

Feb. 9, 1954

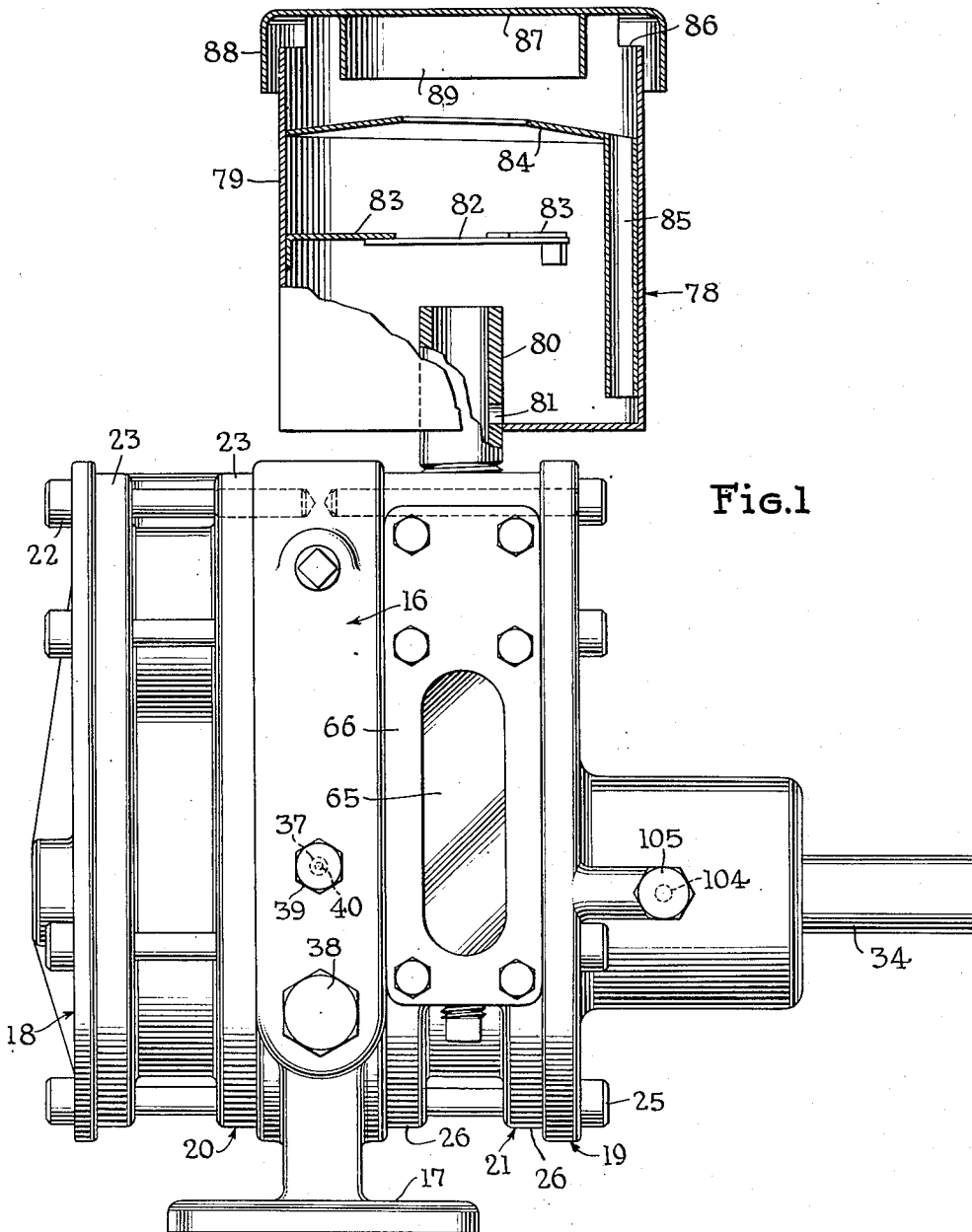
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2,668,655

