May 26, 1970 W. E. RUPP 3,514,227

PUMP

Filed Feb. 14, 1968 9 Sheets-Sheet 1

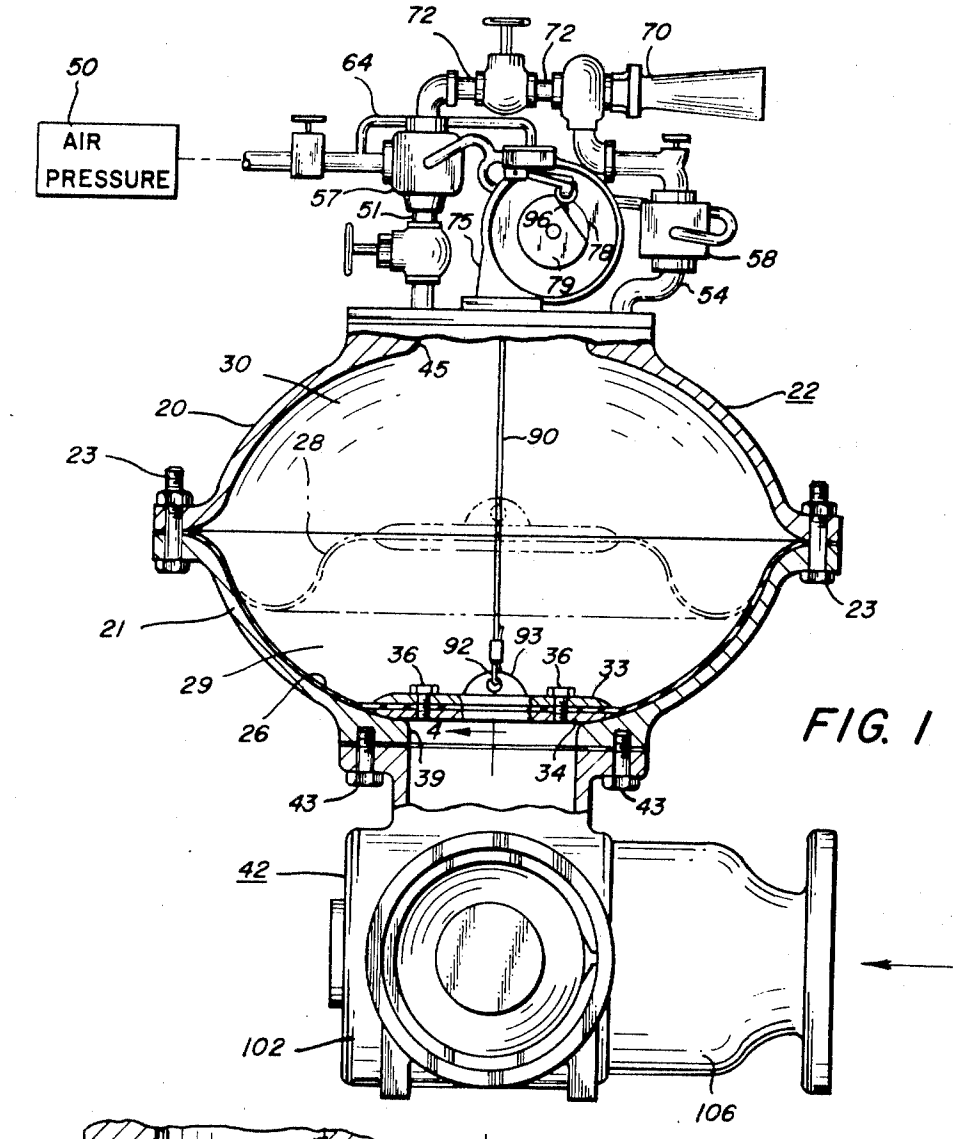


FIG. 1

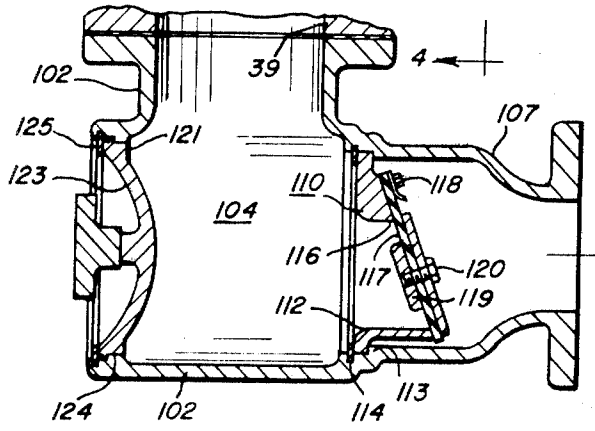


FIG. 4

INVENTOR.
WARREN E. RUPP
BY
Woodling, Krost, Granger & Rust
Attys.

May 26, 1970 W. E. RUPP 3,514,227

PUMP

Filed Feb. 14, 1968 9 Sheets-Sheet 2

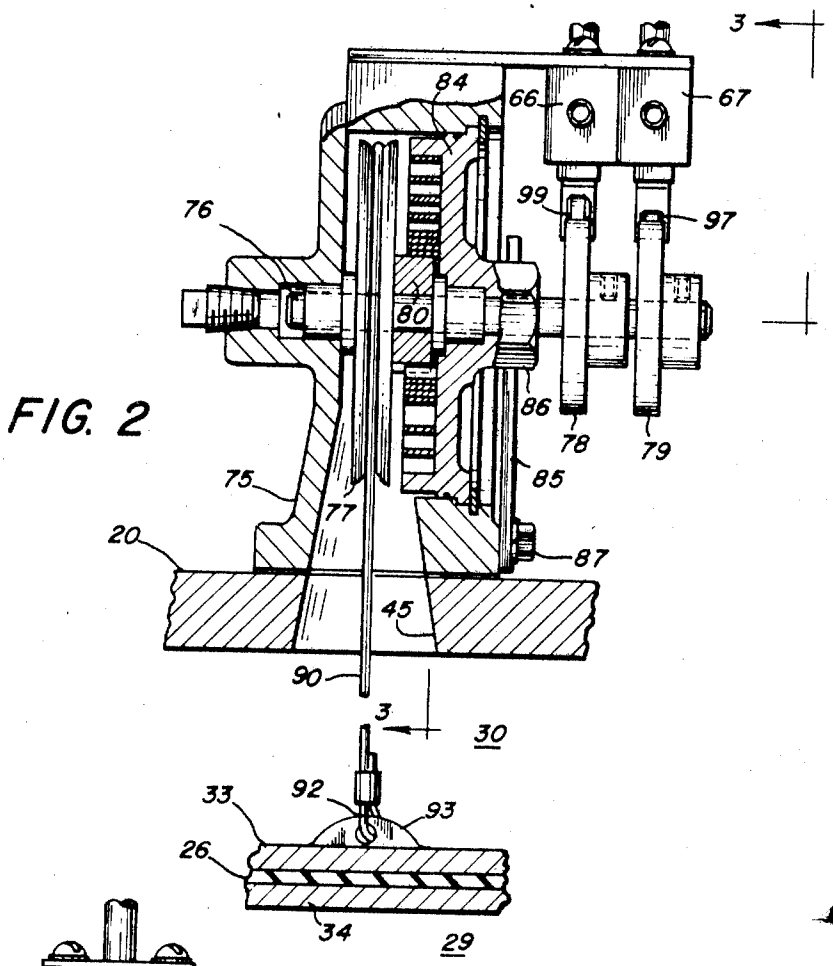


FIG. 2

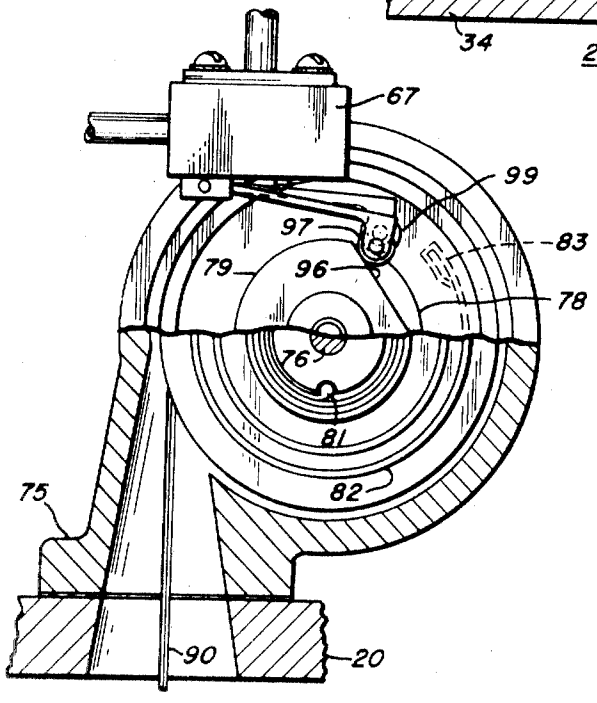


FIG. 3

INVENTOR.
WARREN E. RUPP
BY
Woodling, Krost, Granger & Rust
Attys.

