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(54) **POWER TOOL WITH PERISTALTIC PUMP**

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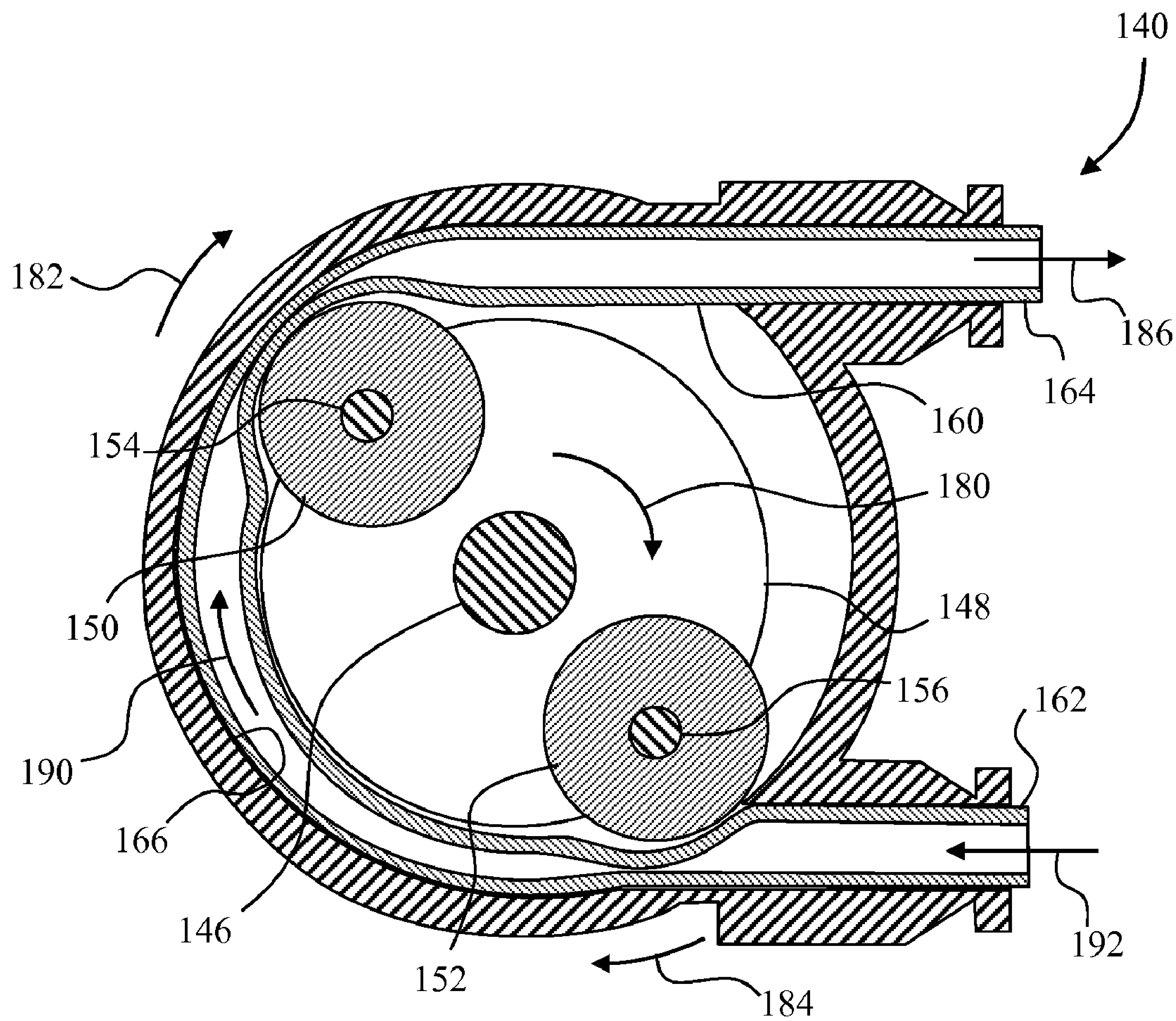
(57) **ABSTRACT**

The present invention in one embodiment is a power tool including a housing, a main power shaft located within the housing, a peristaltic pump assembly positioned within the housing and operably connected to the main power shaft, and an outlet conduit operably connected to the peristaltic pump assembly and extending between the peristaltic pump assembly and an outlet port in the housing such that fluid is forced by the peristaltic pump assembly through the outlet conduit to a location outside of the housing.



