and pumping corrosive or abrasive materials which the diaphragm separates from moving pump parts. At the present state of the art, such diaphragm pumps use circular diaphragms that are reciprocated between apertured support plates to draw in volumes of pumped liquid and force such volumes out. Valves limit the motion of the pumped liquid to a single direction so that the diaphragm acts as a positive displacement pump. Two of such diaphragms can be arranged in series with an inner diaphragm driving an outer diaphragm which pumps the liquid. This protects the diaphragm driving mechanism from a diaphragm failure admitting corrosive or abrasive materials past the outer diaphragm.

The disadvantages of such diaphragm pumps are their expense and relatively short life under certain adverse conditions. The support plates for limiting the diaphragm excursion are complex and expensive and expose large surface areas to liquid environments. When the liquid environment is a hostile corrosive or abrasive material being pumped, a large surface area is available for attack, and an expensive part is rapidly deteriorated. Also, abrasives or foreign particles in the pumped liquid can lodge in the diaphragm support plate region and damage or weaken the diaphragm to reciprocate its failure.

The objects of the invention include, without limitation:

(a) Overcoming the disadvantages of prior art diaphragm pumps;

(b) A diaphragm pump that is capable of pumping slurries, abrasives, high viscosity products, or highly corrosive materials with ease, simplicity, and reliability;

(c) A diaphragm pump that allows use of optimum wear materials at each part of the pump;

(d) A diaphragm pump that is simple, reliable, long-lived, and yet highly versatile in the materials and rates it is capable of pumping; and

(e) A diaphragm pump that better protects its expensive moving parts from damage from a diaphragm failure.

These and other objects of the invention will be apparent hereinafter from the specification which describes the invention, its use, operation and preferred embodiment, from the drawings, which constitute a part of the disclosure, and from the subject matter claimed.

Generally, the inventive pump includes: a limited excursion, reciprocated diaphragm; a flexible tube forming a passageway for pumped material; valves requiring a one-way flow of pumped material through the tube; a liquid-tight chamber around the tube and having the diaphragm arranged as a portion of the chamber boundary; and the chamber being completely filled with a predetermined volume of liquid. This results in the diaphragm driving the tube in compressions and re-expansions to normal to serve as a positive displacement pump. Preferably, the volume of liquid is selected so that when diaphragm excursion gives the chamber maximum volume, the tube assumes its normal configuration of a cylinder of uniform diameter, and when diaphragm excursion gives the chamber minimum volume, the tube is compressed.

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In the drawings:

FIG. 1 is a front elevation of a preferred embodiment of the inventive pump;

FIG. 2 is a cross-section of the pump of FIG. 1 taken along the line 2—2 thereof;

FIG. 3 is a cross-section of a pump of FIG. 2 taken along the line 3—3 thereof; and

FIG. 4 is a cross-sectional view of a preferred alternative embodiment of the inventive pump.

The pumping diaphragm of the inventive pump illustrated in FIGS. 1–3 is a flexible tube **10** arranged so that the pumped liquid or material **28** (shaded for purple) passes through tube **10**. Tube **10** is preferably formed of a flexible material resistant to liquid **28** and having a substantial flex-life. Preferred materials for tube **10** include fluorinated elastomers or fluorinated or polytetrafluorinated polymers such as polytetrafluoroethylene. Ball valves **11** and **12** restrict the flow of liquid **28** to the direction indicated by the arrows in FIG. 2 so that when tube **10** is compressed to its broken line position as shown in FIG. 2, liquid **28** is forced out through outlet valve **11**, and when tube **10** is re-expanded to its solid line position, liquid **28** is brought in through inlet valve **12**.

Tube **10** and valves **11** and **12** are arranged in a reagent head **13** including a plate **32** forming cylinder **14**, valve housings **15** and **16**, collars **17** and **18**, caps **19** and **20**, and connector plates **21** and **22** secured together by bolts **23** and **24**. Each end of tube **10** is formed with a peripheral flange **25** that is clamped between cylinder **14** and collars **17** and **18** respectfully to form a liquid-tight seal between tube **10** and the pump housing.

A chamber formed within cylinder **14** surrounds the mid-section of tube **10** and is filled with a coupling liquid **30** (shaded for gray). Tube **10** is flexed and driven through coupling liquid **30** as described below.

A conventional circular diaphragm **31** is secured between head plate **32** and body plate **33** of the pump and has apertured support plates **34** and **35** arranged on its opposite sides for limiting its excursion. Diaphragm **31** forms a portion of the boundary wall of the chamber surrounding tube **10** and containing liquid **30** so that diaphragm **31** communicates with tube **10** through coupling liquid **30**. Diaphragm **31** is preferably formed of polyurethane or a similar synthetic resin.

