May 10, 1966 J. F. TAPLIN 3,250,225
MECHANICAL SYSTEM COMPRISING FEED
PUMP HAVING A ROLLING DIAPHRAGM
Filed July 13, 1964 3 Sheets-Sheet 1

FIG. 3.

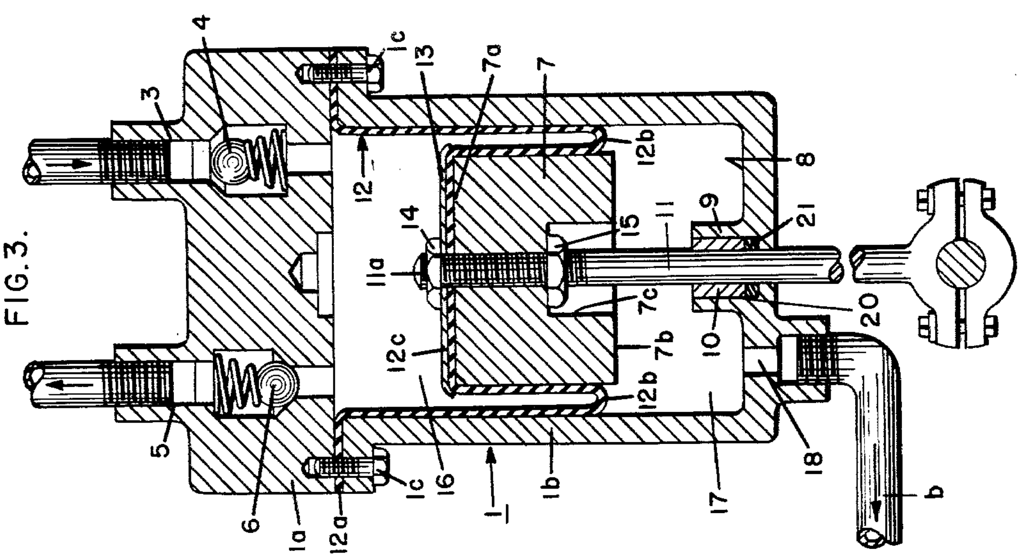


FIG. 1.

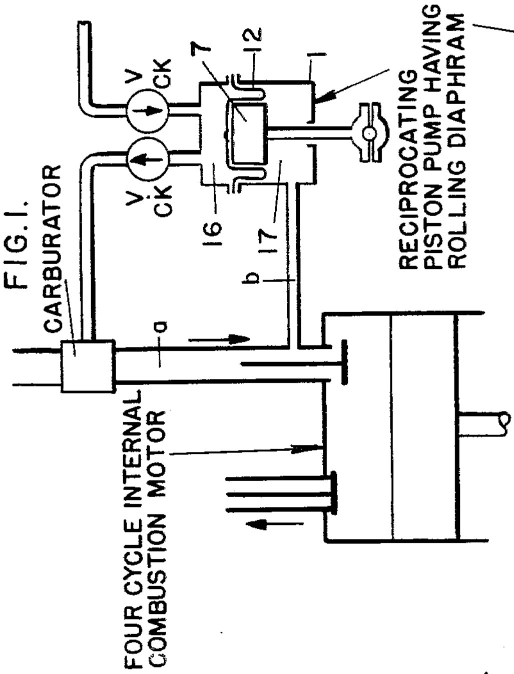
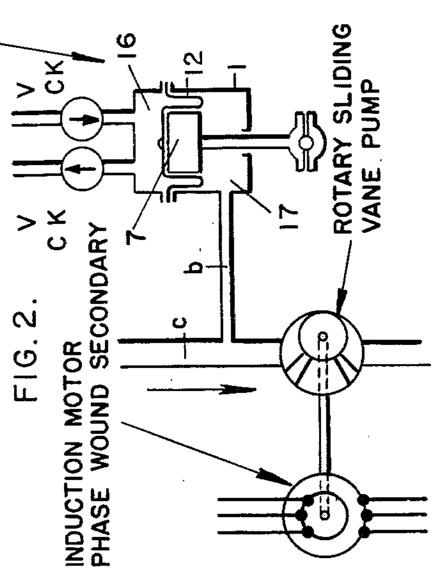


FIG. 2.



