June 9, 1964 A. J. NICHOLAS 3,136,477

MULTI-STAGE COMPRESSOR

Filed March 28, 1961 4 Sheets-Sheet 1

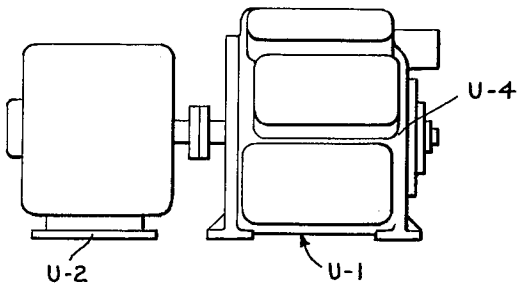


FIG. 1

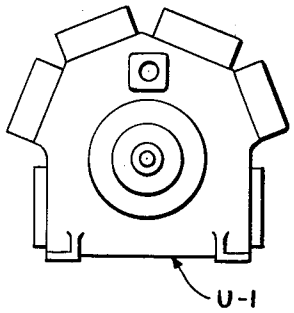


FIG. 2

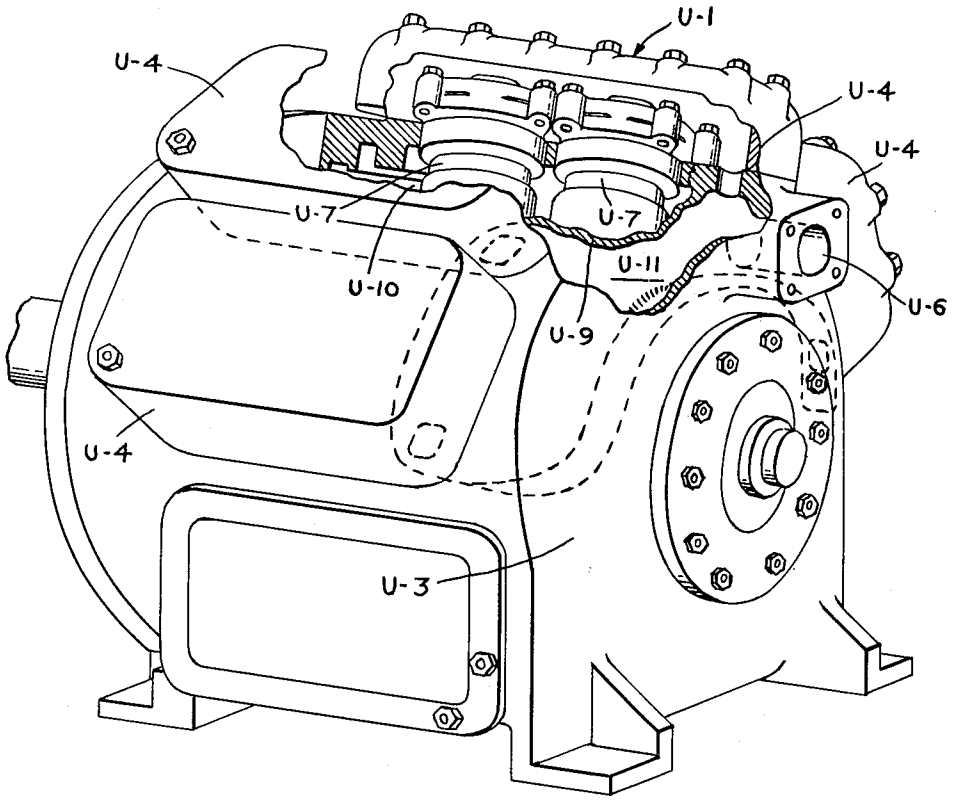


FIG. 3

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MULTI-STAGE COMPRESSOR

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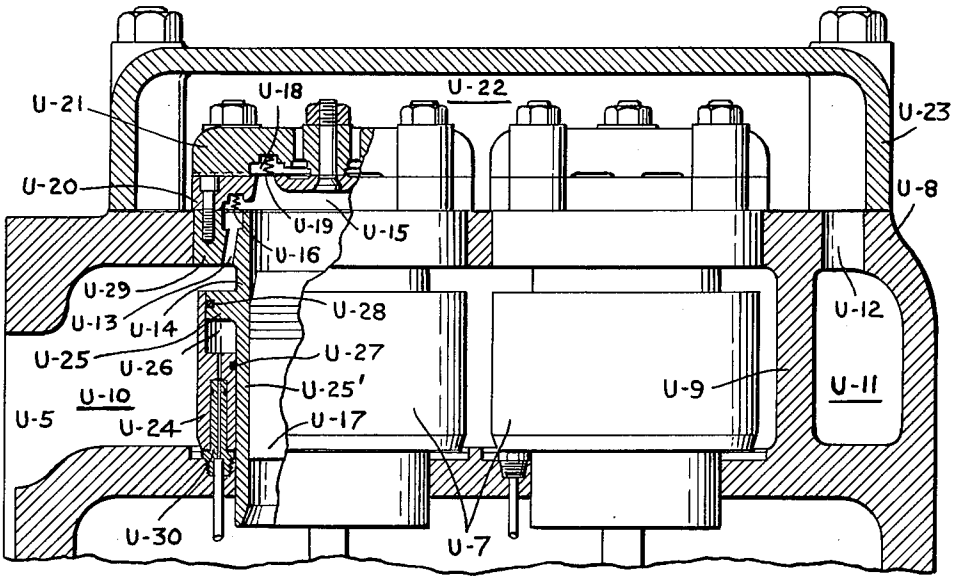