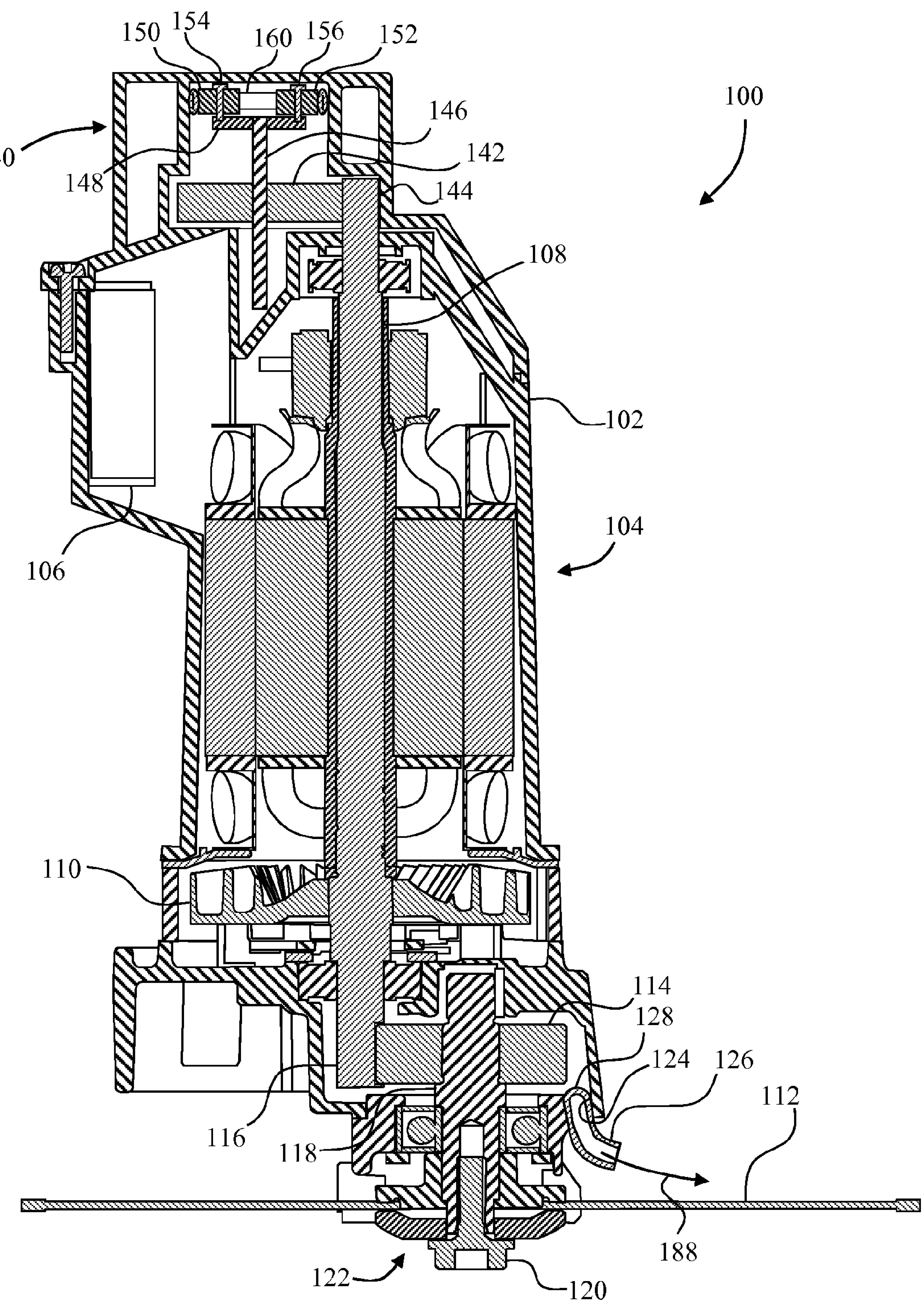

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FIG. 1

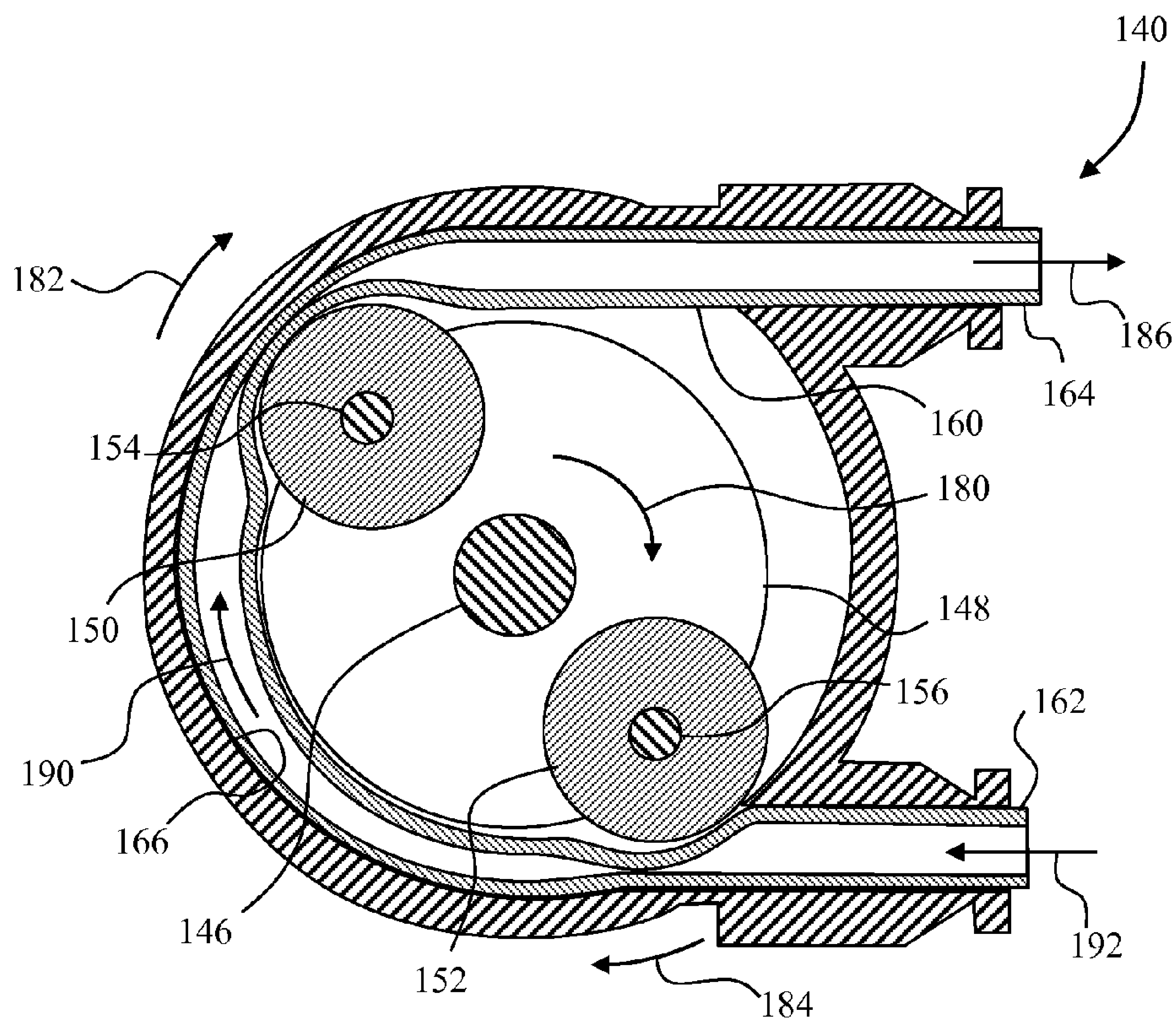

