Nov. 19, 1963 | R. BRYMNER | 3,111,260

ROTARY PUMPS

Filed July 3, 1961 | 4 Sheets-Sheet 1

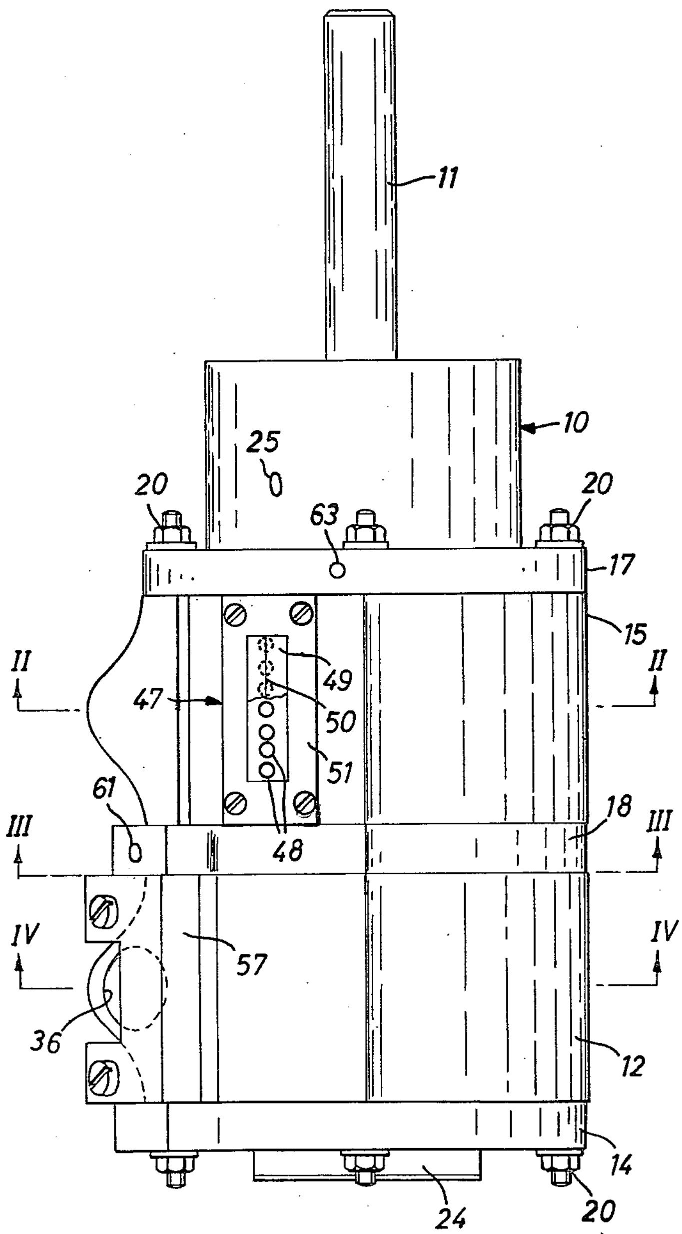

FIG. 1

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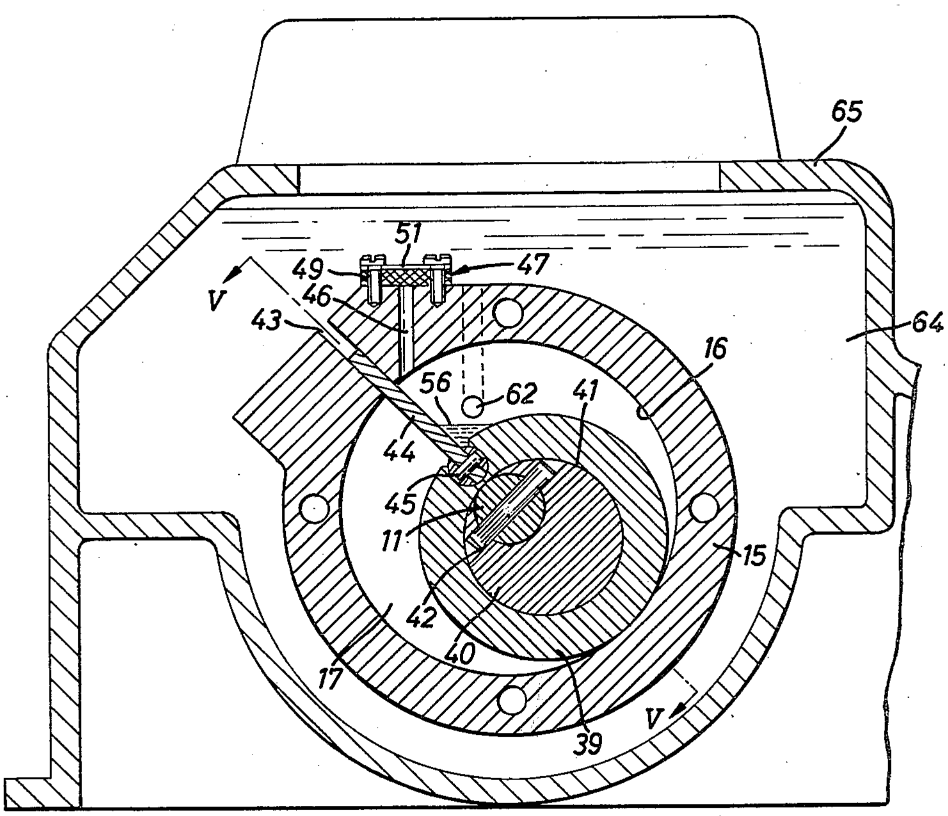

