June 2, 1942. C. H. DUFFY 2,284,645

AIR PUMP OR COMPRESSOR

Filed Jan. 27, 1941 2 Sheets-Sheet 1

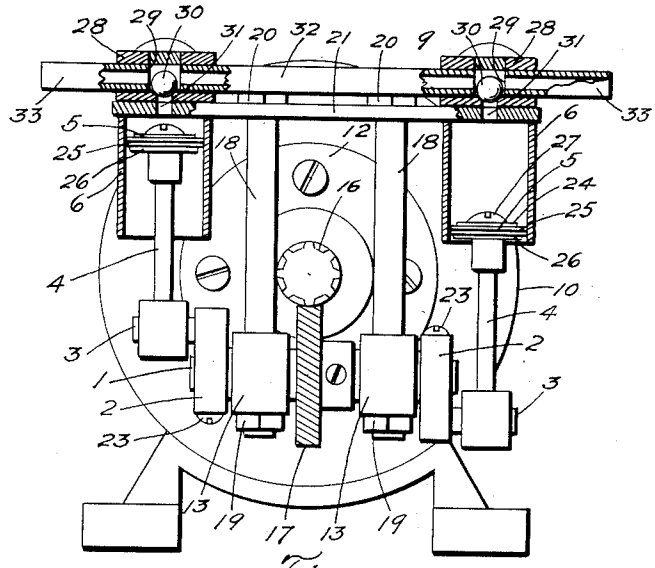



Fig. 1

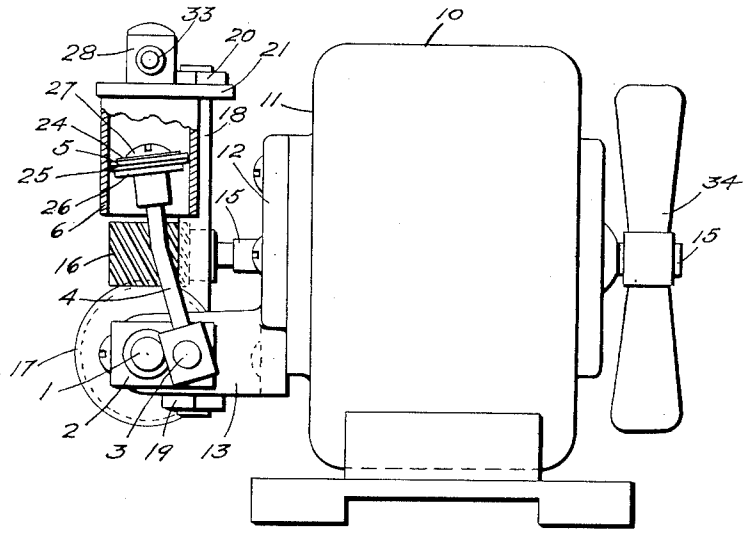



Fig. 2

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Fig. 3

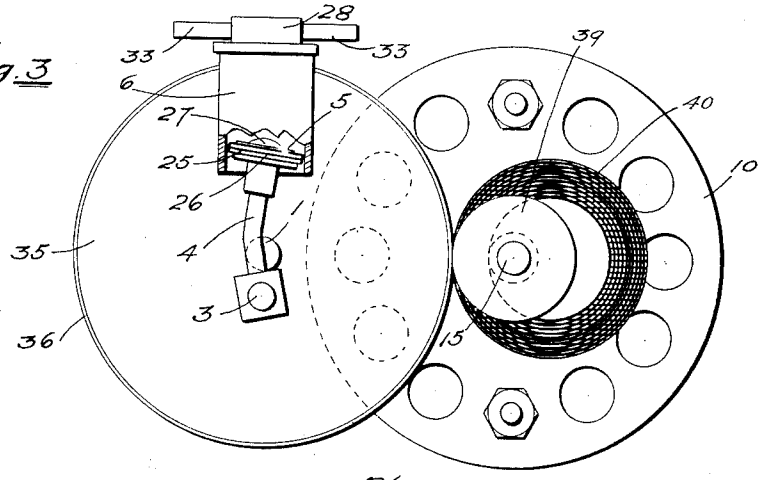
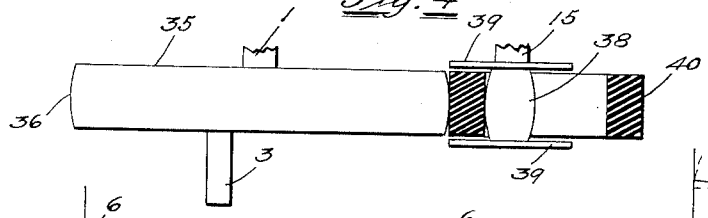



