Feb. 17, 1953 H. G. BOWERING 2,628,770

VACUUM PUMP

Filed May 16, 1950 5 Sheets-Sheet 1

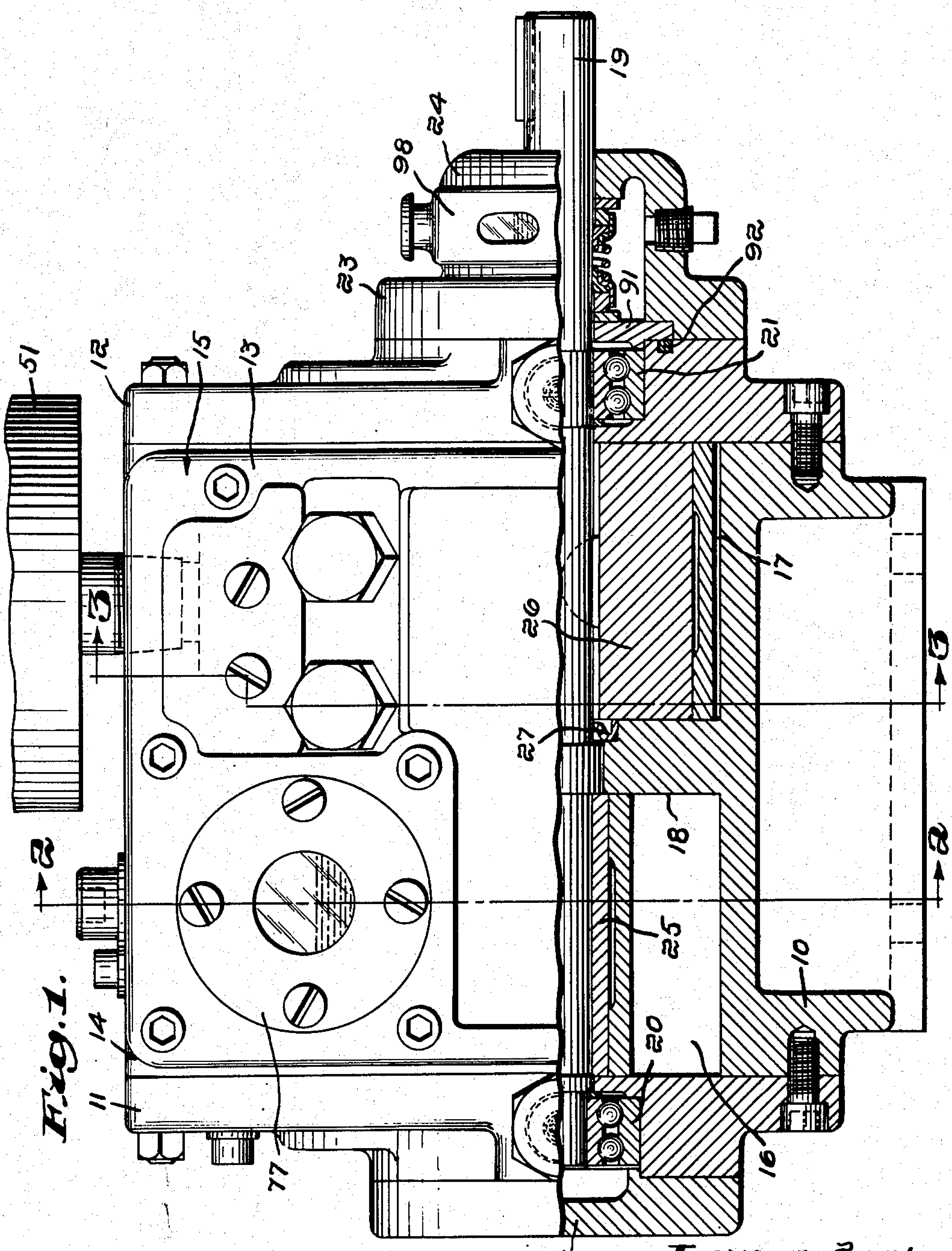

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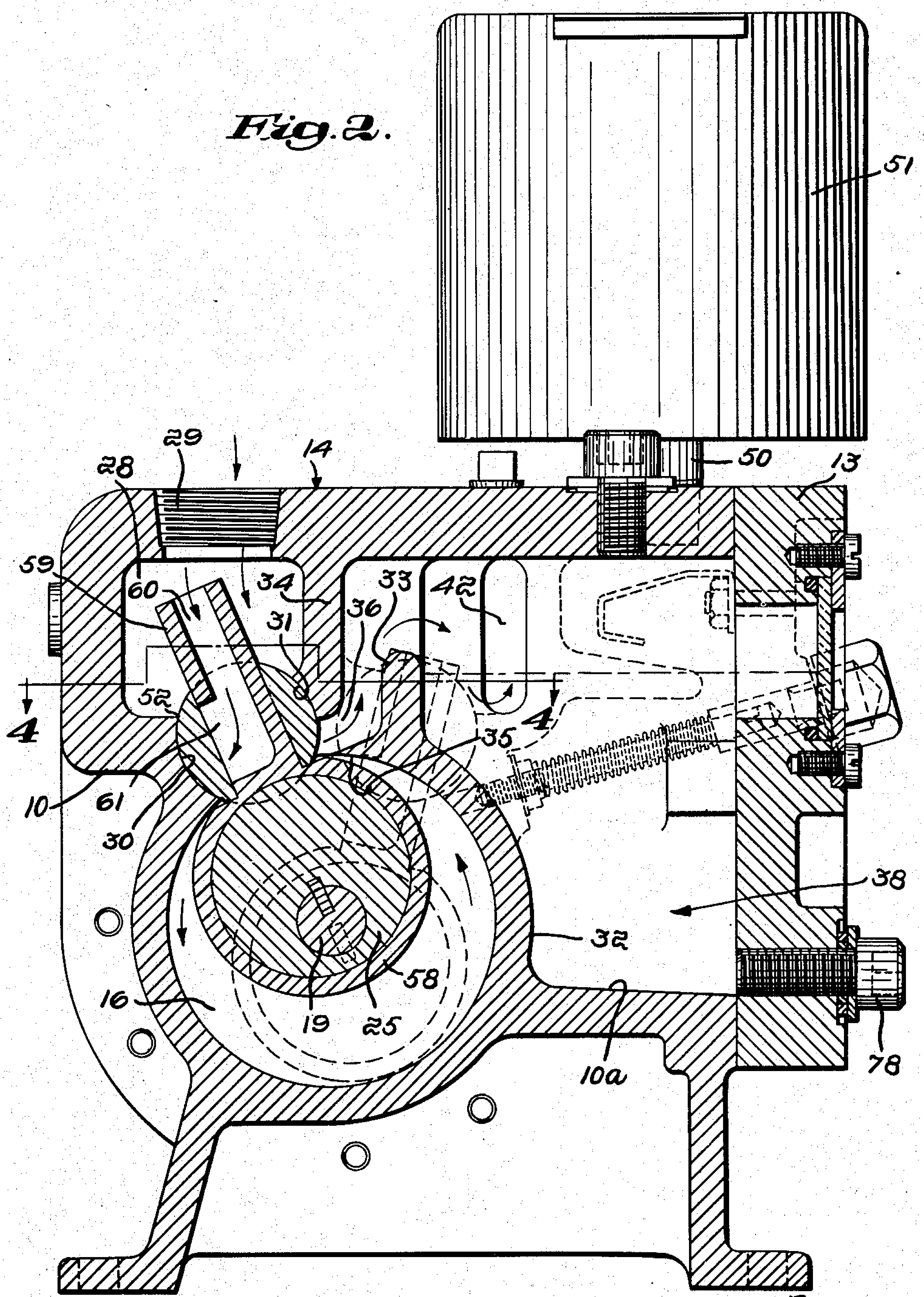
Fig. 2.