May 26, 1970 W. E. RUPP 3,514,227

PUMP

Filed Feb. 14, 1968 9 Sheets-Sheet 3

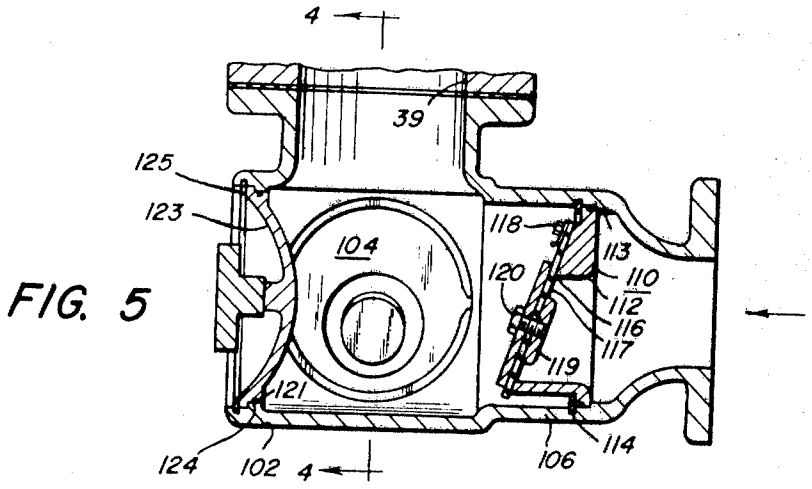


FIG. 5

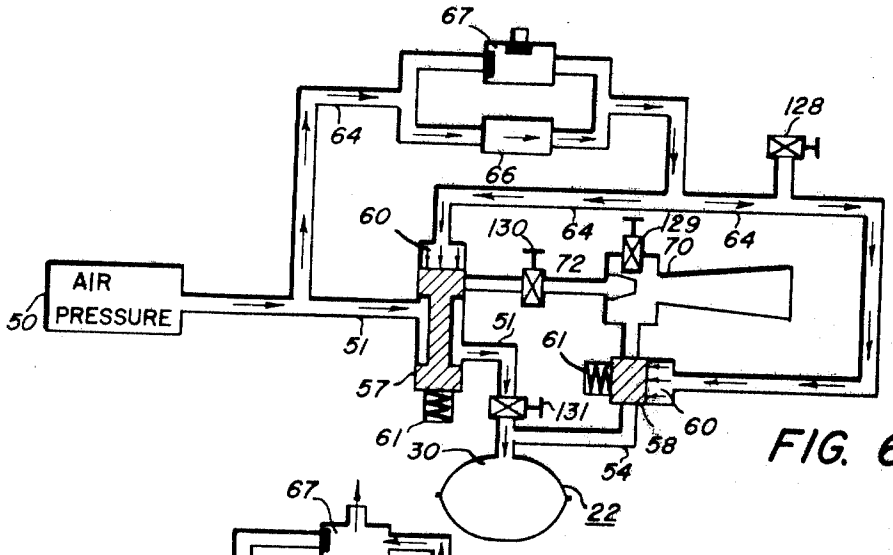


FIG. 6

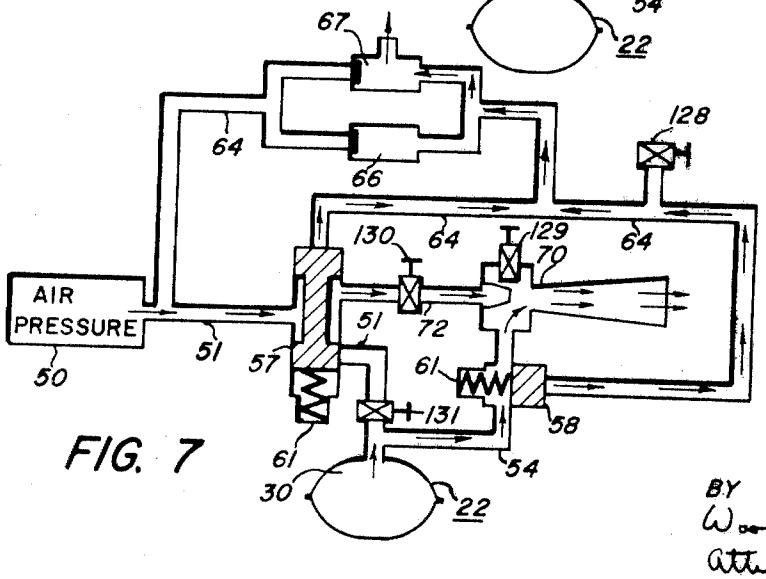


FIG. 7

INVENTOR.
WARREN E. RUPP

BY
Woodling Krost Granger Rust
Attys

May 26, 1970 W. E. RUPP 3,514,227

PUMP

Filed Feb. 14, 1968 9 Sheets-Sheet 4

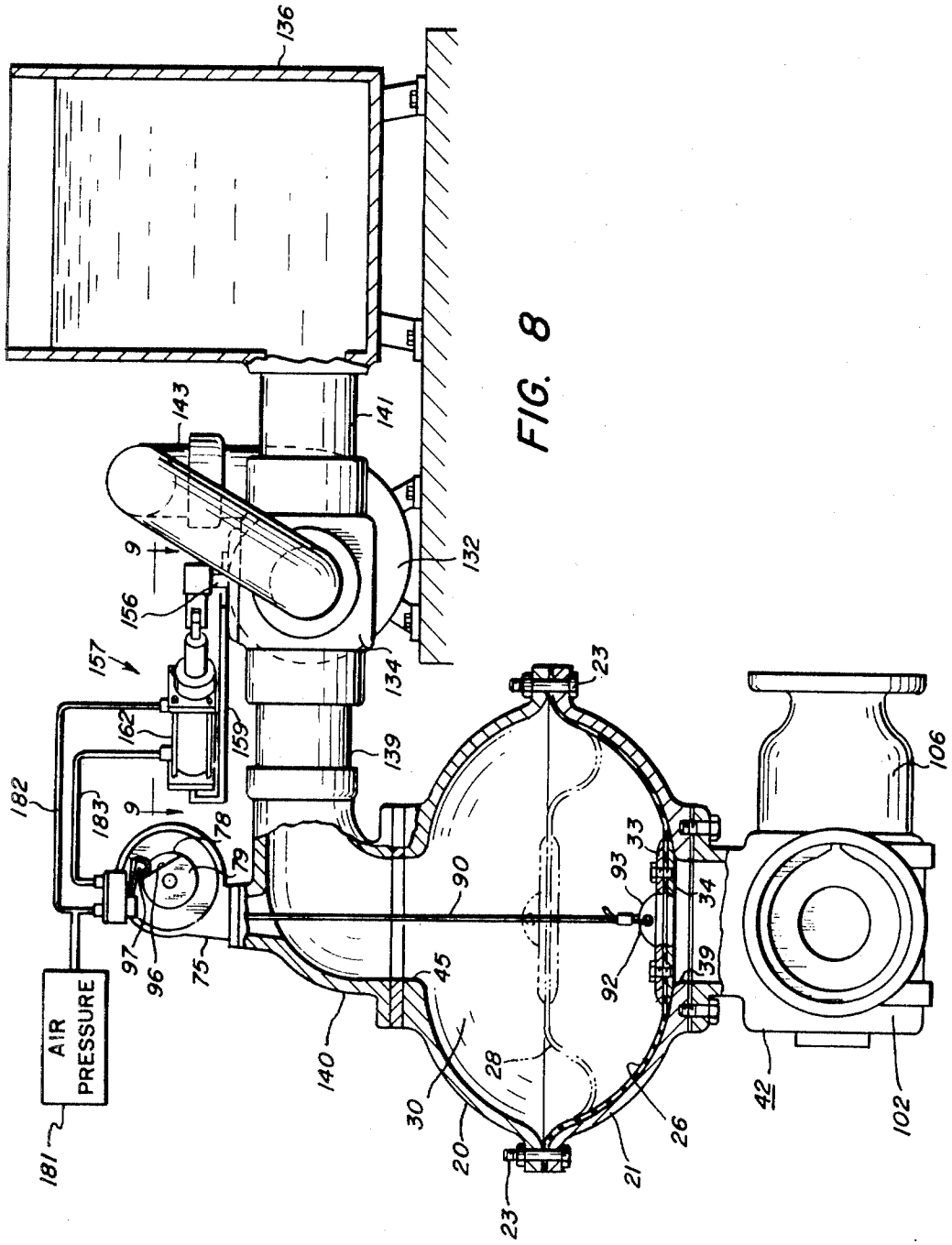


FIG. 8

INVENTOR.
WARREN E. RUPP

BY
Woodling, Krost, Granger & Rust
Attys

May 26, 1970 W. E. RUPP 3,514,227

PUMP

Filed Feb. 14, 1968 9 Sheets-Sheet 5

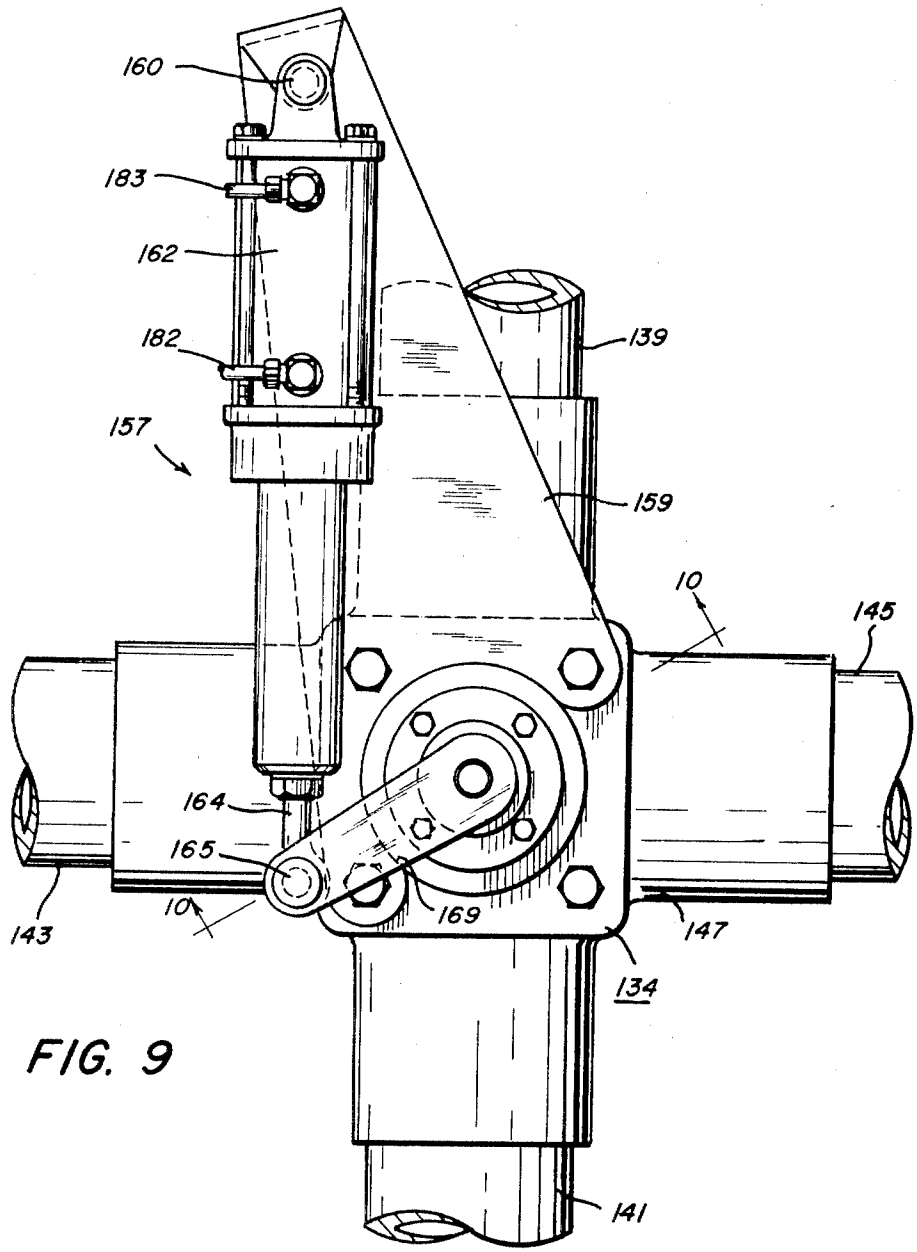


FIG. 9

INVENTOR.
WARREN E. RUPP
BY
Woodling, Krost, Granger & Rust
Attys.

