

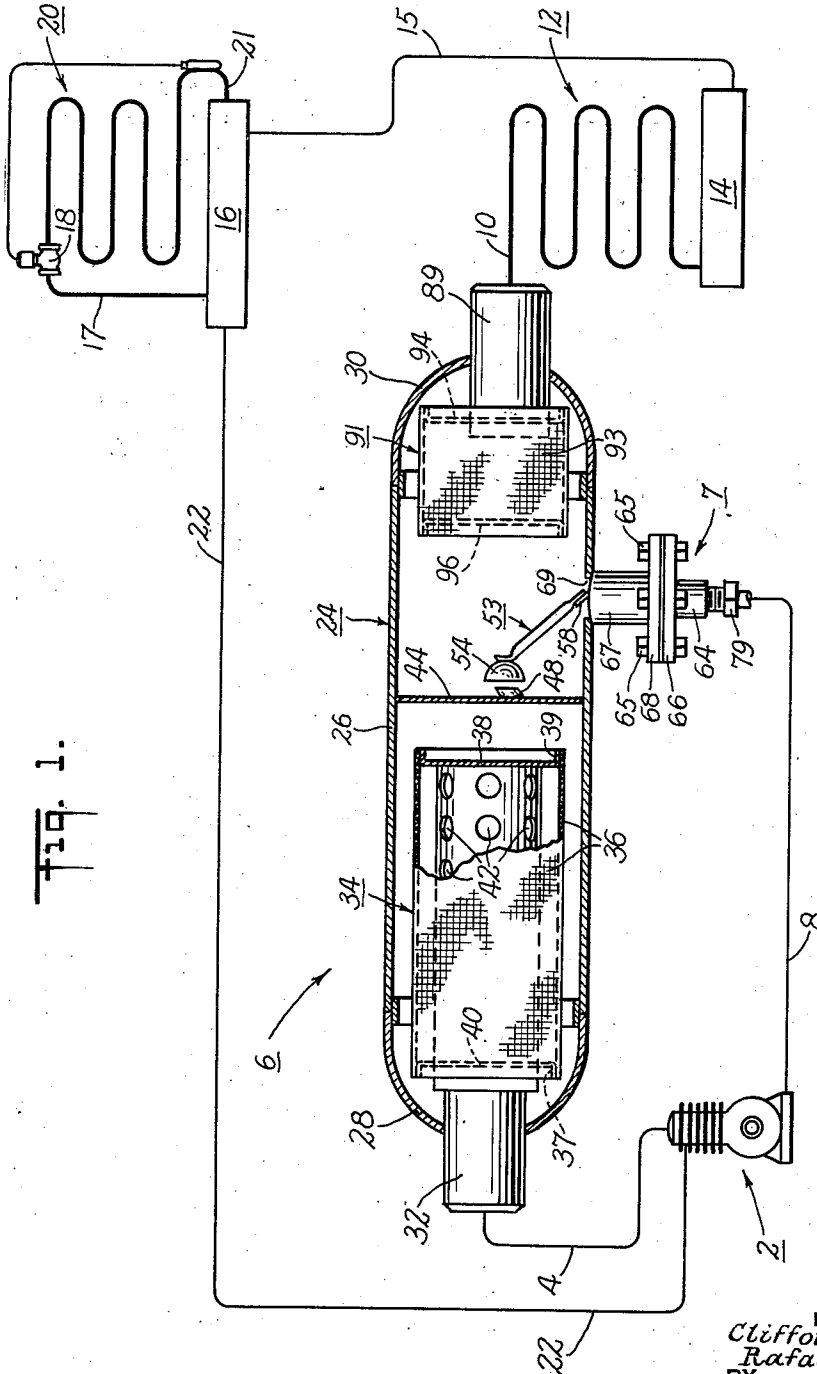
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REFRIGERATION SYSTEM, INCLUDING OIL SEPARATOR
AND MUFFLER UNIT AND OIL RETURN ARRANGEMENT

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Original Filed April 25, 1957

