Dec. 10, 1935. M. E. CROWLEY 2,023,466

PUMP

Filed Feb. 18, 1933

Fig. 1.

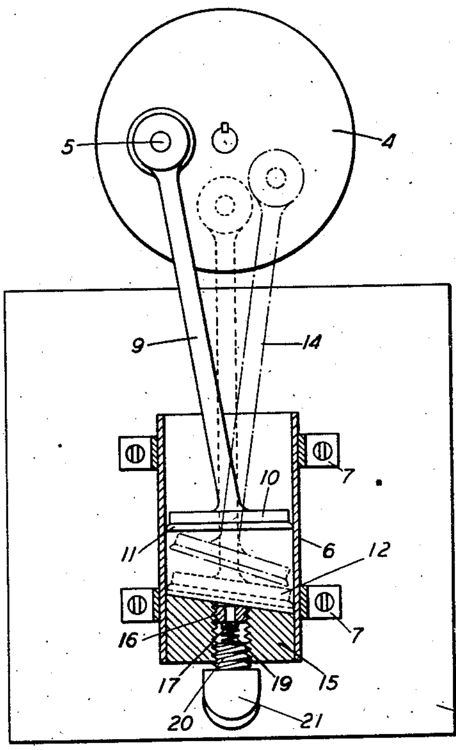


Fig. 2.

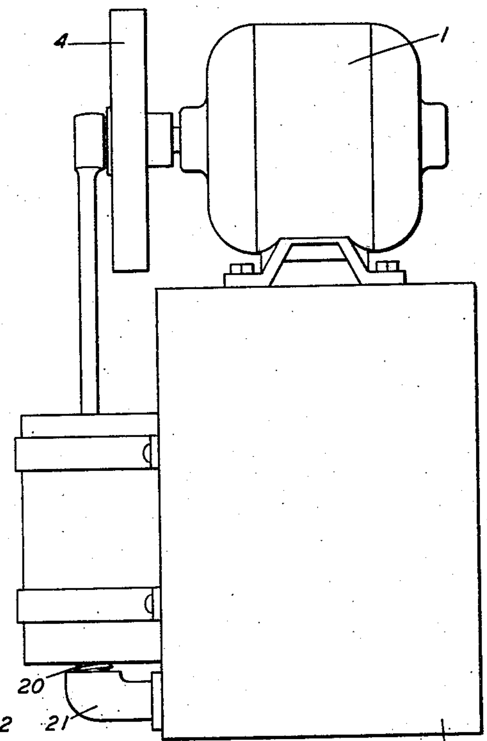


Fig. 3.

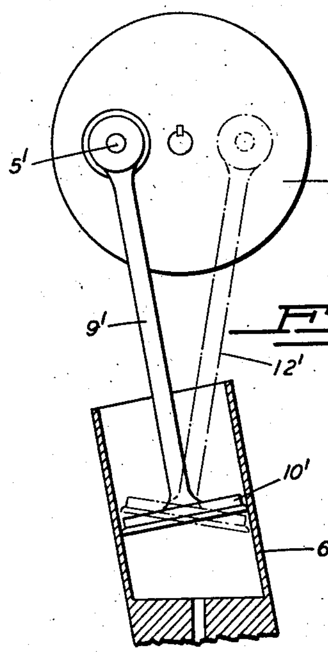
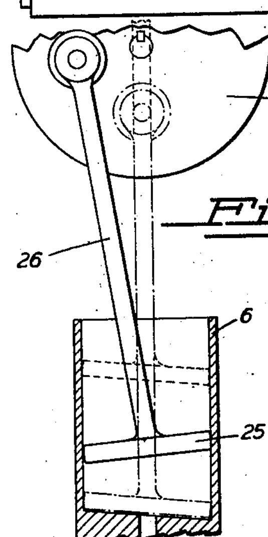


Fig. 4.



INVENTOR.
MILLARD E. CROWLEY.
BY Donald K. Lippincott
ATTORNEY

UNITED STATES PATENT OFFICE

2,023,466

PUMP

Millard E. Crowley, San Francisco, Calif., assignor of one-half to Blake F. Hopkins, San Francisco, Calif.

Application February 18, 1933, Serial No. 657,335

10 Claims. (Cl. 230—172)

My invention relates to pumps of the reciprocating type, and particularly to air compressors, this application being a continuation in part of my copending application, Serial No. 586,433, now forfeited, insofar as it relates to common subject matter.

Among the objects of this invention are: To provide a combined piston and mechanically operated valve for reciprocating pumps; to provide a mechanically operated intake valve which is applicable to compressors even in very small sizes; to provide a high efficiency pump of the compressor type; to provide an air pump of small size which can be run at high speed; and to provide a pump of high output which is small in size and economical in manufacture and operation.

