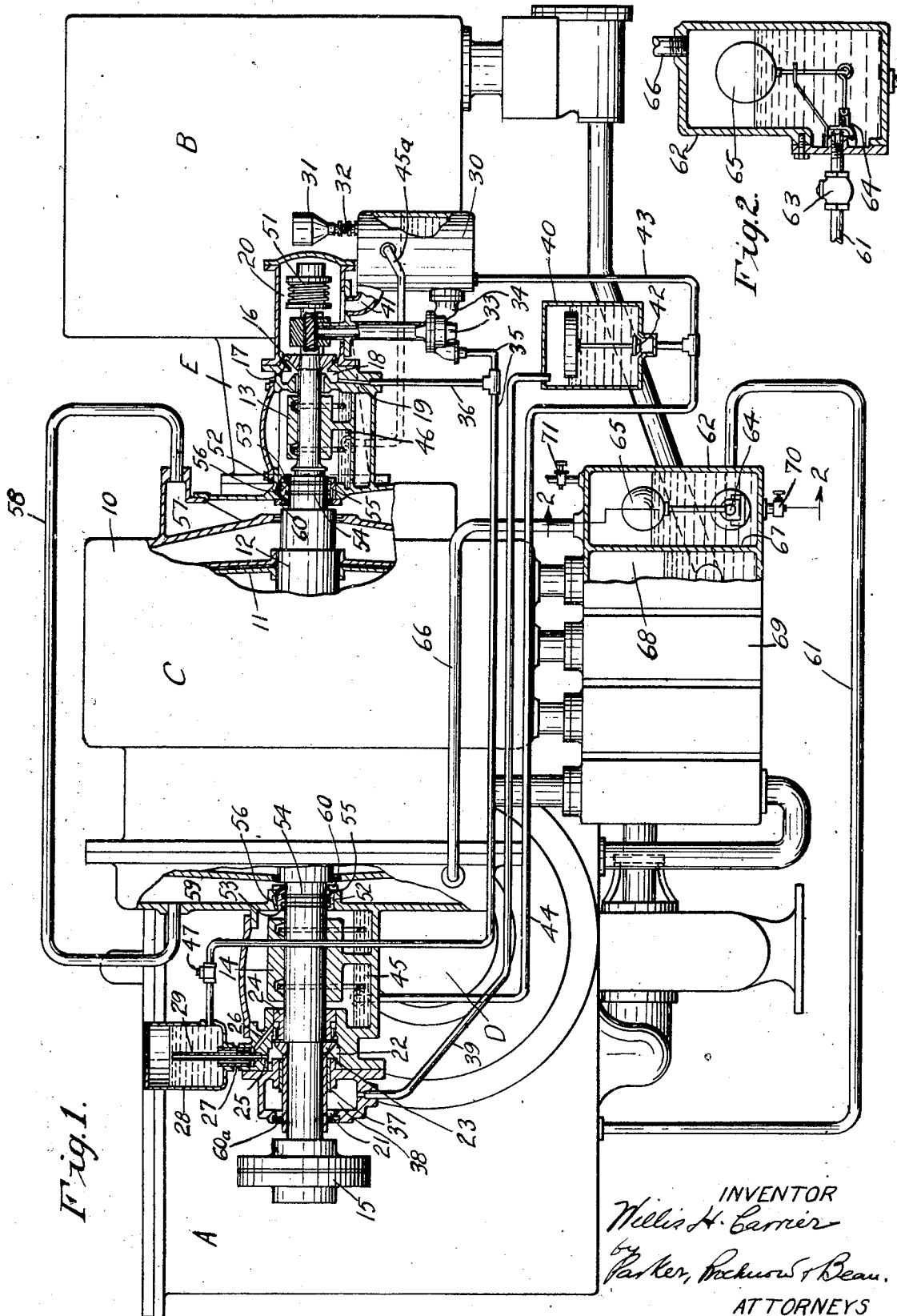


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REFRIGERATION AND OTHER APPARATUS INCLUDING
FLUID COMPRESSORS AND THE LIKE
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REFRIGERATION AND OTHER APPARATUS INCLUDING FLUID COMPRESSORS AND THE LIKE.