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VACUUM PUMP

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Fig. 3.

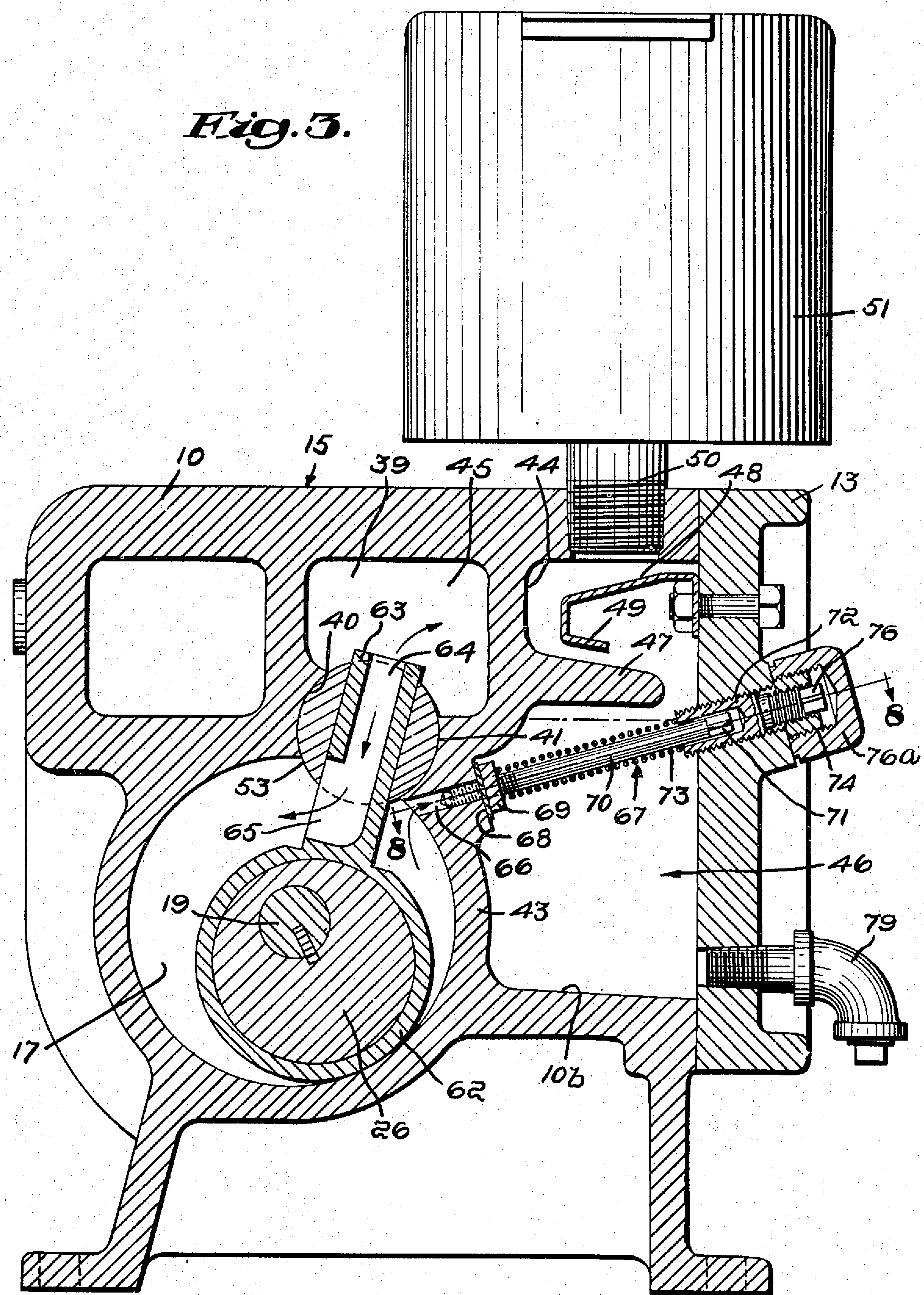

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Fig. 4.

