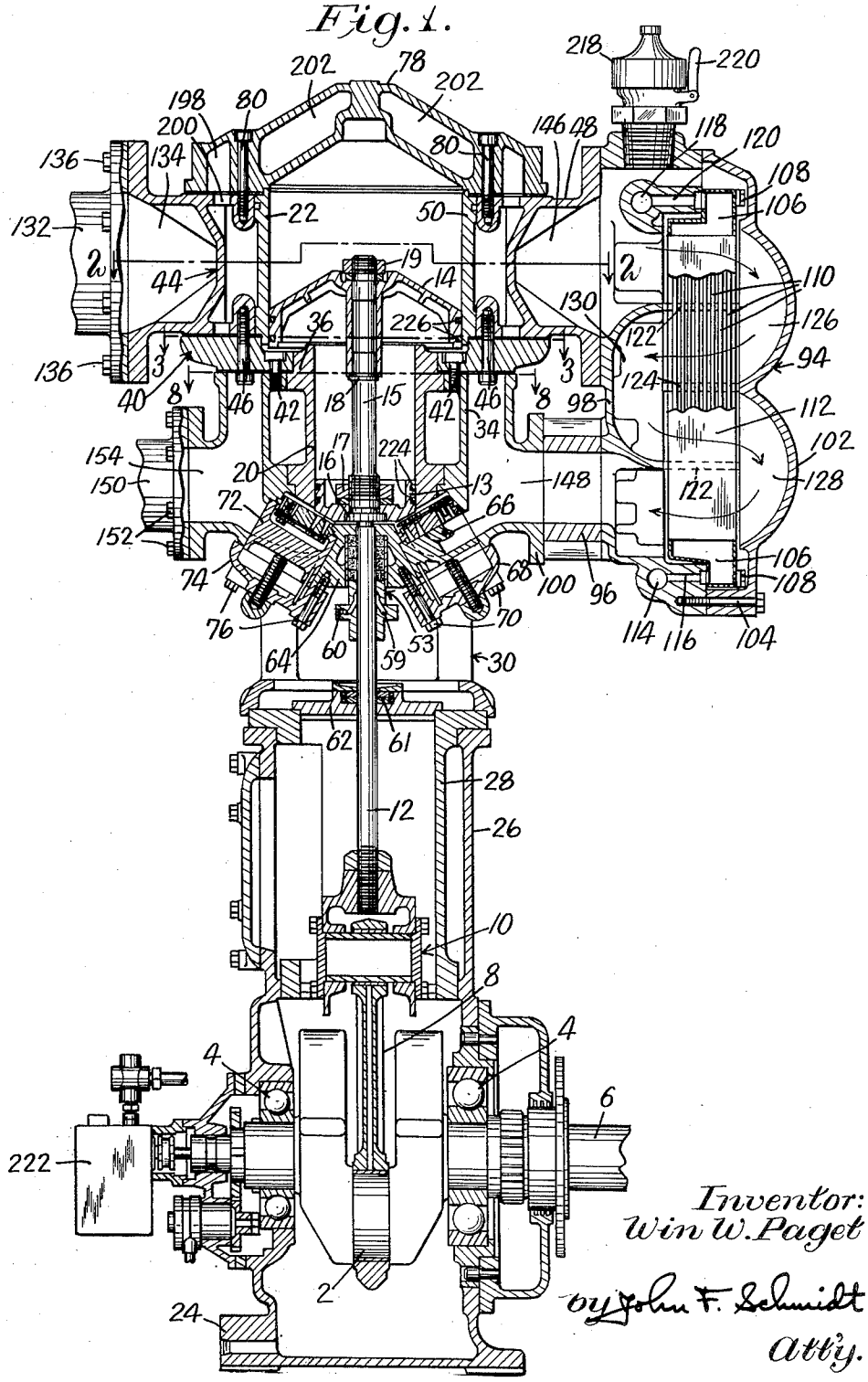
Nov. 23, 1954 W. W. PAGET 2,695,132

COMPRESSOR

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Fig. 1.



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Fig. 2.