May 26, 1970 W. E. RUPP 3,514,227

PUMP

Filed Feb. 14, 1968 9 Sheets-Sheet 6

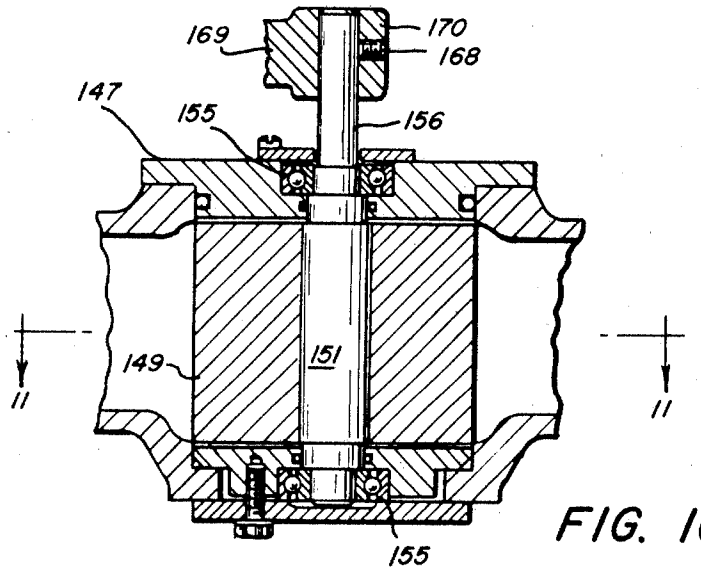


FIG. 10

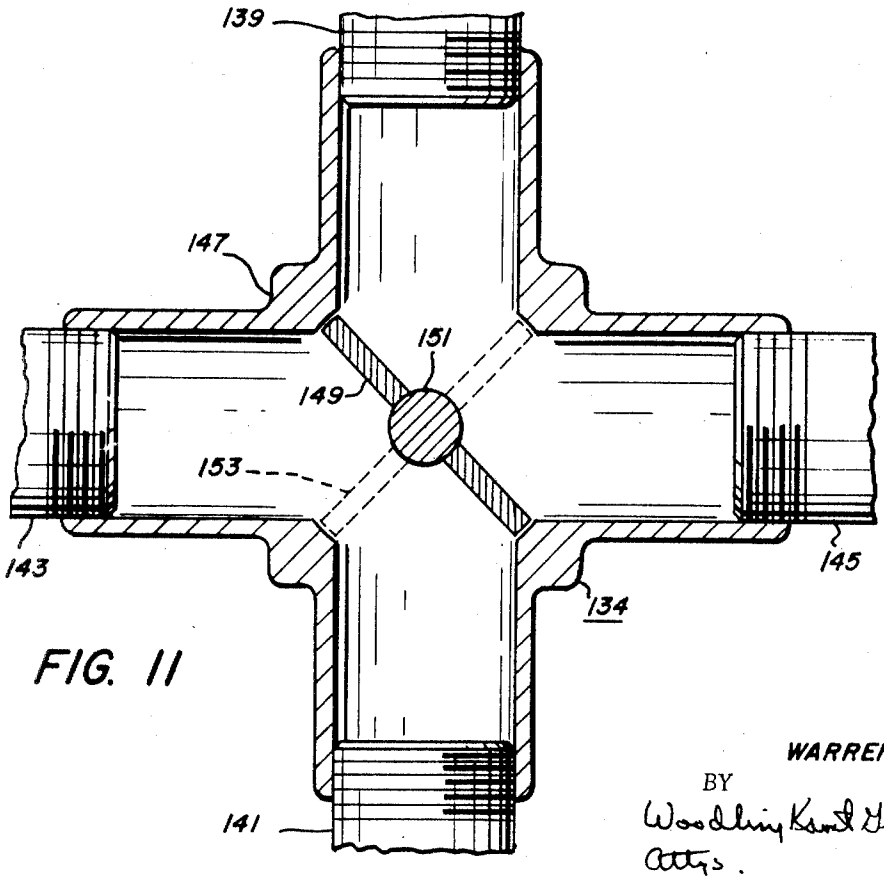


FIG. 11

INVENTOR.
WARREN E. RUPP
BY
Woodling Kent & Granger Rust
Attys.

May 26, 1970 W. E. RUPP 3,514,227

PUMP

Filed Feb. 14, 1968 9 Sheets-Sheet 7

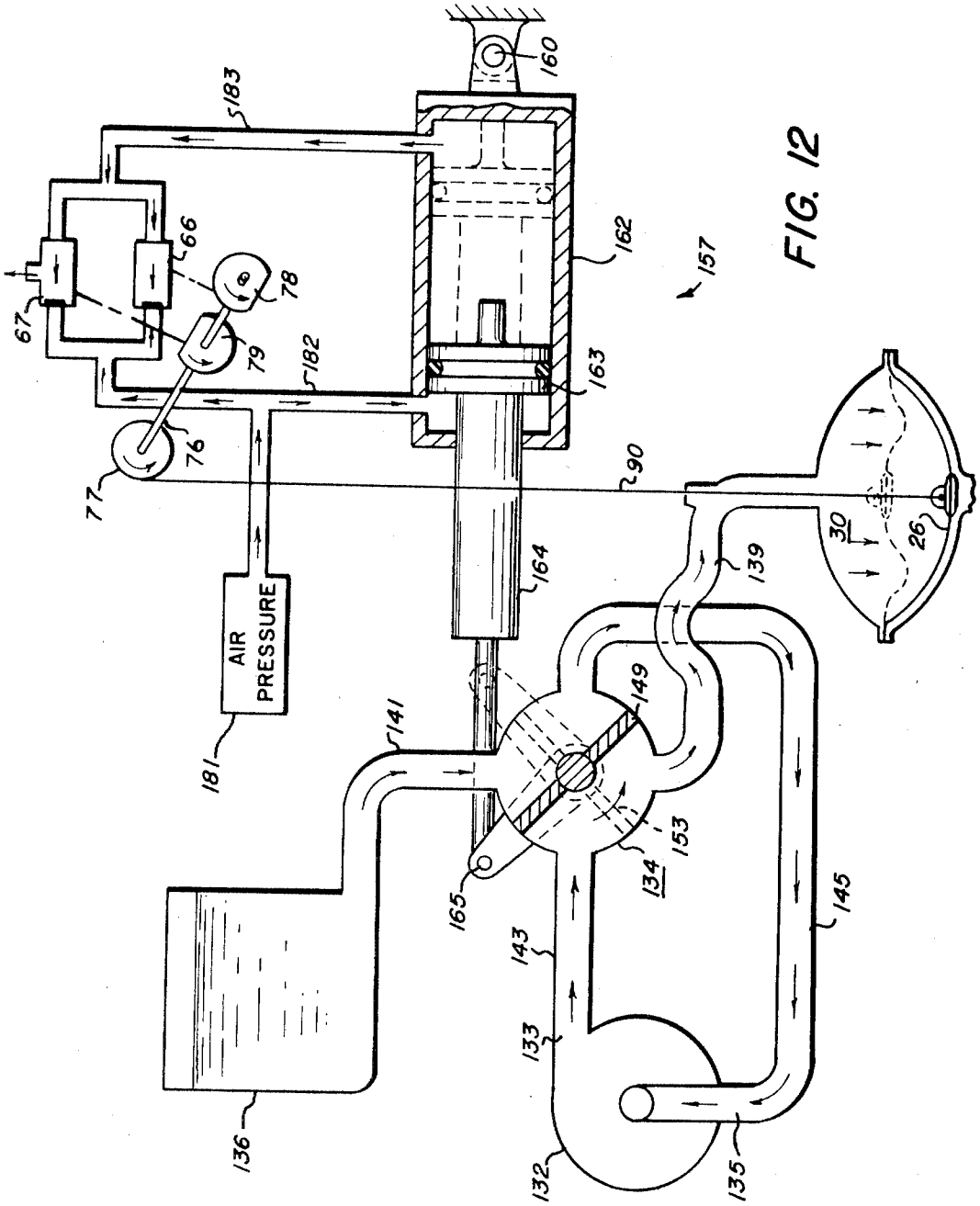


FIG. 12

INVENTOR.
WARREN E. RUPP

BY
Woodling Knost Hemgart Rust
Attys.

May 26, 1970 W. E. RUPP 3,514,227

PUMP

Filed Feb. 14, 1968 9 Sheets-Sheet 8

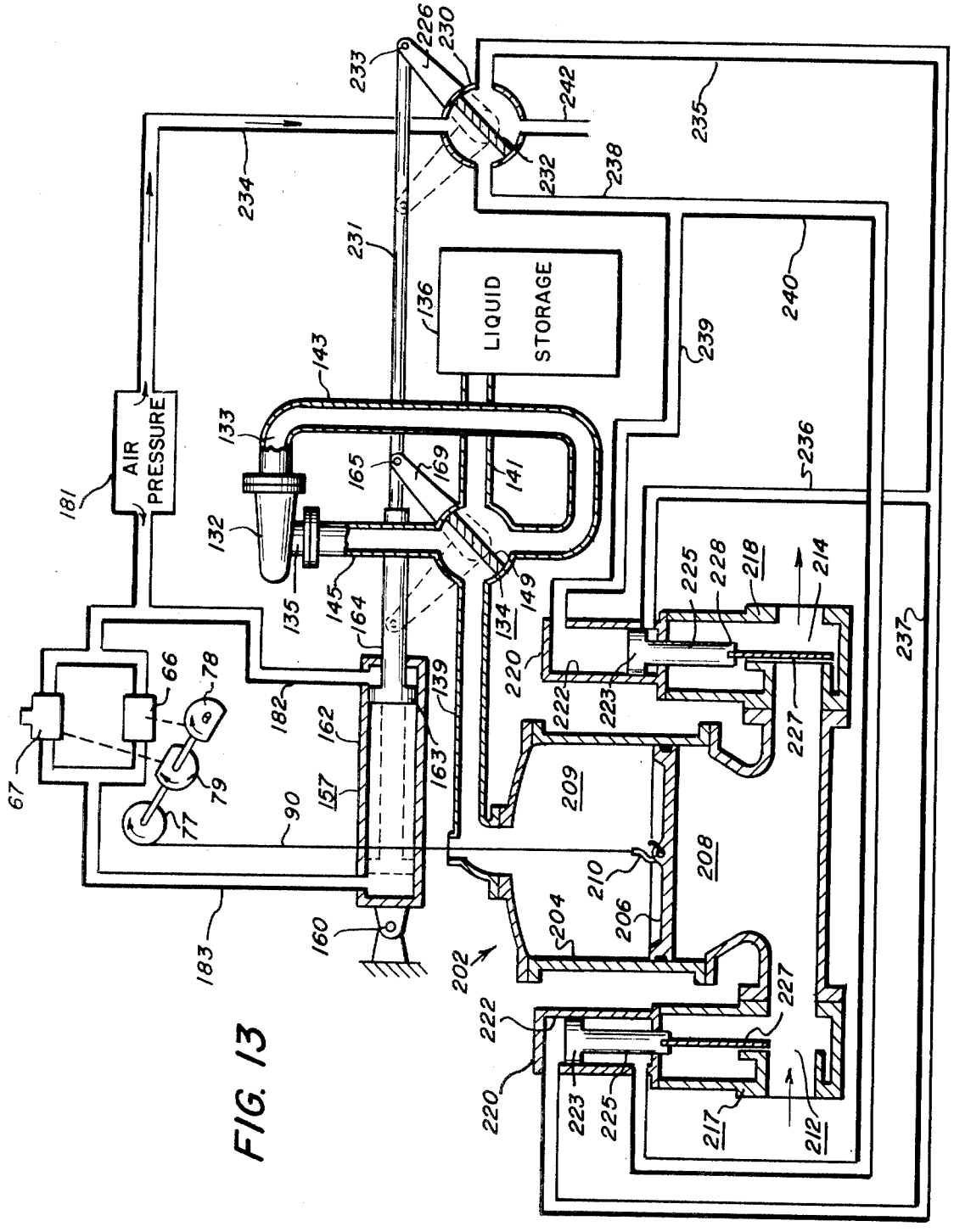


FIG. 13

INVENTOR.
WARREN E. RUPP

BY
Woodling Krost Granger & Rust
Attys.

