



(22) Date de dépôt/Filing Date: 2006/06/28

(41) Mise à la disp. pub./Open to Public Insp.: 2007/02/28

(45) Date de délivrance/Issue Date: 2010/02/09

(30) Priorité/Priority: 2005/08/31 (US11/216,591)

(51) Cl.Int./Int.Cl. *F28G 1/16* (2006.01),
F16K 1/36 (2006.01), *F16K 1/54* (2006.01),
F28G 15/00 (2006.01)

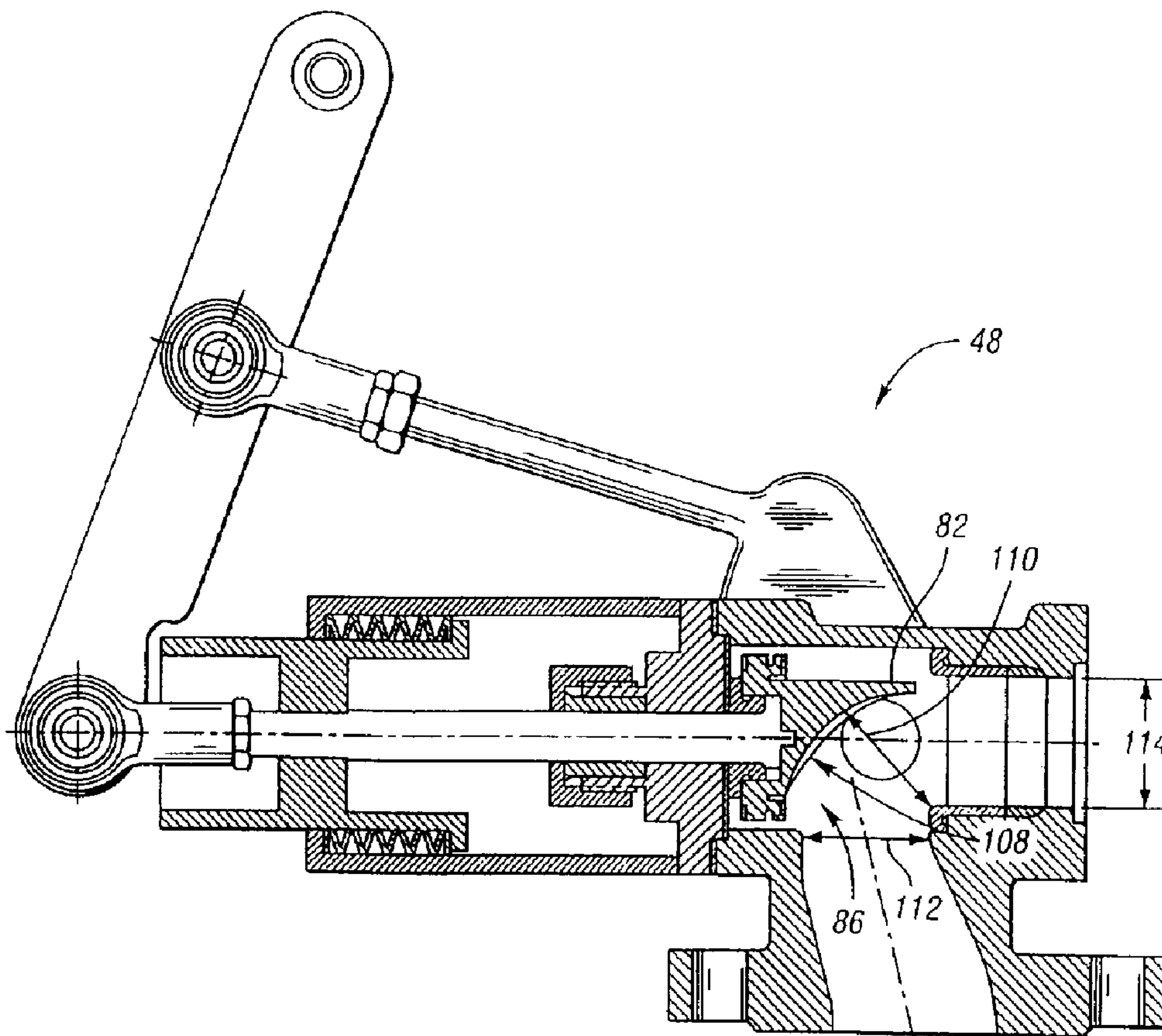
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(54) Titre : SOUPAPE A MANCHON A FAIBLE PERTE POUR DISPOSITIF DE NETTOYAGE

(54) Title: LOW LOSS POPPET VALVE FOR A CLEANING DEVICE



(57) Abrégé/Abstract:

A poppet valve for use with a sootblower for removing debris from an interior volume of a boiler is provided. The poppet valve assembly includes a valve housing and a valve head configured to move within the valve housing between an open position and a



(57) **Abrégé(suite)/Abstract(continued):**

closed position. The poppet valve assembly enables the cleaning fluid to undergo relatively small pressure loss as it flows through the poppet valve assembly when the valve head is in the open position. More specifically, the poppet valve assembly has a loss factor that is substantially less than currently-known valves. The poppet valve causes the cleaning fluid to undergo relatively small pressure loss while flowing therethrough.

ABSTRACT

A poppet valve for use with a sootblower for removing debris from an interior volume of a boiler is provided. The poppet valve assembly includes a valve housing and a valve head configured to move within the valve housing between an open position and a closed position. The poppet valve assembly enables the cleaning fluid to undergo relatively small pressure loss as it flows through the poppet valve assembly when the valve head is in the open position. More specifically, the poppet valve assembly has a loss factor that is substantially less than currently-known valves. The poppet valve causes the cleaning fluid to undergo relatively small pressure loss while flowing therethrough.

Low Loss Poppet Valve For A Cleaning Device

FIELD OF THE INVENTION

[0001] The invention relates generally to a sootblower for removing debris from an interior of a boiler. More specifically, the invention relates to a valve for controlling the flow of a cleaning fluid into sootblower.

BACKGROUND OF THE INVENTION

[0002] During the operation of large-scale combustion devices, such as boilers that burn fossil fuels and pulp mill organics, slag and ash encrustations develop on interior surfaces of the boiler. The presence of these deposits degrades the thermal efficiency of the boiler. Therefore, it is periodically necessary to remove such encrustations. Various systems are currently used to remove these encrustations.

[0003] One such type of system includes a device referred to as a sootblower. Sootblowers are used to project a stream of cleaning fluid, such as air, steam or water, into the interior volume of the boiler. In the case of retracting type sootblowers, a lance tube is periodically advanced into and withdrawn from the boiler and conducts the cleaning fluid to spray from one or more nozzles fastened to the lance tube. For example, the lance tube slidingly receives a fluid-supplying feed tube in a telescopic manner so that the combined feed/lance tube has an adjustable effective length. As the lance tube is advanced into and withdrawn from the boiler, it may rotate or oscillate in order to direct one or more jets of cleaning fluid at desired surfaces within the boiler. In the case of stationary sootblowers, the lance tube is always maintained within the boiler cavity and the lance tube has a fixed effective

length. In other words, a stationary sootblower typically does not require a feed tube.

[0004] Sootblowers deliver the cleaning fluid, typically steam, into the boiler at a relatively high pressure to facilitate the removal of the encrustations. Sootblowers typically require the steam to be delivered to the lance tube at a pressure of at least 120 pounds per square inch. Additionally, sootblowers typically receive the supply of steam from an inlet line extending in a direction generally perpendicular to the lance tube. The inlet line typically extends generally vertically from the floor, and the sootblower lance tube and feed tube usually extends generally horizontally into the boiler. Therefore, such sootblower have plumbing components that fluidly couple the respective perpendicular components, such as a conduit or valve having a 90 degree bend. Therefore, in a traversing sootblower having a feed tube and a lance tube, the inlet tube and the feed tube are typically connected by a connector element having a 90 degree bend, commonly known as an elbow joint. Similarly, in a stationary sootblower that does not include a feed tube, the inlet tube and the lance tube are typically connected by an elbow joint.

[0005] The elbow joint typically includes a valve device that controls the flow of steam flowing into the lance tube. The valves currently used are generally of the poppet valve type, and in addition to turning the flow "on" or "off" they may be provided with a means of adjusting flow in the on positions by controlling the cross-sectional flow through the valve. The means of adjusting flow may be an

on-off valve and/or a valve that includes intermediate positions to more precisely control fluid flow.

