July 24, 1934. R. T. LUCAS 1,967,957

VACUUM PUMP

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FIG. 1

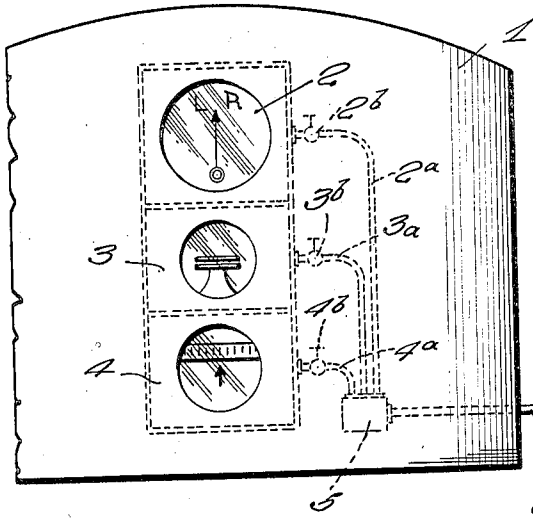
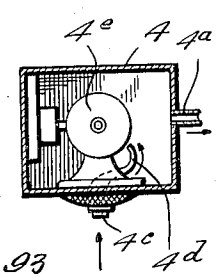


FIG. 2



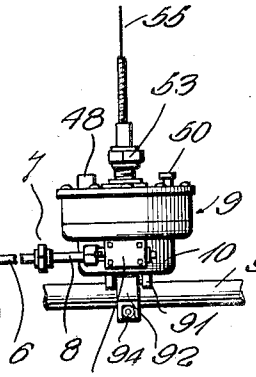


FIG. 4

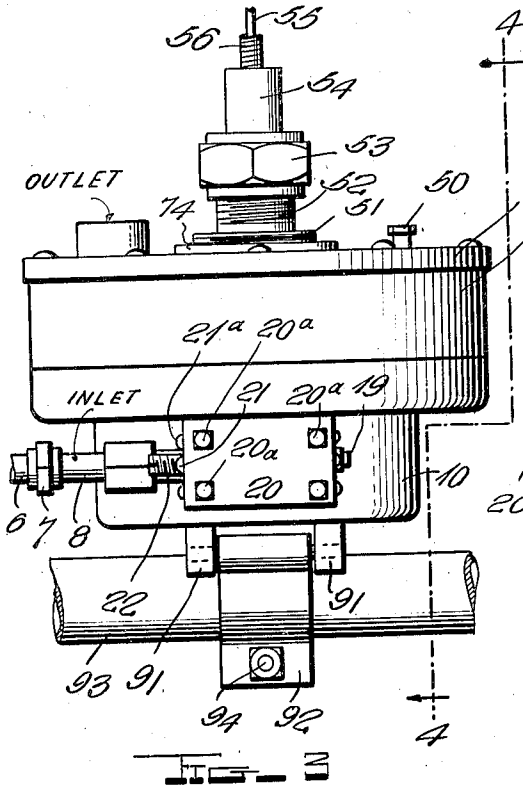
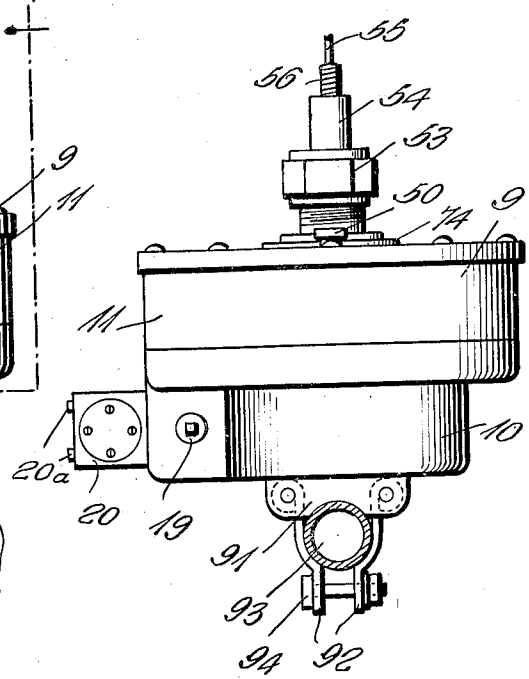