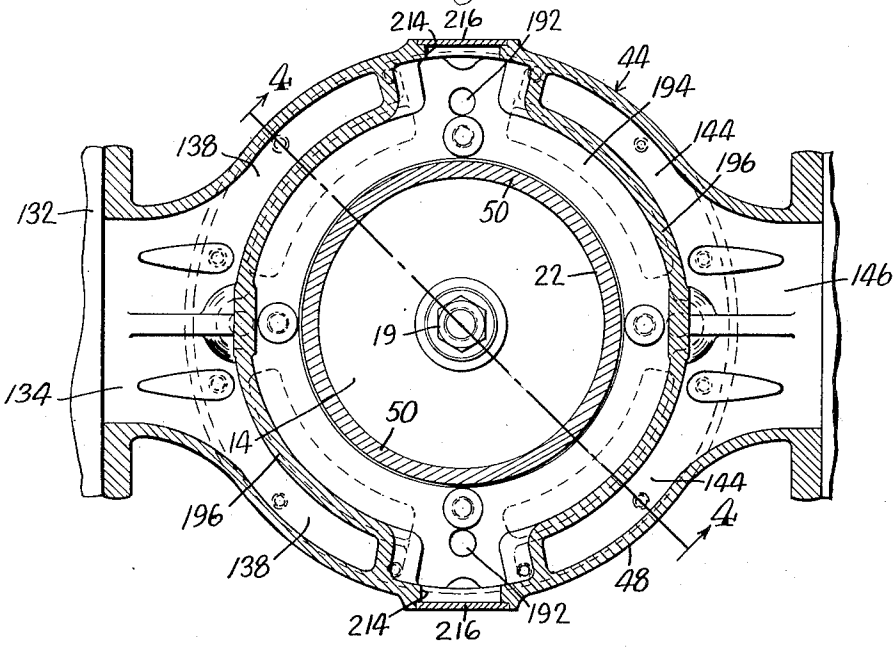
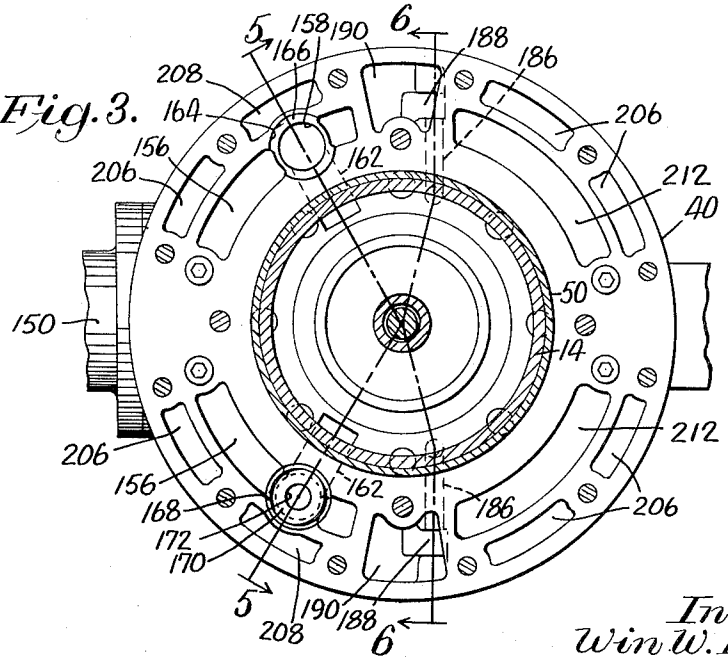


Fig. 3.



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Fig. 4.

