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[54] **AIR COMPRESSOR**

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[51] **Int. Cl.** **F04b 7/04**
[58] **Field of Search** 92/78, 240, 241, 92/245, 246, 248, 249, 162; 417/313, 490, 491, 493, 494, 495

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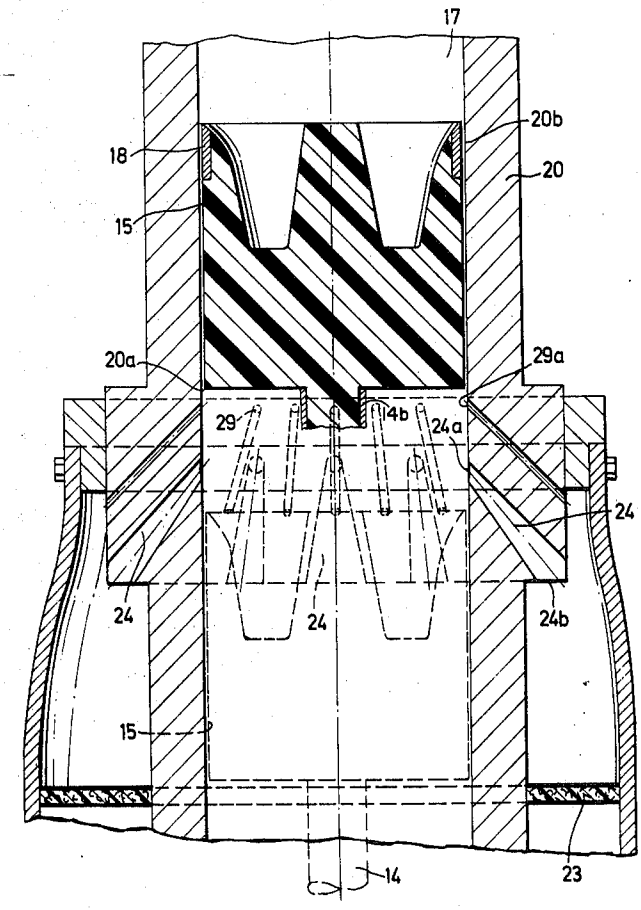
[57] **ABSTRACT**

A compressor which is adapted to operate in a dry condition without any lubricant. The compressor has a cylinder which defines a compression chamber in its interior and which is provided with a gas intake and a gas outlet. A piston which is made substantially entirely of plastic reciprocates in the cylinder and defines a gap with the inner surface thereof, the gas inlet being in the form of nozzle-shaped openings extending through the cylinder wall and inclined with respect to the cylinder axis. In addition to the latter openings there are balancing bores which extend through the cylinder wall to provide a stable reciprocation of the piston, and the axes of these bores not only are inclined with respect to the cylinder axis but they are also inclined with respect to the axes of the inlet openings in a manner according to which air entering through the latter will retard any tendency of air or other gas to leak out through the balancing bores. Preferably there are a pair of pistons which are directly opposed to each other so that one reciprocates along its suction stroke while the other reciprocates along its compression stroke. According to the method the pistons are reciprocated at a speed of at least 1500 strokes per minute, so that in this way compressed air or other gas can be supplied to chemical, food, or other industries in large quantities for such purposes as the pneumatic operation of bulk material conveyors and the like.

