Nov. 15, 1960 D. E. LUPFER ET AL 2,960,038

BELLOWS PUMP

Filed April 18, 1955 2 Sheets-Sheet 1

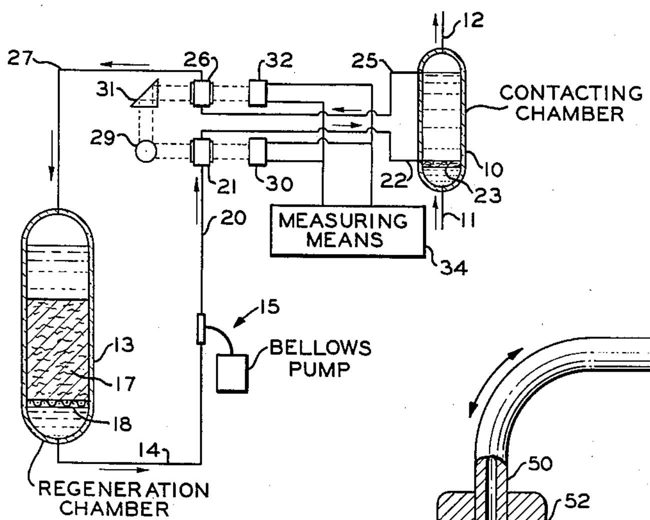

FIG. 1

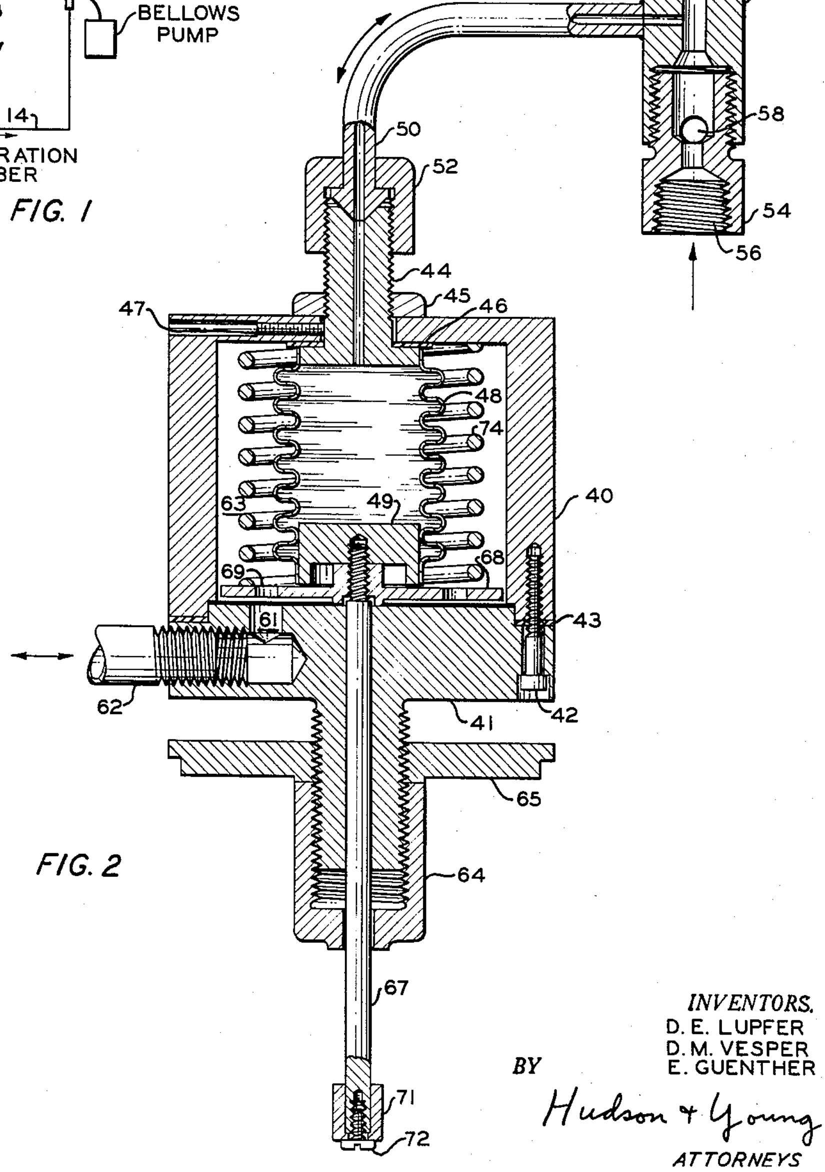

FIG. 2

INVENTORS.
D. E. LUPFER
D. M. VESPER
E. GUENTHER

BY Hudson & Young

ATTORNEYS

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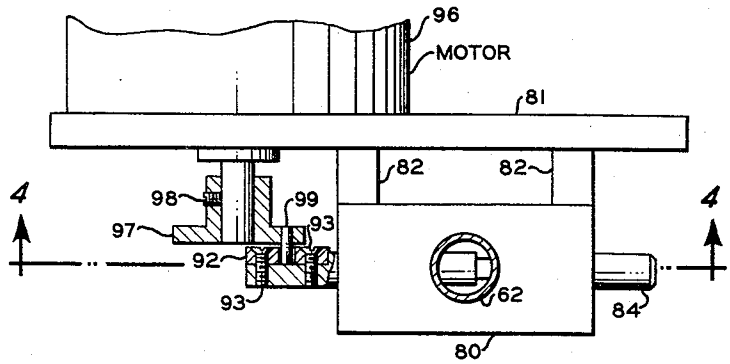

FIG. 3

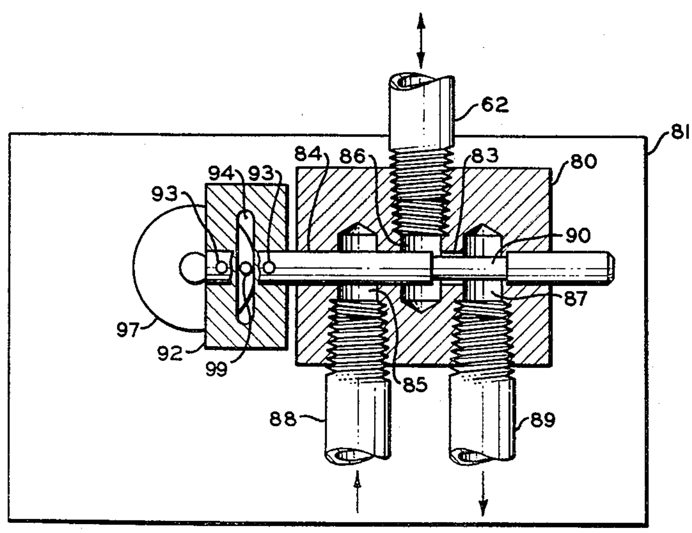

FIG. 4

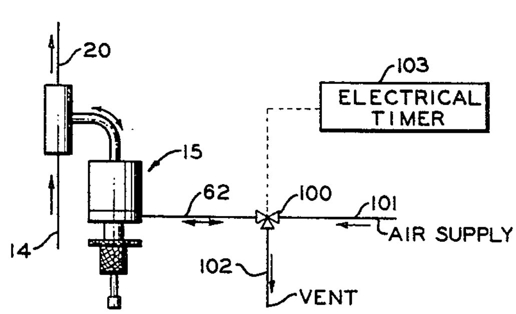

FIG. 5

INVENTORS.
D. E. LUPFER
D. M. VESPER
E. GUENTHER

BY Hudson & Young

ATTORNEYS

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BELLOWS PUMP

Dale E. Lupfer, Daniel M. Vesper, and Emmerich Guenther, Bartlesville, Okla., assignors to Phillips Petroleum Company, a corporation of Delaware

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1 Claim. (Cl. 103—38)

This invention relates to bellows pumps. In another aspect it relates to pneumatic actuating systems for bellows pumps.

In various chemical operations there is a need for pumps which are capable of delivering accurately measured quantities of liquids. For example, a photometric analyzer has recently been developed which utilizes the change in color of a liquid reagent when contacted by a test gas as the basis for detecting the gas. The liquid reagent is directed through a first optical cell prior to its contact with the gas. The contacted reagent is then directed through a second optical cell. The color of the reagent before contact with the gas is compared with the color of the reagent after contact with the gas. The accuracy of the analysis depends upon maintaining a constant flow of the reagent through the system. Commercially available pumps have not proved satisfactory for use in this analyzer because they have not been able to maintain a constant flow over an extended period of time.