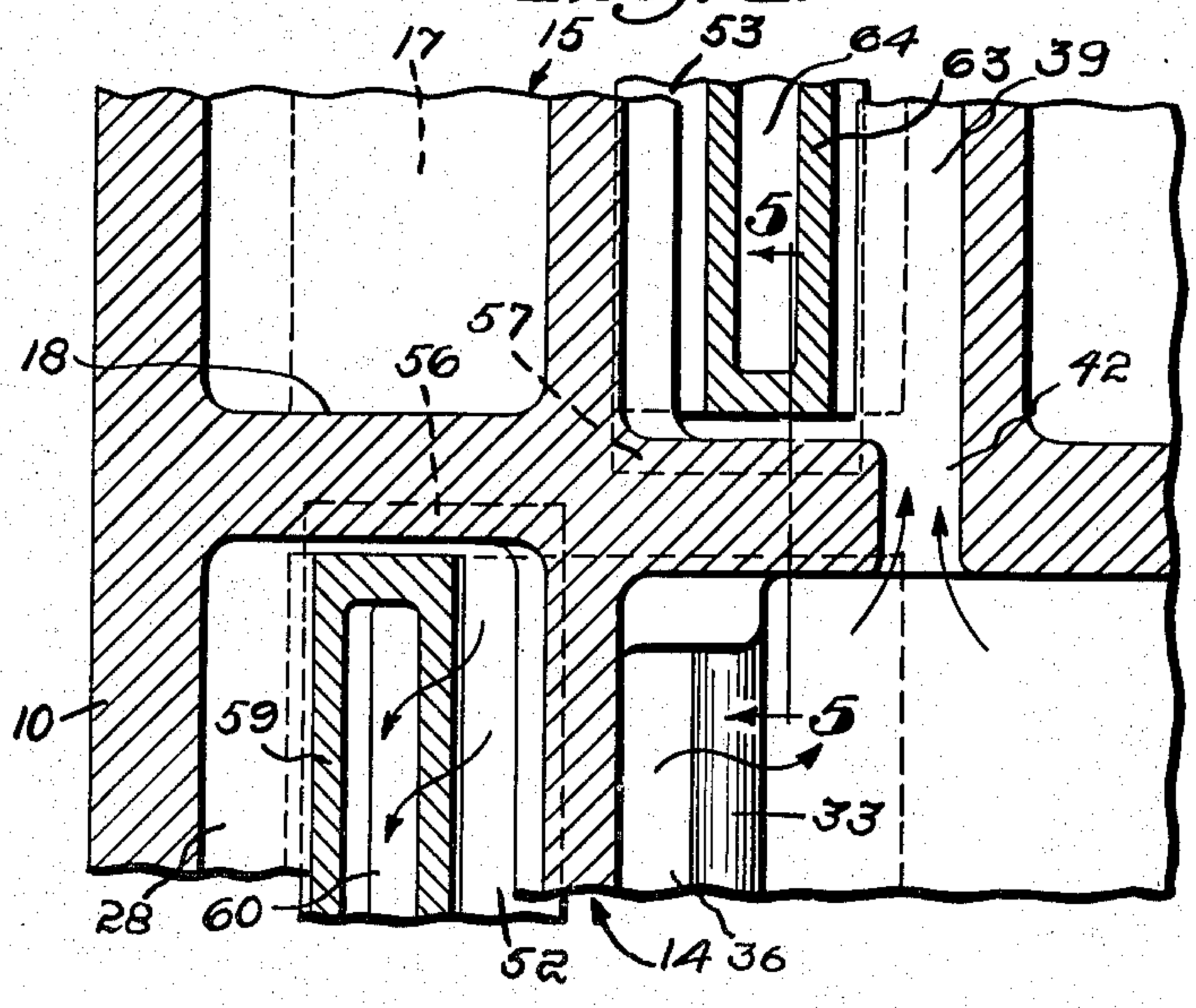


Fig. 5.

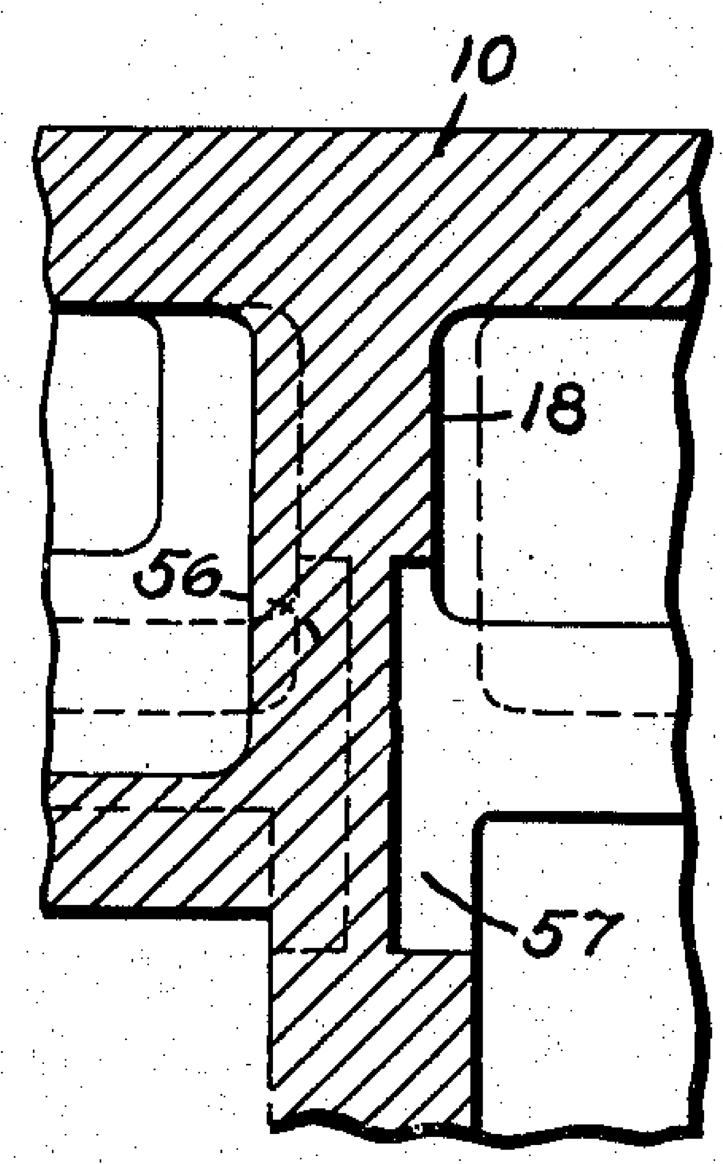


Fig. 7.

