VARIABLE BORE CYLINDER

George P. Schley, Jr., Bethlehem, Pa., assignor to Ingersoll-Rand Company, New York, N.Y., a corporation of New Jersey

Inventors: George P. Schley, Jr., Bethlehem, Pa.

Application Ser. No. 776,252, Nov. 25, 1958. This application June 1, 1962, Ser. No. 199,312

Claims. (Cl. 185—216)

This application is a continuation in copending U.S. application 776,252, filed November 25, 1958, now abandoned.

This invention generally relates to cylinders for compressors, motors and the like, and more particularly to variable bore cylinders having valves in the ends thereof.

Valving a motor or compressor cylinder at its ends is not new, however, present arrangements of such devices have two undesirable features. The first is that terminal travel of the piston shear's communication between the cylinder chamber and the valves causing extremely high pressure at these portions of the piston stroke. An example of this is provided by U.S. Patent 2,683,638 issued July 13, 1954 to W. H. Noble. The second undesirable feature found in present construction is the inclusion of large clearance volumes at the cylinder chamber ends when the aforementioned shear's effects are alleviated as shown in U.S. Patent 1,226,639 issued May 22, 1917 to A. J. Pocock; U.S. Patent 1,513,584 issued October 28, 1924 to C. Cornwall; and U.S. Patent 2,640,434 issued June 2, 1953 to A. L. Leman. Further, as shown in the patents noted above, excessively large casing structures must be provided to obtain the desired construction.

Use of a liner supported at its ends in a cylinder for providing a cylinder bore for the piston is also old in the art and is shown in U.S. Patent 263,989 issued September 5, 1882 to Sterne et al.; U.S. Patent 968,029 issued August 23, 1910 to W. H. Cross; U.S. Patent 1,226,693 issued May 22, 1917 to A. J. Pocock; and U.S. Patent 1,768,799 issued July 1, 1930 to F. D. Stanley. It should be noted that in each of the aforementioned patents, annular outer end surfaces of the liners have face to face contact with annular cylinder surfaces for sealing both ends of an annular chamber encircling the liner between such liner ends. With this type of construction, it is well known that a press fit or better is required to provide such an annular seal, thus necessitating machine tools for inserting and/or removing the liners from the cylinders. This is undesirable because the motor or compressor must be taken out of the work area when a liner is to be removed and results in excessive downtime. Further, with the novel valve means, it has been found that insertion and/or removal of a liner with a machine tool often destroys the cylinder.

Accordingly, an object of this invention is to vary a cylinder bore without effecting valves in the cylinder ends.

Another object of this invention is to provide a variable bore cylinder by changing wet liners without the use of machine tools.

Another object of this invention is to provide a cylinder of the above type in which changing the cylinder bore does not effect the clearance volume in the cylinder chamber.

Another object of this invention is to provide a cylinder with a hand insertable liner and valves in the cylinder ends.

Another object of this invention is to provide a cylinder with valves in the ends thereof adapted to receive hand insertable liners for varying the cylinder bore.

Another object of this invention is to change the bore of a cylinder by changing wet liners which are reusable after being removed from the cylinder.

Another object of this invention is to provide a variable bore cylinder of limited overall size with valves in the ends thereof.

Another object of this invention is to provide a variable bore cylinder having valves in the ends thereof in constant communication with the cylinder chamber.

Another object of this invention is to provide a variable bore cylinder having valves in the ends thereof in which clearance volume in the cylinder chamber is substantially reduced or kept at a minimum.

Another object of this invention is to vary the bore of the aforementioned type cylinder without changing the clearance volume in the cylinder chamber.

This invention contemplates a variable volume double acting cylinder having an inlet and an outlet, comprising a casing having a cylindrical bore open at one end to receive a liner and an annular seat at its outer end, said casing having, further, a tapered bore extending beyond the annular seat, a hand insertable liner disposed in the axial an inner cylindrical wall and having a bore communicating with said tapered bore to form a cylinder chamber, a cap connected to the casing to close the end of the cylinder chamber and with said annular seat to hold said liner against axial movement, valves in the ends of the cylinder connecting the inlet and outlet to the tapered bore at one end of the cylinder chamber and to the other end such chamber, and a piston reciprocal in the liner bore and having a tapered skirt at one end thereof, said skirt substantially filling the tapered bore when said piston is at the end of its stroke at that end of the liner adjacent said annular seat.