FIG. 2

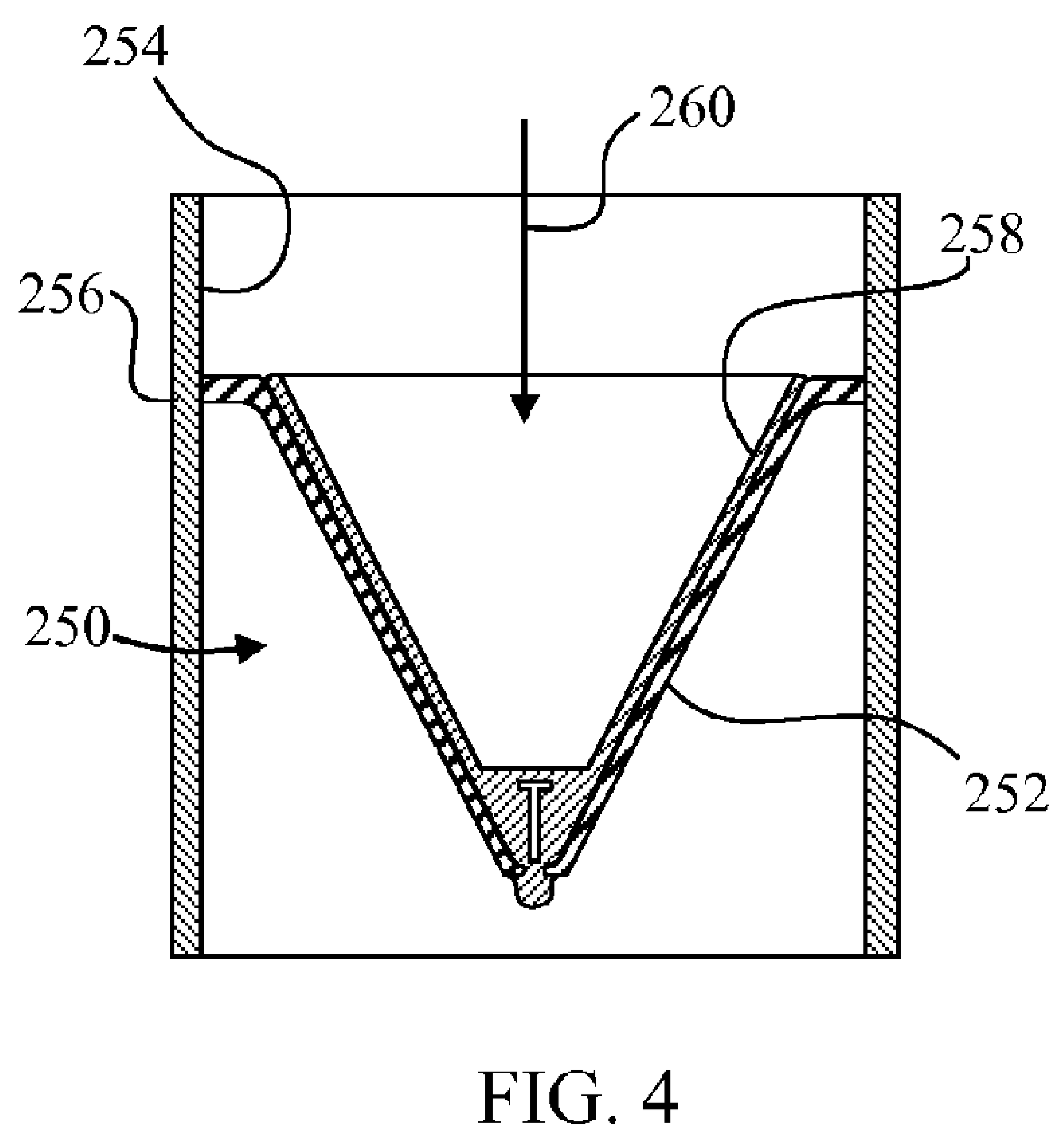

FIG. 4

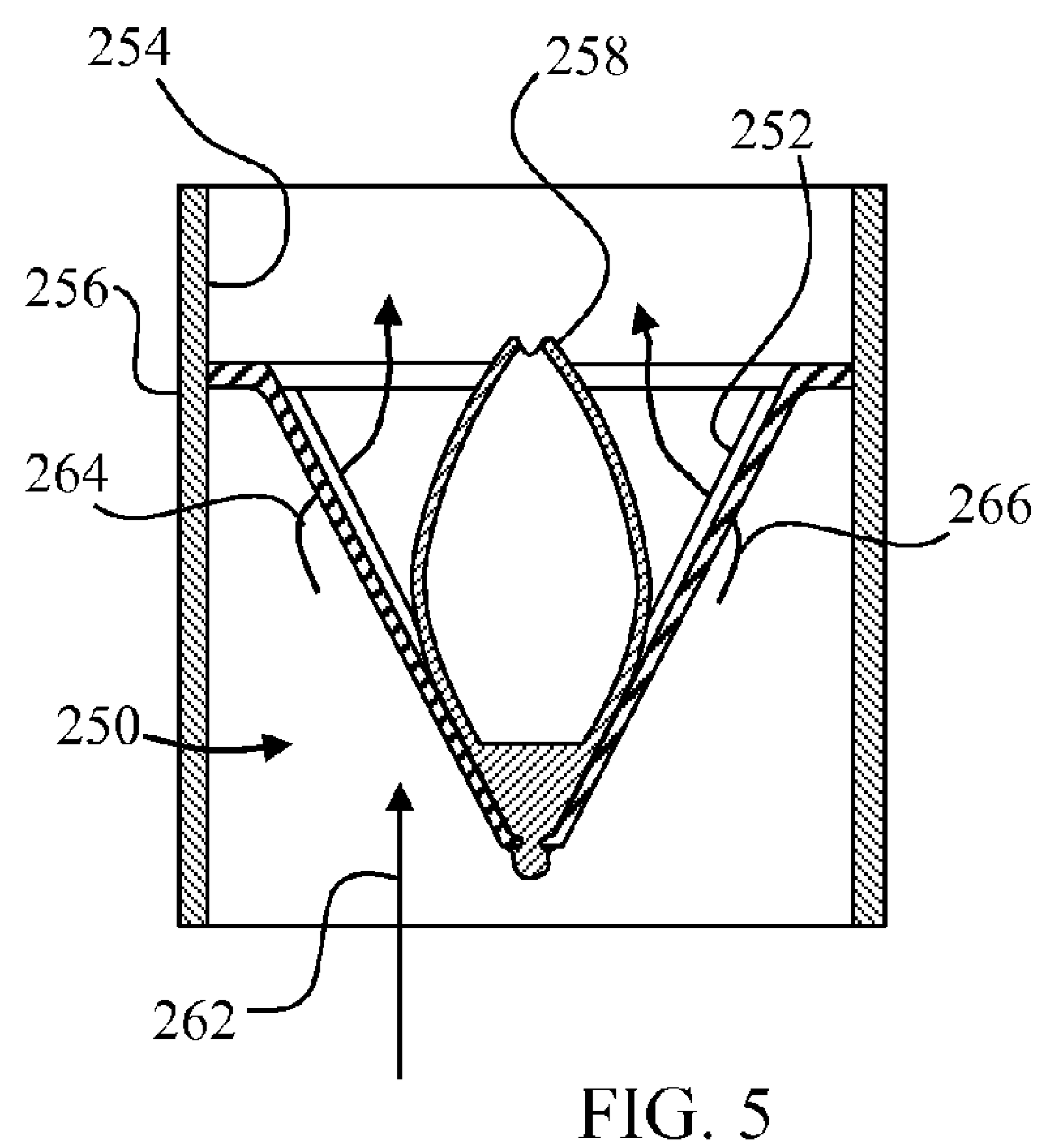

FIG. 5