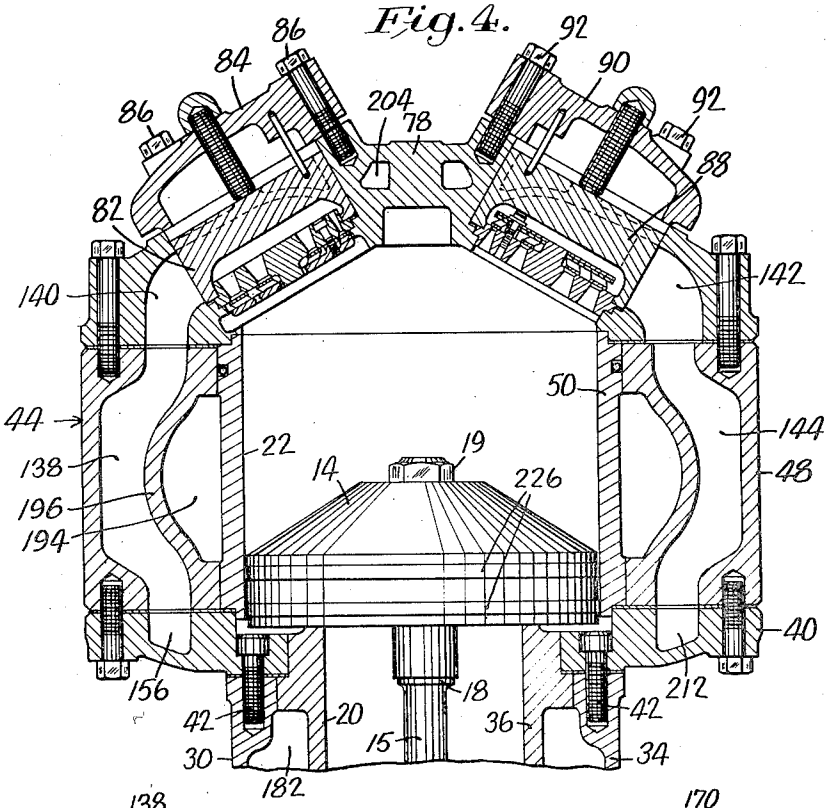


Fig. 5.

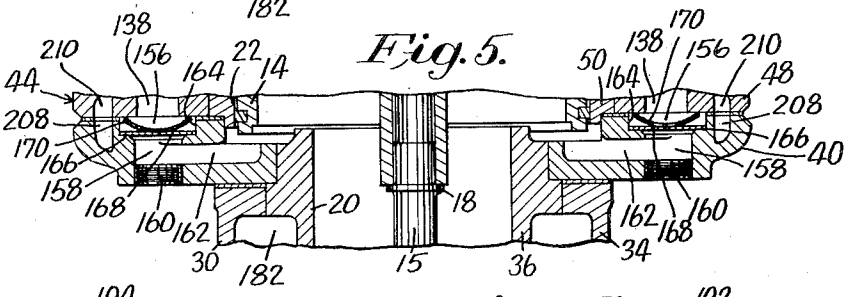


Fig. 6.

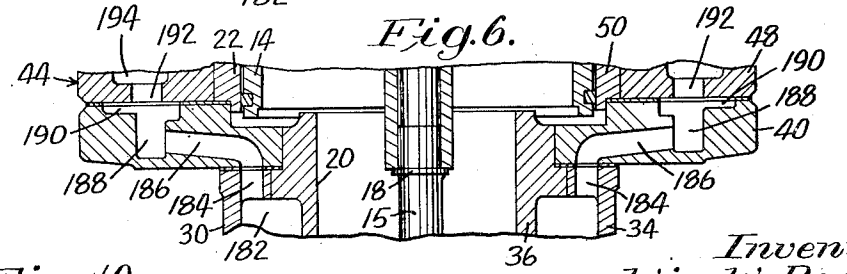


Fig. 10.

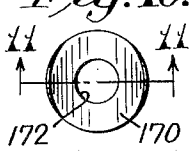
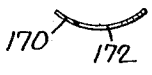


Fig. 11.



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Fig. 7.

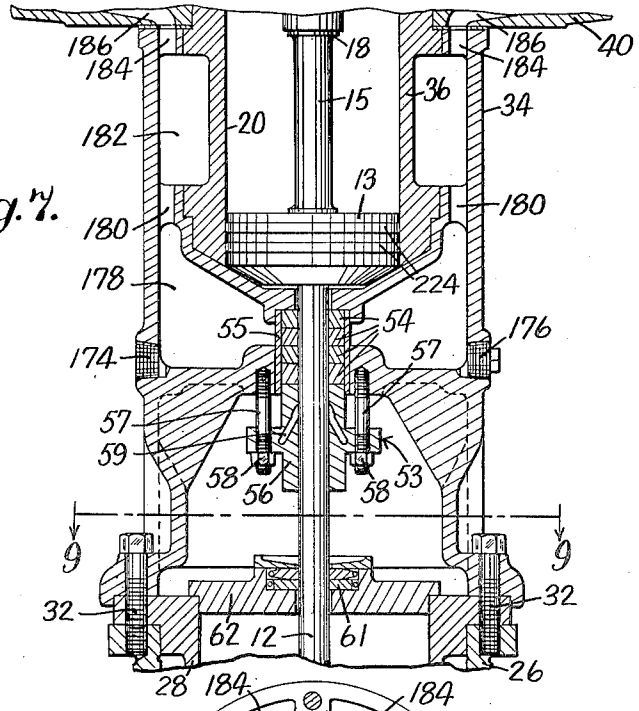


Fig. 8.