14 Claims, 6 Drawing Figures



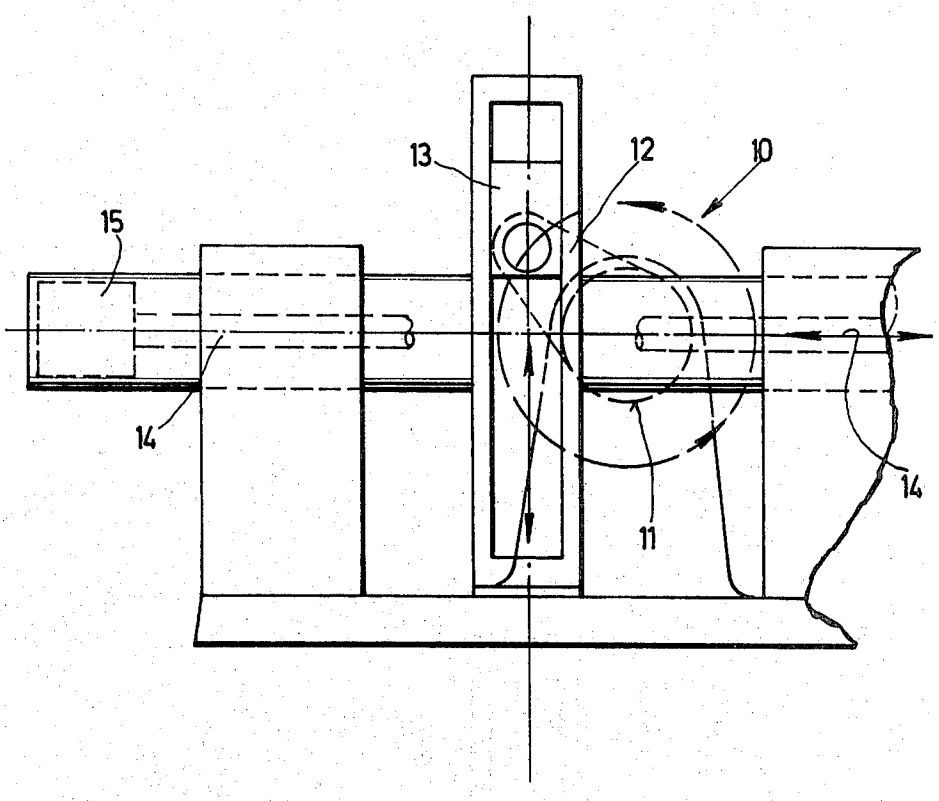


Fig. 1

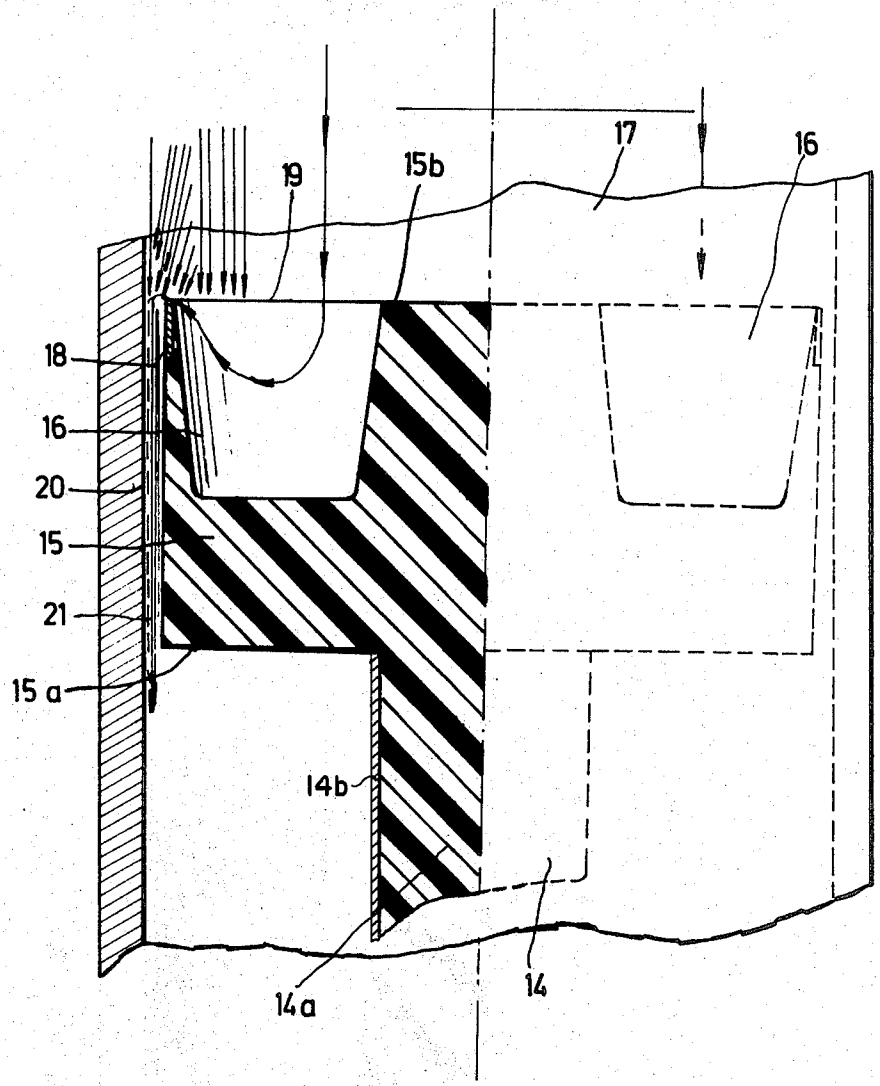


Fig. 2

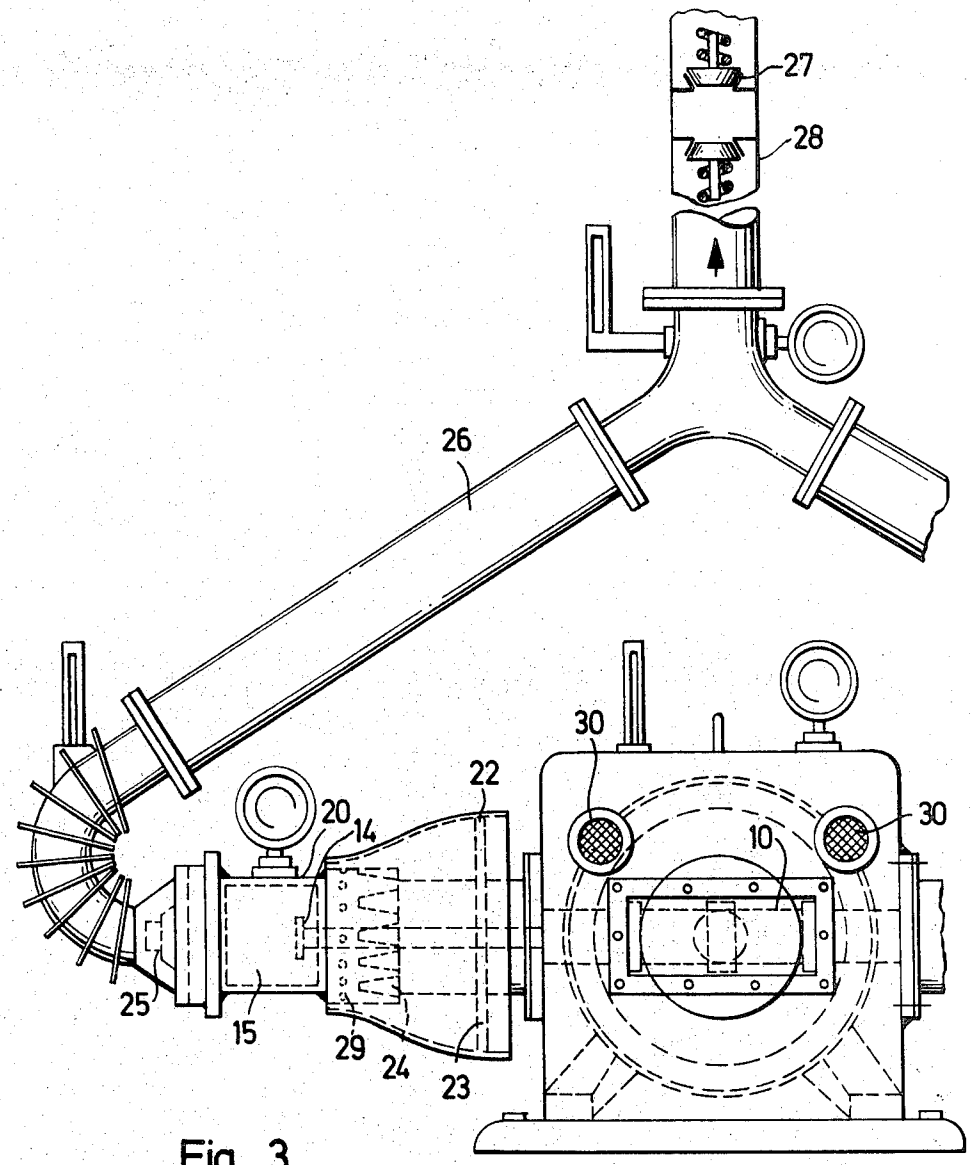
