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Mandroian

[11] **3,898,017**

[45] **Aug. 5, 1975**

[54] **PUMP**

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[21] Appl. No.: **351,277**

[52] **U.S. Cl.** **417/65;** 417/209

[51] **Int. Cl.** **F04b 19/24;** F04f 1/18; F04b 47/14

[58] **Field of Search** 417/52, 207, 383, 65, 279; 119/5

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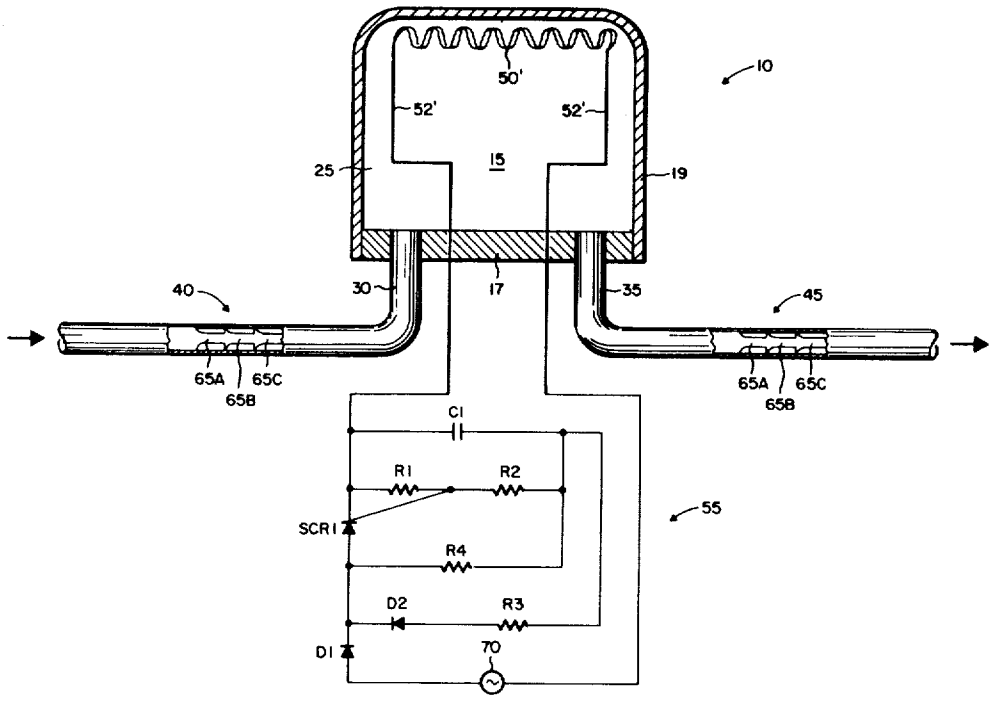
Primary Examiner—William L. Freeh
Assistant Examiner—Richard E. Gluck
Attorney, Agent, or Firm—Nilsson, Robbins, Bissell, Dalgarn & Berliner

[57] **ABSTRACT**

Disclosed is an improved device for pumping fluids, i.e. gasses and liquids.

The pump comprises a substantially enclosed chamber having ingress and egress means for the substance being pumped. Within the chamber is a gas which may or may not be the substance being pumped. Means are provided to heat the gas. Means are provided for selective activation of the heating means. Heating causes expansion of the gas forcing the substance through the egress means. Means, such as mechanical valves or duct constrictions, are provided in some embodiments to restrict upstream flow.