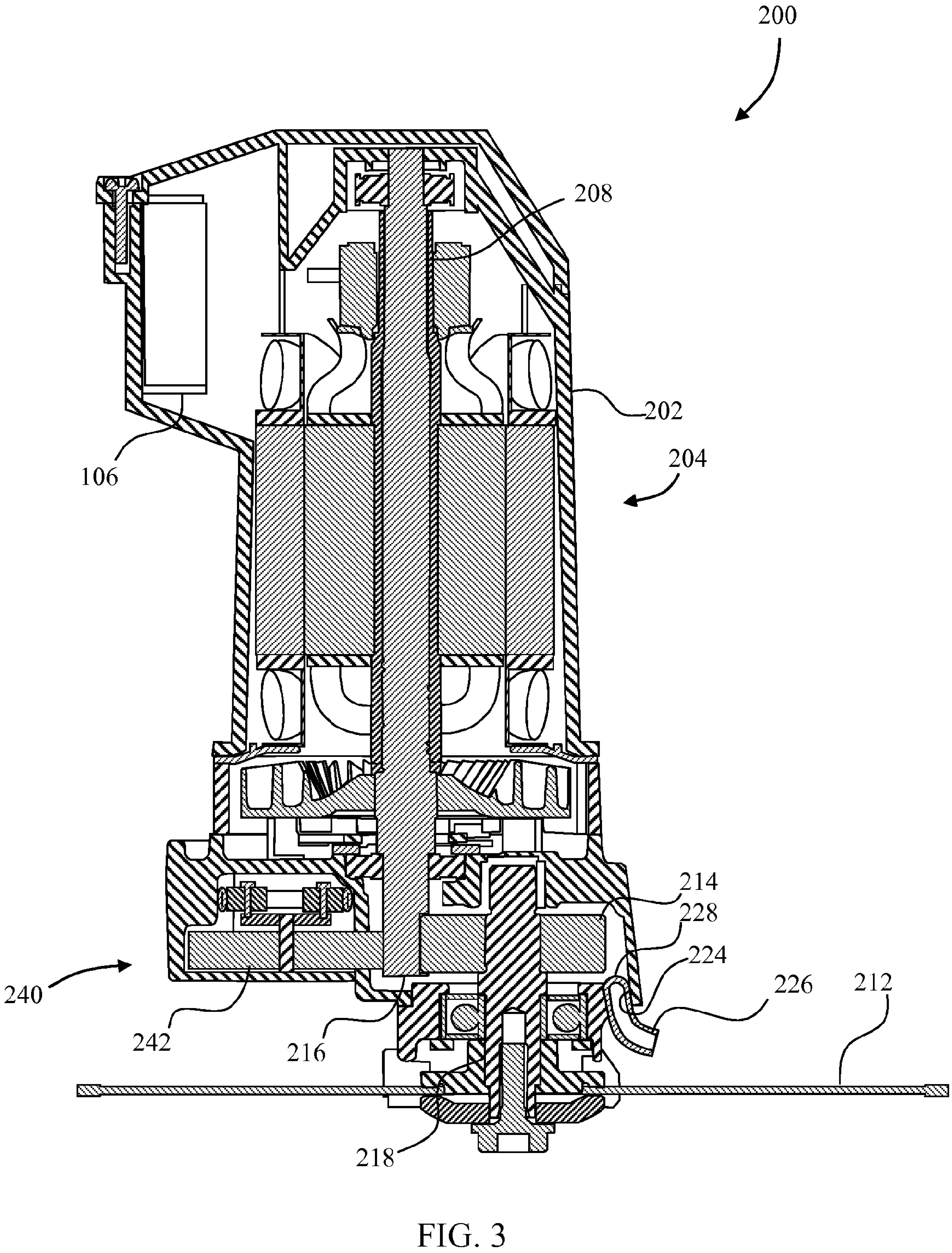

FIG. 3

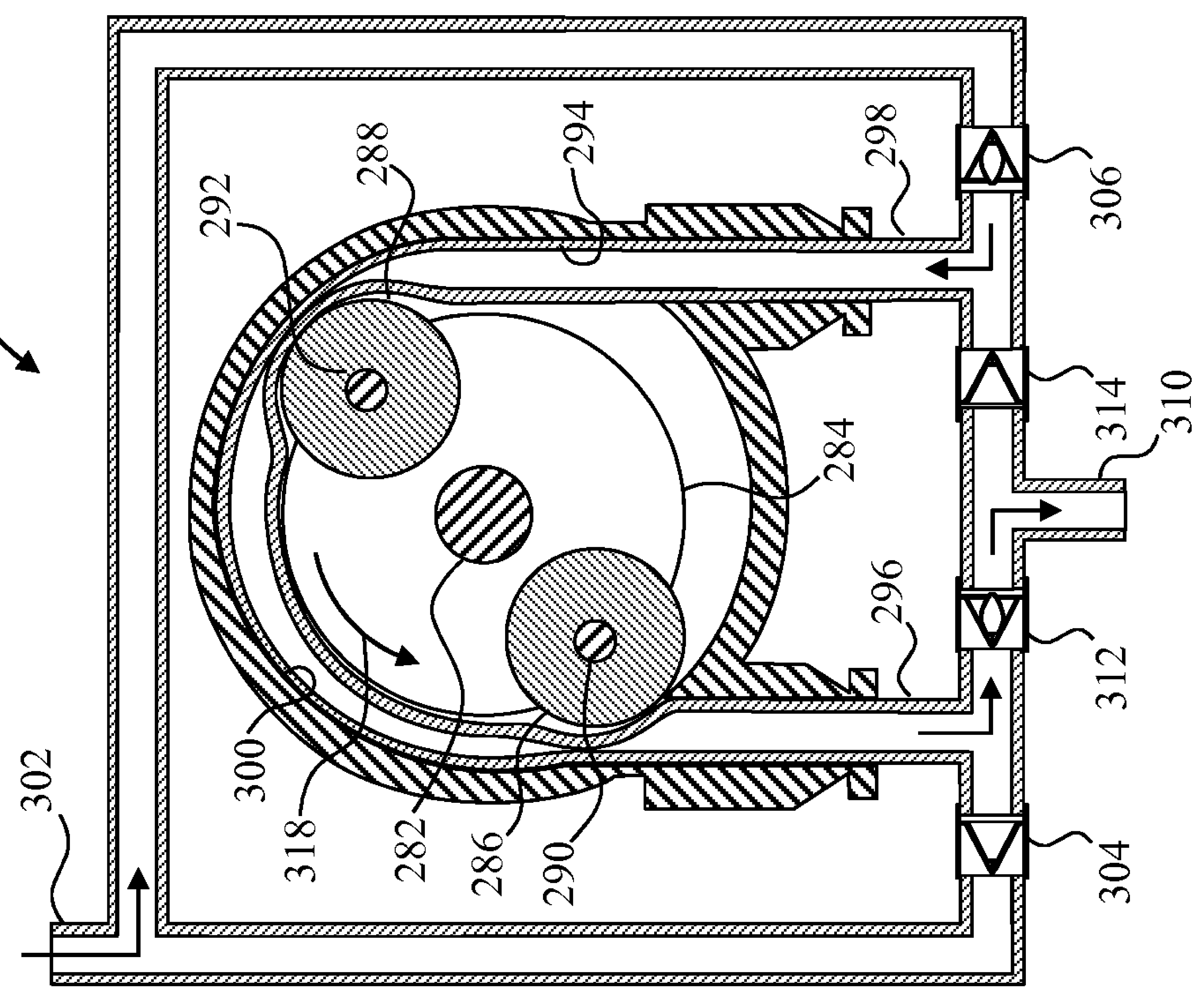
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FIG. 7