FIG. 4

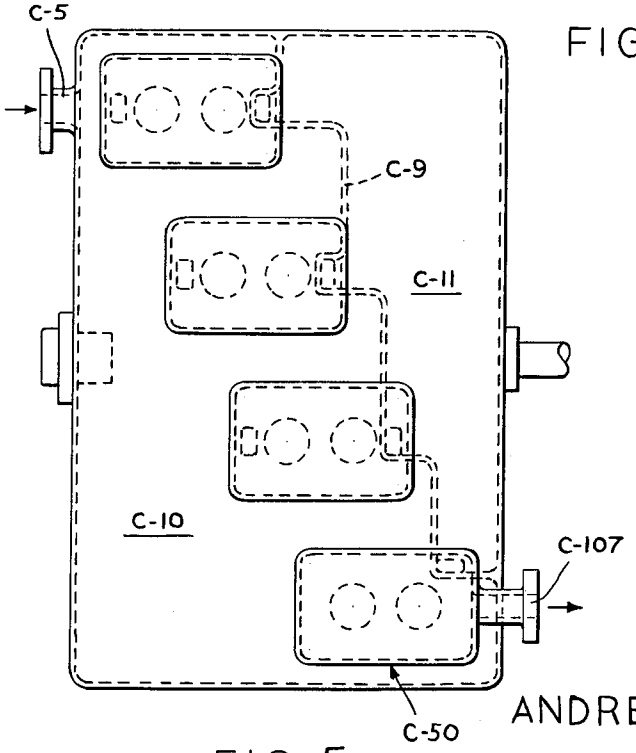


FIG. 5

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MULTI-STAGE COMPRESSOR

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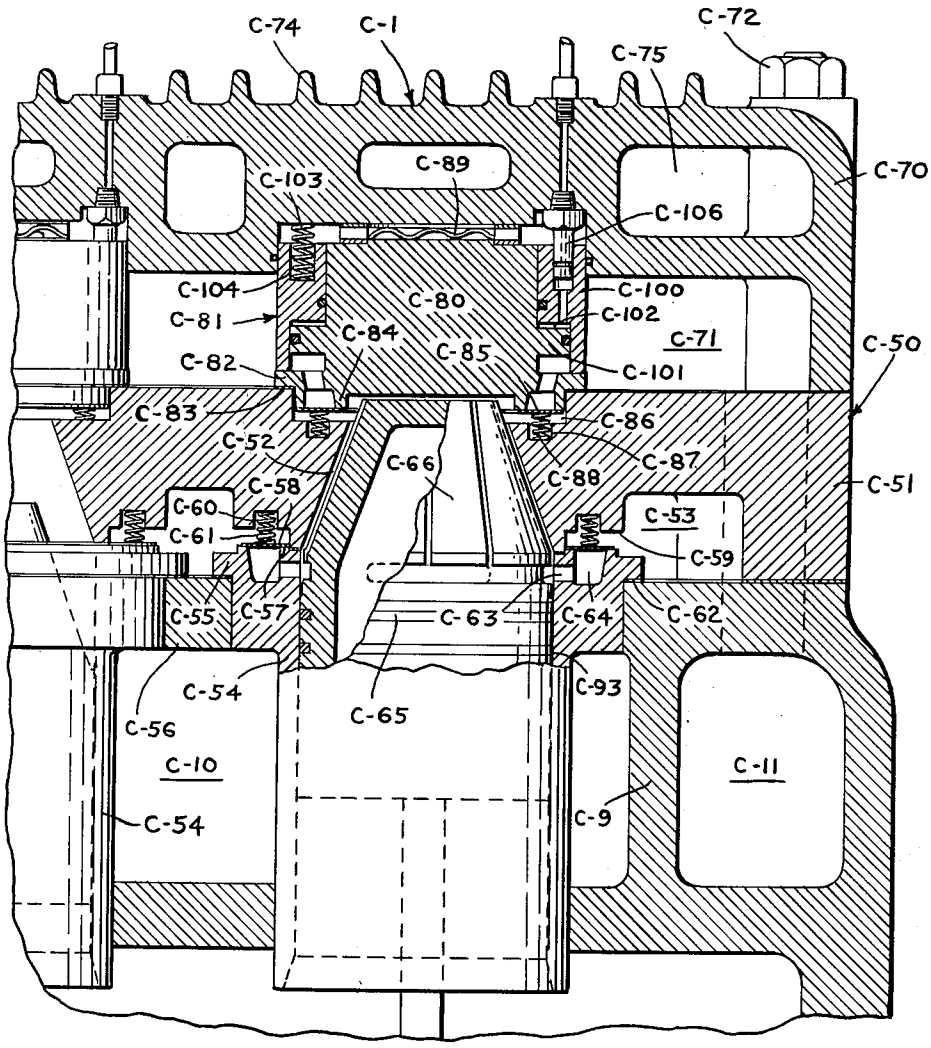