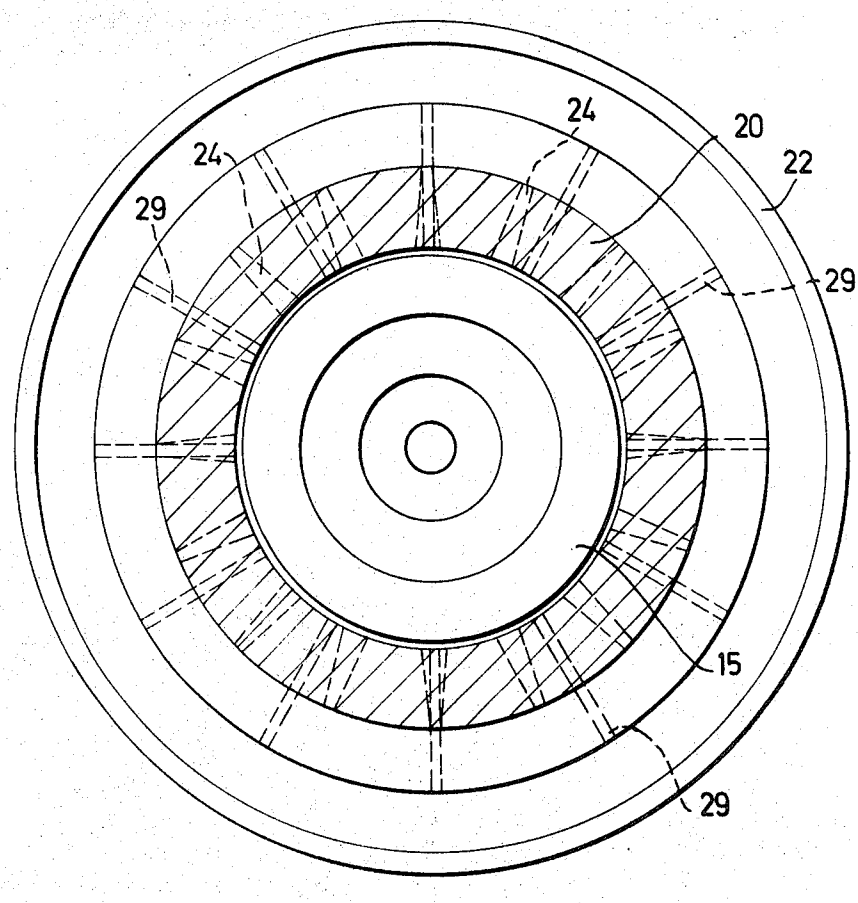


Fig. 3

Fig. 4



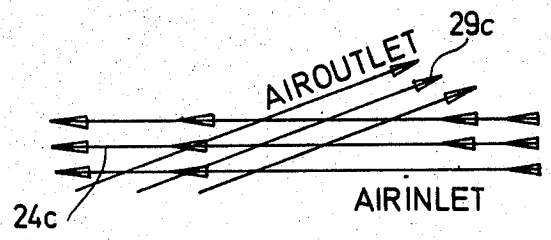
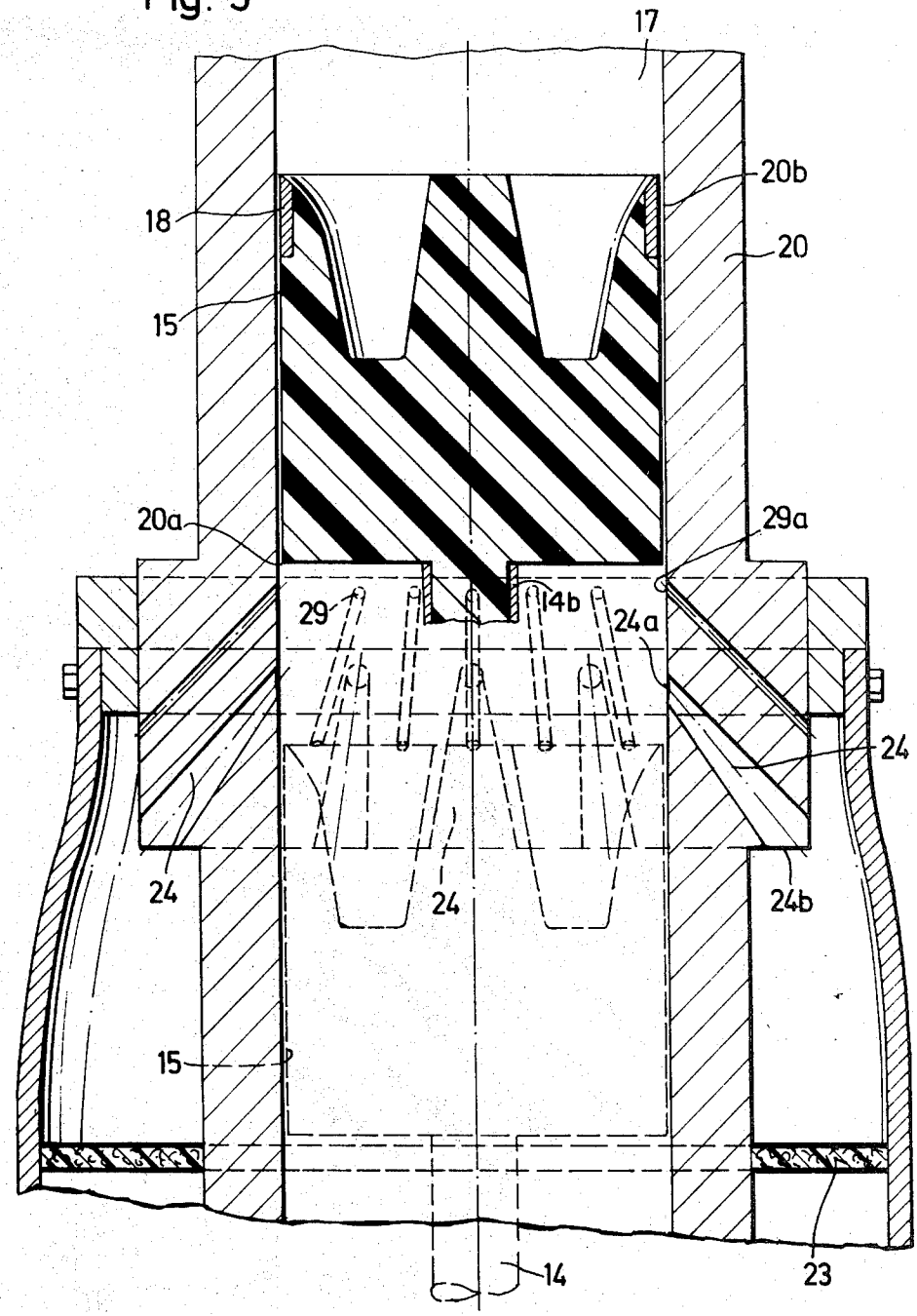


