

Jan. 25, 1966

R. D. BREWER

3,230,889

VENTURI FLUID PUMPS

Filed June 29, 1964

3 Sheets-Sheet 1

FIG.1

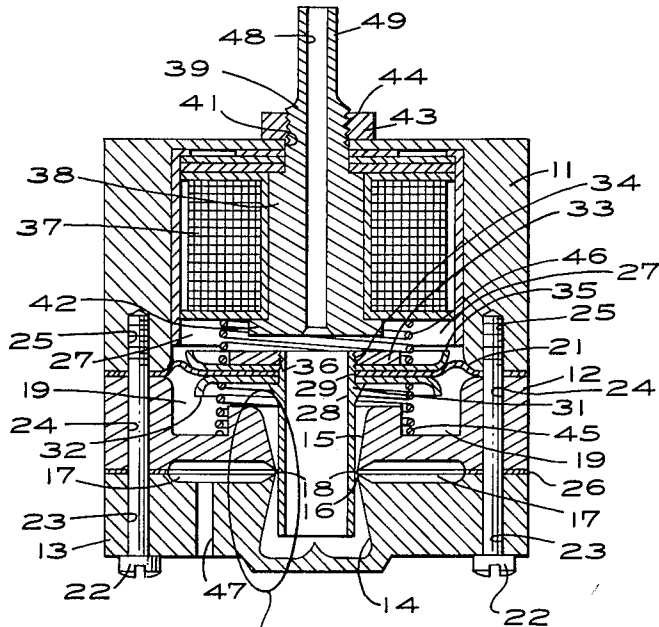
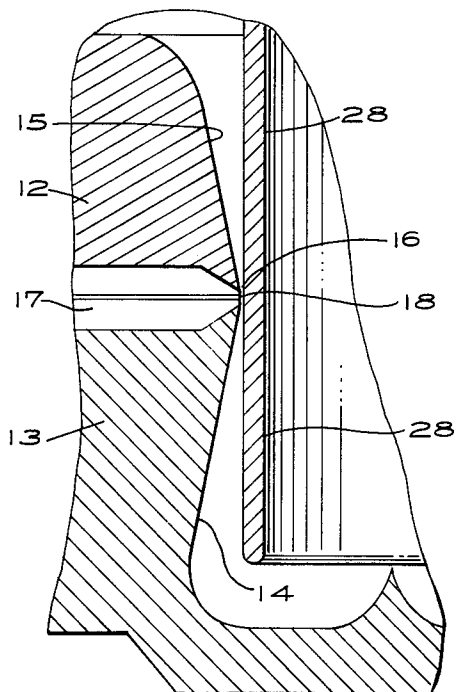


FIG. 2

FIG. 2



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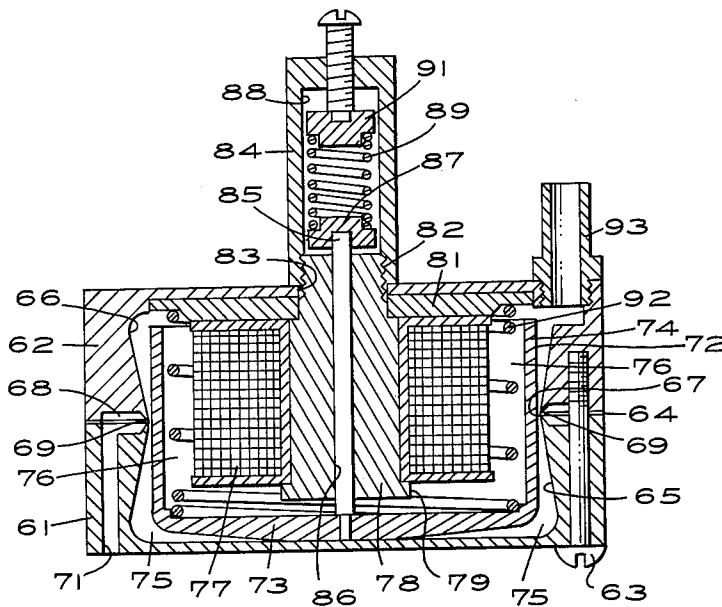
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FIG. 3