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This invention relates to means for use with centrifugal or rotary gas or refrigerant compressors, vacuum pumps and the like for providing a substantially frictionless gas tight closure or seal for the opening through which the pump shaft passes out of the pump housing or casing, lubricating the shaft bearings and for preventing leakage of the lubricating and sealing liquid into the pumped fluid, combined with a rectifier for the separation of the pumped fluid or refrigerant as a vapor from impurities such as oil, water etc.

The invention is especially applicable to refrigeration apparatus such as disclosed in my co-pending applications for United States Patents, Ser. No. 656,152, filed Aug. 7, 1923, now Patent No. 1,639,023, issued August 16, 1927, and No. 586,000 filed Sept. 2, 1922 now Patent No. 1,575,970, issued March 9, 1926. The invention is not, however, restricted in its application to such use, but is applicable to elastic fluid pumps and the like for other purposes where it is important to prevent gas leakage to or from the pump and the leakage of the sealing or lubricating liquid into the rotor chamber of the pump, and to rectify the pumped fluid or refrigerant to separate it from oil or other impurities.

One object of the invention is to provide an improved refrigeration system in which an efficient and practical lubricating and sealing means for the rotor shaft of the compressor is combined with a rectifier for separating the refrigerant as a vapor from the lubricating and sealing liquid or other impurities such as water etc.

Other objects of the invention are to provide efficient means for preventing the leakage of lubricating and sealing liquid into the rotor chamber, thus reducing the amount of necessary rectification to a minimum; also to provide a means for equalizing the pressures in the bearings of the compressor to prevent leakage of the sealing and lubricating liquid into the rotor chamber thus also reducing the amount of necessary rectification to a minimum; and also to improve refrigerating systems of the character mentioned in the other respects hereinafter described and set forth in the claims.

In the accompanying drawings which illustrate a practical embodiment of my invention,

Fig. 1 is an elevation of the refrigeration apparatus with parts broken away to disclose the construction,

Fig. 2 is a sectional view through the rectifier of the apparatus on the line 2-2 of Fig. 1.

In the apparatus illustrated in the drawings of this application, the bearings for the compressor shaft and the mechanism for lubricating the bearings and sealing the shaft opening in the compressor casing are arranged, constructed and operate substantially as disclosed in said application No. 586,000, while the rectifier and other parts of the apparatus are constructed and operate substantially as disclosed in said other application No. 656,152, certain combinations of features disclosed in said applications but not claimed in either of them being claimed in the present application as will hereinafter appear.

Referring to the drawings, A indicates the evaporator in which the refrigerant is vaporized in order to reduce the temperature of the medium to be cooled, and B is the condenser to which the refrigerant vapor is delivered under pressure by a centrifugal fan or compressor C. As usual, in compression refrigerating systems, the liquefied refrigerant is returned from the condenser to be again vaporized, compressed and condensed. The compressor which is driven by a suitable motor, not shown, suitably connected with the compressor shaft, draws the refrigerant vapor from the evaporator A through a connection D and delivers the compressed vapor to the condenser B through a suitable discharge passage E. The evaporator, condenser and compressor may be of the construction disclosed in said applications or of other suitable construction.

In the compressor C, the casing or housing encloses a plurality of rotary impellers 11, one impeller in each stage of the compressor casing 10. The rotor shaft 12 of the compressor is journaled in suitable bearings 13 and 14 at opposite ends of the rotor. One end of the shaft 12, for example, the left end thereof extends outwardly beyond the bearing 14 and out of the pump housing 10 for connection with a driving turbine or motor (not shown) by means of a coupling 15 or other transmission means. The other end

of the shaft 12 is completely housed or enclosed so that it is only necessary to provide a single sealing or packing device for the shaft, this being located in the machine at the left hand end of the housing or casing.