FIG. 2

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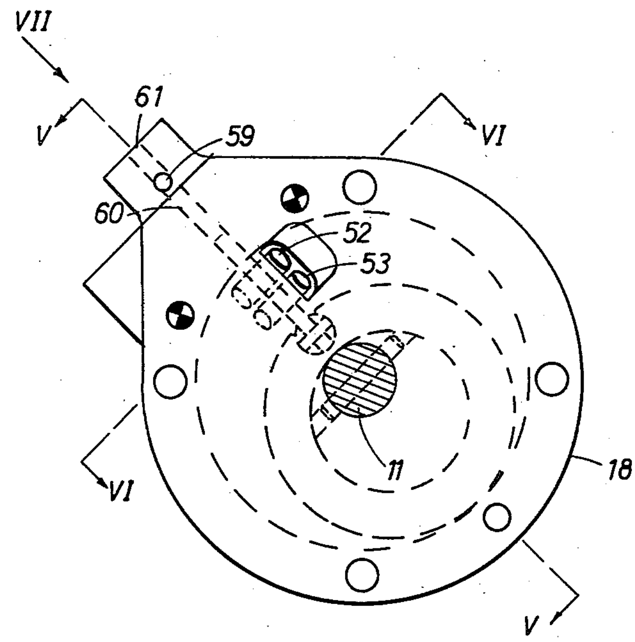

FIG. 3.

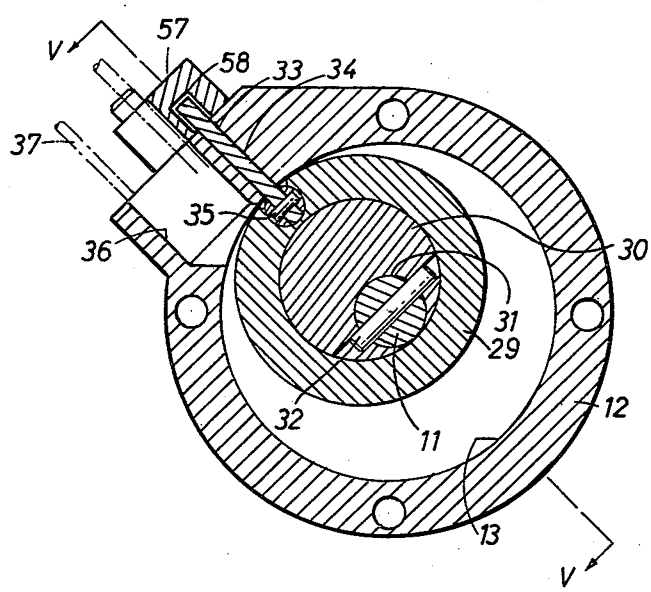

FIG. 4.

