Dec. 13, 1932. J. DUBROVIN 1,890,573

VACUUM PUMP

Filed Dec. 5, 1929 3 Sheets-Sheet 1

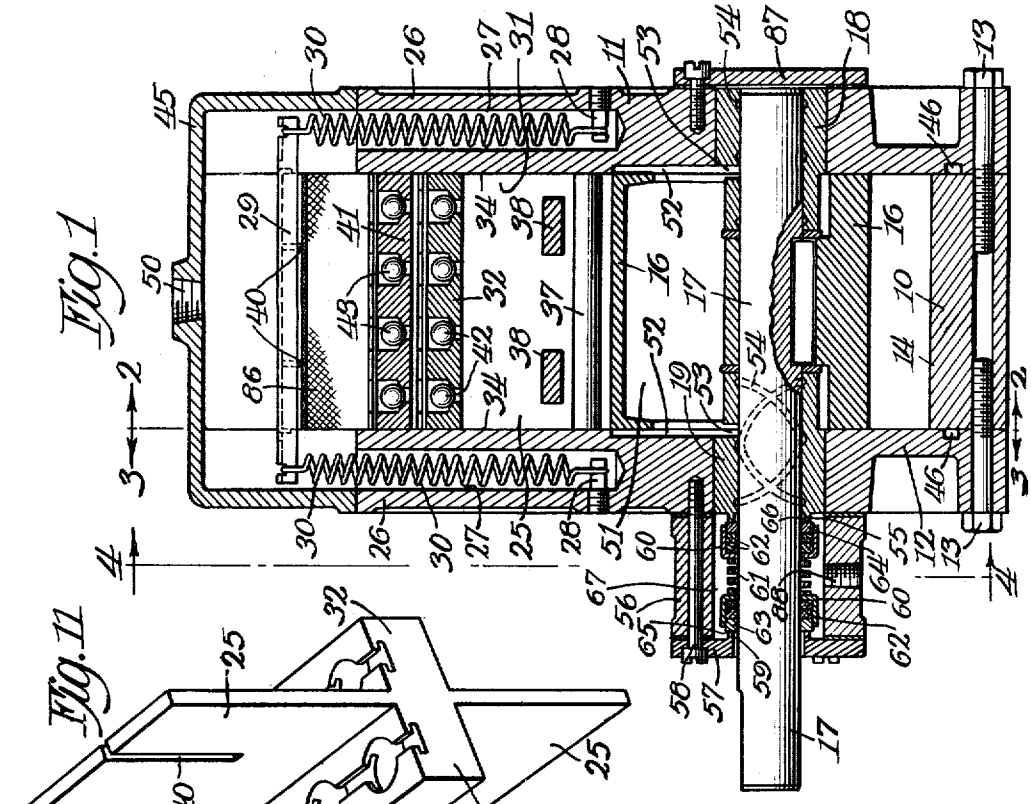


Fig. 1

Fig. 11

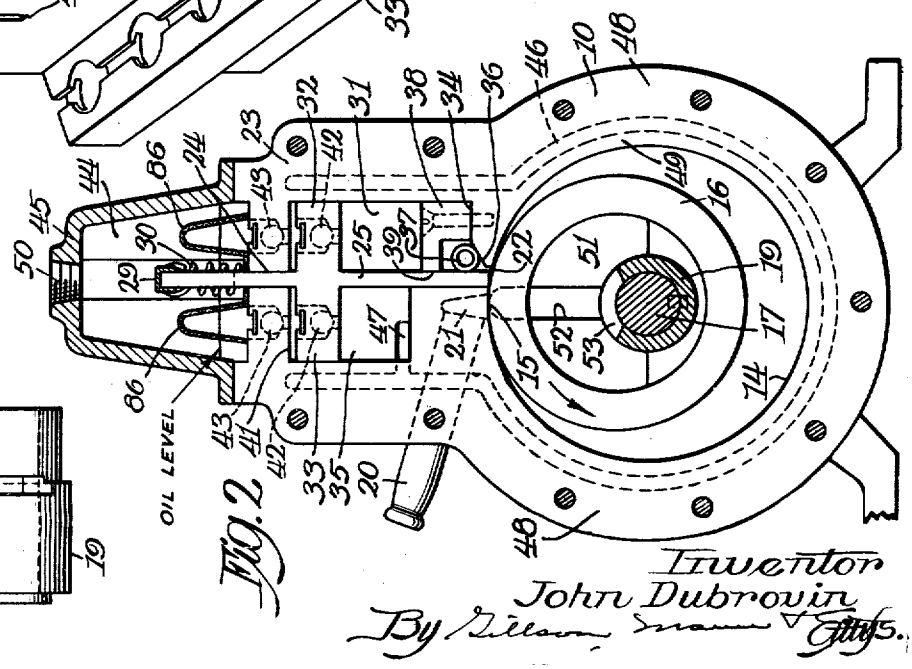


Fig. 2

Fig. 10

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Dec. 13, 1932. J. DUBROVIN 1,890,573