May 26, 1970 W. E. RUPP 3,514,227

PUMP

Filed Feb. 14, 1968 9 Sheets-Sheet 9

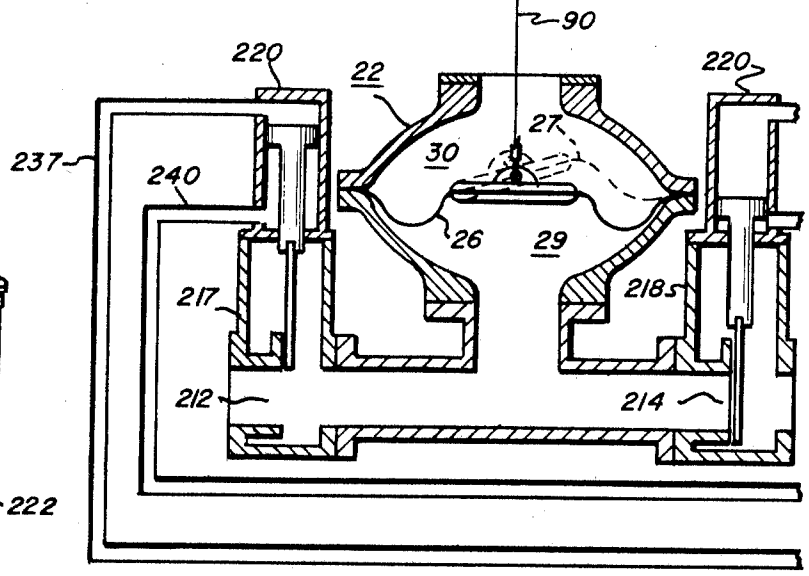


FIG. 16

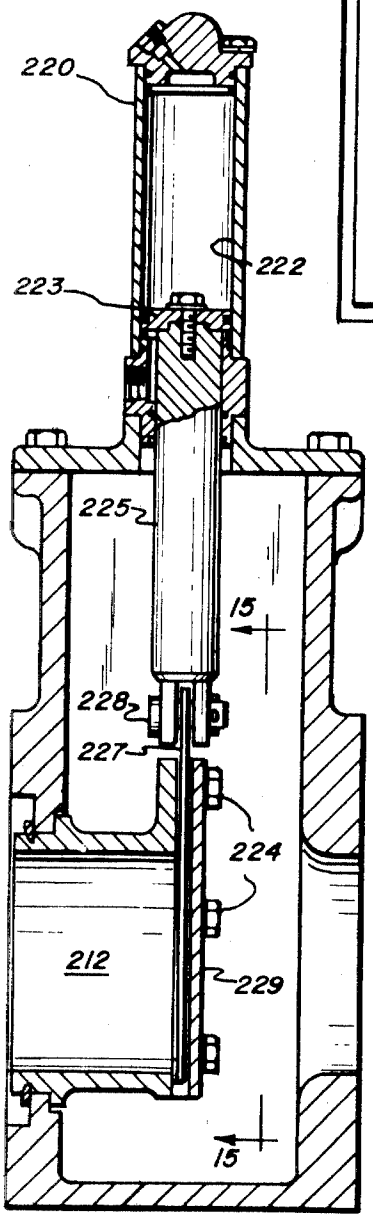


FIG. 14

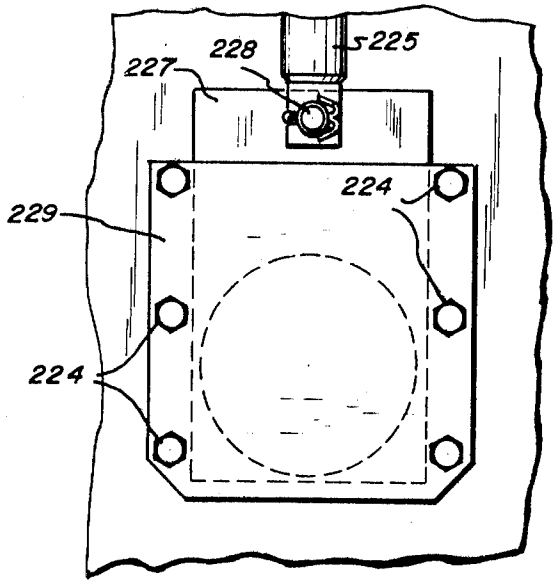


FIG. 15

INVENTOR.
WARREN E. RUPP

BY
Woodling, Krost, Granger & Rust
Attys.

United States Patent Office

3,514,227
Patented May 26, 1970

3,514,227

PUMP

Warren E. Rupp, Mansfield, Ohio, assignor to The Warren Rupp Company, a corporation of Ohio

Continuation-in-part of application Ser. No. 614,143, Feb. 6, 1967, which is a continuation-in-part of application Ser. No. 499,282, Oct. 21, 1965. This application Feb. 14, 1968, Ser. No. 705,438

Int. Cl. F04b 17/00

U.S. Cl. 417—395 14 Claims

ABSTRACT OF THE DISCLOSURE

A pump having an essentially rigid housing with a free flexible membrane therein which divides the housing into two chambers. The free membrane is caused to move back and forth only by the introduction and removal of motivating fluid into one of the chambers and fluid is drawn into and expelled from the other chamber on a pumping cycle by the movement of the membrane. The pump is provided with mechanism for sensing the position of the free membrane within the housing and this in turn controls the introduction and removal of motivating fluid from the first mentioned chamber. The means shown for sensing the position of the membrane is a steel cable, connected at one end to the membrane and at the other end to a sheave mounted on a shaft. The shaft also carries cams engageable with air valves which in turn control the motivating fluid. The cable does not urge or move the membrane but rather only continually senses its position. The introduction and removal of motivating fluid in one embodiment is alternately caused by a pressure fluid source being directed to the first chamber and then being passed through an ejector means or venturi to create a vacuum. In the other embodiment the exhaust and suction side of an auxiliary pump are alternately connected to the first mentioned chamber. The membrane under some conditions may be replaced with a rigid piston and the inlet and outlet of the pump in some instances are provided with valves whose positions are determined by sensing means responsive to the position of the membrane or piston in the housing.

The prior art has utilized membrane type pumps, however, in many cases they are motivated by a rigid member connected to the membrane and extending exteriorly of the housing within which the membrane resides and the rigid member is power operated by some means and as a result the membrane is not moved only by the introduction and exiting of motivating fluid into and out of the first or control chamber as it is sometimes referred to. In many of the prior art devices the membrane is moved in at least one direction by a spring.

The invention generally includes the free flexible membrane movable back and forth on a pumping stroke only by motivating fluid being alternately introduced into and removed from a control chamber adjacent the membrane and the means for sensing the position of the membrane which in turn controls the flow of motivating fluid. The invention also relates to the means for supplying and removing the motivating fluid to and from the control chamber.

This application is a continuation-in-part of U.S. patent application Se. No. 614,143 filed Feb. 6, 1967 entitled Pump, which in turn was a continuation-in-part of U.S. Ser. No. 499,282 filed Oct. 21, 1965 entitled Pump, both of which are now abandoned.

An object of the present invention is to provide a diaphragm or membrane type pump with a unique means of controlling the suction and discharge stroke thereof which is dependent on the position of the diaphragm or membrane in the pump housing.

Another object of the present invention is to provide a novel check valve assembly which provides for intake of fluid on a suction stroke and discharge of fluids on a discharge stroke. This assembly has the advantage of enabling one to quickly gain access to either the suction or discharge portion without disturbing the fixed piping which is the problem on present commercial installations.

Another object of the present invention is to provide a pump of the present design which has an improved diaphragm or membrane in that no reinforcing is required therein since a clamping plate of metal or other firm material is attached thereto in a position to coincide with the ports in the housing and therefore prevent rupturing of the diaphragm or membrane material.

Other objects and a fuller understanding of this invention may be had by referring to the following description and claims, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is an elevational view partially in section illustrating the pump of the present invention;

FIG. 2 is an enlarged fragmentary view partially in section of a portion of the control mechanism shown in FIG. 1;

FIG. 3 is a view taken generally along the line **3—3** of FIG. 2;

FIG. 4 is a view taken generally along the line **4—4** of FIG. 1 showing the discharge portion of the check valve assembly;

FIG. 5 is an elevational view in section taken in the same direction as FIG. 1 and showing in section the suction portion of the check valve assembly;

FIG. 6 is a schematic diagram of the control components and the fluid flow for the pump on the discharge stroke of the pump;

FIG. 7 is a schematic diagram of the control components and the fluid flow for the pump on the suction stroke of the pump;

FIG. 8 is an elevational view partially in section illustrating a modification of the pump of the present invention and particularly the means for causing motivation of the same;

FIG. 9 is a view taken generally along the line **9—9** of FIG. 8;

FIG. 10 is a view taken generally along the line **10—10** of FIG. 9;

FIG. 11 is a view taken generally along the line **11—11** of FIG. 10;

FIG. 12 is a schematic diagram of the pump of FIG. 8 along with the control mechanism and motivation means;

FIG. 13 is a schematic diagram of another modification of the pump of the present invention and the modifi-

cation relates primarily to the valving of material on the inlet and outlet sides of the pump;

FIG. 14 is an elevational view in section of the sliding gate or guillotine valve of the present invention;

FIG. 15 is a view taken generally along the line **15—15** of FIG. 14; and

FIG. 16 is a fragmentary view of a still further modification of the pump of the present invention.