FIG. 6

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MULTI-STAGE COMPRESSOR

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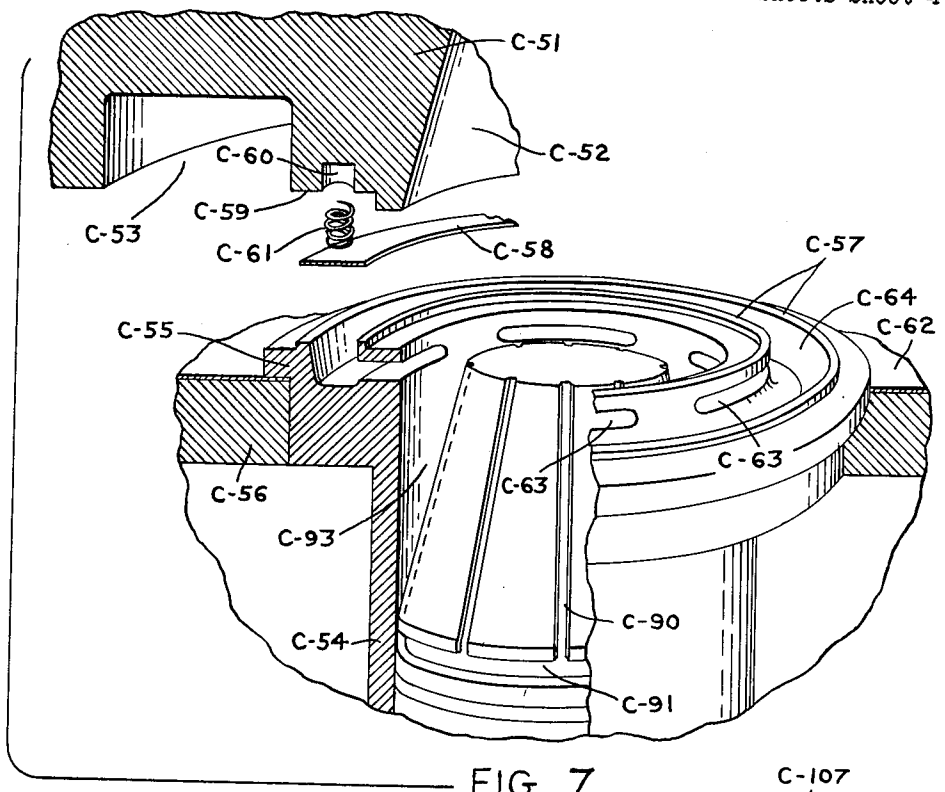


