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SEAL FOR REFRIGERANT COMPRESSOR

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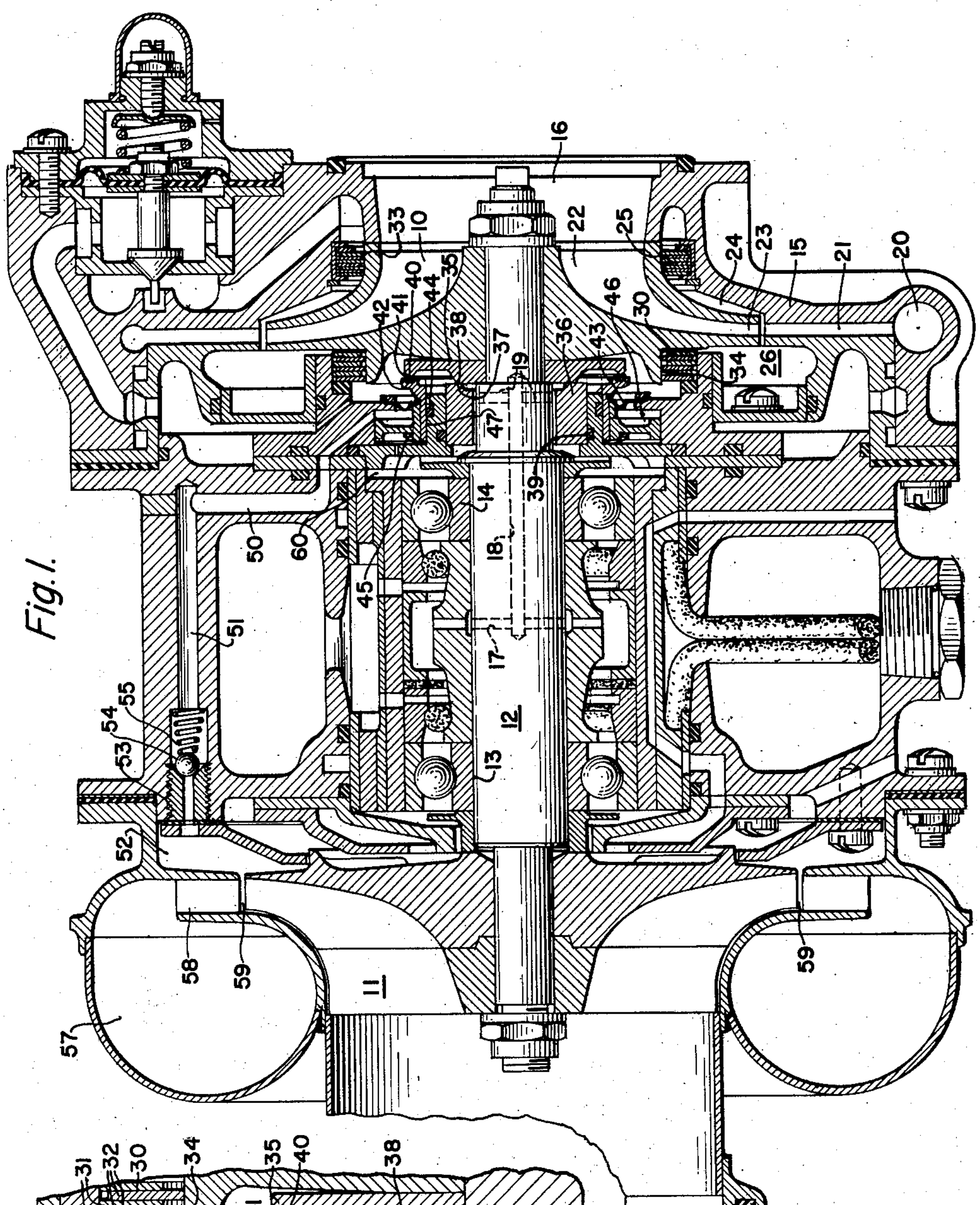

Fig. 1.