The foregoing and other objects and advantages of the invention will appear more fully hereinafter from a consideration of the detailed description which follows, taken together with the accompanying drawings wherein several embodiments of the invention are illustrated, by way of example. It is to be expressly understood, however, that the drawings are for illustration purposes only and are not to be construed as defining the limits of the invention.

FIGURE 1 is an elevational view of a compressor made in accordance with the invention with the central portion cut away to illustrate internal parts thereof.

FIGURE 1A is a fragmentary view of a modified portion of the device of FIGURE 1.

FIGURE 1B is an enlarged fragmentary sectional view taken within the circle of FIGURE 1, illustrating in larger detail the end of the liner and the seal thereof.

FIGURES 2 and 3 are views similar to FIGURE 1 illustrating modifications of cylinder construction, and FIGURE 4 is an end view of a cylinder liner and piston taken on plane 4—4 of FIGURE 3.

Referring now to the drawings and particularly to FIGURE 1, a double-acting cylinder made in accordance with the invention has a cylinder block or casing 10 connected at its inner end 11 to a distance piece guide 8 supported on stanchions or legs 9.

The cylinder casing 10 has a cylindrical bore therein open at an outer surface 12 of the casing and formed by a pair of annular flanges 13 and 14. Interspersed between the flanges is an annular groove 15. Flange 13 is disposed adjacent the surface 12 and is preferably of slightly larger diameter than is the flange 14. Annular flange 14 is disposed at the inner end of the cylinder and is seated at an annular end wall defining a seat 16 for a liner 30 to be disposed in the casing 10 as will be described.

The annular seat 16 defines the open periphery of a tapered bore 17 extending therebeyond and terminated by an end wall 18, at the inner end 11 of casing 10. Wall 18 is provided with a usual rod end passage which in turn receives a rod gland or seal 19 as will be further discussed.

A back head or cylinder cap 20 is connected to the casing 10 and has a surface 21 in sealed face to face abut-
A piston 40 is comprised of a piston rod 41 extending through gland or seal 19 with a reciprocable piston head 43 mounted at its end, within the interior 36 of liner 30. The head 42 has a pair of tapered skirts 43 and 44 which generally conform in size and overall shape to the interior of tapered bores 17 and 22, respectively. Thus, during the terminal portion of the stroke of piston 40, skirt 43 in one direction, skirt 44 enters the tapered bore 22 and reduces the open area therein until its annular wall approaches contact with the wall of tapered bore 22. At the terminal portion the return stroke, by movement of the piston 40 in the opposite direction skirt 43 similarly enters the tapered bore 17. As each of the skirts 43 and 44 enters respectively tapered bores 17 and 22, there is no interference by the piston 40, as by slicing or restriction with communication of valves 25 and 26 to the interior of the overall chamber at either end because of the tapered cylinder chamber end portions, and skirts. It is readily seen that there is relatively low clearance volume in the cylinder chamber with this type of arrangement because skirts 43 and 44 substantially fill tapered bores 17 and 22, respectively, as the head 42 approaches the ends of the liner bore 36.

The valves 25, communicating with the outer end of the cylinder chamber disclosed herein, are mounted in the back head or cap 20 or 20A, which, when removed as one unit, leaves the outer end of the cylinder casing 10 completely open and enables the cylinder liner 30 and the piston head 42 to be removed and replaced by the usual and conventional hand tools without the use of machine tools and without affecting such valves 25 and 26 in any way.

In addition to the case with which liner 30 may be removed as mentioned hereinbefore, the liner 30 is free of valve ports which would ordinarily have to be aligned and because of the loose fit within casing 10 the sleeve or liner is self-centering to compensate to a degree for variations in concentricity as will occur in practically any machined part, despite the most high degree of care exercised in manufacturing such parts.

