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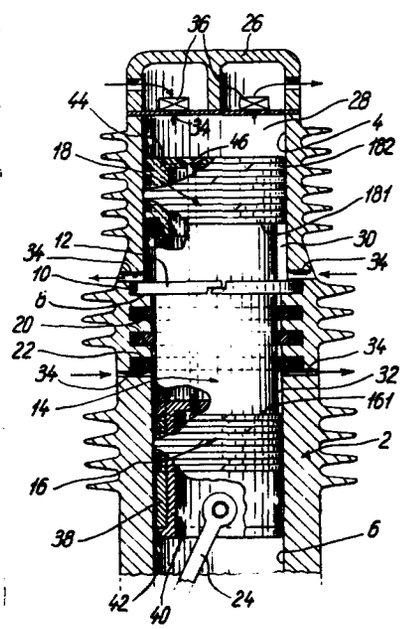
(71) Applicant: **Meilstrup, Jörgen Reimer**
Fjordvej 15
DK-8900 Randers. (DK)

(72) Inventor: **Meilstrup, Jörgen Reimer**
Fjordvej 15
DK-8900 Randers. (DK)

(74) Representative: **Rosenthal, Saul, Dr. et al**
c/o Vereenigde Octrooibureaux
Nieuwe Parklaan 107
NL-2587 BP The Hague. (NL)

(54) A piston air or gas compressor, preferably for filling divers' breathing air cylinders.

(57) A piston compressor preferably for producing compressed air at high pressure for the filling of divers' breathing air cylinders, comprising a cylinder and a plunger type piston provided with sealing rings at both ends thereof, these respective piston ends operating in cylinder bore portions of unequal diameters, the cylinder having stationary sealing rings located between these two bore portions for sealingly engaging the piston wall and thus divide the ring cylindrical space between the sealing rings of the opposed piston ends into two individual compression chambers usable as consecutive compression stages. A first compressing stage of large volume can be provided between the piston top and the cylinder end, and the compressor may thus operate as a three stage compressor with the use of a simple and robust cylinder and piston arrangement.



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A piston air or gas compressor, preferably for filling divers' breathing air cylinders.

This invention relates to piston compressors of the type referred to in the introductory clause of claim 1.

Normally high pressure compressors adapted to produce an air pressure of more than one hundred of atm are made as multi stage compressors having a differential piston comprising a broad piston portion working in a correspondingly wide cylinder portion for producing a precompression, and a so-called steeple piston projecting from the broad piston into a narrow cylinder portion, in which the steeple piston serves to compress the air as precompressed in said wide cylinder portion, the air being transferred from the wide cylinder portion to the steeple cylinder through suitable valve and tube means normally including means for cooling of the precompressed air.

By high pressure compression it is very important that the so-called dead space in a piston compressor be kept as small as possible, and the use of the said steeple piston is based on this requirement. When a large diameter piston is used it is,for various reasons, very difficult to achieve a very high compression between the piston end surface and the adjacent closed end of the cylinder in which the piston is reciprocated, a.o. because in practice the piston end cannot be brought into complete surface engagement with the end or top of the cylinder, and because the uppermost sealing ring on the piston cannot be located flush with the piston top surface, since the seating groove of the sealing ring requires piston material to be

present at both sides thereof. The dead air volume remaining when the piston assumes its top position will of course be smaller, the smaller the piston diameter is, and thence it has been preferred to make use of the said steeple piston arrangement for the last compressor stage, whereby a high final pressure is obtainable.

Another reason for using the steeple piston is that the piston is mountable on the broad piston so as to be reciprocated together therewith; this involves a relatively long working stroke, and since in the final compression stage a reduced volume of air is handled, the cylinder should be correspondingly narrow.

It is well known, however, that the steeple pistons are disadvantageous from a constructional point of view, because they require an extremely accurate mounting and a special cylinder which may well be built together with the cylinder for the larger piston, but still as a separately produced element.