Fig. 6

Fig. 5



AIR COMPRESSOR

BACKGROUND OF THE INVENTION

The present invention relates to compressors as well as to methods for operating the same.

It is customary at the present time to provide compressor pistons with different types of piston rings so as to attempt to achieve between the piston and cylinder a friction which is as low as possible. However, because there is unavoidably mechanical contact between the cylinder wall and the piston there will unavoidably remain a substantial amount of friction, so that the extent to which the friction can be reduced is relatively slight.

It is also conventional to seal the compression chamber with a gland having sealing elements arranged to wipe the oil off the piston rod or the like. Such constructions are particularly suited for low-speed pistons with a relatively short stroke.

However, constructions of the above type are not suited for modern comrpessors which are required to have compression units which are completely free of lubricant of any type and which are required to have a high output of compressed gas per unit of time. From this latter standpoint convenitonal compressors leave much to be desired. It is for reasons as set forth above that the known compressors operate at a relatively low speed. With known compressors the mechanical losses can be up to 10 percent of the useful capacity. On the other hand, friction losses necessarily increase in proportion to the increase in the operating speed. High speed operation in conjunction with mechanical sealing elements result in considerable reduction in the operating efficiency of compressor pistons.

The following formula may be used to calcualte friction losses of this type:

$ds/dt = \tau/\eta = d\tau/dt \times 1/G$

in which

ds/dt - the speed of deformation

τ - tangential stress

η % dynamic strength

G - modulus of rigidity of the oil layer on the inside cylinder wall.

Piston rings or other types of sealing rings press against the inner surface of the cylinder as a result of the compression pressure. In this way they act as a hydraulic brake.

SUMMARY OF THE INVENTION

It is accordingly a primary object of the present invention to provide a compressor and operating method which will avoid the above drawbacks.

Thus, it is a primary object of the invention to provide a compressor which will eliminate the problems which are unavoidably encountered with conventional compressors.

In particular it is an object of the present invention to provide a compressor and operating method which will enable not only piston reciprocation without the use of any lubricant so that a dry, oil-free operation is achieved, but which will in addition achieve a high output of compressed gas.

In addition it is an object of the present invention to provide a compressor which will greatly reduce the extent of leakage losses.

According to the invention the compressor includes a cylinder which defines a compression chamber in its interior. An inlet means communicates with the compression chamber for supplying gas thereto and an outlet means communicates with the compression chamber for discharging gas thereform. A piston means reciprocates in the cylidner along suction strokes during which gas enters through the inlet means and compression strokes during which gas discharges through the outlet means. This piston is made up substantially entirely of plastic and defines with theinner surface of the cylinder an annular gap which surrounds the piston with the latter operating in a completely dry state free of any oil or other lubricant in the interior of the cylidner. A piston rod is fixed to and extends from the piston means and a drive means is operatively connected to the piston rod for reciprocating the latter and th piston means. According to the invention the drive means provides for the piston a rate of reciprocation which is at least 1500 strokes per minute.

At its head end, which is distant from the piston rod, the piston means carries a blade means in the form of a ring of metal or other material harder than the plastic material of the piston, this blade operating on the gas to retard leakage through the gap between the piston means and the cylinder. Preferably the plastic of the piston is molded, either by casting or injection molding, directly around the blade so as to reduce the manufacturing costs as well as to enable the blade to have the best possible shape for cutting through the gas at the region of the gap between the piston and the cylinder.

Preferably both the piston and the piston rod are molded from a single body of plastic. This construction will improve the friction-free operation of the piston in the cylinder, with the drive taking place from a drive means which includes a rotary crank and crosshead arrangement operatively connected with the piston rod. The piston is firmly fixed through the piston rod to the reciprocating crosshead which reciprocates by way of the rotary crank of th drive means, with all of this latter structure being situated in a suitable crank chamber, and the desired rigidity in the transmission is achieved in this way without any additional measures. If desired, however, the piston rod may be provided with at least one bracing or reinforcing member, in particular a metallic reinforcing rib or th like extending axially along the piston rod coaxially with respect to the axis thereof. However, this reinforcing member may also take the form of a seamless tube around which the piston rod is molded, as by injection molding. This construction will assure a rigidity in the transmission even under extreme operating conditions at very high compression pressures, high outputs, and high operating speeds, etc.