Other objects of my invention will be apparent or will be specifically pointed out in the description forming a part of this specification, but I do not limit myself to the embodiment of my invention herein described, as various forms may be adopted within the scope of the claims.

Referring to the drawing:

Figure 1 is a partly diagrammatic sectional view of a pump embodying my invention, the plane of section being taken through the pump cylinder.

Figure 2 is a side elevation of the pump shown in Figure 1.

Figure 3 is a diagrammatic sectional view showing a section through the cylinder of a modified form of pump embodying my invention.

Figure 4 is a similar view showing a modified form of piston as applied to the pump of Figure 1.

In general terms the pump of my invention comprises the usual cylinder, within which is fitted a piston having a head of such form that it may be tilted within the cylinder. Means are provided for reciprocating the piston within the pump and tilting it within the cylinder in concurrent cycles, so that on one stroke of the piston, which may be called the advance stroke, the piston contacts with the entire cylinder wall, while on the other or return stroke the tilted piston contacts only a portion of the wall, permitting the fluid which is to be pumped to pass by the piston into the space beneath it. The tilting piston head therefore operates not only as a piston but as a mechanically operated valve whose cycle of operation is properly timed with respect to the piston stroke.

Reciprocating pumps operating on compressible fluid, i. e., compressors, are inefficient at best. Even in pumps of large size, where there is ample room for the mounting of valves and operating mechanism, the thermodynamic cycle is such that high efficiency is difficult of attainment, but in the small sizes, where considerations of space and expense makes the use of mechanically operated valves of the usual poppet or slide-valve type impracticable, and resort is had to spring controlled intake valves operated by the pressure of the external air, the efficiency drops with startling rapidity.

One of the major causes of the low efficiency is the fact that a sufficiently high vacuum must be established within the cylinder to hold the valve open during the intake portion of the stroke, so that at the beginning of the compression stroke the gas within the cylinder is at less than atmospheric pressure. Furthermore, unless great care is used in design the tendency of the spring to close the intake valve keeps the effective port small, and the gas must enter at high velocity, causing "wire-drawing" with consequent loss of efficiency. The result is that a very small amount of compressed air is obtained when the power expended to operate the apparatus is considered. The outlet valve, through which the gas passes at low velocity, and usually into a tank or receiver where the pressure is relatively high, although causing a loss in efficiency, is not nearly as important a factor as the intake valve. This invention is primarily directed toward reducing intake valve losses, although simplicity of construction is also an important factor.

In the drawing a preferred form of the invention is shown, this drawing being in semi-diagrammatic form so that the essential features of the invention may not be obscured by non-essential detail.

The compressor illustrated is a small size, relatively high speed type, adapted for operation by a fractional horse power electric motor 1. The motor is mounted upon a rectangular air tank or receiver 2, which serves as a base and mounting for both the motor and the compressor.

A fly wheel 4 is preferably provided on the motor shaft in order to reduce vibration, a crank pin 5 being affixed to the fly wheel. Suitable counter weighting for the pin and other reciprocating parts may be provided within the rim of the fly wheel, in accordance with well known practice, but this is not shown as it is a mere mechanical expedient well known in the art.

A cylinder 6 is mounted upon one face of the receiver 2 by means of straps or clamps 7. The cylinder is conveniently formed of seamless drawn tubing, and may be of round, rectangular, or other cross section, as convenience may dictate.

Journaled on the pin 5 and extending into the cylinder is a piston comprising a connecting-rod 9, rigidly secured to a piston head 10. The latter is preferably relatively thin and flat, and fits within the cylinder with sufficient clearance so that it may tilt freely without binding. It is preferably, although not necessarily, provided with a cup leather 11, which forms a seal with the wall of the cylinder. The cup leather may be of leather, rawhide, fiber, or other conventional material.

In the form of the invention illustrated in Figure 1, the piston head is disposed at an oblique angle to the piston rod. This angle may be referred to as the "fixed angle" or angle of cock, and measured as between the axis of the connecting-rod and a perpendicular erected to the face of the piston. The proper magnitude of the fixed angle is dependent on the length of the connecting-rod and the throw of the crank, and is preferably such that the plane of the piston head is normal to the cylinder axis when the piston is in the position shown in the drawing by the full line, i. e., when the piston has completed approximately one-half of the compression stroke, it being noted that the cylinder in this case is mounted with its axis perpendicular to and intersecting the axis of the drive crank. It follows from this arrangement that immediately the piston passes beyond this midpoint of its down stroke it starts to tilt, the tilt increasing to that shown in the dotted line 12 of Figure 1 at the end of the stroke. Up to the end of the down stroke the cup leather has remained in contact with the cylinder wall, compressing the air beneath it. Beyond this point the tilt continues to increase, so that one edge of the piston head clears the wall during the greater portion of the return stroke, permitting the air to flow past its edge and thus acting as an intake valve. This situation is shown by the dot-and-dash lines 14 of the figure.

