United States Patent

King, III et al.

[15] **3,645,643**

[45] **Feb. 29, 1972**

[54] **SEAL AND LUBRICATION SYSTEM FOR ROTATING MACHINERY**

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[73] Assignee: **Carrier Corporation**, Syracuse, N.Y.

[22] Filed: **May 11, 1970**

[21] Appl. No.: **36,152**

[52] **U.S. Cl.** **415/111**

[51] **Int. Cl.** **F01d 11/00**

[58] **Field of Search** 415/111

[56] **References Cited**

UNITED STATES PATENTS

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2,900,919	8/1959	Anderson et al.	415/111
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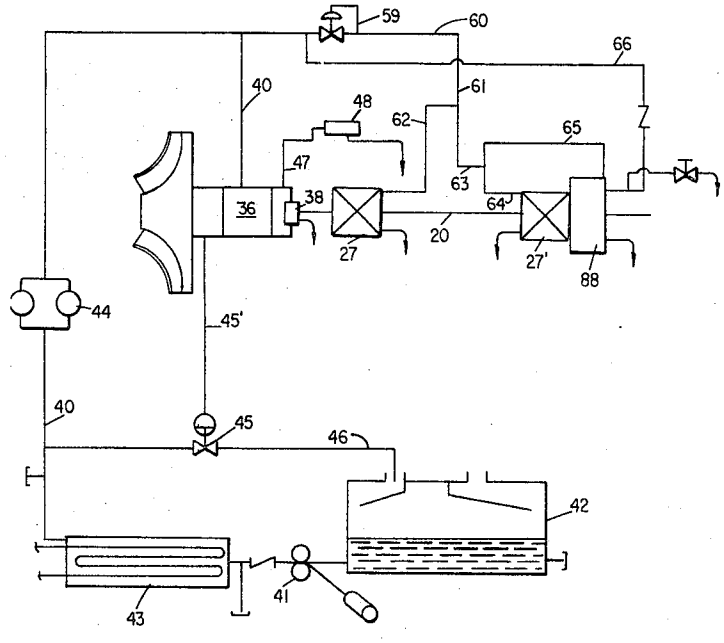
[57] **ABSTRACT**

An arrangement for preventing leakage of gas from a compressor by supplying fluid at a pressure that always exceeds the pressure of the gas by a predetermined value to a location of likely leakage wherein means are provided to assure flow of the fluid through the location over a wide variation in the pressure of the gas so that adequate cooling of the parts involved may be always obtained. Included in the arrangement is a pressure regulator valve unit constructed so that the operating parts will function despite minor misalignment such as may be encountered in assembling the parts.