5 Claims, 10 Drawing Figures



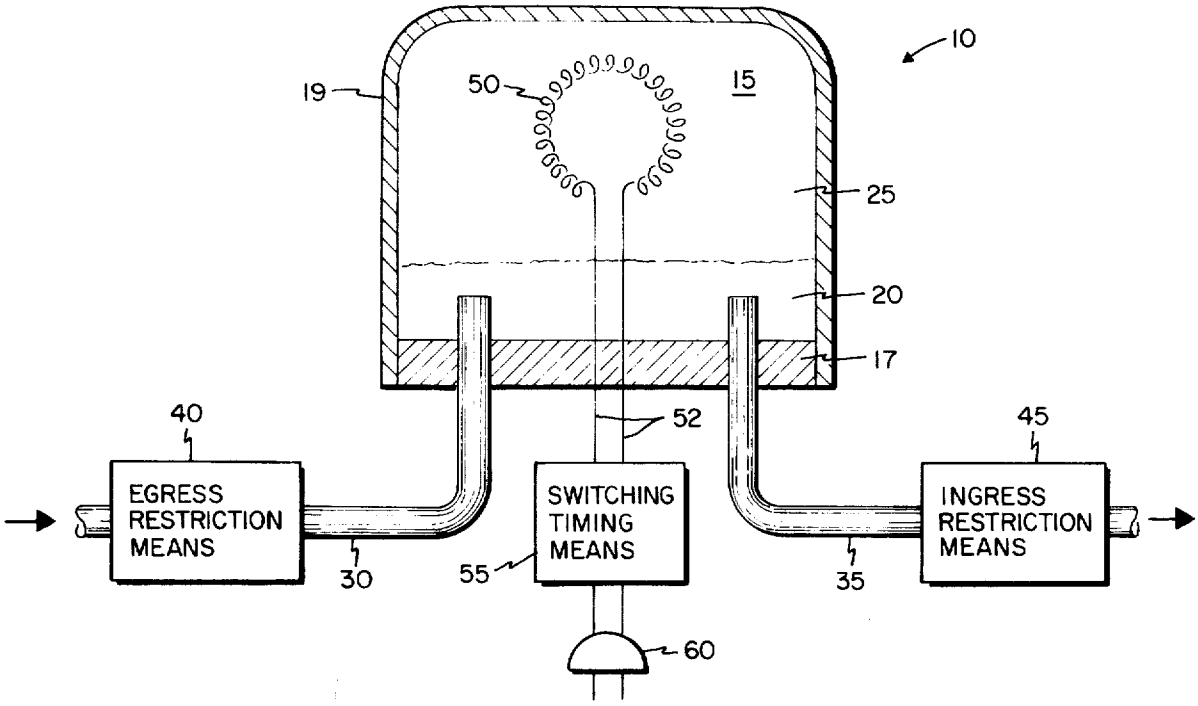


Fig. 1

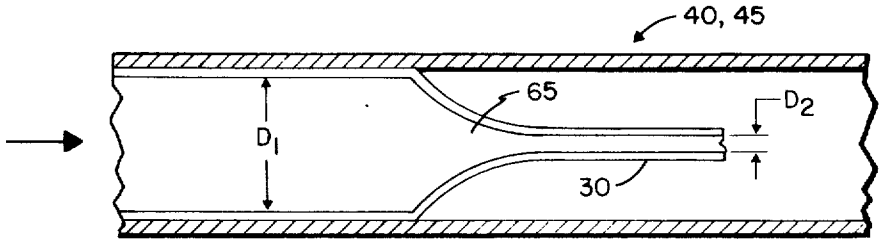


Fig. 2

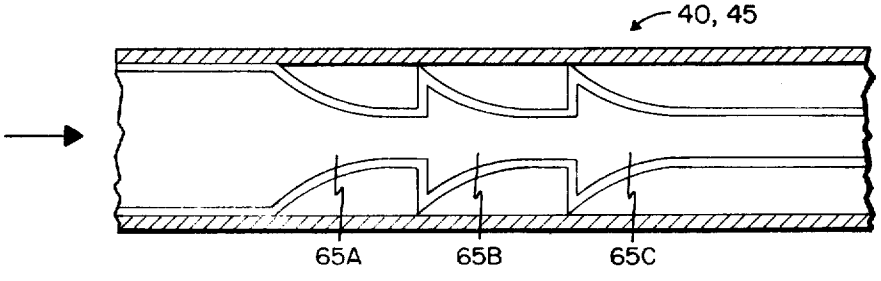


Fig. 3

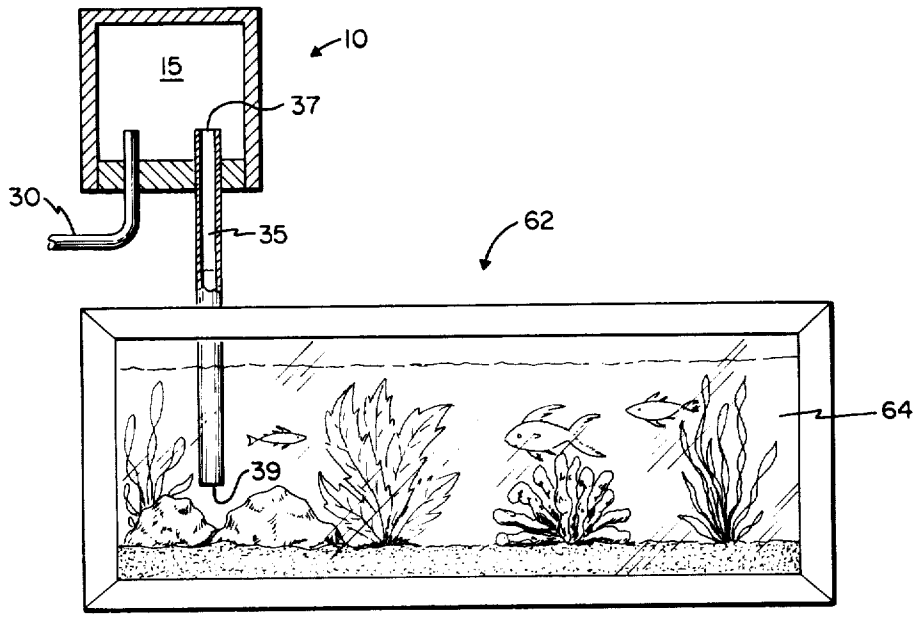


Fig. 4

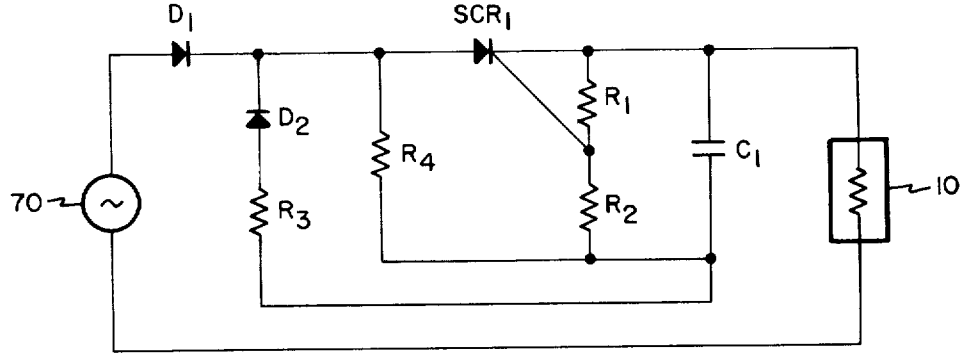


Fig. 5