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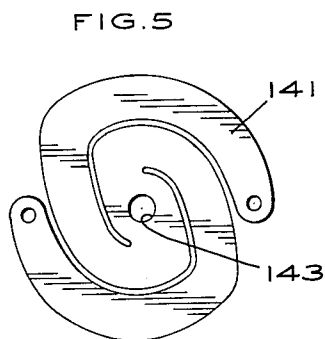
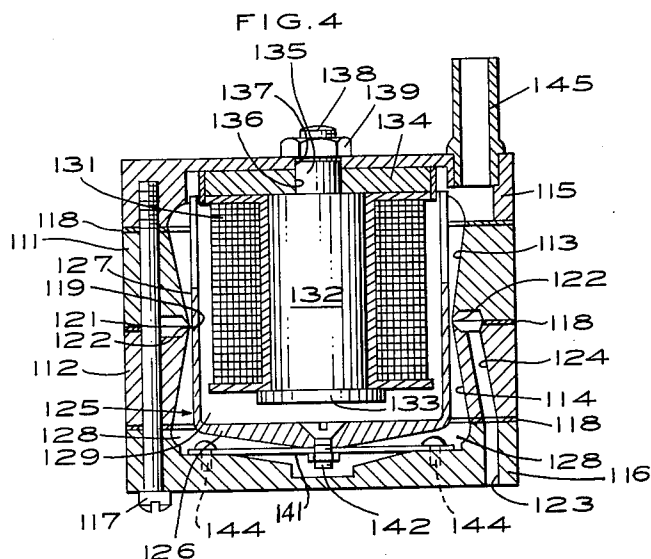
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3 Sheets-Sheet 3



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3,230,889

VENTURI FLUID PUMPS

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11 Claims. (Cl. 103—53)

This invention relates to venturi fluid pumps and more particularly to improvements in the venturi pump shown in my prior Patent No. 2,872,877, entitled "Fuel Pump," issued February 10, 1959.

A venturi pump employs the decreased static pressure generated by fluid flow through the throat of a venturi as a source of pressure differential for pumping fluids. Since the pressure differential is independent of the direction of flow, fluid may be pumped by causing a reversing flow through the venturi. In my aforementioned patent, a reciprocating diaphragm is employed at one side of the venturi to cause alternating flow through its throat. A diaphragm also is positioned at the opposite end of the venturi to form a surge chamber.

The present invention contemplates increasing the capacity of a venturi pump by forming two separate driving chambers that communicate with opposite sides of the throat of the venturi. By decreasing the volume of one chamber simultaneously with an increase in volume of the other chamber, fluid may be driven through the throat. Reversing the change in the volumes of the chambers causes the fluid to flow in an opposite direction. The use of two separate chambers communicating with opposite sides of the throat permits a more positive flow reversal with a resulting increase in pump capacity.

It is, therefore, a principal object of this invention to provide a venturi pump having an increased flow capacity from that heretofore known.

Although the pump shown in my earlier patent could be modified to create a positive flow in both directions by positively actuating both of its diaphragms, the additional driving mechanism would be prohibitively costly.

It is a further object of this invention to provide a venturi fuel pump wherein a single actuating member controls the change in volume of fluid chambers communicating with the venturi on opposite sides of its throat.

A pump embodying this invention includes a venturi and a movable wall that defines first and second fluid chambers. Fluid communication is provided between the first chamber and the venturi on one side of its throat and between the second chamber and the venturi on the other side of its throat. A fluid inlet extends from a fluid source to the throat of the venturi. A fluid outlet extends from a position that is spaced from the throat of the venturi. Means are provided to move the wall in opposite directions to alternately compress the volumes of the first and second fluid chambers and drive fluid in opposite directions through the venturi throat. The fluid flow through the throat causes a pressure differential to be established between the fluid inlet and the fluid outlet.