The operation and effectiveness of the device depend on the asymmetric tilting of the piston on the two strokes of the pump. Thus during the compression or down stroke the angle of tilt as between the piston head and the perpendicular to the axis of the cylinder is relatively small so that the cup washer 11, owing to its slight flexibility, maintains contact with the wall during substantially the entire stroke. At the bottom of the stroke the tilt rapidly increases, the washer breaking its contact with one side of the cylinder before the piston has risen appreciably, and the gap thus formed remains open during the entire intake or up stroke. At the top of the stroke the tilt rapidly decreases again, and the cup washer contacts the entire periphery of the cylinder, maintaining this contact throughout the down stroke. Where the diameter of the cylinder is large the mere difference in area of the opening between the piston and the cylinder walls on the two strokes is sufficient to allow operation of the device without a cup washer although at reduced efficiency. For best operation, however, the cup washer should be used, and the amount of tilt should be so related to the flexibility of the washer as to obtain the conditions described.

For the condition of maximum efficiency the clearance between the piston head and the cylinder head at the lower limit of the stroke should be a minimum. For this reason it is preferable to form the lower cylinder head 15 with an inclined surface, the degree of inclination being substantially equal to the fixed angle of the piston head to the connecting-rod.

The outlet valve of the pump may conveniently be carried by the lower cylinder head. A conventional type of valve is shown, a valve seat 16 being threaded into an opening through the block 15. The valve 17 is held against the seat by a spring 19. Connection with the receiver is made through a nipple 20 and elbow 21.

The shape of the piston head must, of course, correspond substantially with the cross section of the cylinder. As has been stated above, the cylinder may be round, square, or rectangular, or, in fact, of any shape. A square or rectangular piston has the advantage of giving the maximum area of opening between the piston and cylinder wall with a minimum differential in the amount of tilt. On the other hand, it is somewhat more difficult to maintain a good seal at the corners of a cylinder having interior angles, and a round cylinder and piston is advantageous from this point of view. Both types of cylinder have been used in practice, and have shown approximately the same efficiency. Because of its ease in manufacture, the round cylinder is probably to be preferred but this is a matter which does not essentially affect the invention.

It will be observed that the operation of the device depends upon the rocking of the piston through a cycle concurrent and synchronous with its cycle of reciprocation, through an arc which is asymmetrical with respect to the cylinder axis. Where this rocking is achieved in the obvious manner, i. e., by the use of a rigid connection between the piston head and the connecting rod, this involves as a corollary the fact that the piston head is tilted at an oblique angle to the axis of the cylinder when at the end of the stroke.

Another arrangement wherein the condition mentioned may be fulfilled is shown in the diagrammatic drawing of Figure 3. In this case the cylinder 6′ is tilted with respect to the normal through the axis of rotation of the crank, i. e., the axis of the cylinder is tangent to a circle drawn with the axis of rotation of the crank as a center. Under these circumstances the connecting-rod 9′ is mounted perpendicular to the piston head 10′. The attitude of the piston on the return stroke is shown by the dot-and-dash line 12′.

The actual magnitude of the tilt used depends very largely on the dimensions of the pump, and upon the method of obtaining the seal. In the type shown in Figure 1, where a cup leather is employed, the fixed angle of the piston head with respect to the connecting-rod may be even greater than the maximum angle between the connecting-rod and the cylinder axis, so that the piston head at no time becomes perpendicular to the axis. Thus one successful pump utilizing this form of seal was built with a one inch crank throw, a six and one-quarter inch connecting-rod, and with the piston head at fourteen degrees from the perpendicular to the connecting-rod, whereas others, with stiffer cup leathers, and with the same length connecting-rod and crank throw have utilized an angle of tilt from the perpendicular of about ten degrees, as shown in the drawing. This would correspond, in the form of device shown in Figure 3, to an angle of tilt of the cylinder with respect to a perpendicular dropped from the crank axis to the center of the lower cylinder head varying between fourteen and ten degrees, the angle of the lower piston head being varied accordingly to give minimum clearance at the bottom of the stroke.

As has been indicated above, it is not essential that a cup leather be used to form a seal with the cylinder wall. In Figure 4 there is shown a modified form of the device where the piston head **25** is an equatorial zone of a sphere. Here the fixed angle is one-half of the maximum angle between the cylinder axis and the connecting-rcd **26**, and the arc of the zone forming the piston head is approximately the same.