It is already known, though probably not used in the present preferred connection, that in a normal large size compressor having a large diameter piston working with considerable stroke length in a first, ordinary cylinder chamber, it is possible to arrange for a small size compression chamber without making use of a steeple piston, viz. when the small chamber is confined between the cylindrical inner wall of the cylinder and the cylindrical outer wall of a plunger type piston, i.e. a ring cylindrical space confined axially between sealing rings on the respective opposite piston ends, the cylinder midways having a constriction such that one piston end works in a cylinder portion wider than the cylinder or bore portion in which the opposite piston end works. By each working stroke of the piston the volume of the larger chamber will be reduced more than the volume of the smaller chamber is increased, and a resulting compression action is obtained. However, the said smaller chamber represents a dead space which will normally be far too large for high compression purposes, and though such a differential compressor type is of simple design due to the cylinder and the piston having at least substantially the same diameters throughout their lengths, it has been preferred to use the much more expensive system comprising the said steeple piston.

This invention is based on the cognition that it is possible to increase in a simple manner the efficiency of the compressor type in which the compression is effected in an annular cylindrical space about the piston, to such a degree that the said steeple piston arrangement will no longer be required.

According to the invention there is provided a compressor of the type referred to, which is characterized by the features stated in the characterizing clause of claim 1. When the said annular sealing means are mounted stationarily in the wall of the cylinder immediately adjacent the said constriction of the cylinder bore, or so as to direct constitute the constriction, the piston sealing ring structure of the cooperating end of the piston may be moved, by the compression stroke of the piston, practically into face-to-face engagement with the fixed sealing means, whereby there will be practically no dead space left between these parts. The space, of course, should be connected with external inlet and outlet valve means, but the valve means may be arranged, in known manner, so as to give rise to only a very small dead space.

In practice the compressor according to the invention is well suited to be designed with a compression chamber at either side of the fixed sealing means, both cooperating with a common, throughgoing plunger piston having sealing ring means at both ends, whereby a simple double stage compressor is provided when the cylinder bore portions at both sides of the fixed sealing means are of mutually different diameters. Moreover, the piston may be used additionally for serving an ordinary compression chamber adjacent the free end of the piston and a closed end of the cylinder, such that a simple and robust three-stage high pressure compressor may be built from a cylinder block and a piston of substantially uniform cross dimensions along the entire length thereof.

In the following the invention is described in more detail, by way of example, with reference to the accompanying drawing, which shows a sectional view of a compressor according to the invention.

The compressor shown comprises a cylinder block 2 having an upper bore 4 and a lower, narrower bore 6 located at either side of a shoulder 8, which constitutes a lower side wall of a holding groove 10 for a sealing ring 12. In the cylinder 2 is mounted a cylindrical plunger piston 14 having adjacent its lower end a set of piston rings 16 working in the bore portion 6, and having adjacent its upper end another set of piston rings 18 of increased diameter, working in the upper bore portion 4.

The said sealing ring 12 is the uppermost ring in a set of sealing rings 20 mounted in seating grooves in a middle portion of the cylinder 2 and operating to slidingly seal against the cylindrical surface of the piston 14, these rings being of the contraction type as kwnon e.g. from stuffing boxes about piston rods. The lowermost of the rings 20 is designated 22. The bottom of the piston is hinged to a connector rod 24 which in a conventional manner connects the piston with a driving crank (not shown) for reciprocating the piston in the cylinder. The top of the cylinder is closed by a top piece 26.

In the compressor shown is provided three compression chambers, viz. a larger chamber 28 between the piston top and the top piece 26, a ring cylindrical middle size chamber 30 confined axially between the lowermost ring 181 of the top piston rings 18 and the uppermost sealing ring 12 of the fixed ring group 20, and a smaller ring cylindric chamber 32 confined axially between the lowermost sealing ring 22 of the fixed ring group 20 and the uppermost ring 161 of the lower piston ring group 16, respectively. Each of these compression chambers is in a manner not shown, but known per se, connected with respective suction and exhaust valve means through channels generally designated 34, such valve means being indicated solely at 36 in the top piece 26.