The compressor shown is of a design such that it produces end thrust on the rotor shaft in one direction, to the left as shown in the drawings, and the shaft with the parts carried thereby, is adapted to have a slight end-wise movement in its bearings. This thrust is balanced or resisted and prevented from causing friction in the following manner:—

An annular collar or thrust bearing 16 surrounds and is rigid with the rotor shaft 12 outside of the bearing 13. This member faces a stationary, annular member 17 of the pump casing which acts as a stop to limit the movement of the shaft to the left due to the end thrust thereon. The stop member 17 forms one end of a liquid pressure chamber 18 provided in the casing 10 around the shaft 12. Liquid, preferably lubricating oil, is supplied under pressure to this chamber through an inlet passage 19 and this oil is adapted to exert pressure in an outward or right hand direction against the thrust balancing member 16 so as to move the same outwardly away from the opposing stop member 17 and permit the oil to escape between the two members into a chamber 20 surrounding the thrust balancing member 16. Oil is maintained under pressure in the pressure chamber 18 during the operation of the compressor and the pressure thereof against the member 16 tends to move the shaft in opposition to the end thrust created thereon by the compressor, thereby balancing or resisting the end thrust. This pressure is sufficient to hold the collar slightly out of contact with the stop member 17 so that the thrust is exerted through the thrust balancing member 16 on the oil which thus forms an oil cushion and reduces or prevents friction due to the end thrust of the shaft.

Formed in the compressor housing and surrounding the compressor shaft 12, preferably between the shaft bearing 14 and opening 21 in the casing through which the shaft 12 projects out of the casing, is a sealing chamber 22. Surrounding the shaft and rigid therewith within this chamber 22, is an annular valve or member 23 arranged adjacent to and adapted, when the compressor is not running, to seat against the outer end of a stationary bushing 24 surrounding the shaft 12. This bushing is secured in the pump casing and forms the inner end of the sealing chamber 22. The portion of the sealing chamber immediately surrounding the valve 23 is but slightly larger in diameter than the valve so as to leave only a narrow, annular passage for the liquid around said valve. This valve is adapted to move away from its seat a slight distance which is limited or de-

termined by the engagement of the thrust-balancing collar 16 against its stop 17, and on the other hand, the valve 23 limits the distance to which the thrust balancing collar can move away from its seat 17, this distance being very slight, preferably only a few thousandths of an inch so that the oil will always exert sufficient pressure on the thrust balancing collar 16 to balance the end thrust on the shaft when the compressor is running and hold the thrust collar out of contact with its seat. A passage 25 is adapted to deliver a sealing liquid, preferably lubricating oil, to the sealing chamber 22 at the outer end of the valve 23 and a passage 26 is adapted to deliver the oil to the space between the inner end of the sealing chamber 22 and the opposing, adjacent end of the valve 23. The passage 26 connects by a pipe 27 to the lower end of a closed receptacle or regulating chamber 28 and the other passage 25 connects with a pipe 29 which communicates at its upper end with the upper portion of said receptacle 28 below its top. Preferably the passage 26 leads to a circumferential groove in the bushing 24 from which holes or passages extend through the bushing to an annular groove in the end thereof against which the valve 23 seats so as to deliver the liquid to the space between the valve and the bushing.

The oil or sealing liquid is supplied continuously to the sealing chamber 22 and pressure chamber 18 preferably as follows:—A main oil or liquid reservoir 30 is provided with a filling funnel or pipe 31 equipped with a stop cock 32 for tightly closing the reservoir. An oil circulating pump 33 takes the oil from the reservoir 30 through a suction passage 34 and delivers the oil under pressure through a pipe 35 to oil receptacle 28, and by a branch pipe 36 to the inlet 19 for the pressure chamber 18. The oil delivered to the sealing chamber 22 is adapted to escape from the same through the bushing 24 into the chamber containing the adjacent shaft bearing 14, and also through a sleeve or bushing 37 surrounding the compressor shaft 12 into a chamber 38 in the compressor casing 10 surrounding the shaft 12, and from this chamber the oil returns through a pipe 39 to a trap 40. The oil escaping out of the pressure chamber 18 past the thrust balancing collar 16, is returned to the oil reservoir through a suitable passage 41, leading from the chamber 20 of the casing to the reservoir 30. The trap 40 has a discharge passage controlled by a suitable float valve 42 and connects with a return pipe 43 leading to the reservoir 30. An over-flow pipe 44 returns surplus oil from the oil chamber 45 containing the left hand shaft bearing 14 to the return pipe 43, and an over-flow pipe 45* returns surplus oil from the chamber 46 for the right hand shaft bearing 13 to the oil reservoir 30. The oil pump 33 is operatively