VACUUM PUMP

Filed May 19, 1951

6 Sheets-Sheet 1



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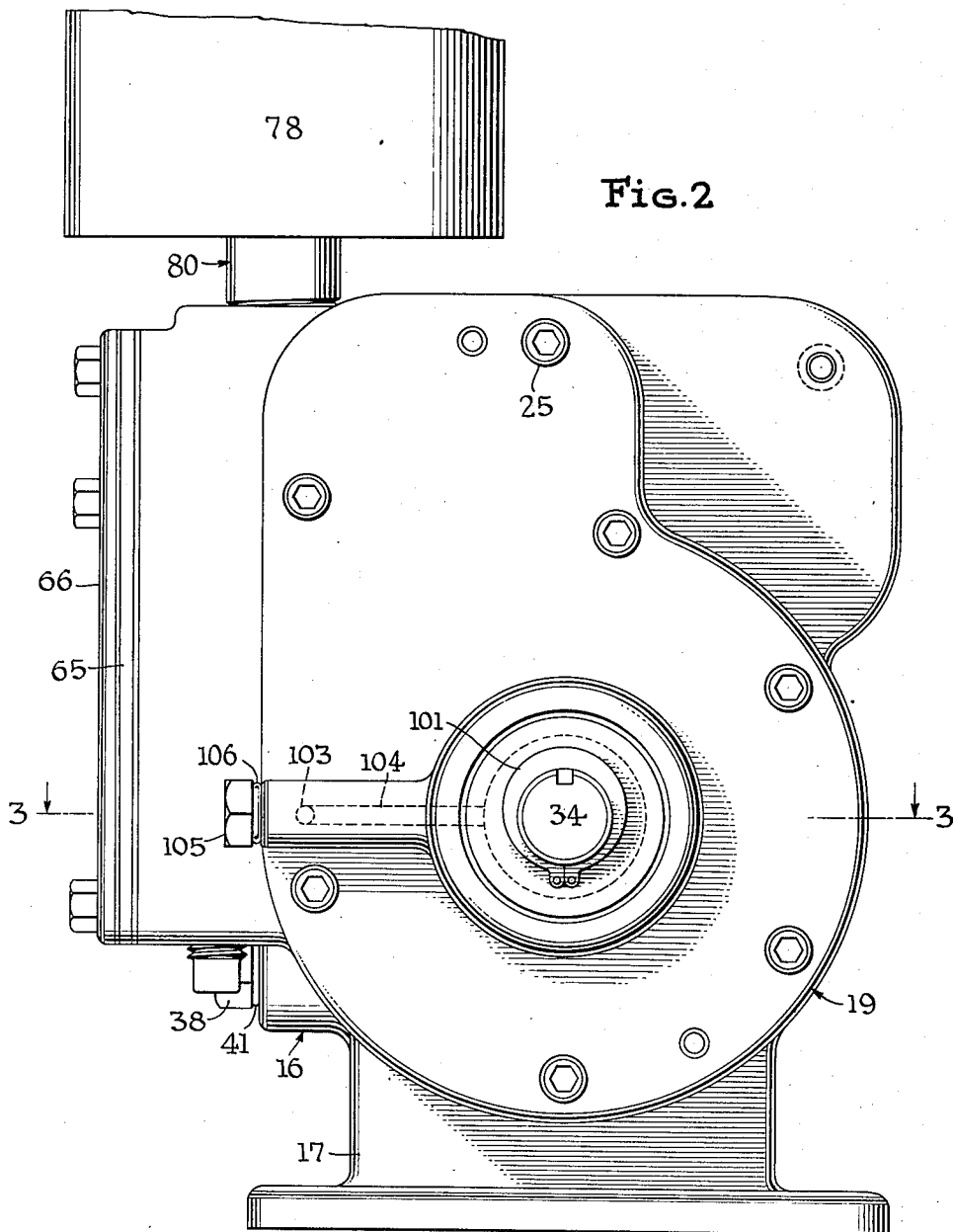
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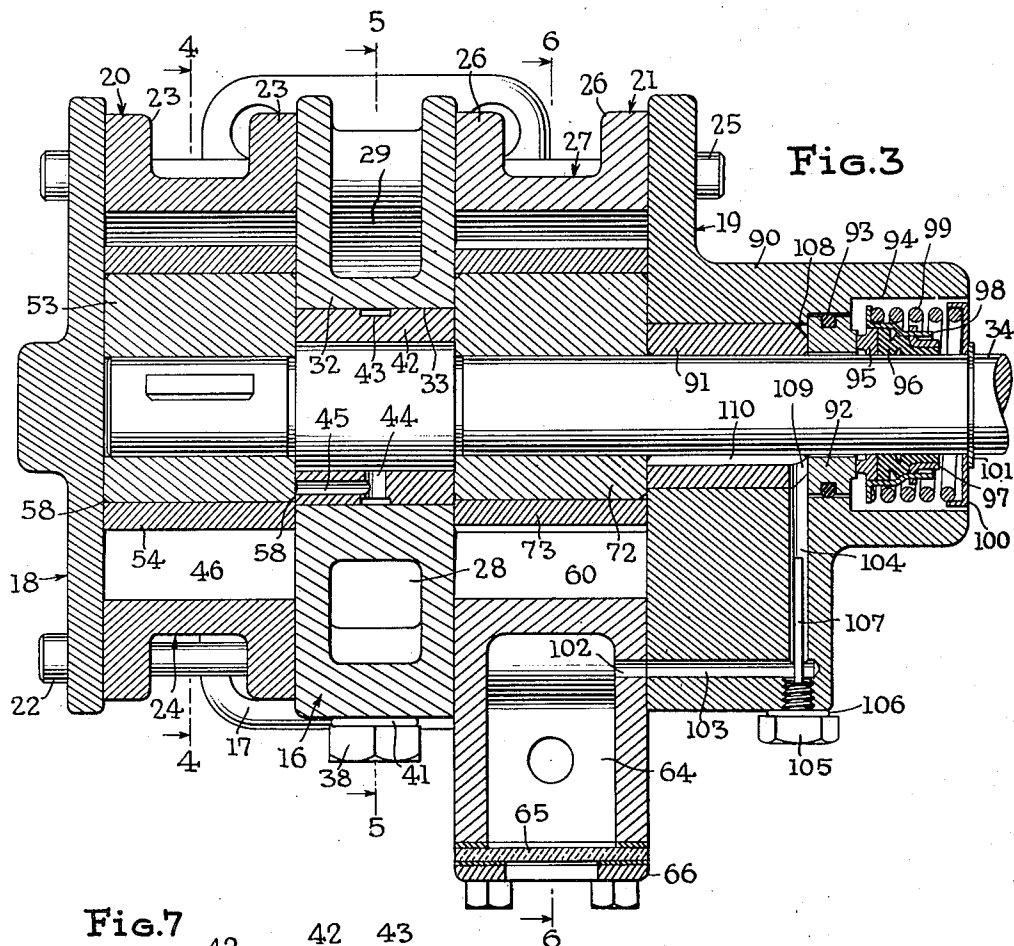