With the self-alignment feature and, also, absent any valve ports and the like, the cost of manufacture of the liner 30 is within reason and, of course, assembly or replacement costs are relatively minimal since replacement can be conveniently carried out in the field.

A back head or cylinder cap 50, which is modification of cap 20A, is connected to casing 10 as shown in FIGURE 2. Cap 50 has a surface 51 in sealed face to face abutment with surface 12 of casing 10, and cap 50 is provided with an opening 52 in diameter equal to that of the interior diameter of liner 30, same being concentric with the bore 36 of liner 30 and terminated by an end wall 53 with a central recess 54 therein. Here again, shims 37 are disposed between the outer end of liner 30, and now, the surface 51 of end cap 50. The cap 50 has two ports in end wall 52 to receive valves 25 and 26 that are to communicate with bore 52. In this case the valve ports in cap 50 are generally parallel to the normal reciprocating movement of the piston 60.

A modified piston 60 is now required and has a rod 61 extending through gland or seal 19 with a head 62 fixed to the end thereof by a nut 64. Piston head 62 has only one frustoconical skirt 63 that corresponds to skirt 43 of piston head 42. It will thus be seen that as the head 62 approaches the terminus of its outward stroke it enters bore 52, and bolt 64 enters the recess 54. The return stroke of head 62 is similar to that of head 42 and skirt 63 substantially conforms to tapered bore 17. Accordingly, piston head 62 does not restrict communication of valves 25 and 26 with the cylinder chamber as head 62 reaches the terminus of its stroke, and there is substantially low clearance volume in the cylinder chamber. However, the clearance volume will increase when liner 30 and piston 60 are replaced to provide a smaller bore 36 and a correspondingly reduced piston head 62.
This, however, may be held to a minimum by the modified arrangement of FIGURE 3. The modified arrangement as shown in FIGURE 3 includes a cylinder liner 70, corresponding to liner 36, having a pair of spaced annual flanges 71 and 72. Each of the flanges 71 and 72 has an annular groove 74 to receive a resilient O-ring seal 75 that performs a functional correspondence to that set forth in connection with the previously described O-ring seals 35. The liner 70 has an internal diameter 76 which with tapered bore 17 cooperates to provide a cylinder chamber to receive piston head 62. The outer or cap end of the liner 70 has a reduced annular outer extension 77 to provide a shoulder 78 that engages cap 50. The reduced portion 77 extends into bore 52 of cap 50 and is provided with radial slots 79 to provide communication between the liner bore 76 or cylinder chamber and valves 25 and 26. With this modified arrangement, clearance volume is limited by the outer end portion 77 of liner 70 in bore 52 to the slots 79 that is a bore of the valve bores in the cap 50.

The arrangement of FIGURE 3 illustrates a further modification of the inner end 11A of a modified cylinder 10A. Valves 25 and 26, in this instance, are disposed on an axis extending radially from and in a transverse plane normal or perpendicular to the axis of casing 10A. With the valves 25 and 26 disposed in this manner in the inner end 11A of the casing 10A, the cylinder is only slightly larger than the arrangement of FIGURES 1 and 2. However, it should be readily seen that the valves 25 and 26 in the inner end 11A of casing 10A cannot be disposed axially, as are the valves in the cap 50, because of the seal or gland 19.

By changing the liner 30 or 70 and the piston 40 or 60, to cooperative members of larger or smaller diametrical measurements, the capacity of the cylinder can be changed. However, if machine tools were required to insert and extract the liners 30 or 70 from the casing 10 or 10A, the compressor or motor would have to be removed from the field of operation causing excessive down time which is highly undesirable. Thus, advantages of the present invention, a readily changeable liner and piston; both for replacement and for affecting variations in compressor capacity can be readily appreciated.

Further, if machine tools were required to insert liner 30 or 70 to provide a press fit, stresses would be induced by annular flange 32 or 72 to the annular seal flange or wall 16. In addition thereto, the axial force of such a machine tool, for example, a ram, would be transmitted to the annular seal flange 16 when the inner end of the liner 30 or 70 is disposed therein. It has been found that such induced tension together with the axial force transmitted to the seal 16 tends to cause fatigue around the base of valves 25 where the cylinder structure is relatively thin.