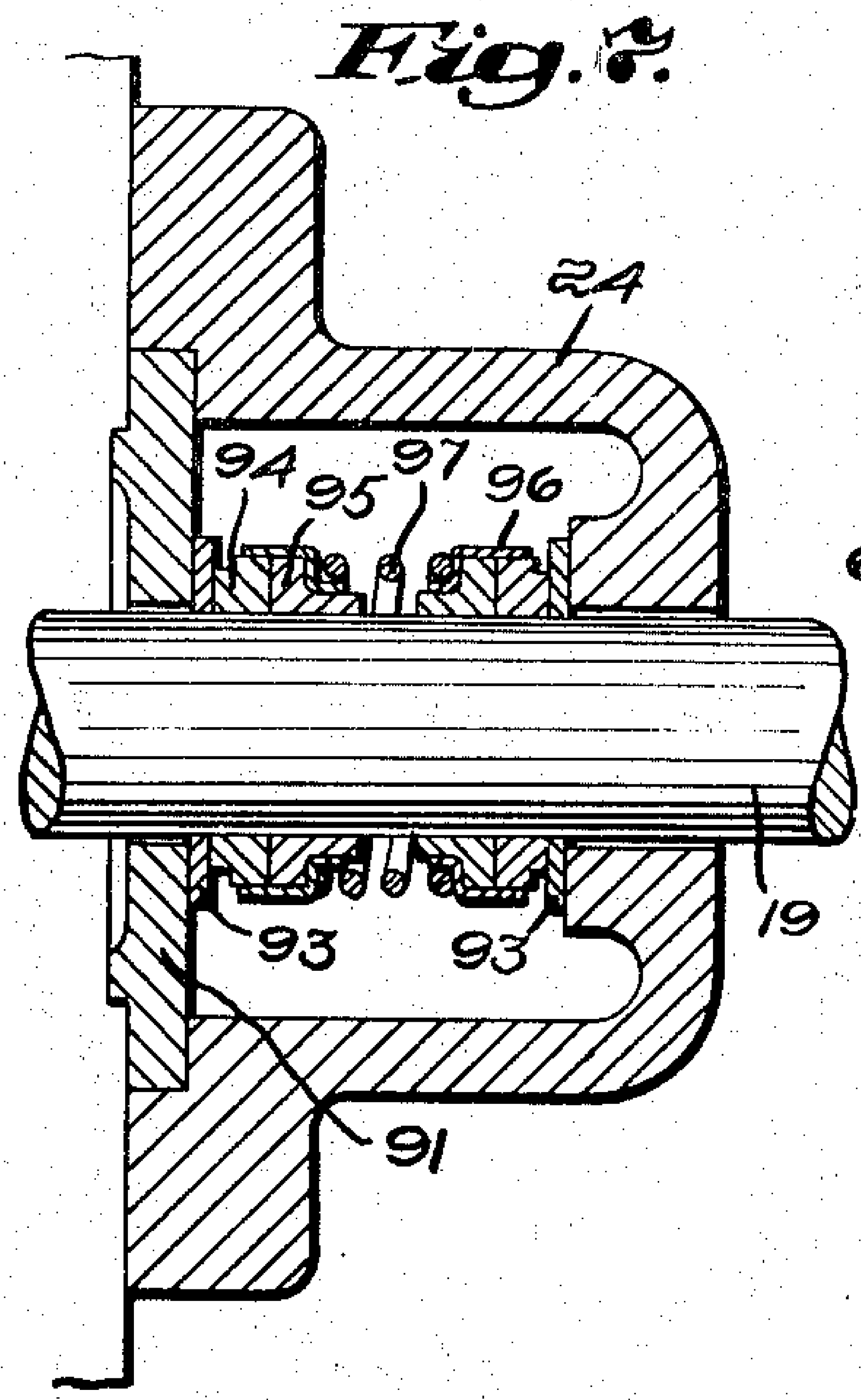
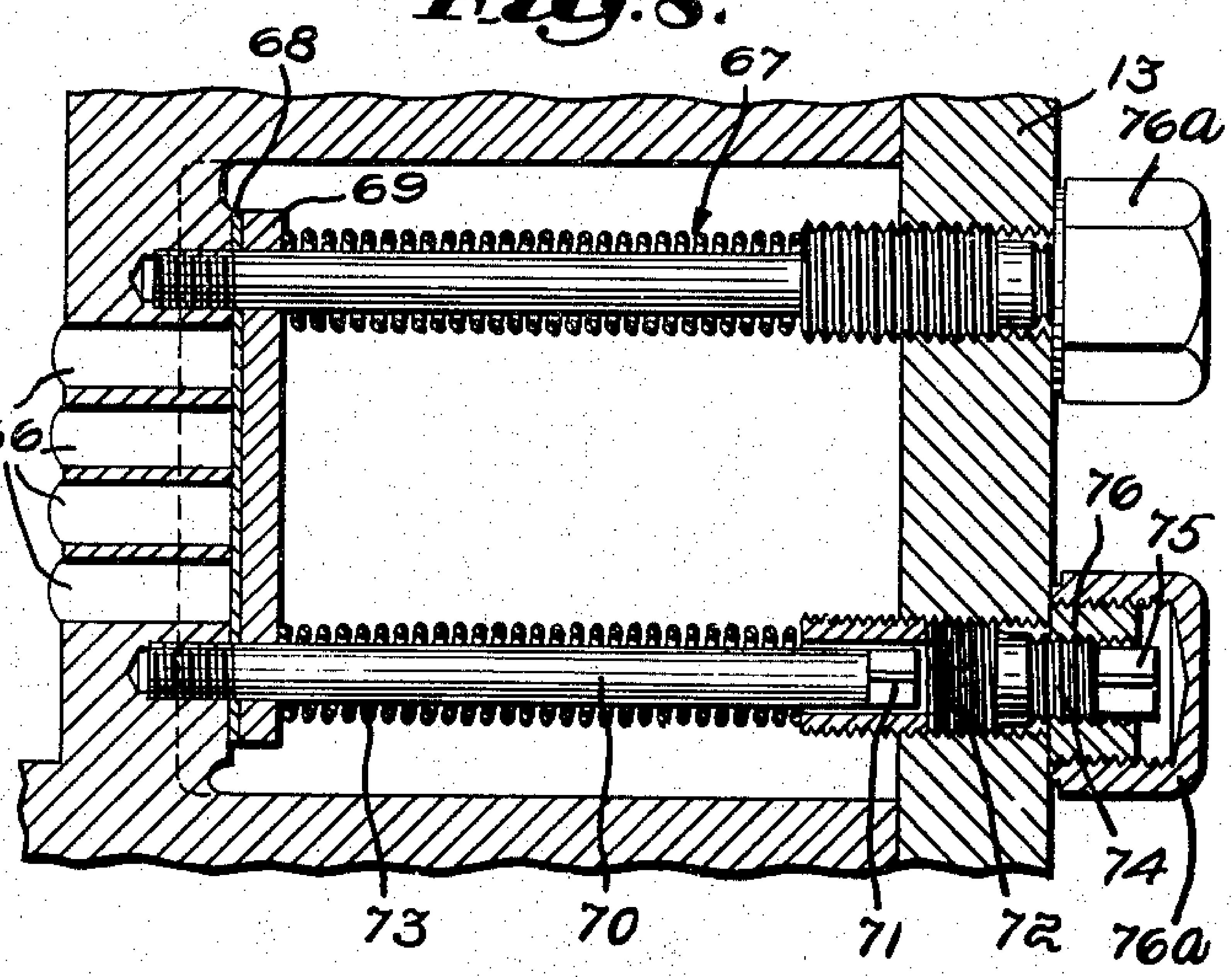


Fig. 8.