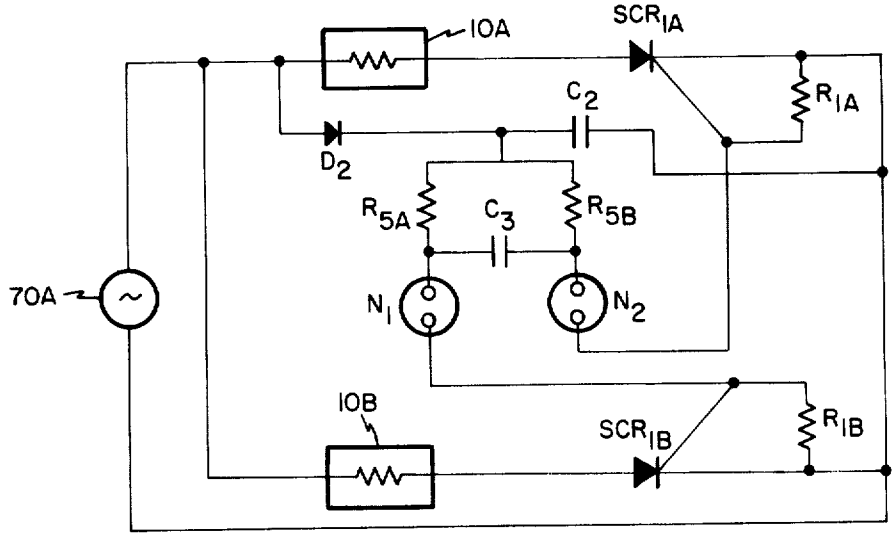


Fig. 6

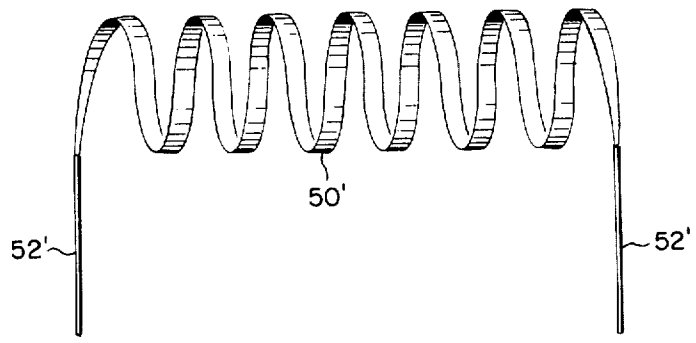

50'
52'
52'

Fig. 7

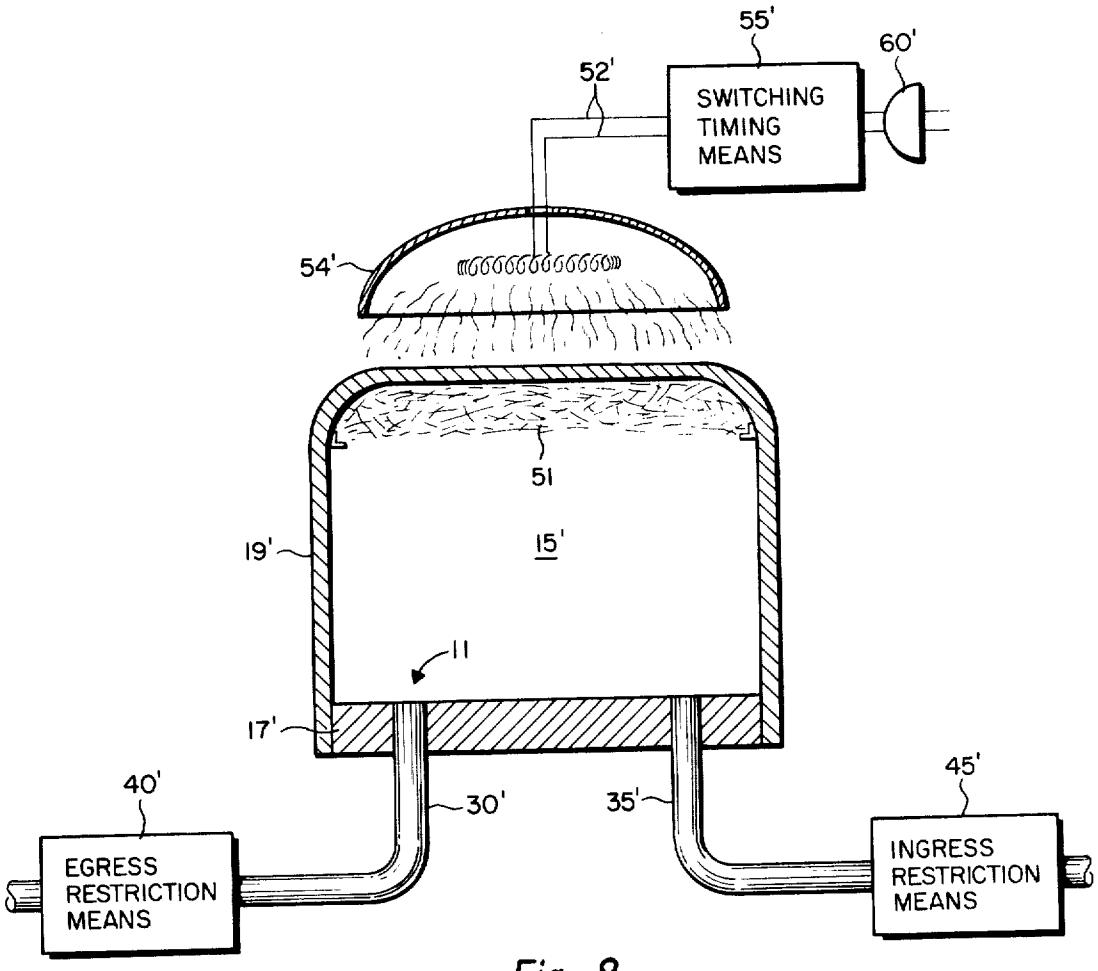

55'
60'
52'
SWITCHING TIMING MEANS
54'
51
15'
19'
11
17'
40'
30'
35'
45'
EGRESS RESTRICTION MEANS
INGRESS RESTRICTION MEANS

