

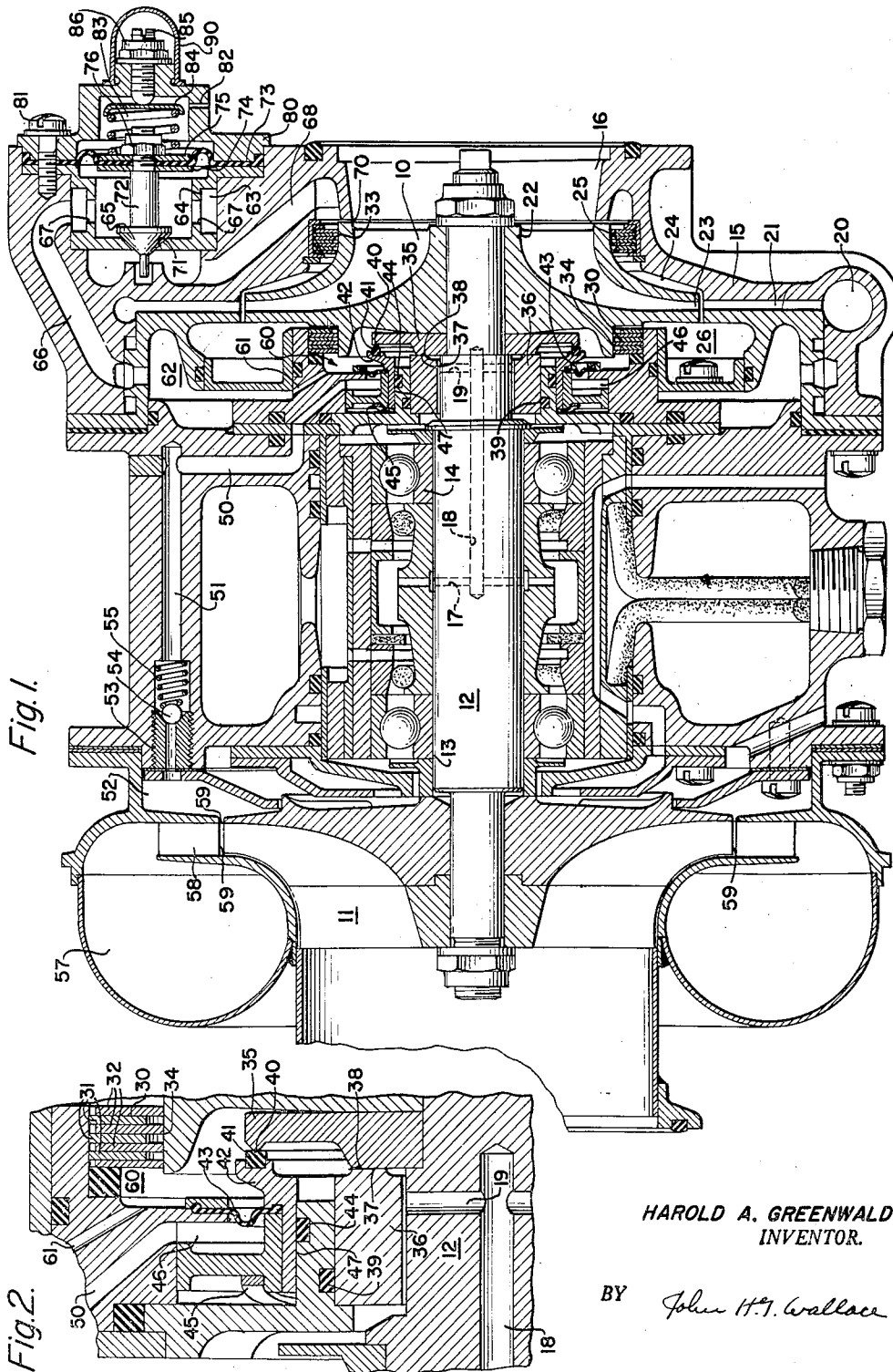
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SEAL FOR REFRIGERANT COMPRESSOR

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1

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SEAL FOR REFRIGERANT COMPRESSOR

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This invention pertains to compressors and more particularly to centrifugal compressors.