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VACUUM PUMP

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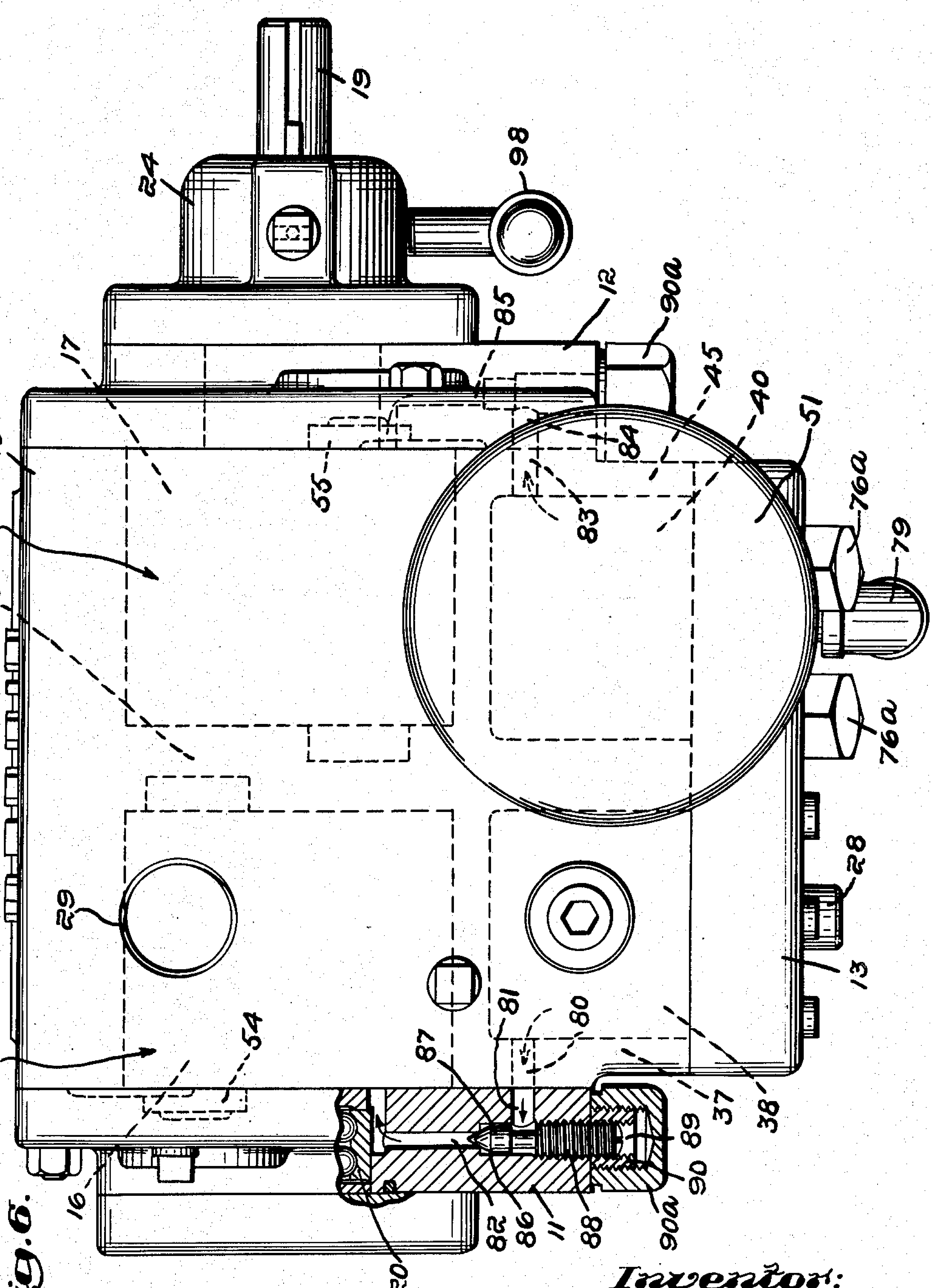

Fig. 6.

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UNITED STATES PATENT OFFICE

2,628,770

VACUUM PUMP

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Application May 16, 1950, Serial No. 162,302

6 Claims. (Cl. 230—147)

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My present invention relates to vacuum pumps and particularly to that type of pump in which two vacuum pumps, arranged in series, are combined as a unit.

It has long been recognized that increased pumping efficiency, in the region of high vacuum, may be attained by utilizing two vacuum pumps in series. In such an installation, the second pump, frequently termed "the second stage" or "backing up" pump, discharges to atmosphere and has its inlet connected to the outlet of the first pump, generally called "the first stage" or "high vacuum pump."

The advantages of such an installation are that the outlet region of the first stage pump is maintained at a low pressure, between 15 and 20 microns, for example, which pressure the second stage pump is adapted to maintain efficiently and that this same function of the second stage pump is effective to remove dissolved or entrained gas or both from the sealing oil for the first stage pump which is discharged through its outlet into the reservoir for that oil, exposed to the inlet of the second stage pump.

While separate pumps may be hooked up in series by suitable air-tight piping that is adapted to remain air-tight when subjected to pump vibration, the usual requirements for pumps adapted to maintain pumping efficiency in the region of high vacuum are best served by combining such pumps in a single unit. While such pumps have proved highly satisfactory in use and eliminate leakage attributable to vibration, the fact that the first and second stage pumps have a common wall results in troublesome interpump leakage and it is to the elimination of that factor and to a general improvement in pumping efficiency that this invention is primarily directed.

Each of the pumps which I combine in series is of the type which has an eccentric rotatable in a plunger and which is caused thereby to sweep its cylinder. The plunger includes an arm slidably guided in a rotatable pin so that the arm reciprocates relative thereto as the plunger sweeps its cylinder. The arm is effective to ensure that at all times, the pump inlet and outlet ports are never in communication with each other and hence the length of the arm is equal to that of the cylinder requiring that the length of the slide pin be greater than the length of the cylinder.

Where such pumps have been combined as a unit, the casing of that unit included a main casting having a transverse wall common to both pumps and those parts of both of the faces of

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that wall that established ends for the alined cylinders and sockets for the pins were machined. Prior to my invention, the pin sockets were in alinement and inter-pump leakage through the pin sockets resulted.

Such leakage is attributable to several factors. Among these may be noted that the common wall, being located in the middle of the casting, was difficult to test for porosity, actual pin holes or "sponginess." In addition, the length of the slide pins required that their sockets extend farther into the common wall than the recesses established by the machined areas thereof that define cylinder ends. As a consequence, it was necessary to have the common wall relatively thick in order to ensure adequate stock between the alined pin sockets even though such a wall was excessively thick between the cylinder ends. By that, I mean that the common wall of such a casting was appreciably thicker than other walls thereof which substantially increased the likelihood of its being porous. In the production of metal castings, if the casting walls are not approximately uniform, the thicker wall or walls, particularly if internal, are much more likely to be unsound than when wall uniformity exists. Thus, with a common wall of optimum thickness between the machined areas, there was, between alined pin sockets, an inadequate amount of metal, even if sound without making the casting excessively heavy. The expedient of increasing wall thickness to ensure sufficient metal between alined pin sockets for a barrier against interstage leakage, increased the chance of the casting being unsound between machined areas and pin sockets. These factors, while present in all units, regardless of size, are particularly troublesome with small units.