VACUUM PUMP

Filed Dec. 5, 1929 3 Sheets-Sheet 2

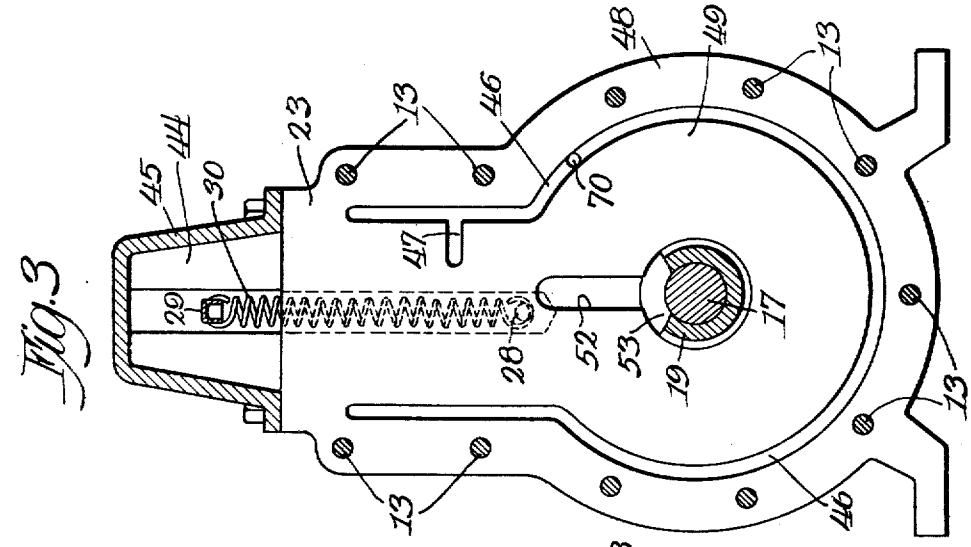


Fig. 3

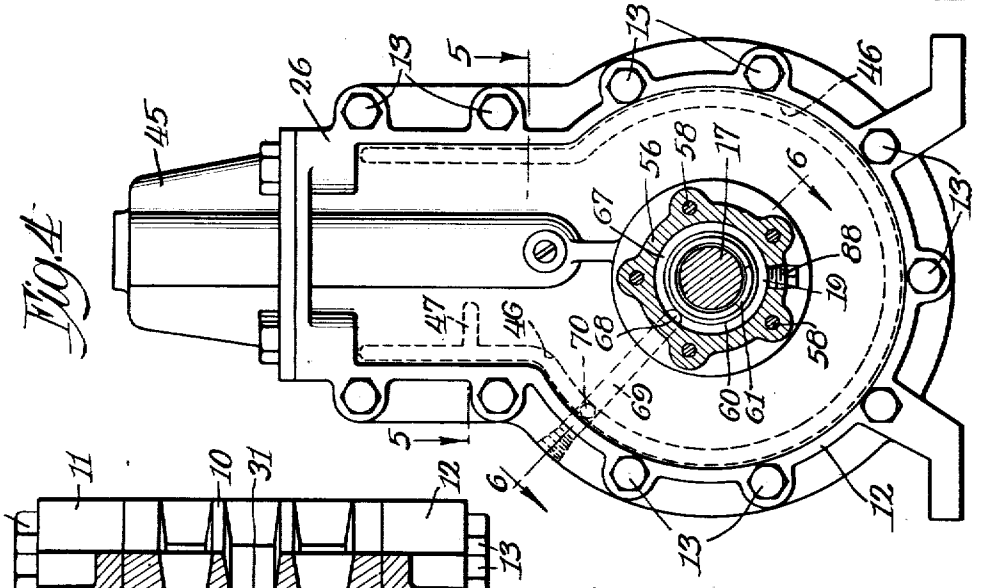


Fig. 4

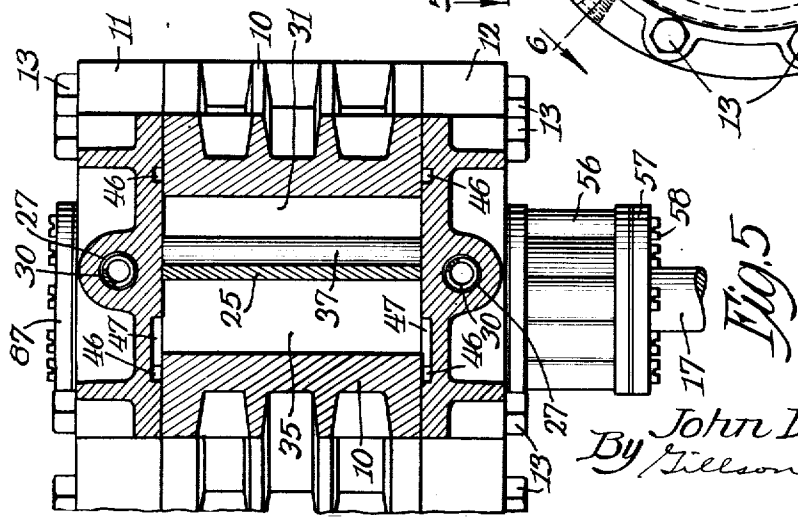


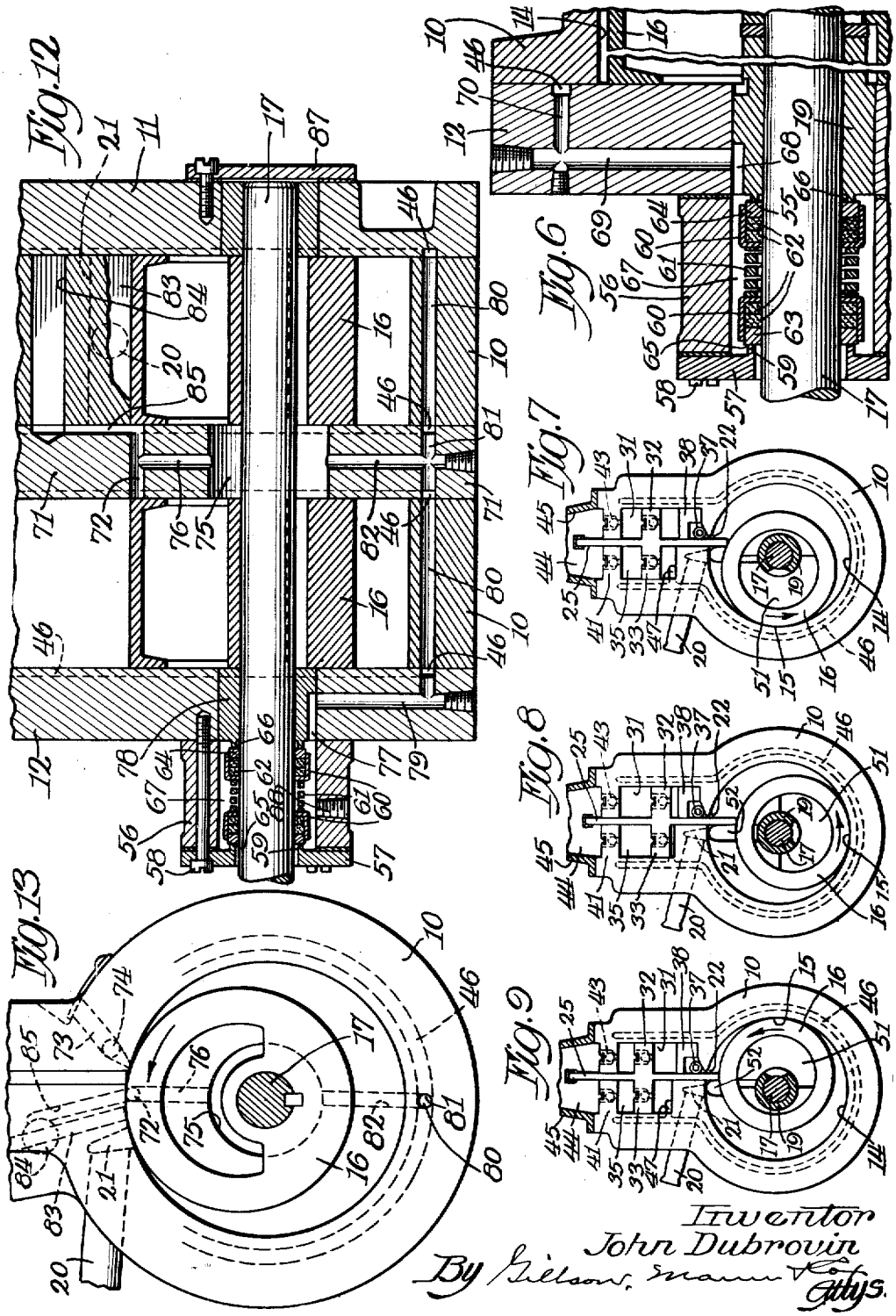
Fig. 5

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Dec. 13, 1932. J. DUBROVIN 1,890,573

VACUUM PUMP

Filed Dec. 5, 1929 3 Sheets-Sheet 3



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Patented Dec. 13, 1932 1,890,573

UNITED STATES PATENT OFFICE

JOHN DUBROVIN, OF CHICAGO, ILLINOIS, ASSIGNOR TO CENTRAL SCIENTIFIC COMPANY, A CORPORATION OF ILLINOIS

VACUUM PUMP

Application filed December 5, 1929. Serial No. 411,755.

This invention relates to pumps, and particularly to those eccentric pumps commonly used for producing high vacua. This application is a companion to my application Serial No. 411,754 filed December 5, 1929 for improvement in pumps.

In my Patent No. 1,385,101 I disclosed a rotary pump which produced a lower vacuum in the same time than had hitherto been possible. I later discovered that the limit of vacuum which it would produce was not set by the vapor pressure of the oil (the theoretical limit of the pump) but by the fact that gases dissolved and adsorbed in the oil were given up in the high vacuum chamber.