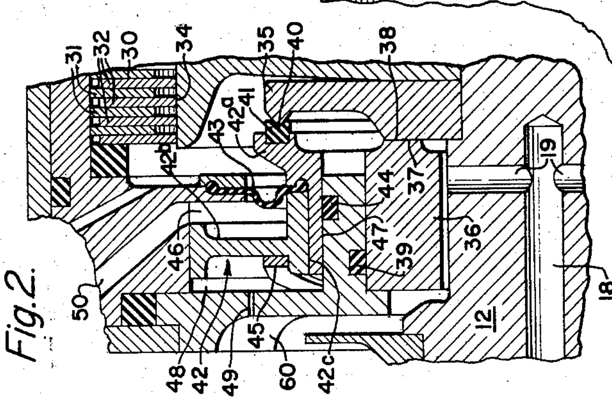

Fig. 2.

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SEAL FOR REFRIGERANT COMPRESSOR

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This invention pertains to compressors and more particularly to turbine driven centrifugal refrigeration compressors.

This application is a continuation-in-part of my copending application Serial No. 31,183, entitled "Seal for Refrigerant Compressor," filed May 23, 1960, now abandoned and which in turn was a division of my application Serial No. 629,884, entitled "Seal for Refrigerant Compressor," filed December 21, 1956, now Patent No. 2,973,135 issued February 28, 1961.

In centrifugal refrigeration compressors it is desirable to provide means 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. This shutoff valve will automatically close when the compressor is stopped and automatically open when the compressor is started.

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

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 turbine which drives 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.

Referring to the drawing, there is shown in FIG. 1 a compressor having an impeller **10** of the single inlet type 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 housing of the turbo-compressor unit by means of two balls 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 discharge conduit, 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 **23** of the impeller, a small amount will leak axially past the outer edges of the discharge and tend to 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 metal ring **35** adjacent the outer periphery thereof and a valve closure ring **41** formed preferably of slightly resilient, high temperature elastomeric material, such as Teflon or other material which is unaffected by the refrigerant, mounted on the end of an annular piston, shown generally at **42**, which is adapted to move axially in an annular cylinder **47** formed in the impeller housing **15**. Thus the valve seat **40** rotates with the shaft when the unit is running while the valve closure ring **41** is moved axially into and out of engagement with the valve seat in the manner hereinafter described.

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**. The inner diameter of the diaphragm **43** is clamped between an axially extending member **42*a*** carrying the valve ring **41** and a radially extending member **42*b*** which are secured together at **42*c*** by a press fit or other means well known in the art to form the annular piston **42**. A ring type spring **45** is provided for urging the annular piston **42** to the right as shown in the drawing to bias the valve closure ring **41** into engagement with the valve seat **40** when the compressor is shut down.

In order to prevent frictional damage to the valve ring **41**, means are provided for introducing a compressed fluid into the annular area **46** on the right-hand side of the member **42*b*** of the annular piston **42** when the compressor is started. This fluid pressure will act in opposition to the force of the ring spring **45**, thus moving the piston into the annular chamber **48** and retracting the valve ring **41** from the valve seat.

Communicating with the annular area **48** is a vent opening **49** which extends through the wall of the impeller housing **15** to a chamber **60** in the housing in which the bearings **13** and **14** are mounted. The vent functions to prevent a buildup of pressure in the chamber **48** when the annular piston **42** is moved into that chamber. The vent opening **49** additionally functions to permit pressurized fluid which has leaked from chamber **46** past the periphery of member **42*b*** into the chamber **48** to flow through the vent to the chamber **60** in the bearing housing, thus maintaining the pressure in chamber **48** substantially the same as the pressure in the housing. When the spring **45** functions to urge the annular piston to the right as shown in the drawing the vent opening **49** permits fluid to flow from the bearing housing into the chamber **48**, thus relieving the partial vacuum which would otherwise hinder closing movement of the valve ring **41**.

As shown in FIG. 1 of the drawing, the pressurized fluid used to drive the turbine wheel **11** is utilized for moving the annular piston **42** in the direction to retract the valve ring **41** from the valve seat **40**. This pressurized fluid is conducted to the annular area **46** on the right-hand side of the member **42*b*** of the annular piston by means of a passageway **50** formed in the main compressor housing and a passageway **51** formed in the turbocompressor housing. As hereinafter noted, a small ball check valve **54**, which is actuated by a spring **55**, is provided in the passageway **51** to retard the backflow of fluid from the annular area **46** into the turbine housing when the turbine unit is shut down. 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.