In a first embodiment of this invention, the movable wall comprises a resilient diaphragm. The means that provides communication between one of the fluid chambers and the venturi is a tubular member that is affixed to the diaphragm and extends through it and the throat of the venturi. A small annular clearance is provided between external surface of the tubular member and the internal diameter of the throat.

The use of the flexible diaphragm in the aforementioned embodiment necessitates the provision of a seal around the periphery of the diaphragm. This seal is eliminated in other embodiments of the invention through

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the use of a cup-shaped member that defines opposing fluid chambers. The cup-shaped member has a wall that extends normal to the longitudinal axis of the venturi throat. A tubular portion surrounds the wall and extends axially through the throat of the venturi.

Further objects and advantages of this invention will become more apparent when considered in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a cross-sectional view taken through the longitudinal axis of a venturi pump showing a first embodiment of this invention.

FIGURE 2 is an enlarged cross-sectional view of the circled area of the pump shown in FIGURE 1.

FIGURE 3 is a cross-sectional view taken through the longitudinal axis of a second embodiment of this invention.

FIGURE 4 is a cross-sectional view, in part similar to FIGURE 3, showing a third embodiment of the invention.

FIGURE 5 is a top plan view of the return spring employed in the pump shown in FIGURE 4.

Referring now in detail to the embodiment shown in FIGURES 1 and 2 of the drawings, the pump comprises three cylindrical members, indicated by the reference numerals 11, 12 and 13. The cylindrical member 13 forms the lower portion 14 of a venturi section. A mating upper portion 15 of the venturi section is formed within the cylindrical member 12. The venturi portions 14 and 15 converge at a throat, indicated by the reference numeral 16.

An annular cavity 17 is formed by corresponding recesses in the adjacent surfaces of the members 12 and 13 around the periphery of the throat 16. The cavity 17 is positioned in fluid communication with the throat 16 by a plurality of radially extending passages 18. The passages 18 form a fluid inlet to the throat 16 as will become more apparent as this description proceeds.

A first fluid chamber 19 is formed in part by a cylindrical recess in the upper surface of the cylindrical member 12. The first fluid chamber 19 is in open communication with the upper portion 15 of the venturi section. A resilient diaphragm 21 extends across the upper surface of the cylindrical member 12 to enclose the first fluid chamber 19. A plurality of bolts 22 extend through apertures 23 and 24 in the cylindrical members 13 and 12, respectively. The bolts 22 are threaded into tapped holes 25 formed in the cylinder member 11. A gasket 26 is positioned between the cylinder members 12 and 13 to provide a fluid tight connection between them, and the diaphragm 21 forms a seal between the cylinder members 11 and 12.

A second fluid chamber 27, formed by a cylindrical recess in the member 11, is enclosed by the upper surface of the diaphragm 21. The second fluid chamber 27 is positioned in fluid communication with the lower portion 14 of the venturi section by a tubular member, indicated generally by the reference numeral 28. The tubular member 28 passes through a central aperture 29 in the diaphragm 21 along the axis of the venturi section. A shoulder 31 formed on the tubular member 28 engages a rigid disc 32 that bears against the lower surface of the diaphragm 21. A ferromagnetic annular member 33 is threaded upon a threaded upper end 34 of the tubular member 28. The ferromagnetic member 33 engages a rigid disc 35 that bears against the upper surface of the diaphragm 21 in opposition to the disc 32. The diaphragm 21 is compressed between the discs 32 and 35 by threading the ferromagnetic member 33 onto the tubular member 28.