The larger compression chamber 28 is adapted to take in air from the atmosphere and deliver the pre-compressed air to the suction side of the intermediate compression chamber 30, the valve channel 34 of which are located immediately above the sealing ring 12. The exhaust valve of the chamber 30 is connected, through external cooling means (not shown) to the intake valve of the narrow compression chamber 32, the valve channels 34 of which are located immediately

underneath the lowermost sealing ring 22 of the fixed ring group 20. In a manner not illustrated the outlet of the chamber 32 may communicate, through the respective exhaust valve, with a connector pipe for connection with a high pressure bottle or cylinder to be filled with compressed air at high pressure.

The said crank for driving the piston is so dimensioned that the piston is moved between a first outer position, in which the top of the piston is located close to the top piece 26 and in which the upper piston ring 161 of the bottom ring set 16 is located immediately adjacent the underside of the lower sealing ring 22 of the fixed ring group 20, and an opposite outer position in which the lower piston ring 181 of the upper ring group 18 is located immediately above the uppermost sealing ring 12 of the fixed ring group 20.

Adjacent the top of the piston the compression chamber 28 will in the usual manner be downwardly limited by means of the uppermost piston ring, designated 182, of the upper ring group 18, and since the ring 182 is by practical necessity situated somewhat axially spaced below the top surface of the piston itself the chamber 28 will not be able to be reduced to zero by the upstroke of the piston. However, the chamber is perfectly usable as a precompression stage serving to deliver precompressed air to the intermediate chamber 30.

In the chamber 30 the air will be further compressed by the following downstroke of the piston, not between the ring members 181 and 12, and here it is important that these ring members are mounted such that they may be moved very closely together to practically eliminate any dead space therebetween. Finally and correspondingly the air as further compressed in the chamber 30 is supplied to the narrow compression chamber 32, wherein the air is still further compressed to a very high pressure when the piston ring 161 is moved upwardly to a position extremely close to a surface engagement with the underside of the lower sealing ring 22 of the fixed ring group 20.

It will be appreciated that with the use of the fixed sealing rings 20 and especially the lowermost ring 22 thereof as projecting against the piston surface direct from the wall of the cylinder bore portion cooperating with the lower piston rings 16, the chamber 32 between these respective rings will be narrowable practically to zero, whereby the dead space of the last compressor stage may be kept as small as possible.

A known compressor type is principally rather similar to the compressor shown in the drawing, but is not provided with the fixed sealing rings 12, 20, 22, whereby a compression chamber 30 is formed direct between the two opposed sets of piston rings 16 and 18, the bore 6 underneath the constriction 8 being only slightly larger than the piston diameter. However, the entire space underneath the constriction 8, down to the bottom piston rings in the lowermost position of the piston will then constitute the said dead space, which will be of a considerably size. The provision of the fixed sealing rings 20 according to the present invention constitutes an important improvement in this respect, even if it is chosen to mount the uppermost fixed ring 12 in a seating groove spaced slightly below the constriction shoulder 8 between the bore portions 4 and 6.

The compressor shown can be manufactured in a relatively simple manner, since both the cylinder and the piston are of substantially uniform width throughout their length. The piston is assembled from a cylindrical tube 38 bottomwise provided with the piston rings 16, an inverted cup shaped bottom piece 40 having a lower edge flange 42 engaging the lower edge of the tube 38, and a cylindrical top piece 44 provided with the upper set of piston rings 18 and forming a piston top of slightly increased diameter. The top piece 44 serves to hold a pair or number of axial bolts 46 screwed down into screw threaded holes in the top side of the bottom piece 40, which is thereby held clamped against the lower edge of the piston tube 38. The compressor is assembled by mounting the sealing rings 20 in the cylinder and introducing from below the piston tube 38 with its lower piston rings 16 and bottom piece 40; the piston top piece 44 with the piston rings 18 is introduced from above through the open top end of the cylinder, whereafter the bolts 46 are tightened and the cylinder tope piece 26 is mounted.

