Aug. 2, 1966 D. R. JOHNSON 3,263,617

METHOD AND APPARATUS FOR PUMPING FLUID

Filed May 27, 1964 2 Sheets-Sheet 1

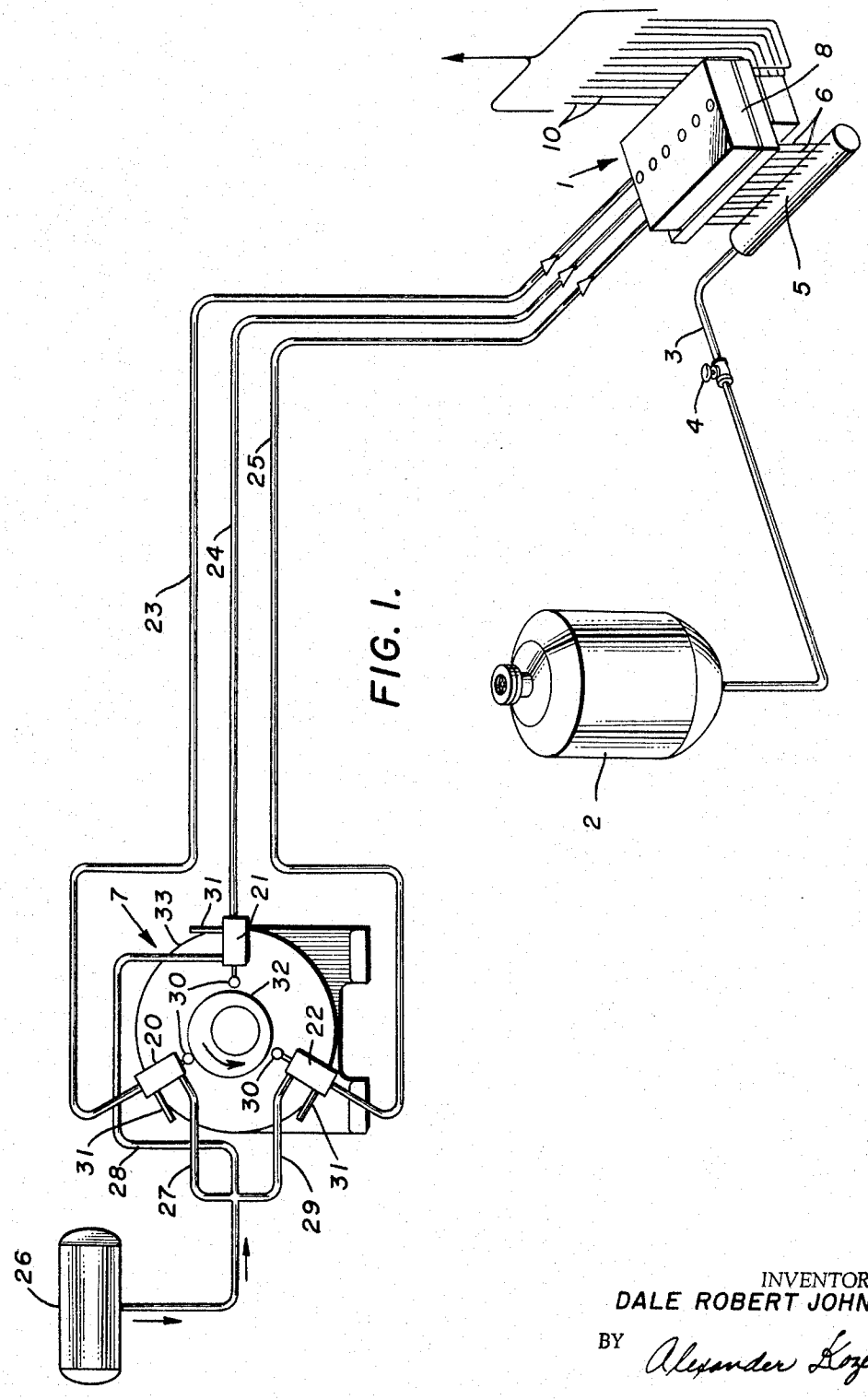

FIG. 1.