In centrifugal compressors used in refrigeration systems having single inlet impellers it is usually desirable to vent the back side of the impeller to the suction inlet in order to prevent an undue pressure build-up on the back side of the impeller. In refrigeration compressors using a refrigerant which has a suction pressure below normal atmospheric pressure, when operating at the designed suction pressure, direct venting of the back of the impeller to the suction inlet would result in a pressure below atmospheric existing on the back side of the impeller. This would mean that the surrounding atmosphere would tend to leak past the shaft seal into the impeller housing and contaminate the refrigerant.

Another problem also exists in centrifugal refrigeration compressors in that some means must be provided for isolating the compressor and the refrigeration system from the surrounding atmosphere when the compressor is shut down. If the compressor and refrigeration systems are not isolated, refrigerant may be lost by leakage past the shaft seal when the pressure in the system is above atmospheric or air could leak into the system when the pressure is below atmospheric. The refrigerant pressure in the system depends on the characteristics of the particular refrigerant used and the surrounding atmospheric conditions.

This invention solves the above problems by providing a shutoff valve integral with the compressor for isolating it and its associated refrigeration system from the surrounding atmosphere. The shutoff valve will automatically close when the compressor is stopped and automatically open when the compressor is started. In addition, the invention also provides a means for venting the back side of the compressor impeller while maintaining the pressure on the back of the impeller above the surrounding atmosphere or housing pressure. This insures that any small leakage when the compressor is operating will be from the compressor to the surrounding atmosphere instead of the reverse. When the compressor is not operating, leakage is prevented because it can not pass both the shutoff device and the shaft seal.

Accordingly, it is the principal object of this invention to provide a novel means for venting the back side of an impeller of a centrifugal compressor, to the suction inlet of the impeller, which incorporates means for controlling the pressure on the back side of the impeller so that it is slightly in excess of the surrounding atmospheric pressure or the pressure in the remainder of the compressor or bearing housing.

Another object of this invention is to provide a novel shutoff device for isolating the compressor and refrigeration system from the surrounding atmosphere or remainder of the compressor or bearing housing when the compressor is shut down.

Another object of this invention is to provide a novel construction of the regulating device which will regulate the venting and therefore the pressure at the back side

2

of the impeller to the inlet of the impeller, so that the pressure on the back side of the impeller always exceeds the surrounding atmosphere or housing pressure by a predetermined amount when the compressor is running.

Another object of this invention is to provide a novel shutoff means for isolating the compressor and refrigerating system when the compressor is shut down which is rendered inoperative when the compressor is operated.

Another object of this invention is to provide a novel means for operating the shutoff device which utilizes the same medium for operating the shutoff device that is used for operating the prime mover of the compressor.

Another object of this invention is to provide a novel means for holding the shutoff device open after the compressor is shut down for the period of time required for it to coast to a stop.

These and other objects and advantages of this invention will be more apparent to those skilled in the art from the following detailed description when taken in conjunction with the attached drawings in which:

Fig. 1 is a longitudinal cross-section of a turbine driven compressor embodying the novel features of this invention; and

Fig. 2 is a partial longitudinal section of the shutoff device shown in Fig. 1, drawn to an enlarged scale.

The compressor unit shown in Fig. 1 has an impeller 10 of the single inlet type which is mounted on one end of a shaft 12. The compressor is driven by a turbine having a turbine wheel 11 which is mounted on the other end of the shaft 12. The shaft in turn is rotatably mounted in the main frame of the compressor unit by means of two ball bearings 13 and 14. The impeller rotates in a suitably shaped impeller housing 15. The impeller housing 15 is provided with an inlet 16 which is aligned with the inlet 22 of the impeller and a diffusing section 21 which is aligned with discharge 23 of the impeller. After the refrigerant flows through the diffusing section of the casing, it flows into a scroll shaped collecting ring 20 and is discharged from the compressor through a suitable opening, not shown.