In accordance with my invention, I combine such pumps as a unit with the slide pin and sockets of one pump being located on the side of a center line through the axis of the pump cylinder that is opposite to the location of the slide pin and sockets of the other pump with reference to that line. The offset relation of the pin sockets results in my being able to insure that each socket is backed by adequate stock, preferably including the unbroken skin of the opposite surface of the casting without an excessive wall thickness between the cylinders. Another important consequence of pin spacing in accordance with my invention is that vibration is minimized.

In the accompanying drawings, I have shown an illustrative embodiment of my invention from which these and other of its novel features and advantages will be readily apparent.

In the drawings:

Fig. 1 is a partly sectioned side view of a pumping unit in accordance with my invention.

Figs. 2 and 3 are sections along the lines 2—2 and 3—3, respectively, of Fig. 1.

Fig. 4 is a fragmentary section along the lines 4—4 of Fig. 2.

Fig. 5 is a fragmentary section along the lines 5—5 of Fig. 4.

Fig. 6 is a top plan view of the unit, partly sectioned to show the details of the circulating systems for the sealing oil.

Fig. 7 is a partial horizontal section through the shaft seal, and

Fig. 8 is a section along the lines 8—8 of Fig. 3.

In the embodiment of my invention shown in the drawings, I have indicated at 10 a casting having heads 11 and 12 bolted to its first stage and second stage ends, respectively. A cylinder cover 13 is similarly secured to one of its sides. For convenience, I have indicated generally the first stage pump and the second stage pump at 14 and 15 respectively.

The casting 10 has its first stage pump cylinder 16 axially alined with the second stage pump cylinder 17. A transverse wall 18 separates the cylinders 16 and 17 and freely receives the drive shaft 19 which is supported by bearing units 20 and 21 carried, respectively, by the heads 11 and 12. The head 11 has a cap 22 attached to it while the head 12 has a cap 23, and a shaft seal attached thereto, the housing for which is indicated at 24. The shaft 19 protrudes from the housing 24 to be connected to any suitable drive.

Eccentrics 25 and 26 in the cylinders 16 and 17, respectively, are keyed to the shaft 19 and spaced 180° apart and the wall 18 is recessed on its second stage side to receive the shaft seal 27.

With reference to the first stage pump 14, it will be noted from Fig. 2, that the casting 10 has an inlet chamber 28 located above the cylinder 16 and at one side of a center line, for example, a perpendicular through its axis. The inlet chamber 28 has a threaded port 29 to enable the unit to be connected, by means of suitable air tight piping, to the system or chamber to be exhausted. Spaced arcuate supports 30 and 31 define a passageway between the inlet chamber 28 and the cylinder 16.

The wall part 32 of the cylinder 16 is spaced a substantial distance inwardly of the cylinder cover 13 and includes a lip or dam 33 extending upwardly in spaced relationship to the wall 34 of the inlet chamber 28, the lower part of which establishes the arcuate support 31. The dam 33 is on the opposite side of the perpendicular through the cylinder axis while the extremity 35 of the wall part 32 is substantially in the plane of the wall 34. I thus provide an L-shaped outlet 36 opening into the cylinder 16 in the zone of that perpendicular and into the passageway between the inlet chamber 28 and the cylinder 16 defined by the supports 30 and 31. This enables the outlet 36 which is preferably a cored passageway, to be of relatively large size, ensuring effective gas flow, and at the same time have such a small direct opening into the cylinder 16 that it can be blocked by the rotary displacing means, later to be detailed, once on each rotation of the shaft 19.

The wall part 32, the dam 33, the wall 18, the bottom part 10*a* of the casting 10, the casting end wall 37 (see Fig. 6), and the cylinder cover 13 define, in the assembled unit, a reservoir 38 for the sealing oil for the first stage pump 14.

With reference to the second stage pump 15 and, as may be best seen in Fig. 3, it will be noted that the casting 10 establishes an inlet chamber 39 above the cylinder 17 and on the same side of the perpendicular to the axis of the cylinders as the outlet 36 from the cylinder 16 and on the opposite side of that perpendicular relative to the inlet chamber 28. Spaced arcuate supports 40 and 41 define a passageway between the chamber 39 and the cylinder 17. The wall 18 has a port 42 effecting communication between the outlet side of the first stage pump 14 and the inlet chamber 39 of the second stage pump 15 and the lower edge of the port 42 is an appreciable distance below the top of the dam 33.

The wall part 43 of the cylinder 17 is spaced a substantial distance inwardly of the cylinder cover 13 and joins the wall 44 of the inlet chamber 39 so that they, the cylinder cover 13, the bottom part 10*b* of the casting 10, the adjacent end 45 of the casting 10 (see Fig. 6), and the wall 18 establish, in the assembled unit, a reservoir 46 for the sealing oil for the second stage pump 15. The wall 44 includes a baffle 47 disposed towards the cylinder cover 13 and the cylinder cover 13 has a baffle 48 terminating in a reversely disposed flange 49 disposed closely adjacent the intermediate part of the upper surface of the baffle 47. Above the baffle 48, the casting 10 has a threaded port to receive the outlet conduit 50 to the oil trap, generally indicated at 51, and which is open to atmosphere.

It will be appreciated that the cylinders 16 and 17 are carefully machined as are those portions of the wall 18 and the heads 11 and 12 that constitute the ends thereof.

The arcuate supports 30 and 31, and 40 and 41 are likewise machined to rotatably support the guide pins 52 and 53 of the first and second stage pumps, respectively. For the proper support of the slide pins, machined sockets in the wall 18 and the heads 11 and 12 are provided to receive the end portions of those pins. I have indicated the sockets in the heads 11 and 12 at 54 and 55 respectively (see Fig. 6), and the sockets in the wall 18 for the other ends of the pins at 56 and 57, respectively. (See Figs. 4 and 5.)

The laterally spaced relation of the inlet chambers 28 and 39 enables the slide pins 52 and 53 to be so spaced that their sockets 56 and 57 do not even overlap, although each of said sockets is shown as having a relatively small area of overlap with the machined cylinder end on the opposite side of the wall 18. This arrangement has the advantages that the major portion of the metal skin on the wall surface opposite either of those sockets is not broken and hence ensures against inter-pump leakage between adjacent pin sockets, and the wall 18 is of satisfactory thickness in the zone of each socket without being too thick in the zone of the cylinder ends.