Fig. 4



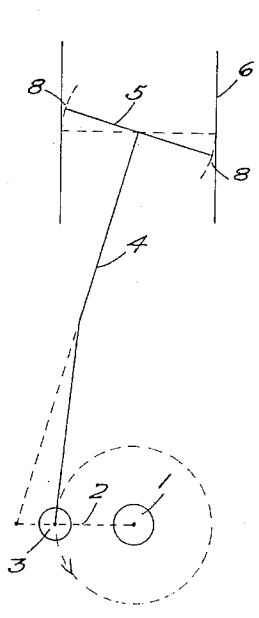




Fig. 5

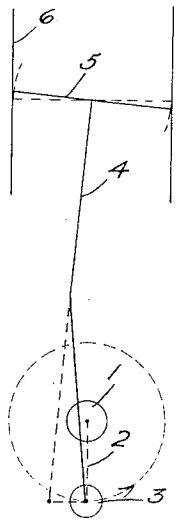



Fig. 6

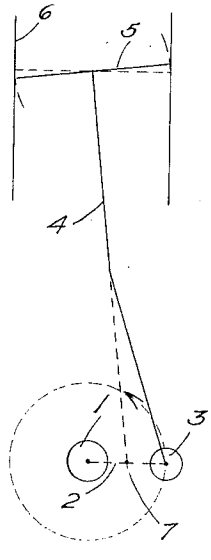



Fig. 7

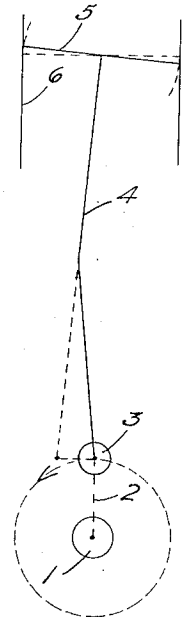



Fig. 8

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Patented June 2, 1942

2,284,645

# UNITED STATES PATENT OFFICE

2,284,645

## AIR PUMP OR COMPRESSOR

Charles Hugh Duffy, Miami, Fla.

Application January 27, 1941, Serial No. 376,120

13 Claims. (Cl. 230—190)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

The invention described herein may be manufactured and used by or for the Government of the United States for governmental purposes without the payment to me of any royalty thereon in accordance with the provisions of the act of April 30, 1928 (Ch. 460, 45 Stat. L. 467).

This invention relates to air-pumps or compressors, and has for its object to provide a device of this class which is particularly applicable for laboratory use, or for aerating the water in small tanks or the like where a small portable electrically driven pump or compressor is desirable.

The invention consists of the pump which dispenses with an air intake valve, and in the piston and rod arrangement, and in the construction for mounting the pump directly on the electric driving motor; while in one embodiment, the invention consists of the frictional driving mechanism for driving the pump.

Referring to the accopanying drawings:

Fig. 1 is a front elevation of one example of the invention showing the same directly mounted on the electric driving motor, some of the parts of the pump being shown in vertical section.

Fig. 2 is a side elevation of the same.

Fig. 3 is a somewhat diagrammatic front elevation of a modified construction illustrating the friction drive mechanism for actuating the pump.