The suction inlet 22 of the compressor is isolated from the discharge of the impeller by means of a labyrinth seal 25. The labyrinth seal 25 is mounted in the impeller housing 15 by any desired means, such as a press fit, and co-operates with a cylindrical surface 33 formed on the outer periphery of the impeller adjacent the inlet thereof. Another labyrinth seal 30, similar to the labyrinth seal 25, is provided for isolating the discharge 23 of the impeller from the shaft opening in the impeller housing. The labyrinth seal 30 is mounted in the impeller housing 15 by any desired means, such as a press fit, and co-operates with a cylindrical surface 34 which is formed on the outer periphery of an annular flange projecting from the back side of the impeller 10. Each of the labyrinth seals is formed from a stack of alternate ring shaped members 32 and spacing rings 31 as shown in Fig. 2. The stack of ring members 32 and spacing rings 31 are held together as a unit by any desired fastening means, such as a plurality of circumferentially spaced rivets (not shown). The inner diameter of the ring shaped members 32 is slightly larger than the corresponding diameter of the cylindrical surfaces 33 or 34 on the impeller 10.

The above described construction provides an impeller 10 which may be rotated by the turbine 11 so as to draw the refrigerant in through the inlet 16 of the impeller housing and discharge it into the scroll shaped collecting ring 20 of the impeller housing. As the refrigerant is discharged through the discharge opening 23 of the impeller, a small amount will leak axially past the outer edges of the discharge 23 of the impeller and tend to

3

escape into the spaces 24 and 26 on the front and back side of the impeller, respectively. The labyrinth seals 25 and 30 limit the escape of refrigerant from the spaces 24 and 26 to a relatively small amount.

While the above described labyrinth seal 30 prevents any substantial leakage of the refrigerant from the space 26 to the back side of the compressor impeller, a small amount of refrigerant will leak past the labyrinth seal 30. In order to prevent the escape of the refrigerant from the compressor to the atmosphere or the housing in which the bearings are mounted, a shaft seal is provided on the shaft 12. Shown is a typical face type seal such as a carbon ring type of shaft seal which consists of a carbon ring 36 mounted in the compressor housing 15 and a metal ring 35 which is secured to the shaft 12. The carbon ring 36 is mounted in the compressor housing with its left end abutting against an inwardly projecting shoulder formed in the compressor housing 15. The outer periphery of the carbon ring is sealed by means of an O-ring 39, while its inner periphery is spaced from the shaft 12. The metal ring 35 is preferably formed of hardened steel or a similar material while the carbon ring 36 is formed of graphitic carbon or a similar material. The adjacent radial surfaces 37 and 38 of the carbon ring 36 and the metal ring 35, respectively, are optically flat rubbing surfaces. Thus the steel ring 35 which rotates with the shaft when the unit is running and the carbon ring which does not rotate form an effective seal to prevent any but minute amounts of the refrigerant from leaking from the system along the shaft 12. The natural lubricating properties of the carbon ring 36 together with oil mist which flows from the bearing housing through passageways 17, 18 and 19 formed in the shaft 12 provide the desired lubrication and cooling.

While the shaft seal provides an effective means for preventing all but minute amounts of leakage of refrigerant from the system when the compressor is operating, the pressure difference across the seal may be greater when the unit is idle than when it is operating. This will tend to increase leakage of refrigerant to the atmosphere on hot days, or allow the atmosphere to leak in on cold days when the refrigerant pressure is below atmospheric or the bearing housing pressure. In order to prevent this leakage of refrigerant out or atmosphere in, a shutoff device is provided which consists of a valve surrounding the shaft seal which is actuated by an annular piston to open when the compressor is started and spring biased to close when the compressor is stopped. The valve consists of a valve seat 40 shown in Fig. 2 which is formed on the ring 35 adjacent the outer periphery thereof and a valve ring 41 which is mounted on the end of the annular piston. The valve ring 41 consists of a ring of slightly resilient material such as a molded plastic or a similar material which is unaffected by the refrigerant. The valve ring 41 is mounted on the end of the annular piston 42 which, in turn, is adapted to move axially in an annular cylinder 47 formed in the impeller housing 15. The inner diameter of the annular piston 42 is sealed by means of an O-ring 44, or equivalent means, which is mounted in the impeller housing 15. The outer diameter of the annular piston is sealed by means of a flexible diaphragm 43 or equivalent means, the outer edge of which is secured to the impeller housing 15 and inner diameter is secured to the annular piston 42. A ring type of spring 45 is provided for urging the annular piston to the right as shown in the attached drawing so as to engage the valve disc 41 with the valve seat 40 when the compressor is shut down.