Diaphragm **31** is reciprocated between support plates **34** and **35** by piston **36** that is reciprocated in cylinder **37** as shown by the arrows. A driving liquid **29** (shaded for purple) communicates with piston **36** and diaphragm **31** so that the reciprocating motion of piston **36** impresses a corresponding reciprocating motion on diaphragm **31**. Spring-loaded ball valves **38** and **39** are arranged in respective inlet and outlet openings for regulating the amount of liquid **29**. Plugs **40**, **41**, and **42** stop filling and drain holes for the liquids **29** and **30**.

Liquid **29** is preferably oil, but can be any suitable hydraulic material. Liquid **30** is preferably compatible with the material **28** being pumped so that minimum damage will be done by any rupture of tube **10**. Liquid **30** can be water for many applications. If liquid **30** is properly selected, detectors such as electrical detectors or visual detectors can be used to indicate any leakage of the pumped material **28** into the chamber normally filled by liquid **30**.

Tube **10** normally assumes the configuration of a cylinder with uniform diameter such as shown in solid lines in FIG. 2, and the amount of liquid **30** is selected so that tube **10** assumes such normal configuration when diaphragm **31** is in its maximum excursion position as illustrated in solid lines in FIG. 2. This results in repeated compression of tube **10** inward from its normally assumed cylindrical shape, but no expansion of tube **10** outward beyond such cylindrical shape. Since the amount of liquid **30** in the chamber surrounding tube **10** is fixed and cannot increase, such a relationship between tube **10** and diaphragm **31** is readily maintained during pumping.

In the alternative embodiment illustrated in FIG. 4, resilient tube **45** is arranged in a similar fashion in head **46** with ball valves **47** and **48** checking the inlet and outlet respectively for pumped material **49** (shaded for purple) moving through tube **45**. The chamber surrounding tube **45** is filled with a coupling liquid **50** (shaded for gray) of a pre-selected volume. Plugs **51** and **52** stop the inlet and outlet openings to the chamber containing liquid **50**. Circular diaphragm **53** and one of its support plates **54** are shown in communication with liquid **50** for driving tube **45** in a manner similar to the embodiment of FIGS. 1–3. The differences in the FIG. 4 embodiment are generally a simplified pump housing and reagent head **46** affording more economical construction.

In operating the embodiment of FIGS. 1–3, a power source reciprocates piston **36** in cylinder **37** to make reciprocating displacements in driving liquid **29**. These move diaphragm **31** in a reciprocating motion between its support plates **34** and **35**. The motion of diaphragm **31** produces displacements in coupling liquid **30** that repeatedly squeeze tube **10** inward to discharge material **28** through outlet valve **11** and then draw tube **10** back to its normal cylindrical configuration to intake liquid **28** in through inlet valve **12**. The result is positive displacement in tube **10** that move the pumped liquid **28** in the direction of the arrows in FIG. 2.

The flexure of tube **10** is controlled through its direct relationship with diaphragm **31** whose excursion is limited. Regardless of blockages or other conditions in the line for the pumped material **28**. Diaphragm **31** is limited in its travel between support plates **34** and **35**. Also, the amount of coupling liquid **30** is predetermined and fixed so that only predetermined displacements are transmitted to tube **10**. Hence tube **10** cannot be overcompressed or forced into the outlet, nor can it be overexpanded to be drawn outward beyond its normal cylindrical shape. This protects tube **10** against undue stresses and prolongs its life. Also, it allows the inventive pump to be used safely on high viscosity materials and in circumstances in which line pressures fluctuate widely.

Tube **45** of the embodiment of FIG. 4 is subjected to a controlled flexure in a similar manner by diaphragm **53**.

Only the valves and a minimum of surfaces of the inventive pump are exposed to the pumped liquid, and deterioration of parts from corrosive or abrasive materials in the pumped liquid is minimal. A simple reagent head mounts tubes **10** or **45**, and since their flexure is controlled, they can be formed of flexible materials that are highly resistant to the pumped material and still maintain a long life. The large surface areas and complex configurations of support surfaces **54** or **34** do not contact corrosive materials and are not worn excessively during

pumping. Furthermore, eliminating a set of such complex and expensive support surfaces materially reduces the expense of the inventive pump. Conventional diaphragms **31** and **53** can be formed of materials most suited to moving between support surfaces, for example, polyurethane. Such materials are not also the most resistant to corrosive materials that must be pumped. The optimum material such as polytetrafluoroethylene for tubes **10** and **45** is not deteriorated by the pumped material, but is not satisfactory as a conventional diaphragm, because cold flow against support surfaces soon deteriorates and destroys a conventional circular diaphragm made of materials like polytetrafluoroethylene. Hence, the inventive pump permits use of optimum materials for each function within the pump.