Expressed mathematically, with this form of the device, if the length of the connecting-rod, measured from the center of the crank pin to the center of the piston head is called L, and the crank throw T, the fixed angle should be one half of the angle whose tangent is T/L. This will cause the piston valve to close at the top of the stroke and maintain the seal during the entire compression half of the cycle, opening rapidly on the return stroke.

I claim:

1. A pump comprising a cylinder having an inlet and an outlet opening in opposite ends thereof, a piston tiltable within said cylinder, a crank for actuating said piston, and a connecting-rod joining said piston and crank and rigidly connected to said piston, said piston being so disposed with respect to said cylinder and connecting rod as to form an oblique angle with the axis of the cylinder when the piston is at either end of its stroke.

2. A pump comprising a cylinder having an inlet and an outlet opening in opposite ends thereof, a piston tiltable within said cylinder, a crank for actuating said piston mounted with its axis intersecting the axis of the cylinder, and a connecting-rod journaled on said crank and rigidly attached to said piston and forming an oblique angle with the face thereof.

3. A pump comprising a cylinder having an inlet and an outlet opening in opposite ends thereof, a combination piston and valve comprising a piston head tiltable within the cylinder, and means for reciprocating said piston head within said cylinder and tilting said piston head with respect to the axis of said cylinder in synchronous cycles, said tilting being asymmetric with respect to said axis.

4. A pump comprising a cylinder having an inlet and an outlet opening in opposite ends thereof, a combination piston and valve comprising a piston head tiltable within the cylinder, means for reciprocating said piston head within said cylinder and tilting said piston head with respect to the axis of said cylinder in synchronous cycles, said tilting being asymmetric with respect to said axis, and means for maintaining a seal between said piston head and the wall of said cylinder during approximately one-half of said tilting cycle.

5. A pump comprising a cylinder having an inlet and an outlet opening in opposite ends thereof, a combination piston and valve comprising a piston head tiltable within the cylinder, means for reciprocating said piston head within said cylinder and tilting said piston head with respect to the axis of said cylinder in synchronous cycles, said tilting being asymmetric with respect to said axis, and a cup leather mounted on the face of said piston head for maintaining a seal between said piston head and the wall of said cylinder during approximately one-half of said tilting cycle.

6. A pump comprising a cylinder having an inlet and an outlet opening in opposite ends thereof, a rigid T-shaped piston within said cylinder, and a crank whereon said piston is journaled, said cylinder being so mounted with respect to said crank that the axis of said cylinder is tangent to a circle having the crank axis as a center.

7. A pump comprising a cylinder having an inlet and an outlet opening in opposite ends thereof, a piston within the cylinder comprising a connecting-rod and a piston head rigidly affixed thereto, a crank whereon said connecting-rod is journaled, said cylinder, connecting-rod and crank being relatively so mounted that said piston head forms an oblique angle with the axis of the cylinder when the piston is at the end of its stroke, and a head on said cylinder forming an angle with the cylinder walls substantially equal to the angle formed between the piston head and the cylinder axis at the end of the stroke.

8. A pump comprising a cylinder having an inlet and an outlet opening in opposite ends thereof, a piston head within the cylinder whose periphery is formed substantially as the equatorial zone of a sphere, a connecting-rod rigidly attached to said piston head, and a crank whereon said conecting-rod is journaled, said cylinder, connecting-rod and crank being relatively so disposed with respect to said piston head that the latter forms an oblique angle with the axis of the cylinder substantially equal to one-half the arc of its peripheral zone when at the end of its stroke.

9. A pump comprising a crank, a cylinder having an inlet and an outlet opening in opposite ends thereof mounted with its axis intersecting the axis of rotation of said crank, a connecting-rod journaled on said crank, and a piston head within the cylinder rigidly affixed to said connecting-rod within the cylinder and formed substantially as the equatorial zone of a sphere, said piston head forming a fixed angle with the perpendicular to said connecting rod substantially equal to one-half of the angle whose tangent is T/L, where T is the throw of the crank and L the length of the connecting-rod.

10. A pump comprising a crank, a cylinder having inlet and outlet openings at opposite ends thereof mounted with its axis intersecting the axis of rotation of said crank, a connecting-rod journaled on said crank, and a piston head within the cylinder rigidly affixed to said connecting-rod within the cylinder and formed substantially as the equatorial zone of a sphere, said piston head forming a fixed angle with the perpendicular to said connecting-rod substantially equal to one-half of the angle whose tangent is T/L, where T is the throw of the crank and L the length of the connecting-rod, and the angle subtended at the center of said zone being substantially equal to said fixed angle.

MILLARD E. CROWLEY.