If the single sealing rings of the various ring groups 16, 18 and 20 were entirely sealing it would of course be sufficient to use but a single ring in each respective group, but so far no entirely selaing and yet practically usable sealing ring has been developed, so it is preferred to use respective multiple ring systems. In this connection it is important that the fixed rings 12, 20, 22 are mounted in a cylinder bore portion generally of the same relatively small diameter as that of the lower bore portion 6, because leaking air from both of the compression chambers 30 and 32 will then intrude into a relatively narrow space, in which a high counter pressure will then be rapidly built up, so as to effectively limit the leakage and therewith restrict the effective size of the said dead space.

For the invention it is the compression chamber 30 or particularly 32 which is of primary importance, and of course the invention will also comprise a compressor which is built solely with one or both of these chambers, or which is provided with two cylinders comprising various respective low, intermediate and high pressure chambers, when at least one of these chambers, preferably the last high pressure chamber, is designed in accordance with the principle of the invention.

CLAIMS

1. A piston compressor, prerferably a high pressure air compressor for charging breathing air cylinders for divers, comprising a high pressure working chamber and preferably one or more additional compression chambers connected in series therewith, said high pressure chamber being constituted by a ring cylindrical space confined radially between the cylindrical outside of the piston and the inside of the cylinder bore in which the piston works and axially between a piston sealing ring structure on the piston and a constriction of the cylinder bore, annular sealing means being provided for sealing the space between the piston surface and the constricted portion of the cylinder bore, characterized in that said constriction of the cylinder bore is located close to or constituted by the side of said annular sealing means facing the high pressure working chamber, these sealing means being mounted fixed to the inside of the cylinder bore for sealing against the outside of the piston as reciprocated relative thereto, said piston being reciprocable so as to bring, by each working stroke, said piston sealing ring structure into a position axially very close to said annular sealing means.

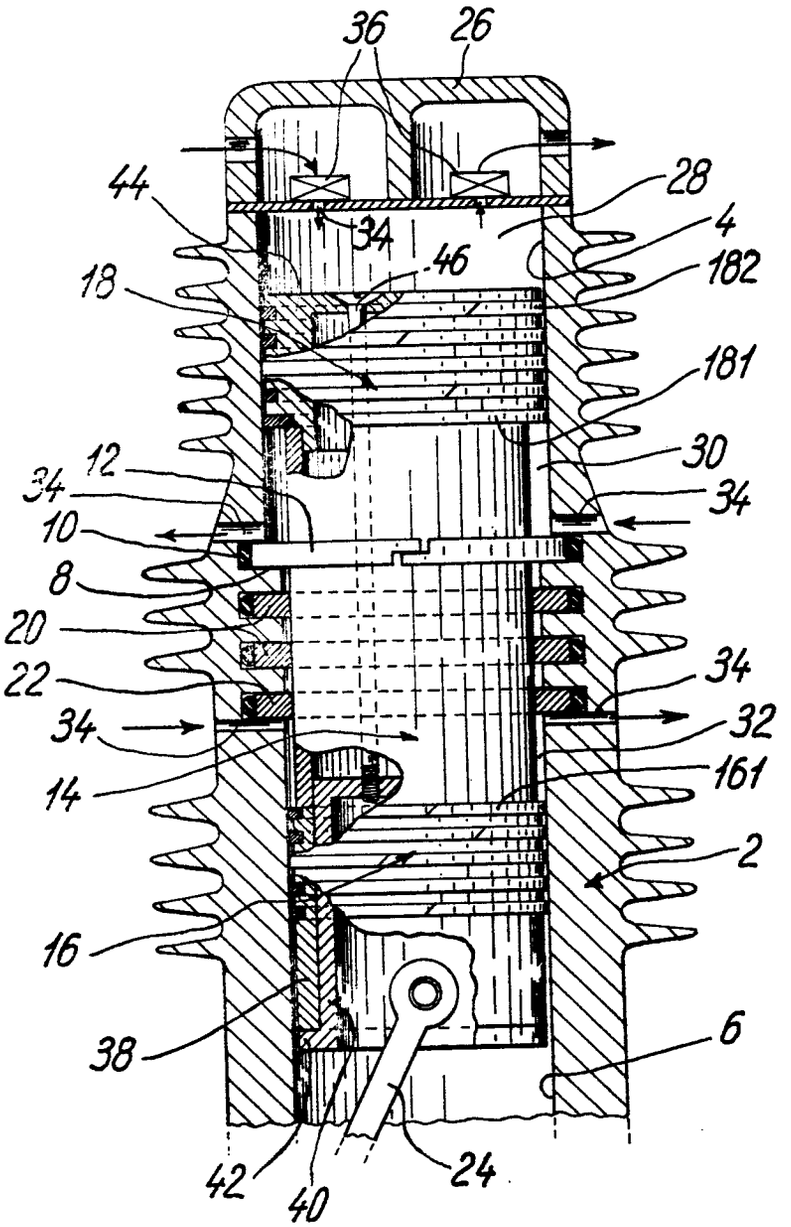
2. A piston compressor according to claim 1, characterized in that said annular sealing means are seated in holding groove means in the wall of a cylinder portion of generally the same diameter as that of the bore of the high pressure working chamber.