Fig. 4 is a fragmentary top plan view of the same, the friction ring or member being shown in horizontal section.

Figs. 5, 6, 7 and 8 are diagrammatic views illustrating the positions which the piston and rod assume at the four principal points in a complete cycle.

Like numerals of reference indicate the same parts throughout the several figures.

For a quicker understanding of the invention, it is, perhaps, preferable to describe first the pump or piston action as illustrated in the diagrammatic Figures 5, 6, 7 and 8.

In these views, 1 indicates the rotating pump shaft, 2 the crank, and 3 the crank-pin. 4 indicates the piston rod, 5 indicates the piston and 6 the wall of the pump cylinder.

It will be noted that the piston rod is rigidly connected to the piston so that the piston assumes various angular positions within the pump cylinder as the crank-pin 3 revolves about the pump shaft 1, and also that the piston rod 4 may be bent out of a straight line so that when the crank-pin 3 is on upper and lower dead centers as shown in Figs. 6 and 8, the plane of the piston 5 is disposed angularly to the vertical axis of the pump cylinder 6, and not perpendicularly to said axis as would be the case if the piston rod 4 were straight. The extent of the angularity which the piston will assume with respect to the cylinder 6 will depend, of course, upon the amount of the bend imparted to the piston rod.

While for successful operation the exact amount that the piston rod is bent out of a straight line is not critical, I have found that the amount of bend illustrated in the diagrammatic Figures 5 to 8 is very satisfactory. In this instance, it will be seen by reference to Fig. 7, that a line projected downwardly from the center of the piston 5 and perpendicular to the plane of the piston, will exactly bisect the crank 2, at the point 7 which is the mid-point of the crank 2. This causes the angularity of the rigidly connected piston 5 with respect to the cylinder 6 when the crank 2 is horizontal on its upstroke to be exactly the same as it would be if the piston rod were straight and the length of the crank 2 were one-half the actual length illustrated. It will also be seen that by reason of this amount of bend imparted to the piston rod 4, the angularity of the piston 5 with respect to the vertical axis of the cylinder 6 is the same when the crank 2 is on bottom dead center, as in Fig. 6; on top dead center as in Fig. 8, and horizontal on its upstroke as in Fig. 7.

But comparing Fig. 7 with Fig. 5, which illustrates the angularity of the piston 5 when the crank 2 is horizontal on the down-stroke, a very decided difference will be seen. In the case of Fig. 5, the bend in the piston-rod 4 has disposed the plane of the piston 5 at the same angle with relation to the vertical axis of the cylinder 6, as would be the case if the throw of the crank 3 were one and one-half times longer than it is actually illustrated to be.

With this description of the preferred extent of bending the piston-rod 4 of the rigidly connected piston 5, the effect of such bending on the piston action is as follows: It being understood that the piston is in the nature of a disk, and is made up of one or more disks of suitable pliable material, such as leather, as will be presently described, it will now be assumed that the piston 5 is at the top dead center, as shown in Fig. 8, and is about to commence its down stroke. As the crank-pin swings over its top dead center, the angularity of the piston 5 is progressively increased as it continues its down-stroke, and reaches a maximum when the crank 2 reaches its horizontal position as shown in Fig. 5. This progressive increase in angularity of the piston has definitely opened up two spaces 8 on diametrically opposite