In my application Serial No. 411,754, I disclosed means to prevent gassy and polluted oils from reaching the high vacuum chamber and in the application described a pump which produces vacua at least six times lower than those produced by my prior design.

For a long time it has been customary to operate vacuum pumps immersed in a tank of oil which acts as the sealing liquid. The exhaust valve of the pumps are under the oil so that the discharge passes through it to reach the atmosphere. All parts of any such pump are reached, lubricated and sealed by the oil which is driven down the smallest mechanical clearances by the pressure differential between the surface of the oil and the inside of the pump. To immerse such a pump necessarily requires a large volume of oil, nearly all of which ultimately is circulated through it, and all of which must be quite thoroughly outgassed before low pressures are attainable.

A further difficulty associated with immersed pumps is one of speed. The specific heat of oil is so low that a pump in a tank of oil must be rigidly limited in revolutions per minute to guard against liberating too much mechanical energy and overheating the oil.

The primary object of my invention is to produce a pump having a better performance and producing lower pressures; and my incidental objects thereto are to eliminate the oil tank; construct the pump casing to protect it against ingress of gases; reduce the volume of oil necessary for sealing and lubrication to the lowest possible limit; to expose the entire outer surface of the casing directly to the atmosphere to the end that the pump will run cooler at higher speeds; and to provide means for continuously outgassing the sealing medium.

Further objects and advantages of the invention will be revealed as the disclosure proceeds and the description is read in connection with the accompanying drawings, in which

Fig. 1 is a longitudinal vertical section through a preferred embodiment of the invention in an eccentric vacuum pump;

Figs. 2 and 3 are sections taken on the line 2—2 of Fig. 1, Fig. 2 looking to the right and Fig. 3 looking to the left;

Fig. 4 is a section taken on the line 4—4 of Fig. 1, looking to the right;

Fig. 5 is a transverse section taken on the line 5—5 of Fig. 4;

Fig. 6 is a fragmentary sectional view taken on the line 6—6 of Fig. 4;

Figs. 7, 8 and 9 are reduced diagrammatic views similar to Fig. 2, and illustrating successive stages in the operation of the pump; and

Fig. 10 is a detail showing of the bushing 19 illustrating the sealing channels and gas passages therein; Fig. 11 is a detail perspective view of the blade 25 showing the pistons.