FIG. 7

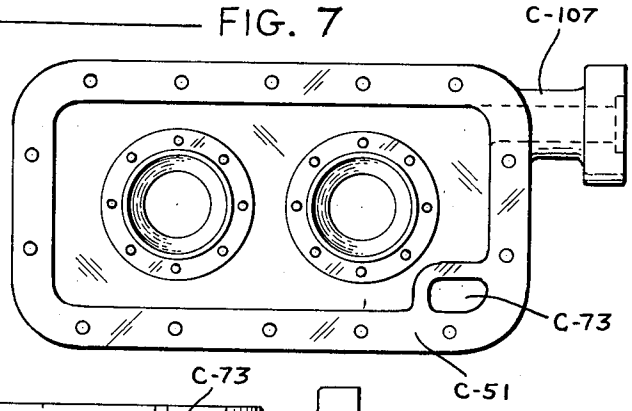


FIG. 8

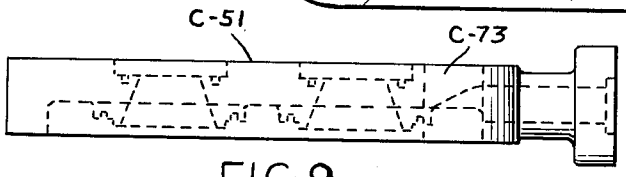


FIG. 9

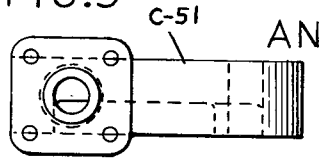


FIG. 10

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3,136,477

MULTI-STAGE COMPRESSOR

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Filed Mar. 28, 1961, Ser. No. 98,914
8 Claims. (Cl. 230—40)

This invention relates to multi-stage compressors and is an improvement of the unit shown in the copending application of Henri Soumerai Serial Number 63,045 filed October 17, 1960, now abandoned, for a compressor including means for converting a multi-cylinder unit to multi-stage operation.

To this end the unit disclosed in the above application provides a high pressure stage in the usual multi-cylinder unit with the incorporation of a sealing member and a plate like structure which directs fluid compressed by the low pressure stage to the suction inlet of the high pressure stage.

It has been found that an arrangement of the plate like structure as is disclosed in above patent application does not provide or permit the necessary inter-cooling, for optimum compressor operation, of the fluid passing from the discharge of the low pressure stage to the inlet of the high pressure stage.

Accordingly it is an object of this invention to provide means for converting a multi-cylinder compressor to multi-stage operation which entails providing a minimum of modified components for the multi-cylinder unit including cooling means arranged to inter-cool fluid passed from the discharge of the low pressure stage to the inlet of the high pressure stage.

It is another object of the present invention to provide an unloader means for use with the multi-stage compressor which has relatively few parts and hence can be manufactured at less cost, and is adaptable for assembly in a unit including a cooling means.

It is a further object of this invention to provide an improved multi-stage compressor including means for varying the capacity thereof which is simple in construction.

It is another object of this invention to convert a multi-cylinder compressor to multi-stage operation without costly redesign.