3 Claims, 3 Drawing Figures



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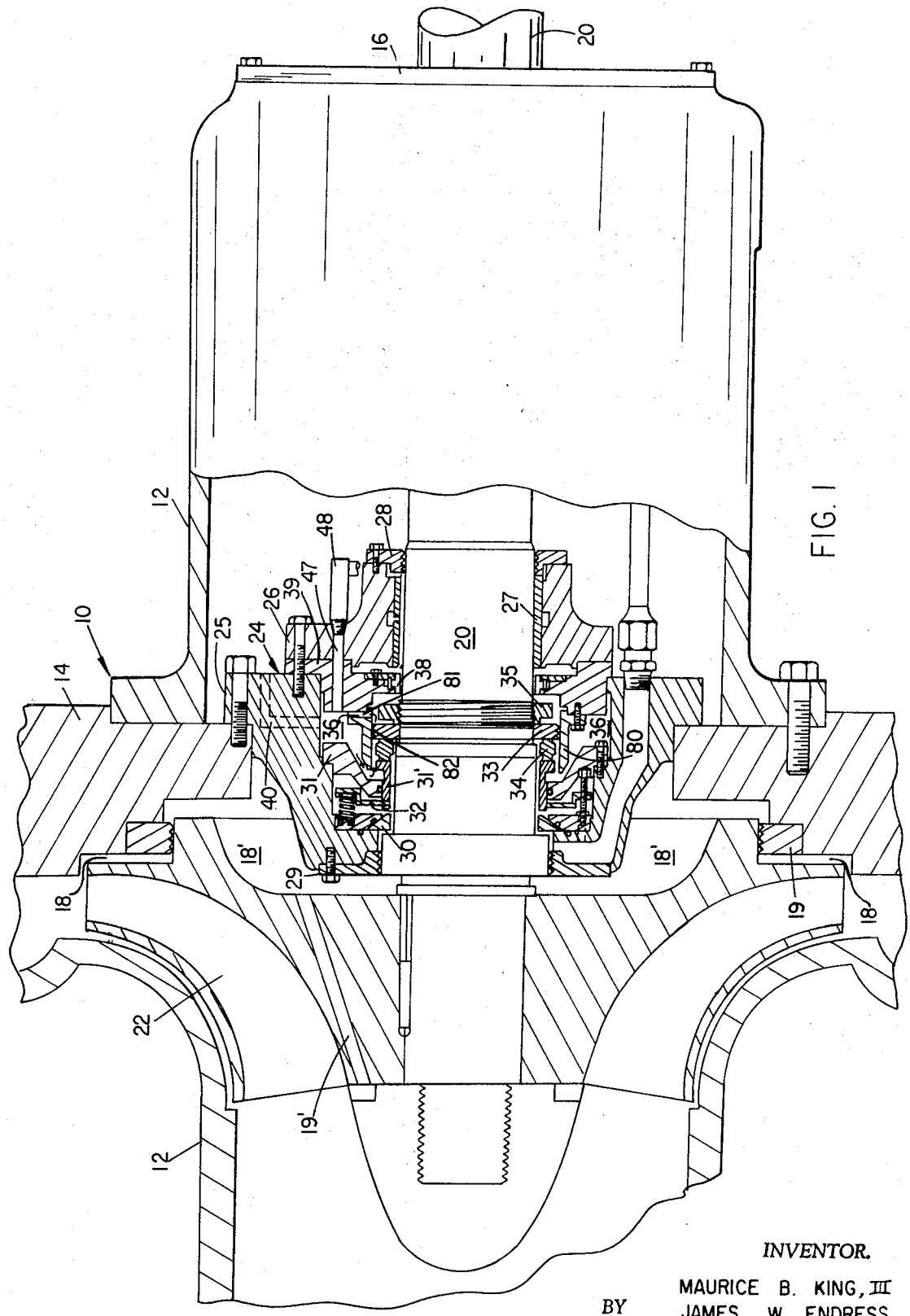