[0006] Currently known sootblowers typically have a feed tube with an outer diameter of approximately 2.75 inches and an inner diameter of approximately 2.375 inches. Additionally, currently known sootblowers typically have a lance tube with an outer diameter of approximately 3.5 inches. Thus, currently existing poppet valves typically have an outlet with an inner diameter of 2.75 inches or 3.5 inches to mate with either the feed tube or the lance tube, depending on whether the sootblower includes a feed tube. Therefore, when installing a replacement poppet valve it is desirable for the replacement poppet valve to have an outlet equal to that of the poppet valve being replaced so as to minimize part costs and maintenance costs for replacing the currently-existing feed tube and/or lance tube.

[0007] During operation of the boiler, waste steam is often created as a byproduct. The excess steam is typically not capable of being used for boiler cleaning since it has a relatively low pressure, such as 100 pounds per square inch. A particular contributor to pressure loss through the sootblower steam supply system is the currently available poppet valves. Even in the fully opened condition, substantial pressure loss is encountered in flow through the valve. More specifically, the poppet valve head in currently-known valves is positioned along the flow path of the cleaning fluid, thereby causing turbulent flow around the valve head. Therefore, due to pressure flow losses existent in the systems, currently-known sootblower systems have difficulty utilizing waste steam without using a pressure boosting device.

[0008] Since high pressure steam is generally required for sootblowers, a fraction of the steam generated by the boiler is diverted for cleaning. This diversion represents an overall thermal efficiency loss for the boiler operation.

[0009] As evident from the foregoing, it is desirable to provide a cleaning device having minimal flow loss, a 90 degree bend in fluid flow, and a low loss control valve that permits a relatively low-pressure fluid, such as boiler waste process steam, to be utilized as cleaning fluid without the use of a pressure boosting device. It is also desirable to provide a cleaning device control valve that is able to be interchanged with a currently-used control valve without replacing the lance tube or the feed tube.

SUMMARY OF THE INVENTION

[0010] In one aspect of the present invention, a poppet valve assembly is described for use with a sootblower for removing debris from an interior volume of a boiler. The poppet valve assembly includes a valve housing and a valve head configured to move within the valve housing between an open position and a closed position. The poppet valve assembly enables the cleaning fluid to undergo relatively small pressure loss as it flows through the poppet valve assembly when the valve head is in the open position. More specifically, the poppet valve assembly has a loss factor substantially less than currently-known valves (which have a loss factor of 6.0) when the valve head is in the open position. Preferably, the valve has a loss factor less than half of that currently known in the art. For example, the loss factor is preferably between 0.5 and 0.25 when the valve is in the open position.

[0011] In another aspect of the present invention, the valve housing includes first and second passages that extend along first and second directions that are

substantially not parallel with each other. Furthermore, the valve head includes a connecting surface extending between the first and second passages when the valve head is in the open position. The connecting surface has a radius of curvature that is generally equal to the diameter of each of the first and second passages.

[0012] In another aspect of the present invention, a method of delivering a cleaning fluid into the interior volume of a boiler is described, including the steps of inserting a lance tube into the interior volume to deliver the cleaning fluid, providing a valve in fluid communication with the lance tube, and delivering the cleaning fluid to the valve.

[0013] Further objects, features and advantages of this invention will become readily apparent to persons skilled in the art after a review of the following description, with reference to the drawings and claims that are appended to and form a part of this specification.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Figure 1 shows a long, retracting type sootblower having a retractable lance tube and a poppet valve controlling a flow of cleaning fluid thereto, where the sootblower embodies the principles of the present invention;

[0015] Figure 2 is a cross-sectional view of a feed tube of the sootblower taken along line 2-2 in Figure 1, showing a front, elevation view of the poppet valve;

[0016] Figure 3 is a cross-sectional view taken along line 3-3 in Figure 2, where the valve head is in the closed position;

[0017] Figure 4 is a cross-sectional view similar to that in Figure 3, where the valve head is in the open position;

[0018] Figure 5 is a cross-sectional view taken along line 5-5 in Figure 2, showing a bypass conduit extending through the valve housing;

[0019] Figures 6a is a cross-sectional view of an alternative embodiment of a poppet valve embodying principles of the present invention, where a linkage arm is in a first position;

[0020] Figure 6b is a side view of the poppet valve shown in Figure 6a;

[0021] Figure 7a is a cross-sectional view of the poppet valve shown in Figure 6a, where the linkage arm is in a second position;

[0022] Figure 7b is a side view of the poppet valve shown in Figure 7a;

[0023] Figure 8a is a cross-sectional view of the poppet valve shown in Figure 6a, where the linkage arm is in a third position; and

[0024] Figure 8b is a side view of the poppet valve shown in Figure 8a.

DETAILED DESCRIPTION OF THE INVENTION

[0025] Referring now to the drawings, Figure 1 shows a sootblower 10 embodying principles of the present invention. The sootblower 10 principally includes a frame assembly 12 (indicated by phantom lines), a lance tube 14, a feed tube 16, and a carriage 18. The sootblower 10 is shown in its normal at rest position in Figure 1, but upon actuation the lance tube 14 is extended into and retracted from a boiler (not shown) while being simultaneously rotated.

[0026] The frame assembly 12 shown in the Figures includes a generally rectangular-shaped frame box 20 which forms a housing for the entire unit. The carriage 18 is guided along tracks (not shown) located on opposite sides of frame box 20 to enable longitudinal movement of carriage 18. The frame assembly 12 is supported at a proximal end 22 and at a distal end 24 that is adjacent to and/or

connected to the boiler. The carriage 18 drives lance tube 14 into and out of the boiler via a drive motor 26 and a gear box 28. More specifically, the carriage 18 drives a pair of pinion gears 30 and 32 that engage rack assemblies 34, to advance the carriage 18 and the lance tube 14. A pair of bearings (not shown) engage the tracks to support the carriage 18.

[0027] A front support bracket 36 includes canted rollers which support lance tube 14 during its longitudinal and rotational motion. Additionally, an intermediate support bracket 38 is provided to prevent excessive deflection of the lance tube 14. A coiled electrical cable 40 supplies power to the drive motor 26 as the carriage 18 and the drive motor 26 move along the feed tube 16.

[0028] The lance tube 14 slidably receives the feed tube 16 in a telescoping manner to form an adjustable-length component having an overlapping portion 42 between the lance tube 14 and the feed tube 16. Therefore, the lance tube 14 preferably has an outer diameter 43 that is larger than the feed tube outer diameter 45. During traversal of the sootblower 10, the position of the feed tube 16 remains generally unchanged as the lance tube 14 is advanced and retracted, causing that the length of the overlapping portion 42 to be varied. In a preferred exemplary design, the lance tube outer diameter 43 is equal to 3.5 inches and the feed tube diameter 45 is equal to 2.75 inches. The feed tube 16 preferably has a wall thickness of $\frac{3}{16}$ inches (0.1875 inches) and therefore the feed tube 16 inner diameter is preferably equal to 2.375 inches. In an alternative preferred exemplary design, the lance tube outer diameter is equal to 4.0 inches and the feed tube diameter is equal to 3.25 inches. However, the components may have any other suitable dimensions.

[0029] During operation of the sootblower 10, the cleaning fluid flows along the length of the feed tube 16, into the lance tube 14, and through a sootblower nozzle 46. Multiple nozzles 46 may be provided, each having throats that are appropriately shaped and sized to control the velocity and the spray pattern of cleaning streams flowing therefrom.

[0030] The volume of the cleaning fluid flowing into the feed tube 16 is controlled by a poppet valve assembly 48 that controls the flow of the cleaning fluid. The poppet valve assembly 48 is actuated through linkages, such as first, second and third linkages 50, 52, 54 shown in Figure 1. The first, second and third linkages 50, 52, 54 are engaged by the movement of the carriage 18 via a carriage rod 56, thereby permitting the cleaning fluid to flow into the feed tube 16 as the carriage 18 moves. The carriage 18 is connected to the carriage rod 56 such that the respective components 18, 56 move in unison with each other. The carriage rod 56 is also pivotably connected to a top portion 58 of the first linkage 50 such that the top portion 58 also moves in unison with the carriage 18. A middle portion 60 of the first linkage 50 is pivotably connected to the second linkage 52 such that the first linkage 50 pivots about the middle portion 60 as the carriage 18 moves. The pivoting movement of the first linkage 50 causes a bottom portion 62 of the first linkage 50 to move in a direction opposite that of the top portion 58. The bottom portion 62 of the first linkage 50 is connected to the third linkage 54, thereby moving the third linkage 54 in a direction opposite that of the carriage 18. The second linkage 52 shown in Figures 1-4 is fixedly connected to a portion of the poppet valve assembly 48 by any suitable means, such as a fastener or a welding joint. Alternatively, the second linkage 52 is an integral portion of the poppet valve assembly 48.