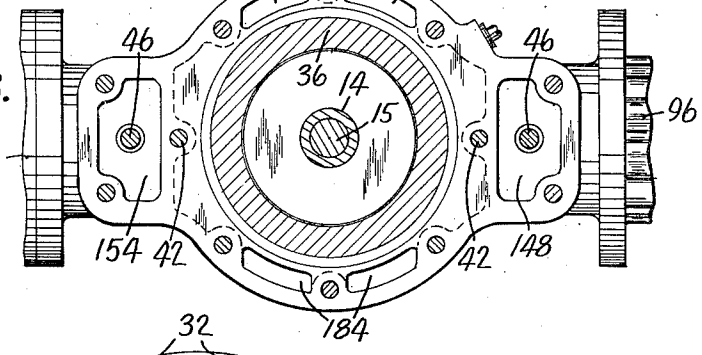
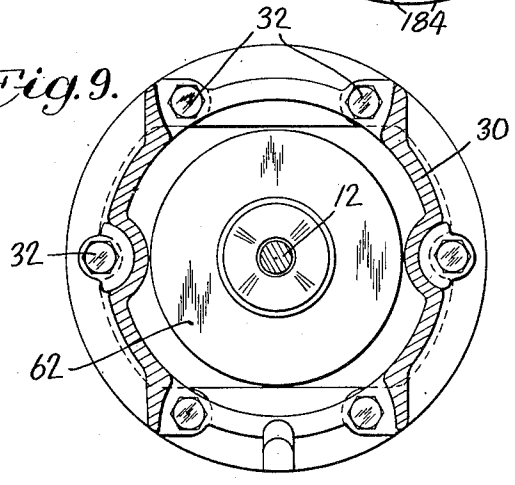


Fig. 9.



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2,695,132

COMPRESSOR

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4 Claims. (Cl. 230—183)

This invention relates to gas pumps, especially to air compressors of the two-stage type.

There are many industrial uses for compressed air, and efficient, reliable compressors are in considerable demand. One of the problems associated with the supply of compressed air concerns the fact that the temperature of the air increases materially in the compression process, and the increased temperature of the air results in increased volume; or, to put it another way, the increase in temperature itself causes a pressure increase which is lost after the air has cooled down. One of the principal problems, therefore, is concerned with temperature increase during compression.

Size of the apparatus is another concern of the compressor designer. It is desirable to keep compressor size to a minimum consistent with efficient operation, in order to keep bulk and weight down. Accordingly, another problem is the arrangement of the compressor elements in the manner which will provide most efficient operation for a given size and weight.

In a compressor made according to this invention, the high pressure and low pressure stage cylinders are closely adjacent, and are so arranged that the two pistons in fact reciprocate in communicating spaces. Inasmuch as the two pistons displace different volumes, there is a volume differential on each stroke which gives a pumping action. Unless the pumping action is taken into account, it can result in substantial power losses.

It is accordingly among the objects of the invention to provide a two-stage air compressor having such a new and improved arrangement of elements as to permit a minimum of temperature increase during the compression of the air and to provide for a maximum of efficient operation with a minimum of weight, and with occupation of a minimum of space. It is another object of this invention to provide a two-stage air compressor in which losses arising out of the unproductive pumping of air are substantially eliminated. These and other objects are accomplished in a two-stage air compressor in which coaxial high and low pressure stages are operated from a single crank through a common piston rod; in which cooling between stages is provided for by an efficient arrangement of parts including an intercooler; and in which the repeated unproductive movement of entrapped air is largely obviated by a valve mechanism and arrangement which permits the escape of entrapped air and prevents the admission of air directly from the atmosphere.