connected with the main compressor so that during the operation of the latter, the oil pump operates and continuously delivers the oil from the reservoir 30 to the receptacle 28, and to the pressure chamber 18 for the thrust balancing device, the oil being returned from the sealing chamber and the pressure chamber 18 to the reservoir and being continuously circulated.

The supply pipe 35 for the oil receptacle 30 is provided with a check valve 47 so that the oil is maintained under pressure in the receptacle and an air cushion is formed in the upper end of the receptacle above the oil therein. The pipe 29 opens into the receptacle 28 at such a height that when the oil pump is running, the air cushion in the top of the receptacle 28 is compressed sufficiently for the oil to rise in the receptacle to the upper end of the pipe 29 so that under these conditions the oil discharges from the receptacle through the pipe 29 and the pipe 27 to the sealing chamber 22 at opposite ends of the valve 23. This balances the pressure in the sealing chamber at opposite ends of the valve 23 and forms an oil seal surrounding the compressor shaft which effectively prevents the leakage of air or gas through the shaft opening 21. When the compressor and oil pump stop running, the pressure in the receptacle 28 will be reduced and the air cushion in the top of the receptacle will force the oil in the receptacle down below the upper end of the stand-pipe 29 so that the oil cannot then discharge through said pipe. The latter pipe then serves as a vent pipe for the receptacle 28, admitting air to the same, the air leaking into the sealing chamber 22 through the shaft opening 21 in the casing and the bushing 37 at the outer side of the sealing chamber. The oil will then feed by gravity from the receptacle 28 through the pipe 27 and connecting passages in the bushing 24, and pass between the seat and the valve and through the shaft opening in the bushing 24 into the oil chamber 45 for the adjacent shaft bearing 14. At such time the valve 23 is seated against the end of the bushing 24, and only sufficient oil can seep through between the valve and its seat to form an oil film between these parts which assists the valve in maintaining a gas tight closure around the compressor shaft 12. When the compressor shaft 12 is rotating, the sealing valve 23 is held off its seat by the end thrust of the compressor on said shaft, but when the pump stops rotating, the valve 23 is seated to effect the closure of the shaft opening by a spring or other suitable means 51, which moves the shaft endwise in the opposite direction from that in which the thrust is exerted.

It is desirable to reduce the work of the rectifier to be hereinafter described to a minimum by preventing the leakage of oil from

the shaft bearings 13 and 14 along the shaft into the rotor chamber of the compressors C and for this purpose a suitable barrier or dam for the oil is preferably provided between each of the shaft bearings and the adjacent end of the rotor chamber. The barrier shown consists of a sleeve 52, through which the shaft passes and which is provided with a plurality of internal, circumferential grooves 53. The shaft is provided opposite each of these grooves with a circumferential groove 54 the edges of which act by centrifugal force when the shaft is running to throw any oil collecting on the shaft off the same into the grooves 53. The grooves 53 preferably connect at their bottoms with a passage 55 adapted to return the oil to the oil chamber for the adjacent shaft bearing.

In order to equalize the pressure at opposite ends of this labyrinth barrier and thus prevent any tendency for the oil to be forced through the same by reason of unequal pressures at opposite ends of said barrier, an equalizing passage 56 is provided which connects the two chambers in the compressor casing at opposite ends of the barrier. The chamber 57 between the barrier and the rotor chamber at the discharge end of the compressor is preferably connected by an equalizing passage 58 with a chamber 59 at the opposite or suction end of the pump. A partial vacuum is thus maintained in the chambers at opposite ends of the compressor casing and the equalizing passage 56 connecting each of these chambers 57 and 59 with the adjacent bearing chamber, equalizes the pressure at opposite ends of the barriers and in the two bearing chambers. Suitable packing rings 60 are also preferably provided around the shaft 12 at the inner end of the barrier and between the chambers 57 and 59 and the rotor chamber of the pump. Packing rings 60^a are provided in the shaft opening 21 through which the shaft extends out of the pump casing.