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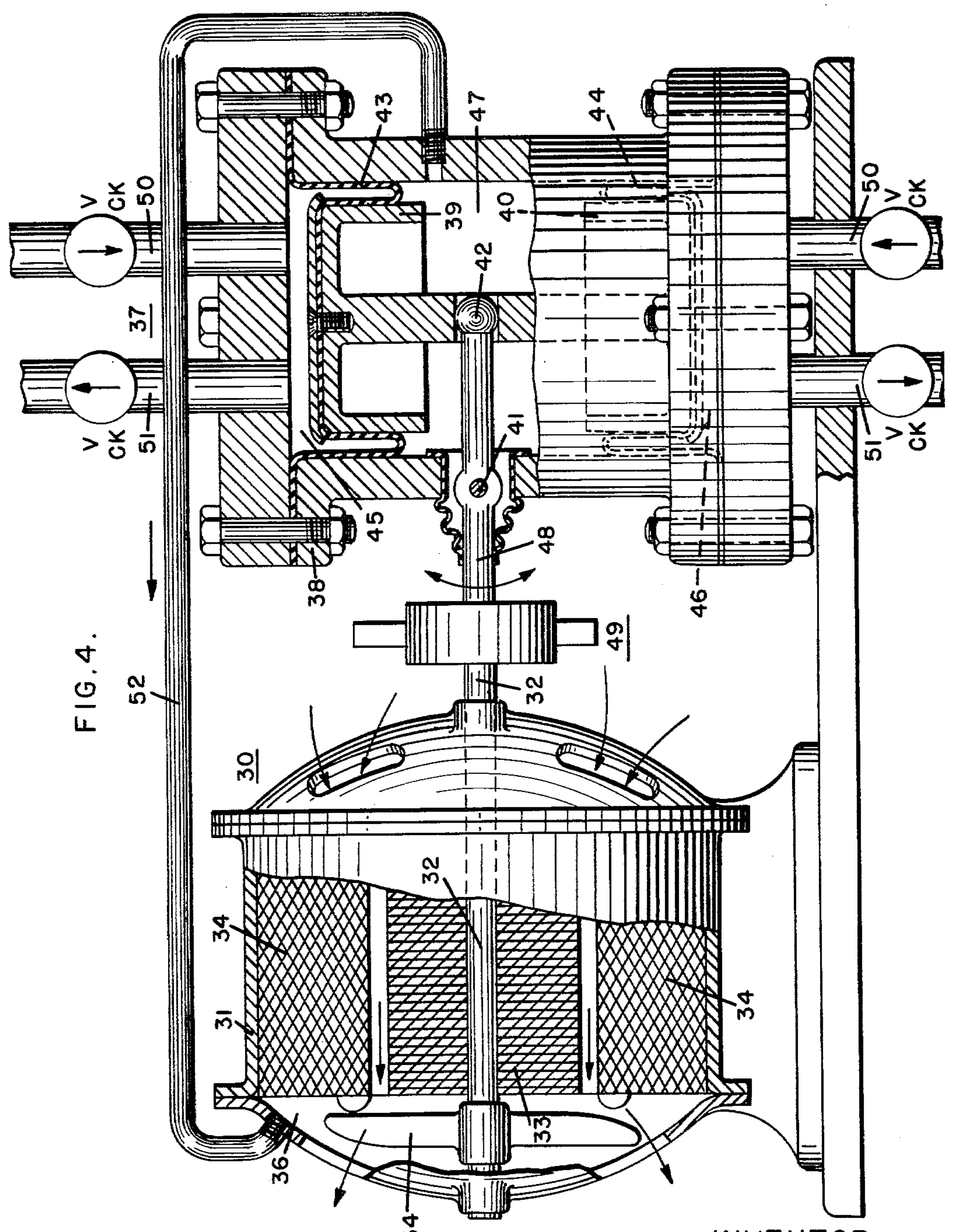

FIG. 4.