[0031] The movement of the third linkage 54 transversely actuates a portion of the poppet valve assembly 48, as will be discussed in further detail below. The force of the third linkage 54 onto the poppet valve assembly 48 may be varied based on the ratio of the distance between the top portion 58 and the middle portion 60 and the distance between the middle portion 60 and the bottom portion 62.

[0032] Referring now to Figures 2 through 4, the poppet valve assembly 48 will now be discussed in further detail. The poppet valve assembly 48 includes a poppet valve housing 64 defining a passageway 66 therethrough that fluidly connects a supply line (not shown) to the feed tube 16. More specifically, the supply line, which may be any suitable fluid-carrying conduit, is connected to an inlet 68 formed in a bottom face 69 of the poppet valve housing 64 to supply the cleaning fluid to the poppet valve assembly 48. Additionally, an opening 70 is also formed in a side face 69 of the poppet valve housing 64 to supply the cleaning fluid to the feed tube 16. The bottom face 71 is preferably secured to the supply line via a plurality of fasteners (not shown) that extend through openings 73 in the poppet valve housing 64, or by any other suitable method. Additionally, the side face 69 is secured to the feed tube 16 by a clamping plate connection, or by any other appropriate method. The respective faces 69 and 71 are preferably generally perpendicular to each other in order to correspond with the orientation of currently-existing components, the supply line and the feed tube 16.

[0033] The poppet valve housing 64 further defines a first passage 72 extending from the inlet 68 along a first axis 74 that is shown as being generally vertical in Figure 3. Additionally, the poppet valve housing 64 also defines a second passage 76 extending from the opening 70 along a second axis 78 that is shown as

being substantially horizontal in Figure 3. The two passages 72 and 76 converge at an intersection point 80 that is selectively sealed by a translating poppet valve head 82.

[0034] The poppet valve head 82 has a generally round circumference to be able to selectively form a substantially fluid-tight seal with the poppet valve housing 64 to selectively separate the first and second passages 72, 76 from each other and to selectively prevent the cleaning fluid from flowing therethrough. The poppet valve head 82 is connected to the third linkage 54 and is able to slide transversely along the second axis 78. Therefore, as the carriage 18 is actuated and the linkages are thereby caused to move, the third linkage 54 causes the poppet valve head 82 to move transversely in a direction opposite to that of the carriage 18. In the figures, the poppet valve head 82 moves along a generally linear path, but may travel along any suitable path with the present invention.

[0035] The sootblower 10 may include one or more device, herein referred to as a stopper 83, to temporarily disengage and engage the connection between the carriage and the poppet valve head 82. More specifically, the stopper 83 is engaged with the carriage rod 56 when the carriage 18 is positioned near the poppet valve assembly 48 to open and close the poppet valve head 82. However, once the carriage 18 moves distally a predetermined distance, the stopper 83 becomes disengaged from the carriage rod 56 to temporarily disengage the connection between the respective components 82, 83. For example, when the carriage 18 moves distally from the natural resting position shown in Figure 1, the poppet valve head 82 is actuated along with the carriage 18. However, once the carriage 18 moves to the predetermined point along the feed tube 16, the stopper 83 becomes

disengaged from the carriage rod 56 via a release mechanism. Then, upon return of the carriage 18 to the natural resting position, the stopper 83 again becomes engaged with the carriage rod 56 and causes the poppet valve head 82 to close.

[0036] The poppet valve head 82 is shown in a closed position 84 in Figure 3, where the cross-sectional area of the second passage 76 is substantially obstructed and the cleaning fluid is prevented from flowing therethrough. The poppet valve head 82 is in the closed position 84 when the carriage 18 is in the natural resting position shown in Figure 1, so that the cleaning fluid is not ejected from the nozzle 46 when the lance tube 14 has not been extended into the boiler.

[0037] Additionally, the poppet valve head 82 is movable to an open position 86, shown in Figure 4, where the cross-sectional area of the second passage 76 is substantially unobstructed and the cleaning fluid is permitted to flow therethrough. The poppet valve head 82 is in the open position 86 when the carriage 18 and the lance tube 14 have extended forward from the position shown in Figure 1. Therefore, the cleaning fluid is ejected from the nozzle 46 when the lance tube 14 is extended into the boiler.

[0038] The poppet valve head 82 and the poppet valve housing 64 each preferably include components that provide a fluid-tight seal. For example, a sealing ring 88 is embedded in the poppet valve housing 64 and the poppet valve head 82 includes a satellite face 90 that is aligned with the sealing ring 88. The sealing ring 88 shown in the Figures extends around a rim 92 of the poppet valve housing 64 to substantially prevent the sealing ring 88 from being forced off of the poppet valve housing 64. The satellite face 90 cantilevers from the body of the poppet valve head 82 so as to be flexible, thereby improving the seal between the respective

components 88, 90. The sealing ring 88 and the washer 90 are preferably both composed of stainless steel and/or a hardfacing material.

[0039] To further promote the seal between the poppet valve head 82 and the poppet valve housing 64, the poppet valve head 82 closes in the direction of the fluid flow, generally indicated by reference numeral 94. This configuration causes the cleaning fluid to force the poppet valve head 82 towards the closed position 84 during certain poppet valve head 82 positions. For example, the cleaning fluid may cause such a force if the poppet valve head 82 is in a position such that cleaning fluid is able to flow behind a back surface 98 of the poppet valve head 82.

[0040] Yet another mechanism to promote the seal between the poppet valve head 82 and the poppet valve housing 64 is a spring mechanism, such as a plurality of Belleville washers or a multi-turn wavespring 100 urging the poppet valve head 82 towards the closed position 84. Alternatively, any suitable urging mechanism, such as other types of springs, may be used. A sleeve 102 encircles and is coupled with the third linkage 54 such that the components 54 and 102 move in unison. The sleeve 102 includes a flange 104 engaging a first end of the Belleville washers 100 and the poppet valve housing 64 includes a flange 106 engaging the other end of the Belleville washers 100 to urge the sleeve 102 away from the poppet valve housing 64.

[0041] As shown in the Figures, the poppet valve head 82 includes a generally arcuate surface 108 to minimize pressure flow loss as the cleaning fluid flows through the passageway 66. Preferably, the arcuate surface 108 is generally arcuate along a first plane extending along the cross-section in Figures 3 and 4. For example, the arcuate surface 108 defines a first radius of curvature 110 along the

first plane, as shown in Figure 4. Additionally, the arcuate surface 108 is also preferably generally arcuate along a second plane extending along the cross-section in Figure 5. For example, the arcuate surface 108 defines a second radius of curvature 111 along the second plane, as shown in Figure 5. The curvatures along the respective planes minimizing flow loss by providing a smooth contact surface (the arcuate surface 108) for the cleaning fluid along three dimensions.

[0042] The first radius of curvature 110 is preferably generally equal to a diameter 112 of the first passage 72 and a diameter 114 of the second passage 76. In this configuration, the cleaning fluid flow is not substantially constricted while flowing along the passageway 66 and the flow path of the cleaning fluid is generally smooth. When poppet valve assembly 48 is in the open position, an unobstructed flow path for cleaning fluid flow is provided. This is distinguishable from prior art poppet valves in which a valve head remains in the flow position.

[0043] As discussed above, the feed tube 16, which preferably has an outer diameter 45 of 2.75 inches, is fluidly connected to the poppet valve assembly 48. More specifically, the poppet valve housing 64 defines an enlarged diameter portion 124 at the end of the second passage 76 that receives and forms a fluid-tight seal with the feed tube 16. Therefore, the enlarged diameter portion 124 preferably has an inner diameter 126 (Figure 2) of approximately 2.75 inches. Furthermore, to avoid flow losses, the second passage 76 preferably has an inner diameter 128 generally equal to the inner diameter of the feed tube 16. Therefore, because the feed tube has a wall thickness equal to 0.1875 inches, the second passage 76 inner diameter 128 shown in the figures is generally equal to 2.375 inches, which is calculated from the following formula:

$$OuterDiameter - (2 * WallThickness) = 2.75" - (2 * 0.1875") = 2.75 - 0.375 = 2.375.$$

[0044] The poppet valve head 82 includes an anti-rotation mechanism to prevent the arcuate surface 108 from becoming misaligned with the direction of the fluid flow 94. The anti-rotation mechanism is shown as an elbow joint 116 between the first linkage 50 and the third linkage 54 to prevent rotation therebetween. Furthermore, the poppet valve head 82 is connected to the third linkage 54 such as to prevent rotation therebetween. Alternatively, the anti-rotation mechanism may directly prevent rotation between the poppet valve housing 64 and the poppet valve head 82, such as by a slot-and-tab connection (not shown) between the respective components 64 and 82.