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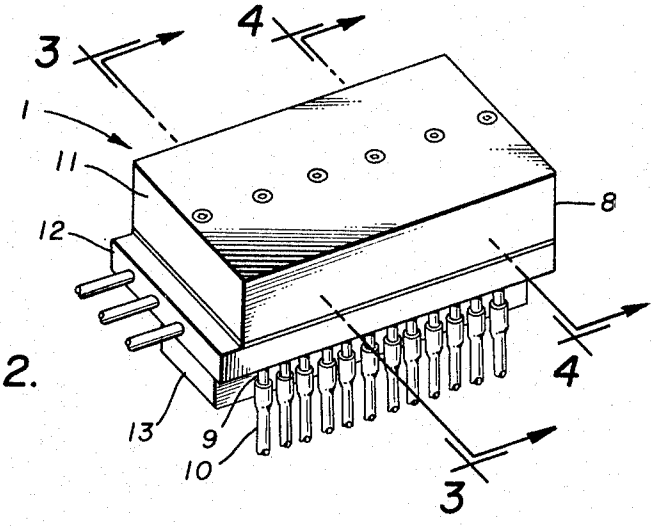

FIG. 2.

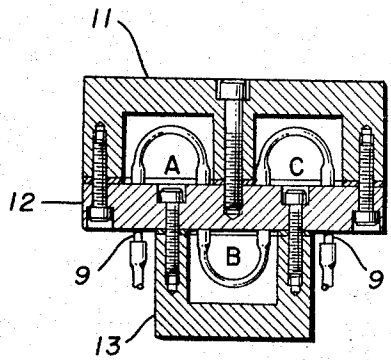

FIG. 3.

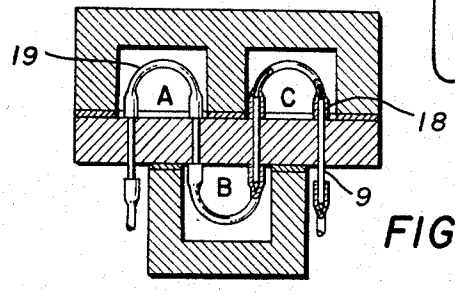

FIG. 4.

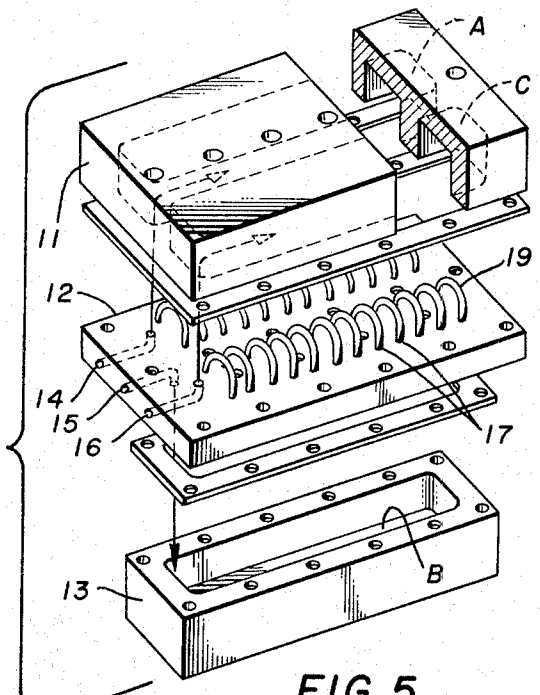

FIG. 5.

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3,263,617

METHOD AND APPARATUS FOR PUMPING FLUID

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Filed May 27, 1964, Ser. No. 370,580
3 Claims. (Cl. 103—44)

This invention relates to a method and apparatus for pumping fluid and, more particularly, relates to a fluid-pressure peristaltic pump and method for providing a plurality of liquid streams.

Some industrial applications require pump apparatus capable of forming a plurality of liquid streams of corrosive liquid material with safe and long maintenance-free periods of operation. Conventional pumps of the squeeze or resilient tube construction provide a measure of safety in that the corrosive liquid being handled is isolated or confined in a rubber tube. However, in operation the rubber tube is compressed or squeezed by mechanical elements such as cams, rollers, and the like. The repeated contact of the rubber tube with the mechanical elements causes early tube wear and rupture and consequent escape of dangerous corrosive fluid therefrom. The use of fluid under pressure in a pump arrangement for collapsing a resilient tube has been suggested, however, the latter type pumps are complicated and require the use of valves.