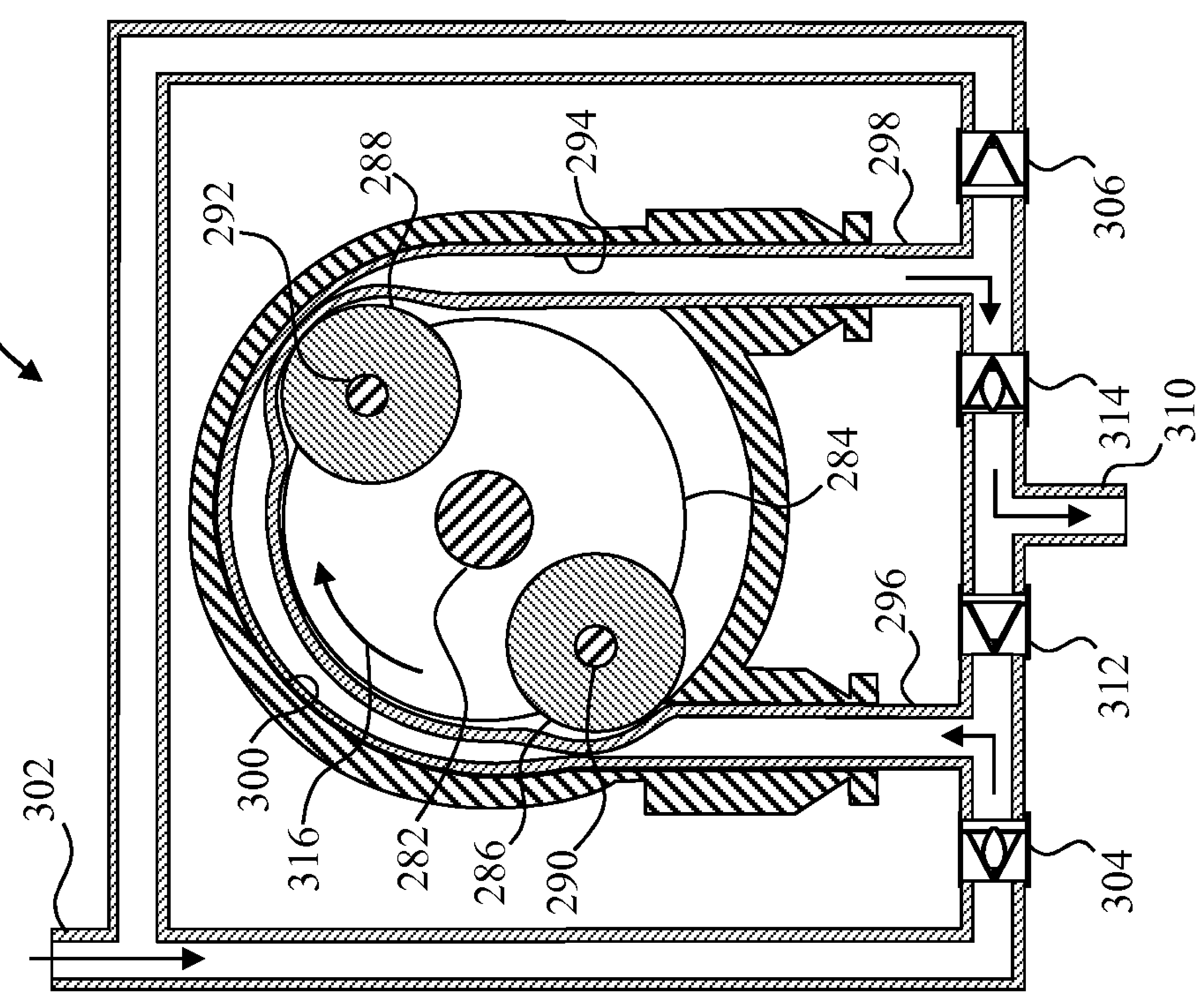
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FIG. 6

POWER TOOL WITH PERISTALTIC PUMP

FIELD OF THE INVENTION

[0001] The present invention relates to power tools and more particularly to power tools which generate dust or debris during normal operation of the power tool.

BACKGROUND

[0002] Power tools are commonly used in various applications which generate significant amounts of dust or debris. By way of example, power tools are used to shape work pieces such as wood, drywall, etc. In many cases, a user marks the work piece so as to guide shaping of the work pieces. Thus, a line may be used to indicate where the work piece is to be cut. In some instances, the mark is only used to initially align the work piece with the power tool. Thereafter, the power tool is operated in a constrained manner such that the desired cut is almost automatically made. For example, a mark may initially be aligned with a blade on a table saw and thereafter a guide is used to precisely maneuver the work piece into contact with the blade.

[0003] In the forgoing example, once the work piece makes contact with the blade, the guide mark may be obscured by saw dust generated by the blade. In such cases, obscuration of the guide mark by saw dust may not be overly problematic. Nonetheless, many users still desire to see the guide mark as the cut is being made, if only to give a sense of security that the work piece has not become misaligned.

[0004] In other instances, a user actively modifies the alignment during a shaping operation. By way of example, jig saws and saber saws are commonly used to make curved cuts in a work piece. Accordingly, the user is constantly modifying the alignment of the power tool with respect to the work piece to follow the curved guide mark. In this type of scenario, obscuration of a guide mark by saw dust may result in a poor cut thereby requiring additional shaping operations or even ruining the work piece.

[0005] In some systems, removal of saw dust from an area that is being shaped is accomplished either by reliance upon air movement resulting from movement of the shaping component, such as a saw blade, or by a motor fan that is attached directly to the main power shaft of the tool and configured such that some of the air from the motor fan is directed toward a work piece. Such approaches may be unsatisfactory for a number of reasons. In some instances, the shaping component simply does not generate sufficient airflow to clear the saw dust. In tools including a motor fan, the motor fan is primarily configured to cool the motor. Accordingly, configuring the motor fan to further clear saw dust and debris severely limits the design of the tool.

[0006] Various alternatives are available to remove debris formed by the shaping operation in addition to those discussed above. Some power tools employ vacuum systems connected to the tool to remove cutting debris. The use of a vacuum system, however, often makes control of the tool more cumbersome, and the vacuum system itself can greatly increase the cost and complexity of a power tool. In other systems, a bellows is used to generate bursts of air which can be directed at the work piece. While such systems can be effective, the pulsed air flow can be distracting. Additionally, the reciprocating nature of the bellows activation mechanism may introduce undesired vibrations into the power tool.

[0007] Accordingly, there is a need for a power tool that allows increased visibility at the point of a shaping operation. A power tool that allows increased visibility at the point of a shaping operation without a reciprocating activation mechanism would be further beneficial.

SUMMARY

[0008] The present invention in one embodiment is a power tool including a housing, a main power shaft located within the housing, a peristaltic pump assembly positioned within the housing and operably connected to the main power shaft, and an outlet conduit operably connected to the peristaltic pump assembly and extending between the peristaltic pump assembly and an outlet port in the housing such that fluid is forced by the peristaltic pump assembly through the outlet conduit to a location outside of the housing.

[0009] In a further embodiment, a power tool includes a housing, a main power shaft at least partially located within the housing, a peristaltic pump assembly operably connected to the main power shaft, and an outlet conduit operably connected to the peristaltic pump assembly and extending between the peristaltic pump assembly and an outlet portion of the outlet conduit, the outlet portion configured to direct fluid toward a predetermined location.