FIG. 1

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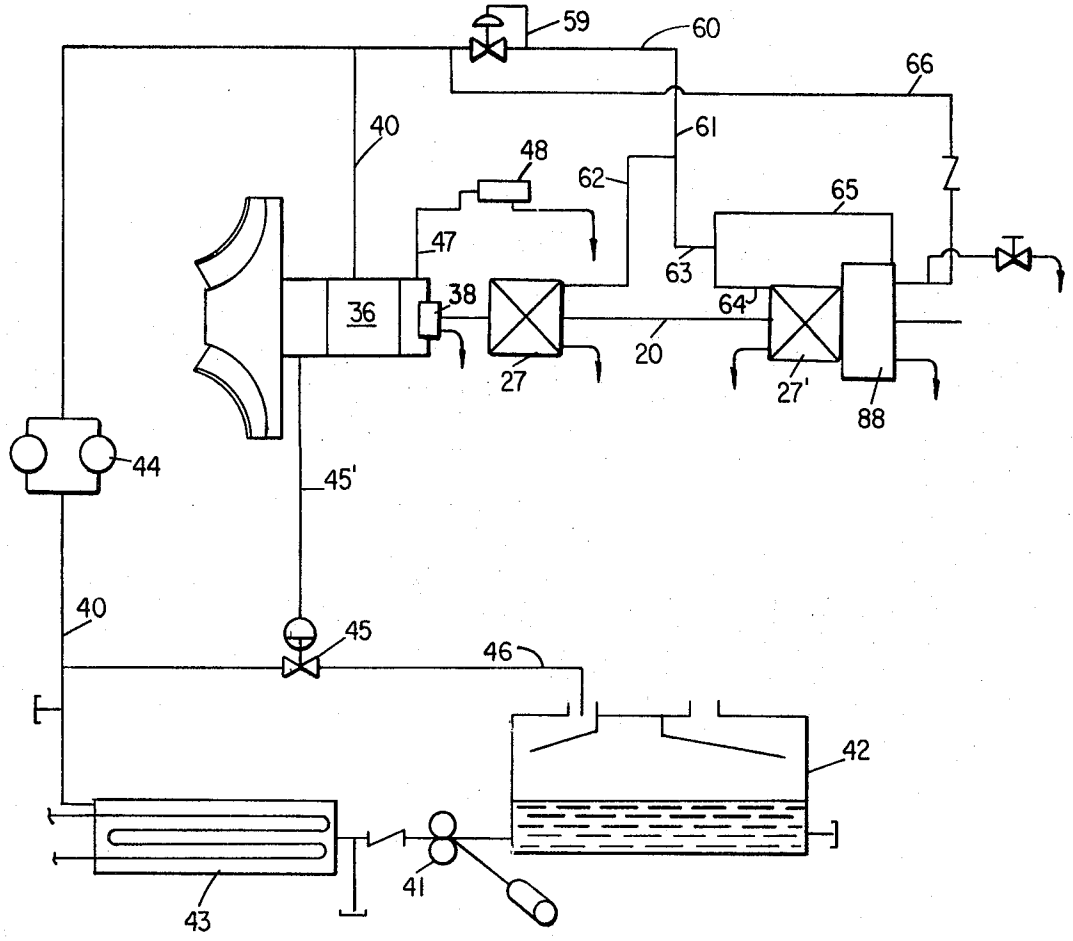

FIG. 2

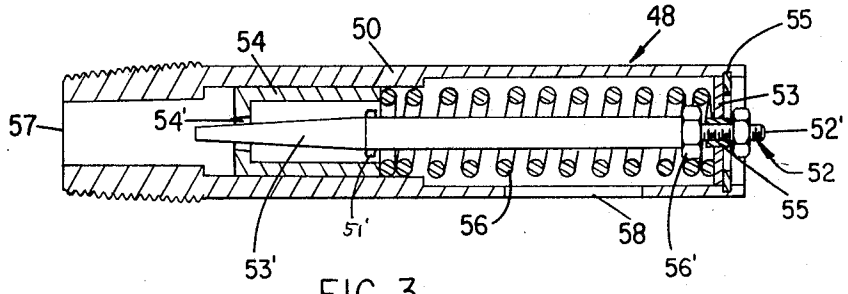

FIG. 3

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SEAL AND LUBRICATION SYSTEM FOR ROTATING MACHINERY

BACKGROUND OF THE INVENTION

This invention is concerned with sealing systems for use with rotating machinery such as centrifugal gas compressors wherein it is necessary that leakage of the gas handled by the machine be prevented.

An illustration of a machine to which this invention pertains is a refrigerant gas compressor employed in refrigeration machines. The refrigerant gas compressor receives the refrigerant gas at a relatively low pressure and discharges it to the condenser at a relatively high pressure. It is extremely important that leakage of refrigerant gas along the shaft of the machine be prevented for one of the most important elements of cost in a refrigeration machine is the refrigerant employed.

It has been proposed in the past to provide a so-called running seal for the purpose of preventing passage of refrigerant from the machine along the shaft. The running seal is disposed in a chamber subject to the flow of a sealing fluid, usually lubricant directed through the chamber at a pressure in excess of the pressure of the gas adjacent the seal. Thus, should leakage between the gas and fluid occur, it would be in a direction such that the fluid would pass into the machine where it could be separated from the refrigerant by conventional means.