sides of the piston between the edge of the piston and the wall of the cylinder 6. These two openings 8 produce the same effect as open valves and permit the air to pass by the piston and into the cylinder during its down or intake stroke. As the crank 2 swings past its horizontal position, on its down or intake stroke, the angularity of the piston progressively diminishes and the extent of the openings 8 progressively diminishes until the crank 2 swings past its lower dead center, as shown in Fig. 6, and starts the piston 5 on its upward or working stroke, at which time the angularity of the piston 5 becomes zero, and the air which has passed by the piston on its down or intake stroke is confined in the cylinder to be compressed or suitably discharged by the upward or compression stroke of the piston. As the crank-pin 3 reaches its horizontal position on this upstroke (Fig. 7), the maximum angularity of the piston 5 occurs. But this maximum is only one-third the maximum angularity which the piston assumed on its down or intake stroke (Fig. 5). This angularity of the piston (Fig. 7) is so slight that the pliability and resiliency of the piston material practically closes the cylinder so that no leakage of air past the piston has been noted. As, however, the crank-pin 3 swings past its horizontal position, the angularity of the piston progressively diminished until it again becomes zero just before the crank pin 3 reaches its top dead center, at which time compression of the air in the cylinder is greatest. As the crank-pin 3 reaches its top dead center. (Fig. 8) the piston 5 has begun to assume the angularity which progressively increases on its downstroke to its maximum (Fig. 5) as heretofore described. The result of this construction and resulting piston action is that no air-intake valve is required, but only a simple outlet check valve need be provided to prevent the air which has been discharged on the compression stroke of the piston from passing back into the cylinder, as will be presently described.

From an examination of the diagrammatic Figures 5 to 8, it becomes obvious that since the piston action depends on the fact that the piston is established in an angular position in the cylinder in the manner described, which angularity is substantially greater during its outward or intake stroke than during its inward or working stroke, such angularity of the piston may be obtained by forming the end surface of the piston rod on the desired angle and without bending the piston, so that when the piston is seated on such angularly formed end, the piston will assume the same angle as is given the end surface of the piston. In this case the piston rod is initially formed to support the piston at the desired angle, or the piston rod is initially formed straight and subsequently bent to dispose the piston at the desired angularity. In either instance, the piston rod may be said to be shaped to rigidly support the piston angularly thereto, and the piston may be described as having its transverse plane tilted with respect to the transverse plane of the cylinder to a lesser extent during its inward or working stroke than during its outward or intake stroke.

Referring now to Figs. 1 to 4 which illustrate two embodiments of the application of this pump action to operative devices, it will be seen from Fig. 1, that the pump 9 is mounted directly on the electric driving motor 10 so that the pump and motor becomes a unitary device. For this purpose, a worm-gear drive, such as is disclosed in U. S. Patent No. 2,082,446, may be conveniently employed. Suitably secured to the front end 11 of the motor 10 is a bracket 12 which includes two parallel and horizontally projecting arms 13, bored out to receive a horizontal driven shaft 1. Upon the motor or armature shaft 15 is secured a suitable worm 16 which meshes with a suitable worm wheel or gear 17 fixed on the horizontal driven shaft 1 between the two arms 13 of the bracket 12. Any suitable speed reduction may be obtained from such worm and gear. Since reciprocating pumps lose efficiency if operated at high speed, I have found that a speed of about 400 R. P. M. for the horizontal driven shaft 1, which, in this case becomes the pump shaft, is entirely satisfactory. To accomplish this reduction of the motor speed, for the particular motor used, an eight thread worm 16 as shown in Fig. 1 is employed while the worm wheel or gear with which the worm meshes has 36 teeth giving a reduction ratio of 4½ to 1.

In the particular pump or compressor illustrated in Figs. 1 and 2, the motor 10 is of the four pole shaded pole type of a fractional H. P. of 1/200, while the pump or compressor which is double acting has pistons of ⅝" diameter with ⅝" strokes, this data being stated merely as an example and not as a limitation.

Referring further to Fig. 1, there is provided in each of the bracket arms 13 at points adjacent to but in rear of the horizontal driven shaft 1, a vertical hole, in each of which is mounted a vertical post 18, each of which posts is secured in its bracket arm 13 by nuts 19 bearing on the underside of the bracket arms.

Secured on the upper ends of the posts 18, as by nuts 20 is a flat horizontal plate 21, which forms the heads for the two pump cylinders, to which plate 21, the cylinders 6 may be effectively attached as by soldering, brazing or welding, or in any other approved manner.