Other objects and advantages of the invention including the basic design and the nature of the improvements thereon will appear from the following description taken in connection with the following drawings; in which:

FIGURE 1 is a side view of an unconverted compressor.

FIGURE 2 is an end view of an unconverted compressor.

FIGURE 3 is a perspective view of an unconverted compressor with a cylinder head partly broken away.

FIGURE 4 is a vertical section through a cylinder head of an unconverted compressor showing the unloader means associated therewith.

FIGURE 5 is a schematic view of a converted compressor of the type shown in FIGURE 3.

FIGURE 6 is a fragmentary vertical section through the converted cylinder head of the compressor schematically shown in FIGURE 5.

FIGURE 7 is an enlarged exploded view partly in section and partly in perspective of the liner and piston portion of the conversion kit.

FIGURE 8 is a plan view of the plate portion of the conversion kit.

FIGURE 9 is a side view of the plate shown in FIGURE 8.

FIGURE 10 is an end view of the plate shown in FIGURES 8 and 9.

Unconverted Multi-Cylinder Compressor

Referring to the drawings FIGURES 1 through 4 show the unconverted multi-cylinder refrigeration compressor generally designated U–1 contemplated for conversion to a multi-stage unit as will be described in detail hereinafter. For purposes of clarity and in order to facilitate the comprehension of the concepts of the advance described herein, parts having generally the same construction and purpose will be given the same reference characters. However, in order to distinguish the units reference characters applied to the unconverted unit will be preceded by a U and those applied to a converted unit will be preceded by a C.

Continuing with the presentation of the construction of compressor U–1: the unit comprises a driving portion U–2 (which may be any known prime mover such as an electric motor) and a compression portion U–3 shown as including a plurality of compression means U–4 which compress fluid passed to the suction opening U–5 from the low side of a refrigeration installation and discharge this fluid out discharge opening U–6 to the high side of a refrigeration installation.

While the plurality of compression means U–4 are shown as comprising 4 banks each including 2 cylinders designated U–7, it is not intended to limit the scope of this invention to this arrangement as any number of banks within the realm of reasonableness may be provided. It will also be understood by those skilled in the art that the conversion means, to be hereinafter described, for embodiment in the multi-cylinder type of compressor to convert same to multi-stage operation may be adapted to a multi-cylinder compressor including single cylinders without departing from the scope of the improvement contemplated herein. It will also be evident that the disclosed invention is as applicable to hermetic type compressors.

Referring to FIGURES 3 and 4, the compression portion U–4 of the unit includes a casing U–8 which is divided by a partition U–9 to provide a first and second compartment U–10 and U–11. In actual construction compartments U–10 and U–11 are cast as separate portions of the casing to provide chambers which are respectively connected to the low and high side of the system.

More particularly compartment U–10 is in communication with suction opening U–5 which is in turn connected to the low side of the refrigeration system.

Compartment U–11 receives compressed fluid from the compression means U–4 through passage or opening U–12 and passes this pressurized fluid to the high side of the system through discharge opening U–6.

As is customary in this type of unit, the compression means U–4 all take suction from the first compartment U–10, and as will be understood by those skilled in this art fluid passes through a port U–13 formed in liner U–14 into cylinder U–15. The usual suction valve U–16 is disposed over port U–13 to regulate flow into and out of cylinder U–15. Piston U–17 driven through usual crank shafts by driving means U–2 compresses the fluid and forces same through the discharge port U–18 by discharge valve U–19, all of which are disposed in valve plate U–20 and valve guard U–21, into discharge chamber U–22.

Discharge chamber U–22 is shown as formed by disposing means comprising a head U–23 on a portion of casing U–8 which communicates with the second compartment U–11 through opening U–12. Fluid passed to compartment U–11 is discharged through discharge opening U–6 to the high side of the system.

In order to operate the compressor at substantially constant speed but at increments of its full capacity, means taking the form of a moveable annular element

U–24 is disposed about the cylinder and in close clearance with a boss U–25 formed on the cylinder liner U–25′ and in such fashion as to provide a chamber U–26 therebetween. Seal means U–27 and U–28, shown as O-rings are disposed in grooves formed in the moveable element and the boss to coact with the liner and the moveable element to confine fluid passed to chamber U–26 therein.