It is most important in sealing systems of the kind described that the fluid supplied to the chamber pass from the chamber because the pressurized fluid serves to cool the individual parts of the sealing assembly. Should undue restriction to passage of the fluid from the chamber exist, the parts constituting the seal would become overheated and possibly fail.

Another problem involved in sealing systems of the kind described is the regulation of the pressure of the sealing fluid relative to the gas adjacent the sealing assembly on the machine side of the seal. It is necessary that the pressure difference between the sealing fluid and the gas be maintained at a certain level for to exceed the level would cause the parts of the seal in running contact with one another to part or separate and cause excessive leakage of sealing fluid or cause a vibratory type engagement which could result in failure of the seal parts.

In refrigerant compressors, the gas adjacent the running seal is at suction pressure due to the construction of the machine. Normally, a space is provided at the rear of the impeller employed in the centrifugal compressor so that leakage from the discharge end of the wheel will cause a part of the refrigerant charge to collect in the space. Usually, a labyrinth seal is interposed between the discharge tip of the wheel and the space so that a pressure drop between two locations is provided. Current design involves venting the space behind the impeller through appropriate passages in the hub of the impeller to the suction side of the machine. Accordingly, conventional sealing systems will maintain the pressure of the sealing fluid supplied to the chamber housing the sealing elements at a pressure level about 25 to 30 pounds higher than the suction pressure of the gas.

At startup when the machine has been subject to ambient conditions, the suction pressure in the machine is relatively high. The sealing system automatically functions to supply sealing fluid from the lubrication system at the pressure differential heretofore defined in excess of the suction pressure. The sealing fluid passes from the chamber through a restriction such as a pressure reducing sleeve encircling the shaft in such volume that movement of the fluid through the chamber is assured and the desired cooling of the parts accomplished.

After the machine has been in operation for a period of time, the suction pressure is substantially reduced. The sealing fluid is correspondingly reduced in pressure so that passage from the chamber through the pressure reducing sleeve is less effective and the sealing fluid is resident within the chamber for a longer period of time than at startup. Should the period of time be permitted to increase, the cooling of the parts forming the seal would not be accomplished and a failure of the sealing system could occur.

SUMMARY OF THE INVENTION

This invention involves the provision of a sealing system for a rotary shaft in a machine handling a process gas such as refrigerant gas wherein the sealing system is provided with means assuring prompt discharge of sealing fluid from the chamber accommodating the sealing elements.

This is accomplished by providing, in addition to the usual passage serving as an outlet from the chamber, an additional passage equipped with a variable orifice valve. The valve is automatically operable so that upon sensing a pressure in the chamber of a predetermined magnitude, the valve will open to provide an additional chamber outlet and thus permit rapid discharge of the fluid from the chamber and to prevent overheating of the parts constituting the sealing means.

An additional feature of the invention is a valve construction of the kind described above wherein the parts are constructed and assembled so that minor misalignments of the parts will not render the device inoperable. To this end a tapered mandrel over which an apertured valve element slides is secured to the casing of the device so that the tapered end may flex when engagement between the sides of the aperture and the tapered end occurs.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary view, partly in section, illustrating a gas compressor equipped with a sealing system forming the subject of this invention;

FIG. 2 is a schematic representation of the lubrication and sealing system employed with the machine illustrated in FIG. 1; and

FIG. 3 is a side view in section illustrating the variable orifice valve utilized with the sealing system serving as the subject of this application.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The problem to which this invention is directed is set forth in U.S. Patent application Ser. No. 712,977, filed Mar. 14, 1968, in the name of George W. Derrickson now U.S. Letters Pat. 3,539,270 and assigned to the assignee of this invention. This invention represents a different solution to the problem than that suggested in the copending application.

FIG. 1 illustrates a refrigerant gas compressor of the centrifugal type. The compressor includes a number of structural parts which form a casing or housing **12** for the operating parts of the compressor. Included within the casing **12** is a partition **14** serving as the means for mounting certain of the operating parts of the compressor.