Fig. 3

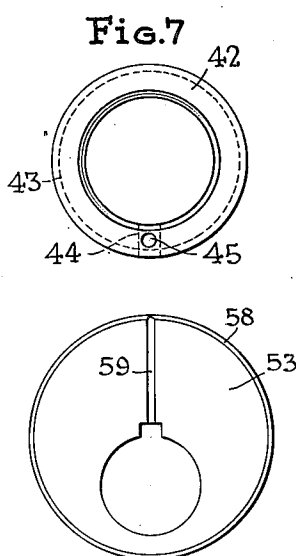


Fig. 7

Fig. 8

Fig. 11

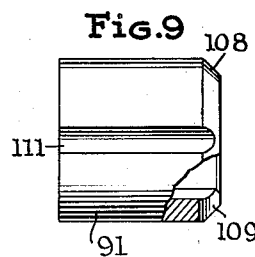


Fig. 9

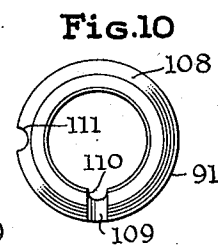


Fig. 10

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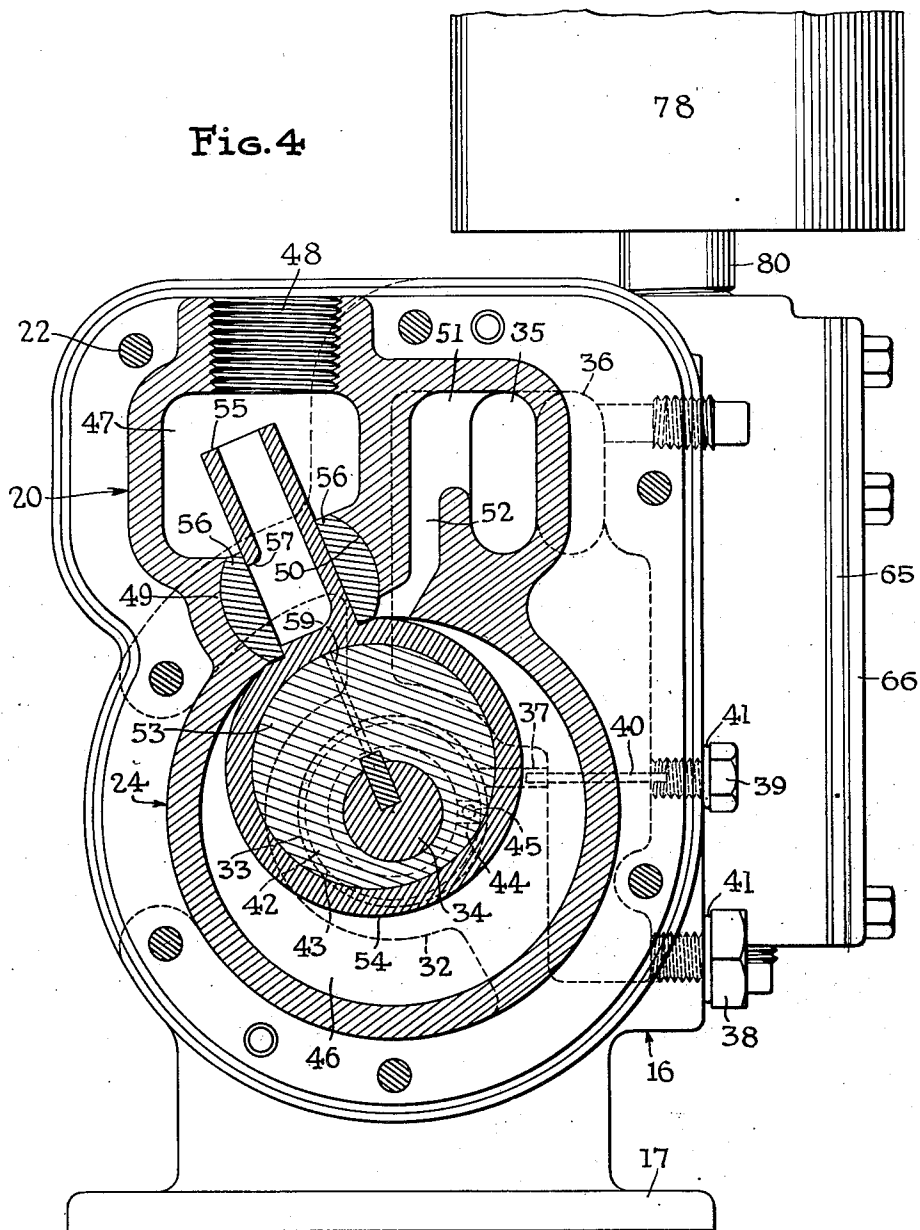
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6 Sheets-Sheet 4