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ROTARY PUMPS

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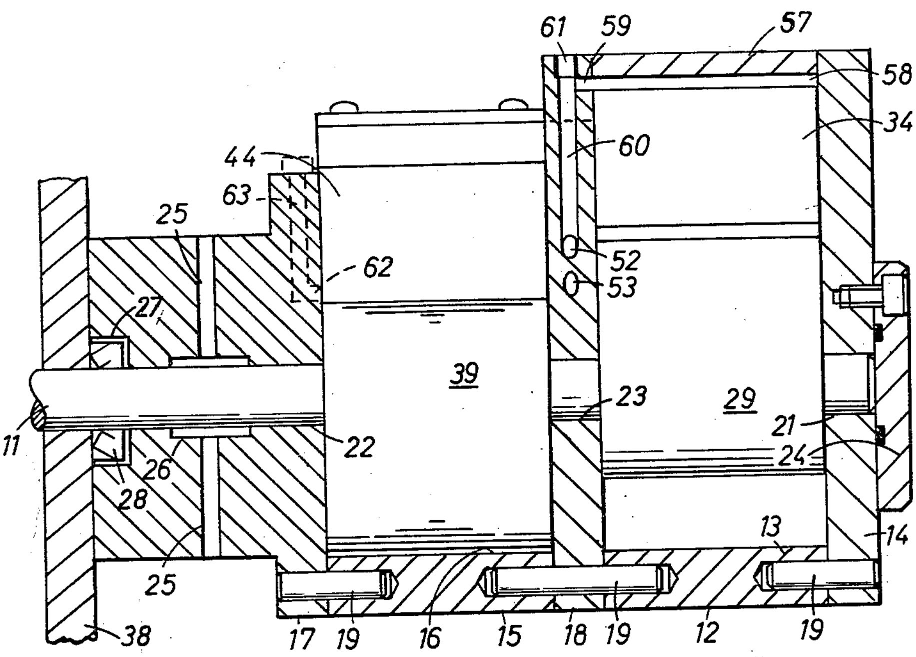

FIG. 5.

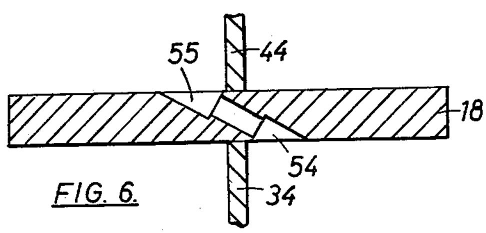

FIG. 6.

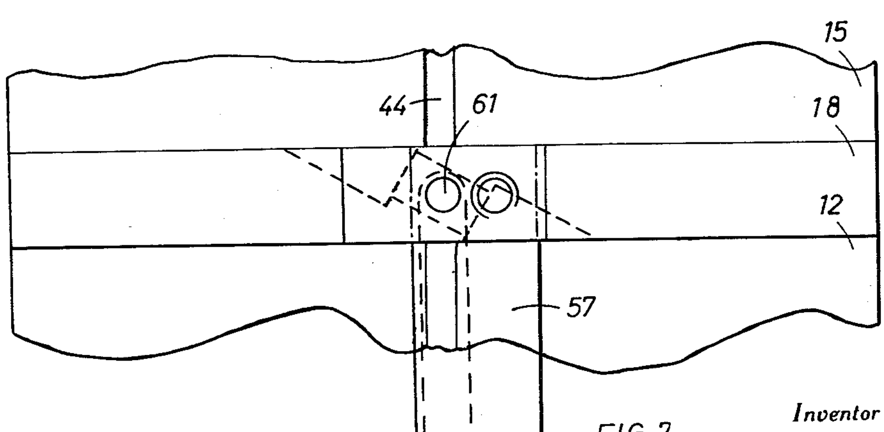

FIG. 7.

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ROTARY PUMPS

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8 Claims. (Cl. 230—147)

The present invention relates to rotary vacuum pumps and is more particularly concerned with multi-stage vacuum pumps.

With a view to achieving high vacuum, that is to say low pressures, it is well known to arrange two rotary vacuum pumps in series, conveniently with a common driving shaft and disposed in a common oil bath. A vessel to be evacuated is connected to an inlet of a first or fine stage pump, the outlet of which is connected to an inlet of a second or roughing stage pump, the outlet of which discharges, usually into the oil bath, through a non-return valve. The two stages are customarily interconnected by pipework often including two short vertical stubs interconnected by a generally horizontal section. Such pipework often is expensive.

According to one feature of the present invention two single stage rotary vacuum pumps are arranged coaxially back-to-back in abutment with an intermediate or transfer plate in which is provided a transfer passage for interconnecting an outlet port of one of said pumps to an inlet port of the other and have a common drive shaft.

The present invention envisages providing a transfer port system in a transfer plate between two opposed cylindrically bored casings each containing a displacer rotatably mounted on an eccentric driving member within the casing bore and pivotally connected to a vane slidable in a slot in the casing wall, one of the casings and its associated displacer and vane serving as first or fine stage and being provided with an inlet port, and the second casing and its associated displacer and vane serving as second or roughing stage and being provided with an outlet port leading to a non-return or lift delivery valve. The transfer port system provides an outlet port for the first stage communicating with an inlet port for the second stage and the ports can be opened and closed by the rotation of the displacers in the casing bores.

The invention is not limited to a two stage pump but it is envisaged that three or more stages can be provided with a transfer plate disposed between adjacent cylindrically bored casings.