In addition to the partition **14** there is provided an end cover **16** through which operating shaft **20** extends for connection to a prime mover. Secured to the forward end of the operating shaft **20** is impeller **22** arranged to receive suction gas at its forward end in an axial direction and to discharge it in a radial direction at an elevated pressure.

A part of the gas discharged from the periphery of the impeller will collect in space **18** and flow through labyrinth ring **19** to an area **18'** located at the rear of the impeller. The impeller is provided with passages **19'** which connect the space **18'** with the suction side of the compressor.

The gas present at the rear surface of the impeller also tends to escape through labyrinth ring **29** along the shaft. The sealing system forming the subject of this invention is provided for the purpose of preventing escape of the gas flowing rearwardly of the shaft **20** from the machine.

A sealing assembly **24** includes an annular member **25** attached to the partition in a manner illustrated in FIG. **1**. Attached to the forward end of the annular member **25** is the aforementioned labyrinth ring **29**. In addition, there is attached to the rearward end of annular member **25** a second annular member **26**.

Attached to the forward end of the annular member 25 is a shutdown ring 30, the function of which is explained in U.S. Pat. No. 3,506,375, granted Apr. 14, 1970, in the name of James W. Endress, and assigned to the assignee of this invention.

Arranged within annular member 24 is support ring 31. Arranged, in turn, within support ring 31 is an axially movable sleeve 31' which cooperates with a spring retainer 32 to apply a predetermined axial force on graphite ring 34, engaging collar 33 secured to shaft 20. A nut 35 prevents separation of the collar 33 from the shaft. The sealing arrangement described so far is conventional and its operation is well known to those skilled in the art.

The annular member 25 is arranged so as to provide a chamber 36 for accommodating the sealing elements described above. Lubricant at a relatively high pressure is supplied to the chamber through line 40. Lubricant is exhausted from the chamber as it passes through the floating seal sleeve 38 attached to ring 39 interposed between annular members 25 and 26.

In addition to the parts described, the sealing assembly includes annular element 80 having circumferentially spaced openings 81 disposed therein. The element 80 is arranged in close proximity to threaded surface 82 of collar 33 so that fluid collecting in the space between the inner surface of element 80 and collar 33 is pumped to and through openings 81. With this arrangement, a portion of the fluid is circulated within chamber 36 as indicated by the arrows.

Referring more particularly to FIG. 2, there is illustrated a schematic representation of a part of the lubrication system of the machine illustrated in FIG. 1. It will be appreciated that a second bearing 27' for shaft 20 is located in the end cover 16 but has not been shown except in the schematic drawing to be described. Lubricant collects in sump 42 and is passed via pump 41 to a heat exchanger 43 as is conventional in the art. From the heat exchanger, the lubricant passes through main supply line 40 and filter elements 44 to the chamber 36 containing the sealing means. Branch line 46 serves as a bypass and contains pressure regulator valve 45, the purpose of which is to assure the pressure of the fluid in chamber 36 containing the sealing means exceeds the suction pressure of the gas by 25 to 30 pounds. Line 45' supplies suction pressure to the top of the diaphragm associated with valve 45 for the purpose of maintaining this pressure difference.

The remainder of the lubrication circuit includes line 60 which supplies lubricant at a reduced pressure to bearings 27 and 27', thrust bearing assembly 88 described in detail in U.S. Pat. No. 3,506,375, mentioned above, via lines 61, 62, 63, 64, and 65. In addition, line 66 provides fluid under pressure to a shutdown seal actuator assembly located in connection with the thrust bearing assembly. The details of the shutdown seal assembly are not necessary to this invention. Serving as a part of the sealing means is conduit 47 communicating chamber 36 with the sump 42. Disposed within the line 47 is a variable orifice valve 48, the function of which will be explained later.