Fig. 12 is a section similar to Fig. 1, illustrating an application of the invention to a two stage eccentric pump.

Fig. 13 is a vertical partial section of the pump looking towards the right in Fig. 12 from behind the cover plate.

These specific illustrations and the correspondingly specific description are used for the purpose of disclosure only to illustrate the application of the invention, and in seeking the true scope thereof regard should be given to the substance of the improvements and not to the particular forms in which they are here embodied.

In that form shown in Figs. 1 to 11, the pump casing includes a ring or cylinder block 10, and two plates or heads 11 and 12 clamped to the opposite sides thereof by bolts 13 pass-

ing through suitable perforations in the plates and in thickened portions on the ring. The inner surface 14 of the ring 10 is cylindrical for cooperation with a zone or area 15 on an eccentric rotor 16, mounted on a shaft 17 passing through the plates or heads 11 and 12, and journaled in bushings 18 and 19 mounted therein. The intake port is provided by a pipe 20 (Fig. 2), threaded into the ring 10 and communicating with a groove 21 in its inner periphery; and the exhaust port is made at 22 through the periphery of the ring 10 at a little distance from the groove 21.

The ring 10 is provided with a lateral extension 23, which is slotted at 24 (Fig. 2) to receive a valve or blade 25, the inner end of which constantly engages the periphery of the rotor 16 and divides the intake from the exhaust. The plates 11 and 12 have similar extensions 26 which cooperate with the edges of the valve.

The extensions 26 are provided with spring bores 27, equipped with pins 28 near the bottom between which and a yoke 29 on top of the blade or valve 25 are stretched helical tension springs 30, which serve to urge the valve or blade into contact with the periphery of the rotor. As shown, the springs are arranged to act substantially parallel to the direction of movement of the blade, whereby friction and binding is reduced to a minimum.

Many pumps of this general type in common use include two eccentric units, but in the form illustrated in Figs. 1 to 9 of this application one of the eccentric units is replaced by a much cheaper pumping unit operated by the valve or blade, or whatever mechanical movement is used to separate the intake and exhaust of the eccentric unit, somewhat after the manner illustrated in my application Serial No. 311,733, filed October 11, 1928.

The eccentric unit, in this instance, will for convenience be referred to as the finishing stage, and the other unit will be referred to as the roughing stage.

As shown in Fig. 2, the slot 24 for the blade 25 is enlarged laterally in its intermediate portion to form, with the companion walls of the plates 11 and 12, chambers 31 and 35 which, for convenience, may be called cylinders, and the blade 25 is equipped with intermediately located projections 32, 33, which for the same reason may be called pistons, and which, of course, are fitted to the walls of the corresponding cylinders.

The bottom wall 34 of the cylinder 31 is inclined at 36, where it approaches the exhaust port 22, and communication through this port is controlled by a check-valve consisting of a cylinder 37, having its periphery cooperating with the adjacent surfaces of the blade or valve 25, and the inclined portion 36 of the bottom 34, and also having its ends bearing against the inner surfaces of the plates 11 and 12. The cylinder 37 is confined within suitable limits by L-shaped blocks 38, secured to the bottom 34, and the left edges 39 of these blocks serve as auxiliary supports for the lower end of the blade 25.

The pistons 32 and 33 are equipped with a plurality of ball chack-valves 42 of familiar construction.

No inlet passage for the oil is shown. It exists in fact, however, in the mechanical clearance between the piston and the cylinder wall and between the blade and the casing. The pressure differential (almost the total atmospheric pressure) between the exhausted space and the exposed surface of the oil is sufficient to drive the oil through the most minute clearances with the single exception, however, that no pressure differential exists between the atmosphere at the top of the pistons 32 and 33, and the atmosphere above the oil. With no differential the valves 43, 43 are effective oil seals, and the oil must be admitted below the valve by the following expedient. The upper portion of the valve 25 is provided with slots 40, which on the down-stroke are exposed about one-eighth of an inch below the top wall 41 of the cylinders 31 and 35, whereby a small amount of oil is supplied to the cylinders at each stroke.

The operation of the eccentric or finishing stage is familiar, and is illustrated in Figs. 2, 7, 8 and 9, which show the parts in four successive positions in the cycle of operations. As the rotor turns counter-clockwise from the position shown in Fig. 2, air or other material in the pump chamber is forced through the exhaust port 22. At the same time suction through the intake port 20 is created and constantly increased on the opposite side of the blade 25. As the parts pass through the successive positions shown in these figures, the contents of the pump chamber of the finishing stage are delivered through the exhaust port 22 into the cylinder 31, and a new charge is drawn into the pump through the intake port 20.