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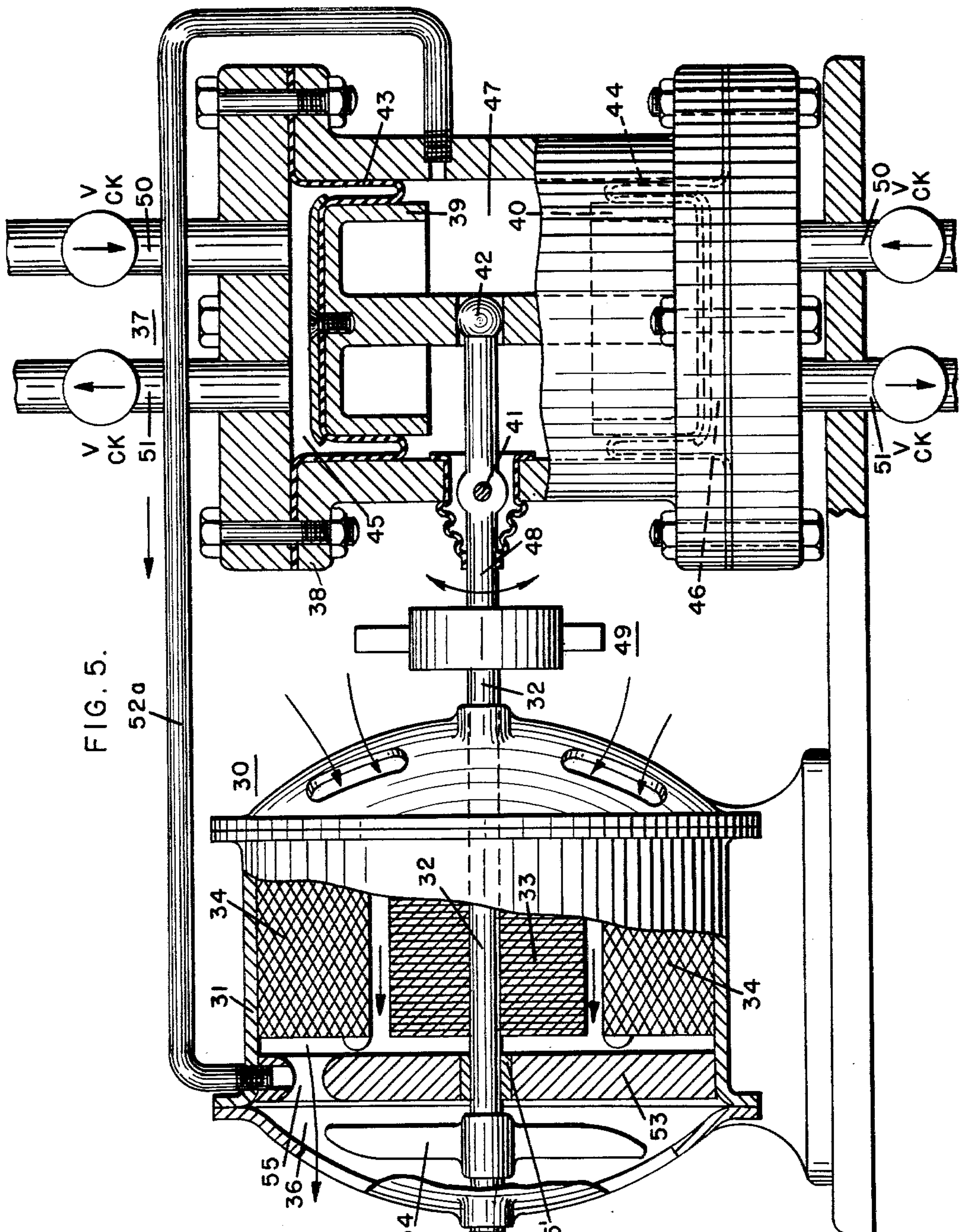

FIG. 5.

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United States Patent Office

3,250,225
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3,250,225

MECHANICAL SYSTEM COMPRISING FEED PUMP HAVING A ROLLING DIAPHRAGM

John F. Taplin, 15 Sewall St., West Newton, Mass.