The means above described for sealing the shaft opening, balancing the end thrust, lubricating the bearings, and preventing passage of oil into the compressor, as before indicated are all substantially as disclosed in said application No. 586,000, but means of other suitable construction adapted to perform these functions could be employed.

In spite of such precautions taken to prevent the passage of oil from the bearing casings into the rotor chamber, some oil actually gets into the rotor chamber in vapor or liquid form and mixes with or is absorbed by the refrigerant. This contamination of the refrigerant by the oil may occur for instance by condensation of oil vapor passing over from the bearings to the refrigerant vapor in the compressor under the influence of both high temperature and high vacuum. In order to remove the oil from the refrigerant

or rectify the latter and prevent a reduction in the efficiency of the apparatus by reason of such pollution of the refrigerant, means are provided for automatically and continuously rectifying the refrigerant and separating it as a vapor from the oil and other impurities such as water, etc., during the operation of the system. Any suitable apparatus may be used for this purpose such as the one illustrated in which a pipe 61 is connected between the liquid space of the evaporator A and a rectifier chamber 62. In order to prevent any backward leakage of the liquid from the rectifier chamber 62 into the evaporator A, a suitable check valve 63 (Fig. 2) is provided on the pipe 61. The liquid level in the rectifier chamber 62 is regulated and at the same time liquid is introduced into said chamber more or less continuously as rectification proceeds, by suitable means, such for example, as a valve 64 actuated by a float 65 in the rectifier chamber. This float is adapted to maintain the liquid in the rectifier chamber at a lower level than the lowest level in the evaporator. A pipe or passage 66 connects the upper portion of the rectifier chamber to the first stage of the compressor, or other suitable point of low pressure in the system, so that the vapor from the refrigerant liquid in the rectifier will be withdrawn therefrom as fast as formed and the pressure equalized on the liquid in the rectifier. Any suitable means of heating the liquid in the rectifier chamber 62 may be used and this heating means may be internal or external. In the apparatus illustrated, one wall 67 of the rectifier also forms a wall of a chamber 68 in the economizer 69 more fully described in said first mentioned application. This economizer chamber 68 contains warm liquid refrigerant which passes through the economizer in its return from the condenser B to the evaporator A, and heat is transferred from said warm liquid through the wall 67 to the liquid in the rectifier causing the same to boil and distill off its vapor. A continuous evaporation or boiling of the refrigerant liquid in the rectifier takes place during the operation of the refrigeration apparatus so that any oil, water, dirt or other impurities of a low volatility or non-volatile character under the conditions named, remains as a residue in said rectifier chamber. These impurities can be drained out of the rectifier from time to time as may be necessary, by opening a drain cock 70 at the bottom of the rectifier chamber and an air vent cock 71 at the upper end of the rectifier chamber. After the impure liquid has been drained from the rectifier, the drain valve and vent cock are closed and the operation of the rectifier and system permitted to continue as before. The temperature in the rectifier will rise in proportion as the impurities accumulate therein, and when a predetermined maximum

temperature is reached which can be ascertained by means of a suitable thermometer, the impurities can be drained off as explained.

I claim as my invention:

1. The combination with a fluid pump having a rotary shaft extending through an opening in the pump casing, of liquid circulating means which operate to maintain a liquid seal for said shaft opening, and a rectifier and connections separate from said liquid circulating means by which portions of the pumped fluid are delivered to the rectifier during the operation of the pump, and means for heating the fluid in said rectifier for separating said fluid as a vapor from less volatile impurities, and means for returning the separated vapor to said pump.