In order to retract the valve ring 41 from the valve seat 40 when the compressor is started so as to avoid friction, means are provided for introducing a compressed fluid into annular area 46 on the right-hand side of the annular piston. This fluid pressure will over-

4

come the force of the ring spring 45, thus moving the piston to the left so as to retract valve ring 41 from the valve seat 40. While any pressurized fluid may be used for moving the annular piston, the unit shown in the attached drawing utilizes the pressurized fluid which drives the turbine wheel 11. This pressurized fluid is admitted to the annular piston by means of the passageway 50 formed in the main compressor housing and a passageway 51 formed in the main compressor frame. In order to retard the backflow of fluid from the annular piston into the turbine unit when the unit is coasting to a stop, a small ball check valve 54, which is actuated by a spring 55, is provided in the passageway 51. The pressurized fluid used for driving the turbine wheel 11 is admitted to a plenum chamber 57 from which it flows into a suitable nozzle ring 58 which directs the pressurized fluid over the blades of the turbine wheel 11. A small portion of the pressurized fluid will escape through the annular area 59 existing between the outer periphery of the turbine wheel 11 and the inner periphery of the nozzle ring 58. After escaping through the annular area 59, the fluid will flow into an annular area 52 from which it will flow through the ball check valve 54 and passageways 50 and 51, previously described.

The above described system thus provides a means whereby the compressor and refrigeration system will be completely isolated by means of a valve which closes when the compressor is shut down. In addition, this valve is automatically opened when the compressor is started since the same medium used by the prime mover of the compressor is used to open the valve. A suitable means is provided in the passageways which supply the pressurized fluid for opening the valve to delay the backflow of the pressurized fluid from the annular piston into the turbine housing when the turbine is shut off. This means, consisting of a small ball check valve, is not necessary but may be desired in order to prevent engagement of the valve seat 41 with the valve disc 40 while the compressor unit is coasting to a stop after the supply of pressurized fluid to the turbine wheel has been shut off.

The above described means effectively seals the compressor from the atmosphere in the bearing case both when it is operating and when it is shut down. As explained above, some refrigerant leaks past the labyrinth seal 30 into the space 60 surrounding the back side of the impeller when the compressor is operating. A means is provided for venting this space to the suction inlet of the compressor in order to prevent undue pressure build-up in this area which would unduly increase axial thrust and bearing losses and increase the pressure differential across the shaft seal. If the pressure were allowed to build up in this area to substantially the discharge pressure of the compressor, it would cause an unbalanced condition to exist in the compressor. This unbalanced condition would produce an extremely high thrust loading on the ball bearings 13 and 14. In order to prevent this pressure build-up, interconnecting passageways 61, 62, 66 and 68 formed in the impeller housing 15 are provided for venting the area 60 to the suction inlet 22 of the compressor wheel. While this passageway will vent the space 60 to the suction inlet of the compressor wheel, it results in reducing the pressure in the area 60 to substantially the suction pressure of the compressor. In some cases this is satisfactory, but in those systems using certain refrigerants which normally operate with a suction pressure below normal atmospheric pressure, it means that a pressure below normal atmospheric exists in the space 60. This could result in air leaking into the refrigeration system from the bearing housing, which operates at substantially atmospheric pressure.

In order to prevent the pressure in the annular space 60 from falling below atmospheric, a regulating means is provided. This regulating means consists of a small, spring-loaded, diaphragm-controlled valve mounted in the passageway 66 which maintains the pressure in the passage-

5

way and thus the annular area 60 at a predetermined amount above atmospheric. The passageway 66 connects with an annular area 63 which surrounds the valve body 64. The refrigerant flows from the annular area 63 into the center of the valve body 64 through a plurality of circumferentially spaced ports 67 and then past the valve disc 65 and into the passageway 68. From the passageway 68 the refrigerant flows through the small axial clearance 70 which exists between the end of the impeller and the impeller housing to the suction inlet 22 of the impeller. The valve disc 65 co-operates with a suitable valve seat 71 formed in the valve body 64 to regulate the flow of refrigerant from the annular area 60 to the suction inlet of the compressor. The valve disc is provided with a valve stem 72, the end of which is secured to a flexible diaphragm 73. The valve stem is secured to the diaphragm 73 by means of two diaphragm washers 74 and 75 which are placed on opposite sides of the diaphragm and a nut 76 which threads onto the end of the valve stem. The outer edge of the flexible diaphragm is secured between an outwardly projecting radial flange formed on the valve body 64 and an outwardly projecting radial flange formed on the valve cap 80. These two radial flanges are secured together by means of a plurality of circumferentially spaced cap screws 81 which pass through both of the flanges and thread into the impeller housing 15. A small compression spring 83, which is retained in the valve cap 80, is provided for urging the valve disc 65 to the left as shown in the attached drawing. The force of the spring 83 may be adjusted by means of the small set screw 85 and spring washer 84. A jam nut 86 is provided for locking the set screw in its adjusted position and a small protective cover 90 is provided for enclosing the top of the set screw 85 and the jam nut 86. The interior of the valve cap 80 is vented to the surrounding atmosphere through a port 82 so that atmospheric pressure will exist on the right-hand side of the diaphragm 73.