FIG. 3

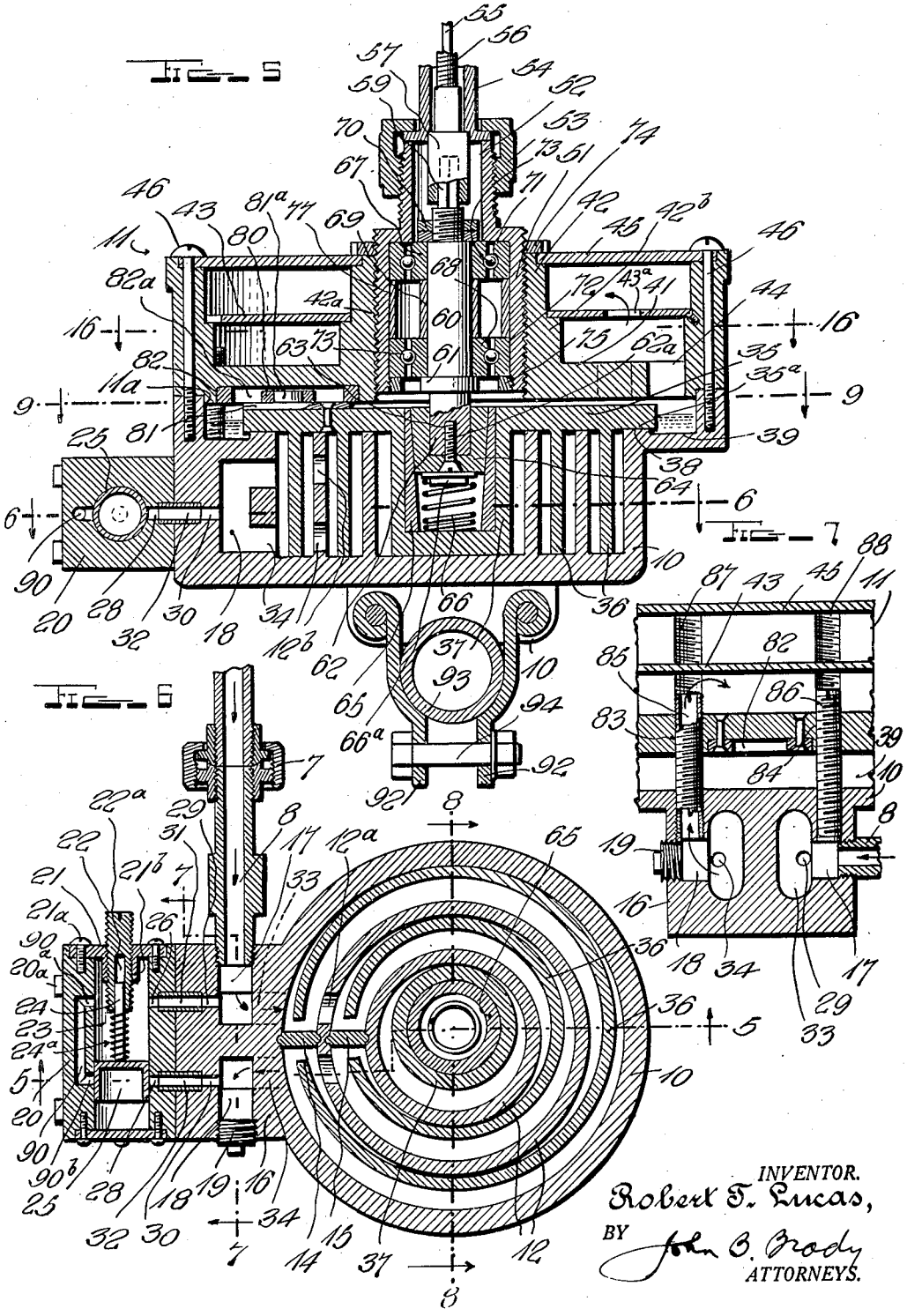


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VACUUM PUMP

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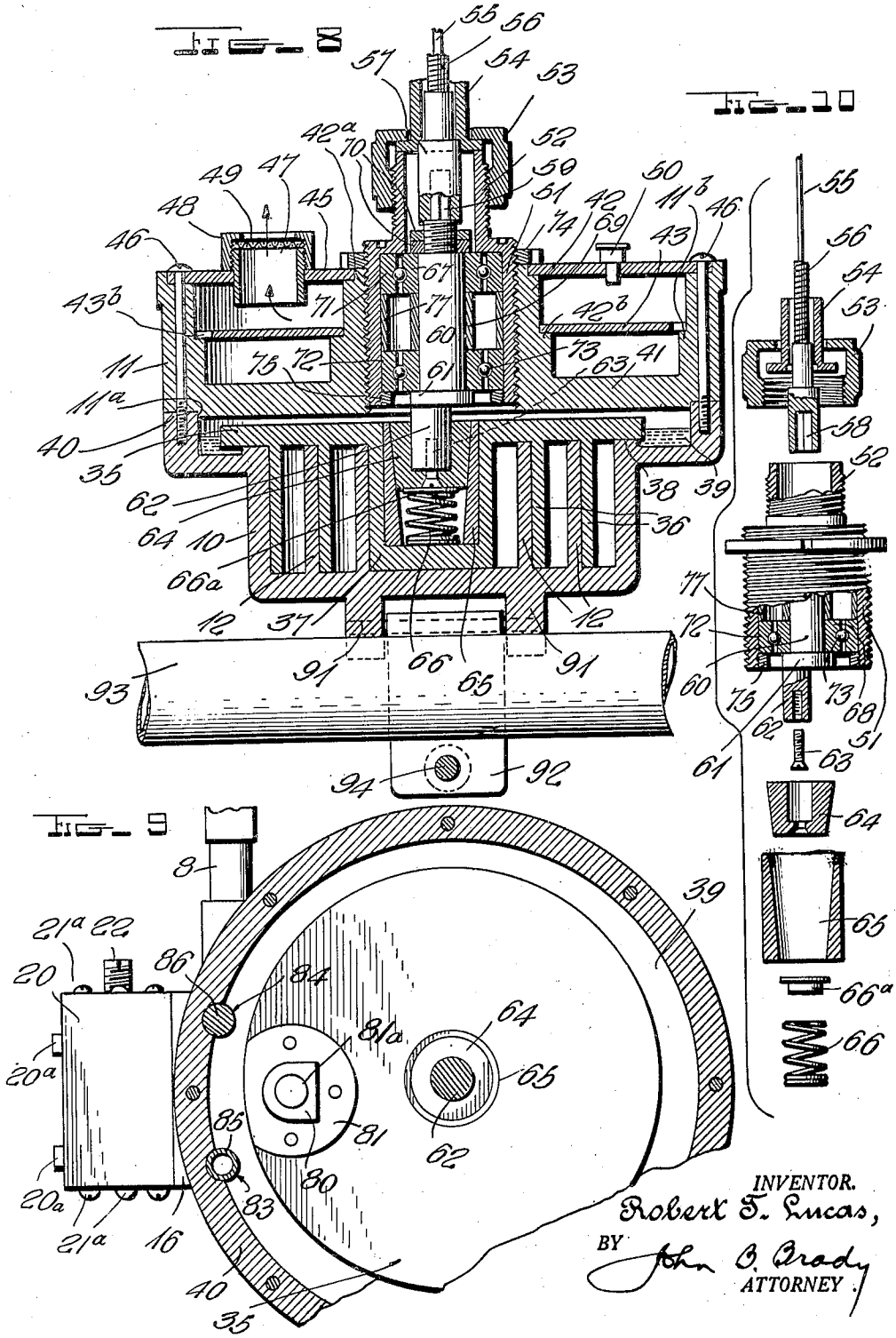


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VACUUM PUMP

Filed May 1, 1933 5 Sheets-Sheet 3



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FIG. 11

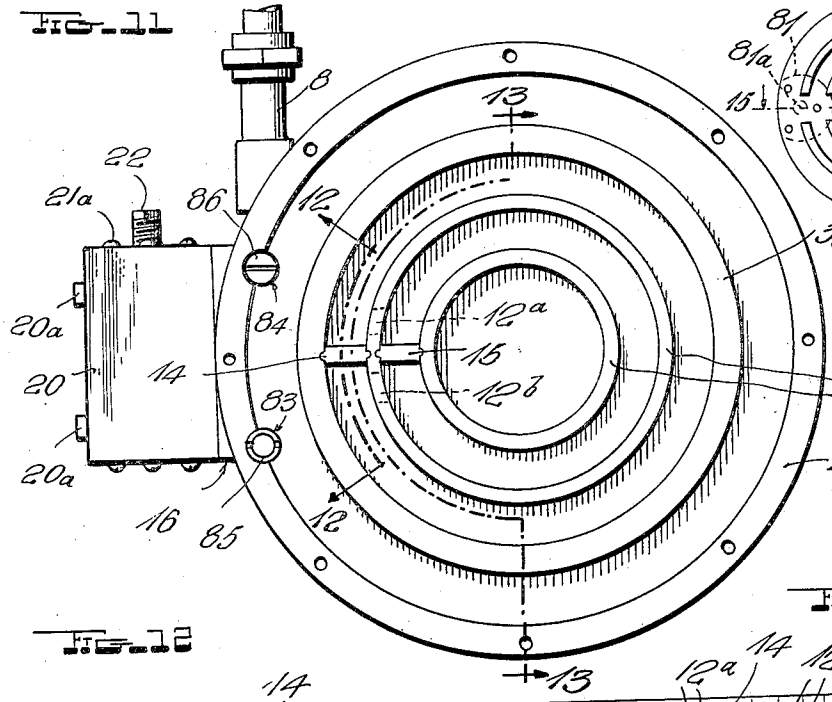


FIG. 14

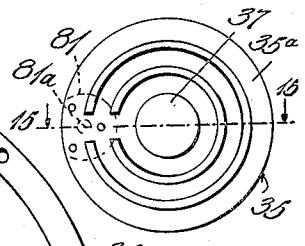


FIG. 12

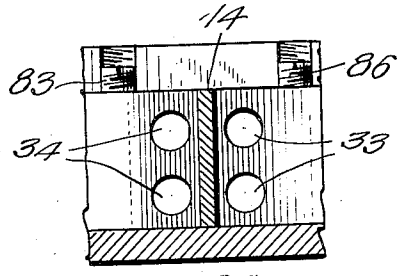


FIG. 13

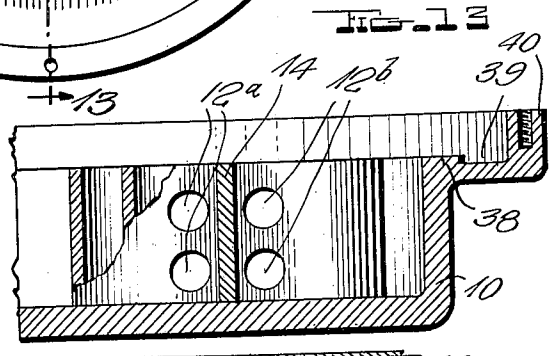
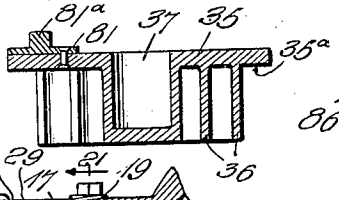