The overall picture of the pump of the present invention is best seen in FIG. 1 of the drawings and includes generally a housing of generally ellipsoidal configuration formed of upper and lower shells **20** and **21** held together by a plurality of bolts **23** which extend through mating flanges on the shells. Positioned within the housing is a diaphragm or free flexible membrane **26** which at times is referred to hereinafter as a dividing member. The position of the diaphragm or flexible membrane **26** has been shown in an intermediate position in FIG. 1 by the dot-dash lines **28**. This has been done for the purpose of illustrating that the membrane divides the housing into what will hereinafter be referred to as a pumping chamber **29** and an air chamber **30**. The chamber **30** has been referred to as an air chamber in this particular instance because the discharge stroke is controlled by air or other gas under pressure, however, it will be readily appreciated by those skilled in the art that the discharge stroke might be initiated by means of a liquid under pressure. The full line position of the membrane **26** in FIG. 1 shows this member slightly beyond the end of its maximum discharge stroke and in position to begin travel on a suction stroke. The designed stroke does not, in normal operation, permit the clamping plate to engage the openings in the housing, as will be more fully discussed hereinafter. The membrane **26** of the present pump is constructed of rubber or other equivalent resiliently flexible material but it does not require the use of fabric-type reinforcement which is commonly used. The normal reason for utilizing a reinforced membrane is to prevent the membrane from rupturing or blowing out the discharge end of the pump and in addition the usual membrane pumps used for pumping slurries and the like have the membrane mechanically clamped in the middle and mechanically actuated instead of being moved back and forth by differential pressure as in the present design. This problem is obviated in the present design by the use of a clamping plate which comprises an upper member **33** and a lower member **34**, which members are held together by bolts which the membrane held therebetween.

First wall means **39** provide an opening or entranceway into the pump by way of the lower shell **21** from a check valve assembly **42** which permits passage of material being pumped on both the discharge and suction strokes. This check valve assembly will be described in more detail hereinafter. The check valve assembly **42** is secured to the lower shell **21** by way of bolts **43**. It will be noted from viewing FIG. 1 that the clamping plate is of a diameter too large to pass through the opening **39** and the outer peripheral portion thereof engages the wall means **39** which form the opening. As mentioned, the maximum stroke of the membrane on suction and discharge strokes is such that the clamping plate and membrane do not quite make contact with the housing or openings in normal operation. In the event of a malfunction of the control means and an overstroke of the membrane, it is prevented from blowing out through the opening **39** on the discharge stroke because of the clamping plate. By the same token the membrane is prevented from blowing out through an opening in the upper shell **20** which is formed by wall means **45** at the end of the suction stroke. The opening **45** leads to a control mechanism which will be described more fully hereinafter.

The circuitry for transmitting air under pressure to the chamber **30** and removing the same therefrom in moving the membrane **26** on the discharge and suction strokes will

now be described and reference is best had to FIGS. 6 and 7 as well as FIG. 1 for a proper understanding. A source of pressurized air **50** is provided and is communicated to the air chamber **30** by way of first conduit means **51** and air is removed from the air chamber **30** on the suction stroke of the pump by way of second conduit means **54**. A first air actuated valve **57** is located in the first conduit means **51** and in a first position (FIG. 6) permits air flow through the first conduit means to the air chamber and in a second position (FIG. 7) prohibits air flow therethrough to the air chamber **30**. A second air actuated valve **58** is located in the second conduit means **54** and in a first position (FIG. 6) prohibits air flow therethrough to atmosphere and in a second position (FIG. 7) permits air flow therethrough to atmosphere. Each of the valves **57** and **58** has been referred to above as air actuated and in this sense has a chamber **60** for the introduction of air under pressure to move the valve to the first from a second position and is also provided with a spring **61** to return the valve from the first to the second position when air under pressure is removed from the same **60**. This type of valve construction is conventional, however, such a valve has not been used in the combination which is disclosed herein in the function, operation and result of the present pump structure.

Third conduit means **64** connect the chamber **60** of the first and second air actuated valves **57** and **58** to the source of air pressure **50** or other convenient source of air pressure, for controlling the position of these valves. Air is conducted from the air source through the third conduit means to the chambers **60** depending upon the position of a first pilot valve **66** which is normally closed (until at least momentarily actuated as will be described hereinafter) and with the pilot valve in a first position it permits fluid flow to the chambers **60** and movement of the same to their first position. When pilot valve **66** is in its normally closed second position it prohibits flow to the chambers **60**.

A second pilot valve **67** (normally closed) is also positioned in the third conduit means **64** and when moved to the first position it permits the flow of air pressure from the chambers **60** of the first and second valves **57** and **58** to atmosphere. This results in movement of these values to their second position by way of the urging of spring **61**. The second pilot valve in its normally closed second position (FIG. 6) prohibits flow to atmosphere. The actuation of pilot valves **66** and **67** will be described in more detail hereinafter.

What has been referred to as an ejector means or mechanism **70** is provided and this ejector means is connected to the air presure source **50** by way of a fourth conduit means **72** when the first air actuated valve **57** is in its second position. The ejector means **70** comprises a venturi effect to cerate a vacuum in the second conduit means **54** when air is flowing through the fourth conduit means.

The control means for actuating the first and second pilot valves **66** and **67** will now be described and as will be understood from above, the actuation of these pilot valves controls the movement of the diaphragm or membrane **26** on its discharge and suction strokes. The control means comprises another housing **75** mounted on the upper shell **20** in line with the opening **45**. Positioned in the housing **75** is a rotatable shaft **76** and a pulley or sheave **77** is connected to the left end of the shaft **76** as seen in FIG. 2 and first and second cams **78** and **79** are connected to the right end of the shaft **76**. The pulley **77** has a hub **80** and secured to this hub is one end **81** of a power spring **82** (clock or motor type) and the other end **83** is secured to a closure **84** which forms a part of the housing **75**. The spring **82** is initially wound by turning closure **84** on shaft **76** relative to housing **75**. The closure **84** is prevented from rotating by means of a locking device **85** in the nature of a box wrench which slips over a projection **86** and is anchored

by means of a bolt **87** connected to the housing **75**. A stainless steel cable **90** is secured at its lower end **92** through an opening in an ear **93** formed on the upper member **33** of the clamping plate and its upper end is secured to the pulley or sheave **77**. Because of this connection it will be seen that as the membrane moves downwardly on the discharge stroke the cable **90** in effect unwinds off of the pulley causing the shaft **76** to rotate in a counter-clockwise direction as seen in FIG. 3 and as the membrane moves upwardly on the suction stroke the power spring **82** causes the shaft and attached pulley to move in a clockwise direction re-winding the cable on the pulley.

The cams **78** and **79** are provided for actuating the pilot valves **66** and **67** respectively. The second cam **79** as seen in FIG. 3 is provided with a flat **96** and when the follower **97** associated therewith comes in contact with the flat the pilot valve **67** is caused to function. This function as described hereinabove is to permit air under pressure trapped in the third conduit means **64** to escape to atmosphere. Cam **78** is also provided with a flat which has not been shown circumferentially or angularly spaced from the flat **96** on cam **79** and when this flat on cam **78** comes in contact with cam follower **99** associated therewith, then pilot valve **66** is actuated. As described hereinabove, actuation of valve **66** by engagement of cam follower **99** with the flat on cam **78** causes air under pressure to be admitted from the source **50** and travels through the third conduit means to the chambers **60** associated with each of the valves **57** and **58**. Movement of the flat from engagement with the follower **99** causes the pilot valve **66** to reclose, however, air under pressure remains trapped between the valves **66**, **67** and the chambers **60** until pilot valve **67** is actuated to exhuast this trapped air to atmosphere.

The check valve assembly **42** is best shown in FIGS. 1, 4 and 5 and this assembly comprises an auxiliary housing **102** which defines a main chamber **104** in direct fluid communication with the opening **39** of the lower shell **21** of the pump housing. There is provided a suction line **106** and a discharge line **107** in direct communication with the main chamber **104** and extending at right angles to each other. An identical removable check valve is provided in both the suction and discharge lines and each is identified by the reference numeral **110**. The only difference of course in these two check valves is that one provides for the flow of fluid into the main chamber on the suction stroke of the pump and the other provides for the exit of fluid from the main chamber on the discharge stroke of the pump. One of the valves of course is installed to provide for entrance into the chamber and one is installed to provide for the discharge from the chamber. Each of the check valves comprises an annular valve seat member **112** located in its associated line and its outer peripheral portion abuts an annular shoulder **113** formed therein. A snap ring **114** is provided in its associated groove in the line in a position to engage the valve seat member to hold it in place against the shoulder **113**. Wall means **116** define a valve seat in the central portion of the valve seat member and valve member **117** is provided for closing the opening **116**. The valve member is made of resilient material and is secured to the valve seat member by a bolt **118** about which it swings or pivots. A valve weight **119** is secured to the valve member and comprises a metal member on either side thereof held together by a bolt **120**.

Wall means **121** define an opening in a wall of the auxiliary housing in the area where the suction and discharge lines come together and this opening **121** is generally in line with the conduit wherein the check valve is positioned. This opening is normally closed by an annular cover **123** which is held against an annular shoulder **124** by means of a snap ring **125**.

The operation of the pump of the present invention will be discussed hereinafter. Assuming the membrane **26** is in the full line position shown in Fig. 1 or in other words at the end of the discharge stroke, the cam follower **97** has just engaged the surface **96** on the second cam **79** which actuates the second pilot valve **67** venting the third conduit means **64** to atmosphere. The circuit in this position is shown in FIG. 7. Venting of conduit means **64** to atmosphere removes air pressure from the two chambers **60** permitting the springs **61** to move values **57** and **58** to their second positions shown in FIG. 7. This shuts off air flow through conduit means **51** and vents the air or control chamber **30** of the pump to atmosphere through the second conduit means **54**. At the same time movement of valve **57** to the second position permits air flow through conduit means **72** from the air pressure source **50** creating a vacuum at the ejector means **70** which aids in exhausting air from the chamber **30** and movement of the membrane to its uppermost position on the suction stroke. It will be noted in the schematic drawings of FIGS. 6 and 7 that a valve **129** has been shown at the ejector means and in communication with the second conduit means **54**. This valve in this particular embodiment is a gravity-type poppet valve which permits the rapid exhausting of compressed air from chamber **30** when the pump is operating against a rather high back pressure or when pumping against a static elevation for the sake of example of say approximately 100 feet of water. In this particular circumstance the pressure in chamber **30** might be on the order of 45 or 50 p.s.i. and without valve **129** it would take some time for the air under pressure to exit chamber **30**. With valve **129** utilized the air can be exhausted almost immediately to atmospheric pressure and the vacuum created by the ejector means **70** will then pull the valve **129** closed. Valve **130** has been disposed in conduit means **72** and this valve is simply a manually controlled valve which controls the rate of air flow to the ejector means **70** and thus enables one to control the rate of evacuation of chamber **30**.