[0045] The arcuate surface 108 shown in the Figures minimizes pressure flow loss across the poppet valve head 82, thereby minimizing the cleaning fluid input pressure required (the pressure of the cleaning fluid entering the poppet valve assembly 48) necessary to provide a sufficiently high output pressure (the pressure of the cleaning fluid supplied to the feed tube 16 from the poppet valve assembly 48) need to produce a desired cleaning effect. As a quantitative example of the pressure flow loss through the poppet valve assembly 48, when the cleaning fluid has a Reynolds number that is typical for sootblowers such as 1.5 million or higher, the assembly is able to provide an output pressure of approximately 120 pounds per square inch by inputting a stream of cleaning fluid to the inlet 68 at an input pressure of approximately 150 – 140 pounds per square inch. In this example, the change in pressure across the poppet valve head 82 is calculated by the following formula:

$$\Delta P = K \frac{\rho \cdot V^2}{2g \cdot c}$$

ΔP is the change in pressure between first and second points,

K is a system constant corresponding to the system loss factor,

ρ is the density of the cleaning fluid,

g is a constant corresponding to the acceleration of gravity,

c is a height change of the cleaning fluid as it flows between the first and second points, and

V is the velocity of the cleaning fluid.

[0046] As can be seen by the above formula, the pressure change across the poppet valve head 82 and the loss factor K are directly proportional with each other. Therefore, it is desirable to minimize the loss factor K for the system to minimize the pressure loss caused by the poppet valve 48. The design shown in the Figures has a loss factor (K) that is generally between 1.75 and 1.25. Currently-used systems typically have a loss factor of 6.0 or higher. Therefore, the design shown in the Figures offers a significant advantage to currently-used systems.

[0047] The poppet valve housing 64 defines a plurality of bypass conduits 122 to deliver a low-pressure stream of secondary cleaning fluid to the boiler interior volume when the poppet valve head 82 is in the closed position 84. More specifically, the bypass conduits 122 in the Figures each extend from the ambient air to the passageway 66 downstream of the poppet valve head 82, thereby fluidly connecting the ambient air and the boiler internal volume regardless of the position of the poppet valve head 82. The above configuration permits the secondary cleaning fluid, for example air, water, or steam, to flow into the feed tube 16 and through the nozzle 46 to prevent debris from collecting around the nozzle 46.

[0048] When the poppet valve head 82 is in the open position 86, the high-pressure cleaning fluid flushes debris from the nozzle 46, thus rendering the secondary cleaning fluid temporarily unnecessary. Therefore, the poppet valve housing 64 may include a secondary valve mechanism (not shown) that prevents the flow of the secondary cleaning fluid when undesirable, such as when the poppet valve head 82 is in the open position 86. Furthermore, the secondary valve mechanism may also include a one-way valve mechanism to prevent the high-pressure cleaning fluid from exiting the sootblower 10 via the bypass conduit 122.

[0049] Some boilers operate at a partial vacuum, such that the pressure in the interior volume of the boiler is less than the ambient pressure. Therefore, for such boiler air is naturally drawn into the boiler interior volume through the bypass conduit 122. Alternatively, a positive displacement pump device may be used to deliver the secondary cleaning fluid into the boiler internal volume.

[0050] The bypass conduit 122 may also be used to provide a pressure increase to the cleaning fluid in the feed tube 16. For example, a fluid displacing device, such as a pump, may be in connection with the bypass conduit 122 to increase the cleaning fluid pressure when the poppet valve head 82 is in the open position 86. Alternatively, the fluid displacing device may be positioned in a location other than adjacent to the bypass conduit 122.

[0051] Referring now to Figures 6a – 8b, an alternative poppet valve assembly 248 is shown, having a poppet valve head 246 with a generally arcuate valve head surface 247. The valve head surface 247 is generally arcuate along a single plane, such that the arcuate nature of the surface is two dimensional, rather than the three dimensional arcuate nature of the poppet valve head shown in

Figures 2-5. In yet another alternative design, the poppet valve head is generally spherical shaped. In this design, the spherical component may be rotationally moved or transversely moved between an open position and a closed position.

[0052] The poppet valve assembly 248 shown in Figures 6a-8b also includes an alternative linkage assembly, including a first, second and third linkages 250, 252, 254. The first, second and third linkages 250, 252, 254 are engaged by the movement of the carriage 18 via the carriage rod 56, thereby permitting the cleaning fluid to flow into the feed tube 16 as the carriage 18 moves. More specifically, the carriage 18 is attached to an upper portion 255 of the first linkage 250 to convert the translational movement of the carriage 18 into rotational movement of the first linkage 250.

[0053] The first linkage 250 includes a first pivot point 258, for applying a relatively high torque on the third linkage 254, and a second pivot point 260 for applying a lower torque on the third linkage 254. More specifically, when the poppet valve head 246 is in the closed position 261, and the fluid pressure is urging the poppet valve head 246 to remain in the closed position 247, then the first linkage 250 pivots about the first pivot point 258 and slides within a slot 262 formed in the second linkage 252. This movement causes the lower portion 264 and the third linkage 254 to move in the opposite direction of the carriage 18; thereby opening the poppet valve head 246. When the first linkage 250 is pivoting about the first pivot point 258 a relatively large first moment arm 266 acts on the carriage 18, thereby lowering the required force to initially open the poppet valve head 246. The first pivot point 258 in the figures is defined by a generally cylindrical pin 268 and a generally arcuate receiving surface 270 configured to permit rotation of the pin 268.

[0054] As shown in Figures 7a and 7b, as the poppet valve head 246 is partially opened, the first linkage 250 slides to the far right portion of the slot 262 formed in the second linkage 252, thereby causing the first linkage 250 to pivot about the second pivot point 260. The second pivot point 260 is defined by a pin 272 and the slot 262 that receives the pin 272 and permits rotation thereof. Rotation about the second pivot point 260 creates a relatively small second moment arm 274 acting on the carriage 18. However, the force required to further open the poppet valve head 246 is not necessarily increased due to the shortened moment arm because the fluid flow 276 is now able to flow through a gap between the poppet valve head 246 and the poppet valve housing, thereby urging the poppet valve head 246 towards an open position.

[0055] Next, as shown in Figures 8a and 8b, the first linkage 250 continues to rotate about the second pivot point 260 and the poppet valve head 246 is moved to an open position 278. While this occurs, the pin 268 slides away from the arcuate receiving surface 270. The relatively small second moment arm 274 acting on the carriage 18 is complimented by a relatively large moment arm 280 acting on the third linkage 254; thereby causing relatively rapid movement of the poppet valve head 246 into the open position 278.

[0056] The poppet valve assembly 248 includes a bypass conduit 322 to deliver a low-pressure stream of secondary cleaning fluid to the boiler interior volume when the poppet valve assembly is closed. More specifically, the bypass conduit 322 in Figures 6a-8b extends from the ambient air into the poppet valve assembly 248, thereby fluidly connecting the ambient air and the boiler internal volume regardless of the position of the poppet valve head. The above configuration

permits the secondary cleaning fluid, for example air, water, or steam, to flow into the feed tube 16 and through the nozzle 46 to prevent debris from collecting around the nozzle 46. The bypass conduit 122 may also extend through the poppet valve housing at an angle to the vertical direction.

[0057] It is therefore intended that the foregoing detailed description be regarded as illustrative rather than limiting, and that it be understood that it is the following claims, including all equivalents, that are intended to define the spirit and scope of this invention.

CLAIMS

What is claimed is:

1. A sootblower for removing debris from an interior volume of a boiler, the sootblower comprising:
 - a lance tube configured to deliver a cleaning fluid into the interior volume of the boiler; and
 - a valve in fluid communication with the lance tube to deliver the cleaning fluid thereto, the valve including a valve housing and a valve head;
 - the valve housing defining a flow path including a first passage extending along a first axis and a second passage extending along a second axis, the first axis and the second axis cooperating to define a flow path angle therebetween that is greater than 45 degrees and less than 135 degrees;
 - the valve head being configured to move along a generally linear path with respect to the valve housing between an open position, where the flow path is substantially unobstructed, and a closed position, where the flow path is substantially obstructed;
 - the valve head including an anti-rotation mechanism to substantially prevent the valve head from rotating with respect to the generally linear path;
 - the valve head defining a generally smooth and arcuate surface to minimize pressure flow loss as the cleaning fluid flows through the first passage, the surface extending between the first and second passages; and
 - the valve having a loss factor that is less than 6.0 when the valve head is in the open position.