The tubular member 28 extends through the venturi throat 16 along its longitudinal axis and terminates with-

in the lower portion 14 of the venturi section. A longitudinal bore 36 that extends through the tubular member 28 provides fluid communication between the second fluid chamber 27 and the lower portion 14 of the venturi section. A slight annular clearance is provided between the outer diameter of the tubular member 28 and the inner diameter of the throat 16 (FIGURE 2).

A solenoid coil 37 is supported within an extension of the cylindrical cavity that forms the second fluid chamber 27. The coil 37 is supported upon a ferromagnetic armature or core 38 having a reduced diameter portion 39 that extends through an aperture 41 formed in the upper wall of the member 11. The coil 37 is supported at its lower end upon a shoulder 42 of the armature 38. A nut 43 is threaded onto threads 44 formed on the reduced diameter portion 39 to axially fix the coil 37 and armature 38 within the pump assembly. A suitable electric circuit (not shown) is provided to energize the coil 37 and create a magnetic field through the armature 38 that attracts the ferromagnetic member 33 that is affixed to the diaphragm 21.

A coil spring 45 is positioned within the first fluid chamber 19 in engagement at one end with the cylindrical member 12 and at the other end with the disc 32 to urge the diaphragm 21 toward the armature 38. A stronger, return spring 46 engages the coil 37 and disc 35 within the second fluid chamber 27 to return the diaphragm 21 to its normal position when the coil 37 is not energized.

A fluid inlet passage 47 extends through the cylindrical member 13 to the cavity 17. The passage 47 may communicate with a source of fluid through a suitable conduit (not shown). Alternatively, the pump may be submerged within a source of fluid whereby the passage 47 will form a direct fluid inlet. A fluid outlet passage 48 extends coaxially through the armature 38 from the second fluid chamber 27. A nipple 49 formed upon the upper end of the armature 38 may be employed for connection to a fluid outlet conduit (not shown).

When the coil 37 is energized, the magnetic field created through the armature 38 will attract the ferromagnetic member 33 and deflect the diaphragm 21 upwardly. This action decreases the volume within the fluid chamber 27 and increases the volume within the fluid chamber 19. Fluid is caused to flow from the second chamber 27 through the bore 36 in the tubular member 28 into the lower portion 14 of the venturi section. The fluid then flows through the clearance between the tubular member 28 and the venturi throat 16 to the first fluid chamber 19. The upward flow of fluid past the throat 16 causes a static pressure decrease at the passages 18 and draws fluid from the inlet passage 47 and cavity 17 into the venturi section. The increased fluid within the system is discharged from the outlet passage 48. When the coil 37 is deenergized, the return spring 46 overcomes the action of the spring 45 and the diaphragm 21 is deflected downwardly to reverse the fluid flow direction through the venturi throat 16. The flow in the reverse direction again causes a static pressure decrease at the throat 16 to drive fluid through the pump.

Referring now to the embodiment shown in FIGURE 3, a pump is depicted that embodies two fluid chambers separated by a common wall as in the previously described embodiment. In this embodiment, however, a diaphragm is not employed with the resulting reduction in sealing problems.

The pump shown in FIGURE 3 comprises a lower cylindrical member 61 and an upper cylindrical member 62 secured together by a plurality of bolts 63 with a gasket 64 positioned therebetween. The lower member 61 forms a lower portion 65 of a venturi section. A complementary upper portion 66 of the venturi section is formed by the cylindrical member 62. The upper and lower venturi portions 66 and 65 converge at a throat 67.

An annular cavity 68 formed within opposing faces of the members 61 and 62 surrounds the throat 67. Radial openings 69 extend from the annular cavity 68 into the throat 67. A fluid inlet passage 71 extends through the lower cylindrical member 61 to the annular cavity 68. As in the previously described embodiment, the inlet passage 71 may communicate with a source of fluid in any suitable manner.