Fig. 8

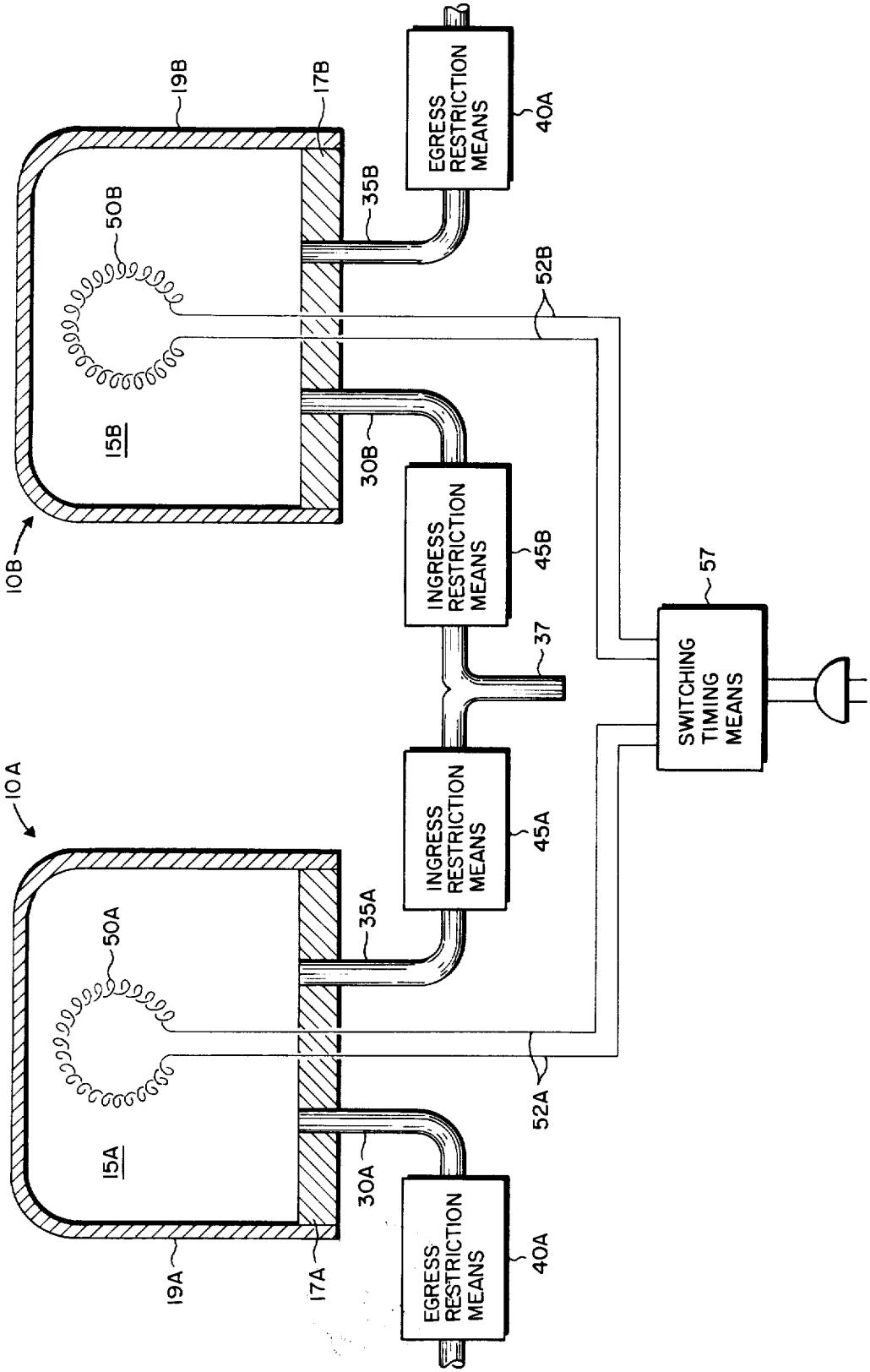

10A
10B
15A
15B
17A
17B
19A
19B
30A
30B
35A
35B
37
40A
40A
45A
45B
50A
50B
52A
52B
57
EGRESS RESTRICTION MEANS
EGRESS RESTRICTION MEANS
INGRESS RESTRICTION MEANS
INGRESS RESTRICTION MEANS
SWITCHING TIMING MEANS