2. A sootblower as in claim 1, the loss factor being less than or equal to 3.0 when the valve head is in the open position.
3. A sootblower as in claim 1, the loss factor being less than or equal to 1.5 when the valve head is in the open position.
4. A sootblower as in claim 1, the loss factor being less than or equal to 0.5 when the valve head is in the open position.
5. A sootblower as in claim 1, the valve configured such that when the cleaning fluid has a flow having a Reynolds number greater than 1.5 million, the cleaning fluid has a first pressure less than or equal to 200 pounds per square inch when entering the valve and a second pressure greater than or equal to 100 pounds per square inch when exiting the valve.
6. A sootblower as in claim 5, wherein the first pressure is less than or equal to 160 pounds per square inch and the second pressure is greater than or equal to 120 pounds per square inch.
7. A sootblower as in claim 1, wherein the flow path angle is generally equal to 90 degrees.
8. A sootblower as in claim 1, wherein the surface is substantially arcuate along a first plane.

9. A sootblower as in claim 8, the connecting surface having a substantially constant radius of curvature along the first plane.

10. A sootblower as in claim 9, wherein the first and second passages have a first diameter generally equal to the radius of curvature.

11. A sootblower as in claim 8, the surface being substantially arcuate along a second plane that is perpendicular to the first plane.

12. A sootblower as in claim 1, the valve head in the closed position being positioned with respect to the first passage such that the cleaning fluid urges the valve head to remain in the closed position.

13. A sootblower as in claim 1, further comprising a linkage configured to move the valve head within the valve housing between the open and the closed positions.

14. A sootblower as in claim 13, wherein the linkage assembly pivots about a third axis to move the valve head within the valve housing.

15. A sootblower as in claim 14, wherein the linkage assembly pivots about the third axis during a first range of movement of the valve head and pivots about the fourth axis during a second range of movement of the valve head.

16. A sootblower as in claim 1, wherein a portion of the valve housing along the second passage has an inner diameter generally equal to 2.75 inches.

17. A sootblower as in claim 1, further comprising a feed tube fluidly connecting the valve housing and the lance tube, wherein a portion of the valve housing along the second passage has an inner diameter generally equal to an outer diameter of the feed tube.

18. A poppet valve assembly for use in a sootblower configured to remove debris from an interior volume of a boiler, the poppet valve assembly comprising:

a valve housing defining a first passage extending along a first axis and a second passage extending along a second axis that is generally perpendicular to the first axis;

a valve head configured to move along a generally linear path with respect to the valve housing between an open position and a closed position, the valve head including an anti-rotation mechanism to substantially prevent the valve head from rotating with respect to the generally linear path;

the valve head defining a smooth arcuate surface to minimize pressure flow loss as cleaning fluid flows through the first passage, the surface extending between the first and second passages; and

the valve having a loss factor less than 6.0 when the valve head is in the open position.

19. A poppet valve assembly as in claim 18, the loss factor being less than or equal to 3.0 when the valve head is in the open position.

20. A poppet valve assembly as in claim 18, the loss factor being less than or equal to 1.5 when the valve head is in the open position.

21. A poppet valve assembly as in claim 18, the loss factor being less than or equal to 0.5 when the valve head is in the open position.

22. A poppet valve assembly as in claim 18, the first and second passages being substantially unobstructed when the valve head is in the open position.

23. A poppet valve assembly as in claim 18, wherein the surface has a substantially constant radius of curvature along a first plane.

24. A poppet valve assembly as in claim 18, further comprising a linkage configured to move the valve head within the valve housing between the open and the closed positions.

25. A poppet valve assembly as in claim 24, wherein the linkage assembly pivots about a third axis to move the valve head within the valve housing.

26. A poppet valve as in claim 25, wherein the linkage assembly pivots about the third axis during a first range of movement of the valve head and pivots about a fourth axis during a second range of movement of the valve head.

27. A poppet valve assembly as in claim 18, wherein a portion of the valve housing along the second passage has an inner diameter generally equal to 2.75 inches.

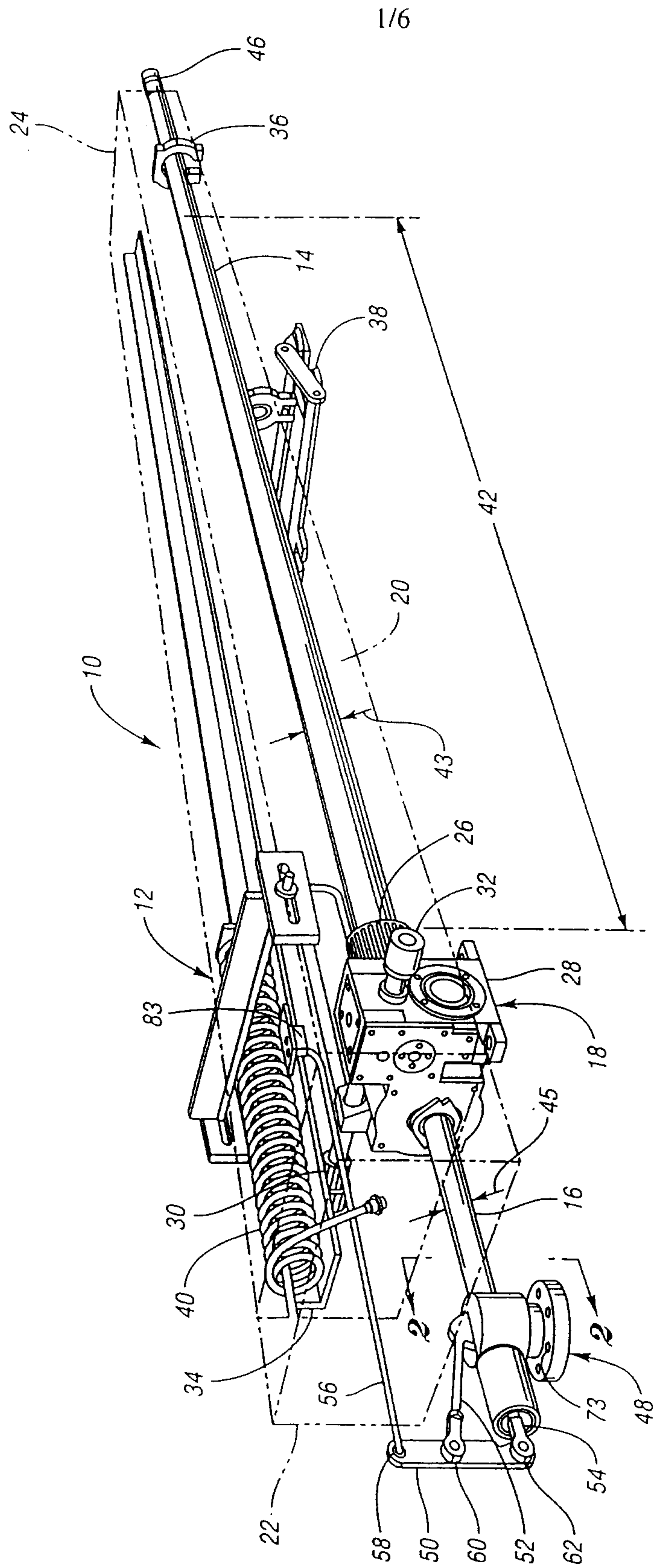
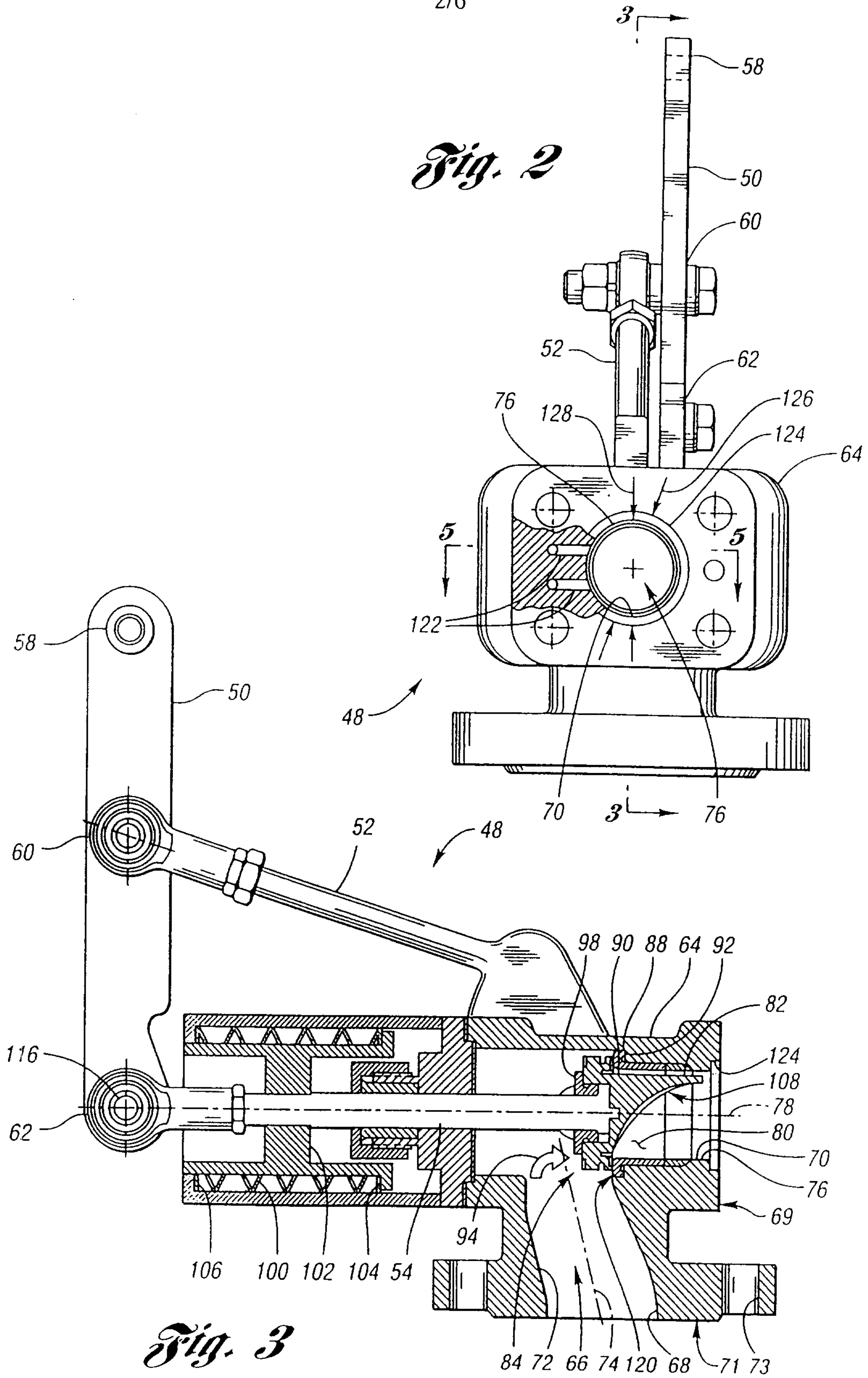