FIG. 15



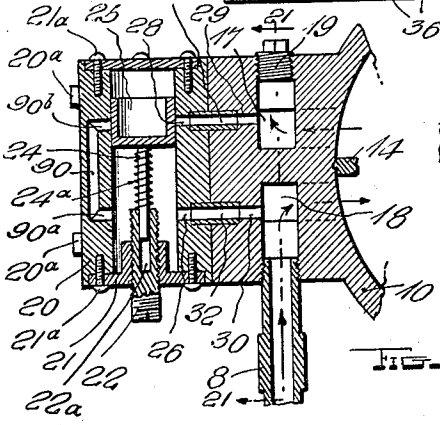


FIG. 20

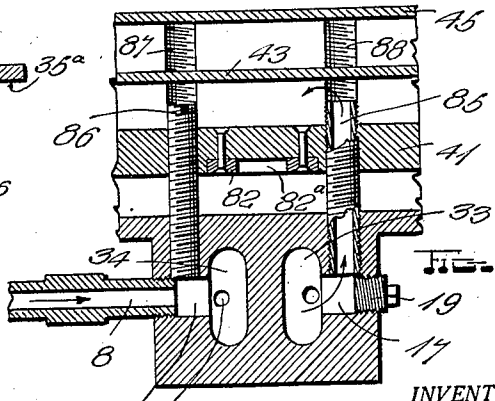


FIG. 21

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VACUUM PUMP

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FIG. 16

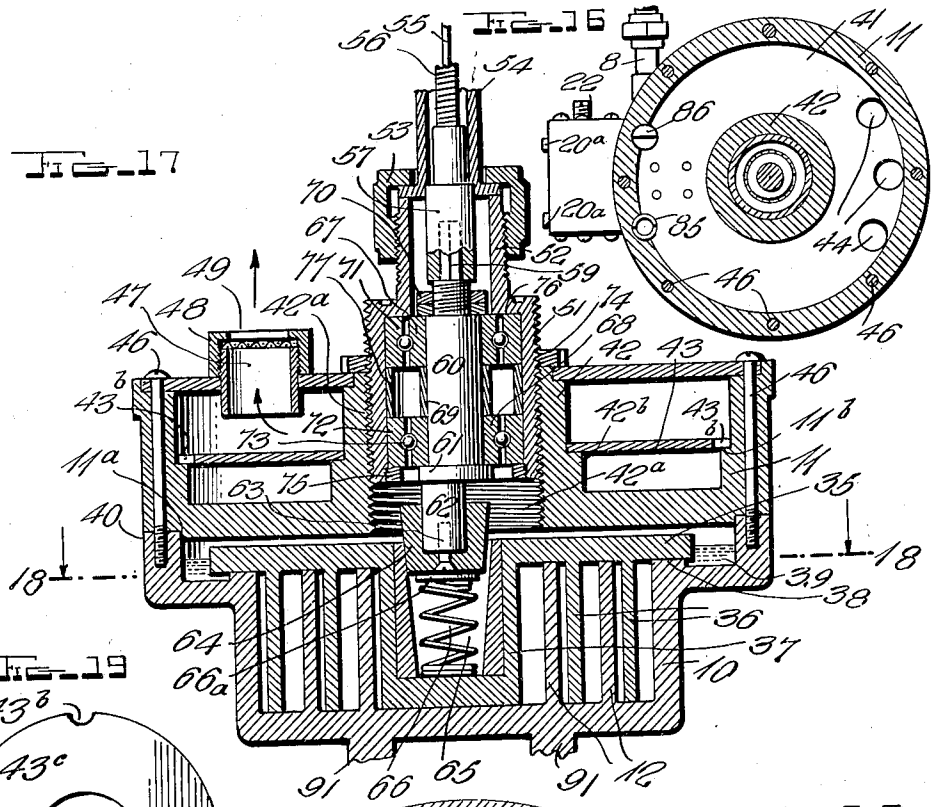


FIG. 17

FIG. 19

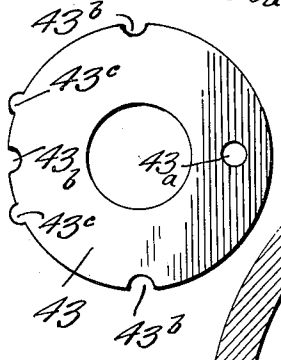
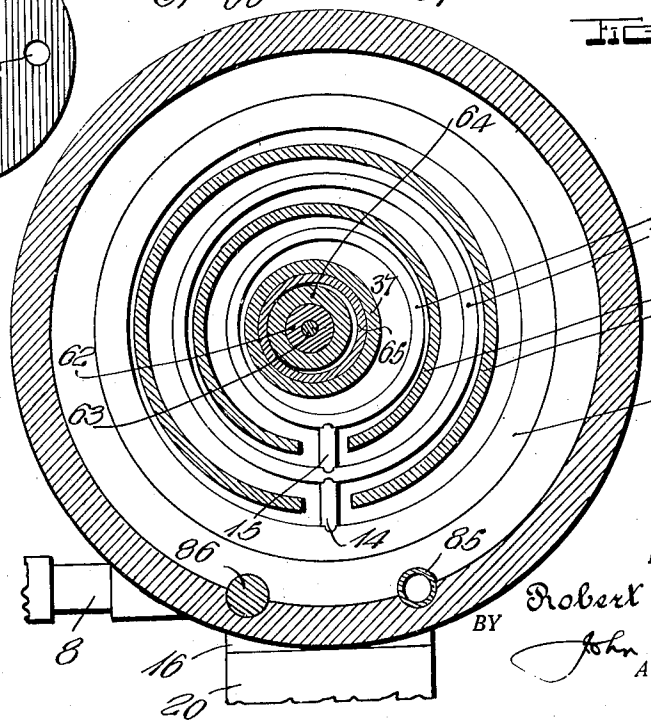


FIG. 18



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Patented July 24, 1934 1,967,957

UNITED STATES PATENT OFFICE

1,967,957

VACUUM PUMP

Robert T. Lucas, Alexandria, Va., assignor to National Electrical Supply Company, Washington, D. C., a corporation of Virginia

Application May 1, 1933, Serial No. 668,868

9 Claims. (Cl. 230—146)

My invention relates broadly to vacuum pumps and more particularly to a construction of vacuum pump which is adjustable to pump any desired degree of vacuum within predetermined limits.

One of the objects of my invention is to provide a construction of vacuum pump having a pair of symmetrically arranged ports in one side of the main casing thereof, either of which may be employed as the suction intake to the pump to allow the pump to be installed in the most accessible and convenient position adjacent associated equipment.