In accordance with the present invention there is provided an improved pneumatically operated bellows pump which is capable of maintaining a constant liquid flow. The assembly is provided with first and second stops which regulate the stroke of the bellows. The bellows is compressed by air under pressure to eliminate mechanical driving means. This greatly increases the accuracy of the pump over an extended period of time. Novel means are provided to introduce the compressed air into the pump body and to exhaust air from the pump body at a predetermined frequency. These means are in the form of a motor-driven air valve or an electrically operated three-way solenoid valve. Each stroke of the bellows forces a predetermined volume of liquid through the pump.

Accordingly, it is an object of this invention to provide an improved bellows pump which is operated by a source of pneumatic pressure.

Another object is to provide a motor-driven valve to supply air under pressure to and exhaust air from a bellows pump at a predetermined frequency.

Another object is to provide a three-way solenoid valve system to supply air under pressure to and exhaust air from a bellows pump at a predetermined frequency.

Other objects, advantages and features of the invention should become apparent from the following description, taken in conjunction with the accompanying drawing, in which:

Figure 1 is a schematic view of a photometric analyzer having the bellows pump of the present invention incorporated therein;

Figure 2 is a detailed view, shown partially in section, of the bellows pump;

Figure 3 is a view, shown partially in section, of a first embodiment of the pneumatic pressure supply control system;

Figure 4 is a view taken along line 4—4 in Figure 3; and

Figure 5 is a schematic view of a second embodiment of the pneumatic pressure supply control system.

Referring now to the drawing in detail and to Figure 1 in particular, there is shown a photometric analyzer in which the bellows pump of the present invention is particularly useful. This analyzer is adapted to measure the oxygen content of a gas stream which is introduced into a liquid-gas contacting chamber **10** through a conduit **11**. The gas is vented from chamber **10** through a conduit **12**. A liquid reagent, which advantageously is an alkaline aqueous solution of sodium anthraquinone-beta-sulfonate, is directed from a regeneration chamber **13** through a conduit **14** which communicates with the inlet port of a bellows pump **15**. A mass of zinc amalgam **17** is supported in chamber **13** by a screen **18**. The sulfonate solution is reduced when contacted by the amalgam and acquires a deep red color. A conduit **20** communicates between the outlet port of pump **15** and the inlet port of a cell **21**. A conduit **22** communicates between the outlet port of cell **21** and the liquid inlet of chamber **10**. A filter **23** is disposed near the bottom of chamber **10**. This filter is permeable to gas but impermeable to liquid. The liquid and gas introduced into chamber **10** ascend together so that the sulfonate solution is partially oxidized by oxygen present in the gas stream introduced through conduit **11**. The red color of the sulfonate solution is reduced in intensity in proportion to the amount of oxygen in the gas sample. The sulfonate solution is removed from chamber **10** through a conduit **25** which communicates with the inlet port of a second cell **26**. A conduit **27** communicates between the outlet port of cell **26** and the top of regeneration chamber **13**.

A first beam of radiation from a source **29** is directed through cell **21** to impinge upon a photovoltaic cell **30**. A second beam of radiation from source **29** is reflected by a prism **31** through cell **26** to impinge upon a second photovoltaic cell **32**. Cells **30** and **32** are connected in opposition to a voltage measuring means **34**. The indicated signal is thus representative of the difference in radiation transmitted through cells **30** and **32**. This in turn is a measure of the change in color of the sulfonate solution when oxidized by the gas being detected.

The apparatus is arranged such that the sulfonate solution returns to chamber **13** from chamber **10** by gravity flow. It is essential that the reagent be circulated at a constant rate to provide an accurate measurement of the oxygen in the test gas. The test gas must also be directed through chamber **10** at a constant rate. Bellows pump **15** is provided to circulate the sulfonate solution.