It is an object of this invention to provide pump apparatus incorporating resilient tube means extending through a plurality of pressure chambers and means for sequentially pressurizing the chambers with fluid to squeeze the resilient tube means and to produce a liquid flow therefrom.

Another object of the invention is to provide fluid-pressure pump apparatus for producing a plurality of metered liquid streams and for handling corrosive liquid agents.

Another object of the invention is to provide a fluid-pressure pump that does not employ moving mechanical parts.

A still further object is to provide a method for initiating a plurality of liquid streams by subjecting supplies of liquid volumes to fluid-pressure-induced peristaltic action.

The pump apparatus embodying the invention according to one construction comprises, in brief, a pump housing including a plurality of resilient conduit or tube means that extend through a plurality of pressure chambers defined in the housing. Each resilient conduit means has one end connected to a source of liquid supply and the opposite end connected to a delivery line. A flow of liquid from the resilient conduit means is produced by connecting the pump housing to a means for sequentially pressurizing and venting the pressure chambers therein. In method, a plurality of resilient conduit means having inlet and outlet ends and supplied with liquid are extended through a plurality of pressure zones. The pressure zones are sequentially pressurized with and vented of fluid under pressure thereby inducing a peristaltic compression-expansion action along the length of the conduit means effecting a flow of liquid therefrom.

The method and apparatus of the invention will be better understood by reference to the more detailed description which follows and to the accompanying drawings.

In the drawings:

FIGURE 1 is a diagrammatic view showing the pumping method and apparatus of the invention;

FIGURE 2 is a perspective view of the pump embodying the invention;

FIGURE 3 is a cross-section view taken through 3—3 of FIG. 2;

FIGURE 4 is a cross-section view taken through 4—4 of FIG. 2;

FIGURE 5 is an exploded perspective view of the embodiment of the pump shown in FIG. 2.

Referring to the drawing, FIGS. 1–5, the fluid-pressure pump apparatus embodying the invention according to the illustrated construction comprises a chambered, multi-stream pump **1** connected to a liquid supply reservoir **2** containing a corrosive agent. The liquid is gravity fed to pump **1** through a pipe **3**, a valve **4**, a manifold **5** and lines **6**. A charging device **7** is provided to pressurize with and vent pump **1** of air in a manner to be explained.

Pump **1** has a plurality of sealed, fluid-tight chambers A, B, and C defined within a housing or casing **8**. A plurality of resilient conduits or tubes **9**, each having an inlet end connected to a line **6** and an outlet end connected to a discharge line **10** extend through chambers A, B, and C. Resilient tubes **9** may be made of metal, rubber, plastic, or the like.

Housing **8** is sectioned and has upper, center, and lower plates **11**, **12**, and **13**, sealingly connected therebetween by suitable seal and bolt means. The wall surfaces of plates **11** and **13** are recessed so as to define chambers A, B, and C when assembled with center plate **12**. Passages **14**, **15**, and **16** extend through the wall of plate **12** and each passage opens into a chamber A, B, and C, respectively. The outer ends of the passages **14**, **15**, and **16** are threaded.

Resilient tubes **9** are preferably aligned in housing **8** with all of the inlet ends thereof projecting outwardly from one side of housing **8** and the discharge ends projecting or opening outwardly therefrom at the opposite side thereof. Each resilient tube **9** extends from adjacent the inlet end thereof into and out of chambers C, B, and A, seriatim, through a plurality of openings **17** formed in center plate **12**. Each of the resilient tubes **9** may be one single piece or length of resilient tubular material which is pressed through openings **17** to provide a fluid-tight sealed connection therebetween, or may be formed as shown in the illustration, where each tube **9** has more rigid resilient tubular portions **18** extending through openings **17** which are interconnected by more flexible tubular portions **19** forming a single continuous tube **9**. Preferably, resilient tubes **9** S-turn in and out of chambers A, B, and C providing reversibly bent, arcuate U-shaped looped portions therein adapting them to deform readily as well as providing a longer length of tube **9** in each chamber.