A cup-shaped member, indicated generally by the reference numeral 72, is supported for reciprocation within the venturi section. The cup-shaped member 72 has a lower wall 73 that extends normally to the longitudinal axis of the venturi section within the lower venturi portion 65. A cylindrical portion 74 surrounds the lower wall 73 and is formed integrally therewith. The cylindrical portion 74 extends coaxially with the longitudinal axis of the venturi section and its outer diameter is spaced radially inwardly of the throat 67. A small annular clearance, therefore, exists between the throat 67 and the cylindrical portion 74.

It should be readily apparent that the cup-shaped member 72 divides the venturi section into two fluid chambers, indicated generally by the reference numerals 75 and 76. The first fluid chamber 75 lies completely on the lower side of the throat 67. A portion of the second fluid chamber 76 lies partially on the lower side of the throat 67. The second chamber 76, however, is in fluid communication with the venturi section only at the upper side of the throat 67 because of the extent of the cylindrical portion 74.

A solenoid coil 77 encircles a ferromagnetic armature or core 78 that extends along the axis of the venturi section. The lower end of the coil 77 is supported upon a shoulder 79 of the armature 78. The upper end of the coil 77 engages a spacer 81 that encircles a threaded upper end 82 of the armature 78. The threaded upper end 82 extends through an aperture 83 in the upper wall of the cylindrical member 62. An internally threaded, hollow cap member 84 engages the threads 82 of the armature 78 to axially position the armature 78 and the coil 77 within the venturi section.

A supporting rod 85 reciprocates within a bore 86 formed along the axis of the armature 78. The rod 85 terminates at a cap 87 that is supported within a bore 88 of the cap member 84. A coil spring 89 engages the cap 87 and an adjustable stop 91 to urge the rod 85 and cup-shaped member 72 to which the rod 85 is affixed in a downward direction. A more rigid return spring 92 is positioned within the venturi section between the spacer 81 and wall 73.

When the coil 77 is energized by means of a suitable electric circuit (not shown), a magnetic field is created through the armature 78. The cup-shaped member 72 is formed of a ferromagnetic material so that the lower wall 73 will be attracted by the magnetic field. The magnetic attraction causes the cup-shaped member 72 to be drawn upwardly and compress the springs 89 and 92. The upward movement of the cup-shaped member 72 compresses the volume in the second fluid chamber 76 and increases the volume in the first fluid chamber 75. A resulting fluid flow occurs through the venturi section in a downward direction through the clearance between the throat 67 and the cylindrical portion 74. The flow through this clearance creates a decreased static pressure at the openings 69 to draw fluid into the venturi section from the fluid inlet passage 71. The fluid is discharged through an outlet connection 93 positioned in the upper wall of the cylindrical member 62. When the coil 77 is deenergized, the springs 89 and 92 will urge the cup-shaped member 72 downwardly and reverse the direction of fluid flow through the clearance between the throat 67 and the cylindrical portion 74. Although the fluid flow takes place in the opposite direction, pumping action will continue since a decreased pressure again is generated within the venturi throat.

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The embodiment shown in FIGURES 4 and 5 is similar to that shown in FIGURE 3. In this embodiment, however, a different form of return spring for the reciprocating member is employed. Referring now to FIGURES 4 and 5, the pump comprises first and second cylindrical members 111 and 112 forming upper and lower portions 113 and 114, respectively, of a venturi section. The venturi section is closed at each end by cylindrical end plates 115 and 116. The cylindrical members 111 and 112 and the end plates 115 and 116 are held together to form a unitary assembly by the plurality of bolts 117 (only one of which is shown). Suitable gaskets 118 are positioned between the adjacent surfaces of each of the pump casing members.

The venturi portions 113 and 114 converge at a throat 119 that is surrounded by an annular cavity 121 formed in opposing surfaces of the cylindrical members 111 and 112. The cavity 121 opens into the throat 119 through a plurality of radially extending openings 122. Fluid inlet passages 123 and 124 formed in the end plate 116 and cylindrical member 112, respectively, connect the annular cavity 121 with a source of fluid, as in the previous embodiments.