According to another feature of the present invention a multi-stage rotary vacuum pump comprises first and second cylindrically bored casings each closed at one end and both disposed with their cylindrical bores substantially coaxial about a horizontal axis and with their open end facing one another and in abutment with a transfer plate, each of said casings containing a displacer rotatably mounted on an eccentrically disposed driving element carried by a drive shaft substantially coaxial with the bore of the casing, which displacer is dimensioned to make a sliding fit within the casing as it is carried round therein by the driving element, and each having a vane pivoted to the displacer and extending therefrom towards the outside of the casing through a substantially radial slot in the peripheral wall of the casing, an inlet port communicating with the inside of the first casing at one side of and adjacent a plane containing the vane in said first casing, a transfer passage in the transfer plate communicating with the inside of the said first casing at the other side of and adjacent said plane containing the vane in said first casing, and with the inside of the second casing at one side of and adjacent a plane containing the vane in the said second casing, and an outlet port communicating with the inside of the second casing at the other side of and adjacent said plane containing the vane in the said second casing.

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As they are rotated when the pump is in operation, the displacers in the first and second casings provide valving action for the transfer passage since each displacer alternately covers and uncovers a port in the face of the transfer plate over which it moves, such port communicating with the transfer passage. One displacer covers and uncovers the port in the face of the transfer plate communicating with the inside of the first casing and which serves as outlet port for that casing, whilst the other displacer covers and uncovers the port in the other face of the transfer plate communicating with the inside of the second casing and which serves as inlet port for that casing. By angularly displacing the displacers relatively to one another relatively to the drive shaft, that is to say by proper phasing of the displacers, the ports can be uncovered and covered in appropriate timed relationship to provide valving action.

A rotary vacuum pump according to the present invention is preferably operated in an oil bath, with the delivery valve preferably below the oil level, and it is necessary for the vane to be well lubricated. If the slot in a casing in which a vane slides is open-ended and below the oil level in the bath, the vacuum created in the casing when the pump is in operation tends to suck oil along the faces of the vane, thus lubricating the vane and also providing an oil seal between the vane and the slot. Some oil, therefore, will be sucked into the casing.

Preferably at least the slot in the second casing through which the vane extends is inclined upwardly outwardly so as to form a pocket for oil at the junction of the upper face of the vane with the displacer. With the outlet port in close proximity to the vane any pocket of oil so formed can be forced upwards through the outlet port at each rotation of the displacer so as to fill most or all of the volume of the port and so reduce the effective clearance volume of the stage at discharge.

In order to prevent oil being sucked along the faces of the vane into the first casing which serves as first or fine stage, the slot in the first casing is preferably sealed at the outside of the casing and is vented to the inlet port of the second casing, conveniently by a passage communicating with the transfer passage. Oil drawn into the second casing, being in contact with a vacuum, tends to be "degassed" and some of the degassed oil leaks past the displacer and along the shaft into the first casing. Thus the lubrication of the first cylindrical casing is achieved with "degassed" oil from the second stage. If too much oil leaks into the first stage it will be discharged to the second stage through the transfer port system.

In a preferred arrangement the slot in the first casing through which the vane associated with that casing extends is also inclined upwardly outwardly, and thus according to a further feature of the present invention a multi-stage rotary vacuum pump comprises first and second coaxial cylindrical casings each closed at one end and both disposed with their open ends facing one another and in abutment with a transfer plate, the axis of the casings being substantially horizontal, a common drive shaft extending substanitally coaxially within said casings, each of said casings containing a displacer which is rotatably mounted on an eccentrically disposed driving element carried by said shaft and which is dimensioned to make a sliding fit within the casing as it is carried round therein by the driving element, and each having a substantially radial slot inclined upwardly outwardly in the uper half of its peripheral wall and a vane pivoted to the displacer and extending therefrom through the slot towards the outside of the casing, an inlet port communicating with the inside of the said first casing at a region below that in which the slot in the peripheral wall thereof penetrates to the inside thereof, an outlet port communicating with the inside of the second casing at a region above that in which the slot in the peripheral wall thereof penetrates to the inside thereof and leading to a delivery lift valve, and a transfer passage in the transfer plate communicating with the inside of the first casing above the plane of movement of the vane therein and with the inside of the second casing below the plane of movement of the vane therein.

In a preferred arrangement the vanes are substantially co-planar and the transfer passage is formed by at least one ported bore extending through the transfer plate obliquely to the axis thereof and so spaced from said axis that ported ends of the bore or bores communicate with the volumes swept by the displacers in the casings. Thus the ported end in one face of the transfer plate lies on one side of the common plane of the vanes and the ported end in the other face of the transfer plate lies on the other side of the common plane. With the vanes substantially co-planar the displacers in the first and second casings are preferably 180° out of phase to provide appropriate valving action.