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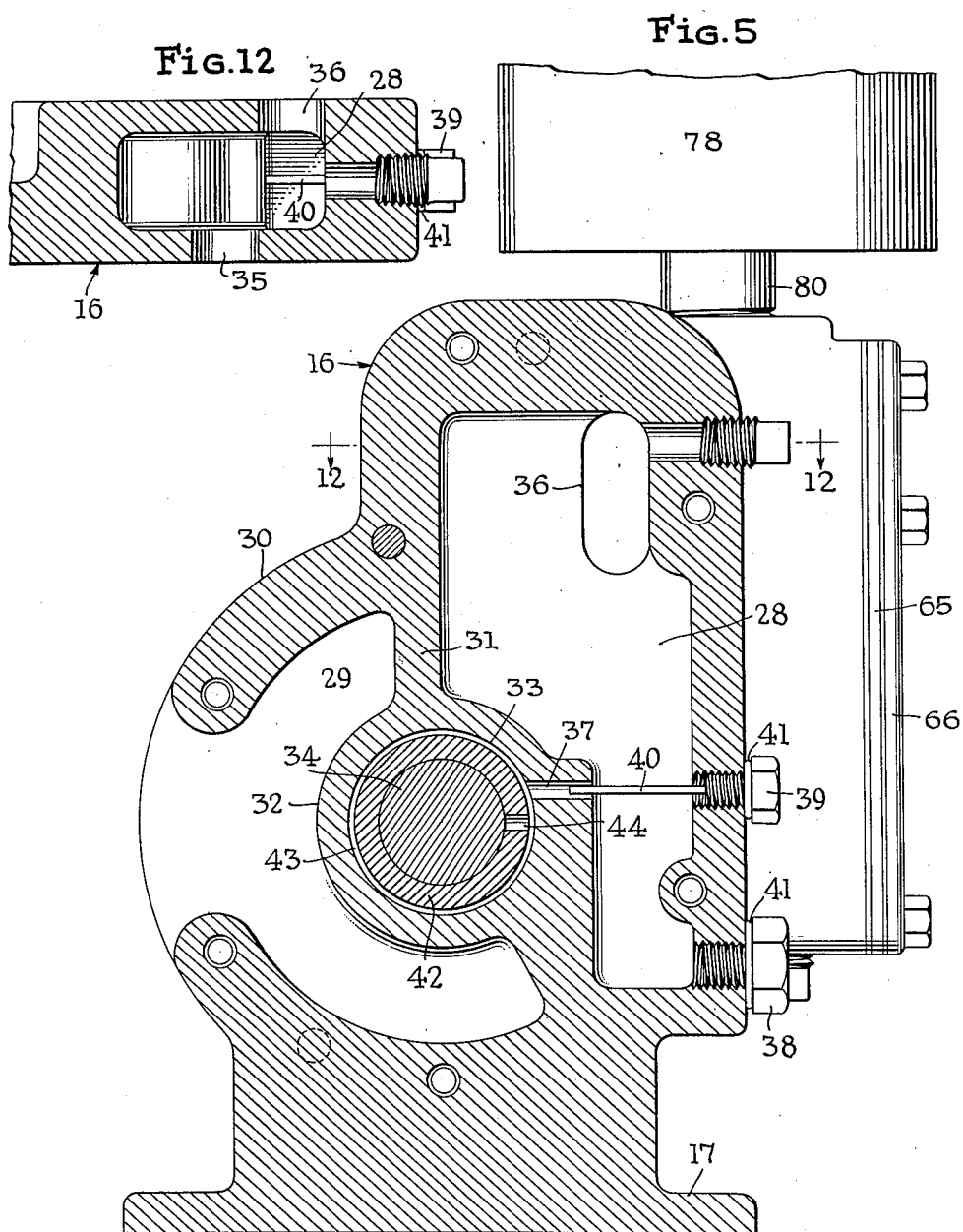
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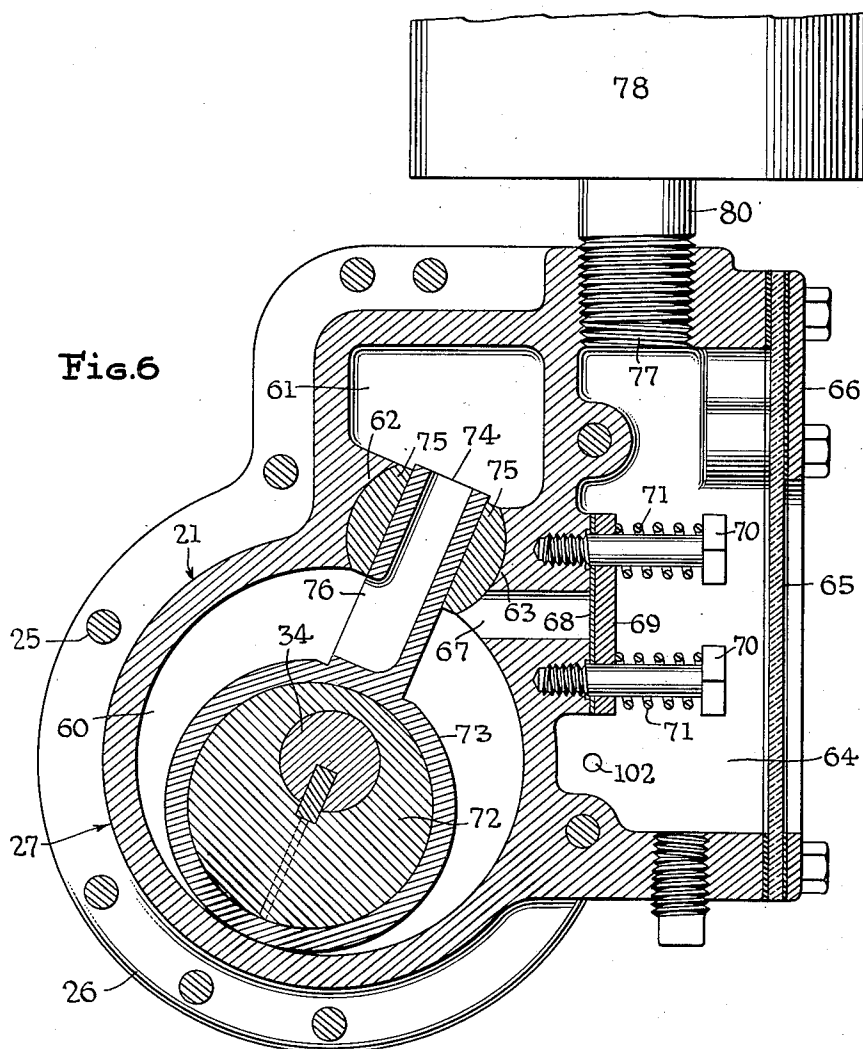
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VACUUM PUMP

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7 Claims. (Cl. 230—158)

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This invention relates to vacuum pump units of the type consisting of first and second stage pumps combined in a single housing and driven by a common shaft with the inlet of the second stage pump being in communication with the outlet of and the oil reservoir for the first stage pump.