Fig. 9

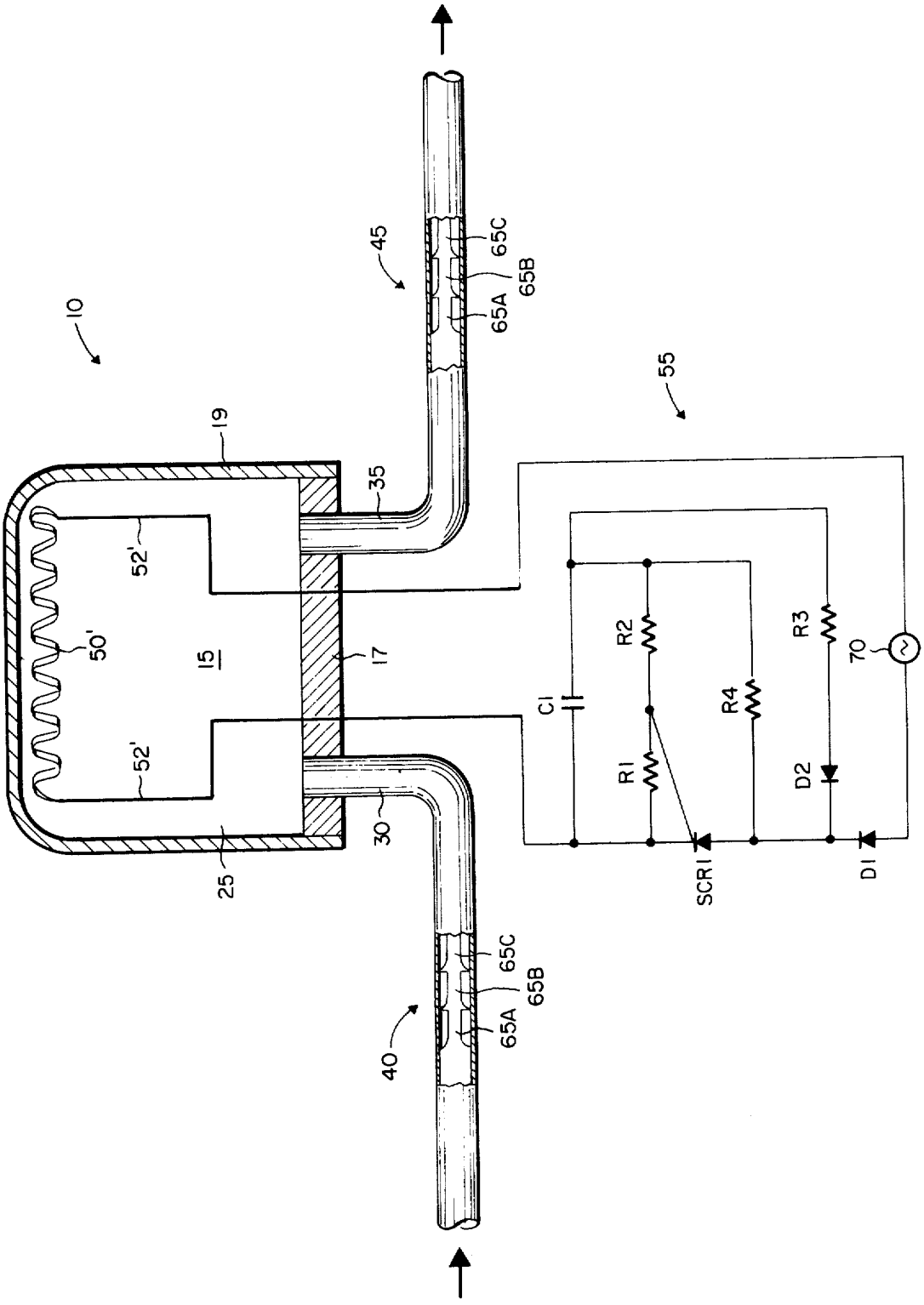

10
19
35
45
65C
65B
65A
55
52'
50'
15
17
52'
25
30
40
65C
65B
65A
C1
R2
R1
R4
R3
70
D2
SCR1
D1

Fig. 10

PUMP

BACKGROUND OF INVENTION

A. Field of Invention

This invention relates to the field of fluid pumps.

B. Description of Prior Art

Fluid pumps commonly in use are typically based on the use of a rotating device such as an impeller which must be bearing-mounted and driven by some motive means such as an electric motor.

While most such mechanical pumps are reasonably efficient in terms of power output v. power input, they uniformly suffer from the problem of wear of their moving parts. Furthermore, as in the case of all rotating and reciprocating machinery, mechanical pumps are noisy. In addition, because the substance pumped must pass through a mechanical structure of the pump, sealing of the pump and seal wear frequently create problems in operation. Finally, mechanical pumps are simply not adapted to transfer certain types of substances, such as blood, which cannot withstand the turbulence, mechanical stresses and the like inherent in such devices.

The use of a non-mechanical pump having no moving parts other than valves would virtually eliminate all these difficulties.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide a non-mechanical fluid pump requiring no moving parts except, in some embodiments, mechanical valves.

Briefly, the pump of the present invention comprises a substantially enclosed chamber having ingress and egress means for the substance being pumped thereby. Within the chamber is a gaseous substance which, in applications where the pump is adapted to transmit liquids, the gas occupies the space above the liquid within the chamber.

Within or external to the portion of the chamber containing the gas is a device for heating the gas, ordinarily a resistance device contained within the gas itself. Means are provided for selectively activating and de-activating the device. Activation, in the case of a resistance element, consists in sending a current through the element, whereby it generates heat, causing the gas to expand, forcing the substance to be pumped out through the egress means. The activation means ordinarily comprises an electrical timing/switching circuit in conjunction with a source of electrical energy, although other means could be used for controlling the operation of the heating device.

In the particular embodiments of the present invention, various means are provided to restrict upstream flow of the substance through the pump. In some embodiments, mechanical valves, such as ball-check valves or flapper valves, are utilized in the inlet and outlet ducting. In other embodiments constriction of the ducts in the downstream direction is employed for this purpose. In yet other embodiments the timing of the activation and de-activation periods of the heating elements plays an important role in furnishing the deisred restrictive effect.

The pumps may be utilized singly, in parallel or in series with other pumps (presumably of like design), and the heating device activation means may be adapted to sequence or otherwise synchronize the operations for the particular application desired.

DESCRIPTION OF THE DRAWING

FIG. **1** is a schematic, partially sectional, view of a pump according to the present invention.

FIG. **2** is a sectional view of a duct constriction.

FIG. **3** is a sectional view of a series of duct constrictions.

FIG. **4** is a schematic diagram of the pump of this invention, for a particular application, showing a particular embodiment of the means provided for restricting upstream flow of the gaseous substance being pumped.

FIG. **5** is an electrical circuit diagram of an embodiment of the present invention.