3. A piston compressor according to claim 1 or 2, characterized in that both the cylinder and the piston extends beyond the opposite side of said annular sealing means and at that side form an additional compression chamber confined between said opposite side of the annular sealing means and an additional piston sealing ring structure mounted on the respective extended portion of the piston.

4. A piston compressor according to claim 3, characterized in that the portion of the additional piston sealing means confining said additional compression chamber is constituted by a sealing ring member projecting from a holding groove arranged adjacent the piston portion forming an end of the piston length having the same diameter as said annular sealing means.

5. A piston compressor according to any of the preceding claims and comprising a cylinder block closed at one end in such a manner that the piston end surface adjacent this cylinder end forms a reciprocable wall in a precompression chamber, while the cylinder block is provided with two coaxial bore portions of mutually different diameters, characterized in that the said annular sealing means are placed immediately between said two bore portions, and that the bore portion of the largest diameter is located adjacent the closed end of the cylinder, the piston being constituted by a cylindrical body which, in the bore portion of the largest diameter, is provided with a piston head of enlarged diameter and serving as a mounting base for piston sealing ring means sealing against the cylinder bore wall of said precompression chamber.

6. A piston compressor according to claims 3 and 5, characterized in that it is built as a three stage compressor comprising both the precompression chamber, the said additional compression chamber, and the said high pressure working chamber, said chambers being series connected through suitable inlet and outlet valve means.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EUROPEAN SEARCH REPORT

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EP 7[illegible] 20 0[illegible]

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	DE - C - 13 273 (BROTHERHOOD) * Figures 1,2; claim *	1,3-6
	FR - A - 349 378 (ELWELL) * Figure; pages 1,2; sealing means in cylinders (a1 and a2) *	1,2
	US - A - 2 486 598 (HOCKENS) * Figures 1 to 3; claims 1 to 4 *	1,2
	DE - A - 2 658 793 (BALKAU) * Figures 1,4; page 17, last paragraph to page 18, second paragraph *	1
A	GB - A - 10 278 A.D. 1 909 (STONE) * Figures 1,2; claim 1 *	1,6

CLASSIFICATION OF THE APPLICATION (Int. Cl.²)

F 04 B 25/02
F 04 B 39/04

TECHNICAL FIELDS SEARCHED (Int.Cl.²)

F 04 B 25/02
F 04 B 25/00
F 04 B 39/04
F 04 B 39/00
F 04 B 37/16
F 04 B 5/00
F 16 J 1/00
F 17 C 5/06

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	19-10-1978	ANDRIES

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