Secured on each end of the driven shaft 1, is a crank 2 fixed thereon by set screws 23, and in each crank 2 is a crank-pin 3.

4 indicates the piston rods mounted on the crank-pins 3, and 5 indicates the pistons which are rigidly secured to the tops of the piston rods 4. In the example shown, each piston 5 includes a thin disk of stiff fibre of about ½" diameter and two thin disks 25 of leather or other suitable flexible and resilient material each ⅝" in diameter and a thin metallic disk 26 of about 9/16" diameter, the fibre disk 24 and metal disk 26 having for their purpose to stiffen the body portions of the two thin flexible disks 25, between which first mentioned disks, the flexible disks are clamped, and at the same time permitting the peripheral edges of the disks 25 a flexible and resilient contact with the cylinder wall. The pistons 5, so constructed, are rigidly secured to the ends of the piston-rods, as by a machine screw 27 threaded into the end of each piston rod 4.

Suitably mounted on the top of the cylinder-head-plate 21 and directly above each cylinder 6, is, what may be termed a valve-chest 28. This is preferably square in cross section, as shown in Fig. 2, and has formed therein a vertical hole 29 reduced near its lower end to form a seat for a ball 30, the reduced bore 31 also passing through the cylinder-head-plate to form a port 31 through which air is discharged from the pump cylinder. Connecting each of the valve-chests 28 is a tube 32, and extending from the outer ends of each valve chest is a short tube 33, to which flexible tubings may be connected. By

this construction, the valve-controlled outlet ports 31 of each cylinder are connected, so that the discharge from both cylinders may be caused to pass out through only one end-tube 33 by suitably closing up the other end-tube 33, or if desired, a simple relief valve (not shown) may be connected to one end-tube 33, so as to relieve as little or as much of the pressure passing from the other end-tube as may be desired.

As will appear from Fig. 2, the piston rods 4 are bent to secure the piston action which has been hereinbefore described with respect to the diagrammatic Figs. 5 to 8, while the armature shaft 15 may extend through the rear end of the motor casing upon which a cooling fan 34 may be mounted, since in some applications of the pump, the operation is continuous over a long period of time.

Referring to Fig. 3, it will be seen that in the embodiment illustrated, the pump is driven by a friction drive which includes a large driven wheel or pulley 35 having a crowned peripheral surface 36 and mounted on a shaft 1. In this case, I prefer to dispense with a crank, and mount the crank-pin 3 directly on the driven wheel or pulley 35. 10 indicates the motor, and 15 indicates the motor or armature shaft. Mounted on this shaft is the crowned driving pulley 38 having two flanges 39.

40 indicates the friction ring, which may be made of a suitable rubber, or synthetic rubber or other resilient and wear resisting composition. This ring 40 has an internal diameter sufficient to permit its being forced over the outside flange 39 of the crowned driving pulley 38 and be positioned between the two crowned surfaces of the driving and driven pulleys 38 and 35. Any suitable means (not shown) may be provided to maintain the motor 10 and its driving pulley 38 in position so as to exert sufficient pressure upon the friction ring 40 to cause effective frictional contact between the driving pulley 38 and the inside surface of the ring 40, and between the outside surface of the ring 40 and the crowned surface of the driven wheel or pulley 35, so that an effective rolling contact may be maintained between the coacting surfaces of all three of these elements.

It is preferable that the width and thickness of the friction ring 40 be such that, in operation, it will maintain its normal annular form by having sufficient inherent rigidity. This will result in smoother operation with absence of vibration.

It is also desirable to prevent contact of the sides of the friction ring with the side flanges 39 of the driving pulley 38, as such contact would create a slight drag and prevent a perfect rolling contact of the pulley 38 on the inner surface of the friction ring. In order to accomplish an effective centering of the friction ring 40 on the pulley 38 and between the two side flanges thereof, the surface of driving pulley 38 is crowned, as shown, while the coacting surface of the driven wheel or pulley 35 may also be crowned as shown for the same purpose.

