METHOD AND APPARATUS FOR PUMPING FLUID

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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 opera-
tion the rubber tube is compressed or squeezed by me-
chanical elements such as cams, rollers, and the like.
The repeated contact of the rubber tube with the me-
chanical elements causes early tube wear and rupture
and consequent escape of dangerous corrosive fluid there-
from. The use of fluid under pressure in a pump ar-
rangement for collapsing a resilient tube has been sug-
gested, however, the latter type pumps are complicated
and require the use of valves.

It is an object of this invention to provide pump ap-
paratus 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 initia-
lizing a plurality of liquid streams by subjecting supplies
of liquid volumes to fluid-pressure-induced peristaltic
action.

The pump apparatus embodying the invention accord-
ing to one construction comprises, in brief, a pump hous-
ing 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 com-
pression-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 descrip-
tion 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 embody-
ing 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 reser-
voir 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 pres-
surize 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 connect-
ed 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 there-
between by suitable seal and bolt means. The wall sur-
faces 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 project-
ing 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
a 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 open-
ings 17 which are interconnected by more flexible tubular
portions 19 forming a single continuous tube 9. Prefer-
ably, 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, 23, 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. 3).

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 25 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 prevents 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” position for venting chamber B. The liquid from reservoir 2 is then filled in 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 squeezing, 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 therebetween, said resilient tube means being faced through said casing means with portions extending through the walls thereof and portions extending therefrom 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 faced through said casing means with portions extending through the walls thereof and portions extending therefrom of said plurality of fluid pressure chambers continuously according to the serial ar-
arrangement of the latter and with said inlet and outlet ends opening exteriorly thereof,
(c) said portions of said continuous tube means exiting 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.

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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