Thus, it can be seen that the invention accomplishes its objects in providing a reliable, versatile, and long-lived pump capable of pumping and metering corrosive and abrasive materials.

I claim:

1. A pump comprising:

(a) a reciprocating piston;
(b) a diaphragm;
(c) aperture plates arranged on each side diaphragm to limit its excursions;
(d) means enclosing a volume of driving liquid between said piston and said diaphragm;
(e) said enclosing means having an inlet and an outlet;
(f) a valve arranged in said inlet to regulate the inflow of said driving liquid;
(g) a valve arranged in said outlet to regulate the outflow of said driving liquid;
(h) a flexible tube configured as a cylinder of uniform diameter and arranged to form a passageway through said tube for material to be pumped;
(i) valve means for limiting the flow of said material through said tube to a pre-determined direction;
(j) means for forming a sealed and liquid-tight chamber around said tube;
(k) a portion of the boundary wall of said chamber being formed of said diaphragm; and
(l) said chamber being substantially completely filled with a pre-determined volume of liquid so that said tube normally assumes said cylindrical configuration when said excursion of said diaphragm gives said chamber maximum volume.

2. The pump of claim **1** including flanges on the ends of said tube and means for clamping said flanges against said chamber forming means.

3. The pump of claim **1** wherein said tube is formed of a polytetrafluorinated polymer.

4. The pump of claim **1** wherein said tube is formed of a fluorinated elastomer.

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ROBERT M. WALKER, Primary Examiner

U.S. Cl. X.R.

92—90, 98; 417—478

REEXAMINATION CERTIFICATE (162nd)

United States Patent [19] | [11] **B1 3,551,076**
Wilson | [45] Certificate Issued **Feb. 14, 1984**

[54] **TUBULAR DIAPHRAGM PUMP**

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[73] Assignee: **Lapp Insulator Co., Inc.,** Leroy, N.Y.

Reexamination Request:
No. 90/000,255, Sep. 9, 1982

Reexamination Certificate for:
Patent No.: **3,551,076**
Issued: **Dec. 29, 1970**
Appl. No.: **715,242**
Filed: **Mar. 22, 1968**

[51] **Int. Cl.**^{3} **F04B 35/02**
[52] **U.S. Cl.** **417/385;** 92/90; 92/98; 417/478
[58] **Field of Search** .... 417/389, 478, DIG. 1; 128/1 D; 92/103 SD

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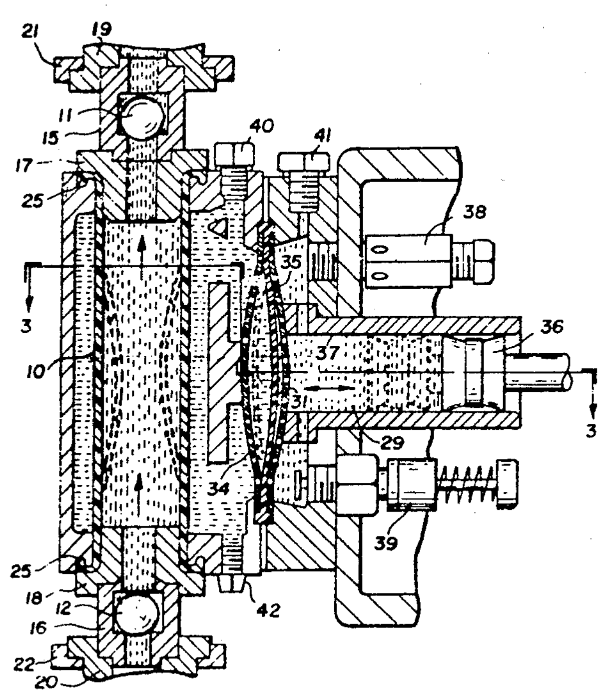
Primary Examiner—William L. Freeh

[57] **ABSTRACT**

A hydraulically reciprocated diaphragm drives a tubular diaphragm through which material is pumped in positive displacements, and a predetermined volume of liquid couples the diaphragm and the tube and surrounds the tube. The diaphragm's excursion is limited, and the liquid volume is set to compress but not expand the tube relative to its normal cylindrical shape.



REEXAMINATION CERTIFICATE ISSUED UNDER 35 U.S.C. 307.

THE PATENT IS HEREBY AMENDED AS INDICATED BELOW

Matter enclosed in heavy brackets [ ] appeared in the patent, but has been deleted and is no longer a part of the patent; matter printed in italics indicates additions made to the patent.

AS A RESULT OF REEXAMINATION, IT HAS BEEN DETERMINED THAT:

Claims **1**-**4**, having been finally determined to be unpatentable, are cancelled.

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