Filed July 13, 1964, Ser. No. 381,986
2 Claims. (Cl. 103—152)

This application is a continuation-in-part of my copending patent application Ser. No. 341,889, filed February 3, 1964, for Piston Pump Having Rolling Diaphragm, disclosing means for precluding pressure reversal. The present invention is concerned with means other than those disclosed in my aforementioned patent application for evacuating the inactive chamber of a piston pump having a rolling diaphragm.

This invention is concerned with mechanical systems including piston pumps having rolling diaphragms.

The rolling diaphragm of piston pumps of the aforementioned description has a radially outer fixed portion clamped to the cylinder of the pump and a radially inner portion which is secured to the top of the piston of the pump. The rolling diaphragm further includes an intermediate portion known as the rolling wall thereof. During the suction stroke of the piston pump the rolling wall of the diaphragm rolls off the piston side wall onto the cylinder side wall. Thereafter during the compression stroke of the piston pump the rolling wall performs a reverse movement, i.e. it rolls off the side wall of the cylinder onto the side wall of the piston. The rolling diaphragm of such a piston pump subdivides the cylinder into two chambers. One of these two chambers is the pump chamber into which a gas or liquid is sucked during the suction stroke of the piston pump, and out of which the gas or liquid is pressed during the following compression stroke of the piston of the pump. The other of the two chambers into which the cylinder is subdivided by the rolling diaphragm may be referred to as the inactive chamber since the gas or liquid to be moved by the pump never enters into that chamber.

In order for a piston pump having a rolling diaphragm to properly perform, the pressure in the pump chamber must always exceed the pressure in the inactive chamber. The term pressure reversal refers to a condition wherein the pressure in the inactive chamber exceeds the pressure in the pump chamber. Pressure reversal may result in a collapse of the rolling diaphragm which, in turn, renders the pump inoperative.

It is, therefore, a principal object of this invention to provide mechanical systems including reciprocating piston pumps having rolling diaphragms which pumps are not subject to pressure reversal and to collapse of their diaphragm.

In a piston pump having a rolling diaphragm wherein the inactive chamber is freely vented the degree of pressure-build-up in the inactive chamber depends upon the size of the latter, the velocity of the reciprocating movement of the piston, the area of the venting or air dumping orifice, etc. One or more of these parameters may unavoidably or necessarily be such as to establish a tendency of pressure reversal and collapse of the rolling diaphragm.

It is, therefore, another object of the invention to provide mechanical systems including piston pumps having rolling diaphragms which pumps depart from the heretofore adhered-to principle of freely venting the inactive chamber to atmosphere, and wherein safer and more effective means are used for precluding pressure reversal and collapse of the rolling diaphragm.

Piston pumps having rolling diaphragms are frequently used in mechanical systems including motor means adapted to establish an evacuated space. In such systems pressure reversal and consequent collapse of the rolling diaphragm of a piston pump can be effectively precluded by providing a duct means connecting the evacuated space with the inactive chamber of the piston pump, thus maintaining the same vacuum in the inactive chamber as in the evacuated space.

The foregoing and other general and special objects of the invention and advantages thereof will more clearly appear from the ensuing description of the invention, as illustrated in the accompanying drawings, wherein

FIG. 1 is a diagrammatic representation of a mechanical system embodying the present invention;

FIG. 2 is a diagrammatic representation of another mechanical system embodying the present invention;

FIG. 3 is a vertical section through a piston pump of the kind diagrammatically shown in FIGS. 1 and 2;

FIG. 4 is partly a side elevation and partly a vertical section of a motor-pump-unit embodying this invention; and

FIG. 5 is an illustration similar to FIG. 4 of a modification of the structure of FIG. 4.