The variable orifice valve 48 includes a first threaded end opening serving as an inlet 57 and a second end opening serving as an outlet 58 disposed in the side of casing 50. In addition, there is provided tapered mandrel 52 connected to an end wall 53 of the variable orifice valve. In addition to the parts described, a cup-shaped piston 54 having an opening 54' in the connecting leg is arranged within the casing so as to be engaged by one end of spring 56. The other end of spring 56 engages the inner surface of end wall 53. Snap ring 55 secures end wall 53 from movement outwardly of casing 50. A bushing 55' is fitted into an opening disposed in the wall 53. Extending through the bushing is threaded end 52' of tapered mandrel 52. An outer nut connects the mandrel to the end wall. An inner nut 56' is located on the threaded portion 52' at a given distance inwardly of the wall 53. The purpose of nut 56' is to prevent separation of the mandrel and the casing by rearward movement of the mandrel outwardly of the casing.

With the mandrel 52 connected only by the nut located outwardly of the end wall 53, the tapered end portion 53' may flex to some extent if engaged by the wall of the aperture 54' of the piston, a condition likely if manufacturing tolerances are not strictly observed. Thus, the valve 54 may not bind or stick on the surface of the tapered portion so that complete closing of the valve may always obtain by contact with collar 51'.

It will be obvious from an observation of FIG. 3 that movement of piston 54 within the casing 50 will vary the size of the opening 54' serving as a part of the passage between inlet 57 and outlet 58.

Considering the operation of the sealing system, fluid is supplied by pump 41 to line 40 at a predetermined pressure in excess of that existing in the suction side of the machine as regulated by the valve 45. Fluid supplied via line 40 flows through the chamber 36 and escapes via sleeve 38 to a collection area, not shown, where it passes to sump 42. Passage of lubricant through line 47 is prevented during start up of the machine because the relatively high pressure fluid present in chamber 36 forces piston 54 to the right of the casing closing the opening 54'. The fluid under pressure continues to be supplied to chamber 36 by the action of pump 41. As the pressure of the fluid is reduced in accordance with a reduction in the suction pressure of the gas handled by the machine, the piston 54 moves to the left opening the valve to modulate flow through the hole 54' and maintain a constant flow through the chamber 36, this being the sum of the flows through sleeve seal 38 and the hole 54'. In order to more effectively exhaust the sealing fluid from chamber 36, line 47 should preferably be located at a position diametrically opposite the connection of supply line 40 with chamber 36.

Thus with the sealing system described, adequate flow of sealing fluid through chamber 36 can be obtained by merely calculating the desired flow rate for efficient cooling of the parts and thereafter sizing mandrel member to assure passage of the flow at all operating pressures encountered by the machine.

While we have described and illustrated a preferred embodiment of our invention, it should be understood that the invention is not limited thereto since it may be otherwise embodied within the scope of the following claims.

We claim:

1. A gas compressor comprising:
   a. casing means forming an enclosure for the operating parts of the compressor,
   b. bearing means arranged within the casing,
   c. a rotary shaft supported within the bearings,
   d. an impeller secured to the shaft for receiving gas at a relatively low pressure and discharging it at a relatively high pressure,
   e. shaft-sealing means disposed within the casing,
   f. means arranged within the casing forming a chamber for accommodating the shaft-sealing means, the chamber having an inlet and an outlet,
   g. means for supplying fluid under pressure in excess of the pressure of the gas at a preselected location in the compressor to the chamber accommodating the sealing means to inhibit leakage of gas along the shaft, said means supplying the fluid to the chamber inlet for passage through the chamber outlet, and
   h. means responsive to pressure of fluid within the chamber regulating the flow of fluid from the chamber whereby passage of sealing fluid through said chamber at a rate sufficient to ensure adequate cooling of the sealing means is maintained.

2. A gas compressor as set forth in claim 1 wherein said last-mentioned means includes a variable pressure valve communicating with said chamber so as to provide a second outlet therefrom.

3. A gas compressor as set forth in claim 2 wherein said variable pressure valve means is operable in response to a predetermined pressure of the fluid within the chamber.

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,645,643 Dated February 29, 1972

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It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 75, after "26" insert --serving as a mounting for a shaft bearing 27. A labyrinth member 28 is secured to the rearward end of second annular member 26--.

Signed and sealed this 11th day of July 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

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