Means for admitting air to the second casing in a region thereof approaching the outlet port in the direction of rotation of the displacer therein may be provided to enable the pump to deal with condensible vapours by the process known as gas ballasting. Such means preferably includes a port opening in the face of an end member closing the end of the bore in the casing opposite to that end which is closed by abutment with the transfer plate, such port being covered and uncovered by rotation of the displacer thereover. By appropriately positioning such port in relation to the ports of the transfer passage and to the phase relationship of the displacers it is possible to ensure that one of the ports of the transfer passage is covered when such air admission port is uncovered, thereby effectively obviating risk of leak back of such admitted air from the second casing to the first, that is to say from the second stage of the pump to the first stage, and reducing the deterioration in ultimate vacuum obtaining with gas ballasting.

The invention will be further described by way of example with reference to the accompanying drawings, in which:

FIG. 1 is a plan view of one embodiment of the invention,

FIG. 2 is a section along the line II—II of FIG. 1, and illustrating part of an oil bath in which the embodiment can be operated,

FIG. 3 is a section along the line III—III of FIG. 1,

FIG. 4 is a section along the line IV—IV of FIG. 1,

FIG. 5 is an inclined longitudinal section taken along the lines V—V of FIGS. 2, 3 and 4,

FIG. 6 is a detailed section along the line VI—VI of FIG. 3, and

FIG. 7 is a detailed view in the direction of the arrow 7 of FIG. 3.

A two-stage rotary vacuum pump comprises a body indicated generally at 10, in which is journalled a shaft 11. The body is formed from a first casing 12 having a cylindrical bore 13, closed at one end by an end member 14, and a second casing 15 having a cylindrical bore 16 closed at one end by an end member 17. The other open ends of the casings 12 and 15 face one another and are in sealing abutment with a transfer plate 18, the end members, casings and transfer plate being relatively located by dowel pins 19 and secured together by screwed rods and nuts 20. The end members 14 and 17 and the transfer plate 18 are bored at 21, 22, 23, to receive the shaft 11 and the bore 21 in the end member 14 is closed by sealing member 24.

Within the bore 13 of the first casing 12 a displacer 29 encircles a driving member 30, which is bored eccentrically at 31 to receive the shaft 11 and is bored transversely to receive a driving pin 32 passing through a transverse bore in the driving shaft. The casing 12 is provided with a substantially radially upwardly outwardly extending slot 33 for slidably receiving a vane 34 having a cylindrical base portion 35 journalled in the displacer 29. When the shaft 11 is rotated the displacer 29 does not rotate, but acts as though it were a connecting rod which causes the vane 34 to reciprocate to and fro in the slot 33 of the casing 12. The dimensions of the displacer 29 are such that it fits the interior of the casing 12 between the end member 14 and the transfer plate 18. The vane 34 is of substantially the same width as the casing 12 and fits the interior of the slot 33.

In like manner there is disposed within the bore 16 of the second casing 15 a second displacer 39, which encircles a driving member 40, which is bored eccentrically at 41 to receive the shaft 11 and is bored transversely to receive a driving pin 42 passing through a transverse bore in the driving shaft. The casing 15 is provided with a substantially radially upwardly outwardly extending slot 43 for slidably receiving a vane 44 having a cylindrical base portion 45 journalled in the displacer 39. When the shaft 11 is rotated the displacer 39 does not rotate, but acts as though it were a connecting rod which causes the vane 44 to reciprocate to and fro in the slot 43 of the casing 15. The dimensions of the displacer 39 are such that it fits the interior of the casing 15 between the end member 17 and the transfer plate 18. The vane 44 is of substantially the same width as the casing 15 and fits the interior of the slot 33.