[0010] These and other advantages and features of the present invention may be discerned from reviewing the accompanying drawings and the detailed description of a preferred embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The present invention may take form in various system and method components and arrangement of system and method components. The drawings are only for purposes of illustrating exemplary embodiments and are not to be construed as limiting the invention.

[0012] FIG. **1** depicts a simplified side cross-sectional view of a hand power tool incorporating features of the present invention with a peristaltic pump assembly operably connected to an end portion of a main power shaft opposite to the end portion of the main power shaft which is used to drive a shaping component;

[0013] FIG. **2** depicts a top cross-sectional view of the peristaltic pump assembly of FIG. **1**;

[0014] FIG. **3** depicts a simplified side cross-sectional view of a hand power tool incorporating features of the present invention with a peristaltic pump assembly operably connected to the same end portion of a main power shaft which is used to drive a shaping component;

[0015] FIG. **4** depicts a side cross-sectional view of a diaphragm check valve in a closed position;

[0016] FIG. **5** depicts a side cross-sectional view of the diaphragm check valve of FIG. **4** in an open position;

[0017] FIG. **6** depicts a top cross-sectional view of a peristaltic pump assembly incorporating four of the check valves of FIG. **4** arranged to force fluid out of an outlet conduit regardless of the direction of rotation of the peristaltic pump assembly with the check valves in the positions resulting from a clockwise rotation of the pump shaft; and

[0018] FIG. **7** depicts a top cross-sectional view of the peristaltic pump assembly of FIG. **6** with the check valves in the positions resulting from a counter-clockwise rotation of the pump shaft.

DESCRIPTION

[0019] A hand power tool generally designated **100** is shown in FIG. **1**. In the embodiment of FIG. **1**, the power tool **100** includes a main housing portion **102**. The main housing portion **102** houses a motor **104** and control electronics **106** for control of the power tool **100**. The main housing portion **102** in one embodiment includes a battery receptacle for receiving a rechargeable battery pack (not shown). In one embodiment, the rechargeable battery pack (not shown) comprises a lithium-ion battery. The power tool **100** in other embodiments is powered by an external power source such as an external battery or a power cord.

[0020] The motor **104** is configured to selectively cause a main power shaft **108** to rotate. The main power shaft **108** in the embodiment of FIG. **1** is located completely within the housing **102**. In other embodiments, a portion of the main power shaft **108** extends outwardly of the housing. A motor fan **110** is fixedly attached to the main power shaft **108** and configured to force cooling air against the motor **104** during operation of the power tool **100**.

[0021] A shaping component **112**, which in this embodiment is a circular blade, is operably connected to the main power shaft **108** by a shaping component gear **114** which is enmeshed with an end portion **116** of the main power shaft **108**. The shaping component gear **114** is fixedly attached to a shaping component drive shaft **118** to which the shaping component **112** is removably attached by a bolt **120** and clamping assembly **122**. In the embodiment of FIG. **1**, the power tool **100** is configured for operably driving the shaping component **112** such that the shaping component **112** rotates about the shaping component drive shaft **118**. In other embodiments, the power tool is configured to oscillate the shaping component which may be formed as a straight saw blade, for example.

[0022] The housing portion **102** includes an outlet port **124** located proximate to the location at which the shaping component drive shaft **118** extends outwardly of the housing **102**. An end portion **126** of an outlet conduit **128** extends through the outlet port **124** and is directed generally along the shaping component **112**. End portion **126** in some embodiments is a directional component that stops close to the housing or a flexible hose or tubing piece. The outlet conduit **128** extends along and within the housing **102** to a peristaltic pump assembly **140**. The outlet conduit **128** is in fluid communication with the peristaltic pump assembly **140** which is described with additional reference to FIG. **2**.

[0023] The peristaltic pump assembly **140** includes a pump gear **142** which is enmeshed with an end portion **144** of the main power shaft **108**. The pump gear **142** is fixedly attached to a pump shaft **146** which is fixedly attached to a rotor **148**. Two rollers **150/152** are rotatably supported by the rotor **148** through axles **154/156**, respectively. The rollers **150/152** are configured to extend outwardly from the rotor **148** so as to contact an elastomeric tube **160**. The elastomeric tube **160** includes an inlet portion **162** and an outlet portion **164**. The elastomeric tube **160** extends about an arcuate pump casing **166** which in this embodiment is formed on the inner surface of the housing **102**.

[0024] In operation, a user activates the power tool **100** such as by use of a power switch (not shown) and the control electronics **106** causes power to be applied to the motor **104**. The motor **104** then causes the main power shaft **108** to rotate. In the embodiment of FIG. **1**, the left side of the main power shaft **108**, as depicted in FIG. **1**, rotates out of the page while the right side of the power shaft **108** rotates into the page.

[0025] Rotation of the main power shaft **108** causes the shaping component gear **114** to rotate in an opposite direction. Thus, the right side of the shaping component gear **114**, as depicted in FIG. **1**, rotates out of the page while the left side of the shaping component gear **114** rotates into the page. Since the shaping component drive shaft **118** is fixedly attached to the shaping component gear **114**, the shaping component drive shaft **118** rotates in the same manner as the shaping component gear **114**. Similarly, since the shaping component **112** is attached to the shaping component drive shaft **118**, the shaping component **112** also rotates in the same manner as the shaping component gear **114**.

[0026] Rotation of the main power shaft **108** further causes the pump gear **142** to rotate in an opposite direction. Thus, the right side of the pump gear **142**, as depicted in FIG. **1**, rotates out of the page while the left side of the pump gear **142** rotates into the page. Since the pump shaft **146** is fixedly attached to the pump gear **142**, the pump shaft **146** rotates in the same manner as the pump gear **114**. Similarly, since the rotor **148** is fixedly attached to the pump shaft **146**, the rotor **148** also rotates in the same manner as the pump gear **142**. This results in a clockwise rotation of the rotor **148** as viewed in FIG. **2**, as indicated by the arrow **180**.

[0027] As the rotor **148** rotates in the direction indicated by the arrow **180**, the rollers **150** and **152** are forced in the direction of the arrows **182** and **184**, respectively. The rollers **150** and **152** extend outwardly of the rotor **148** and are in contact with the elastomeric tube **160**. Accordingly, as the rollers **150/152** are forced in the direction of the arrows **182** and **184**, the rollers “roll” along the stationary elastomeric tube **160** and squeeze the elastomeric tube **160** against the arcuate pump casing **166**. In the embodiment of FIG. **1**, the rollers **150/152**, rotor **148**, elastomeric tube **160** and arcuate pump casing **166** are sized such that the elastomeric tube **160** is totally occluded at locations directly between the rollers **150/152** and the arcuate pump casing **166** (see FIG. **1**). In other embodiments, the components are sized to provide only partial occlusion.