In the drawings:

Fig. 1 is a longitudinal section view through a compressor embodying the invention;

Fig. 2 is a view in section on the planes of line 2—2 of Fig. 1;

Fig. 3 is a view in section substantially on the plane of lines 3—3 of Fig. 1, with one of the valve discs and its spring removed;

Fig. 4 is a view in section on the plane of line 4—4 of Fig. 2;

Fig. 5 is a view in section substantially on the planes of line 5—5 of Fig. 3;

Fig. 6 is a view in section substantially on the planes of line 6—6 of Fig. 3;

Fig. 7 is a view in section substantially on the planes of line 6—6 of Fig. 3, but on a smaller scale than Fig. 6, and taken lower down;

Fig. 8 is a view in section on the plane of line 8—8 of Fig. 1;

Fig. 9 is a view in section on the plane of line 9—9 of Fig. 7;

Fig. 10 is a plan view of a valve spring; and

Fig. 11 is a view in section on the plane of line 11—11 of Fig. 10.

Referring now in detail to the drawings, a crankshaft 2 is shown mounted for rotation in bearings 4 by any suitable power source connected for that purpose through a shaft 6. A connecting rod 8 changes the rotary motion of the crank throw into reciprocating motion of a crosshead indicated generally at 10. The crosshead will not be described in detail herein, but may be any of a number of suitable crossheads, such as the one shown in Patent No. 2,312,335 to Halleck, issued March 2, 1943. A piston rod 12 transmits the translatory motion of crosshead 10 to a high pressure piston 13 and a low pressure piston 14, the connection between the high and low pressure pistons being made through an extension 15 of the rod 12. The high pressure piston 13 is secured to the rod between a collar 16 and a nut 17. The low pressure piston 14 is secured on extension 15 between a collar 18 and a nut 19. The high pressure piston reciprocates in a high pressure cylinder 20, and low pressure piston 14 reciprocates in a low pressure cylinder 22. The two pistons and their respective cylinders cooperate to define a chamber which, with the structure shown, has a constantly varying volume as the pistons reciprocate.

Bearings 4 are mounted in a main frame or base 24 which has integral therewith a pedestal 26. A crosshead guide 28 is removably mounted in the pedestal 26. A cylinder block 30 is mounted on crosshead guide 28 and pedestal 26, and is secured thereto by threaded members 32. Cylinder block 30 has integral therewith an outer cylinder wall 34, and carries a removable liner 36.

A valve-containing element 40 is mounted on cylinder block 30 by means of bolts 42, and in turn low pressure cylinder block 44 is secured to valve-containing element 40 by bolts 46. Low pressure cylinder block 44 is made up of the outer wall member 48 and a removable liner 50 in which there is provided the aforesaid cylinder 22 to receive the reciprocating low pressure piston 14.

A stuffing box 53 is shown as providing a fluid seal about the piston rod 12. The stuffing box 53 includes a number of packing rings 54 held in place in stuffing box sleeve 55 by a packing gland 56. Gland 56 is secured to cylinder block 30 by studs 57 and nuts 58. Gland 56 is provided with an oil collector recess 59 and a threaded opening 60 to which a drainage conduit (not shown) may be fitted. Recess 59 is provided to collect such oil as may get past the scraper rings 61 mounted in plate 62.

Integral with cylinder block 30 there is a high pressure cylinder head 64 in which an air inlet valve 66 is removably mounted by means of a cap 68 and bolts 70; and in which an air discharge valve 72 is removably mounted by means of a cap 74 and bolts 76. The details of valves 66 and 72 will not be described here. For an understanding of these valves, reference may be had to Patent No. 2,213,259—Paget, issued September 3, 1940.

A cylinder head 78 is secured by bolts 80 to cylinder block 44 of the low pressure cylinder. Cylinder head 78 carries a pair of inlet valves, one of which is shown at 82, and is removably held in place by a cap 84 and bolts 86; cylinder head 78 also carries a pair of air discharge valves, one of which is shown at 88 and is held in place by a cap 90 and bolts 92. For a detailed understanding of valves 82 and 88 reference may be had to the above identified patent to Paget.