The casing 12 includes an inlet port 36 to receive an inlet conduit indicated by broken lines at 37. The casing 15 is provided with an outlet port 46 communicating with a lift valve 47. The outlet port is preferably in the form of a series of holes 48 as may be more clearly seen in FIG. 1, above which is clamped a piece 49 of resilient synthetic rubber-like material preferably made from material sold under the name "Nygon," having a central slit 50 and clamped by an apertured plate 51. The casing 12 and the parts contained therein serve, when the pump is in use, as a first stage of the vacuum pump and the casing 15 and the parts contained therein serve as a second stage of the pump. For connecting the two stages in series, the transfer plate is provided with two transfer bores 52, 53, which extend obliquely to the axis of the bore to the transfer plate, as will be more clearly seen in FIG. 6 and at such a distance from the axis that they can communicate with an outlet port 54 leading to the first stage, and an inlet port 55 leading to the second stage, such ports being positioned to communicate with the volume swept by the displacers in each of the stages. The vanes 34 and 44 are substantially co-planar and the outlet port is to one side of and adjacent the plane containing the vanes whilst the inlet port is to the other side of and adjacent the plane containing the vanes. The outlet port 54 is effectively in the discharge port of the first stage and the inlet port is in the suction port of the second stage, the ports 54 and 55 being covered and uncovered in timed relationship by the rotation of the displacers 29 and 39 respectively, which, as can be seen from FIGS. 2 and 4, are substantially 180° out of phase with one another as the driving member 30 is substantially 180° out of phase with the driving member 40. Thus the rotation of the displacers serves to open and close the transfer bores.

It will be appreciated that, when in operation, the shaft 11 is rotated in an anti-clockwise direction, as seen in FIGS. 2, 3 and 4.

The pump is preferably operated immersed in an oil bath 64, contained in a hollow base 65, with the common shaft passing through a wall 38 of the base for driving connection to a suitable prime mover, as illustrated in FIG. 2. The end member 17 abuts the wall 38 and, to obviate or at least minimize undesired leakage of air along the surface of the shaft 11, the end member is counterbored at 27 to receive a seal ring 28, and the bore 22 is enlarged at 26 and communicates with the oil bath through radial passage 25. The vane 44 running in the slot 43 can, when in operation, be effectively oiled externally as the vacuum inside the casing 15 will draw in oil, keep the vane surfaces fully lubricated and maintain a good oil seal between the vane surfaces and the casing and the end member 17 and transfer plate 18.

Owing to the inclined disposition of the vane 44, when the pump is in operation, oil tends to collect in a pocket formed between the base of the vane 44 and the upper surface of the displacer 39 as indicated diagrammatically at 56. As the outlet port 46 is close to the vane 44, this pocket of oil is carried upwards at each revolution and forced upwardly into the port so as to fill the volume of the port and reduce the effective clearance volume at discharge substantially to zero.

In like manner, if the outer end of the slot 33 were open, oil would be sucked in by vacuum in the casing 12 and would tend to form a similar pocket of oil between the vane 34 and the displacer 29. This is not desirable in the first stage as discharge from the first stage to the second stage is effected through the outlet port 54. In order to prevent the ingress of oil through the slot 33 the outer end of the slot is closed by a cover 57 provided with a channel 58, one end of which is closed by end member 14 and the other end of which communicates with a blind bore 59 communicating with a transverse bore 60 leading to transfer bore 52 and closed at its outer end by a plug 61. The presence of the cover 57 substantially prevents the ingress of oil through the slot 33. Any oil which may accumulate between the vane 34 and the cap 57 is effectively returned through the transfer bore 52 to the second stage of the pump. Oil can permeate through into the first stage through the clearance between the shaft 11 and the bore 23 in the transfer plate 18. Such oil has, therefore, emerged from the second stage and the major parts of its volatile constituents will have been removed whilst it was in the second stage of the pump. Moreover any excess oil entering through such clearance will be ejected through the outlet port 54 and the transfer bores 52, 53, back to the second stage, and thus it may be considered that the pump is provided with an oil purifying and recirculating system.

To enable air to be admitted to the discharge side of the second stage of the pump to perform the so-called "gas ballasting," an inlet port 62 is provided in the inner face of the end member 17 communicating with a blind transverse bore 63, to which a very small regulated amount of air can be admitted by means not shown. Any air so admitted goes into the second stage of the pump and little or no air can leak back from the second stage to the first stage. This arises because, as may be seen from examination of FIGS. 2, 3 and 4 of the drawings, as the displacers 29 and 39 of the first and second stages respectively approach their top dead-centre positions, they effectively obscure the outlet port 54 and the inlet port 55 respectively in the transfer plate. Moreover, the bore 62 through which the air is introduced to perform so-called gas ballasting, is in the end member 17 and thus at the opposite end of the displacer 39 to the inlet port 55 in the transfer plate 18, and is in such a position that it is obscured by the displacer 39 at substantially the same time as the outlet port 54 on the transfer plate 18 is obscured by the displacer 29. Thus the amount of gas or air which can leak back from the second stage to the first stage is effectively limited by the valving action between the displacers 29 and 39 and the ports 54, 55 and the bore 62. Such valving action effectively restricting the amount of leak-back reduces the deterioration in the ultimate vacuum occurring when gas ballasting is performed.