The piston means can take the form of a piston which at its head or working end is provided with a central boss surrounded by a relatively deep annular depression which may have a depth of up to approximately two-thirds of the length of the piston. In addition to reducing the weight so as to enhance high-speed operation, so as to more readily achieve the required high speeds, this construction enables a favorable influence on the gas in the compression chamber to be achieved with a high degree of control also bieng achieved. At the same time this construction provides for a more effective cooling of the piston.

According to one construction the compressor may be provided with a pair of opposed pistons, although other constructions are possible.

While an arrangement of opposed pistons is indeed already known, in the particular case of the present in-

vention this particular arrangement greatly improves and simplifies the high-speed compressor so that it is possible to achieve extremely high operating speeds at low costs.

With the present invention it becomes possible to provide a ratio of stroke length to cylinder bore diameter which is greater than 1, so that in contrast with known constructions for outputs of similar types, the volume in the interior of the cylinder can be considerably reduced by reason of the fact that very high speeds are possible. This particular construction is outstanding not only because of the friction-free method of sealing the piston, without lubrication, but also because of the high degree of efficiency achieved from the favorable polytropic exponents. Moreover, because of the ease with which air can flow a more efficient cooling is achieved, and this more efficient cooling is achieved in part by the greater cooling surface at the high speed operation of the piston in a given unit of time.

BRIEF DESCRIPTION OF DRAWINGS

The invention is illustrated by way of example in the accompanying drawings which form part of this application and in which:

FIG. 1 is a schematic representation of a compressor where horizontally arranged opposed pistons are driven through a crosshead type of drive, the piston and piston rod being indicated with dotted lines and being fragmentarily illustrated;

FIG. 2 is a fragmentary partly sectional elevation, at an enlarged scale as compared to FIG. 1, the sectional left part of FIG. 2 being taken in a plane which contains the cylinder axis, and FIG. 2 showing in detail the relationship between the cylinder and piston and schematically representing the gas currents;

FIG. 3 is a schematic fragmentary elevation showing somewhat more than one-half of a compressor assembly of the invention, with inlet openings and balancing bores being schematically illustrated in FIG. 3;

FIG. 4 is a transverse sectional elevation, taken in a plane normal to the cylinder axis, and illustrating thecircumferential distribution of theinlet openings and balancing bores;

FIG. 5 is an axial section showing, also at an enlarged scale as compared to FIG. 3, the arrangement of the inlet openings and balancing bores as well as the piston within the cylinder and the bell-shaped housing through which gas enters; and

FIG. 6 is a diagrammatic representation of the angular relationship between the air inlet openings and the balancing bores.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring first to the particular example of the invention which is illustrated schematically in FIG. 1, the compressor illustrated therein includes a drive means 10 composed of a rotary crank shaft 11 supported for rotary movement in any suitable bearings and driven from any suitable motor, engine, or the like. The rotary crank shaft 11 has cranks interconnected by a crank pin extending through a slide block 13 capable of reciprocating vertically in a suitable guide formed in a crosshead 12. Thie corsshead 12 is guided for horizontal reciprocating motion. Thus, as the crank shaft 11 rotates the crosshead 12 will be reciprocated back and forth horizontally. Fixed to the crosshead 12 are a pair of piston rods 14 which are fixed at their ends distant from the crosshead 12 to a pair of pistons 15 only one of which is indicated at the left of FIG. 1. Thus, with this arrangement there are a pair of opposed piston means 15 which reciprocate horizontally during operation of the drive means 10. This particular type of drive means is in itself known and is therefore not illustrated in greater detail. The rotary cranksahft 11 is driven at high speed by an unillustrated motor, engine, or the like, and through the slide block 13 and crosshead 12 the opposed pistons are reciprocated at high speed. The details of the pistons are shown, for one of the pistons, in FIG. 2. As is apparent from FIG. 2, each piston rod 14 is composed of an elongated plastic body 14*a* formed integrally with the piston means 15 which also is made of plastic.

The piston means 15 of the invention can be made of a plastic material such as polyethylene, polypropylene, polybutene, and especially of polytetrafluoroethylene or polyamide or of a similar synthetic material containing appropraite plasticizers or fillers such as hard fibers, thermoplastics, curing or extrusion of synthetic resins or plastics bieng used in special cases as required. It is also possible to use plastics such as polyoxymethaline or polycarbonate resins. The piston is preferably molded, either by casting or injection molding, in one piece with the piston rod, although a suitable rigid connection can be provided between the piston and piston rod, if desired. Also, it will be noted from FIGS. 2 and 5 that the piston has a smooth exterior side surface of constant diameter extending between opposed ends of the piston.

As is apparent from FIG. 2, the piston means 15 has an upper head or working end sitant from the piston rod and formed with an annular depression 16 which surrounds the central boss 15*b* shown in FIG. 2 at the head end of the piston.

The piston rod 14 can be reinforced by molding it around or within and around an elongated metal tube 14*b* which is coaxial with the piston and which is fragmentarily illustrated in FIGS. 2 and 5

The head end of the piston defines with the interior of the cylinder 20 the compression chamber 17 which may be provided with a spring-loaded, adjustable outlet valve which is not shown in FIG. 2 and which forms an outlet means for the compressed air. An inlet means is provided for admitting air into the compression chamber 17, and this inlet takes the form of suitable openings formed in the cylinder wall and through which air enters, as referred to below.