A means for charging chambers A, B, and C with fluid under pressure is illustrated in FIG. 1 of the drawing. Charging device **7** comprises valves **20**, **21**, and **22** each of which is connected to one end of a pipe **23**, **24**, and **25**, respectively. The opposite ends of pipes **23**, **24**, and **25** are connected to passages **14**, **15**, and **16**, respectively. Each valve **20**, **21**, and **22** is also connected to a source of air under pressure, such as reservoir **26** by a pipe **27**,

28, and 29, respectively, through a branch pipe leading from reservoir 26. Each of the valves has a cam follower 30 which is normally spring biased to an outward "closed" position. In the "closed" position, followers 30 cut off communication of pipes 27, 28, and 29 from pipes 23, 24, and 25 and simultaneously the latter pipes are vented through a vent port 31 provided on each valve. When a follower 30 on one of the valves, valve 20 for example, is moved to an inward or "open" position against the force of the spring biasing it outwardly, the vent port 31 on that valve 20 is closed and the pipe 27 is opened to pipe 23 so that air under pressure flows to chamber A. One means for operating the followers 30 is by a cam 32 adapted to be driven by a motor 33.

The surface configuration of cam 32 is such that when rotated by motor 33 in a counterclockwise direction as shown in FIG. 1, the cam 32 contacts the followers 30 one by one and moves each follower of valves 22, 21, and 20 successively and repeatedly to an "open" position as explained above. The cam is designed to delay closing of each follower 30 contacted so that there is an overlap in the "opening" and "closing" time of the followers 30 whereby chambers A, B, and C of pump 1 are pressurized with fluid under pressure successively and repeatedly in the following sequence—C, CB, B, BA, A, AC, C, etc. When the chambers A, B, and C are not filled with fluid under pressure they are vented through vent ports 31. The pressurizing-venting of the chambers A, B, and C in the given sequence imparts a peristaltic compression-expansion action along the length of the resilient tubes 9.

In operation, a liquid flows to the inlet ends of tubes 9 by gravity flow from reservoir 2. Reservoir 26 is supplied with air under pressure from a suitable source thereof such as a compressor, not shown. Motor 33 is operated to drive cam 32 in a counterclockwise direction (FIG. 1).

For purposes of ease of understanding, the different operations that occur in one revolution of cam 32 are here explained. Assume that cam 32 is rotated in a counterclockwise direction and is in a position where the cam 32 is in contact with follower 30 of valve 22 only and has moved the follower 30 inward to an "open" position while the follower 30 of valves 20 and 21 are in their closed biased outward position. In this condition pipe 29 is connected to pipe 25 through valve 22 and air under pressure flows to chamber C of pump 1 causing all of the tube 9 portions in chamber C to be compressed, deformed or squeezed. Continuing its counterclockwise rotation approximately 120° further cam 32, while still in engagement with the follower 30 of valve 22, engages and "opens" follower 30 of valve 21. Similarly, as in the case of engagement with follower 30 of valve 22, valve 21 connects pipe 28 to pipe 24, thereby causing chamber B to become pressurized with air. Air under pressure in chamber B then compresses the resilient tube 9 portions therein. Since the liquid in the tube 9 portions in chamber B cannot flow in the direction of chamber C because the tube 9 portions in chamber C are compressed and flow is thus "pinched" off, the liquid in the tube portions in chamber B must flow toward chamber A. Further counterclockwise rotation of cam 32 causes the latter to disengage from follower 30 of valve 22 while still being in engagement with follower 30 of valve 21. Follower 30 of valve 22 then returns to its "closed" outward position whereby pipe 29 is cut off from pipe 25 and chamber C is vented through vent port 31 of valve 22. Venting of chamber C permits the tube 9 portions therein to return to their normal expanded or uncompressed state permitting liquid from reservoir 2 to flow thereto.

Upon further rotation of cam 32, the follower 30 of valve 20 is contacted while cam 32 is still in engagement with valve 21. As in the manner in which chambers C and B were pressurized with air from reservoir 26, chamber A is now pressurized. Since the liquid in the tube 9 portions in chamber A cannot flow in the direction of chamber B, the liquid therein is discharged into lines 10.