Fig. 1

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Fig. 2



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Fig. 4

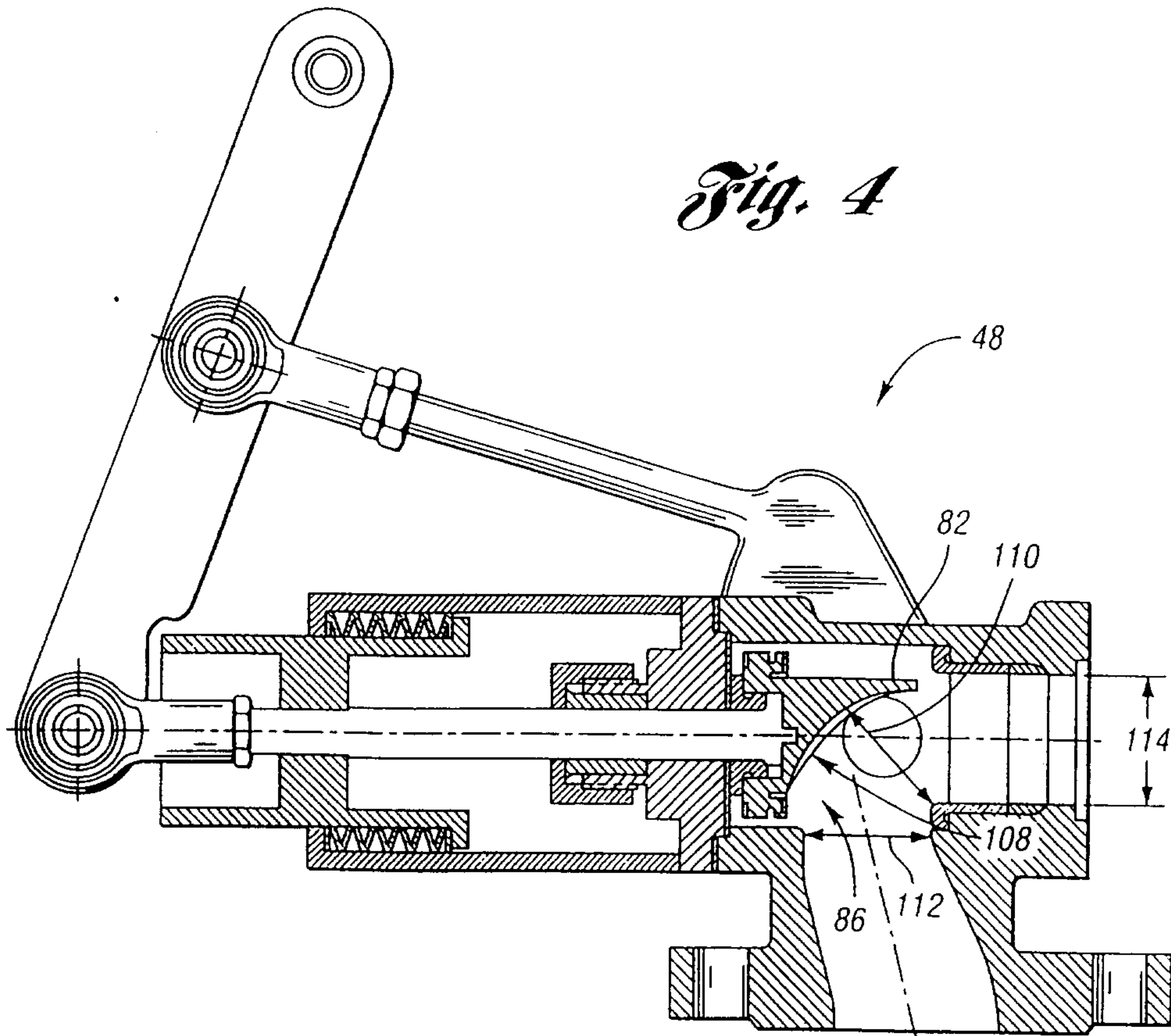
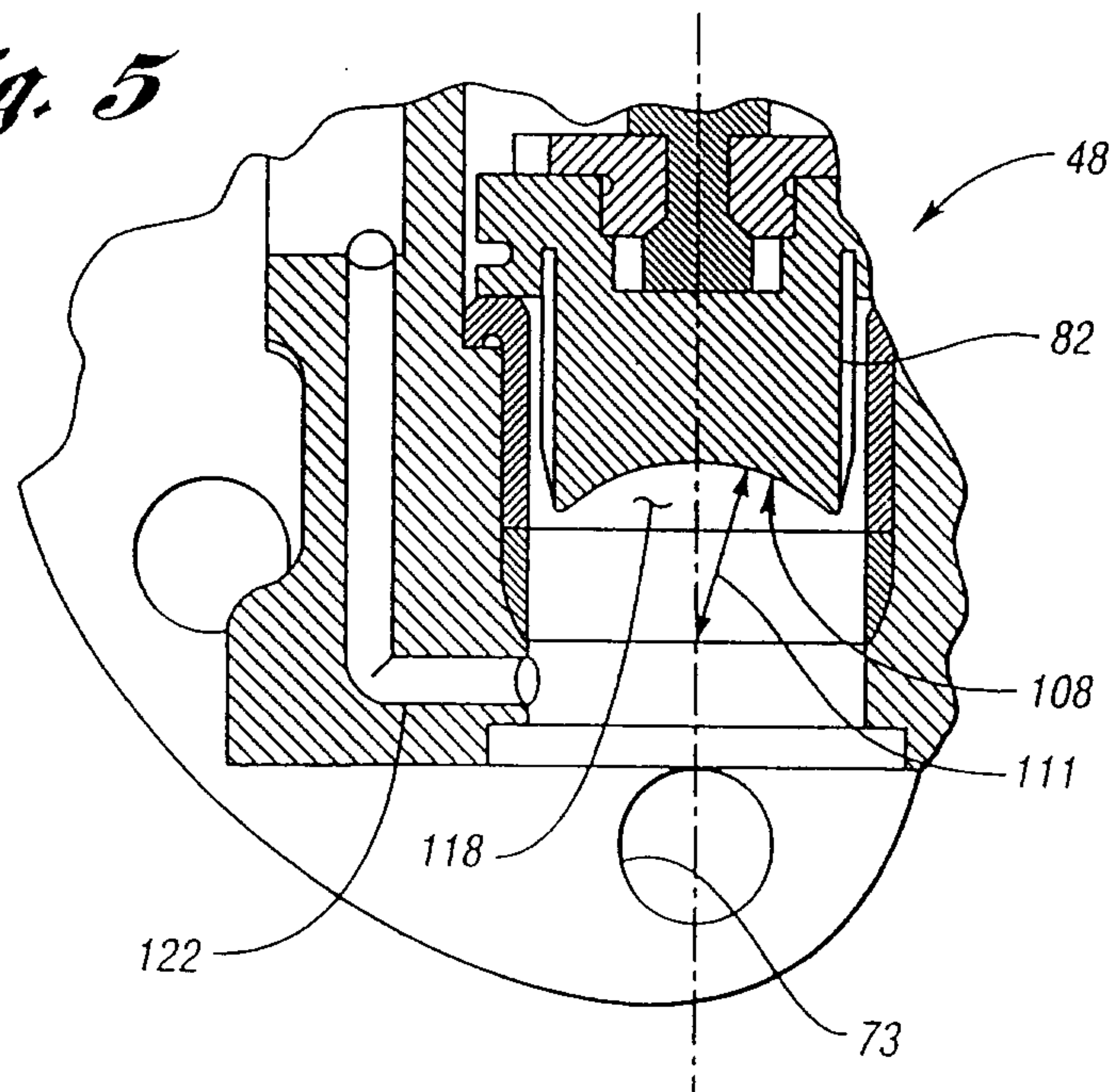