With reference to the first stage pump 14, the eccentric 25 is rotatable within a plunger 58 which has an integral arm 59 slidably extending through the slide pin 52. The arm 59 is hollow to provide a conduit 60 open at its upper end while at its lower end, it has a port 61 with reference to which the pin 52 serves as a valve as the plunger 58 sweeps the cylinder 16 thereby to block the inlet chamber 28 therefrom as the plunger 58 passes and blocks the outlet port 36 so that the chamber 28 and the outlet port 36 are never interconnected.

The second stage pump 15 is shown as being similar to the first stage pump 14 and of the same size. It includes a plunger 62 in which the eccentric 26 is rotatable and having an arm 63 slidable in the slide pin 53. The arm 63 is hollow to provide a conduit 64 having a port 65 at its lower end which the pin 53 closes when the plunger is in a predetermined zone relative to the outlet ports 66 in the cylinder wall part 43.

The outlet ports 66 are controlled by valve means, generally indicated at 67, and which may be seen in Figs. 3 and 8. In practice, that portion of the wall part 43 in which the outlet ports 66 are located is machined and a relatively thin valve plate 68 and a relatively thick valve block 69 are freely positioned thereon by valve guides 70. The valve guides 70 are of substantial length and have their upper ends formed as at 71 to be engageable as by a socket type of wrench.

Threaded into the cylinder cover 13 are adjusting screws 72 chambered to receive the ends 71 of the valve guides 70. Compressed between the valve block 69 and the adjusting screws 72 are valve springs 73 held in place by the guides 70. Each adjusting screw 72 has a threaded portion 74 of reduced diameter, the extremity 75 of which is shaped for wrench engagement and threaded to its portion 74 is a nut 76, to which is threaded a cap nut 76*a*. Valve adjustments may, accordingly, be readily effected since, when the nuts 76 are removed, the extremities 75 of the adjusting screws protrude through the cylinder cover 13.

The cylinder cover 13 has a window 77 by which the oil level in the reservoir 38 can be seen and plugged drains 78 and 79 for the reservoirs 38 and 46 of the first and second stage pumps, respectively. An advantage of my units is that the cylinder covers 13, which define a wall of both reservoirs, may be removed to expose the entire interior of the reservoirs 38 and 46 to enable them to be thoroughly cleansed.

As may be seen in Fig. 6, the casting end wall 37 has a port 80 which registers with a port 81 in the head 11 to enable oil to flow from the reservoir 38 into the needle valve controlled conduit 82 and through that conduit to the bearing unit 20. The casting end wall 45 has a port 83 which registers with a port 84 in the head 12 which is in communication with the needle valve controlled conduit 85 thereof to deliver sealing oil from the reservoir 46 to the bearing unit 21. Each of the conduits 82 and 85 has a seat 86 engageable by the needle valve head 87, the plug part 88 of which is threaded into the outer end of that conduit and partly protrudes therefrom. The exposed extremity of the needle valve part 88 has a kerf 89 to enable valve adjustments to be made with a screw driver and threaded thereon is a nut 90, exteriorly threaded to receive the cap nut 90*a*.

I have found the shaft seal shown in Fig. 7 to be particularly effective. As shown in that view and in Fig. 1, a seal seat 91 and O ring 92 are clamped by the housing 24 against the head 12. Seal washers 93 are backed by the seat 91 and the opposite end of the housing 24. Adjacent each washer 93 is a washer engaging seal 94 and a shaft engaging seal 95 which are confined by a shouldered element 96. The elements 96 are yieldably spaced by the spring 97. An oil cup 98 serves to provide a sight indication of the oil supply for the shaft seal. I prefer that the oil supply for the shaft seal be independent of the oil circulating system for the second stage pump 15 in that it will remain free of contaminants.

From the foregoing description, the operation of my unit will be apparent. At the start up, accumulated oil in the cylinders is pumped out making necessary the baffles between the oil reservoir 33 and the oil trap 51 to prevent oil from being discharged therethrough. Thereafter, the oil level in each reservoir is stabilized and the second stage pump 15 effectively backs the first stage pump 14 and de-gasses the oil in its reservoir 38.

The second stage pump 15 is effective to maintain the pressure in the zone of the outlet and reservoir of the first stage pump 14 in the region of a few microns, 15 to 20 microns for example. Any leakage or any gas entrained in the sealing oil of the second stage pump 15 has a negligible effect on the efficiency of that pump at that pressure but would seriously affect the efficiency of the first stage pump 14.

Since the second stage pump 15 discharges to atmosphere and since the oil in its reservoir 46 is not positively de-gassed, some gas is always present to limit its efficiency. Inter-pump leakage through the pin sockets in the wall 18 is eliminated in accordance with my invention because of their offset location. In the embodiment of my invention shown in the drawings, each pin socket in the wall 18 overlaps the machined cylinder ends established by that wall. With reference to the first stage pump 14, however, the location of the pin socket 57 of the second stage pump 15 is such that it is at all times blocked from the inlet chamber 28 and is in the zone of the outlet 36 which is in direct communication with the inlet chamber 39 of the second stage pump. With reference to the second stage pump 15, the location of the pin socket 56 of the first stage pump 14 is remote from its valve controlled ports 66.

It is essential that the outlets of pumps, such as the pumps 14 and 15, be located as close to the slide pins as possible. With pumps in accordance with my invention, this essential does not result in inter-pump leakage via pin sockets with the consequence that increased pumping efficiency in relation to the size of the unit is ensured.

From the foregoing, it will be appreciated that vacuum pump units in accordance with my invention are characterized by economical production due to the nature of the castings 10, increased pumping efficiency in the region of high vacuum because of the elimination of inter-pump leakage, low power consumption and decreased vibration in operation, and ease of service as to valve adjustments and reservoir cleaning.

What I therefore claim and desire to secure by Letters Patent is:

1. In a high-vacuum two-stage pumping unit, the combination of a housing enclosing two axially alined cylinders, one for each stage, said housing including a cast metal main component in which an integrally cast metal wall separates said cylinders and has opposite parallel machined surfaces which are the proximate end boundary surfaces of respective cylinders; a shaft extending through said wall and axially through said cylinders; and rotary displacing means arranged to be actuated by said shaft, one in each of said cylinders and each including an arm and a slotted oscillating cylindrical pin, through which pin said arm reciprocates as the shaft rotates, each face of said wall being intersected by a socket which receives an end of a corresponding one of said pins, each socket extending part way through said wall, the axes of said sockets being offset from each other on an arc about the shaft axis

by a distance materially exceeding the sum of the radii of the sockets so that the sockets are widely spaced in the zone of their closest approach and the depth of a single socket determines the thickness of the metal barrier between the end of the socket for either cylinder and the proximate end of the other cylinder.