Any desired gear ratio may be obtained, the effective diameter of the driving elements of the device being the actual diameter of the crowned driving pulley 38 plus the cross-section thickness of the friction ring 40.

The description of the pump elements shown in Figs. 1 and 2 apply to the example shown in Fig. 3, except that in the single cylinder pump shown in this figure, the two short tubes 33 extend from the single valve-chest 28, to which tubes 33, flexible tubes may be connected or a relief valve may be connected to one of the tubes 33 for the same purpose heretofore stated with respect to Figs. 1 and 2.

The object of the construction and arrangement of the rolling friction ring 40 as described is to obviate the disadvantages usually resulting from the provision of a resilient ring or cover fixed on the peripheral surface of one or both of the contacting pulleys. If the surface of the driven wheel or pulley 35 is provided with a fixed resilient cover for the purpose of driving a fluctuating load such as the piston pump illustrated, the wear on such cover is localized on one portion of the periphery of the cover which is in contact with the driving pulley during the compression or working stroke of the piston. This, of course, results in an uneven wearing of the surface of the cover and an ultimate eccentricity thereof unfavorable to smooth and steady operation. On the other hand, if the driving pulley is surfaced with a resilient cover, the peripheral area of the same is so small that the wear is excessive and the length of contact with the driven wheel or pulley is so short that slippage is prevented only by the application of greater pressure than is favorable to the armature shaft and bearings. As opposed to these disadvantages, the provision of the solid friction ring 40 of much greater diameter than the crowned driving pulley and rolling between the driving and driven pulleys provides that the points of contact of the periphery of the friction ring are constantly changing with respect to the contacting surface of the driven pulley so that the wear on the friction ring is not localized on any particular portion of its periphery, while the relatively great peripheral area of the friction ring results in the distribution of normal wear over a much greater surface than is the case where the driving pulley is provided with a small fixed frictional cover of relatively small peripheral area.

As an additional advantage, the length of frictional contact between the crowned driving pulley 38 and the internal surface of the friction ring 40 is much greater than if such driving pulley were in contact with a resiliently covered driven pulley, since in the former case, the contact is between the convex surface of the driving pulley and the concave inner surface of the friction ring, while in the latter case the contact would be between the convex surface of the driving pulley and the convex surface of the driven pulley. These materially increased areas of frictional contact between the driving pulley and the friction ring and between the friction ring and the driven pulley result in more effective frictional contacts requiring the application of reduced pressure between the three coacting elements of the friction drive.

Having thus described the invention, it is apparent that the same may be changed, altered or modified in the construction and arrangement of the parts without departing from its spirit and scope, and I consider myself clearly entitled to all such changes and modifications as fall within the limit and scope of the appended claims.

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

1. In an air pump or compressor, the combination with an electric motor having a worm on

its armature shaft, a worm wheel or gear meshing with said worm, a driven shaft upon which said worm wheel or gear is fixed, a bracket fixed on the motor casing for mounting the driven shaft, of a pair of vertical posts mounted on the bracket, a cylinder-head-plate horizontally mounted on the upper ends of the vertical posts, a pair of pump cylinders fixed to the underside of the cylinder-head-plate and depending therefrom, a crank fixed on each end of the said driven shaft, each crank including a crank-pin, a piston-rod mounted on each crank-pin, and a check-valve-controlled discharge port for each pump cylinder, the discharge ports of the two pump-cylinders being connected by a common passage, a piston rigidly fixed on the upper end of each piston-rod, each of the piston-rods being positioned to dispose its rigidly fixed piston in a plane angularly with relation to the longitudinal axis of its cylinder, in such manner that during the outward or intake stroke of the piston, the angularity of its transverse plane with relation to the longitudinal axis of its cylinder is substantially greater than it is on its inward or working stroke, whereby on the outward or intake stroke of the piston, this greater angularity of the plane of the piston is sufficient to create a space between the piston and the wall of the cylinder to permit air to pass by the piston and into the cylinder, while on the inward or working stroke of the piston, the lesser angularity of the plane of the piston with relation to the longitudinal axis of its cylinder results in the piston substantially closing the cylinder to retain the air therein and discharge the same through its cylinder discharge port.