An intercooler indicated generally at 94 is mounted on cylinder blocks 44 and 30, there being a ribbed spacer 96 between the casing 98 of the intercooler and the flange 100 on cylinder block 30 to which the intercooler is secured. A cover 102 is secured to casing 98 by bolts, one of which is shown at 104.

Intercooler 94 may be any of a number of satisfactory heat exchangers, and is here shown as comprising headers 106 held in place by bolts 108. Tubes 110 extend between the headers, and are here shown as covered by a plate 112, broken away in the drawing to disclose the tubes. A cooling water inlet passage 114 communicates

with one header through a passage **116**; the other header communicates with a cooling water outlet **118** via duct or passage **120**.

Tubes **110** are preferably provided with fins for better contact with the air to be cooled. If no fins are used, baffles **122** and **124** should be used to constrain the air flow in the direction of the arrows. If fins are used, the fins themselves may suffice to direct the air across the tubes, serving as baffles. The direction of air flow is reversed once in each of chambers **126** and **128** in cover **102**, and again in chamber **130** in casing **98**.

An air intake conduit **132** is secured to the first stage, or low pressure, intake **134** by bolts **136** in cooperating flanges. Intake **134** communicates with inlet valves **82** via passages **138** in the cylinder block **44** (Fig. 2) and passages in the cylinder head **78**, one of such passages being shown at **140** (Fig. 4).

Discharge valves **88** empty into passages in the cylinder head **78**, one of which is shown at **142**, whence air flows through passages **144** in block **44** to the first stage, or low pressure, outlet **146**, and thence to the intercooler. The high pressure, or second stage, inlet **148** connects the intercooler with the inlet valve **66**, and high pressure conduit **150**, secured by bolts **152** in cooperating flanges, is connected to the compressor discharge **154**.

As will be seen from a consideration of Figs. 1 and 4, the cylindrical opening of cylinder **20** (high pressure) is in constant communication with the cylindrical opening of cylinder **22** (low pressure); upward movement of the piston rod simultaneously moves pistons **13** and **14** and creates a partial vacuum in the space between the pistons because piston **14** displaces a larger volume than piston **13** per unit of linear travel. Similarly, downward movement of the pistons increases the pressure in the space between the pistons; if that space were at atmospheric pressure at the start of the downward stroke, the pressure would be substantially above atmospheric at the end of the stroke.

Thus, fluid between the pistons is subjected to a constant pumping action which represents useless work and which appears as heat. The heat thus generated must be removed. Accordingly, not only is power lost, but the loss of power adds to the problems of the compressor in that it adds to the total heat which must be removed by the cooling system.

This invention includes means for limiting the nonproductive pumping action to a minimum and for thus substantially eliminating the power losses arising out of such pumping. According to this means, the quantity of fluid in the space between the pistons is kept very small. provision being made to pump out of the space the fluid that leaks or blows by the piston rings.

As is best seen in Figs. 3 and 5, the valve containing element **40**, referred to above, is provided with arcuate recesses or slots **156**. In each slot there is an axial passage **158** (its lower end plugged as shown at **160**) which is in communication with a passage **162**; each passage **162** in turn opens at one end into the space between the pistons.

A bore **164** at the upper end of the passage **158** provides a seat **166** for a valve disc **168**. Each disc **168** may be, and preferably is, biased against its seat by a spring **170**, shown in detail in Figs. 10 and 11. Spring **170** may comprise a circular disc which is centrally punched out as at **172**, and which is given a cylindrical curvature as is best seen in Fig. 11.

Arcuate recesses or slots **156** in valve containing element **40** register with the lower ends of the aforesaid air passages **138** in cylinder block **44**, as is best seen in the left half of Fig. 4, thus connecting the space between the pistons with the low pressure cylinder intake via passages **162** and **158**, and bore **164**.

A compressor made according to this invention is preferably water-cooled. Water for this purpose is introduced into cylinder block **30** by any suitable conduit (not shown) engaging threaded opening **174** (Fig. 7). A corresponding opening at the opposite side is plugged as shown at **176**.

Cooling water flows through and fills chamber **178**, passing upward through passages **180** into chamber **182**, whence it flows to the low pressure cylinder block **44**. Flow to block **44** is by way of valve containing element **40**.