In the embodiment described, the series connection of the first stage and second stage of the rotary vacuum pump is effected by the provision of ports and transfer bores in the transfer plate 18, rendering it unnecessary to provide complicated and possibly expensive interconnecting pipework. By providing a cap to the slot in which the vane 34 is reciprocated in the first stage of the pump, the tendency for oil to accumulate in the first stage may be reduced and the ingress of oil into the first stage may be restricted to a path leading from the second stage, so that any oil entering the first stage has effectively been de-gassed in the second stage. It is possible, when the pump is adequately lubricated, by regulating the ingress of oil into both the first and second stages of the pump, to avoid the necessity for either of the displacers 29 and 39 actually to touch the interior of their casings or their end members or the transfer plate and clearances between the displacers and casings, end members and transfer plate, may be of the order of $\frac{3}{1,000}$ of an inch, without causing excessive leakage, and thus it is possible to minimize wear of the parts.

I claim:

1. A multi-stage rotary vacuum pump comprising a transfer plate, first and second cylindrically bored casings, each closed at one end, and both disposed with their cylindrical bores substantially coaxial about a substantially horizontal axis, the open ends of the casings facing one another and being an abutment with said transfer plate, said plate and casings forming part of a stationary pump body, a drive shaft substantially coaxial with the bores of the casings, a pair of eccentrically disposed driving members on said shaft, one in the bore of each of said casings, a pair of displacers rotatably mounted one on each of said driving members, a pair of vanes serving as movable abutments and each pivoted to one of said displacers and extending therefrom towards the outside of the casing in which its displacer is contained and being slidably received in a substantially radially extending slot inclined upwardly outwardly in the peripheral wall of the said casing, both vanes being disposed in substantially the same plane, each displacer being dimensioned to make a sliding fit within the bore of its casing as it is carried round by the driving member on which it is mounted and rendered non-rotating by the vane pivoted to it, the slot in the peripheral wall of the second casing in which the vane in the second casing slides being open-ended at the outside of the second casing, means for closing the outer end of the slot in the peripheral wall of the first casing in which the vane in the first casing slides, the transfer plate, the first casing and the displacer and vane therein serving as a first stage pump, and the transfer plate, the second casing and the displacer and vane therein serving as a second stage pump, an inlet port communicating with the inside of the first casing below and adjacent the plane containing said vanes, said transfer plate defining a transfer passage formed by at least one ported bore extending through the transfer plate obliquely to the axis thereof and communicating with the inside of the said first casing above and adjacent the plane containing the vanes to serve as outlet port for the first stage pump, and connecting with the inside of the second casing below and adjacent the plane containing the vanes, to serve as inlet port for the second stage pump, said bore communicating with the insides of said casings within the volumes swept by the displacers therein, said displacers upon being carried round in the casings serving to open and close said bore, a delivery valve, and an outlet port communicating with the inside of the second casing above and adjacent the plane containing the vanes and leading to said delivery valve.

2. A multi-stage rotary vacuum pump comprising a transfer plate, first and second cylindrically bored casings, each closed at one end, and both disposed with their cylindrical bores substantially co-axial about a substantially horizontal axis, the open ends of the casings facing one another and being in abutment with said transfer plate, said plate and casings forming part of a stationary pump body, a drive shaft substantially co-axial with the

bores of the casings, a pair of eccentrically disposed driving members on said shaft, one in the bore of each of said casings, a pair of displacers rotatably mounted one on each of said driving members, a pair of vanes serving as movable abutments and each pivoted to one of said displacers and extending therefrom towards the outside of the casing in which its displacer is contained and being slidably received in a substantially radially extending slot inclined upwardly outwardly in the peripheral wall of the said casing, both vanes being disposed in substantially the same plane, each displacer being dimensioned to make a sliding fit within the bore of its casing as it is carried round by the driving member on which it is mounted and rendered non-rotating by the vane pivoted to it, the slot in the peripheral wall of the second casing in which the vane in the second casing slides being open-ended at the outside of the second casing, means for closing the outer end of the slot in the peripheral wall of the first casing in which the vane in the first casing slides, the transfer plate, the first casing and the displacer and vane therein serving as a first stage pump and the transfer plate, the second casing and the displacer and vane therein serving as a second stage pump, an inlet port communicating with the inside of the first casing below and adjacent the plane containing the vanes, said transfer plate defining a transfer passage formed by at least one ported bore extending through the transfer plate obliquely to the axis thereof and communicating with the inside of the said first casing above and adjacent the plane containing the vanes to serve as outlet port for the first stage pump, and connecting with the inside of the second casing below and adjacent the plane containing the vanes to serve as inlet port for the second stage pump, said bore communicating with the insides of said casings within the volumes swept by the displacers therein, the displacer in the first casing being substantially 180° out of phase with the displacer in the second casing, said displacers being carried round in the casings for uncovering and covering ports of the transfer passage in timed relationship to one another to provide valving action during rotation of said drive shaft, a delivery valve, and an outlet port communicating with the inside of the second casing above and adjacent the plane containing the vanes and leading to said delivery valve.