Pump **15** is illustrated in detail in Figure 2. A cylindrical hollow pump body **40** defines a bellows chamber **63**. A base **41** is secured to body **40** by a plurality of screws **42**. A gasket **43** is interposed between base **41** and body **40**. A nipple **44**, having a flanged lower portion, extends through a central opening in the top of body **40**. A lock nut **45** is threaded to nipple **44** to retain the flanged portion thereof in engagement with the top of body **40**. A gasket **46** is interposed between the flanged portion of nipple **44** and body **40**. A set screw **47** prevents nipple **44** from rotating. A bellows **48** is positioned within valve body **40** and is secured at one end to nipple **44**, as by soldering. Bellows **48** preferably is made of metal, but can be formed of fabrics for some applications. The second end of bellows **48** is secured to a plug **49**. A conduit **50** is secured to the top of nipple **44** by a cap **52**. The second end of conduit **50** communicates with the interior of a check valve housing **53**. A nipple **54** is threaded to one end of housing **53** and a nipple **55** is threaded to the second end of the housing. Nipple **54** is threaded to form the inlet port **56** of the pump, and nipple **55** is threaded to form the outlet port **57** of the pump. A ball **58** is positioned within nipple **54** to form a first check valve, and a ball 59 is positioned within nipple 55 to form a second check valve.

A passage 61 is drilled in base 41 to communicate between an air supplying conduit 62 and chamber 63. The introduction of air into chamber 63 compresses bellows 48. The amount bellows 48 is compressed is determined by the setting of a cap 64 which is threaded to base 41 and retained in place by a lock nut 65. A rod 67 extends through cap 64 and base 41 and is threaded to a lock plate 68 and plug 49. A plurality of holes 69 is formed in plate 68 to transmit pressure from passage 61 to chamber 63. A stop member 71 is attached to the lower end of rod 67 by a screw 72. The upward movement of rod 67 is thus terminated when member 71 engages cap 64. The length of the compression stroke of bellows 48 can readily be adjusted by movement of cap 64. A compression spring 74 is positioned within chamber 63 to retain bellows 48 expanded in the absence of fluid pressure being applied to the chamber. In some applications this spring is not needed because bellows 48 tends to remain expanded.

Air under pressure is supplied to chamber 63 periodically through conduit 62 by the valve system illustrated in Figures 3 and 4. A valve body 80 is secured to a plate 81 by supports 82. Valve body 80 has a central passage 83 therethrough into which is inserted a plunger 84. Three spaced ports 85, 86 and 87 communicate with passage 83. Conduit 62 is threaded into center port 86. A compressed air supply conduit 88 is threaded into port 85, and a vent conduit 89 is threaded into port 87. A portion 90 of plunger 84 is of smaller diameter than the remainder thereof. When plunger 84 occupies the illustrated position, ports 86 and 87 are in communication and ports 85 and 86 are separated by plunger 84. The diameters of ports 85, 86 and 87 are greater than the diameter of plunger 84 so that the pneumatic pressures in the ports are applied to all sides of plunger 84 to prevent binding. A slotted plate 92 is secured to one end of plunger 84 by screws 93. The slot 94 of plate 92 extends in a direction perpendicular to the longitudinal axis of plunger 84. A synchronous motor 96 is mounted on plate 81. A flange 97 is secured to the drive shaft of motor 96 by a set screw 98 and a pin 99 is attached to flange 97 near the periphery thereof. This pin extends into slot 94 in plate 92. Thus, rotation of motor 96 results in rotation of pin 99 to move plunger 84 back and forth in valve body 80. Recess 90 of plunger 84 moves so that port 86 alternately is in communication with port 85 and port 87.

The operation of the pump should now become apparent. With plunger 84 in the illustrated position, bellows 48 is expanded by the force of spring 74. Air in chamber 63 is vented through passage 61, conduit 62, connected ports 86 and 87, and conduit 89. At this time, the fluid being pumped enters the interior of bellows 48 through check valve 58 and conduit 50. During the following portion of the cycle, plunger 84 is moved so that ports 85 and 86 are in communication. This applies pneumatic pressure to chamber 63 to compress bellows 48. The compression of bellows 48 forces the liquid therein through conduit 50 and check valve 59 to outlet port 57. The cycle then repeats. It should be evident that the rate of pumping is a function of both the length of the compression stroke of bellows 48 and the frequency of movement of plunger 84. The length of the stroke is adjusted by cap 64. The frequency of movement of plunger 84 can be regulated by the use of a variable speed motor in place of synchronous motor 96 or through the use of gears between the motor and flange 97.