The left-hand side of the diaphragm 73 will be subject to the pressure of the refrigerant being vented from the back side of the impeller while the right-hand side of the diaphragm 73 will be subject to the atmospheric pressure plus the force of the spring 83. It is thus seen that the valve disc 65 will assume a position so that pressure of the refrigerant being vented from the back side of the impeller is equal to the atmospheric pressure plus the force of the spring 83, less any small unbalance force that may exist on the valve. Thus, the pressure existing on the back side of the impeller may be maintained above atmospheric pressure by any desired amount by adjusting the force of spring 83. In addition to this, as the atmospheric pressure changes, the pressure on the back side of the impeller will also change. This is important where the compressor is used in an aircraft refrigeration system since the atmospheric pressure surrounding the compressor may vary from sea level to 40,000 feet or more. If a means were not provided for changing the pressure on the back side of the impeller this pressure would be too low at sea level allowing air to leak in and too high at 40,000 feet, for example. Of course, once the aircraft reaches an altitude at which the combination of atmospheric pressure plus the spring force is less than the suction pressure of the compressor the valve will remain fully open and cease to regulate.

While only one preferred embodiment of this invention has been described in detail, it will be apparent to those skilled in the art that many modifications and improvements can be made. Also, while the invention was described as applied primarily to a refrigeration compressor, it can be applied to other centrifugal or other

6

types of compressors and, in addition, may be applied to compressors using other types of motive power such as electric motors or the like.

I claim:

1. A compressor comprising: a drive shaft; a centrifugal impeller having an inlet and discharge, said impeller being mounted on said shaft; bearing means for rotatably supporting said shaft; driving means for driving said impeller; vent means for venting the side of said impeller opposite said inlet to said inlet; flow control means mounted in said vent means, and means for actuating said flow control means in response to the atmospheric pressure surrounding said compressor to maintain the pressure on said side of said impeller above atmospheric pressure.

2. A compressor comprising: a compressor housing having an impeller chamber and a bore opening into said impeller chamber; a shaft extending through said bore into said impeller chamber; an impeller having inlet and discharge openings, said impeller being mounted on said shaft for rotation in said impeller chamber; a rotating seal mounted in said housing for substantially sealing the discharge pressure of said impeller from said bore; vent means for venting the portion of said housing between said rotating seal and said bore to the inlet of said impeller; and regulating means mounted in said vent means for controlling the pressure therein in response to ambient pressure.

3. A compressor comprising: a compressor housing having an impeller chamber and a bore opening into said chamber; an inlet and an outlet in said impeller chamber; a shaft rotatably mounted in said bore; an impeller mounted on said shaft so as to rotate in said chamber; shaft sealing means for sealing said shaft in said bore; impeller sealing means for restricting the flow of fluid from the discharge side of said impeller to said shaft sealing means; vent means for venting the portion of said impeller chamber between said impeller sealing means and said shaft sealing means to the inlet of said impeller; and regulating means controlled by the atmospheric pressure surrounding said compressor for regulating the pressure in said portion of the impeller chamber.

4. A centrifugal compressor comprising: a casing; a shaft rotatably mounted in said casing; an impeller having an inlet and a discharge, said impeller being fixedly mounted on said shaft; a shaft seal mounted in said casing; passage means for venting to the inlet of the impeller the portion of the casing between the back side of the impeller and the shaft seal; and regulating means including a pneumatically actuated valve means mounted in said passage means for controlling the pressure in the portion of said casing between the back side of the impeller and the shaft seal, said pneumatically actuated valve means being responsive to the pressure in the passage means.

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