Fig. 5



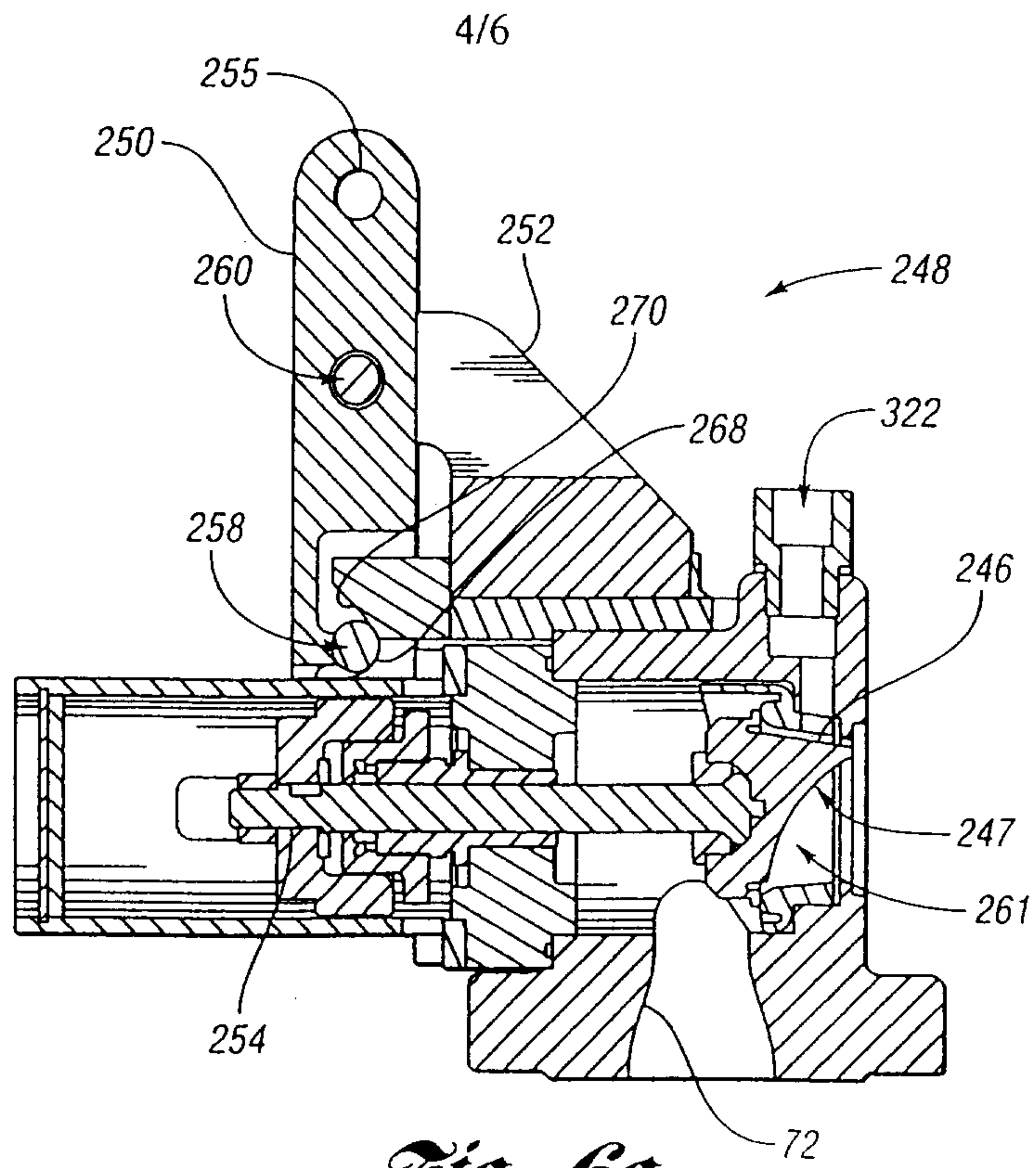


Fig. 6a

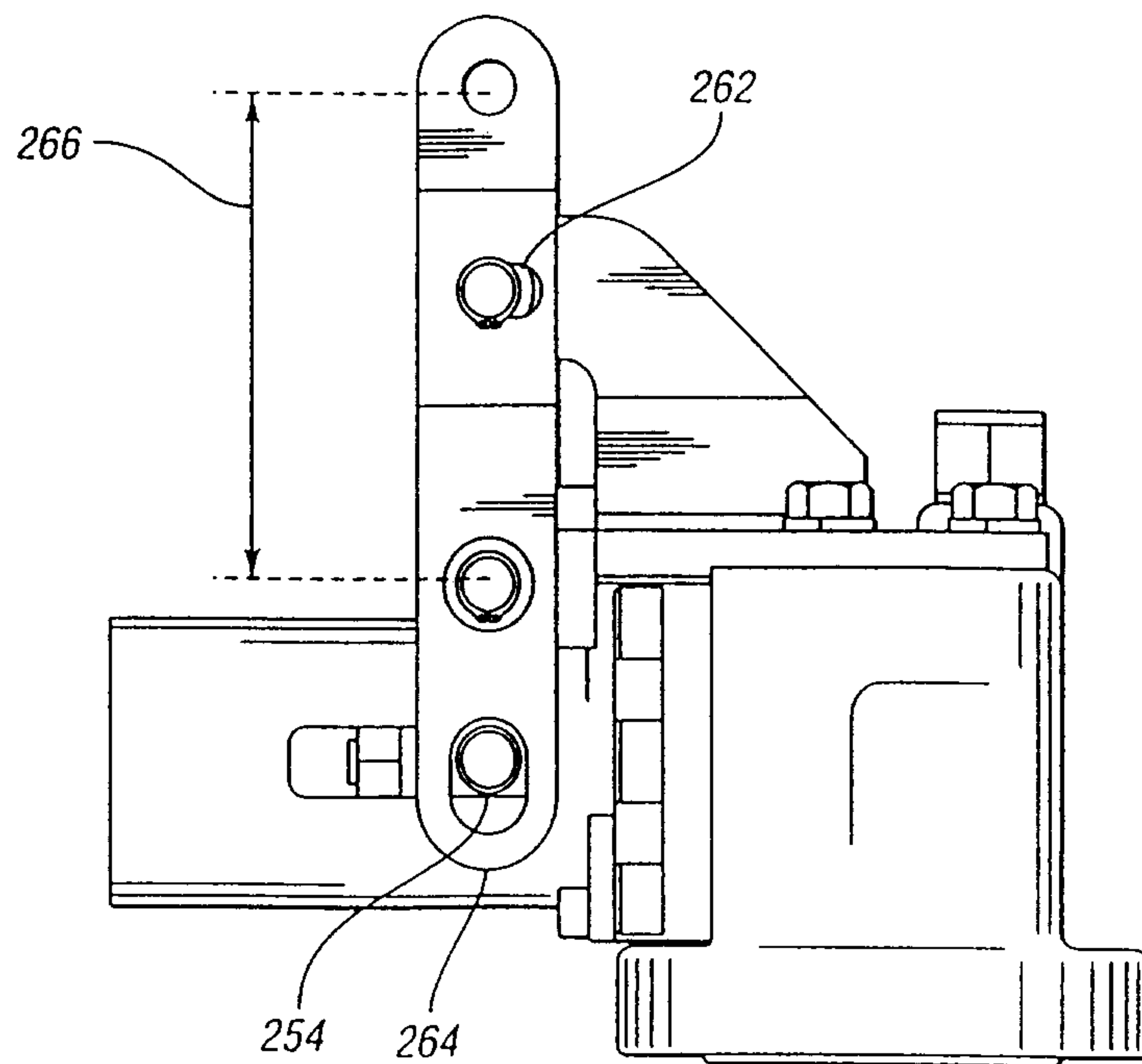


Fig. 6b

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