A cup-shaped member, indicated generally by the reference numeral 125, is supported for reciprocation within the venturi section. The cup-shaped member comprises a lower wall 126 that extends normally to the longitudinal axis of the venturi section. An integral cylindrical portion 127 surrounds the lower wall 126 and extends coaxially with the venturi section through the throat 119. A small annular clearance is provided between the outer surface of the cylindrical portion 127 and the inner surface of the throat 119 for fluid flow therethrough.

The cup-shaped member 125 divides the venturi section into two fluid chambers, indicated generally by the reference numerals 128 and 129. The first chamber 128 lies completely on the lower side of the throat 119. A portion of the second chamber 129 also lies below the throat 119. The chamber 129 is in fluid communication with the venturi section at the upper side of the throat 119 because of the axial extent of the cylindrical portion 127.

A solenoid coil 131 is supported coaxially within the venturi section by a ferromagnetic armature or core 132. The lower edge of the coil 131 is supported upon a shoulder 133 of the armature 132 and the upper end engages a spacer 134. A reduced diameter portion 135 of the armature 132 extends through apertures 136 and 137 in the spacer 134 and end plate 115, respectively. The upper end of the portion 135 is threaded, as at 138, for receipt of a nut 139 that axially affixes the coil 131 and armature 132 in the pump assembly. Suitable electric circuit means (not shown) are provided to alternately energize the coil 131.

A flat spiral leaf spring, indicated generally by the reference numeral 141 and shown in more detail in FIGURE 5, is positioned within the lower end of the pump assembly to function as a return and centering spring for the cup-shaped member 125. A threaded fastener 142 passes through an aperture in the lower wall 126 and a complimentary aperture 143 formed in the spring 141. The outer ends of the spring 141 are secured to the end plate 116 by screws 144.

When the coil 131 is energized a magnetic field is created through the armature 132. The cup-shaped member 125 is formed from a ferromagnetic material and the armature 132 draws the cup-shaped member 125 upwardly. During the upward motion the spring 141 is deformed from its normal, flat shape into a conical shape. As the cup-shaped member 125 moves upwardly the volume of the second fluid chamber 129 is decreased and the volume of the first chamber 128 is increased. This causes fluid to be driven downwardly through the clearance between the cylindrical portion 127 and the throat 119. The flow through the clearance causes a decrease in static pressure so that fluid enters the venturi section. Fluid is there-

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fore driven out of the venturi section through an outlet conduit 145 positioned in the cover plate 115. When the coil 131 is deenergized, the spring 141 returns to its flattened shape and causes fluid flow in the opposite direction between the throat 119 and the cylindrical portion 127. A pressure differential is thereby generated again between the fluid inlet and fluid outlet and fluid flow takes place.

It is to be understood that the invention is not limited to the embodiments shown and described, but that various changes and modifications may be made without departing from the spirit and scope of the invention as defined by the appended claims.

I claim:

1. A pump comprising a venturi, a movable wall defining first and second fluid chambers, means providing fluid communication between said first fluid chamber and said venturi on one side of its throat, means providing fluid communication between said second fluid chamber and said venturi on the other side of said throat, fluid inlet means extending from a fluid source to said venturi at said throat, fluid outlet means extending from said venturi at a point remote from said throat, and means for moving said wall in opposite directions to alternately compress the volumes of said first and said second fluid chambers to drive fluid in opposite directions through said throat for generating a pressure differential between said fluid inlet means and said fluid outlet means.

2. A pump comprising a venturi, first and second fluid chambers separated by a common movable wall, means comprising a tubular member extending through said venturi for providing fluid communication between said first fluid chamber and said venturi on one side of its throat, said tubular member being spaced radially inwardly of said throat to provide a clearance therebetween, said second fluid chamber being in fluid communication with said venturi on the other side of said throat, fluid inlet means extending from a fluid source to the throat of said venturi, fluid outlet means extending from said venturi at a point remote from said throat, and means for moving said wall in opposite directions to alternately compress the volumes of said first and said second fluid chambers to drive fluid in opposite directions through the clearance between said tubular member and said throat for generating a pressure differential between said fluid inlet means and said fluid outlet means.