Another object of my invention is to provide a construction of vacuum pump comprising a stator element and a coacting oscillatory element having means for continuously lubricating the oscillatory element for insuring operation of the pump with minimum wear upon the bearing face of the oscillatory element.

Still another object of my invention is to provide a compact construction of vacuum pump and associated lubricating means having adjustable means associated with the pump for controlling the degree of pressure under which the vacuum pump may be operated.

A further object of my invention is to provide a construction of vacuum pump and an associated vacuum control valve wherein the vacuum control valve structure and either of the two inlet ports for the pump are reversible in position for allowing the pump to be installed in the most convenient manner with respect to associated equipment.

A still further object of my invention is to provide a construction of vacuum pump and coacting lubricating reservoir section having means mounted in the lubricating reservoir section for imparting eccentric movement to an oscillatory impeller element of the vacuum pump.

Another object of my invention is to provide an improved method of mounting an anti-friction bearing for a vertically disposed drive shaft of a vacuum pump.

Still another object of my invention is to provide a construction of oil tank and baffle for a vacuum pump of compact form.

Other and further objects of my invention reside in a construction of vacuum pump and associated parts as set forth more fully in the specification hereinafter following in which:

Figure 1 is a front elevation of the vacuum pump showing a typical installation of the pump of my invention in association with the instrument board of an airplane; Fig. 2 is a detailed sectional view through one of the compartments to be evacuated; Fig. 3 is a front elevation of the pump on an enlarged scale; Fig. 4 is a vertical transverse sectional view taken on line 4—4 of Fig. 3; Fig. 5 is a sectional view taken substantially on line 5—5 of Fig. 6; Fig. 6 is a horizontal sectional view taken substantially on line 6—6 of Fig. 5; Fig. 7 is a detailed sectional view taken on line 7—7 of Fig. 6; Fig. 8 is a sectional view taken substantially on line 8—8 of Fig. 6; Fig. 9 is a horizontal sectional view taken on line 9—9 of Fig. 5; Fig. 10 is a disassembled sectional view of the driving unit and associated parts; Fig. 11 is a top plan view of the lower body portion of the pump; Fig. 12 is a detailed sectional view on line 12—12 of Fig. 11; Fig. 13 is a sectional view taken on line 13—13 of Fig. 11; Fig. 14 is a bottom plan view of the impeller, the view being made on a reduced scale; Fig. 15 is a sectional view taken on line 15—15 of Fig. 14; Fig. 16 is a horizontal view taken on line 16—16 of Fig. 5; Fig. 17 is a vertical transverse sectional view showing the pump adjusted to create a smaller degree of vacuum than in the adjustment illustrated in Figs. 5 and 6; Fig. 18 is a horizontal sectional view taken on line 18—18 of Fig. 17; Fig. 19 is a plan view of the baffle plate employed within the housing of the vacuum pump; Fig. 20 is a view of the central valve in a position which is reversed with respect to the position shown in Figs. 6 and 9 and showing the reversed position of the intake with respect to the position of the intake in Fig. 6; and Fig. 21 is a cross sectional view taken on line 21—21 of Fig. 20 and illustrating more clearly the reversed position of the plug and sleeve with respect to the positions illustrated in Fig. 7.

I have illustrated my invention as applied to aircraft for use in coaction with such instruments as the bank and turn indicator, the gyrocompass, and the horizon gauge. It will be appreciated, however, that the vacuum pump of my invention may be used for various purposes for evacuating vessels or receptacles of different kinds. By reason of the compact size of the pump, the device is particularly suitable for use in Doctor's offices or in hospital operating rooms for pumping a vacuum where necessary. The device is also applicable to machines employed in the manufacture of glassware and in many other instances in which predetermined degrees of vacuum may be required. In the particular application of my invention as described herein, the vacuum pump is arranged adjacent the instrument board of an aircraft and is connected with the bank and turn indicator, gyrocompass, and the horizon gauge. These instruments require approximately four and one-half pounds of vacuum per square inch for their operation. Heretofore, operation of the instruments on aircraft has been unsatisfactory for the reason that the vacuum required has generally been produced by means of a wind driven pump or a Venturi tube, either of which require that the aircraft be in flight. Inasmuch as the required vacuum

is not obtainable, the calibration of the several instruments cannot be made except when the aircraft is in flight which is a very unsatisfactory requirement. The vacuum pump of my invention may be readily driven through a flexible drive connected with the aircraft engine in much the same way as a speedometer is driven. The fact that the vacuum pump of my invention is continuously driven by the aircraft engine makes the calibration of the instruments on the aircraft wholly independent of flight conditions as the instruments and degree of vacuum may be adjusted with the aircraft on the ground and the engine running as well as with the aircraft in flight. If it is inconvenient in certain aircraft installations to establish a driving connection between the pump and the aircraft engine, I may drive the vacuum pump by an appropriate small size electric motor electrically operated from a storage battery source or generator on the aircraft. The driving power required is relatively small and may be accomplished through a flexible drive shaft encased in a flexible tubular conduit. The pump consists of a two-section casing, one section of which includes a stator element coacting with an oscillatory element and the other section of which includes a lubricant control chamber. The section constituting the lubricant control chamber provides an anti-friction mounting for a vertically disposed shaft having an eccentric on the extremity thereof. The eccentric on the vertically disposed shaft engages the oscillatory element of the pump for imparting oscillatory motion to the oscillatory element for effecting oscillatory movement with respect to the stator element of the pump. The driving power is transmitted to the vertical shaft through a flexible shaft which engages the upper end of the vertical shaft. The oscillatory element is symmetrically arranged, with respect to the stator element, and a pair of inlet connections are provided in the pump casing in such positions, with respect to the stator element, that the suction inlet connection may be readily made at either of two separate positions, thus facilitating the installation of the vacuum pump. I have found that installations of the vacuum pump of my invention must be made in various forms of aircraft where available driving power may be either clockwise or counterclockwise and, for this reason, I have so constructed the vacuum pump of my invention that the pump may be installed in any desired position regardless of the direction of rotation of the driving source. In order to control the degree of vacuum which is obtainable in the vacuum pump of my invention, I provide a spring controlled by-pass valve which may provide a shunt path between the inlet port and outlet end of the pump, when the degree of vacuum reaches a predetermined value. For all values of vacuum below a predetermined value, the automatic control device of my invention is ineffective but as soon as the vacuum exceeds the desired value, the control mechanism of my invention becomes effective for again reducing the vacuum to the desired value. It will be appreciated that many conditions may arise where one of the instruments requiring vacuum may be cut out thereby requiring a radically different value of vacuum. Adjustment of the spring-controlled by-pass valve enables the required degree of vacuum to be very readily fixed or changed to meet the capacity requirements which may change from time to time in accordance with the number of instruments controlled by the vacuum pump. The spring-controlled by-pass valve is adjustable to any desired degree of vacuum by means of an adjustable set screw which may be selectively adjusted in accordance with readings obtainable on the various gauges with which the vacuum pump of my invention is associated. The spring-controlled valve structure is reversible in position when the inlet and outlet connections to the pump are reversed. I also provide means interiorly of the pump which are interchangeable in their positions for defining the inlet and discharge paths between the sections of the pump for facilitating the circulation of lubricant through the pump. In addition to the vacuum control afforded by the spring-actuated by-pass valve I provide a screw threaded major adjustment for controlling the degree of vacuum. The vertically disposed shaft which is mounted in antifriction bearings is provided with an eccentric drive which is adjustably coupled with the impeller. By varying the coupling the eccentric path of the impeller may be modified to vary the contact relation between the impeller and the stator elements for correspondingly changing the degree of vacuum produced by the pump. The several parts of the pump structure of my invention are extremely simple for manufacture and production.