In operation, when the supply of pressurized fluid flowing to the turbine is shut off, the check valve **54** closes to retard the backflow of the pressurized fluid from the annular area **46** into the turbine housing. However, the ball of the check valve **54** is scored to deliberately provide a small leakage past the valve sufficient to gradually allow the pressure in annular area **46** to dissipate. As the pressure in the area **46** dissipates, the spring **45** moves the annular piston **42** to the right, as shown in the drawing, until the valve ring **41** engages the valve seat **40**. The retarding of the flow of fluid from the area **46** permits the compressor unit to coast to a stop, or nearly to a stop, before the valve ring **41** engages the valve seat **40**, thus preventing damaging the elastomeric material in the valve ring **41**.

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 types of centrifugal compressors.

I claim:

1. In a turbine driven centrifugal compressor:

a housing;

a shaft rotatably mounted in said housing;

an impeller chamber adjoining said housing;

a compressor impeller mounted on said shaft for rotation in said impeller chamber;

a driving turbine operatively connected to said shaft;

a plate member mounted on said shaft and having an annular valve seat disposed contiguous said impeller;

first sealing means for preventing leakage of fluids between said housing and said impeller chamber including piston means surrounding said shaft and having an annular valve closure member adapted to be moved into and out of engagement with said valve seat;

means defining a cylindrical chamber, said piston means being disposed for movement in said cylindrical chamber;

resilient means engaging said piston means for biasing said valve closure member into engagement with said valve seat when the compressor is idle;

means for conducting fluid under pressure from the inlet of said driving turbine to one side of said cylindrical chamber to actuate said piston means in opposition to the resilient means to move said valve closure member out of engagement with said valve seat when motive fluid is admitted to the driving turbine;

means for retarding the flow of fluid from said cylindrical chamber when said driving turbine is shut down to prevent engagement of the valve closure member with the valve seat while the compressor is coasting to a stop;

and second sealing means in series with said first sealing means and including a sealing ring having a surface contacting said plate member of said first sealing means.

2. In a turbine driven centrifugal compressor:
a housing;
a shaft rotatably mounted in said housing;
an impeller chamber adjoining said housing;
a compressor impeller mounted on said shaft for rotation in said impeller chamber;
a driving turbine operatively connected to said shaft;
a plate member mounted on said shaft and having an annular valve seat disposed contiguous said impeller;
sealing means for preventing leakage of fluids between said housing and said impeller chamber including piston means surrounding said shaft and having an annular valve closure member adapted to be moved into and out of engagement with said valve seat;
means defining a cylindrical chamber, said piston means being disposed for movement in said cylindrical chamber;
resilient means engaging said piston means for biasing said valve closure member into engagement with said valve seat when the compressor is idle;
means for conducting fluid under pressure from the inlet of said driving turbine to one side of said cylindrical chamber to actuate said piston means in opposition to the resilient means to move said valve closure member out of engagement with said valve seat when motive fluid is admitted to the driving turbine;
and means for retarding the flow of fluid from said cylindrical chamber when said driving turbine is shut down to prevent engagement of the valve closure member with the valve seat while the compressor is coasting to a stop.

3. In a turbine driven centrifugal compressor:
a housing;
a shaft rotatably mounted in said housing;
an impeller chamber adjoining said housing;
a compressor impeller mounted on said shaft for rotation in said impeller chamber;
a driving turbine operatively connected to said shaft;
sealing means for preventing leakage of fluids between said housing and said impeller chamber including an annular valve seat disposed on said shaft contiguous said impeller and an annular piston having an annular valve closure member adapted to be moved into and out of engagement with said valve seat;
means defining a cylindrical chamber, said annular piston being disposed for movement in said cylindrical chamber;
resilient means engaging said piston for biasing said valve closure member into engagement with said valve seat when the compressor is idle;
means for conducting fluid under pressure from the inlet of said driving turbine to one side of said cylindrical chamber to actuate said piston in opposition to the resilient means and move said valve closure member out of engagement with said valve seat when motive fluid is admitted to the driving turbine;
and means for retarding the flow of fluid from said cylindrical chamber when said driving turbine is shut down to prevent engagement of the valve closure member with the valve seat while the compressor is coasting to a stop.