As is best seen in Figs. 3 and 6, water flows upward from chamber **182** through passages **184** in the upper end of high pressure cylinder block **30**, into element **40**. Element **40** has curved passages **186** which communicate with passages **184** in block **30** and with deep recesses **188** in element **40**. Recesses **188** open into larger but shallow recesses **190** in the face of element **40**.

Recesses **190** are in communication with passages **192** in cylinder block **44**, and passages **192** open upward into chamber **194**. Chamber **194** is the space between the inner wall portions **196** of outer wall member **48** and cylinder liner **50**; Figs. 2 and 4.

As is best seen in Fig. 1, chamber **194** communicates with cooling water chambers **198** in cylinder head **78** through passages **200** in the upper wall of block **44**. Cooling water chambers **202** are connected to be supplied with cooling water by other passages, not shown, and are centrally connected by annular chamber **204**, as will be readily understood by those skilled in the art.

Arcuate recesses **206** and **208** in element **40** serve to reduce weight somewhat, and cooperate with similar recesses **210** (Fig. 5) in cylinder block **44**. Arcuate recesses **212** in element **40** are located opposite the recesses **156**, but recesses **212** serve no such purpose as that served by the recesses **156**. Instead, recesses **212** register with the lower openings of passages **144**, closing those passages at the lower end of block **44**. See Fig. 4.

Cleanout holes **214** (Fig. 2) are provided in cylinder block **44**. They may normally be kept covered by any suitable means as by cover plates **216**.

A safety valve **218** of any suitable design is preferably provided in the circuit, as for example at the low pressure discharge as shown in Fig. 1. Valve **218** is provided with a lever **220** for the manual release of the valve.

A lubricator **222** of any satisfactory type may be mounted to be driven by the compressor crankshaft, and may be connected to supply oil by suitable conduits, not shown, to those parts requiring lubrication.

As will be understood by those skilled in the art, pistons **13** and **14** fit closely in their respective cylinders and are preferably provided with rings **224** and **226** respectively, in order to provide a substantially gas-tight seal.

Operation

Air is drawn from the atmosphere by way of conduit **132**, and passes into the low pressure cylinder by way of passages **134**, **138**, **140**, and valves **82**. Compressed air from the first stage leaves the cylinder by way of discharge valves **88**, passages **142**, **144** and **146** to enter the intercooler. The air flows across the upper ends of tubes **110** in a direction indicated by the arrow into the chamber **126**, where its direction is reversed and it flows back across the tubes as indicated into the chamber **130**, where the direction of flow is again reversed and the air flows outward across the tubes again as indicated into the chamber **128**; the flow is again reversed and the air passes across the lower ends of the tubes to the passage through the spacer **96**.

The air which is thus cooled enters the high pressure stage by way of passage **148** and inlet valve **66**. In the high pressure cylinder the air is given its final compression, and is discharged by way of discharge valve **72** and passage **154** into the high pressure conduit **150**.

As was set forth above, the communicating space in the high and low pressure cylinders between the two pistons is subjected to the joint action of the high and low pressure pistons. As will be understood by those skilled in the art, the action of these pistons on the fluid in the space between them is that of compression on the downward stroke and expansion on the upward stroke. To keep the resultant heating losses to a minimum, provision is made for keeping to a minimum the quantity of fluid trapped between the two pistons. Inasmuch as a perfect seal by piston rings **224** and **226** is practically impossible, some air (or other fluid which may be compressed) is practically certain to leak past the rings. Before the quantity of air in the space between the pistons can reach any substantial proportions, it is discharged through the passages **162** and **158**, and bores **164**, past the valve **168** into the compressor inlet passage **138** by way of arcuate passages **156**.

If the cylinder walls become so worn as to be no longer usable, the liners may be easily replaced by new ones at a minimum of expense and trouble, and with little lost time. To this end, the low pressure stage liner is removably clamped between cylinder head **78** and valve

containing element **40**, and the high pressure stage liner is removably clamped between the high pressure stage cylinder head and the aforesaid element.

The advantages of a compressor made according to this invention lie in the compactness of the machine; in the ability of the machine to handle air at a desired pressure with a minimum of heat losses; and in low maintenance costs, with a minimum of time loss.