The blade means 18 which is made of a material such as a suitable metal much harder than the plastic material of the piston means is shown at the left part of FIG. 2 and is also illustrated in FIG. 5. Instead of having the particular construction illustrated in FIGS. 2 and 5 it is also possible for the blade means to project slightly beyond the end surface 19 indicated in FIG. 2. The nature of the whirling currents of air or other compressed gas forming a cushion between the inside surface of the cylinder 20 and the outside of the piston means 15 is illustrated schematically by the arrows indicating the flow patterns of compressed gas in FIG. 2. It will be seen that the gas flows past the blade means 18 which is firmly fixed to the piston and into the annular gap 21 which surrounds the piston. From the point where the compressed gas or air enters into the gap it flows on a greatly reduced scale, as compared to the volume of air in the compression chamber 17, to the housing where

the drive means is located. Because the piston rides on a layer of compressed air or other gas it is clear that the friction losses with the invention are only a fraction of those found in conventional compressors which utilize mechanical sealing elemtns which frictionally slide along the inner surface of the cylinder. A much higher efficiency is achieved with the invention, and the degree of efficiency is increased by the fact that permanently lubricated friction bearings are used in the crank system and/or lapped shaft journals of special nitriding steels are used. The bearings which are used at the drive means in the crank mechanism and crosshead mechanism can be completely enclosed and protected. A further advantage resides in the fact that the usual methods of sump lubrication, or pumping of lubricants by a gear pump and oil lines to the bearings can be completely eliminated with the compressor of the invention. The crank case serves with the compressor of the invention as an additional cooling chamber. A further advantage resides in the fact that a plurality of filters are mounted on the outer wall of the crank case to assure that the air is maintained clean. Furthermore, the possibility of explosions are greatly reduced with the compressor of the invention.

The use of plastic for the piston means results in a reduction in weight. It also makes possible a higher operating speed which in conjunction with the rigid support of the piston means through the piston rod which may be reinforced as pointed out bove results in a practically friction-free movement of the piston along the interior of the cylinder, with only the air layer forming a cushion for the piston in the gap which surrounds the latter between the piston and th inner surface of the cylinder. No lubrication whatsoever is required and the piston requires neither sealing rings nor piston rings.

The narrow annular gap between the piston means and inner surface of th cylinder with the high-speed crosshead type of drive provided with the invention produces at high operating speeds on the order of, for example, about 3000—6000 rpm, or even more, a so-called dynamic gas contraction which serves to reduce the escape of compressed gas or air from the compression chamber to the driving means. This sytem of gas flow is also rendered effective by using the blade means **18** which has a sharply inclined leading edge at the head end of the piston means. This edge of the blade means literally breaks up or cuts into the gas dividing it up so that a type of countercurrent is created in the transition from the compression chamber which is of relatively large diameter to the annular gap which has only a small radial dimension, and this relationship leads to a constriction and therefore a reduction of the available mechanical annular gap between the piston and cylinder wall. While the hydrodynamics of flow layers of fluids are not yet fully understood, it may be assumed that the relative movements of the boundary layers on the inner surface of th cylinder and the piston surface produces a whirling motion which prevents the compressed air from flowing to the region of the drive means and becoming lost. At the high speeds which are used in accordance with the method of the invention the amount of time available for compressed air to escape from the compression chamber extremely small.

The compressor of the invention can be used as a suction pump or as a vacuum pump. Also the compressor of the invention may be used in control and measuring applications, in dental technology, in the manufacture of foodstuffs, in the production of plastics, in the chemical industry (to reduce theh azards of explosion), in refineries, in mines, in filling machines, in hospitals, in the petrochemical industry, in munitions factories, in automatic packaging applications, in glassworks, and in the iron and steel industry. There is practically no wear and tear with the compressor of the invention. It is in fact often wear of conventional piston-type compressors, together with the oil carbon that settles on the head or working head of the piston during operation that causes the hazards of explosion. In fact many fatalities and injuries have been caused by the precipitation of oil carbon on the working end of the piston.

The compressor of the invention is also particularly suited for prefabricated assembly. Thus, a plurality of compressors of the invention can be combined together to form a single unit.

The particular design and type of compressor construction referred to above results in a balanced circulation of the materials and an almost maintenance-free compressor which can be operated at very low cost.

The cylinder of the compressor of the invention is preferably made of a seamless, drawn iron or, in particular, from a section of steel pipe, wherein general the drawn pipe is longer than the cylinder.

Referring to FIG. **3**, which shows primarily the left half of an installation according to the invention, it will be seen that the cylinder **20** carries a bell-shaped housing element **22** made of metal, preferably sintered or fritted metal. The bell-shaped housing **22** is open at its right end, as viewed in FIG. **3**. The manner in which this housing is mounted on the cylinder **20** is particularly apparent from FIG. **5**. Thus, it will be seen that the housing **22** is fixedly carried by a ring which in turn is fixed directly onto the cylinder **20**. At its open end the housing **22** accommodates in it interior a filter **23** which may be made of a porous plastic material. Intake air is required to pass through this filter **23** in order to reach the interior of the housing **22**.

An inlet means communicates with the compression chamber **17** in order to admit air into the latter during the suction strokes of the piston means **15**. This inlet means includes the nozzle-shaped openings **24** which are formed in the wall of the cylinder **20**, passing therethrough and distributed circumferentially around the axis of the cylinder at an annular wall portion thereof. Thus, the air which enters through the inlet openings **24** reach the compression chamber portion **20a** indicated in FIG. **5** and in which the piston **15** reciprocates.

Spaced axially from the inlet openings **24**, in the direction in which the piston means moves during its compression strokes, is a balancing means for stabilizing the movement of the piston means while maintaining the gap surrounding the piston means between the latter and the inner surface of the cylinder, this balancing means being constituted by a circumferential wall portion of the cylinder formed with at least one group of circumferentially arranged balancing bores **29** in the form of bores passing also through the cylinder wall as well as through part of the ring which surrounds the latter and carries the housing **22**. These bores **29** enable balancing air to provide a stable movement of the piston means within the cylinder **20**. Thus, a second annular portion of the cylinder **20** is formed with the balancing bores **29**. It will be noted that both the balancing bores **29** as well as the nozzle-shaped inlet openings **24** have axes which are inclined with respect to the cylin-

der axis. These inlet openings and balancing bores are uniformly distributed about the cylinder axis with the axes of the inlet openings **24** forming elemento of one cone whose center is situated at the cylinder axis while the axes of the bores **29** form elements of another cone whose apex is situated in the cylinder axis.