FIG. **6** is an electrical circuit diagram of another embodiment of the present invention.

FIG. **7** is a perspective view of a metallic ribbon resistance element employed in an embodiment of the invention.

FIG. **8** is a schematic, partially sectional view of a pump according to an alternative embodiment of the invention, wherein electromagnetic heating means, wholly external to the pump chamber is employed.

FIG. **9** is a schematic, partially sectional view of a double-chambered pump oriented so that the pump chambers operate in parallel, according to yet another embodiment of the invention.

FIG. **10** is a schematic, partially sectional, view of a single-chambered pump according to an embodiment of the present invention, incorporating features shown in FIGS. **1**, **3**, **5** and **7**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The "working chamber" of the preferred embodiment of the pump **10** of the present invention consists of a substantially enclosed chamber **15** having a base **17** and envelope **19**. While the chamber may be constructed of any reasonably substantial material, I have found that particularly satisfactory results may be obtained if the envelope **19** is constructed of glass and the base **17** consists of a rubber stopper, metallic cap or the like inserted into the lower portion of the envelope.

Chamber **15** contains a gaseous substance **25**. In the embodiments of this pump **10** which are adapted to transmit gaseous substances, such as air, this gas would, of course, be the substance being pumped. In embodiments where the pump is adapted to transmit liquids, the gas could be air or any other gaseous material which is reasonably inert with respect to the liquid **20** being pumped.

The substance being pumped enters the chamber **15** by means of ingress means **30**, which, in the case of the preferred embodiment of this invention, consists of a hollow tube or other duct inserted through the base **19** into the chamber. The substance is transferred from the pump through egress means **35**, which may be similar, in construction and relative disposition, to the ingress means **30**.

In order to restrict upstream flow of the substance being pumped, egress restriction means **40** and ingress restriction means **45** are provided. The nature of these means in the preferred embodiments of this invention will be more fully described below. Suffice to say at this juncture, that these means will insure that, for the most

part, the flow of the substance being pumped will be in the direction of the arrows shown in FIG. 1.

Within the chamber 15 of this embodiment of this invention, is a heating means 50. In the preferred embodiment, the heating means consists of a resistance heating element, such as a wire 50 (see FIG. 1) or ribbon 50' (see FIG. 7) of nickel, nichrome or any other of the various materials well known to those familiar with the art of resistance heating. It should be noted that the resistance means 50 is for the most part contained within the gaseous substance 25 contained within the chamber 15. Expansion of this gaseous substance by the heat radiated and conducted from the heating means 50 creates the forces which drive the substance being pumped from the chamber 15 through the egress means 35. Likewise, cooling of the gas within the chamber 15 creates a net pressure differential between the chamber and the ambient, causing a "replacement charge" of the material being pumped to be drawn through the ingress means 30 into the chamber 15.

Lead wires 52 from the heating means 50 project through the base 19 for electrical communication between the heating means and the timing/switching means 55. In the preferred embodiment of this invention in which the heating means 50 consists of a resistance heating element, the switching/timing means 55 consists of electrical circuitry which regulates the flow of electrical current from a source 60 to the heating element 50 through the lead wires 52. While purely mechanical switching/timing means could be employed in connection with the pump of this invention, purely electrical circuitry means are considered superior since they need contain no moving parts. Examples of specific electrical circuitry adapted for this purpose will be given below.

It should be noted that other means, some of which are external to the chamber 15, may be employed for heating the gas. Examples are means to create an electrical discharge through the gas, as in a neon tube, and means, external to the chamber, for generating electromagnetic energy directed at the gas, e.g., an infrared heat lamp 54 (see FIG. 8) or coils, lasers, and the like where the heat source is external to the chamber, it is preferable to place, within the upper region of the chamber, a heat absorbing structure, such as a metallic mesh 51, as shown in FIG. 8. Operation of all these devices may be controlled similarly to the resistance element 50, employed in the preferred embodiment of this invention.

Before specifying the exact nature of the egress restriction means 40, the ingress restriction means 45 and the switching/timing means 55 employed in the various preferred embodiments of the present invention, it is worthwhile to note the sequence of events comprising one complete cycle of operation of the pump 10. For the purpose of this example, it will be assumed that the substance being pumped is a liquid 20 operated on by atmospheric pressure and that the gaseous substance 25 filling the remainder of the chamber 15 is air and/or another gas. Those skilled in the art will note, however, that the steps are substantially identical in the case where it is air which is being pumped.

During the first step, the heating element 50 is deactivated and, as it cools, the surrounding gaseous substance 25 likewise cools. This creates a pressure differential between the interior of the chamber 15 and the ambient which, because of the operation of the ingress restriction means 45, causes additional water to be forced, by atmospheric pressure, through the ingress means (a duct) 30 into chamber 15.

During the remaining step, the switching/timing means 55 causes an electrical current to flow through one of the lead wires 52 into the heating element 50 causing the latter to radiate heat into the gas 25 surrounding it. This causes the gas to expand and, because of the operation of the egress restrictions means 40, causes the water 20 to be pumped through the egress means (another duct) 35.

Subsequent deactivation of the heating element 50 by the switching/timing means 55 causes a resumption of the first step.

Consideration will be now given to the nature of the various egress restriction means 40 and ingress restriction means 45 which may be utilized in connection with the pump of the present invention. It should be noted that the following are given only as examples of means which may be used. Doubtless, there are many others which might be utilized by those skilled in the art without departing from the spirit and scope of the present invention.

As a first example, either the egress restriction means 40 or the ingress restriction means s 45, or both, may be any sort of commonly used mechanical valve, for example, a ball-check valve, flapper valve or poppet valve having correct orientation with respect to the flow of material through the pump.