4. In a turbine driven centrifugal compressor:
a housing;
a shaft rotatably mounted in said housing;
an impeller chamber adjoining said housing;
a compressor impeller mounted on said shaft for rotation in said impeller chamber;
a driving turbine operatively connected to said shaft;
sealing means for preventing leakage of fluids between said housing and said impeller chamber including an annular valve seat disposed contiguous said impeller and an annular piston having an annular valve closure member adapted to be moved into and out of engagement with said valve seat;

means defining an operating pressure chamber, said piston being subjected on one side to the pressure in said operating pressure chamber;
resilient means engaging said piston for biasing said valve closure member into engagement with said valve seat when the compressor is idle;
passage means for conducting fluid under pressure from the inlet of said driving turbine to said operating pressure chamber to actuate said piston in opposition to the resilient means and move said valve closure member out of engagement with said valve seat when motive fluid is admitted to the driving turbine;
and means for retarding the flow of fluid from said operating chamber when said driving turbine is shut down to prevent engagement of the valve closure member with the valve seat while the compressor is coasting to a stop.

5. In a turbine driven centrifugal compressor:
a housing;
a shaft rotatably mounted in said housing;
an impeller chamber contiguous said housing;
a compressor impeller mounted on said shaft for rotation in said impeller chamber;
a driving turbine operatively connected to said shaft;
an annular valve seat formed on said impeller ;
sealing means for preventing leakage of fluids between said housing and said impeller chamber including a piston surrounding said shaft and having a valve closure member adapted to be moved into and out of engagement with said valve seat;
resilient means engaging said piston for biasing said valve closure member into engagement with said valve seat when the compressor is idle;
means defining an operating pressure chamber, said piston being subjected on one side to the pressure in said operating pressure chamber and on the opposite side to the pressure in said housing;
passage means for conducting fluid under pressure from the inlet of said driving turbine to said operating pressure chamber to actuate said piston in opposition to the resilient means and move said valve closure member out of engagement with said valve seat when motive fluid is admitted to the driving turbine;
and means for retarding the flow of fluid from said operating pressure chamber when said driving turbine is shut down to prevent engagement of the valve closure member with the valve seat while the compressor is coasting to a stop.

6. In a turbine driven centrifugal compressor:
a housing;
a shaft rotatably mounted in said housing;
an impeller chamber contiguous said housing;
a compressor impeller mounted on said shaft for rotation in said impeller chamber;
a driving turbine operatively connected to said shaft;
an annular valve seat disposed contiguous said impeller;
sealing means for preventing leakage of fluids between said housing and said impeller chamber including a valve closure member adapted to be moved into and out of engagement with said valve seat;
resilient means for biasing said valve closure member into engagement with said valve seat when the compressor is idle;
means actuated by the fluid medium utilized for operating the driving turbine for moving said valve closure member out of engagement with said valve seat when motive fluid is admitted to the driving turbine;
and means for retarding the engagement of the valve closure member with the valve seat when the driving turbine is shut down until the compressor has coasted to a stop.

7. In a turbine driven centrifugal compressor:
a housing;

a shaft rotatably mounted in said housing;
an impeller chamber contiguous said housing;
a compressor impeller mounted on said shaft for rotation in said impeller chamber;
a driving turbine operatively connected to said shaft;
an annular valve seat disposed contiguous said impeller;
sealing means for preventing leakage of fluids between said housing and said impeller chamber including a valve closure member adapted to be moved into and out of engagement with said valve seat;
resilient means for biasing said valve closure member into engagement with said valve seat when the compressor is idle;
fluid operated means for moving said valve closure member out of engagement with said valve seat when motive fluid is admitted to the driving turbine;
passage means connecting said fluid operated means to the inlet of said driving turbine;
and means including a check valve mounted in said passage means for retarding the escape of fluid from said fluid operated means when said driving turbine is shut down to prevent engagement of the valve closure member with the valve seat while the compressor is coasting to a stop.

8. In a turbine driven centrifugal compressor:
a housing;
a shaft rotatably mounted in said housing;

an impeller chamber contiguous said housing;
a compressor impeller mounted on said shaft for rotation in said impeller chamber;
a driving turbine operatively connected to said shaft;
an annular valve seat disposed contiguous said impeller;
sealing means for preventing leakage of fluids between said housing and said impeller chamber including a valve closure member adapted to be moved into and out of engagement with said valve seat;
resilient means for biasing said valve closure member into engagement with said valve seat when the compressor is idle;
and means actuated by the fluid medium utilized for operating the driving turbine for moving said valve closure member out of engagement with said valve seat when motive fluid is admitted to the driving turbine.

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