3. A pump comprising a venturi, first and second fluid chambers separated by a common wall, said wall being supported for reciprocation, means including a tubular member extending through said venturi for providing fluid communication between said first fluid chamber and said venturi on one side of its throat, said tubular member being spaced radially inwardly from said throat to provide a clearance therebetween, said second fluid chamber being in open communication with said venturi on the other side of said throat, fluid inlet means extending from a fluid source to said venturi at its throat, fluid outlet means extending from said venturi at a point remote from said throat, means interconnecting said wall with one of said tubular member and said venturi for simultaneous reciprocation, and means for reciprocating said wall to alternately compress the volumes of said first and said second fluid chambers to drive fluid in opposite directions through said throat for generating a pressure differential between said fluid inlet means and said fluid outlet means.

4. A pump comprising a venturi, first and second fluid chambers separated by a common wall, said wall being supported for reciprocation, means including a tubular member extending through said venturi for providing fluid communication between said first fluid chamber and said venturi on one side of its throat, said tubular member being spaced radially inwardly from said throat to provide a clearance therebetween, said second fluid chamber being in open communication with said venturi on

the other side of said throat, fluid inlet means extending from a fluid source to said venturi at its throat, fluid outlet means extending from said venturi at a point remote from said throat, means interconnecting said wall with said tubular member for simultaneous reciprocation, and means for reciprocating said wall and said tubular member to alternately compress the volumes of said first and said second fluid chambers to drive fluid in opposite directions through the clearance between said tubular member and said throat for generating a pressure differential between said fluid inlet means and said fluid outlet means.

5. A pump comprising a venturi, first and second fluid chambers separated by a diaphragm, means including a tubular member extending through said venturi for providing fluid communication between said first fluid chamber and said venturi on one side of its throat, said tubular member being spaced radially inwardly from said throat to provide a clearance therebetween, said second fluid chamber being in fluid communication with said venturi on the other side of said throat, fluid inlet means extending from a fluid source to said venturi at said throat, fluid outlet means extending from said venturi at a point remote from said throat, and means for reciprocating said diaphragm to alternately compress the volumes of said first and said second fluid chambers to drive fluid in opposite directions through said throat for generating a pressure differential between said fluid inlet means and said fluid outlet means.

6. A pump comprising a casing having a cavity opening into a venturi, a diaphragm extending across said cavity and defining first and second fluid chambers, means providing fluid communication between the first of said fluid chambers and said venturi on one side of its throat, said second fluid chamber being in open communication with said venturi on the other side of said throat, fluid inlet means extending from a fluid source to said venturi at its throat, fluid outlet means extending from said venturi at a point remote from said throat, a ferromagnetic member affixed to said diaphragm, a coil positioned adjacent said ferromagnetic member, and means for alternately causing current flow through said coil for reciprocating said diaphragm to alternately compress the volumes of said first and said second fluid chambers and drive fluid in opposite directions through said throat for generating a pressure differential between said fluid inlet means and said fluid outlet means.

7. A fluid pump comprising a housing having a cavity opening into a venturi section, a diaphragm extending across said cavity and dividing said cavity into first and second fluid chambers, a tubular member affixed to said diaphragm and extending therethrough, said tubular member further extending through the throat of said venturi for fluid communication between said first fluid chamber and said venturi on one side of said throat, said tubular member being spaced radially inwardly from said throat to provide a clearance therebetween, said second fluid chamber being in open communication with said venturi on the other side of said throat, fluid inlet means extending from a fluid source to said venturi at said throat, fluid outlet means extending from a point remote from said throat, and means for reciprocating said diaphragm to alternately compress the volumes of said first and said second fluid chambers to drive fluid in opposite directions through the clearance between said tubular member and said throat for generating a pressure differential between said fluid inlet means and said fluid outlet means.