2. In an air-pump or compressor, the combination with an electric motor and its armature shaft, of a crowned driving pulley mounted on the armature shaft, side flanges on the driving pulley, a driven pulley having a crowned peripheral surface adjacent the crowned driving pulley, a friction ring of suitable resilient material having an internal diameter greater than that of the crowned driving pulley and disposed on the crowned driving pulley and between the crowned surface thereof and the crowned surface of the driven pulley, whereby a rolling contact is established between the crowned driving pulley and the internal surface of the friction ring, and between the external surface of the friction ring and the crowned surface of the driven pulley, the friction ring being maintained centrally of the driving pulley by the coaction between the two crowned surfaces of the two pulleys on the internal and external surfaces of the friction ring, the width and thickness of the friction ring being such as to impart enough rigidity to the ring to cause it to maintain substantially into normal annular form in operation.

3. In an air pump or compressor, the combination with an electric motor and its armature shaft, of a crowned driving pulley mounted on the armature shaft, side flanges on the driving pulley, a driven pulley having its peripheral surface adjacent the crowned driving pulley, a friction ring of suitable resilient material and having an internal diameter greater than that of the crowned driving pulley and disposed thereon between the crowned surface thereof and the adjacent surface of the driven pulley, whereby a rolling contact is established between the crowned driving pulley and the internal surface of the friction ring, and between the external surface of the friction ring and the contacting surface of the driven pulley, the friction ring being maintained centrally of the driving pulley by the coaction between the crowned surface of the driving pulley and the internal surface of the friction ring.

4. In a friction drive for air pumps and the like, a driving pulley having side flanges, a driven pulley having its peripheral surface adjacent the driving pulley, the adjacent surface of one of the pulleys being crowned, and a friction ring of greater internal diameter than the driven pulley and disposed thereon between and in contact with the adjacent surfaces of the two pulleys, the friction ring being maintained centrally of the driven pulley by the coaction between the contacting crowned surface of one of the pulleys with the friction ring.

5. In an air-pump or compressor, the combination with an electric motor having a worm on its shaft, a worm wheel meshing with said worm, a driven shaft upon which said worm wheel is fixed, a bracket fixed on the motor casing for mounting the driven shaft, of posts mounted on the bracket, a cylinder-head-plate mounted on the outer ends of the posts, a pair of pump cylinders fixed on the cylinder-head-plate, a crank fixed to each end of the driven shaft, each crank including a crank-pin, a piston rod mounted on each crank-pin, a piston rigidly fixed on the upper end of each piston-rod and disposed for operation in the said pump cylinders, a discharge port and check valve for each pump cylinder, the latter preventing return of air back through the discharge port into the pump cylinder, the transverse plane of each piston being tilted with respect to the transverse plane of its cylinder to a lesser extent during its inward or working stroke than during its outward or intake stroke for the purposes described.

6. In an air-pump or compressor, the combination with an electric motor having worm gearing and provided with a bracket fixed on the motor casing and having a driven shaft mounted in said bracket, of a pair of pump cylinders and means for mounting them on the bracket, a crank and crank pin on each end of the driven shaft, a piston rod mounted on each crank pin, a piston rigidly fixed on each piston rod and disposed for operation in the pump cylinders, and a discharge port and check valve for each pump cylinder, the transverse plane of each piston being tilted with respect to the transverse plane of its cylinder to a lesser extent during its inward or working stroke than during its outward or intake stroke for the purposes described.