When the membrane **26** has reached the end of the suction stroke, the pulley **77** has been permitted to turn in a clockwise direction as seen in FIG. 3 rewinding cable **90** thereon because of the pressure of spring **82**, and in turn the cam follower **99** engages the flat (not shown) on cam **78** which actuates pilot valve **66** and moves the circuitry into the position shown in FIG. 6. In this position air under pressure travels into conduit means **64** to chambers **60** which causes valves **57** and **58** to be moved to their first position as shown in FIG. 6. With valve **57** in its first position air under pressure travels to chamber **30** through conduit means **50** which in turn causes the membrane **26** to move downwardly on the discharge stroke. It will be appreciated that as the membrane moves downwardly the cable **90** is unwound off the pulley **77** and cams **78** and **79** are accordingly rotated. The cam follower **99** moves off of the flat surface of cam **78**, however, it will be appreciated that air is thus trapped in conduit **65** keeping valves **57** and **58** in the position shown in FIG. 6 until the end of the discharge stroke. At the end of the discharge stroke cam follower **97** engages surface **96** actuating valve **67** as above described exhausting condiut means **64** to atmosphere. Valve **131** is disposed in conduit means **51** and is for the purpose of adjusting the rate of flow of compressed air into chamber **30** which controls the rate at which the membrane **26** is allowed to move downwardly on the discharge stroke.

Valve **128** is located in conduit means **64** and is in the nature of a needle valve which can be adjusted to a comparatively slow rate of air flow and is for the purpose of preventing the pump from becoming "hung up" in its cycling as will be described hereinafter. If we assume that a large piece of debris has been sucked into the pumping chamber **29** and remains lodged there, it will be seen that the membrane **26** will be prevented from moving downwardly far enough to cause cam **79** to actuate pilot valve **67** and exhaust conduit means **64** to atmosphere. In other

words, the suction stroke would not be triggered. By having the valve **128** disposed in conduit means **64** and adjusted for the sake of example to bleed air out of the conduit means **64** in ten seconds, (also assuming for example a normal two second cycle) it will be seen that even though pilot valve **67** did not exhaust conduit means **64** to atmosphere, the pilot air would be exhausted in this example in ten seconds to the point where springs **61** would reposition valves **57** and **58** back to the position shown in FIG. 7 thereby causing the membrane to move upwardly on a suction stroke and of course thereafter again on a discharge stroke. This same procedure might be repeated several times before the debris is finally dislodged from the pumping chamber.

It of course is appreciated that on the suction stroke the valve member **117** on the suction line **106** is opened whereas the valve on the discharge line is maintained closed and vice-versa on the discharge stroke.

It will also be seen from FIG. 1 that in the event of malfunctioning of the control means and forcing of the membrane against either opening **39** or **45** that the clamping plate engages the periphery of openings **39** and **45** thereby preventing the unreinforced membrane **26** from blowing out through these openings. This is a highly advantageous construction in the sense that it permits the membrane to be constructed of rubber or other equivalent material without the necessity of incorporating reinforcing materials such as fabric as is done in most conventional designs. It will be appreciated by those skilled in the art from a review of the above that the membrane is moved by a very slight pressure differential across it and hence there is no need for reinforcing fabric. This is particularly true if the stroke of the membrane were shortened by proper angular adjustment of the cams **78** and **79** on the shaft **76** by way of the set screws which have not been numbered.

It will also be seen from the disclosure above that the pulley **77** and cable **90** arrangement provides for a fair amount of flexibility in the movement of the membrane **26** off the vertical axis of the pump in its movements back and forth on suction and discharge strokes since there can be no complete assurance that the membrane will move along the vertical axis in a plain reciprocal manner but may wobble back and forth in its movement. The pulley **77** and wall means **45** assure that the cable **90** can move sideways while still not jumping off the pulley **77**. This has many obvious advantages over any rigid means which might be attached to the clamping plate. In the specific disclosure it will be obvious that the present preferred embodiment has disclosed a completely mechanical device without the introduction of an electrical control circuit. This has the advantage of enabling the pump to be used in hazardous locations without having to resort to electrical fittings and conduits made in an explosion-proof manner to comply with underwriter requirements. It will be appreciated that in place of the air valves which are actuated by the cams it would be possible to control the mechanism by the use of micro-switches that would actuate solenoid controlled air valves and a different actuating mechanism could be utilized in place of the specifically disclosed cams **78** and **79**. The solenoid operated valves referred to above could be used to replace the specifically disclosed valves **57** and **58** shown in FIGS. 6 and 7 of the drawings. It will also be appreciated by those skilled in the art that in the check valves which are disclosed in FIGS. 4 and 5, one might use a ball-type valve member in place of the swing check valve **117** which has been specifically shown.

FIGS. 8 through 12 illustrate a modification of the pump of the present invention and this modification relates primarily to the means for actuating or motivating the membrane pump. As a result, in these FIGS. 8 through 12 where the pump construction is the same as that illustrated in FIGS. 1 through 7, the same reference numerals have been applied to the structure.

Referring specifically to FIG. 8, the added structural elements in this modification include a separate centrifugal pump **132** in combination with a four-way valve **134** and a fluid reservoir **136**. The four-way valve **134** as seen in FIGS. 10 and 11 is comprised of four legs and first conduit means **139** serve to connect the chamber **30** to one arm of the four-way valve. The first conduit means **139** includes a fitting **140** which appropriately provides for the cable **90** to extend through the top of the membrane pump so as to be operatively connected to the control means to be described hereinafter. Second conduit means **141** serve to provide fluid communication from the reservoir **136** to another leg of the four-way valve **134**. The separate centrifugal pump **132** has a pressure side **133** and a suction side **135** and third conduit means **143** serve to connect the pressure side of the pump to another leg of the four-way valve and fourth conduit means **145** serve to fluidly connect the suction side of the pump **132** to the final leg of the four-way valve.

The details of the four-way valve are best seen in FIGS. 10 and 11 and it will be noted that the four-way valve comprises a housing **147** within which a valve **149** is adapted to move between the full line position shown in FIGS. 10 and 11 and the dotted line position **153** shown in FIG. 11. This arcuate movement is accomplished by means of a valve shaft **151** having opposed ends journalled in bearings **155** and an extension **156** of the valve shaft **151** extends exteriorly of the housing to be operatively connected to a valve operator **157**. The extremities of the valve blade **149** are provided with a substantial clearance relative to the walls of the valve housing **147**, both in the direction seen in FIG. 10 as well as in the direction shown in FIG. 11. This substantial tolerance along with the mounting of the shaft on bearings **155** assures smooth turning movement of the valve blade and any internal leakage does not contribute any substantial amount to inefficiencies in the system. For example, if the centrifugal pump **132** is pumping 200 gallons per minute, and the internal leakage amounts to on the order of 5 gallons, then there is only about a 2½% loss of the pump potential. It is important that the valve blade **149** be permitted free and easy turning movement.

The valve operators **157** is comprised of a mounting plate **159** which pivotally mounts at **160** an end of an air cylinder **162**. A piston **163** (FIG. 12) is adapted to be reciprocated within the cylinder and by way of a piston rod **164** is pivotally connected at **165** to an operating arm **169**. The other end of the arm **169** is fixedly connected by means of a boss **170** and set screw **168** (FIG. 10), to extension **156**.

The valve operator **157** is actuated, in principle, in the same manner as the actuation is instituted in the device shown in FIGS. 1 through 7. In other words, the cable **90** is connected at one end to the membrane **26** and the other end is adapted to be wound upon a sheave **77** as seen in FIG. 2. In like manner the sheave which is connected to shaft **76** controls cams **78** and **79** which in turn control followers **99** and **97** which actuate pilot vales **66** and **67**. The actuation of pilot valves **66** and **67** controls the pilot air to the valve operator **157** and as a result controls the position of the valve blade **149**. Specifically it will be seen (FIG. 12) that control air pressure from a source **181** is always present on the left face of piston **163** by way of conduit **182**. In the position of membrane **26** and cams **78** and **79** shown in FIG. 8, valve **67** is actuated exhausting conduit **183** to atmosphere. As a result air pressure (via conduit **182**) acts only on the left face of the piston **163** (FIG. 12) and it is forced to the right as seen and the valve blade **149** is moved to the dotted position **153** of FIG. 12. When the shaft **76** and cams **78** and **79** are located 180 degrees (or some other predetermined angular position depending on several factors such as the stroke desired, size of sheave **77**, length of cable **90**, etc.) from the position shown in FIG. 8, valve **66** is actuated pressurizing the right face

of piston 163 through conduit 183. This shifts the piston back to the full line position shown because the effective area is larger on the right side than on the left side of piston 163.

The operation of the device shown therein is best understood from the schematic diagram shown in FIG. 12. With the valve blade 149 in the full line position, hydraulic fluid, which for the sake of example might be simply water, is drawn from the reservoir 136 through the four-way valve to the suction side 135 of the pump 132 by way of conduit means 141 and 145. This fluid is expelled through the pressure side 133 of the pump through third conduit means 143 to the four-way valve and into chamber 30 by way of conduit means 139. As a result, the membrane 26 is caused to move downwardly on the pressure stroke of the membrane pump and this downward movement causes the sheave 77 by way of cable 90 to rotate shaft 76 to rotate cams 78 and 79, which, when the membrane approaches the full line position of FIG. 8, causes the valve operator 157 to be reversed moving the valve blade 149 to the dotted line position 153. This causes the pressure side of pump 132 to be connected to the reservoir and causes chamber 30 to be connected to the suction side of pump 132 which in turn causes membrane 26 to move upwardly on a suction stroke. This cycle is constantly repeated during operation of the pump.

The four-way valve 134 disclosed herein is highly advantageous in the present system in that in moving between its two extreme positions shown in the full line position and the dotted line position 153 of FIGS. 11 and 12, the flow of fluid is never completely shut off from the centrifugal pump 132, thereby eliminating all fluid hammer, commonly referred to as water hammer when water is being used. It will also be appreciated by those skilled in the art that the separate centrifugal pump 132 might be replaced by many different kinds of hydraulic pumps, for example a vane type or a gear type pump in the event it might be necessary to go to higher pressures. It is believed, however, that the specific use of a centrifugal pump, which is non-positive, has particular advantages in the present combination. With the use of a centrifugal pump the accelerating forces encountered in switching the movement of the membrane from one position to another is minimal. It would also be possible instead of using a hydraulic fluid such as water, that the separate pump 132 might be designed to provide air pressure which in turn could be exhausted from the chamber 30 by the same construction. In utilizing the separate pump 132 which has an efficiency of on the order of 80 percent, advantages are obtained over the less efficient ejector means 70.