The moveable element U–24 is normally held in abutment with flange U–29 formed as an extension of the liner U–25′ by resilient means (not shown) disposed in an opening in the bottom portion of the moveable element U–24 and in engagement with the lower bulk head of the compression means.

During the stage of compressor operation when element U–24 is in abutment with the flange portion U–29, it functions to preclude passage of gas from the suction compartment U–10 to cylinder U–15 through chamber U–13.

The moveable element is guided and aligned during assembly of the various elements by a fluid connecting means U–30 which is in communication with the fluid type chamber U–26 at one end and a source of fluid such as the lubrication system of the compressor at the other end.

When proper conditions occur or when desired, fluid is passed from the source (not shown) to the fluid tight chamber U–26 to move the moveable element U–24 downwardly and thereby open communication between the suction compartment U–10 and the cylinder.

While only one bank is described it will be evident to one skilled in the art that the remaining banks of the unconverted compressor U–1 are of similar construction and function in the manner described above.

The compressor U–1 generally described above can readily be adapted to multi-stage operation should a particular refrigeration system require same. Thusly the above described unit may be converted to multi-stage operation as hereinafter described without the need for complicated and costly redesign.

Conversion Means

The desired conversion to multi-stage operation is accomplished by associating conversion means generally designated C–50 with at least one bank of the multi-cylinder compressor described above.

Accordingly in this manner the remaining unconverted stages will act as a low pressure stage and provide the initial increase in pressure to the fluid which is then raised to the final or output pressure by the converted or high pressure stage as will be evident from the description that follows. And with the advance contemplated herein the fluid passing from the low pressure stage to the inlet of the high pressure stage is cooled to thereby provide a more efficient compressor.

With more particularity the conversion means C–50 comprises a plate means C–51, having a frusto like opening C–52 and forming a discharge chamber C–53, which is mounted in association with cylinder liners C–54. The liners C–54 form cylinders C–93 and are distinguishable from those shown in connection with the low pressure stages in FIGURES 1 to 4 in the flange means C–55 is seated on the top portion of bulk head C–56 and is machined to form a seat C–57 for the discharge valves C–58.

Plate means C–51 is counter bored as at C–59 and provided with a series of drilled holes C–60 which receive springs C–61 acting to keep the discharge valve on its seat.

A gasket C–62 is disposed between the flanges and bulk head and functions to seal the cylinder from the suction compartment C–10. Passage means comprising spaced cut-outs C–63 and recessed pocket C–64 connect the cylinder through discharge valve C–58 with the discharge chamber C–53.

A piston C–65 having a frusto like head C–66 conforming to the shape of opening C–52 is disposed within the cylinder to act as usual on the fluid to be compressed.

A second plate C–70 forming a suction and cooling compartment C–71 is disposed over the discharge plate C–51. The plates C–70 and C–51 are connected to the casing of the compressor by any well known means such as by bolt members C–72.

The suction compartment C–71 is connected to the second compartment C–11 through a passage way C–73 formed in the plate C–51 and segregated from the discharge chamber C–53.

Controlling the superheat of the gases discharged from the low pressure stages and collected in the second compartment C–11 is accomplished with the provision, in plate means C–70, of cooling fins C–74 and cooling passages C–75 which are shown as cast water or other cooling medium passages which may be connected to a source of cooling fluid not shown.

The head portion and suction valve cage of the cylinders comprising the high pressure stage are formed by the body portion C–80 of the unloader element generally designated C–81. A flange C–82 formed on the lower end of the body portion C–80 is seated on the top portion C–83 of the discharge plate C–51 and is provided with a seat C–84 for the ring type suction valve C–85.

Counter-bore C–86 and drilled holes C–87 are formed in the plate C–51 to receive spring means C–88 and provide the clearance space and seating function for the suction valve in similar fashion as was described above regarding the discharge valves. A Belville washer C–89 firmly positions the body portion C–80 of the unloader means on the plate means C–51 and coacts therewith to form an operative cylinder.