7. In an air-pump or compressor, the combination with an electric motor having worm gearing and provided with a bracket fixed on the motor casing and having a driven shaft mounted in the said bracket, of a pair of pump cylinders and means for mounting them on the bracket, piston rods and pistons rigidly fixed on the rods and disposed for operation in the pump cylinder and actuated by the driven shaft, the transverse plane of each piston being tilted with respect to the transverse plane of its cylinder to a lesser extent during its inward or working stroke than during its outward or intake stroke for the purposes described.

8. In an air-pump or compressor, the combination with an electric motor having worm gearing and provided with a bracket fixed on the motor casing and having a driven shaft mounted in the said bracket, of a pump cylinder and means for mounting it on the bracket, a piston rod and

piston rigidly fixed thereon and disposed for operation in the pump cylinder and actuated by the driven shaft, the transverse plane of the piston being tilted with respect to the transverse plane of the cylinder to a lesser extent during its inward or working stroke than during its outward or intake stroke for the purposes described.

9. In an air-pump or compressor, the combination with an electric motor having a driven shaft and worm gearing for driving the shaft and provided with a bracket for the driven shaft fixed on the motor casing, of vertical posts mounted on the bracket, a cylinder-head-plate horizontally mounted on the upper ends of the vertical posts, a pair of pump cylinders fixed to the underside of the cylinder-head-plate and depending therefrom, a crank and crank-pin on each end of the driven shaft, a piston rod mounted on each crank-pin, pistons disposed for operation in the pump cylinders and actuated therein by the piston rods, a discharge port and check valve for each pump cylinder, the latter preventing return of air back through the discharge port into the pump cylinder, and means for effecting communication between the discharge ports of the pump cylinders.

10. In an air-pump or compressor, the combination with an electric motor having a driven shaft and worm gearing for driving the shaft and provided with a bracket for the driven shaft fixed on the motor casing, of posts mounted on the bracket, a cylinder-head-plate mounted on the posts, a pair of pump cylinders fixed on the cylinder-head-plate, a crank and crank pin on each end of the driven shaft, a piston-rod mounted on each crank-pin, pistons on the piston rods disposed for operation in the pump cylinders and actuated therein by the piston rods, a discharge port for each pump cylinder and means for preventing return of air back through the discharge ports of the pump cylinders.

11. In an air-pump or compressor, the combination with an electric motor having a driven shaft and worm gearing for driving the shaft, and provided with a bracket for the driven shaft fixed to the motor casing, of a pair of pump cylinders and means for mounting them on the bracket, a crank and crank-pin on each end of the driven shaft, a piston-rod mounted on each crank-pin, pistons on the piston rods disposed for operation in the pump cylinders and actuated by the piston rods, a discharge port for each cylinder and means for preventing return of air back through the discharge ports of the pump cylinders.

12. In an air-pump or compressor, the combination with an electric motor and gearing, which includes a worm gear on the motor shaft, a driven shaft, a bracket fixed on the motor casing, the bracket having arms extending outwardly from the motor casing for mounting the driven shaft transversely of the motor shaft and a worm-wheel fixed on the driven shaft for meshing engagement with the worm on the motor shaft, of a pair of pump cylinders and means for mounting them on the said bracket arms in such manner that the bracket arms which mount the driven shaft also mount the pump cylinders, pistons disposed for operation in the pump cylinders and piston rods operated by the driven shaft for actuating the pistons.

13. In an air-pump or compressor, the combination with an electric motor and gearing, which includes a worm gear on the motor shaft, a driven shaft, a bracket fixed on the motor casing, the bracket having arms extending outwardly from the motor casing for mounting the driven shaft transversely of the motor shaft and a worm-wheel fixed on the driven shaft for meshing engagement with the worm on the motor shaft, a pump cylinder and means for mounting it on the said bracket arms in such manner that the bracket arms which mount the driven shaft also mount the pump cylinder, a piston disposed for operation in the pump cylinder, and a piston rod operated by the driven shaft for actuating the piston.

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