As a second example, either the egress restriction means 40 or the ingress restrictions means 45, or both, might consist of a tube constriction 65 in which the upstream diameter D1 is greater than the downstream diameter D2. As will be readily apparent to those skilled in the art and science of gaseous and fluid flow, such a constriction will promote the smooth flow of material in the direction of the arrow shown in FIG. 2 while restricting flow in the opposite or upstream direction, owing to the creation of turbulence resulting from the inherent viscosity of the material and similar factors. Such a constriction 65 may be used singly as shown in FIG. 2 or in series with other similar constrictions as shown in FIG. 3. The effect of this series of constrictions 65*a*, 65*b*, 65*c* is to compound the effect obtained from the use of a single constriction 65.

In the embodiment of the present invention wherein the substance being pumped is air drawn from the ambient which, upon pumping, is discharged into a liquid (such as water contained in a home aquarium), a third means may be employed to restrict upstream flow. As shown in FIG. 4, this means consists of providing an ingress means 30 consisting of an inlet duct having, at least somewhere, an internal cross-sectional area of rather small value; and providing an egress means 35 consisting of an outlet duct whose minimum internal cross-sectional area is greater than that of the inlet duct. In addition, the exit 39 of the outlet duct 35 is immersed in the liquid 64 contained within a container 62, the surface level of the liquid being below the entrance 37 of the outlet duct 35. Finally, the swtiching-/timing means is adapted to cause the periods of non-activation of the heating means to exceed the duration of periods of activation thereof.

To illustrate the operation of this latter embodiment, it will be assumed that the period of non-activation during each pump cycle is 10 seconds whereas, the period

of activation is only 1 second. Accordingly, for 10 seconds air is drawn into the chamber **15** of the pump **10** through the rather narrow inlet duct **30**. At the same time, the ambient pressure acting on the water **64** drives the water up through the outlet duct **35** toward its entrance **37**. However, because of the specific gravity of water, as compared with that of air, the level of the water within the outlet duct **35** does not reach its entrance **37**. During the short period of activation of the pump, the air is forcibly ejected from the chamber **15**. However, due to the fact that the minimum internal cross-sectional area of the outlet duct **35** exceeds that of the inlet duct **30** much more air is discharged through the outlet than through the inlet.

It can be immediately seen that this latter embodiment of the present invention is particularly adaptable for use in connection with aeration of home aquariums.

Having now described in detail the structural features of the various preferred embodiments of the present invention, attention will now be focussed on the electrical aspects thereof, specifically the switching/timing means **55**. It should be again noted at this juncture that mechanical means and electrical means other than those about to be described may be employed for this purpose without departing from the spirit and scope of the present invention. Such alternative means will doubtless be apparent to those skilled in the art to which this invention pertains.

FIG. **5** shows the circuit diagram of the switching-/timing means **55** utilized in the preferred embodiment of the present invention. There, the flow of current from a source of alternating current **70** to the pump **10** is regulated by the circuitry shown. In that circuitry D1 and D2 represents diodes; SCR1 represents a silicon controlled rectifier; **R1, R2,** R3 and R4 represent resistors; and C1 represents a capacitor. The cycle time of the pump increases as the value of resistor R2 or capacitor C1 increases; the duration of activation of the heating element **50** within each cycle increases with the increase of the value of resistor R3 or capacitor C1. In particular, I have found that highly satisfactory results and a cycle time of approximately 2 seconds (which varies somewhat with the characteristics of the particular SCR) can be obtained if the values are set as follows:

R1 = 33,000 ohmns
R2 = 500,000 ohmns
R3 = 500 ohmns
R4 = 50,000 ohmns
C1 = 100 microfarad.

In any event, in the preferred embodiment of the present invention the timing and switching means causes current to flow from the current source through the resistance heating element **50** at specified times and for specified durations depending on the nature of the circuitry employed and the specific values of the circuit components incorporated therein. In particular, with circuitry as shown in FIG. **5**, each cycle of the pump is of substantially constant duration, both the activation periods and non-activation periods thereof being likewise substantially constant. With circuit components having the values given above, the non-activation period within each cycle exceeds the activation period.

For optimum results, the structural aspects should be "tuned" to the various time constants of the circuitry. I. e., the internal cross-sectional areas of the inlet duct **30** and outlet duct **35**, the volume of the chamber **15** and the nature of the heating means **50** can be adjusted so that a maximum amount of material can be drawn into the chamber **15** during the deactivation period of heating element **50** and pumped out during the activation period thereof. This will require only a small amount of optimization, well within the skill of those familiar with this art. It should be noted, in addition, that this adjustment is only required if the efficiency of the pump is to be maximized, since satisfactory results may be obtained almost without regard to the exact values of the quantities.

For some applications, it is desirable to employ a pump having more than one chamber **15** and associated ingress means **30** and egress means **35**. For example, a pump may be constructed according to the present invention having two such chambers in series or in parallel (see FIG. **9**). This may be easily visualized by reference to FIG. **9**.

For series applications, the egress means **35** of the first chamber **15** would constitute the ingress means **30** of the second chamber **15**. The switching/timing means **55** would be adjusted so that during a single cycle of the pump operation, material would be drawn into the first chamber then pumped into the second chamber then pumped out of the second chamber. Modification of the circuitry shown in FIG. **5** and otherwise described above to accomplish this is well within the skill of an ordinary electronic engineer. Such a series pump would most likely be employed in applications where increased pressure at the outlet were desired.

Another example of a double-chambered pump according to the present invention is one where the two chambers **15A, 15B** are adapted to operate in parallel as shown in FIG. **9**, i.e., where the egress means **35A, 35B** of both chambers transmit material to a single commercial outlet **37** or other user facility. Such an arrangement would have at least two general applications. First, it could be used to pump two different materials from different sources into a single line for mixing. Second, it could be used to pump the same material from a single source, in which case the timing/-switching means could be adapted to provide alternate pumping and, therefore, a more continuous discharge flow.