In order to compensate for the small clearance between the head portion of the piston and the opening C–52, peripheral grooves C–90 are formed in the truncated portion C–66 of piston C–65 and terminate in a horizontal groove C–91 formed therein. It will be evident that at top piston dead center the groove C–91 aligns itself with the slots in the liner C–63 to permit free flow of compressed fluids out discharge valve C–58.

The usual sealing means are provided to maintain fluid type relationship between the various chambers described hereinabove.

In order to operate the multi-stage compressor at substantially constant speed but at increments of its full capacity, means taking the form of a moveable annular element C–100 is disposed about the body portion C–80 and in close clearance with the boss C–101 formed thereon and in such fashion as to provide a fluid type chamber C–102 therebetween. The usual seal means such as O-rings are disposed in the boss and moveable element to coact with the liner and the moveable element to confine fluid passed to chambers C–102 therein.

The moveable element C–100 is normally held in abutment with flange C–82 formed on the body portion C–80 by spring means C–103 disposed in an opening C–104 in the top portion of moveable element C–100.

During the stage of compressor operation when the moveable element C–100 is in abutment with the flange portion C–82 as is shown in FIGURE 6, it functions to preclude passage of gas from the second compartment C–11 to cylinder C–93 through the suction valve C–85.

The moveable element is guided and aligned during assembly of various elements by a fluid connecting means C–106 which is in communication with the fluid type chamber C–102 at one end and a source of fluid such as the lubrication system of the compressor at the other end.

When proper conditions occur or when desired, fluid is passed from the source of the fluid type chamber to thereby actuate the moveable element out of engagement with the flange C–82 and open communication between

the suction compartment C–71 and the cylinder to be acted upon thereby and then discharged out of discharge opening C–107 to the installation including this multi-stage compressor.

Operation of the Converted Compressor

In operation of the multi-stage unit, low pressure gas from the system enters the first compartment C–10 through the opening C–5 in the casing C–8. Gas from the first compartment passes through the inlets of low pressure banks for compression by the usual pistons. Sealing means formed on the high pressure stage prevents the passage of gas from compartment C–10 to the high pressure bank.

The gas compressed by the low pressure stages is discharged through the usual valving into the second compartment C–11 and flows through the ports of passageway C–73 to the suction compartment C–71 as is clearly shown in FIGURES 5 and 6.

Gas or fluid in the second compartment C–11 passes through to the suction compartment C–71 and through the suction valve C–85 into the cylinder of the high pressure stage and is acted thereon by the piston and compressed to the desired pressure.

The gas is then discharged through discharge valves C–58 into the discharge passage C–53 formed in plate C–51 and out discharge opening C–107 to the high side of the system.

Desired compressor capacity variation can be accomplished by loading or unloading the cylinders of either the low pressure or high pressure stage or stages. Furthermore by maintaining the cylinders in an unloaded condition on start-up usual wear can be considerably reduced as is evident to those skilled in the art.

As was mentioned above that while the unit shown in the drawings and described hereinabove comprises a two stage compressor including plural cylinders in each stage it will be obvious that the multi-stage compressor can be furnished in other forms by merely adding valve plates and sealing arrangements to a low stage thereof. Furthermore, a multi-cylinder unit comprising stages including one cylinder can be converted to multi-stage operation in accordance with the concepts discussed herein.

Although the invention has been described with reference to specific apparatus it will be appreciated that a wide variety of changes may be made within the ability of one skilled in the art without departing from the scope of this invention. For example, some of the components of the apparatus may be reversed, certain features of the invention may be used independently of others, and equivalence may be substituted for the apparatus, all within the sphere and scope of the invention as defined in the claims.