Referring to the drawings in more detail, reference character 1 designates an instrument panel of an aircraft on which the various instruments incidental to the operation of the aircraft are mounted, including the bank and turn indicator 2, the horizon indicator 3 and the gyrocompass 4. A manifold 5 is indicated in dotted lines from which leads are taken to each of the instruments adjacent the instrument panel through pipe lines 2*a*, 3*a* and 4*a*. Each pipe line includes a valve designated at 2*b*, 3*b* and 4*b*, by which the suction may be cut off from any one of the instruments. The suction intake pipe leading to the manifold 5 is represented at 6 connected through coupling 7 with the suction intake 8 of the vacuum pump. The vacuum pump 9 is illustrated as including the pump section 10 and the oil distribution section 11. The vacuum pump is formed from a casting in which the pump section 10 includes the stator element 12 consisting of concentrically disposed ring members integrally connected with the pump section 10. The concentrically disposed ring members 12 have baffle plates 14 and 15 disposed in radial alignment for dividing the inlet and discharge portions of the pump. The pump section 10 has a cast projection 16 on one side thereof through which the inlet and discharge connections for the pump are made. In the embodiment of my invention illustrated the inlet connection 8 is made in the screw-threaded port 17 while the oppositely disposed port 18 is closed by means of a plug 19. In other installations where it may be more convenient for the suction intake pipe 8 to approach the opposite side of the pump casing, the plug 19 is removed and the suction pipe 8 connected in its place and then the plug 19 screwed into position in the screw-threaded port 17 and the valve control mechanism reversed. The pump is now operated in the opposite direction for securing the same degree of suction as before. The valve control mechanism is mounted within the valve housing 20 which is aligned with the cast projection 16 on the pump casing 10. The valve control mechanism includes a removable end plate 21 secured by screws 21*a* to the end of

the valve housing 20 with an internal screw-threaded sleeve 21*b* carried thereby for receiving a screw-threaded adjusting screw 22. The end of the screw-threaded adjusting screw may be engaged by any suitable tool for advancing or retracting the screw-threaded adjusting screw 22 with respect to the interior of cylinder 23. The screw-threaded adjusting screw 22 has an axially extending socket 22*a* therein into which the valve stem 24 telescopically slides, the valve stem 24 carrying the cup shaped piston device 25 fitting within the cylinder 23.

Spring 24*a* is disposed on valve stem 24 and acts between the end of the screw threaded member 22 and the cup-shaped valve 25 for resisting the movement of the cup-shaped valve 25 in the direction of the screw threaded adjusting screw 22. The valve housing 20 is provided with a pair of ports 26 and 28 adjacent opposite ends of the valve housing which are aligned with ports 29 and 30 in the cast projection 16 of the pump casing 10. In order to render the passages through the ports airtight, and to provide for the alignment of the passages in housing 20 in either of its two positions, I provide coupling tubes 31 and 32 interconnecting the aligned ports 26—29 and 28—30, thus preventing leakage of air at the juncture of the valve control housing with the cast projection 16 on the casing. Ports 29 and 30 connect with ports 17 and 18, respectively, which are in turn connected with the ports 33 and 34 which lead to the interior of the pump casing 10. As illustrated in Fig. 6, the port 33 provides part of the suction intake passage from suction intake tube 8 and enters the suction side of the stator elements 12 in pump casing 10 on one side of baffle plates 14 and 15 which extend between concentric stator elements 12. It will be observed that one of the stator elements 12 is apertured at 12*a* in alignment with port 33 and adjacent baffle plates 14 and 15, whereby both chambers of the pump become effective to produce suction pressure with respect to the suction inlet 8. I also provide apertures 12*b* in one of the stator elements 12 adjacent the opposite side of baffle plates 14 and 15 in alignment with port 34 for the discharge of air and oil as will be hereinafter explained in more detail. When the valve housing 20 is in reversed position as shown in Figs. 20 and 21, port 18 becomes the suction intake, and port 17 is then the exhaust side. In this position the oscillatory movement of the pump is reversed and all functions heretofore explained with reference to Fig. 6 are reversed.

As shown more clearly in Fig. 5, I provide an oscillatory element 35 including a pair of concentrically disposed impeller elements 36 and a central socket portion 37. The concentrically disposed impeller elements 36 and socket portion 37 coact with the stator elements 12 in interleaved relation. That is to say, the impeller elements 36 of the oscillatory element 35 each include a gap at one side of the circumference thereof with the ends of the impeller elements disposed on opposite sides of the baffle plates 14 and 15. The socket portion 37 of the oscillatory element 35 is eccentrically disposed within the inner stator element 12. The oscillatory element 35 has an annular face 35*a* on the under surface thereof which is ground to coact with the annular face 38 on the edge of the casing 10. The annular faces 35*a* and 38 are ground to provide an accurate coacting fit. The impeller elements 36 are also ground on their extremities to provide an accurate fit over the areas of the casing 10 between the stator elements 12. Likewise the areas on the under surface of the oscillatory element 35 are ground to provide an accurate coacting fit with the upper extremities of the stator elements 12 so that oscillatory movement imparted to the oscillatory element 35 insures an accurate sliding movement on all coacting bearing surfaces on oscillatory element 35 with respect to corresponding bearing surfaces on the stator elements in casing 10.

The casing 10 is provided with an annular trough 39 which surrounds the ground edge 38 and is disposed intermediate the depending portion of the casing 10 and an upwardly projecting circumferential portion 40. The circumferential portion 40 provides a marginal wall for the pit or trough 39 and also acts as a support or foundation for the oil distribution section 11. The oil distribution section 11 has an annular shoulder 11*a* formed thereon which engages the circumferential wall 40 of the pump casing. The oil distribution section 11 has a cast base portion 41 integrally connected with the side wall portion and integrally connected with a central upstanding cylindrical portion 42. The outer cylindrical wall of the oil distribution section 11 and the upstanding cylindrical portion 42 are each provided with annular shoulder members 11*b* and 42*b*, as shown. These shoulder members provide supports for the laterally extending baffle plate 43 as shown. The baffle plate 43 is shown more clearly in Fig. 19 containing a discharge aperture 43*a* and a plurality of peripheral notches 43*b* forming oil return passages. The baffle plate 43 is secured in position by any suitable means such as tongues or lugs 43*c* which enter notches formed in the marginal wall of the oil distribution section 11 as shown in Fig. 5. The discharge aperture 43*a* is substantially aligned with the discharge apertures 44 in the cast base portion 41. The top of the oil distribution section 11 is closed by laterally extending plate member 45 secured in position by means of screws 46 which extend through the outside wall of the oil distribution section 11 and into the circumferential casing 40. The plate 45 contains the outlet port 47 consisting of a tubular member secured in plate 45 and projecting into the oil distribution section 11 and screw threaded on its exterior for engagement by the cylindrical member 48 which anchors the screen 49 in position, as shown in Fig. 17. The screen 49 prevents the discharge of oil while permitting the discharge of air. Oil may be introduced into the oil distribution section 11 through suitable oil cup 50.