8. A pump comprising a housing defining a venturi, a cup-shaped member having a wall extending normal to the longitudinal axis of said venturi and surrounded by a tubular portion that extends parallel to the longitudinal axis, said tubular portion extending axially through the throat of said venturi and being spaced radially inwardly

therefrom to provide a clearance therebetween, fluid inlet means extending from a source of fluid to the throat of said venturi, fluid outlet means extending from said venturi at a point spaced from said throat, and means for reciprocating said cup-shaped member in opposite directions along the axis of said venturi for driving fluid in opposite directions through the clearance between said tubular portion and said throat for generating a pressure differential between said fluid inlet means and said fluid outlet means.

9. A pump comprising a housing forming a venturi, a cup-shaped member supported within said venturi, said cup-shaped member having a wall extending normally to the longitudinal axis of said venturi on one side of its throat, said cup-shaped member further having a cylindrical portion surrounding said wall and extending parallel to said longitudinal axis and axially through said throat, said cylindrical portion being spaced radially inwardly from said throat to provide a clearance therebetween, a fluid inlet extending from a fluid source to the throat of said venturi, a fluid outlet extending from said venturi at a point spaced from said throat, at least a portion of the wall of said cup-shaped member being formed of a ferromagnetic material, a coil positioned in proximity to the ferromagnetic portion of said wall, biasing means urging said wall away from said coil, and means for causing an electrical current to flow alternately through said coil for reciprocating said cup-shaped member and driving fluid in opposite directions through the clearance between said throat and said cylindrical portion for generating a pressure differential between said fluid inlet and said fluid outlet.

10. A pump comprising a housing forming a venturi, a cup-shaped member supported within said venturi, said cup-shaped member comprising a wall portion extending normally to the longitudinal axis of said venturi on one side of its throat, said cup-shaped member further having a cylindrical portion surrounding said wall portion and extending parallel to said longitudinal axis and through said throat, said cylindrical portion being spaced radially inwardly from said throat to provide a clearance therebetween, fluid inlet means extending from a fluid source to said throat, fluid outlet means extending from said venturi at a point spaced from said throat, at least the central part of said wall portion being formed of a ferromagnetic material, a ferromagnetic core extending along the longitudinal axis of said venturi and terminating adjacent said central part, a guide member affixed to said wall portion and supported for reciprocation by said core, biasing means urging said guide member and said cup-shaped member away from said core, a coil encircling said core, and means for causing an electrical current flow through said core for reciprocating said cup-shaped member to drive fluid in opposite directions through the clearance between said cylindrical portion and said throat for generating a pressure differential between said fluid inlet means and said fluid outlet means.

11. A pump comprising a housing forming a venturi, a cup-shaped member supported within said venturi, said cup-shaped member comprising a wall portion extending normally to the longitudinal axis of said venturi on one side of its throat, said cup-shaped member further having a cylindrical portion surrounding said wall portion and extending parallel to said longitudinal axis and through said throat, said cylindrical portion being spaced radially inwardly from said throat to provide a clearance therebetween, fluid inlet means extending from a fluid source to said throat, fluid outlet means extending from said venturi at a point spaced from said throat, at least the central part of said wall portion being formed of a ferromagnetic material, a ferromagnetic core extending along the longitudinal axis of said venturi and terminating adjacent said central part, a guide member affixed to said wall and supported for reciprocation by said core, a spiral shaped leaf spring affixed at one end to said central part

and at another end to said housing, a coil encircling said core, and means for causing an electrical current flow through said core for reciprocating said cup-shaped member to drive fluid in opposite directions through the clearance between said cylindrical portion and said throat 5 for generating a pressure differential between said fluid inlet means and said fluid outlet means.

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