By use of flexible O-ring seals 35 or 75, liner 30 or 70 is hand insertable and prevents leakage from chamber 27 or 27A. In addition, the removed liner 30 or 70, barring injury through use, may be claimed and later reused with new O-ring seals 35 or 75.

Thus, I have now described preferred embodiments of my invention generally as a cylinder with valves in the ends thereof communicating with a variable cylinder bore provided by a hand insertable liner. The novel cylinder has substantially low clearance volume generally unaffected by changing the cylinder bore, has no restriction of communication between the valves and the cylinder chamber, and has overall outside dimensions, including the valves maintained without desired restricted limits.

Although several embodiments of the invention have been described and illustrated in detail, it is to be expressly understood that the invention is not limited thereto. Various changes may also be made in the design and arrangement of parts without departing from the spirit and scope of the invention as will now be understood by those skilled in the art.

I claim:

1. A reciprocating compressor comprising a casing having a cylinder means therein and a piston reciprocably moveable in said cylinder means; and valve means in communication with the interior of said cylinder means; said cylinder means comprising a cylindrical bore in said casing; a removable wet liner disposed within said bore and in circumferential contact with said piston, said liner means having an outer-circumferential wall including a pair of outwardly disposed annular flanges and a circumferential recess interposed therebetween, said generally cylindrical bore being open at one end and having inwardly directed annular flanges at its terminal edges and a circumferential recess interposed therebetween; the flanges on said liner and the inwardly directed flanges in said bore and said one end of said liner and said bore being in loosely opposed face-to-face relation; seal means disposed between the associated faces of each of said face-to-face flanges; whereby the volume between the opposed reciprocates defines a chamber for receiving fluid coolant surrounding said liner; said seal means being compressible to accommodate movement of said liner in said cylindrical bore, and means for closing the open end of said cylindrical bore and retaining said liner against axial displacement within said bore.

2. A reciprocating compressor as defined in claim 1, wherein the inner end cylindrical bore in said casing is provided with an annular seat and the inner edge of said liner is in contact with said seat and including further shimm means disposed between the opposite end of said liner and said liner retainer and cylinder closing means.

3. A reciprocating compressor as defined in claim 2 wherein said valve means is located beyond the terminal edge of said liner.

4. A compressor as defined in claim 2 wherein said compressor includes a tapered extension of said cylindrical bore in said casing beyond the annular seat and wherein said closure means is counterbored to receive said shims and said one end of said liner.

5. A compressor as defined in claim 4, wherein said closure means is defined by a removable cap having a tapered bore therein extending beyond said counterbore.

References Cited by the Examiner

UNITED STATES PATENTS

221,223 11/79 Epping 309-36
263,898 9/82 Sterne et al. 103-175
968,029 8/10 Cross 103-216
1,027,841 5/12 Hilderbrand 230-188
1,062,375 5/13 Tyson 103-175
1,092,396 4/14 Riesner 230-188
1,226,693 5/17 Poock 103-175
1,513,584 10/24 Cornwall 103-216
1,528,097 3/25 Cooper 103-216
1,595,370 8/26 Watts 230-188
1,635,753 7/27 Johnston 308-244
1,768,799 7/30 Stanley 100-329
1,817,095 8/31 Penick et al. 103-216
1,969,507 8/34 Gehres 230-21
2,304,992 12/42 Foster 103-216
2,530,246 11/50 Kirkpatrick et al. 103-216
2,640,434 6/53 Leman 103-216
2,683,658 7/54 Noble 103-216
2,771,037 11/56 Johnston 103-216
2,852,653 4/58 Wilson 103-216
2,901,981 9/59 Wawakon 103-216
2,976,813 3/61 Redman 103-216

DONLEY J. STOCKING, Primary Examiner.

LAURENCE V. EFINER, J. H. BRANSON, Jr., KARL J. ALBRECHT, Examiners.