Still further counterclockwise rotation of cam 32 causes the cam 32 to disengage from the follower of valve 21 permitting the follower 30 to return to its "closed" posittion for venting chamber B. The liquid from reservoir 2 will then fill the tube portions in both chambers C and B.

As the cam 32 rotates further to complete one revolution, the cam follower 30 of valve 22 is again engaged and the same sequence is repeated.

As explained, chambers A, B, and C in pump 1 are pressurized successively and repeatedly in the order C, CB, B, BA, A, AC, C, etc. causing a sequeezing, compressing or collapsing of tubes 9 at points progressively along their lengths from inlet to outlet effecting a peristaltic action and furnishing a plurality of liquid streams.

By controlling the pressure of air and therefore the degree of force exerted on the resilient tubes, metered streams of liquid may be formed.

The method for producing a plurality of flows of liquid comprises extending a plurality of resilient tubes each having an inlet and an outlet end through a plurality of serially arranged pressure zones. Liquid is supplied to each of the inlets of the resilient tubes and the pressure zones are simultaneously, sequentially, and successively pressurized and depressurized to generate a compression-expansion peristaltic wave movement along the length of said resilient tubes from inlet to outlet ends thereof producing a plurality of flows of liquid.

The pump apparatus as described is simple in construction and has safe and long-lasting operating features. Although a plurality of resilient tubes and three pressure chambers are shown in the illustrated embodiment of the pump, one resilient tube would suffice and more than three pressure chambers may be provided.

It will be understood that variations and modifications of the illustrated embodiment of the pump apparatus and method are contemplated within the spirit of the invention and the scope of the following claims.

I claim:

1. Pump apparatus comprising in combination,

(a) casing means defining a plurality of sealed, serially arranged fluid pressure chambers therein,

(b) resilient tube means having an inlet and an outlet end and normally providing an axial opening therethrough, said resilient tube means being laced through said casing means with portions extending through the walls thereof and portions extending through each of said plurality of fluid pressure chambers continuously according to the serial arrangement of the latter and with said inlet and outlet opening exteriorly thereof,

(c) said portions of said resilient tube means extending through said fluid pressure chambers being bent reversibly to a substantially U shaped form, and

(d) means connected to said casing means for sequentially pressurizing and depressurizing said fluid pressure chambers for effecting flow of a liquid normally delivered to said inlet end of said resilient tube means.

2. Pump apparatus as in claim 1, wherein a plurality of said resilient tube means extend through each of said fluid pressure chambers.

3. Pump apparatus comprising,

(a) casing means defining a plurality of sealed, serially arranged fluid pressure chambers therein,

(b) continuous tube means having an inlet and an outlet end and normally providing an axial opening therethrough, said continuous tube means being laced through said casing means with portions extending through the walls thereof and portions extending through each of said plurality of fluid pressure chambers continuously according to the serial ar-

rangement of the latter and with said inlet and outlet ends opening exteriorly thereof,

(c) said portions of said continuous tube means exing through said fluid pressure chambers being bent rigid and said portions extending through said fluid pressure chambers being resilient and bent reversibly to a substantially U shaped form, and

(d) means connected to said casing means for sequentially pressurizing and depressurizing said serially arranged fluid pressure chambers for effecting flow of a liquid normally delivered to said inlet end of said continuous tube means.

References Cited by the Examiner

UNITED STATES PATENTS

2,291,912	8/1942	Meyers	103—44
2,747,510	5/1956	Von Seggern	103—44
2,952,210	9/1960	Clancy	103—44
3,039,309	6/1962	Vesper et al.	103—44

FOREIGN PATENTS

894,503	10/1953	Germany.

ROBERT M. WALKER, *Primary Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,263,617 August 2, 1966

Dale R. Johnson

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, lines 5 and 6, for "posittion" read -- position --; line 14, for "sequeezing" read -- squeezing --; column 5, line 4, strike out "ing though said fluid pressure chambers being bent" and insert instead -- tending through the walls of said casing means being --.

Signed and sealed this 1st day of August 1967.

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

EDWARD J. BRENNER

Commissioner of Patents