Returning to FIG. **3** it will be seen that the compressed air is discharged by an outlet means **25** in the form of a suitable valve assembly which opens to allow the compressed air to discharge, substantially at the end of each compression stroke, into a curved, semi-elastic discharge hose or tube **26** provided with suitable cooling fins. The compressed air flows away from the installation of the invention through a pipe **28** provided with suitable valves **27** which may be biasing or one-way, non- return valves.

Referring to FIGS. **4–6** which illustrate the details of the arrangement of the intake openings and balancing bores **29,** it will be seen that the nozzle-shaped inlet openings **24** have their small ends **24***a* at the inner surface of the cylinder **20** and their large ends **24***b* at the outer surface of the cylinder **20.** When the piston means **15** has reached the end of its suction stroke and is about to start along its compression stroke, it will have the dotted line position indicated in FIG. **5,** and at this time filtered air will flow into the region **20***a* of the compression chamber in the cylinder **20.** It is this air which will be compressed during the subsequent compression stroke of the piston **15** which is moved by the piston rod **14** toward the outlet means **25.**

The balancing bores **29** preferably have a circular uniform cross section and a relatively small diameter as compared with the average diameter of each inlet opening **24.** These bores **29** are provided primarily to stabilize or balance the piston in a centralized position uniformly spaced from the inner surface of the cylinder so that the gap between the piston and cylinder will have a uniform thickness at all points. It is possible to provide two circumferentially distributed rows of balancing bores **29** which may be axially or circumferentially displaced one with respect to the other. The balancing bores **29** will function to stabilize the movement of the piston means **15,** achieving a smooth reciprocating movement thereof. Small amounts of leakage air, which may pass along the gap **20***b* indicated in FIG. **5** and escape through the bores **29** are countered by the special axial relationship of the bores **29** and th inlet openings **24,** as is diagrammatically represented in FIG. **6.** The angular relationship illustrated in FIG. **6** is between the axes **29**i c of the bores **29** and th axes **24***c* of the inlet openings **24.** Thus FIG. **6** shows how on the one hand leakage air will tend to flow out through the bores **29** in the direction of the arrows **29***c* of FIG. **6,** while the air flowing in, in the direction of the arrows **24***c* of FIG. **6** will oppose this tendency so that the extent two which air can escape through the bore **29** is greatly diminished by the air flowing in through the inlet openings **24.** The angle between the arrows **29***c* and the arrows **24***c* of FIG. **6** is on the order of **24–30°.** Thus, air admitted into the chamber portion **20***a* through the inlet openings **24** forms a stream flowing along the inner surface fo the cylinder in the manner of a layer of air such as a boundary layer, and the direction in wich this inlet air flows is such that it will flwo directly toward the gap **20***b* impinging upon and cutting off the leadage of air which might tend to flow out of the chamber portion **20***a* through the balancing bores **29,** and thus in this way the air from the latter will reliably function to provide the cushioning or supporting layer of gas on which the piston mvoes.

It is to be noted that the inner ends **24***a* of the openings **24** anethe corresponding openings **29***a* at the inner ends of the bores **29** have a predetermined distinct relatively small axially-spaced relationship illustrated most clearly in FIG. **5.** FIG. **4** also illustrates this relationship, and in FIG. **4** the dimensions of the openings **24** are illustrated at a smaller scale.

Various modifications of the above compressor and operating method will occur to those skilled in theart. Thus, a filtering means may be situated directly at the intake ends **24***b* of the inlet openings **24.** According to the invention it is preferred to provide a reciprocating speed for the piston means on the order of 3,000–6,000 strokes per minute. It is also an advantage of the invention that when one driving motor is substituted for another, such as an electric motor having a higher speed which may be a speed twice that of a previously used motor, the compressor of the invention can be operated very simply in one or more different power ranges.

As may be seen from FIG. **3,** the housing which encloses the drive means **10** is provided with filters **30** mounted in openings which pass through wall portions of the housing, so tthat in this way only clean air can have access to the interior of the housing for the drive means.

What is claimed is:

1. In a compressor, a cylinder defining a compression chamber in its interior, inlet means communicating with said comrpession chamber for admitting into the latter gas to be compressed therein, outlet means communicating with said comrpession chamber for discharging compressed gas therefrom, piston means situated in said cylinder for reciprocation therein along suction strokes during which gas enters into said comprssion chamber through said inlet means and compression strokes during which gas discharges from said compression chamber through said outlet means, said piston means being made substantially entirely of a plastic material and defining with an inner surface of said cylinder a gap surrounding said piston means and remaining at all times substantially dry and free of lubrication, a piston rod fixed to and projecting from said piston means, and drive means operatively connected with said piston rod for reciprocating the latter an said piston means therewith in said cylinder along said strokes, said piston means having a head end sitant from said piston rod and forming the working end of said piston means, and blade means of a material substantially harder than said piston means carried by the latter at said head end thereof for acting on the gas to promote a sealing effect at said gap, said blade means being made of metal and being in the form of a cylindrical member carried by said piston means at the head end thereof at theouter periphery of said piston means, said piston means being formed at its head end with an annular groove and with a central boss surrounded by said annular groove so that the latter together with said blade means promote the sealing effect.

2. In a compressor, a cylinder of predetermined bore diameter defining a compression chamber in its interior, inlet means communicating with said compression chamber for admitting into the latter gas to be compressed therein, outlet means communicating with said compression chamber for discharging compressed gas

therefrom, piston means situated in said cylinder for reciprocation therein along suction strokes during which gas enters into said compression chamber through said inlet means and compression strokes during which gas discharges from said compression chamber through said outlet means, said strokes each having a length greater than said cylinder bore diameter, said piston means being made substantially entirely of a plastic material, having a smooth exterior side surface of constant diameter extending between opposed ends of said piston means and defining with an inner surface of said cylinder a gap surrounding said piston means and remaining at all times substantially dry and free of lubrication, a piston rod fixed to and projecting from said piston means, and drive means operatively connected with said piston rod for reciprocating the latter and said piston means therewith in said cylinder along said strokes at a speed of at least 1,500 strokes per minute, said inlet means including an annular wall portion of said cylinder formed with permanently open, uninterrupted inlet openings passing therethrough and distributed about the axis of the cylinder, said inlet openings being tapered and forming inlet nozzles and said inlet openings respectively having axes inclined to the axis of said cylinder.