Referring now to the drawings, and more particularly to FIG. 1 thereof, the mechanical system shown therein comprises a four cycle internal combustion engine having a carburator and a reciprocating piston pump for supplying fuel to the carburator. These constituent parts of the system of FIG. 1 have been labelled therein. The piston of the internal combustion motor establishes a vacuum, i.e. a region of lower pressure than atmospheric pressure, in the manifold *a*. The reciprocating feed pump comprises a cylinder body **1**, a rolling diaphragm **12** having a radially outer portion secured to cylinder body **1**, an intermediate rolling wall and a radially inner portion secured to piston **7** and subdividing the interior of cylinder body **1** into a pump chamber **16** and an inactive chamber **17**. A duct means *b* such as, for instance, a pipe or a length of tubing connects the manifold *a* to inactive chamber **17** of the feed pump to maintain in said chamber **17** the same vacuum, or degree of reduced pressure, as in manifold *a*. Thus the internal combustion engine coacts with the feed pump to preclude pressure reversal and collapse of its rolling diaphragm.

The same arrangement as shown in FIG. 1 to prevent collapse of a rolling diaphragm of a fuel pump might also be used to prevent collapse of the rolling diaphragm of a supercharger pump.

Referring now to FIG. 2, the mechanical system shown therein comprises an electric motor driving a rotary pump, e.g. a phase wound induction motor driving a rotary sliding vane pump establishing a low pressure region in duct *c*. Duct *b* connects duct *c* and the inactive chamber **17** of a piston pump including cylinder body **1**, a rolling diaphragm **12** and a piston **7**. The rolling diaphragm **12** separates the pump chamber **16** from the inactive chamber **17**.

Arrangements of the kind shown in FIG. 2 have many applications. The rotary pump, for instance, may produce the vacuum required for operating a milking machine and the piston pump may be used to feed the milk from one point to another. Both pumps coact in a novel way, the rotary pump precluding pressure reversal in, and collapse of the diaphragm of, the piston pump.

Referring now to FIG. 3 of the drawings showing the structural details of the piston pump, reference numeral **1** has been applied to generally indicate a cylinder body comprising an upper cylinder body portion **1a** and a lower cylinder body portion **1b** held together by screws **1c**. The aforementioned cylinder body portions **1a**, **1b** may be formed, for instance, of aluminum castings. The upper portion **1a** of the cylinder body **1** defines a suction inlet **3** including a spring biased inlet check valve **4** and a pressure outlet **5** including a spring biased outlet check valve **6**. Reciprocating piston **7** is arranged inside of cylinder body **1** and has a top surface *7a* and a bottom surface *7b*. The lower portion *1b* of cylinder body **1** defines an internal bottom surface **8** which includes an upstanding collar **9** arranged in coaxial relation to, and inside of, cylinder body **1**. Collar **9** accommodates a slide bearing **10** guiding a piston rod **11** secured to piston **7**. The bottom surface *7b* of piston **7** has a cylindrical recess *7c* adapted to receive collar **9** when piston **7** is in its lowest position, i.e. is completing the suction stroke thereof. Speaking more generally, the bottom surface *7b* of piston **7** is shaped to conform substantially with the internal bottom surface **8** of cylinder body **1**. Reference numeral **12** has been applied to generally indicate a rolling diaphragm made of a woven fabric impregnated with an appropriate elastomer. Rolling diaphragm **12** includes a radially outer portion *12a* clamped between portions *1a*, *1b* of cylinder body **1**, an intermediate rolling wall *12b*, and a radially inner portion *12c* secured to the top surface *7a* of piston **7**. To this end the radially inner portion *12c* of rolling diaphragm **12** is covered by a clamping plate **13** screwed against the top surface *7a* of piston **7** by means of nut **14** riding on the screw-threaded top end *11a* of piston rod **11**. Screw-nut **15** is arranged inside of the center recess *7c* of piston **7** and clamps the latter against the radially inner portion *12c* of rolling diaphragm **12** and against clamping plate **13**. Rolling diaphragm **12** subdivides the interior of cylinder body **1** into the upper pump chamber **16** and a lower chamber **17** referred to as the inactive chamber. The lower portion *1b* of cylinder body **1** defines a duct **18** connecting inactive chamber **17** with evacuating pipe *b* described more in detail in connection with FIGS. 1 and 2. The lower portion *1b* of cylinder body **1** is provided with a circular groove **20** receiving a so-called O-ring **21**, or an equivalent annular elastic seal surrounding piston rod **11**. Seal **21** limits the inflow of air into inactive chamber **17** and thus makes it possible to maintain therein a pressure lower than atmospheric pressure.