2. The combination with a fluid pump having a rotary shaft extending through an opening in the pump casing, of liquid circulating means which operate while the pump is running to maintain a liquid seal for said shaft opening, a supplemental device which closes said shaft opening when the rotation of said shaft stops, a rectifier and connections separate from said liquid circulating means by which portions of the pumped fluid are delivered to the rectifier during the operation of the pump, and means for heating the fluid in said rectifier for rectifying said fluid to separate it as a vapor from less volatile impurities, and means for returning the separated vapor to said pump.

3. The combination with a fluid pump having a rotary shaft extending through an opening in the pump casing, of a valve and valve seat which cooperate to form a closure for said shaft opening when the pump is not running, said valve being held off its seat when the pump is running, liquid circulating means which maintain a sealing liquid between said valve and valve seat and form a liquid seal for said shaft opening when the pump is running, a rectifier and connections separate from said liquid circulating means by which portions of the pumped fluid are successively delivered to the rectifier during the operation of the pump, and means for heating the fluid in said rectifier for rectifying said fluid to separate it as a vapor from less volatile impurities.

4. The combination with a fluid pump having a rotary shaft extending through an opening in the pump casing, of a bearing rotatably supporting one end of said shaft, liquid circulating means for maintaining a sealing liquid under pressure to form a liquid seal for said shaft opening outwardly beyond said bearing, means for preventing substantially flow of said sealing liquid into the rotor chamber of said pump, a rectifier and connections separate from said liquid circulating means by which portions of the pumped fluid are delivered successively to the rectifier during the operation of the pump and means for heating

the fluid in said rectifier for separating the fluid as a vapor from less volatile impurities.

5 5. The combination with a compressor for the vapor of a volatile liquid having a shaft
extending through an opening in the com-
pressor casing, of means including a different
liquid and circulating means therefor which
maintain a liquid seal for said shaft open-
ing, a rectifier and connections separate from
10 said liquid circulating means by which por-
tions of said volatile liquid are successively
delivered to the rectifier during the operation
of the compressor, and means for heating the
liquid in said rectifier for vaporizing the li-
15 quid and separating the vapor from less vola-
tile impurities.

6. The combination with a compressor for
the vapor of a volatile liquid having a shaft
opening, of means including a different li-
20 quid and circulating means therefor which
maintain a liquid seal for said shaft opening,
a rectifier, means separate from said liquid
circulating means for delivering a portion of
said volatile liquid to said rectifier substan-
25 tially continuously during the operation of
said compressor, and means for heating the
volatile liquid in said rectifier to separate it as
a vapor from less volatile impurities.

7. The combination with a fluid compres-
30 sor having a shaft which extends through an
opening in the compressor casing, of en-
closed bearings for the compressor rotor re-
spectively at the suction and pressure ends of
the compressor, means for equalizing the
35 fluid pressure in said bearing enclosures, a
pressure liquid seal for said shaft opening
arranged outwardly beyond the adjacent
bearing with the bearing between the liquid
seal and the compressor, and a rectifier to
40 which portions of the pumped fluid are de-
livered during the operation of the compres-
sor and by which the liquid is vaporized for
separating said fluid from said sealing liquid.

8. The combination with a fluid compres-
45 sor having a shaft which extends through an
opening in the compressor casing, of an en-
closed bearing for the compressor rotor hav-
ing the bearing enclosure in communication
with the suction end of the compressor, a
50 pressure oil seal for said shaft opening ar-
ranged outwardly beyond the bearing with
the bearing between the oil seal and the com-
pressor, so that oil from the oil seal flows into
the bearing, oil circulating means for main-
55 taining said oil seal and a rectifier and con-
nections separate from said oil circulating means
by which portions of the pumped fluid are de-
livered to the rectifier during the operation of
the compressor for separating said fluid from
60 said oil.

9. The combination with a fluid compres-
sor having a shaft which extends through an
opening in the compressor casing, of en-
closed bearings for the compressor rotor re-
65 spectively at the suction and pressure ends

of the compressor, means for equalizing the
fluid pressure in said bearings, a pressure oil
seal for said shaft opening, a common closed
oil pressure circuit for supplying oil to said
oil seal and bearings, and a rectifier to 70
which portions of the pumped fluid are de-
livered during the operation of the com-
pressor for separating said fluid from said
oil.