3. In a compressor, a cylinder of predetermined bore diameter defining a compression chamber in its interior, inlet means communicating with said compression chamber for admitting into the latter gas to be compressed therein, outlet means communicating with said compression chamber for discharging compressed gas therefrom, piston means situated in said cylinder for reciprocation therein along suction strokes during which gas enters into said compression chamber through said inlet means and compression strokes during which gas discharges from said compression chamber through said outlet means, said strokes each having a length treater than said cylinder bore diameter, said piston means being made substantially entirely of a plastic material, having a smooth exterior side surface of constant diameter extending between opposed ends of said piston means and defining with an inner surface of said cylinder a gap surrounding said piston means and remaining at all times substantially dry and free of lubrication, a piston rod fixed to and projecting from said piston means, and drive means operatively connected with said piston rod for reciprocating the latter and said piston means therewith in said cylinder along said strokes at a speed of at least 1500 strokes per minute, said piston means being formed at its head end with an annular groove and with a central boss surrounded by said annular groove.

4. In a compressor, a cylinder defining a compression chamber in its interior, inlet means communicating with said compression chamber for admitting into the latter gas to be compressed therein, outlet means communicating with said compression chamber for discharging compressed gas therefrom, piston means situated in said cylinder for reciprocation therein along suction strokes during which gas enters into said compression chamber through said inlet means and compression strokes during which gas discharges from said compression chamber through said outlet means, said piston means being made substantially entirely of a plastic material and defining with an inner surface of said cylinder a gap surrounding said piston means and remaining at all times substantially dry and free of lubrication, a piston rod fixed to and projecting from said piston means, and drive means operatively connected with said piston rod for reciprocating the latter and said piston means therewith in said cylinder along said strokes, said inlet means including an annular wall portion of said cylinder formed with inlet openings passing therethrough and distributed about the axis of the cylinder, said inlet openings being tapered and forming inlet nozzles and said inlet openings respectively having axes inclined to the axis of said cylinder, said cylinder being also formed along a second annular wall portion thereof, spaced axially from said inlet openings in the direction in which said piston means moves during a compression stroke, with a plurality of bores passing through the cylinder and providing balancing gas for stabilizing the movement of said piston means, said bores also respectively having axes inclined to the cylinder axis, and the axes of said bores bbeing inclined with respect to the axes of said inlet openings at an angle which enables gas flowing through said inlet openings to retard leakage out of said cylinders through said bores.

5. The combination of claim 4 and wherein a substantially bell-shaped housing is fixed to and surrounds said cylinder at said annular portions thereof so that said bores and openings are surrounded by said bell shaped housing, and a filter situated between said housing and cylinder for filtering gas entering into said bell-shaped housing to reach said bores and openings.

6. In a compressor, a cylinder of predetermined bore diameter defining a compression chamber in its interior, inlet means communicating with said compression chamber for admitting into the latter gas to be compressed therein, outlet means communicating with said comprssion chamber for discharging compressed gas therefrom, piston means situated in said cylinder for reciprocation therein along suction strokes during which gas enters into said compression chamber through said inlet means and compression strokes during which gas discharges from said compression chamber through said outlet means, said strokes each having a length greater than said cylinder bore diameter, said piston means being made substantially entirely of a plstic material, having a smooth exterior side surface of constant diameter extending between opposed ends of said piston means and defining with an inner surface of said cylinder a gap surrounding said piston means and remaining at all times substantially dry and free of lubrication, balacing means for stabilizing the movement of said piston means in said gap spaced from said inner surface of said cylinder, said balancing means being axially spaced from said inlet means in the compression direction in which said piston means moves during a compression stroke, and said balancing means being constituted by a circumferential wall portion of said cylinder means which has an inner surface defining part of said gap and an outer surface communicating with the surrounding atmosphere, said wall portion being formed with a plurality of bores circumferentially distributed about the axis of said cylinder means and each incliend to said axis with each bore having inner and outer ends respectively at said inner and outer surfaces of said wall portion, and said inner end of each bore being displaced from its outer end in said compression direction, a piston rod fixed to and projecting from said piston means, and drive means operatively connected with said piston rod for reciprocating the latter and said

piston means therewith in said cylinder along said strokes at a speed of at least **1500** strokes per minute.

7. The combination of claim **6** and wherein said cylinder has the form of a seamless drawn steel pipe.

8. The combination of claim **6** and wherein said piston means is made of a material selected from the group consisting of polyethylene, polypropylene, polybutene, polytetrafluoroethylene, polyamide, polyoxymethaline, and polycarbonate.

9. The combination of claim **6** and wherein said piston means is operated at a speed of approximately 3,000–6,000 strokes per minute.

10. The combination of claim **6** and wherein a housing encloses said drive means and has a wall portion formed with an opening and a filter located in said opening for cleaning air which enters said housing through said opening.

11. The combination of claim **6** and wherein said piston means has a head end distant from said piston rod and forming the working end of said piston means, and blade means of a material substantially harder than said piston means carried by the latter at said head end thereof for acting on the gas to promote a sealing effect at said gap.

12. The combination of claim **11** and wherein said blade means is made of metal.

13. The combination of claim **1** and wherein said piston rod also is made of a plastic material, said piston means and piston rod being in the form of a single body and said piston rod carrying a reinforcing member.

14. The combination of claim **13** and wherein said reinforcing member is in the form of an elongated tube extending axially of said rod.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,779,672 Dated December 18, 1973

Inventor(s) Walter Schroeder

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the heading, the address should be:

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Signed and sealed this 22nd day of October 1974.

(SEAL)
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Attesting Officer

C. MARSHALL DANN
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