The central portion of the upstanding cylindrical portion 42 is screw threaded as represented at 42*a* for receiving the externally screw threaded cylindrical member 51. The member 51 has an upper portion 52 of reduced diameter which is also screw threaded to receive screw threaded cap member 53 having exterior tool engaging surfaces by which the flanged end 54 of a tubular casing may be secured with respect to the end of the screw threaded portion 52. Through the tubular member 54 there extends a flexible drive shaft 55 protected by a suitable protective tube 56. Flexible shaft 55 connects with the engine on the aircraft or with a drive shaft operating either in a clockwise or counterclockwise direction. The shaft 55 connects with a coupling member 57 having a socket 58 therein which engages the upstanding polygonal shaped end 59

of spindle 60. Spindle 60 has a flange 61 adjacent the lower extremity thereof and from flange 61 there projects the drive pin 62 which is screw threaded at 62a to receive screw member 63 which passes through the end of the frusto conical member 64. The frusto conical member 64 projects into a frusto conical sleeve 65 which is disposed concentrically within the socket 37 of the oscillatory element 35. A coil spring 66 is disposed between the lower extremity of the socket 37 and the cap 66a which bears directly against the end of the frusto conical member 64. Coil spring 66 tends to constantly urge frusto conical member 64 out of frictional engagement with the frusto conical sleeve 65 while the advancement of the cylindrical member 51 into the screw threaded cylindrical portion 42 tends to move frusto conical member 64 against the coil spring 66. The spindle 60 carries roller members 67 and 68 adjacent each end thereof as shown. Roller member 68 is disposed in abutment with flange 61. Sleeve 69 is disposed over spindle 60 and in direct abutment with the roller member 68. Roller member 67 is disposed over spindle 60 and is maintained in abutment with the end of sleeve 69. Lock nuts 70 engage the screw threaded end of spindle 60 and serve to maintain roller member 67 in position. Roller members 67 and 68 form ball races with coacting members 71 and 72 with antifriction bearings 73 disposed therebetween. In order to maintain the ball races in position interiorly of the screw threaded member 51, I provide internal screw threads adjacent the end of the cylindrical member 51 which screw threads are engaged by means of the screw threaded ring member 75. The ball race, constituted in part by member 67, is mounted in abutment with the shoulder 76 of the screw threaded member 51. Spacing sleeve 77 is provided in abutment with ball race 71. Ball race 72 is disposed in abutment with spacing sleeve 77 and annular member 75 is engaged in the end of cylindrical member 51 for securing the ball race 72 in position and providing an antifriction mounting for the vertically disposed spindle.

The cylindrical member 51 is advanced to the desired position in the central screw threaded member 42 and then locked in any selected position by means of lock nut 74. In Fig. 5 I have shown cylindrical member 51 screwed to a position where frusto conical member 64 establishes engagement with frusto conical sleeve 65 for driving the oscillatory element 35 in an oscillatory path under control of the eccentric 62, driven from spindle 60. In order to guide the oscillatory element 35 in an oscillatory path, I provide a pivotally mounted spacer member 80 pivoted on stud 81a extending from plate member 81 which is riveted to the oscillatory element 35. The pin member 81a which projects from plate 81 serves to rockably mount the spacer member 80 in position for confined movement in a slot 82a formed in a frame 82 secured in a recess in the cast base plate 41 of the oil distribution section. Spacer member 80 reciprocates in the slot 82a formed in the frame 82 carried in the base 41 of the oil distribution section, allowing the oscillatory element 35 to freely swing with respect to the stud 81a within certain predetermined limits governed by the eccentricity of the drive pin 62 and the relative areas between the stator elements 12 and the impeller elements 36.

As illustrated in Fig. 6, the oscillatory element 35 has been driven to one position in which the side walls of the impeller elements 36 engage the side walls of the stator elements 12. The intimacy of contact along section line 8—8 has been illustrated in Fig. 8. The wide gaps which remain along the diametric axis normal to the section 8—8 is clearly shown along section line 5—5 in Fig. 6. The varying size of the gap between the impeller elements and the stator elements in the course of the oscillatory movement of the oscillatory element with respect to the stator elements will be fully understood from an examination of Figs. 17 and 18. Figs. 17 and 18 also illustrate the method of adjustment of the vacuum pump by which the driving frusto conical member 64 is varied in position with respect to the driven frusto conical sleeve 65. By backing off on the screw threaded sleeve 51 the frusto conical member 64 is withdrawn from intimate engagement with frusto conical sleeve 65 thereby allowing greater play between the driving and driven members and consequently greater space between the impeller and stator elements in the course of the oscillatory movement thereof. This lowers the efficiency of the pump as there is no true contact between the sides of the impeller and stator elements and results in the decrease of the vacuum which is created.

It has heretofore been pointed out that ports 17 or 18 may be selectively employed for the inlet to the pump for installations under different conditions where a short connection to the suction intake is desirable or where clockwise or counterclockwise driving movement is encountered. In effecting this interchange of inlet connections I must also provide an interchange of exhaust connections interiorly of the pump. For this purpose I provide a symmetrical arrangement of vertically disposed ports illustrated at 83 and 84 disposed in alignment through the cast base 41 of the oil distribution section and the pump casing 10, as shown more clearly in Fig. 7. The ports 83 and 84 are screw threaded to receive either the screw threaded sleeve 85 or the screw threaded plug 86. In the arrangement shown, the screw threaded sleeve 85 is secured in engagement with the screw threaded ports 83, providing a path for the discharge of air and lubricant from discharge port 34 through port 18 and sleeve 85 into the oil distribution section 11, immediately beneath baffle plate 43. This is the condition where the suction intake 8 is connected to the port 17 as shown. The discharge from the pump takes place from port 34 through port 18 and sleeve 85 into the oil distribution section 11 beneath the baffle plate 43. The drive pin 62 under this condition is operating in a clockwise direction for producing oscillatory movement of the oscillatory element 35 in a direction to produce suction at port 33. If however, the direction of rotation is changed the sleeve 85 must be removed and plug 86 substituted therefor and sleeve 85 placed in the position previously occupied by plug 86 at the same time that suction intake pipe 8 is removed from port 17 and connected to port 18, and plug 19 is removed from port 18 and connected with port 17.

It will be understood that the instruments, apparatus or equipment with which the vacuum pump of my invention is employed, may be of a varied nature. The several compartments and instruments illustrated in Fig. 1 which are evacuated by the vacuum pump of my invention are to be considered wholly in an illustrative sense. Fig. 2 illustrates one of the instrument compart-

ments shown generally in Fig. 1 as at 4. In this compartment the gyrocompass is mounted. Pipe line 4a leads to the manifold 5 from the gyrocompass casing 4. As soon as the receptacle is evacuated to the desired extent, fresh air rushes into the small pipe shown at 4c and after being screened escapes through the small nozzle 4d thus turning the drive wheel 4e of the gyrocompass. The pump is so adjusted that it creates a vacuum required by the gyrocompass of approximately 4½ pounds per square inch as required by the gyrocompass.