The sensing of the membrane position by means of the cable 90 and associated construction might be replaced by other mechanical means or electrical means. One might use proximity sensing devices which work by reflected radiation or change in inductance, capacitance, or resistance. Any of the means recited would in turn control valve means.

FIGS. 13 through 16 illustrate still further modifications of the pump of the present invention and the modification shown in FIG. 13 relates primarily to the valving of material to be pumped by the mechanism.

In the meat packaging industry, and this is used solely as an example, it is often necessary that the pump handle material which is of a very thick consistency and not very fluid. For example, it is sometimes necessary to pump viscera and bone fragments which have about the consistency of thick hamburger and sometimes has bone fragments of on the order of two inches in length intermixed therein.

The difficulty encountered in pumping this type of material with the valve structure shown in Fig. 5 is because of the extremely heavy consistency of the material, that it is taken into the pump chamber 29 on the suction stroke of the pump, however, on the pressure stroke of the pump the check valve 110 on the inlet side might not close and the material may, in effect, be pumped back up the inlet side of the pump.

The present invention obviates this difficulty because a sliding gate valve is provided on the inlet side of the pump as well as on the outlet side. The position of these two valves at any given point in time is opposite each other and their opening and closing movement is determined as a function of the position of the piston in the main pumping chamber as will be more fully described and understood hereinafter. The particular disclosure under consideration at the present time utilizes a free piston which is a non-flexible or of a solid construction as distinguished from the flexible diaphragm or membrane 26.

Referring specifically to FIG. 13, the added structural elements in this modification have been indicated with new reference numerals, however, where the construction is the same as that illustrated in FIGS. 1 through 12, the same reference numerals have been applied thereto. The additional structure which differs from FIGS. 1 through 12 includes a free piston pump 202, as distinguished from the flexible membrane pump disclosed hereinbefore, and this includes a housing 204 within which is reciprocally mounted a solid piston 206 which is adapted to move up and down in sealing contact with the inner walls of the housing in much the same manner as a piston within a cylinder. The cable 90 as disclosed hereinbefore is attached to the central portion of the piston 206 by what has been shown as a hook 210. The piston 206 divides the housing into a pump chamber 208 and a control chamber 209 and a casting which is attached to the lower portion of the housing 204 defines a pump inlet 212 and pump outlet 214. A first sliding gate valve otherwise referred to as a guillotine valve 217 is suitably attached to the pump inlet and a second sliding gate valve 218 of the same construction is appropriately secured to the pump outlet 214. Each of the valves 217 and 218 is provided with fluid operated mechanism 220 which serves the fuction of opening and closing the gate valves as desired. This mechanism in each of the valves comprises a chamber 222 with in which a piston 223 is dapted to reciprocate and the piston has connected thereto a piston rod 225. Each of the valves has a gate 227 which opens and closes the openings which comprise the inlet and outlet and each of the gates is pivotally connected (FIGS. 14 and 15) as at 228 to the respective piston rods 225. It will be noted that when fluid pressure is admitted to that portion of the chamber above the piston that the gate valves are caused to close and when fluid pressure is admitted to the underside of the pistons 223 the gate valves are caused to be opened. The gates are provided with guides 229 which are held in position by bolts 224 so that the track for the gates is open at both the top and the bottom so that material being handled cannot be easily trapped.

There is additionally provided in this system valve means 230 which in this embodiment is of the same construction as the four-way valve 134. This valve means comprises a valve blade 232 which is movable from the position in which is shown in FIG. 13 to a position (dotted line) 90 degrees removed therefrom. An extension 231 is provided on the end of the piston rod 164 and this extension is pivotally connected at 233 to an arm 226 which is operatively connected to the valve blade 232. A conduit 234 serves to conduct air under pressure from the source 181 to the valve means 230 and conduits 235 and 238 serve to conduct air under pressure from the valve means depending upon the position of the valve means. The conduit 235 is split and continues on as conduits 236 and 237 with conduit 236 leading to the chamber 222 of gate valve 218 to a position on the underside of the piston 223. Conduit 237 leads to chamber 222 of valve 217 to the upper side of piston 223. Conduit 238 is split into conduits 239 and 240 with conduit 239 lead-

ing to the top of the piston in valve **218** and conduit **240** leading to the underside of the piston in valve **217**. When the valve means **230** is in the position shown in FIGURE **13**, air under pressure in conduit **235** is exhausted to atmosphere through conduit **242**, and when in the opposite position air is exhausted from conduit **238** through conduit **242**.

The operation of the pump and system shown in FIG. 13 is as follows. With the valve operator **157** in the full line position shown because of the condition of pilot valves **66** and **67** which condition in turn is dependent upon cams **78** and **79**, the centrifugal pump **132** has its suction side **135** connected to control chamber **209** and its pressure side **133** is connected to the liquid storage **136**. This causes the free piston **206**, by the vacuum created in chamber **209**, to travel upwardly drawing material to be pumped through the pump inlet **212** and into pump chamber **208**. The gate valve **217** is in the open condition with gate valve **218** being in the closed position because valve means **230** is caused to be placed in the position shown in FIGURE 13 by the action of the operator **157**. With the valve means **230** in this position, air under pressure is conducted through the valve means through conduit **238** and thereafter through conduits **239** and **240**. The air pressure through conduit **239** causes valve **218** to close thereby preventing the passage of material through the outlet **214** of the pump and the action of air pressure through conduit **240** causes gate valve **217** to be moved to the open position thereby permitting the flow of material to be pumped through the inlet **212** of the pump.

When the free piston **206** has reached the top of its stroke this position is sensed through the cable **90**, cams **78** and **79**, which cams thereby act upon valves **66** and **67** causing air pressure to be removed from conduit **183** and the action of air pressure acting on the opposite face of the piston **163** causes it to be shifted to the dotted position. This shifts the valve **134** so as to connect the pressure side of the centrifugal pump **132** to the control chamber **209** which starts the free piston on its downward or pressure stroke. At the same time the valve means **230** is also shifted so as to place the air pressure source **181** by way of conduit **234** in fluid communication with conduit **235**. The connection of conduit **235** with conduits **236** and **237** causes the gate valve **217** to be closed and the gate valve **218** to be opened thereby causing material pumped to pass out the pump outlet **214**.

FIG. 16 is a schematic view showing the construction of the flexible membrane or diaphragm pump construction for example of FIG. 1 interposed in the system of FIG. 13 as distinguished from the free piston construction which involves the rigid piston as distinguished from the flexible membrane **26**. In all other respects the construction is the same and previous identifying numerals have been used. The dotted position **27** has been shown to demonstrate that the position of the membrane in the housing is not symmetrical at all times. It will also be appreciated that the membrane **26** is secured by its peripheral edge portion to the housing as shown and the central portion is unsupported and substantially unrestrained in its ability to move.

It will be observed that closing of the valves **217** and **218** is effected by fluid pressure on pistons **223** and in the event a solid object is located beneath blade **227**, the blade **227** may not be completely bottom or close. The object normally traps other objects as in a "log jam" and the valve is effectively closed for all practical purposes even though the blade may be slightly open.

As a result of the above constructions the present invention is capable of carrying out and accomplishing the advantages more fully set forth in the objects of the present application, such as the novel means of controlling the stroke of the pump as a function of the position of the pump membrane and the check valve assembly provides for quick and convenient access to this portion of the pump without having to dismantle any other portion of the pump circuitry. The specific construction of the membrane which includes the clamping plate also provides an economical membrane design.

Although this invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and scope of the invention as hereinafter claimed.

What is claimed is:

1. A pump including in combination a housing, a movable dividing member partitioning said housing into a pump chamber and a control chamber, wall means defining an opening through said housing into said pump chamber to provide for the entrance of pumpable material on a suction stroke and the exit of pumpable material on a discharge stroke, conduit means communicating with said control chamber, first means connectable with said conduit means for introducing a fluid under pressure into said control chamber to expand the volume of same and move said dividing member on said discharge stroke, second means connectable with said conduit means for producing a suction to exit fluid from said control chamber to contract the volume of same thereby producing a vacuum on said dividing member to move same on said suction stroke, control means for controlling actuating of said first and second means and thereby controlling said suction and discharge strokes, means acting between said dividing member and said control means whereby said control means is actuated by the position of said dividing member in said housing, said means acting between said dividing member and said control means comprising a rotatable shaft with means carried thereby and cooperating with said control means to actuate the same, and a cable member connected at one end to said dividing member and connected at the other end to said shaft.

2. A pump including in combination a housing, a dividing member partitioning said housing into a pump chamber and a control chamber, wall means defining an opening through said housing into said pump chamber to provide for the entrance of pumpable material on a suction stroke and the exit of pumpable material on a discharge stroke, conduit means communicating with said control chamber for introducing and exiting fluid under pressure and thereby moving said dividing member on said suction and discharge strokes, control means for controlling flow of fluid through said conduit means and thereby controlling said suction and discharge strokes, said control means comprising valve means in said conduit means alternately permitting the introduction of an exiting of fluid relative to said control chamber, first and second pilot operated valves, one of which when actuated moving said valve means to a first position and the other of which when actuated moving said valve means to a second position and mechanical means extending between said dividing member and said first and second pilot operated valves for actuating same and thereby controlling the cycle of said pump depending on the position of said dividing member in said housing.

3. A pump as recited in claim **2** wherein means are provided for producing fluid pressure in said conduit means and in said control chamber on said discharge stroke and for creating a vacuum in said conduit means and in said control chamber on said suction stroke.

4. A pump including in combination a housing, a dividing member in said housing dividing same into a pumping chamber and a control chamber, first wall means in said housing providing fluid communication to and from said pumping chamber, first conduit means connecting a source of fluid pressure to said control chamber,

second conduit means connecting said control chamber to atmosphere, a first fluid actuated valve in said first conduit means and in a first position permitting flow therethrough and in a second position prohibiting flow therethrough, a second fluid actuated valve in said second conduit means and in a first position prohibiting flow therethrough and in a second position permitting flow therethrough, third conduit means connecting said first and second fluid actuated valves to a source of fluid for actuating the same, a first pilot valve in said third conduit means and in a first position permitting flow to said first and second fluid actuated valves and movement of same to their said first position and in a second position prohibiting flow to said first and second fluid actuated valves, a second pilot valve in said third conduit means and in a first position permitting flow from said first and second fluid actuated valves to atmosphere and movement of same to their said second position and in a second position prohibiting flow to atmosphere, ejector means located in said second conduit means, fourth conduit means connecting said ejector means to a source of fluid through said first fluid actuated valve in its second position to produce a vacuum in said second conduit means, control means for actuating said first and second pilot valves in response to the position of said membrane in said housing comprising a rotatable shaft, a pulley connected to said shaft at one portion, first and second cams carried by said shaft at another portion and engageable respectively with said first and second pilot valves to move same between their said first and second positions, a cable connected at one end portion to said pulley and at the other end portion to said dividing member whereby said position of said pilot valves and the strokes of said pump are controlled by the position of said dividing member.