For the first of these two applications, the basic pump **10** shown in FIG. **1** would be used in duplicate a as dual elements **10A, 10B**, as shown in FIG. **9** and the two egress means **35A, 35B** would be fed into a single line **37**. The switching/timing means **55** of each "pump element" could be entirely independent or, preferably, could be a single means **57** operating both heating elements **50A, 50B**.

In the second of these application, the two elements would be functionally related in a similar manner, however, the switching/timing means **55** would have to be adjusted so that the activation of the heating elements **50A, 50B** would be alternated. The circuit shown in FIG. **6** accomplishes just this result. Here, the flow of current from alternating current source **70***a* to the two pump elements **10***a*, **10***b* is regulated. In FIG. **6**, SCR1*a* and SCR1*b* represent silicon-controlled rectifiers; R1*a*, R1*b*, R5*a* and R5*b* represent resistors; D2 represents a diode; C2 and C3 represent capacitors; and N1 and N2 represent neon discharge tubes. Using circuit elements having the values given below, the switching/timing means **57** will operate the two pump elements **10***a*, 10*b* in alternate fashion, each heating element **50** (*a* or *b*)

being activated during one-half the cycle duration of the overall pump;

R1*a* = 33,000 ohmns
R1*b* = 33,000 ohmns
R5*a* = 2.2 million ohmns
R5*b* = 2.2 million ohmns
C2 = 0.1 microfarad
C3 = 1 microfarad

It can easily be seen that any number of pump elements may be employed, each pair of pump elements within any particular grouping (or, indeed, the totality) being in parallel or in series. This only requires that the various ingress means **30** and egress means **35** be caused to be in the particular materialtransmissive communication to accomplish the desired pumping result, and that the switching/timing means **55** be appropriately modified to regulate the activation and deactivation of the heating elements **50** of the various pump elements, the latter being well within the capability of the ordinary skilled electronic engineer.

In particular, a multiple-element pump of the type described above may be designed in such a manner as to operate in parallel with each heating element **50** activated once within each overall pump cycle (i.e., sequentially). whereby a pump having particularly smooth and continuous flow is achieved. Likewise, such a pump may be fashioned to operate in series, whereby the pressure of the final discharge may be made quite large, owing to the compounding of the effects of the pump elements in the series. In either case, the elements may easily be adapted to operate sequentially or wholly or partially simultaneously, by appropriate modification of the activation control (switching/timing) means. The duration of operation of each element during each cycle and the cycle time (in effect, the elapsed time between successive occurrences of the same overall pump activation/de-activation configuration) of the pump may be similarly adjusted.

It might be noted, in passing, that the single-chambered pump **10** of the preferred embodiment of the present invention is actually a metering pump. I. e., incorporation of the switching/timing circuitry shown in FIG. **5** insures that the pump cycle time and the heating element "on" time (within each cycle) will each be substantially constant. This, in turn, insures that the quantity of heat introduced into the gas **25** within the chamber **15** during each pump cycle will also be substantially constant, resulting in the fact that the amount of gas expansion during each cycle will be substantially constant. Accordingly, the quantity of material pumped during each cycle will likewise be substantially constant. By substituting a rheostat for the fixed resistor R_3, the valve of this constant may be selected at will, and the quantity of material pumped per cycle (or, indeed, per unit time) may be adjusted as desired.

Similarly, the multiple-chambered embodiments of this invention may be likewise adapted for metering applications.

I claim:

1. A pump, comprising: a substantially enclosed chamber containing a gaseous substance, said chamber having ingress and egress means for the fluid to be pumped thereby;

means to restrict ingress through said egress means;

means to restrict egress through said ingress means;

means within said chamber including a metallic ribbon which upon the passage of electrical current there through will become activated to heat the gaseous substance contained in said chamber, said heating means adapted, upon activation thereof, to heat substantially only that portion of the gaseous substance which is sufficiently displaced from that fluid to be pumped so that the temperature of the fluid will remain substantially unaffected by said activation; and

means to intermittently provide electrical current flow through said ribbon to activate said heating means.

2. A pump comprising: a substantially enclosed chamber containing a gaseous substance, said chamber having ingress and egress means for the fluid to be pumped thereby;

means in said egress means to restrict ingress through said egress means including a tube, at least a portion of which has a progressively decreasing internal cross-sectional area along the direction away from the interior of said chamber;

means to restrict egress through said ingress means;

means to heat the gaseous substance contained in said chamber, said heating means adapted, upon activation thereof, to heat substantially only that portion of the gaseous substance which is sufficiently displaced from the fluid to be pumped so that the temperature of the fluid will remain substantially unaffected by said activation; and

means to intermittently activate said heating means.

3. A pump, comprising: a substantially enclosed chamber containing a gaseous substance, said chamber having ingress and egress means for the fluid to be pumped thereby;

means to restrict ingress through said egress means;

means in said ingress means to restrict egress through said ingress means including a tube, at least a portion of which has a progressively decreasing internal cross-sectional area along the direction toward the interior of said chamber;

means to heat the gaseous substance contained in said chamber, said heating means adapted, upon activation thereof, to heat substantially only that portion of the gaseous substance which is sufficiently displaced from the fluid to be pumped so that the temperature of the fluid will remain substantially unaffected by said activation; and

means to intermittently activate said heating means.

4. Pump as in claim **2**, wherein a plurality of said tubes is provided in series.

5. Pump as in claim **3**, wherein a plurality of said tube is provided in series.

* * * * *