When piston **7** is moved downward by motor means (not shown in FIG. 3) operating piston rod **11**, i.e. during the suction stroke of piston **7**, liquid enters through suction inlet **3** into pump chamber **16** as indicated by an arrow until the latter chamber is filled with liquid. Upon reversal of the motion of piston **7**, i.e. during the compression stroke thereof, liquid contained in pump chamber **16** is expelled out of it through pressure outlet **5** and check valve **6**. The pressure in inactive chamber **17** is always maintained below the pressure in pump chamber **16**, this being due to the fact that the pressure in the manifold *c* of FIG. 1 and in the suction duct *c* of FIG. 2 is always lower than atmospheric pressure. Thus the air in inactive chamber **17** is rarified and the pressure of air in chamber **17** is maintained at any point of time below the pressure prevailing in pump chamber **16**. In other words, the so-called pressure reversal condition is effectively precluded, thus preventing collapse of the rolling diaphragm **12**.

Because of the geometry or configuration of the surface *7a* of piston **7** and that of the juxtaposed surface **8** of cylinder body **1** the volume of chamber **17** at the end of the downward stroke of piston **7** is minimized. Consequently the amount of residual air remaining in chamber **17** at the end of each downward stroke of piston **7** is likewise minimized. This, in turn, makes it relatively easy to establish a relatively high vacuum in inactive chamber **17**.

The entire volume of piston **7** consists of a homogenous mass, e.g. aluminum. In other words, piston **7** is not hollow, and this precludes air contained in chamber **17** from entering into the piston **7**, being temporarily trapped therein and later, when discharged from piston **7**, to degrade the relative vacuum prevailing in chamber **17**.

The pressure reversal preventing means diagrammatically shown in FIGS. 1 and 2 and described in connection therewith lend themselves particularly well to be applied in existing systems originally not designed with the problem of precluding pressure reversal in mind. Venting or evacuating ducts *c* may be installed in such systems as additions thereto. This duct may consist of a flexible hose of an elastomeric substance which can generally be installed even in cases where most severe space limitations prevail.

In the structure of FIGS. 1 and 2 the reciprocating piston pump may be driven by the internal combustion motor, or the electric induction motor, respectively. There is then a dual functional relationship between the motor and the piston pump, namely a torque-transmitting relationship and a pneumatic relationship, the latter serving the purpose of precluding pressure reversal and collapse of the rolling diaphragm of the piston pump.

FIGS. 4 and 5 illustrate diagrammatically motor-piston-pump units which are predicated upon the aforementioned dual functional relationship.

Shown at the left of FIGS. 4 and 5 is an electric motor generally designated by reference character **30**. Motor **30** includes a housing **31**, a rotatable shaft **32** supporting rotor **33** and a stator **34**. Motor **30** may, for instance, have a squirrel-cage-wound rotor **33** and a stator energized by a three phase A.C. circuit. Mounted on the shaft **32** is a suction fan **54** establishing a flow of air for cooling motor **30**. The flow of air enters motor **30** at the right and leaves motor **30** at the left side thereof as seen in FIGS. 4 and 5. The air flows through a passageway inside of housing **31** generally defined by the geometry of rotor **33** and stator **34**. Numeral **36** has been applied in FIG. 4 to indicate a space inside of housing **31** where air velocity is relatively high and air pressure relatively low. Motor **30** operates a piston pump generally indicated by reference character **37**. Piston pump **37** comprises a cylinder body **38** housing a pair of tandem operated pistons, namely an upper piston **39** and a lower piston **40**. Pistons **39** and **40** are operated by a common reciprocating drive lever **48** fulcrumed at **41** and pivotally connected at **42** to the composite piston structure **39, 40**. Reference numerals **43** and **44** have been applied to indicate a pair of rolling diaphragms. Each rolling diaphragm has a radially outer flange attached to cylinder body **38**, a radially inner flange attached to the end surface of one of the pistons **39, 40** and an intermediate rolling wall arranged in the annular gap defined by cylinder body **38** and pistons **39, 40**. Rolling diaphragms **43, 44** subdivide the interior of cylinder body **38** in a pair of pump chambers **45, 46** and an inactive chamber **47**. Drive lever **48** is operated by motor shaft **32** by the intermediary of a transmission generally indicated at **49** for converting the rotary motion of shaft **32** into the oscillatory motion of drive lever **48**. Transmission **49** may, for instance, be formed by a cam and a slotted slide bar. Pump chambers **45, 46** are provided with inlet ducts **50** and outlet ducts **51** of which each is under control of an appropriate check valve.