5. A pump including in combination a relatively rigid housing, a flexible membrane partitioning said housing into a pump chamber and a control chamber, said membrane having a peripheral edge portion and a central portion with said edge portion being secured to said housing and said central portion being unsupported and substantially unrestrained in its ability to move, wall means defining an opening through said housing into said pump chamber to provide for the entrance of pumpable material on a suction stroke and the exit of pumpable material on a discharge stroke, a fluid source, a separate fluid pump having an outlet side and an inlet side, a rotary fluid valve having first, second, third and fourth ports and having a rotatable valve member, first conduit means connecting said control chamber to said first port, second conduit means connecting said fluid source to said second port, third conduit means connecting said outlet side of said pump to said third port, fourth conduit means connecting said inlet side of said pump to said fourth port, first means connected to said rotatable valve member for moving the same between first and second positions, and means operatively connected at one end to said membrane and operatively connected at the other end to said first means whereby the position of said membrane in said housing determines the position of said rotary fluid valve.

6. A pump as claimed in claim 5 wherein said four way valve comprises a housing having a central chamber and first, second, third and fourth conduits leading to said central chamber, a land between each conduit, a shaft mounted for rotative movement, a valve blade connected to said shaft for rotation thereby, said blade having first and second opposed side portions for coacting with said lands, said opposed side portions coacting with two opposed lands to direct fluid between said first and third conduits and between said second and fourth conduits, said opposed side portions when said valve blade is rotated coacting with the other two opposed lands to direct fluid between said first and fourth conduits and between said second and third conduits.

7. A pump including in combination a housing, a dividing member partitioning said housing into a pump chamber and a control chamber, wall means defining an opening through said housing into said pump chamber to provide for the entrance of pumpable material on a suction stroke and the exit of pumpable material on a discharge stroke, conduit means communicating with said control chamber for introducing and exciting fluid under pressure and thereby moving said dividing member on said suction and discharge strokes, said intorducing and exiting of fluid pressure being substantially the only means for moving said dividing member, control means for controlling flow of fluid through said conduit means and thereby controlling said suction and discharge strokes, said control means in being actuated between first and second conditions alternately permitting the introduction of and exiting of fluid relative to said control chamber, and mechanical means physically connected at all times to said dividing membed at one end portion for continuous movement therewith and with another end portion thereof operably connected to said control means for continuous movement in accordance with the continuous movement of said one end whereby the position of said dividing member in said housing is continuously monitored with respect to said control means and said first and second conditions of said control means are determined by the position of said dividing member in said housing as transmitted by said mechanical means.

8. A pump including a housing, a dividing member in said housing dividing the same into a pump chamber and a control chamber, wall means in said housing defining an opening to said pump chamber to provide for the entrance of pumpable material on a suction stroke from a pump inlet and the exit of pumpable material on a discharge stroke through a pump outlet, a separate centrifugal pump having an inlet side and an outlet side, a rotary fluid valve having first, second, third and fourth ports and having a rotatable valve member, first conduit means connecting said control chamber to said first port, second conduit means for connecting a reservoir to said second port, third conduit means connecting said outlet side of said pump to said third port, fourth conduit means connecting said inlet side of said pump to said fourth port, a piston and cylinder arrangement operatively connected to said rotatable valve member for moving the same between first and second positions, control valve means for controlling fluid flow to and from said piston and cylinder arrangement for moving same between first and second operative positions, cam means carried by a rotatable shaft and cooperating with said control valve means to actuate the same, a cable connected at one end to said dividing member and at the other end to said shaft whereby the position of said dividing member in said housing determines the position of said cam means and consequently the position of said rotary fluid valve, a first valve movable between open and closed positions and located at said pump inlet, a second valve movable between open and closed positions and located at said pump outlet, first fluid operated mechanism for moving said first valve between said open and closed positions, second fluid operated mechanism for moving said second valve between said open and closed positions, valve means movable between first and second positions for supplying fluid to and from said first and second fluid operated mechanisms and in said first position opening said first valve and closing said second valve and in said second position closing said first valve and opening said second valve, and means operably connecting said cable to said valve means whereby the position of said valve means is determined by the position of said dividing member in said housing.

9. A pump including a housing, a dividing member in said housing dividing the same into a pump chamber and a control chamber, wall means in said housing defining an opening to said pump chamber to provide for

the entrance of pumpable material on a suction stroke from a pump inlet and the exit of pumpable material on a discharge stroke through a pump outlet, a separate pump having an inlet side and an outlet side, a valve mechanism having first, second, third and fourth ports and having a valve member, first conduit means connecting said control chamber to said first port, second conduit means for connecting a reservoir to said second port, third conduit means connecting said outlet side of said pump to said third port, fourth conduit means connecting said inlet side of said pump to said fourth port, first means operatively connected to said valve member for moving the same between first and second positions, control means for controlling said first means for moving same between first and second operative positions, a mechanical member connected at one end to said dividing member and at another portion being operably connected to said control means whereby the position of said dividing member in said housing determines the position of said valve member, a first valve movable between open and closed positions and located at said pump inlet, a second valve movable between open and closed positions and located at said pump outlet, first mechanism for moving said first valve between said open and closed positions, second mechanism for moving said second valve between said open and closed positions, means actuable between first and second positions for actuating said first and second mechanisms and in said first position opening said first valve and closing said second valve and in said second position closing said first valve and opening said second valve, and means operably connecting said mechanical member to said means actuable between first and second positions whereby the position of the same is determined by the position of said dividing member in said housing.

10. A pump including in combination a housing, a dividing member partitioning said housing into a pump chamber, wall means defining an opening through said housing into said pump chamber to provide for the entrance of pumpable material through a pump inlet on a suction stroke and the exit of pumpable material through a pump outlet on a discharge stroke, fluid means for moving said dividing member on said suction and discharge strokes, a first valve at said inlet movable between open and closed positions and a second valve at said outlet movable between open and closed positions, each said first and second valves having motively powered means for moving same between said open and closed positions, control means for controlling said motively powered means, mechanical means connected to said dividing member and to said control means for actuating said control means and thereby controlling the opening and closing of said first and second valves depending on the position of said dividing member in said housing.

11. A pump including in combination a housing, a movable dividing member partitioning said housing into a pump chamber and a control chamber, wall means defining an opening through said housing into said pump chamber to provide for the entrance of pumpable material on a suction stroke and the exit of pumpable material on a discharge stroke, conduit means communicating with said control chamber, first means connectable with said conduit means for introducing a fluid under pressure into said control chamber to expand the volume of same and move said dividing member on said discharge stroke, second means connectable with said conduit means for producing a suction to exit fluid from said control chamber to contract the volume of same thereby producing a vacuum on said dividing member to move same on said suction stroke, control means for controlling actuating of said first and second means and thereby controlling said suction and discharge strokes, means acting between said dividing member and said control means whereby said control means is actuated by the position of said dividing member in said housing, said means acting between said dividing member and said control means comprising cam means cooperating with said control means to actuate the same, and a cable member connected at one end to said dividing member and operably connected at the other end to said cam means.

12. A pump including in combination a housing, a dividing member partitioning said housing into a pump chamber and a control chamber, wall means defining an opening through said housing into said pump chamber to provide for the entrance of pumpable material on a discharge stroke, a fluid source, a separate fluid pump having an outlet side and an inlet side, a rotary fluid valve having first, second, third and fourth ports and having a rotatable valve member, first conduit means connecting said control chamber to said first port, second conduit means connecting said fluid source to said second port, third conduit means connecting said outlet side of said pump to said third port, fourth conduit means connecting said inlet side of said pump to said fourth port, first means connected to said rotatable valve member for moving the same between first and second positions, and means operatively connected at one end to said dividing member and operatively connected at the other end to said first means whereby the position of said dividing member in said housing determines the position of said rotary fluid valve.

13. A pump including in combination a relatively rigid housing, a flexible membrane partitioning said housing into a pump chamber and a control chamber, said membrane having a peripheral edge portion and a central portion with said edge portion being secured to said housing and said central portion being unsupported and substantially unrestrained in its ability to move, wall means defining an opening through said housing into said pump chamber to provide for the entrance of pumpable material on a suction stroke and the exit of pumpable material on a discharge stroke, a fluid source, a separate fluid pump having an outlet side and an inlet side, a fluid valve having not more than first, second, third and fourth ports and having a valve member, first conduit means connecting said control chamber to said first port, second conduit means connecting said fluid source to said second port, third conduit means connecting said outlet side of said pump to said third port, fourth conduit means connecting said inlet side of said pump to said fourth port, first means connected to said valve member for moving the same between first and second positions, and means operatively connected at one end to said membrane and operatively connected at the other end to said first means whereby the position of said membrane in said housing determines the position of said fluid valve.

14. A device including a housing, a dividing member dividing said housing into first and second chambers, first means connectable with said first chamber for introducing a fluid under pressure thereinto to expand the volume of same and to move said dividing member on a discharge stroke, second means connectable with said first chamber for producing a suction action therein to exit fluid therefrom and contract the volume of said first chamber thereby producing a vacuum on said dividing member to move same on a suction stroke, control means for controlling the actuation of said first and second means and being movable to first and second conditions, mechanical means physically connected at all times to said dividing member at one end portion for continuous movement therewith and with another end portion thereof operably connected to said control means for continuous movement in accordance with the continuous movement of said one end whereby the position of said dividing member in said housing is continuously monitored with respect to said control means and said first and second conditions of said control means are determined by the position of said dividing member in said housing as transmitted by said mechanical means, said first means introducing said fluid directly into said first chamber for producing said dis-

charge stroke, and said second means including an ejector and passing said fluid through said ejector which in turn is connected to said first chamber for producing said suction stroke.

References Cited

UNITED STATES PATENTS

1,067,613	7/1913	Lane	103—152
1,891,408	12/1932	Gorman	103—150 XR
2,625,886	1/1953	Browne	103—150
2,644,401	7/1953	Ragland	103—45
2,673,525	3/1954	Lucas	103—152

2,732,069	1/1956	Henderson	60—60 XR
2,780,066	2/1957	Tarry	60—60
2,803,195	8/1957	Lock	103—152
3,035,524	5/1962	Kastner	103—52

FOREIGN PATENTS

240,132	5/1960	Australia.
1,126,793	7/1956	France.

ROBERT M. WALKER, Primary Examiner

U.S. Cl. X.R.

60—60