3. A pump according to claim 2, including means for admitting controlled air to the second casing in the region thereof approaching the outlet port in the direction of rotation of the displacer therein.

4. A pump according to claim 3, in which said air admitting means comprises an air admission port opening in the face of the bore of the second casing opposite that which is closed by abutment with said transfer plate, the displacer in said second casing being adapted, upon rotation of said drive shaft, to cover and uncover said air-admission port.

5. A pump according to claim 4, in which said air admission port is so positioned in relation to the ported bore of the transfer passage and the angular relationship of the displacers in the first and second casings that, upon rotation of the drive shaft, one of the transfer ports is covered by a displacer when said air admission port is uncovered by a displacer.

6. A multi-stage vacuum pump formed with two pumps connected in series with one another, each pump comprising a stationary cylindrically bored casing, an eccentric rotatable therein; a displacer freely carried by the eccentric, a vane freely slidable in an upwardly outwardly inclined radial slot in the casing and pivotally connected to the displacer, the eccentric and vane upon rotation of the eccentric causing the displacer to move as a non-rotating planetary piston within the cylindrical casing with a part of the surface of the cylindrical surface of the displacer always in contact with the inner wall of the cylindrical casing and the vane to reciprocate in its slot,

a transfer plate intermediate said cylindrical casings, ported transfer passage means in said transfer plate communicating with the casing of a first one of said pumps above a plane containing the vanes to provide an outlet port therefor and with the casing of a second one of said pumps below said plane to provide an inlet port therefor, an inlet port communicating with the casing of the first one of said pumps below said plane, an outlet port communicating with the casing of the second one of said pumps above said plane, a shaft journalled in said transfer plate and at least the casing of the second one of said pumps, and carrying said eccentrics, and having a driving extension extending from the casing of said second one of said pumps, an oil bath containing said pumps, means for closing the outer end of the slot in the casing of the first one of said pumps and passage means communicating with said outer end of said slot and with said transfer passage means.

7. A pump according to claim 6 including means for journalling said shaft in the casing of the first one of said pumps and sealing means for preventing the ingress of oil into said last mentioned casing through said journalling means.

8. A multi-stage rotary vacuum pump comprising a transfer plate, first and second cylindrically bored casings, each closed at one end, and both disposed with their cylindrical bores substantially co-axial about a substantially horizontal axis, the open ends of the casings facing one another and being in abutment with said transfer plate, said plate and casings forming part of a stationary pump body, a drive shaft substantially co-axial with the bores of the casings, a pair of eccentrically disposed driving members on said shaft, one in the bore of each of said casings, a pair of displacers rotatably mounted one on each of said driving members, a pair of vanes serving as movable abutments and each pivoted to one of said displacers and extending therefrom towards the outside of the casing in which its displacer is contained and being slidably received in a substantially radially extending slot inclined upwardly outwardly in the peripheral wall of the said casing, both vanes being disposed in substantially the same plane, each displacer being dimensioned to make a sliding fit within the bore of its casing as it is carried round by the driving member on which it is mounted and rendered non-rotating by the vane pivoted to it, the slot in the peripheral wall of the second casing in which the vane in the second casing slides being open-ended at the outside of the second casing, means for closing the outer end of the slot in the peripheral wall of the first casing in which the vane in the first casing slides, the transfer plate, the first casing and the displacer and vane therein serving as a first stage pump and the transfer plate, the second casing and the displacer and vane therein serving as a second stage pump, an inlet port communicating with the inside of the first casing below and adjacent the plane containing said vanes, said transfer plate defining a transfer passage formed by at least one ported bore extending through the transfer plate obliquely to the axis thereof and communicating with the inside of the said first casing above and adjacent the plane containing the vanes to serve as outlet port for the first stage pump, and connecting with the inside of the second casing below and adjacent the plane containing the vanes, to serve as inlet port for the second stage pump, said bore communicating with the insides of said casings within the volumes swept by the displacers therein, said displacers upon being carried round in the casings serving to open and close said bore, passage means communicating with the outer end of the slot in the peripheral wall of the first casing and said transfer passage, a delivery valve, and an outlet port communicating with the inside of the second casing above and adjacent the plane containing the vanes and leading to said delivery valve.

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