Referring now particularly to FIG. 4, duct **52** connects space **36** where the air velocity is relatively high and the air pressure relatively low with inactive chamber **47** to evacuate the latter by the action of fan **54**, thus precluding pressure reversal in pump **37** and collapse of rolling diaphragms **43, 44**.

Referring now to FIG. 5, the structure shown therein is generally similar to that shown in FIG. 4 and the same reference characters have been applied in both figures to indicate like parts. The electric motor **30** of the structure of FIG. 5 includes a barrier of partition **53** defining a venturi tube **55**. Shaft **32** projects transversely across partition **53** and the latter is provided with a seal or gland **55'** for the passage of shaft **32**. Venturi tube **55** includes an upstream portion and a downstream portion both having a relatively large cross-sectional area. Venturi tube **55** further includes an intermediate portion having a relatively small cross-sectional area. Duct **52a** connects a point of said intermediate portion of venturi tube **55** to inactive chamber **47** of pump **37** to evacuate chamber **47** by the joint action of fan **54** and venturi tube **55**. Thus pressure reversal and collapse of rolling diaphragms **43** and **44** is effectively precluded.

While this invention is not limited to systems having piston pumps having any particular kind of rolling diaphragm, best results will be achieved by using piston pumps having a rolling diaphragm made in accordance with the teachings set forth in United States Patents 2,849,026 to John F. Taplin, issued on Aug. 26, 1958, for Flexible Fluid Sealing Diaphragm.

While, in accordance with the patent statutes, I have disclosed the specific details of four embodiments of my invention, it is to be understood that these details are merely illustrative and that many variations thereof may be made without departing from the spirit and scope of the invention. It is, therefore, my desire that the language of the accompanying claims shall be accorded the broadest reasonable construction, and shall be limited only by what is expressly stated therein, and by the prior art.

I claim as my invention:

1. A mechanical system comprising in combination:

(a) an electric motor including a housing and a rotatable shaft;

(b) a fan for cooling said motor mounted on said shaft;

(c) air passage means inside said housing for a current of air established by said fan, said air passage means including a space where air velocity is relatively high and air pressure relatively low;

(d) a reciprocating piston pump driven by said electric motor, said pump including a cylinder body, a piston, and a rolling diaphragm having a radially outer portion secured to said cylinder body, an intermediate rolling wall and a radially inner portion

secured to said piston and subdividing the interior of said cylinder body into a pump chamber and an inactive chamber; and

(e) duct means connecting a point of said space where air velocity is relatively high and air pressure relatively low with said inactive chamber to evacuate said inactive chamber by the action of said fan.

2. A mechanical system comprising in combination:

(a) an electric motor including a housing and a rotatable shaft;

(b) a fan for cooling said motor mounted on said shaft;

(c) air passage means inside said housing for a current of air established by said fan, said air passage means including a venturi tube having an upstream portion and a downstream portion both of relatively large cross-sectional area and having an intermediate portion of relatively small cross-sectional area;

(d) a reciprocating piston pump driven by said electric motor; said pump including a cylinder body, a piston, and a rolling diaphragm having a radially outer portion secured to said cylinder body, an intermediate rolling wall and a radially inner portion secured to said piston and subdividing the interior of said cylinder body into a pump chamber and an inactive chamber; and

(e) duct means connecting a point of said intermediate portion of said venturi tube to said inactive chamber to evacuate said inactive chamber by the joint action of said fan and of said venturi tube.

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