While there is in this application specifically described one form which the invention may assume in practice, it will be understood that this form of the same is shown for purposes of illustration, and that the invention may be modified and embodied in various other forms without departing from its spirit or the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent is:

1. In a compressor having an intake and a discharge, a large diameter cylinder block comprising an outer wall member and a cylinder liner circumferentially bounding a large diameter cylinder and removably held in the outer wall member, a cylinder head engaging one end of said liner and secured to the outer wall member, an element secured to that end of the outer wall member which is opposite the cylinder head and engaging the end of the cylinder liner opposite the cylinder head, a small diameter cylinder block comprising an outer wall member and a cylinder liner removably received therein and circumferentially bounding a small diameter cylinder, means to secure the second outer wall member to the element, the second cylinder liner being engaged at one end by the element, the element having an opening therethrough whereby the large diameter cylinder communicates with the small diameter cylinder, a piston in each cylinder reciprocable in the respective liner thereof, means connecting the two pistons for simultaneous reciprocation, the pistons and liners defining, with the element, a chamber and the element having a passage therethrough which opens at one end into the chamber and at its other end to the intake, and a one-way valve in the passage through the element, said valve being spring-biased shut and openable only for fluid flow toward the intake.

2. In a multi-stage compressor comprising a plurality of single-acting piston-and-cylinder compression stages each stage having intake and discharge passages, a large diameter cylinder forming a first stage compression chamber, a small diameter cylinder forming a second stage compression chamber, the small cylinder having one end adjacent an end of the large cylinder, a closely fitting piston in each cylinder, the pistons being connected for simultaneous reciprocation in their respective cylinders, the two cylinders connected with each other at their adjacent ends to form with the pistons an intermediate chamber, the intermediate chamber having a constantly varying volume and receiving only fluid that leaks past the pistons, an element having passage means connecting the intermediate chamber exclusively with the first stage intake passage, and a valve in the passage means operable to a fully closed position to prevent fluid flow in the passage means to the intermediate chamber and operable to a fully open position to freely connect the intermediate chamber with the first stage intake passage.

3. In a multi-stage compressor comprising a plurality of single-acting piston-and-cylinder compression stages, a large diameter cylinder forming a low pressure compression chamber, a small diameter cylinder forming a high pressure compression chamber, the small cylinder having one end adjacent an end of the large cylinder, a closely fitting piston in each cylinder, the pistons being connected for simultaneous reciprocation in their respective cylinders, the two cylinders connected with each other at their adjacent ends to form with the pistons an intermediate chamber, the intermediate chamber having a constantly varying volume and receiving only fluid that leaks past the pistons, passage-providing means connecting the intermediate chamber exclusively with the atmosphere, and a valve in the passage of the passage-providing means and operable to a fully closed position to prevent fluid flow to the intermediate chamber and operable to a fully open position to freely connect the intermediate chamber with the atmosphere.

4. In a multi-stage compressor comprising a plurality of single-acting piston-and-cylinder compression stages, a large diameter cylinder forming a low pressure compression chamber, a small diameter cylinder forming a higher pressure compression chamber, the small cylinder having one end adjacent an end of the large cylinder, a closely fitting piston in each cylinder, the pistons being connected for simultaneous reciprocation in their respective cylinders, the two cylinders connected with each other at their adjacent ends to form with the pistons an intermediate chamber, the intermediate chamber having a constantly varying volume and receiving only fluid that leaks past the pistons, and means for maintaining pressure in the intermediate chamber at a minimum including passage providing means leading from the intermediate chamber and having a check valve in said passage operable to a fully open position to freely connect the intermediate chamber with the exterior of the cylinder and operable to a fully closed position to prevent fluid flow in the passage into the intermediate chamber, the intermediate chamber having its sole communication with the exterior of the cylinders through said check valve-controlled passage of the passage providing means.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
703,648	Garrison	July 1, 1902
1,066,261	Diesel	July 1, 1913
1,467,489	Nordberg	Sept. 11, 1923
1,513,422	Raymond	Oct. 28, 1924
1,520,853	Cable	Dec. 30, 1924
1,580,973	Rembold	Apr. 13, 1926
1,840,265	Spohrer	Jan. 5, 1932
2,403,814	Maniscalco	July 9, 1946

FOREIGN PATENTS

Number	Country	Date
520,703	Great Britain	May 1, 1940
837,768	France	Feb. 20, 1939