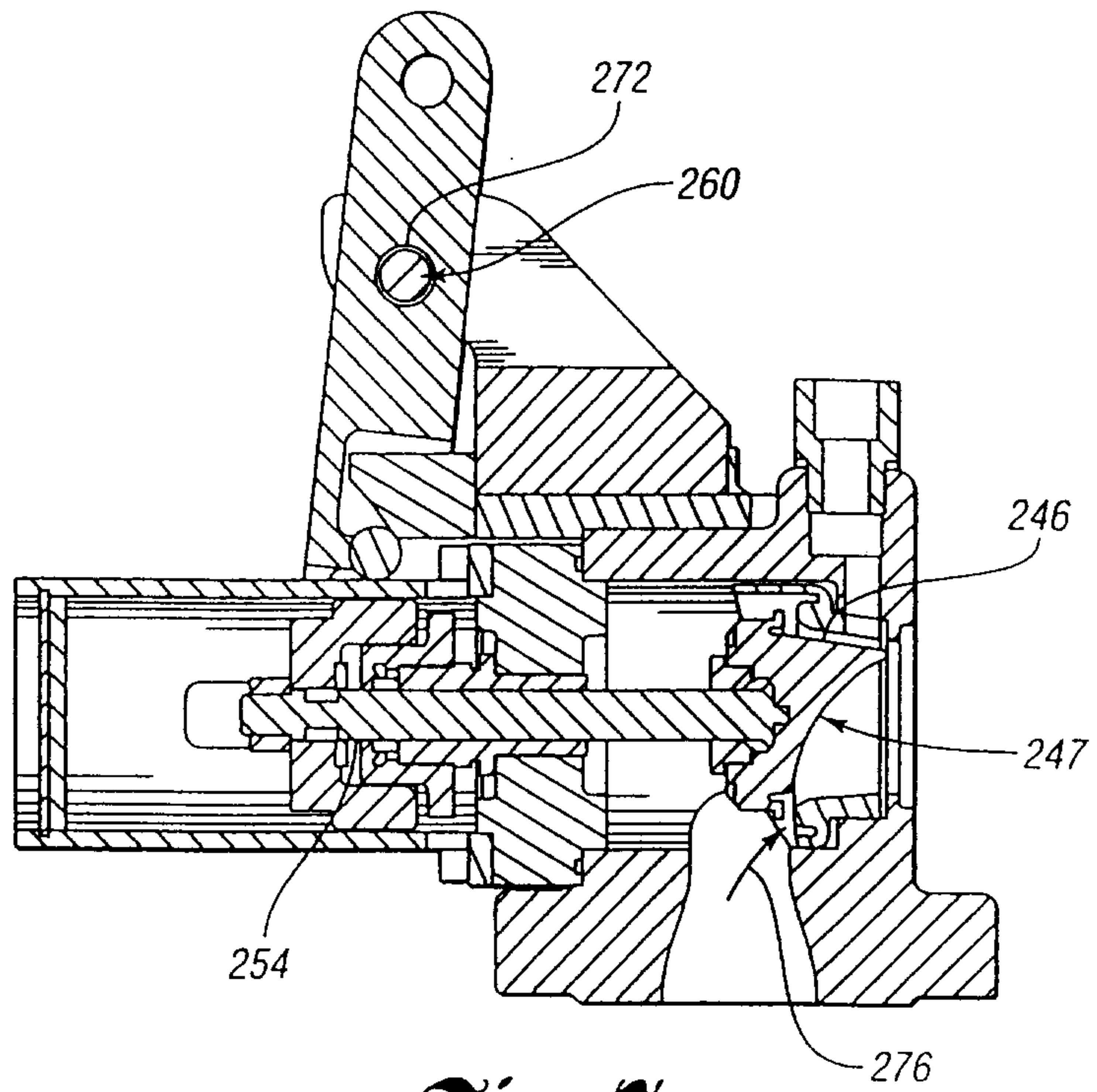


Fig. 7a

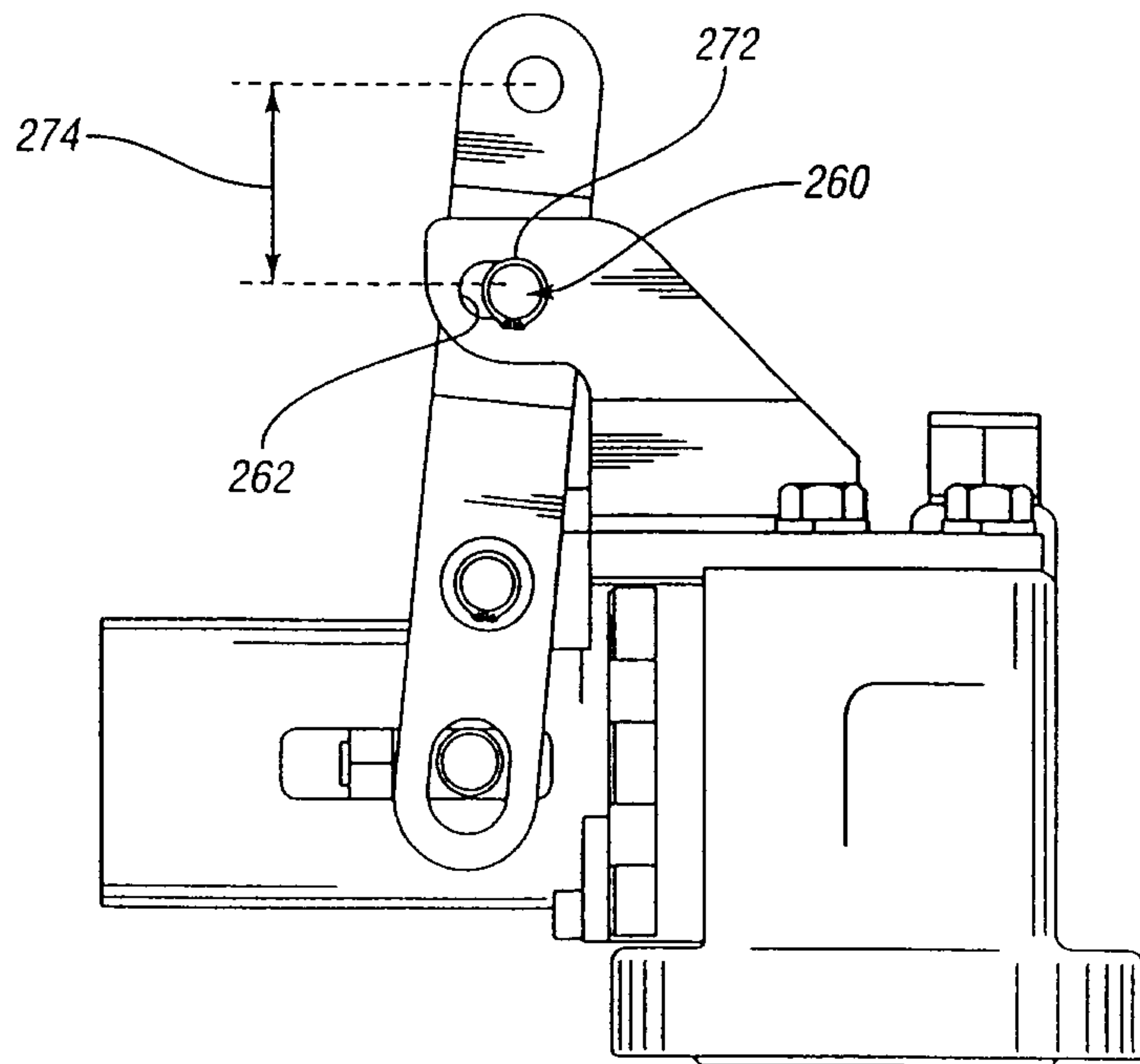


Fig. 7b

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