10. The combination with a fluid compres- 75
sor having a shaft which extends through an
opening in the compressor casing, of en-
closed bearings for the compressor rotor re-
spectively at the suction and pressure ends of
the compressor, an oil barrier between each 80
bearing and the rotor chamber of the com-
pressor for obstructing passage of oil from
the bearing into the rotor chamber, fluid pres-
sure connections for equalizing the fluid
pressure in the bearing enclosures and at op- 85
posite sides of said oil barriers, and a recti-
fier to which portions of the pumped fluid are
delivered during the operation of the com-
pressor for separating said fluid from said
oil. 90

11. The combination with a rotary fluid
compressor, of an enclosed bearing for the
compressor rotor, the bearing enclosure be-
ing in communication with a low pressure
portion of the interior of the compressor cas- 95
ing, lubricant circulating means for supply-
ing lubricant to said bearing, a rectifier for
the pumped fluid, and means separate from
said lubricant circulating means for auto-
matically passing portions of the pumped 100
fluid through said rectifier during the oper-
ation of the compressor for separating said
fluid from any lubricant carried thereby.

12. The combination with a rotary fluid
compressor, of enclosed bearings for the com- 105
pressor rotor respectively at the suction and
pressure ends of the rotor, means for sup-
plying lubricant to said bearings, means for
equalizing the fluid pressure in said bear-
ings, and a rectifier to which portions of the 110
pumped fluid are delivered during the oper-
ation of the compressor for separating said
fluid from said lubricant.

13. In a refrigeration system employing a
volatile liquid refrigerant, the combination 115
with a rotary compressor for the refrigerant
vapor having an enclosed bearing for the
compressor rotor, an equalizing connection
between the bearing enclosure and a low
pressure portion of the refrigeration system, 120
means for supplying lubricant to said bear-
ing, and a rectifier and means separate from
said lubricant supply means by which por-
tions of the refrigerant liquid are delivered
to the rectifier during the operation of the 125
system for separating the refrigerant from
said lubricant.

14. In a refrigeration system employing a
volatile liquid refrigerant, the combination
with a rotary compressor for the refrigerant 130

vapor having an enclosed bearing for the compressor rotor, the bearing enclosure being in communication with the interior of the compressor casing, means for supplying lubricant to said bearing, and a rectifier and means separate from said lubricant supply means by which portions of the refrigerant liquid are delivered to the rectifier during the operation of the system for separating the refrigerant from said lubricant.

15. The combination with a fluid pump having a shaft extending through an opening in the pump casing, of means including a circulating liquid for maintaining a liquid seal for said shaft opening, a rectifier, connections separate from said means for delivering to the rectifier, during operation of the pump, portions of the pumped fluid, and a connection from the rectifier above the fluid level therein to the suction side of said pump for withdrawing from the rectifier as a vapor, the volatile portions of the fluid therein, whereby the less volatile portions constituting the impurities will be retained in the rectifier.

16. The combination with a pump for vaporizable fluids having a casing with a shaft extending through an opening in said casing, of means including a circulating liquid for maintaining a liquid seal for said shaft within said casing and adjacent said

opening, a rectifier, connections separate from said means for delivering to the rectifier, during operation of the pump, portions of the pumped fluid, a connection from the rectifier above the fluid level therein to the suction side of said pump for withdrawing from the rectifier as a vapor, the volatile portions of the fluid therein, whereby the less volatile portions constituting the impurities and including any leakage of said liquid from said seal will be retained in the rectifier, and means for heating the portion of the pumped fluid which is within the rectifier to facilitate the separation.

17. The combination with a pump for vaporizable fluids having a casing with a shaft and bearings for said shaft within said casing, of means for lubricating said shaft with a liquid lubricant, a rectifier, connections separate from said means for delivering a portion of the pumped fluid to said rectifier, a connection from the rectifier above the fluid level therein to the suction side of said pump for withdrawing from the rectifier as a vapor the volatile portions of the fluid therein, whereby the less volatile portions constituting the impurities and including any leakage of lubricant into the pumped fluid will be retained in the rectifier.

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