Such compound vacuum pump units are widely used because of their pumping efficiency in the region of high vacuum. The function of each pump of such a unit, in attaining that efficiency, is that the second stage pump serves as a "roughing" stage in which it functions to "back-up" the first stage pump and to de-gas its sealing oil while the first stage pump serves as a "finishing" stage. The second stage pump, however, has the heavier load since its discharge to atmosphere is through a spring loaded outlet valve. In practice, it maintains a low pressure, typically in the range of from 15 to 25 microns, on the outlet of the first stage pump and on the oil in its reservoir to remove dissolved or entrained air, or both, therefrom to condition it for sealing purposes. The first stage pump must be adapted to maintain a substantially lower pressure, .05 micron or less, on the chamber or system with which its inlet is in communication. The pressures referred to herein are based on MacLeod gauge readings.

Leakage into a vacuum pump would, of course, make satisfactory performance impossible and care is exercised to provide suitable air-tight housings. The housings for compound vacuum pumps vary considerably in their specific forms but each commonly includes a pair of casing parts for the pump mechanisms, a center wall part separating them, and a head to close the other end of each casing part. The shaft extends through the head for the second stage end of the housing, through the center wall part and is supported by a bearing unit located in a blind recess in the head for the first stage pump. In some housings, each part is a separate casting while in other types, the center wall and casing parts are combined in a single casting.

While such housings suitably safeguard against air leakage into them, interstage leakage, when it occurs, impairs performance and is difficult to locate. There is a substantial pressure differential between the stages of a compound vacuum pump and even the slightest leak from the second stage pump to the first stage pump is serious because of the substantial volume to which gases expand at the low pressures maintained by the first stage pump.

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There are two probable paths for interstage leakage. One of them is along the shaft and the second is through the center wall. Spongy cast iron commonly results when the casting is thick or where adjacent portions thereof differ in thickness. Even where it occurs, the surface or skin of the casting is usually sound. If the surface skin of the casting is machined away on only one side, the skin on the other side usually will prevent leakage therethrough. If opposite surfaces are machined, leakage through the metal between the machined faces will occur often enough to be a commercial problem.

The principal objective of the present invention is the provision of a compound or two stage rotary vacuum pump in which the probability of interstage leakage, both through the center wall and along the shaft, is virtually eliminated.

This result is attained by providing a rotary two stage vacuum pump the housing of which has two axially alined cylindrical working spaces isolated from each other by a partition. The partition isolates and forms the proximate end walls of the working spaces and includes within itself chambers, formed in the casting operation and retaining the casting skin. These chambers are directly interposed between the parallel machined surfaces which are the proximate end surfaces of the two working spaces and approximately surround a central hub which has a bore coaxial with both working spaces. Sealed in the bore is a plain bearing-bushing rotatably supporting the shaft which extends into the working spaces and operates the rotary displacing means of which there is one in each working space.

One of the chambers is the oil reservoir for the first stage pump and has ports opening through the machined surfaces to establish the outlet for the first stage pump and the inlet port for the second stage pump. The bearing-bushing is formed with oil passages which are fed by an oil passageway leading from that oil reservoir. One such passage leads to the shaft and the other is arranged to deliver oil to the first stage pump for lubricating and sealing purposes without breaking the shaft lubricating oil film and thus destroying its effectiveness as a seal against interstage leakage along the shaft.

With the exception of the machined surfaces which serve as the proximate end surfaces of the working spaces and the axial bore for the bearing-bushing, all other surfaces of the partition have an unbroken casting skin which serves as an effective barrier against leakage. Those portions of the machined surfaces which are

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backed by the hub are the only places where an unbroken casting skin is not available to serve as such a barrier. The center wall, however, measured in the direction of the shaft axis, is thick enough to guard against leakage lengthwise of the hub. The proper proportioning of the chambers ensures that the cross-section of the walls formed thereby is nearly uniform, and, in practise, the hub is cored to ensure that the thickness of its wall is approximately that of the other walls. Thus sponginess throughout the casting is minimized and even should it occur, the skin of the casting is effective to prevent leakage.

These features of the invention make possible adequate protection against interstage leakage in compound vacuum pumps and enable other changes to be made in the construction of the first stage pump that also contribute to economy in production and improved efficiency both in operation and in relation to weight and horse power requirements as will be apparent from the accompanying drawings showing these and other features in an illustrative embodiment of the invention.

In the drawings:

Fig. 1 is a side view of a compound vacuum pump in accordance with the invention with its oil trap partly sectioned.

Fig. 2 is a side view of that pump as viewed from its second stage end.

Fig. 3 is a section through the pump on a plane indicated by the lines 3—3 of Fig. 2.

Figs. 4, 5, and 6 are sections through the pump on planes indicated by the lines 4—4, 5—5, and 6—6 respectively, of Fig. 3.

Fig. 7 is an end elevation of the main shaft bearing-bushing carried by the center wall looking at its first stage end.

Fig. 8 is a longitudinal section of that bearing-bushing.

Fig. 9 is a side elevation of the main shaft bearing-bushing carried by the second stage head, a part being broken away to expose an oil passage.

Fig. 10 is a view of that bushing as viewed from its outer end.

Fig. 11 is an end view of the eccentric of the first stage. That for the second stage is identical, and

Fig. 12 is a section along the lines 12—12 of Fig. 5.

In the embodiment of the invention illustrated in the drawings (see particularly Fig. 1) there is illustrated a two stage vacuum pump housing comprising a center wall member generally indicated at 16 and supported by a pedestal 17, heads 18 and 19, and pump casing parts 20 and 21 each clamped between a corresponding head and the center wall.