As the rotor moves successively from the position shown in Fig. 2 through that shown in Fig. 7, to that shown in Fig. 8, the blade 25, with its piston 32, descends and the air forced from the finishing stage through the exhaust 22 passes the check-valves 42, except a small portion remaining above the blocks 38 in the position shown in Fig. 8.

As the rotor moves from the position shown in that figure through that shown in Fig. 9 to that shown in Fig. 2, the charge in the cylinder 31 is discharged, through check-valves 43 in the head 41, into a chamber 44 formed by securing the oil cap 45 to the top of the pump casing.

With the proportions of the parts shown the volume delivered by the eccentric or finishing stage, when the vessel to be exhausted

is near atmospheric pressure, will be in excess of the volumetric capacity of the cylinder 31 at the same pressure, and for that reason air will be forced past the check-valves 42 and 43 throughout the greater part of the rotor's revolution; but as the pressure in the vessel to be exhausted is decreased the condition changes, and at length the cylinder 31 will be able to take the exhaust of the eccentric or finishing stage between the positions shown in Figs. 2, 7 and 8, during which time the piston 32 will exhaust from the cylinder 31 the previous charge. Later, as the rotor moves between the positions shown in Fig. 8 to Fig. 2, the exhaust from the finishing stage will pass the valves 37 and 42 in almost equal amounts.

The oil bath illustrated in my prior application No. 311,733 is eliminated in the embodiment shown in this application. The inner faces of the plates or heads 11 and 12 are provided with grooves 46 (Fig. 2), which almost entirely surround the several pump chambers, and are provided with lateral extensions 47 which communicate with the cylinder 35. The area outside of the groove 46, and generally indicated in Fig. 2 by the reference numeral 48, is treated with shellac or other gasket cement, but the area on the opposite side of the groove 46, and generally indicated by 49, is not so treated.

The grooves 46 are filled with oil, and this may be easily accomplished by supplying a suitable amount of oil to the chamber 44 through the opening 50 in the cap 45, whence it will descend through the check valves and enter the grooves 46, after which the oil should be at about the level indicated in Fig. 2.

During the operation of the pump described above the piston 33 will reciprocate in the cylinder 35 and pump air or other volatiles out through the head 41 into the oil chamber 44. This will have the effect of applying a partial vacuum to the area represented by the groove 46, and will result in the extraction from the oil of all absorbed air and volatiles. It also results in reducing the pressure differential between the area represented by the grooves 46 and the interior of the pump chambers. Any fluids passing through the area 48 along the joints to the oil grooves are thus removed, and there is but slight tendency for the oil in the grooves 46 to seep into the pump chambers; and such oil as does so seep has already been relieved of any volatiles that would seriously interfere with the speed or efficiency of the finishing and roughing stages of the pump.

The rotor 16 is hollowed out at 51 to produce balance and prevent vibration, and the inner faces of the plates 11 and 12 are provided with grooves 52 to connect the hollow of the rotor with the chamber of the finishing stage, thereby adding the volume of the hollow to the system to be exhausted and permitting the pump to reduce the pressure in the whole system with substantial uniformity.

Incidentally the walls of the grooves 52 also serve to scrape lubricant from the sides of the rotor and deliver it, through the openings 53 in the bushings 18 and 19, to the shaft 17 along which it is fed through the grooves 54.

The bushing 19 (Fig. 1) terminates at the left in a narrow annular ring 55. The plate 12 is equipped with a ring 56 and a soft metal disc 57 secured in place by bolts 58. The disc 57 has a narrow annular flange 59, similar to and facing the flange 55. Between these flanges are two cupped rings 60, urged apart by springs 61 and containing yielding washers 62. The left cup, 60, is also equipped with a hardened steel ring 63, yieldingly supported on the shaft by the rubber washers 62 and urged against the annular flange 59. The cupped ring on the right has a similar hardened steel ring 64, also yieldingly held to the shaft and urged against the flange 55.

The net effect of this structure is to provide a sealing contact or stuffing box at 65, between the shaft and the disc 57, and therefore the casing, and another sealing contact at 66 between the shaft and the flange 55.