What is claimed is:

1. In combination with a compressor including a casing having compression chambers connected to compress a fluid through a single stage of compression to a low pressure, at least one of said compression chambers being operable at a second pressure higher than the pressure in said remainder of said compression chambers and forming a high pressure stage, each of said compression chambers having a piston reciprocably guided therein:

(A) said remainder of the compression chambers including:

(*a*) inlet means communicated with a source of the fluid,

(*b*) a low pressure manifold,

(*c*) discharge means communicating said remainder of said compression chambers to said low pressure manifold,

(B) a conversion assembly carried on the casing and cooperative with said at least one compression chamber, and being in communication with the low pressure manifold to receive fluid from the latter, said conversion assembly including:

(*a*) means forming a cooling compartment having an inlet and outlet,

(*b*) means forming a passage communicating said inlet in said means forming the cooling compartment with the low pressure manifold for directing compressed fluid into said cooling compartment prior to introduction thereof to said at least one compression chamber,

(*c*) means in the conversion assembly forming an opening disposed cooperatively with the reciprocably guided piston in said at least one compression chamber,

(*d*) said last mentioned means forming an opening including, means forming a passage having a valved inlet and a valved discharge port communicating therewith, and

(C) unloader means positioned in the conversion assembly cooperative with said valved discharge port to regulate passage of compressed fluid passing therethrough.

2. In combination with a compressor including a casing having compression chambers connected to compress a fluid through a single stage of compression to a low pressure, at least one of said compression chambers being operable at a second pressure higher than the pressure in said remainder of said compression chambers and forming a high pressure stage, each of said compression chambers having a piston reciprocably guided therein:

(A) said remainder of the compression chambers including:

(*a*) inlet means communicated with a source of the fluid,

(*b*) a low pressure manifold,

(*c*) discharge means communicating said remainder of said compression chambers to said low pressure manifold,

(B) a conversion assembly carried on the casing cooperative with said at least one compression chamber, and being in communication with the low pressure manifold to receive fluid from the latter, said conversion assembly including:

(*a*) means forming a cooling compartment having an inlet and outlet,

(*b*) a plate having a first side sealably engaging the casing and having means forming a transverse opening extending through the plate slidably receiving at least a portion of a reciprocably guided piston,

(*c*) valve means positioned at the side of the plate sealably engaging the casing, and being communicated with said means forming a transverse opening thereby defining a discharge valve for said at least one compression chamber,

(*d*) means at the side of the plate remote from the casing forming a valved passage communicating the means forming the cooling compartment with said at least one compression chamber, and

(C) unloader means positioned in the conversion assembly cooperative with said valved passage communicating the means forming the cooling compartment with said at least one compression chamber.

3. In the combination defined in claim 2, wherein the unloader means defines a head portion at the upper surface of said plate in at least one compression chamber and provides a closure to said means forming a transverse opening.

4. In the combination defined in claim 2, wherein the unloader means positioned in the conversion assembly is operable to disconnect the means forming a cooling compartment from said at least one compression chamber.

5. In the combination defined in claim 2, wherein the

means at the side of said plate remote from the casing forming a valved passage includes:

(A) means forming an annular channel in said plate surface opening into said at least one compression chamber, and being communicated with said means forming a cooling compartment to pass fluid from said means forming a cooling compartment into said at least one compression chamber, and

(B) a valve member operably positioned in said means forming an annular channel and being normally biased to prevent fluid flow to said at least one compression chamber.

6. In the combination defined in claim 2 wherein said means forming a transverse opening in the plate is formed in a frustro-conical-like configuration, and the portion of said reciprocably guided piston received in said transverse opening includes an outer wall formed in a frustro-conical-like configuration having a plurality of longitudinally extending slots therein.

7. In the combination defined in claim 5 wherein said unloader means is operable with the means at the side of said plate remote from the casing forming a valved passage, to discontinue the flow of fluid from said means forming a cooling compartment to said at least one compression chamber.

8. In the combination defined in claim 5 wherein the unloader means includes:

(A) an unloader member received in the means forming an annular channel in said plate surface, said unloader member being biased toward the plate surface therein forming a fluid tight seal therewith,

(*a*) means forming a passage in said unloader member communicating the means forming a cooling compartment with said at least one compression chamber,

(B) said valve member being operably positioned in the annular channel and normally biased into sealing contact with the unloader member to control flow of fluid from the means forming a cooling compartment through said annular passage into said at least one compression chamber.

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