2. In a high-vacuum two-stage pumping unit, the combination of a housing enclosing two axially alined cylinders, one for each stage, said housing including a cast metal main component in which an integrally cast metal wall separates said cylinders and has opposite parallel machined surfaces which are the proximate end boundary surfaces of respective cylinders; a shaft extending through said wall and axially through said cylinders; and rotary displacing means arranged to be actuated by said shaft, one in each of said cylinders and each including an arm and a slotted oscillating cylindrical pin, through which pin said arm reciprocates as the shaft rotates, each face of said wall being intersected by a socket which receives an end of a corresponding one of said pins, each socket extending part way through said wall, the axes of said sockets being offset from each other on an arc about the shaft axis by a distance materially exceeding the sum of the radii of the sockets so that the sockets are widely spaced in the zone of their closest approach and the depth of a single socket determines the thickness of the metal barrier between the end of the socket for either cylinder and the end of the other cylinder, the casting skin on both faces of said wall being intact except for said machined surfaces and except where intersected by said sockets.

3. In a high-vacuum two-stage pumping unit, the combination of a housing enclosing two axially alined cylinders, one for each stage, spaced inlets and outlets for each stage, and a reservoir for each stage with which the outlet of that stage is in communication, the outlet for one stage being in approximate longitudinal alinement with the inlet for the other stage; said housing including a cast metal main component in which an integrally cast metal wall separates said cylinders and their respective inlets, outlets and reservoirs and has opposite parallel machined surfaces which are the proximate end boundary surfaces of respective cylinders and a port by which the alined inlet and outlet are placed in communication; a shaft extending through said wall and axially through said cylinders; and rotary displacing means arranged to be actuated by said shaft, one in each cylinder and each including an arm extending into the inlet for that cylinder and a slotted oscillating cylindrical pin through which said arm reciprocates as the shaft rotates, and a seat for each pin including a socket extending part way through said wall, the inlets of the respective cylinders being so spaced relative to each other that the axes of said sockets are offset from each other on an arc about the shaft axis by a distance materially exceeding the sum of the radii of the sockets so that the sockets are widely spaced in the zone of their closest approach and the depth of a single socket determines the thickness of the metal barrier between the end of the socket for either cylinder and the proximate end of the other cylinder.

4. In a high-vacuum two-stage pumping unit, the combination of a housing enclosing first and second axially alined cylinders for the first and second stage, respectively, said housing including a cast metal main component in which an

integrally cast metal wall separates said cylinders and has opposite parallel machined surfaces which are the proximate end boundary surfaces of respective cylinders; a shaft extending through said wall and axially through said cylinders; and rotary displacing means arranged to be actuated by said shaft, one in each of said cylinders and each including an arm and a slotted oscillating cylindrical pin parallel with said shaft, through which pin said arm reciprocates as the shaft rotates, each pin being mounted in a cylindrical seat which intersects the corresponding cylinder and terminates in a socket extending part way through said wall and intersecting a portion of the machined surface, the axes of said sockets being offset from each other on an arc about the shaft axis by a distance materially exceeding the sum of the radii of the sockets so that the sockets are widely spaced in the zone of their closest approach and the depth of a single socket determines the thickness of the metal barrier between the end of the socket for either cylinder and the proximate end of the other cylinder, the displacing means for each stage being disposed relatively to each other to provide minimum compression in the second stage in the zone of the socket for the first stage pin.

5. In a high vacuum two-stage pumping unit, the combination of a housing enclosing first and second axially alined cylinders for the first and second stage, respectively, spaced inlet and outlet chambers for each stage, each having a passageway in communication with the cylinder of that stage, the outlet chamber of the first stage being longitudinally alined with the inlet chamber of the second stage, said housing including a cast metal main component in which an integrally cast metal wall separates said cylinders and their respective chambers and has opposite parallel machined surfaces which are the proximate end boundary surfaces of respective cylinders and a port by which said alined chambers are placed in direct communication; a shaft extending through said wall and axially through said cylinders; and rotary displacing means arranged to be actuated by said shaft, one in each of said cylinders and each including a ported arm and a slotted oscillating cylindrical pin parallel with said shaft through which pin said arm reciprocates as the shaft rotates providing a valve open through a predetermined partial rotation of said displacing means, each pin being mounted in a cylindrical seat in the passageway between its cylinder and its inlet chamber, each seat intersecting the corresponding cylinder and terminating in a socket extending part way through said wall and intersecting a portion of the machined surface, the axes of said sockets being offset from each other on an arc about the shaft axis by a distance materially exceeding the sum of the radii of the sockets so that the sockets are widely spaced in the zone of their closest approach and the depth of a single socket determines the thickness of the metal barrier between the end of the socket for either cylinder and the proximate end of the other cylinder, the outlet passageway for said first stage opening into the first stage cylinder and its inlet passageway at their junction, the first stage displacing means and the pin and arm of the first stage simultaneously blocking said first stage passageways once in each revolution of said first stage displacing means.

6. In a high-vacuum two-stage pumping unit, the combination of a housing enclosing first and

second axially alined cylinders for the first and second stage, respectively, spaced inlet and outlet chambers for each stage, each having a passageway in communication with the cylinder of that stage, the outlet chamber of the first stage being longitudinally alined with the inlet chamber of the second stage, said housing including a cast metal main component in which an integrally cast metal wall separates said cylinders and their respective chambers and has opposite parallel machined surfaces which are the proximate end boundary surfaces of respective cylinders and a port by which said alined chambers are placed in direct communication; a shaft extending through said wall and axially through said cylinders; and rotary displacing means arranged to be actuated by said shaft, one in each of said cylinders and each including a ported arm and a slotted oscillating cylindrical pin parallel with said shaft, through which pin said arm reciprocates as the shaft rotates providing a valve open through a predetermined partial rotation of said displacing means, each pin being mounted in a cylindrical seat in the passageway between its cylinder and its inlet chamber, each seat intersecting the corresponding cylinder, the axes of said seats being offset from each other on an arc about the shaft axis by a distance materially exceeding the sum of the radii of the seats so that the seats are widely spaced in the zone of their closest approach, the outlet passageway for said first stage opening into the first stage cylinder and its inlet passageway at their junction, the first stage displacing means and the pin and arm of the first stage simultaneously blocking said first stage passageways once in each revolution of said first stage displacing means.

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