Between these two sealing contacts is an air space or chamber 67 surrounding the shaft.

By providing a passage between this chamber and the cylinder 35, a partial vacuum is maintained therein, and hence the pressure differential across the contact 66 is materially reduced. This is accomplished, in the present embodiment as best shown in Fig. 6, by providing the bushing 19 with a longitudinal slot 68, which communicates with a bore 69 inclining upward and outward in the plate 12, and in turn communicating with an inwardly directed bore 70 which communicates with the groove 46, and therefore with the chamber 35.

Figs. 12 and 13 illustrate a two stage eccentric pump, in some respects like the pump illustrated in Figs. 1 to 9 and in other respects like the pump illustrated in my companion application above referred to. As far as possible the corresponding parts are marked with the same numerals as used in Figs. 1 to 9.

There are two cylinder rings 10, and two eccentric rotors 16 separated by an intermediate plate 71.

The intake to the finishing stage consists of the pipe 20 and the groove 21, as shown in Fig. 2, but the exhaust of the finishing stage and the intake of the roughing stage consist of a passage 72 drilled through the intermediate plate 71. The exhaust of the roughing stage is made by drilling the correspond-

ing ring 10 at 73 and fitting it with suitable valves 74.

The hollows of the two eccentrics are connected by a bore 75 in the intermediate plate, which in turn is connected with the passage 72 by the passage 76.

The chamber 67 is connected with the bore 75, and therefore with the intake of the roughing stage, by a groove 77 in the bushing 78, a passage 79 in the plate 12, a passage 80 in the left ring 10, and passages 81 and 82 in the intermediate plate 71. The grooves 46 in the faces of the several plates are connected with the passage 82 by the passages 80 and 81.

The blade or valve 83 of the finishing stage is surrounded by a groove 84, as in the companion application referred to, and this groove is connected with the passage 72 by a groove 85 in the corresponding wall of the intermediate plate 71. The pump is sealed by the cover plate 87 held to the head 11 by cap screws, as shown. A clean out plug is screwed into the tapped hole 88 in the ring 56. Both the plate 87 and the plug are forced home after being coated with a special cement.

From this description it will be obvious that the oil bath is omitted, and the various sealing surfaces are connected with the intake of the roughing stage whereby oil in them is subjected to a partial vacuum and any fluid entering them from the outside is intercepted before it reaches the finishing stage, and therefore before it can interfere with the efficiency of the pump. Although it is not shown in detail in Figs. 12 and 13, for lack of space, it will be obvious that the top of the pump is fitted with an oil cap 45, similar to that shown in Fig. 2.

In each of the several forms illustrated in this and the companion application, the joints along the intermediate area are subjected to a partial vacuum by means of which air seeping in or absorbed in the oil, and all fractions of the oil which are volatile at the temperature and pressure existing in the partial vacuum, are removed, together with any excess of oils. And the pressure differential between this partial vacuum and the pump chamber being relatively small, a small amount of seepage through the remaining area of the joint into the pump chamber is insufficient to seriously interfere with the efficiency of the pump.

I claim as my invention—

1. A vacuum pump comprising, in combination, a casing provided with a pump chamber and including two structurally separate parts having contacting surfaces where they join, one of the contacting surfaces having a groove between the pump chamber and the exterior of the casing, a sealing liquid filling the groove, an eccentric rotor in the pump chamber, a reciprocating valve in the casing and cooperating with the rotor, and a second pump operated by said valve and connected with the groove to reduce the gaseous content of the sealing liquid.

2. A vacuum pump comprising, in combination, a casing providing a pump chamber with inlet and outlet ports and including two structurally separate parts having contacting surfaces where they join, one of the surfaces having a groove between the pump chamber and the exterior of the casing, a sealing liquid filling the groove, an eccentric rotor in the chamber, a blade projecting into the chamber and cooperating with the rotor, and two additional pumps operated by the blade one connected with the exhaust port of the main pump and the other connected with the groove for outgassing said sealing fluid.

3. In a vacuum pump comprising, in combination, a casing provided with a pump chamber and including two structurally separate parts having contacting surfaces where they join, one of the contacting surfaces having a groove between the pump chamber and the exterior of the casing, a sealing liquid filling the groove, and suction means connected with the groove and removing air adsorbed by said liquid.