Machine screws 22 extend through the head 18, the flanges 23 of the casing part 20 and are threaded into the center wall 16. The resulting assembly is the housing of the first stage pump and is generally indicated by the numeral 24. Machine screws 25 extend through the head 19, the flanges 26 of the casing part 21 and are threaded into the center wall 16 thus providing the housing of the second stage pump, indicated generally by the numeral 27. In practise, each face of the center wall 16 is provided with locating pins to ensure correct assembly.

The contacting faces of the castings are precisely machined to ensure surfaces that can be tightly sealed together to render the joints air

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tight. No gaskets are used between such faces. As the heads 18 and 19 have only their inner surfaces machined and casing parts 20 and 21 have only their inner and end surfaces machined, they present no serious leakage problem.

As best shown in Figs. 3, 5 and 12, the center wall member 16 has, between its machined faces a first chamber or cavity 28 and a second chamber or cavity 29. The chambers are produced in the casting operation, by coring or otherwise. These cavities are located and dimensioned to provide an external shell 30 and a partition 31 in the form of a web having a hub portion 32. The hub may be cored and in any case is bored at 33 to permit the bearing-bushing 42 (hereinafter described) to be pressed into position.

The first cavity 28 extends from a point below the hub portion 32 to a point well above it and has, adjacent its upper end, a cored port 35 opening through one face of the center wall 16 and a cored port 36 opening through the other face thereof (see Fig. 12). These ports are laterally offset with respect to each other and constitute, respectively, the outlet port of the first stage pump and the inlet port of the second stage pump.

The cavity 28 serves as an oil reservoir for the first stage pump and has a drilled passageway 37 in communication with the bushing receiving bore 33. The center wall 16 has a removable drainage plug 38. At 39, there is a plug, carrying a stem 40 which extends into the passageway 37 to provide interchangeable means for regulating the rate of oil flow therethrough. Both plugs seat against toric, rubber-like gaskets 41.

As no surface of the cavities is machined, the casting skin of those surfaces is effective to back the machined surfaces, ensuring against leakage. While not all portions of the machined faces of the center wall 16 are so backed, the unbacked portions are suitably separated. The hub 32 is of substantial axial length, as will be apparent from Fig. 3, but the design of the center wall permits such uniformity of metal sections as will ensure sound castings. Where, additionally, the hub is cored, it is unlikely to be spongy. The cavities, furthermore, make it possible to provide a center wall, including an oil reservoir of adequate capacity for all of the sealing oil for the first stage pump. This member is not excessively heavy and is characterized by a relatively long bore 33 for the bearing-bushing 42.

The main shaft 34 is supported in the center wall bore 33 by the plain bearing-bushing 42 extending from end to end of that bore. The bushing 42 has an encircling annular groove 43 intermediate its ends, positioned to receive oil discharged through the supply passageway 37. A radial port 44 leads from this to the journal of the shaft 34, and to the passage 45 which leads to the first stage end of the bushing 42.

As best shown in Figs. 3 and 4, the casing 20 encloses an open, right circular cylindrical chamber 46, the ends of which are closed by plane surfaces of the parts 18 and 19. This is the first stage working space. Casing 20 also includes an inlet chamber 47 having a threaded inlet connection 48 and a cylindrical seat 49, 50 for the two guide blocks 56. These are sectors of a right circular cylinder equal in length with the chamber 46. The casing part 20 also has an opening 51 extending from end to end thereof and serving as an outlet chamber in communication with the reservoir port 35 in the center wall 16. An outlet port 52 opens into the working space 46

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adjacent to and through the lower extremity of the cylindrical guide seat 50 and extends upwardly to open into the outlet chamber 51 over a dam or rim extending above the bottom thereof. This dam (see Fig. 4) serves to cause retention of a limited column of sealing oil in the lower part of the port 52 by controlling discharge of excess oil.

The displacing abutment comprises an eccentric 53 keyed to the shaft 34 and rotatable in the cylindrical sleeve 54 which has a radial hollow, open-ended, plate-like arm 55 extending into the inlet chamber 47. Arm 55 fills the interval between the guide blocks 56 and is guided thereby. The eccentric 53, the sleeve 54, the arm 55, and the guide blocks 56 are all of the same length as the casing part 20. The arm 55 has a port 57 shown in Fig. 4 as closed by one of the guide blocks 56 when the sleeve 54 sweeps past the outlet port 52. It remains closed until the plunger has again started its sweep of the working space 46. The sleeve 54 does not engage the cylindrical wall of its working space, but requires for effective pumping action an oil seal.

Each end of the eccentric 53 is beveled at its outer edge as shown at 58 in Figs. 3 and 11, to establish with the sleeve 53 an annular groove in which a radial groove 59 in each end of the eccentric is in communication. On each rotation of the eccentric 53 the radial groove 59 adjacent the center wall 16 receives oil from the bearing passageway 45 (see Figs. 3 and 8). This oil flows outwardly to the groove 58. Sealing oil may also flow through the running clearances between the eccentric and its sleeve to the opposite end of the sleeve where it is distributed in a similar manner to establish an oil seal at that end of the working space.

The second stage pump 27 is essentially similar to the first stage pump and, as best shown in Fig. 6, has its casing part 21 formed with an opening extending from end to end thereof. The opening affords a right circular cylindrical working space 60 axially aligned with the similar working space 46, an inlet chamber 61 with which the center wall port 36 communicates, and a seal 62, 63 for the guide blocks 75. The casing part 21 also encloses cavity 64 which, when the gasketed window 65 and frame part 66 are in place, serves as an oil reservoir for the second stage pump. The outlet 67 of this pump opens into the working space 60 adjacent to and through the lower part of the seat 63. The outlet 67 is controlled by a lightly loaded check valve (see Fig. 6) consisting of a facing element 68 and a valve block 69 freely guided by the bolts 70. Springs 71 tend to seat the valve. The window makes it possible to check the quantity and condition of the oil and the operation of the valve.