Fig. 21 illustrates more clearly the manner in which the casing of the oil distribution section 11 is drilled and screw threaded at one side thereof as represented at 87 and 88 for interchangeably receiving, as continuations of screw threaded ports through the base 41 and in alignment with screw threaded ports through the casing 10, the interchangeable screw threaded sleeve 85 and screw threaded plug 86, respectively. In this arrangement the suction intake pipe 8 connects to port 13 which directs the suction into the pump casing 10. The exhaust from the pump casing is directed through passage 33 and port 17 and through sleeve 85 to a position beneath baffle 43 in the oil distribution chamber. The oil which passes through the pump is returned to the oil pit 39 through discharge ports 44. The air is forced through aperture 43a in baffle plate 43 and through screened outlet 49. Any oil which is carried along with the air drains back to the oil pit through notches 43b in baffle plate 43 as heretofore explained. The one-half section screw threaded bores 87 and 88 are closed by tongues 43c on baffle plate 43 for preventing any return of oil through the discharge passage 85.

As will be clearly seen by comparing Figs. 6 and 20, the valve control housing is bodily reversible when the plug and sleeve interiorly of the pump are interchanged in position. Screw members 20a serve to secure valve housing 20 in reversible position with respect to the projection 16 of casing 10. As I have heretofore explained, the coupling tubes 31 and 32 permit the ready realignment of the passages through the wall of the pump casing 29 and 30 and the passages 26 and 28 in the valve housing 20 in reversed position. Such reversal of the valve housing 20 displaces the adjusting stem from the position illustrated in Fig. 6 to the position illustrated in Fig. 20. The valve housing 20 has an internal air passage 90 formed therein, which passage terminates in ports 90a and 90b in alignment with ports 26 and 28 in such manner that aligned ports 28 and 90b may be closed by cup-shaped valve 25. It will be seen that suction pressure created in pipe line 8 by operation of the oscillatory element of the pump tends to produce the movement of the cup-shaped piston 25 against the resistance of spring 24a. When such suction pressure reaches a predetermined value the cup-shaped valve 25 is moved against the pressure spring 24a to a position which uncovers ports 28 and 90b, thus providing a by-pass for the suction in parallel to the pump. This at once drops the degree of suction pressure. Such operation does not occur except at a predetermined suction pressure controlled by spring 24a adjusted by screw threaded stem 22.

As has been heretofore explained, the decrease in effective suction pressure may also be brought about by varying the coupling relationship between the driving frusto conical member 64 and the driven frusto conical member 65 in the oscillatory element 35. As the coupling is decreased, as represented for example in Fig. 17, the efficiency of the pumping operation is lowered by causing a wider gap between the impeller elements and the stator elements. Under such condition there is no true contact between the walls of the impeller elements and the walls of the stator elements, thus lowering the vacuum pressure which is created as the impeller elements roll with respect to the stator elements.

In order to maintain the vacuum pump of my invention in position so that the oil distribution chamber is maintained horizontal, I provide fastening means 91 on the rear of the casing 10 to which there is attached pivotally mounted strap members 92 which provide clamps engaging the support 93. The clamps 92 are secured in position by means of a bolt member 94 passing through the clamps 92 for rigidly mounting the pump in position with respect to associated equipment as represented more clearly in Fig. 1. It will be understood that a variety of methods may be employed for mounting the equipment.

In the operation of the vacuum pump of my invention it has been clearly set forth that the movement of the oscillatory element with respect to the stator is confined to such limits that a rolling movement of the impeller elements is effected with respect to the stator elements. It will be readily seen that the rocking center about which the oscillatory element 35 moves is stud 81a. Stud 81a rocks in spacer member 80, which spacer member in turn, reciprocates in slot 82a in frame 82. The eccentric drive of the oscillatory element 35 through pin 62 is such as to produce rolling movement of the impeller elements with respect to the stator elements. That is to say, the movement of the oscillatory element is a combined reciprocatory and oscillatory movement about stud 81a as a center. The lateral displacement of the oscillatory element is such that the movement of the oscillatory element is confined within limits permitted by the area between the stator elements and the impeller elements. The maximum movement which is permitted under conditions of very close coupling between the frusto conical driving member 64 and the frusto conical driven sleeve 65 is such as to produce an intimate rolling action of the impeller elements upon the stator elements for a maximum distance. However, as the coupling between the driving and driven elements is loosened, the lateral displacement of the impeller elements is lessened and the actual surface contact between the impeller elements and the stator elements may be so reduced as to render the pumping action relatively inefficient, thus materially reducing the suction pressure to a value which may be required for the particular function for which the pump is employed. It will be fully understood that the peripheral edge of the oscillatory element does not perform a rotary movement as the limits of movement of the impeller elements are limited by the slots therein which bridge the baffle plates 14 and 15 intermediate the stator elements 12. However, the driving force imparted eccentrically to the oscillatory element does result in the rolling of the surfaces of the impeller elements 36 upon the coacting surfaces of the stator elements 12. The length of such zone of contact and the intimacy of the contact is directly controlled by the coupling relation brought about by the movement of the screw threaded sleeve 51 into or out of the screw threaded central portion 42 of the oil distribution section 11.

It is believed that the theory of operation of the pump of my invention will be clearly understood from the foregoing specification but in order to summarize the method of operation it will be pointed out that the oscillatory movement of the impeller elements under control of the eccentric drive, and as limited by the reciprocatory movement of the impeller, is in fact a rolling operation of the surfaces of the impeller elements with respect to the surfaces of the stator elements by which a compression of the pumping medium is obtained for producing a suction pressure at the suction intake. The fact that two stages of impeller and stator elements are employed allow double capacity in the operation of the pump.

I have described the pump particularly for use in the production of vacuum. It will be understood that the pump is equally applicable for the pumping of fluids including water, oil, beverages, refrigerant, and other consistencies, and that by describing my invention in connection with the establishment of vacuum I do not intend my invention to be limited to the particular use disclosed.

I have found the pump construction of my invention highly practical for many uses and particularly convenient for operation on aircraft. I have described my invention in one of its preferred embodiments but I realize that modifications may be made in the construction by those skilled in the art and I desire that it be understood that the construction disclosed shall be considered in the illustrative sense and not in the limiting sense. No limitations upon my invention are intended except as may be imposed by the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. A vacuum pump comprising a casing including a plurality of projecting concentrically arranged cylindrical stator elements, intermediate baffle plates interconnecting said stator elements, said stator elements having passages interconnecting the areas between said stator elements at opposite sides of the baffle plates and separated into high and low pressure sides by the baffle plates, an oscillatory element, a plurality of annular impeller elements projecting from said oscillatory element in positions intermediate said stator elements with their ends spaced from opposite sides of said baffle plates and overlapping said passages, means for rockably and reciprocatively mounting said oscillatory element with respect to said stator elements, and means for imparting eccentric movement to said oscillatory element for effecting a rolling movement of said impeller elements with respect to said stator elements between the high and low pressure sides of said pump, said means including a rotatably mounted axially tapered cam engaging a correspondingly tapered surface of the oscillatory element and shiftable axially along the same to adjust the eccentricity of movement of the oscillatory element.