A second embodiment of the pneumatic control system is illustrated in Figure 5. Air under pressure is supplied to the first outlet port of a two-way solenoid valve 100 by a conduit 101. The inlet port of valve 100 is connected by conduit 62 to pump 15. Valve 100 is actuated by electrical pulses from a timer 103. In the absence of current being supplied to valve 100, conduit 62 is in communication with a conduit 102 that is connected to the second outlet port of valve 100. Chamber 63 of the pump is connected to vent conduit 102 at this time. When the valve is energized by current being supplied thereto from timer 103, conduits 101 and 62 are in communication so that compressed air is supplied to the bellows chamber of pump 15. The frequency of the operation of valve 100 by timer 103 thus regulates the rate fluid is passed by pump 15. Timer 103 can be any known type of instrument, either electronic or electro-mechanical, which supplies electrical signals of sufficient magnitude to operate the solenoid valve. If desired, the frequence of timer 103 can be varied to vary the rate of pumping.

From the foregoing description it should be apparent that there is provided in accordance with this invention an improved pneumatically operated bellows pump and a pneumatic control system therefor. This pump delivers accurately measured volumes of liquid, and does not employ mechanical driving elements which are likely to wear to destroy the accuracy of the pump. The speed of the pump can be maitained constant by the use of a small synchronous motor. The motor need not be large, because it is used only to move a pneumatic valve. The primary operating energy is supplied by the pneumatic pressure. This pressure need not be absolutely constant because the length of stroke of the pump is controlled by the stops on the pump, and the speed of operation is controlled by the synchronous motor.

While the invention has been described in conjunction with present preferred embodiments thereof, it should be apparent that the invention is not limited thereto.

What is claimed is:

A pneumatically operated bellows pump comprising a hollow cylindrical pump body having a fluid passage in one end thereof, the second end of said pump body being provided with external threads, first conduit means communicating with said fluid passage, a first check valve in said first conduit means to permit fluid flow through said first conduit means toward said fluid passage, second conduit means communicating with said first conduit means between said fluid passage and said first check valve, a second check valve in said second conduit means to permit fluid flow through said second conduit means away from said fluid passage, a bellows positioned within said pump body and secured to said one end so that said fluid passage communicates with the interior of said bellows, a plate secured to the second end of said bellows, a spring extending between said plate and said one end of said pump body to urge said bellows to an expanded position, a rod attached to said plate and extending therefrom through the second end of said pump body, a first stop member secured to the second end of said rod, a second stop member threaded to the external threads of said pump body so that the distance between the stop members can be varied, a lock nut threaded to the external threads of said pump body to retain said second stop member in position, and means forming a second fluid opening in said pump body so that the introduction of pneumatic pressure into said body through said second opening compresses said bellows until said stop members are in engagement.

References Cited in the file of this patent

UNITED STATES PATENTS

253,683	Catterall et al.	Feb. 14, 1882
862,867	Eggleston	Aug. 6, 1907
1,067,613	Lane	July 15, 1913
1,072,636	Mueller	Sept. 9, 1913
1,623,049	Dorsey	Apr. 5, 1927
1,641,280	Joslin et al.	Sept. 6, 1927
1,836,344	Stokes	Dec. 15, 1931

(Other references on following page)

UNITED STATES PATENTS

1,848,546	Redmond	Mar. 8, 1932
1,926,208	Mantle	Sept. 12, 1933
2,126,092	Corydon et al.	Aug. 9, 1938
2,186,972	Hollander et al.	Jan. 16, 1940
2,254,539	Mattox	Sept. 2, 1941
2,311,229	Herbert	Feb. 16, 1943
2,455,837	Waldie	Dec. 7, 1948
2,501,004	Reese	Mar. 21, 1950
2,534,504	Engstrom	Dec. 19, 1950
2,572,390	Righton	Oct. 23, 1951
2,613,610	Saalfrank	Oct. 14, 1952
2,675,758	Hughes	Apr. 20, 1954
2,699,119	Healey	Jan. 11, 1955
2,706,950	Becker	Apr. 26, 1955
2,711,134	Hughes	June 21, 1955
2,731,906	King	Jan. 24, 1956
2,732,127	Booth	Jan. 24, 1956

FOREIGN PATENTS

782	Great Britain	Apr. 1, 1853
370,842	Great Britain	Oct. 24, 1931