The pumping mechanism of the second stage pump includes an eccentric 72 keyed to the shaft 34 and rotatable in the sleeve 73. This has a hollow, open-ended, plate-like arm 74 extending into the inlet chamber 61 and slidably guided between the guide blocks 75. These are segments of the same cylinder as the seats 62 and 63. The arm 74 has a port 76 which is closed by one of the guide blocks 75 when the plunger 73 sweeps past the outlet 67. Like the corresponding parts of the first stage pump, the eccentric 72, the sleeve 73, the arm 74, and the guide blocks 75 are of the same length as the cylindrical working space 60 and at each end of the eccentric 72 are oil grooves identical to the

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grooves 58 and 59 of the first stage pumping mechanism.

The reservoir 64 has an outlet 77 provided with an oil trap, generally indicated at 78, which is employed to conserve oil and to prevent damage by the discharge of oil in the vicinity of the pump. I have shown the oil trap 78, in Fig. 1, as having a cylindrical body 79 through the center of the bottom of which extends an inlet pipe 80. The upper end of the pipe 80 extends a substantial distance above the bottom of the body 79 to provide a sump out of the path of gas flow. The pipe 80 has a lateral oil return port 81.

Above the upper end of the pipe 80 is a disc baffle 82 supported by brackets 83 while above the baffle 82 is an annular second baffle 84 of frustoconic section. This establishes a gutter which is slightly inclined to direct oil collecting therein towards the conduit 85, extending into the sump. The body 79 has outlets 86 adjacent its upper end overhung by a cap 87 having a downturned flange 88 spaced outwardly from the outlets 86. The cap 87 has a pendant annular baffle 89 located above the middle part of the baffle 84 so that oil dripping therefrom is caught and returned to the sump.

The shaft 34 extends through the head 19 which includes a hub 90 and is bored to receive the shaft supporting plain bearing-bushing 91. The hub 90 is counterbored to receive the ring 92 which carries a seal 93 of the toric type sealing against leakage between the ring 92 and the hub 90. A second counterbore 94 provides a chamber for the rotary shaft seal. The rotary shaft seal is shown as including a running ring 95 seated against the ring 92 and to which is attached the larger end of the corrugated resilient sleeve 96. At its outer end, the sleeve 96 is confined by a ring 97 connected to a sleeve compressing holder 98 which is under the influence of a spring 99. This spring is sustained by the cap 100 locked to the shaft 34 by the retainer 101. By these or equivalent means, leakage into the second stage pump 27 along the shaft 34 is prevented.

In order to return the sealing oil to the second stage pump 27 from its reservoir, there is provided a reservoir outlet port 102 which registers with a bore 103 in the head 19. The bore 103 intersects a passageway 104 opening into the bushing supporting bore in the head 19. The passageway 104 is sealed by a threaded plug whose head 105 is seated against a toric gasket 106. The plug carries a stem 107 restricting the flow of oil.

The bearing 91 has a beveled outer end 108 which defines with the seal ring 92 an annular groove. The beveled end 108 feeds a radial slot 109 which communicates with one end of a channel 110 extending from end to end of the bearing along its inner surface. The outer surface of the bushing 91 is provided with a longitudinal channel 111, slightly larger than the channel 110 and circumferentially displaced therefrom. By this construction, oil is fed into the second stage pump along both surfaces of the bushing 91, while oil is also supplied to lubricate the wear ring 95.

From the foregoing, it will be appreciated that the invention provides a novel center wall and a novel interstage shaft seal. These, when combined, solve the problems of interstage leakage and in addition make possible further improvements in the first stage pump. By the use of

a plain bearing-bushing in the center wall both as a shaft support and as part of the interstage seal and the oil supply system for the first stage pump, the usual bearing unit carried by the first stage head is eliminated. The elimination of the bearing unit in the first stage head results in an overhung construction, practicable when the first stage pump is of the type in which the plunger sweeps the cylinder without contact therewith. This is so because the load on such a pump is negligible. This simplifies the pump construction and eliminates an axial bearing pocket which, in prior constructions, had to be exhausted. Particularly in smaller pumps, this clearance volume had the effect of appreciably limiting their pumping speed.

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

1. A rotary two stage vacuum pump, comprising a housing enclosing two axially aligned cylindrical working spaces isolated from each other, said housing including a cast partition which isolates and forms the proximate end walls of said working spaces and includes within itself chambers formed in the operation of casting the partition and retaining the casting skin, said chambers being directly interposed between parallel machined surfaces which are the proximate end surfaces of said two working spaces, there being a central hub in said partition which is approximately surrounded by said chambers and is formed with a bore coaxial with both working spaces; a plain bearing-bushing sealed in the bore of said hub; a shaft rotatably mounted in said bushing and extending into said working spaces; and rotary displacing means arranged to be operated by said shaft, one in each of said working spaces; one of said chambers serving as an oil reservoir and said pump having oil delivery means in communication with said reservoir and including two independent passages, one communicating with the journal intermediate the ends of said bushing and the other opening into said first working space at the partition end thereof.