2. A vacuum pump including a casing, a plurality of concentrically arranged cylindrical stator elements in said casing, intermediate baffle plates interconnecting said stator elements, said stator elements being formed with passages at opposite sides of the baffle plates interconnecting the areas between said stator elements and separated into high and low pressure sides by said intermediate baffle plates, an oscillatory element in said casing, a plurality of annular impeller elements projecting from said oscillatory element and fitting between said stator elements with their ends spaced from opposite sides of the baffle plates, means for rockably and reciprocatively mounting said oscillatory element with respect to said stator elements, a vertically adjustable bearing carried by said casing above said oscillatory element, a driving shaft mounted in said bearing and shiftable vertically therewith, means eccentrically coupling said drive shaft with said oscillatory element for eccentrically driving the oscillatory element relative to the stator element for establishing rolling movement between surfaces of said impellers and stator elements between high and low pressure sides of the pump, said means consisting of an axially tapered cam carried by the driving shaft and engaging a correspondingly tapered surface of the oscillatory element and shiftable along the same with the shaft, and interchangeable means for controlling directional flow of fluid through the casing when the pump is in operation in accordance with the direction of rotation of said driving shaft.

3. A vacuum pump comprising a casing, a multiplicity of concentrically disposed cylindrical stator elements within said casing, baffle plates extending intermediate said stator elements and dividing said pump into high and low pressure sides, said stator elements having passages therein on opposite sides of said baffle plates interconnecting the areas between said stator elements, a circular ground edge on said casing, an oscillatory element including a central axially tapered socket portion and a multiplicity of substantially cylindrical impeller elements, said socket portion projecting into said casing and contacting with the interior face thereof, said impeller elements being disposed intermediate said stator elements and being cut away at one edge thereof and terminating on opposite sides of said baffle plates for overlapping said passages, an annular ground surface on said oscillatory element coacting with the circular ground edge on said casing, and means extending into said socket for imparting eccentric movement to said oscillatory element and producing a rolling movement of said impeller elements with respect to said stator elements intermediate the high and low pressure sides of said pump, said means including a cam received in the socket and movable axially of the socket to adjusted positions for controlling eccentricity of movement of the oscillatory element, and means interchangeably transferable from one position to another at opposite sides of said baffle plates for selectively controlling flow of fluid through the casing in accordance with the direction of rotation of the means extending into the socket.

4. A pump comprising a casing, a multiplicity of cylindrical stator elements projecting vertically within said casing, baffle plates disposed intermediate said stator elements and in a substantially radial plane, an upstanding peripheral edge on said casing, an oscillatory element having a bearing surface mounted on said upstanding peripheral edge, a multiplicity of impeller elements projecting from said oscillatory element in positions intermediate said stator elements and terminating on opposite sides of said baffle plates, an annular oil trough circumferentially disposed about the peripheral edge of said casing, and having an upstanding outer marginal wall, an oil distribution chamber disposed above said oil trough and directly secured upon the outer marginal wall thereof, vertically adjustable driving means journaled in said oil distribution chamber

for imparting eccentric movement to said oscillatory element, said driving means including cam means shiftable vertically therewith for varying the eccentric movement, and interchangeable elements for selectively controlling flow of fluid through the casing and oil distribution chamber in accordance with the direction of rotation of said journaled means.

5. A pump comprising a casing, a multiplicity of cylindrical stator elements projecting vertically within said casing, baffle plates disposed intermediate said stator elements and in a substantially radial plane, an oscillatory element supported on said casing and having a multiplicity of impeller elements depending therefrom in positions intermediate said stator elements and terminating on opposite sides of said baffle plates, an annular oil trough circumferentially disposed about the peripheral edge of said casing, an oil distribution chamber supported on said casing above said annular oil trough and oscillatory element, a central screw threaded cylindrical bore extending through said oil distribution chamber, the oscillatory element having a pocket below said bore, a threaded sleeve screwed into said bore for vertical adjustment therein, a driving shaft journaled in said sleeve, a head carried by said driving shaft adapted to have wedging fit in said pocket and eccentrically drive said oscillatory element with respect to said stator elements, and a spring in said pocket engaging said head for urging the head upwardly in the pocket.

6. A pump comprising a casing, a multiplicity of stator elements projecting vertically within said casing, baffle plates disposed intermediate said stator elements, an upstanding peripheral edge on said casing, an oscillatory element having a bearing surface resting on said upstanding peripheral edge, a multiplicity of impeller elements projecting from said oscillatory element and disposed between said stator elements with their ends terminating on opposite sides of said baffle plates, an annular oil trough circumferentially disposed about the peripheral edge of said casing, an oil distribution chamber disposed above said annular oil trough and supported upon said casing, a central cylindrical bore extending through said oil distribution chamber, a sleeve adjustable vertically in said bore, a driving shaft journaled through said sleeve, an eccentric pin carried by the end of said shaft, a clutch element carried by said eccentric pin for frictional engagement with said oscillatory element whereby rotary motion imparted to said shaft operates to eccentrically drive said impeller elements with respect to said stator elements, and yieldable means for urging said clutch element out of engagement with the oscillatory element.

7. A pump comprising a casing, means for mounting said casing in a substantially horizontal position, a plurality of cylindrical stator elements concentrically disposed within said casing and extending in a vertical position, and an upstanding ground peripheral edge on said casing, baffle plates extending across the space between said stator elements in a substantially radial plane, an oscillatory element having a circular bearing face resting upon said ground peripheral edge, impeller elements depending from said oscillatory element between said stator elements and terminating in spaced relation on opposite sides of said baffle plates, said casing having passages extending therethrough on opposite sides of said baffle plates for admitting and discharging the pumping medium to and from said pump, an oil distribution chamber over said casing, an annular trough on said casing surrounding the ground peripheral edge thereof, a rotary drive shaft journaled through said oil distribution chamber, means carried by said rotary drive shaft and projecting below the base of said oil distribution chamber and frictionally engaging said oscillatory element for eccentrically driving said oscillatory element, a spring urging the last mentioned means out of position for frictional engagement with the oscillatory element, an upstanding stud carried by said oscillatory element, a cam pivotally mounted on said stud, and a slotted frame member carried by the base of said oil distribution chamber constituting a guide for said cam for controlling the rocking and reciprocative movement of said oscillatory element in accordance with the eccentric movement imparted thereto through said drive shaft.

8. A pump comprising a casing having a pair of interchangeable inlet connections, a multiplicity of concentrically disposed cylindrical stator elements projecting vertically within said casing, baffle plates disposed intermediate said stator elements in a radial plane, passages interconnecting each of said inlet connections with said stator elements and providing a suction intake on one side of said baffle plates and a discharge on the other side of said baffle plates, an oscillatory element supported by said casing, said oscillatory element having a plurality of circular impeller elements intermeshing with said stator elements and terminating on opposite sides of said baffle plates, an oil distribution chamber connected with said casing, a rotatable drive shaft journaled through said oil distribution chamber and eccentrically connected with said oscillatory element, and interchangeable plug and sleeve connections between said interchangeable inlet connections and said oil distribution chamber for selectively defining the path of discharge from said pump according to the position of the connection of the suction intake with the inlet connections and in accordance with the direction of rotation of said rotary drive shaft.

9. A pump comprising a casing having interchangeable inlet connections, stator elements in said casing, baffles extending across the space between said stator elements, passages leading from said inlet connections and providing a suction intake on one side of said baffles and an outlet on the other side of the baffles, an oscillatory element carried by said casing and having impeller elements fitting between said stator elements and terminating on opposite sides of said baffles, an oil distribution chamber connected with said casing, a rotary drive shaft journaled through said chamber and operatively connected with said oscillatory element, and interchangeable plug and sleeve connections between said interchangeable inlet connections and said chamber for selectively defining the path of discharge from said pump according to the position of the connection of the suction intake with the inlet connections and in accordance with the direction of rotation of said rotary drive shaft.

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