[0028] As the roller **150** moves toward the tube outlet **164** from the location depicted in FIG. **2**, fluid within the elastomeric tube **160** between the roller **150** and the tube outlet **164** is forced through the elastomeric tube **160** and out of the tube outlet **164** as indicated by the arrow **186**. The fluid is then forced into the outlet conduit **128** which is in fluid communication with the tube outlet **164**. In one embodiment, the outlet conduit **128** is integrally formed with the elastomeric tube **160**.

[0029] The fluid that is forced into the outlet conduit **128** flows out of the end portion **126** as indicated by the arrow **188** of FIG. **1**. In the embodiment of FIG. **1**, the end portion **126** is located adjacent to the shaping component **112**. In some embodiments wherein the fluid that is pumped is air, the end portion **126** is oriented such that the air flow will impact the area of a work piece that is being shaped by the shaping component **112**, taking into account the effect of the movement of the shaping component **112**. In embodiments wherein the fluid that is pumped is a liquid, the end portion **126** may be oriented such that the liquid contacts the shaping component **112**, thereby cooling the shaping component **112**.

[0030] Returning to FIG. **2**, as the roller **150** forces fluid out of the tube outlet **164**, the roller **152** forces fluid within the elastomeric tube **160** between the roller **150** and the roller **152**

in the direction of the arrow **190**. Accordingly, when the roller **150** moves past the tube outlet **164**, the fluid between the roller **150** and the roller **152** is forced out of the tube outlet **164**. Because the rollers **150**/**152** are located generally opposite to one another on the rotor **148**, a substantially continuous stream of fluid is forced out of the tube outlet **164**. In embodiments where a substantially continuous stream of fluid is not desired, a single roller may be used. In single roller embodiments, the distance between the inlet and the outlet portions of the tube along the arcuate pump casing may be modified to provide the desired interruption in the effluent stream. In embodiments with more than two rollers, the rollers are preferably equally spaced about the rotor.

[0031] Continuing with FIG. **2**, the elastomeric tube **160** is made of a material which regains its shape once the pressure applied by the rollers **150**/**152** is removed at a particular location. Some commonly used elastomers include silicone, PVC, EPDM+polypropylene (as in SANTOPRENE), polyurethane and NEOPRENE. Extruded fluoropolymer tubes such as FKM (Viton, Fluorel, etc.) may also be used. Accordingly, as the roller **152** moves away from the tube inlet **162**, the elastomeric tube **160** regains its shape, thus creating a vacuum which allows additional fluid to be forced into the elastomeric tube **160** through the tube inlet **162** behind the roller **152** as indicated by the arrow **192**.

[0032] The elastomeric tube **160** is thus refilled with fluid until the roller **152** collapses the elastomeric tube **160** at a location adjacent to the tube inlet **162**. In some embodiments, a filter (not shown) is used to filter fluid which comes through the tube inlet **162**. The tube inlet **162** may be configured to take a suction within the housing **102** or from outside of the housing **102**. By positioning the tube inlet **162** next to the motor **104**, the effectiveness of the motor fan **110** may be increased. In embodiments wherein the fluid is a liquid, the tube inlet **162** may be immersed within a liquid reservoir.

[0033] While the invention is shown in one configuration in the embodiment of FIG. **1**, the invention may be modified in a number of ways to support different designs. By way of example, FIG. **3** depicts a tool **200** which includes a main housing portion **202**. The main housing portion **202** houses a motor **204** and control electronics **206** for control of the power tool **200**. The motor **204** is configured to selectively cause a main power shaft **208** to rotate. A shaping component **212** is operably connected to the main power shaft **208** by a shaping component gear **214** which is enmeshed with an end portion **216** of the main power shaft **208**.

[0034] The housing portion **202** includes an outlet port **224** located proximate to the location at which a shaping component drive shaft **218** extends outwardly of the housing **202**. An end portion **226** of an outlet conduit **228** extends through the outlet port **224** and is directed generally along the shaping component **212**. The outlet conduit **228** extends within the housing **202** to a peristaltic pump assembly **240**.

[0035] The outlet conduit **228** is in fluid communication with the peristaltic pump assembly **240** which is substantially the same as the peristaltic pump assembly **140** of FIG. **2**. The main difference is that the pump gear **242** is enmeshed with the end portion **216** of the main power shaft **208** at a location substantially opposite to the side of the main power shaft **208** whereat the shaping component gear **214** is enmeshed with the main power shaft **208**.

[0036] In addition to modification of the physical location of the peristaltic pump assembly within or outside of the housing of a power tool, the function of the peristaltic pump assembly may be modified. As discussed above, in some embodiments the tube inlet to the peristaltic pump assembly is positioned to increase the effectiveness of a motor fan. In other embodiments, the tube outlet or outlet conduit is positioned to provide cooling directly to the motor of the power tool. In these embodiments, the tube inlet is typically not positioned to also take suction from the motor location.

[0037] While the embodiments of FIGS. **1** and **3** are power tools which rotatably drive a shaping component in only a single direction, in some embodiments, the main power shaft rotatably drives a shaping component in alternate directions. In embodiments wherein the main power shaft can be rotated in different directions, the peristaltic pump assembly is generally configured to produce the same flow of air through an outlet conduit. One such embodiment incorporates diaphragm check valves such as the check valve **250** depicted in FIGS. **4** and **5**.

[0038] With initial reference to FIG. **4**, the check valve **250** includes a seat portion **252** which is sealingly engaged with the inner wall **254** of a tube **256**. A resilient diaphragm **258** is positioned in the seat **252** and configured such that in the absence of any pressure from fluid within the tube **256** acting upon the diaphragm **258**, the diaphragm **258** is seated firmly against the seat **252**. Accordingly, if pressure is applied to the diaphragm **258** in the direction of the arrow **260**, the diaphragm **258** is more firmly seated against the seat **252** and no fluid is allowed to pass.

[0039] When pressure is applied in the direction of the arrow **262** of FIG. **5**, however, the pressure resiliently deforms the diaphragm **258** forcing the diaphragm **258** away from the seat **252** as depicted in FIG. **5**. Accordingly, the fluid providing the pressure is free to move past the seat **252** as indicated by the arrows **264**/**266**.

[0040] With reference now to FIG. **6**, a peristaltic pump assembly **280** includes a pump shaft **282** which is fixedly attached to a rotor **284**. Two rollers **286**/**288** are rotatably supported by the rotor **284** through axles **290**/**292**, respectively. An elastomeric tube **294** includes a first end portion **296** and a second end portion **298**. The elastomeric tube **294** extends about an arcuate pump casing **300**.

[0041] An inlet **302** is in interruptible fluid communication with the first end portion **296** through a check valve **304**. The inlet **302** is also in interruptible fluid communication with the second end portion **298** through a check valve **306**. An outlet conduit **310** is in interruptible fluid communication with the first end portion **296** through a check valve **312**. The outlet conduit **310** is also in interruptible fluid communication with the second end portion **298** through a check valve **314**.