2. A rotary two stage vacuum pump, comprising a housing enclosing first and second axially aligned cylindrical working spaces isolated from each other, said housing including a cast partition which isolates and forms the proximate end walls of said working spaces and includes within itself chambers formed in the operation of casting the partition and retaining the casting skin, said chambers being directly interposed between parallel machined surfaces which are the proximate end surfaces of said two working spaces, there being a central hub in said partition which is approximately surrounded by said chambers and is formed with a bore coaxial with both working spaces; a plain bearing-bushing sealed in the bore of said hub; a shaft rotatably mounted in said bushing and extending into said working spaces; and rotary displacing means arranged to be operated by said shaft, one in each of said working spaces, one of said chambers serving as an oil reservoir, said hub having a passage effecting communication between said reservoir and said bearing-bushing intermediate its ends; and said bearing-bushing having two independent passages both disposed to be fed by said hub passage, one opening to the journal and the other extending lengthwise of said bearing-bushing and opening into said first working space.

3. A rotary two stage vacuum pump, compris-

ing a housing enclosing first and second axially aligned cylindrical working spaces isolated from each other and each having an inlet and an outlet, said housing including a cast partition which isolates and forms the proximate end walls of said working spaces and includes within itself chambers formed in the operation of casting the housing and retaining the casting skin, said chambers being directly interposed between parallel machined surfaces which are proximate end surfaces of said two working spaces, there being a central hub in said partition which is approximately surrounded by said chambers and is formed with a bore coaxial with both working spaces; a plain bearing-bushing sealed in the bore of said hub; a shaft rotatably mounted in said bushing and extending into said working spaces; and rotary displacing means arranged to be operated by said shaft, one in each of said working spaces, one of said chambers serving as an oil reservoir having a predetermined oil level, the outlet of the first working space and the inlet of the second working space opening into said reservoir above that level; and said hub having a passage effecting communication between said reservoir and said bearing-bushing.

4. A rotary two stage vacuum pump, comprising a housing enclosing first and second axially aligned cylindrical working spaces isolated from each other and each having an inlet and an outlet, said housing including a cast partition which isolates and forms the proximate end walls of said working spaces and includes within itself chambers formed in the operation of casting the partition and retaining the casting skin, said chambers being directly interposed between parallel machined surfaces which are the proximate end surfaces of said two working spaces, there being a central hub in said partition which is approximately surrounded by said chambers and is formed with a bore coaxial with both working spaces; a plain bearing-bushing sealed in the bore of said hub; a shaft rotatably mounted in said bushing and extending into said working spaces; and rotary displacing means arranged to be operated by said shaft, one in each of said working spaces, one of said chambers serving as an oil reservoir having a predetermined oil level, the outlet of the first working space and the inlet of the second working space opening into said reservoir above that level so that oil therein is de-gassed by the operation of the rotary displacing means in said second working space; said hub having a passage effecting communication between said reservoir and said bearing-bushing having two independent passages both disposed to be fed by said hub passage, one opening to the journal and the other extending lengthwise of said bearing-bushing and opening into said first working space to deliver de-gassed oil thereto.

5. A rotary two stage vacuum pump, comprising a housing enclosing two axially aligned right cylindrical working spaces isolated from each other, said housing including a cast, plate-like member which isolates and forms the proximate end walls of said working spaces, and includes within itself chambers formed in the operation of casting the plate-like member and retaining the casting skin, said chambers being directly interposed between said working spaces and between parallel machined surfaces which are formed on opposite faces of the plate-like member and serve as mounting seats and as said proximate end walls, said plate-like member in-

cluding a central hub approximately surrounded by said chambers and formed with a bore coaxial with both working spaces, said housing further including enclosing means, one for each of said working spaces, pump assembly bolts extending through each such enclosing means and into the shell wall which the chambers establish to seal each enclosing means and each sealed to a respective one of said mounting seats; a shaft extending through said hub bore and into said working spaces; and rotary displacing means arranged to be operated by said shaft, one in each of said working spaces.

6. A rotary two stage vacuum pump, comprising a housing enclosing first and second axially aligned right cylindrical working spaces isolated from each other and each having an inlet and an outlet, said housing including a cast partition which isolates and forms the proximate end walls of said working spaces, and includes within itself chambers formed in the operation of casting the partition and retaining the casting skin, said chambers being directly interposed between said working spaces and between parallel machined surfaces which are the proximate end walls of said working spaces, one of said chambers serving as an oil reservoir open to the outlet of said first working space and the inlet of said second working space, said partition including a central hub approximately surrounded by said chambers and formed with a bore coaxial with both working spaces, said housing further including enclosing means, one for each of said working spaces, the enclosing means for the second working space having a bore coaxial with said hub bore, a bearing in each of said bores, the bearing in said bore being a plain hub bearing-bushing sealed therein and extending from end to end thereof; said hub having a passage effecting communication between said reservoir and an intermediate part of said bearing-bushing and said bearing-bushing having a passage fed by said hub passage and opening into said first work-

ing space; a shaft rotatably mounted in said bearings and extending through the second and into the first working space; and rotary displacing means arranged to be operated by said shaft, one in each of said working spaces, whereby the rotary displacing means in the first working space is overhung as to the shaft bearings.

7. A rotary two stage vacuum pump comprising a housing enclosing first and second axially aligned, cylindrical working spaces isolated from each other, each working space having an inlet and an outlet, said housing including a partition which isolates said working spaces and has opposite machined faces which are the proximate end boundary surfaces of the working spaces and includes within itself chambers isolated from each other and directly interposed between said machined faces and establishing end walls and a hub having a bore coaxial with both working spaces; a shaft extending through said hub bore and into said working spaces; and rotary displacing means arranged to be operated by said shaft, one in each working space; one such chamber constituting an oil reservoir and having two ports adjacent its upper end, one opening through each end wall, one such port constituting a part of the outlet of the first stage and the other port constituting a part of the second stage inlet, said chambers and said ports being formed in the operation of casting the partition and including the casting skin, said pump having oil delivery means in communication with said reservoir and the first stage working space at the partition end thereof.

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