4. In a vacuum pump comprising, in combination, a casing providing a pump chamber with inlet and outlet ports and including two structurally separate parts having contacting surfaces where they join, one of the surfaces having a groove between the pump chamber and the exterior of the casing, a sealing liquid in said groove, piston means cooperating with the chamber, and a second pump having an inlet port connected with the groove whereby the liquid will be outgassed and fluid entering the joint between the separate parts of the casing is intercepted and removed by the second pump.

5. In a vacuum pump exposed directly to the atmosphere, having a casing made of joined parts, and a high vacuum cylinder within the casing, that method of protecting the high vacuum cylinder from the ingress of gas which consists in forming channels in the contacting faces of the joined parts, continuously filling the channels with a liquid having a vapor-pressure below that attainable with the pump and continuously subjecting the liquid within the channels to a high vacuum during the operation of the vacuum pump for outgassing said liquid.

6. A liquid sealed vacuum pump comprising a casing made of joined parts having channels in the contacting surfaces where they join, a liquid having a vapor pressure below the pressure which can be produced by the pump filling the channels and forming simultaneously the sealing and lubricating means, a high vacuum pumping element and a second vacuum pumping element within the casing, the intake of the second element being connected to the channels for outgassing

the sealing liquid and for removing the entrained polluting substances therefrom during the operation of the pump.

7. A liquid sealed vacuum pump having a casing directly exposed to the atmosphere, means for sealing the casing comprising a low vapor-pressure liquid occupying channels formed in the casing, a vacuum cylinder within the casing having inlet and exhaust ports thereto, and a second vacuum pump acting upon the sealing liquid for removing adsorbed and dissolved gases therefrom.

8. A liquid sealed vacuum pump having a casing made of joined parts, and having channels in the mating surfaces where they join, an oil reservoir within said casing, a piston chamber within said casing, a piston for said chamber, said chamber being supplied with oil from said reservoir, means for sealing the casing comprising a liquid in the channels and means to remove the adsorbed air and dissolved gases in the liquid supplied to said chamber and to said grooves.

9. A vacuum pump comprising, in combination, a casing having a pump chamber therein, a rotary piston for said chamber, intake and exhaust ports for said casing, a shaft member for said piston, bearing members for said shaft members, certain of said members having grooves therein for containing a lubricant, a reciprocating blade for engaging said rotary piston, a pump chamber at each side of said blade, a piston on said blade at each side thereof for said last named chambers, one of said chambers being in communication with said first named pump chamber for receiving gas discharged therefrom and discharging the same into the air, and the other in communication with said grooves for lowering the pressure therein and for outgassing the lubricant contained therein.

In testimony whereof I affix my signature.

JOHN DUBROVIN.

CERTIFICATE OF CORRECTION.

Patent No. 1,890,573. December 13, 1932.

JOHN DUBROVIN.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, lines 83 and 93, claims 3 and 4, respectively, for "In a" read "A"; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 21st day of February, A. D. 1933.

(Seal)

M. J. Moore,
Acting Commissioner of Patents.

the sealing liquid and for removing the entrained polluting substances therefrom during the operation of the pump.

7. A liquid sealed vacuum pump having a casing directly exposed to the atmosphere, means for sealing the casing comprising a low vapor-pressure liquid occupying channels formed in the casing, a vacuum cylinder within the casing having inlet and exhaust ports thereto, and a second vacuum pump acting upon the sealing liquid for removing adsorbed and dissolved gases therefrom.

8. A liquid sealed vacuum pump having a casing made of joined parts, and having channels in the mating surfaces where they join, an oil reservoir within said casing, a piston chamber within said casing, a piston for said chamber, said chamber being supplied with oil from said reservoir, means for sealing the casing comprising a liquid in the channels and means to remove the adsorbed air and dissolved gases in the liquid supplied to said chamber and to said grooves.

9. A vacuum pump comprising, in combination, a casing having a pump chamber therein, a rotary piston for said chamber, intake and exhaust ports for said casing, a shaft member for said piston, bearing members for said shaft members, certain of said members having grooves therein for containing a lubricant, a reciprocating blade for engaging said rotary piston, a pump chamber at each side of said blade, a piston on said blade at each side thereof for said last named chambers, one of said chambers being in communication with said first named pump chamber for receiving gas discharged therefrom and discharging the same into the air, and the other in communication with said grooves for lowering the pressure therein and for outgassing the lubricant contained therein.

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