[0042] The peristaltic pump assembly **280** is configured to provide fluid flow outwardly through the outlet conduit **310** regardless of the direction in which a main power shaft (not shown) operably connected to the pump shaft **282** is turning. By way of example, if the main power shaft (not shown) is rotated such that the pump shaft **282** turns in the direction of the arrow **316** of FIG. **6**, the roller **288** will force fluid out of the second end portion **298**. The check valve **306** is arranged such that an increase in pressure at the second end portion **298** causes the check valve **306** to be fully shut. Accordingly, no fluid passes through the check valve **306**. The check valve **314**, however, is arranged such that an increase in pressure at the second end portion **298** causes the check valve **314** to open. Accordingly, fluid passes through the check valve **314**, resulting in a higher pressure at the outlet conduit **310**.

[0043] At the same time that the roller **288** is forcing fluid out of the second end portion **298**, the elastomeric tube **294** is regaining its normal shape as the roller **286** moves away from the first end portion **296**, thereby creating a low pressure area at the first end portion **296**. The resultant pressure drop from the higher pressure generated in the outlet conduit **310** as described above, along with the low pressure at the first end portion **296** causes the check valve **312** to be firmly seated. Additionally, the low pressure at the first end portion **296** causes fluid from the inlet **302** to move through the check valve **304** to the first end portion **296**.

[0044] Consequently, rotation of the pump shaft **282** in the direction of the arrow **316** causes suction at the inlet **302** through the check valve **304** while fluid is emitted through the outlet conduit **310** by way of the check valve **314**.

[0045] If the rotation of the pump shaft is reversed, the pump shaft **282** turns in the direction of the arrow **318** of FIG. **7**, and the roller **286** will force fluid out of the first end portion **296**. The check valve **304** is arranged such that an increase in pressure at the first end portion **296** causes the check valve **304** to be fully shut. Accordingly, no fluid passes through the check valve **304**. The check valve **312**, however, is arranged such that an increase in pressure at the first end portion **296** causes the check valve **312** to open. Accordingly, fluid passes through the check valve **312**, resulting in a higher pressure at the outlet conduit **310**.

[0046] At the same time that the roller **286** is forcing fluid out of the first end portion **296**, the elastomeric tube **294** is regaining its normal shape as the roller **288** moves away from the second end portion **298**, thereby creating a low pressure area at the second end portion **298**. The resultant pressure drop from the higher pressure generated in the outlet conduit **310** as described above, along with the low pressure at the second end portion **298** causes the check valve **314** to be firmly seated. Additionally, the low pressure at the second end portion **298** causes fluid from the inlet **302** to move through the check valve **306** to the second end portion **298**.

[0047] Consequently, rotation of the pump shaft **282** in the direction of the arrow **318** causes suction at the inlet **302** through the check valve **306** while fluid is emitted through the outlet conduit **310** by way of the check valve **312**.

[0048] Therefore, by the addition of check valves, a peristaltic pump assembly can be configured to provide a stream of effluent through an outlet conduit regardless of the direction of rotation of a pump shaft. Thus, the peristaltic pump assembly may be used with power tools which allow for the direction of shaft rotation to be reversed.

[0049] While the present invention has been illustrated by the description of exemplary processes and system components, and while the various processes and components have been described in considerable detail, applicant does not intend to restrict or in any limit the scope of the appended claims to such detail. Additional advantages and modifications will also readily appear to those skilled in the art. The invention in its broadest aspects is therefore not limited to the specific details, implementations, or illustrative examples shown and described. Accordingly, departures may be made from such details without departing from the spirit or scope of applicant's general inventive concept.

1. A power tool comprising:
a housing;
a main power shaft located within the housing;
a peristaltic pump assembly positioned within the housing and operably connected to the main power shaft; and
an outlet conduit operably connected to the peristaltic pump assembly and extending between the peristaltic pump assembly and an outlet port in the housing such that fluid is forced by the peristaltic pump assembly through the outlet conduit to a location outside of the housing.

2. The power tool of claim **1**, wherein the peristaltic pump assembly comprises:
an arcuate pump casing;
a tube positioned along the arcuate pump casing;
a rotor and an eccentric shaft operably connected to the main power shaft; and
at least one roller rotatably supported by the rotor.

3. The power tool of claim **2**, wherein the peristaltic pump assembly further comprises:
a pump shaft fixedly connected to the rotor; and
a pump gear meshed with the main power shaft.

4. The power tool of claim **3**, wherein the at least one roller comprises:
a first roller extending outwardly from the rotor; and
a second roller extending outwardly from the rotor, the second roller extending outwardly from the first roller at a location generally opposite from the location at which the first roller extends outwardly from the rotor.

5. The power tool of claim **3**, wherein:
the pump gear is meshed with a first end portion of the main power shaft; and
a second end portion of the main power shaft is configured for operably driving a shaping component.

6. The power tool of claim **5**, wherein the power tool is configured to rotatably drive a shaping component.

7. The power tool of claim **3**, wherein the outlet conduit extends outwardly of the outlet port.

8. The power tool of claim **7**, wherein the outlet conduit and the elastomeric tube are integrally formed.

9. The power tool of claim **2**, wherein the arcuate pump casing comprises a portion of the housing.

10. The power tool of claim **2**, further comprising;
a check valve positioned between the outlet conduit and a first end portion of the elastomeric tube.

11. A power tool comprising:
a housing;
a main power shaft at least partially located within the housing;
a peristaltic pump assembly operably connected to the main power shaft; and
an outlet conduit operably connected to the peristaltic pump assembly and extending between the peristaltic pump assembly and an outlet portion of the outlet conduit, the outlet portion configured to direct fluid toward a predetermined location.

12. The power tool of claim **11**, wherein the peristaltic pump assembly comprises:
an arcuate pump casing;
an elastomeric tube positioned along the arcuate pump casing;
a rotor operably connected to the main power shaft; and
at least one roller rotatably supported by the rotor.

13. The power tool of claim **12**, wherein the peristaltic pump assembly further comprises:
a pump shaft fixedly connected to the rotor; and
a pump gear meshed with the main power shaft.

14. The power tool of claim **12**, wherein the at least one roller comprises:

a first roller extending outwardly from the rotor; and
a second roller extending outwardly from the rotor, the second roller extending outwardly from the first roller at a location generally opposite from the location at which the first roller extends outwardly from the rotor.

15. The power tool of claim **12**, wherein:
the pump gear is meshed with a first end portion of the main power shaft; and
a second end portion of the main power shaft is configured for operably driving a shaping component.

16. The power tool of claim **15**, wherein the power tool is configured to rotatably drive the shaping component.

17. The power tool of claim **12**, wherein:
the arcuate pump casing comprises a portion of a housing; and
at least a portion of the main power shaft is located within the housing.

18. The power tool of claim **12**, wherein the outlet conduit and the elastomeric tube are integrally formed.

19. The power tool of claim **12**, further comprising;
a first check valve positioned between the outlet conduit and a first end portion of the elastomeric tube; and
a second check valve positioned between the outlet conduit and a second end portion of the elastomeric tube.

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