2 Sheets-Sheet 1



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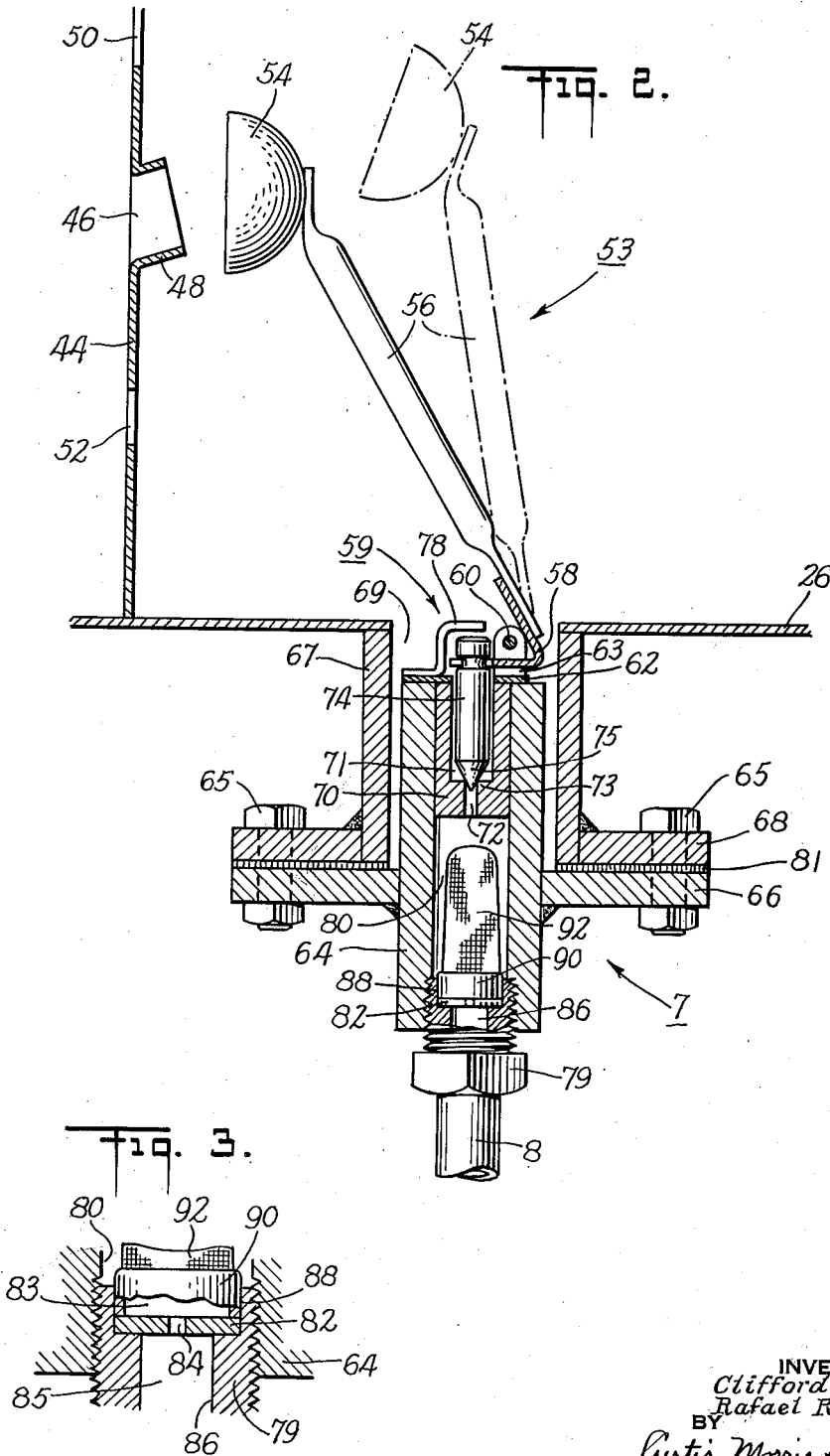
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REFRIGERATION SYSTEM, INCLUDING OIL SEPARATOR AND MUFFLER UNIT AND OIL RETURN ARRANGEMENT

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Continuation of abandoned application Ser. No. 655,119, Apr. 25, 1957. This application Mar. 31, 1961, Ser. No. 102,348

18 Claims. (Cl. 62—473)

This invention relates to refrigeration, and more in particular to mechanisms for reducing the noise in refrigeration systems and for separating oil from compressed gas and for returning it to the compressor. This application is a continuation of our co-pending application, Serial No. 655,119, filed April 25, 1957, and now abandoned.

An object of this invention is to provide improved refrigeration systems. A further object is to provide an improved oil separator. A further object is to provide combined oil separator and muffler mechanisms. A further object is to provide refrigeration systems having mechanisms incorporated therein which muffle the noise. A further object is to provide refrigeration systems with improved arrangements for separating the oil from the compressed refrigerant passing from the compressor and for returning it to the compressor. A further object is to provide an improved refrigeration system into which a mechanism is incorporated to separate oil and to reduce the noise. A further object is to provide improved equipment and modes of operation whereby the functions of oil separation and noise abatement are performed in an efficient and dependable manner. A still further object is to provide for the above with structure which is sturdy, compact, efficient and dependable, and which is adaptable to varying conditions of operation and use. These and other objects will be in part obvious, and in part pointed out below.

In the drawings:

FIGURE 1 is a schematic representation of a refrigeration system constituting one embodiment of the invention, with the oil separator and muffler unit shown in enlarged section;

FIGURE 2 is an enlarged sectional view of the oil outlet structure shown in the lower central portion of FIGURE 1; and,

FIGURE 3 is a greatly enlarged view of the orifice structure shown in the lower portion of FIGURE 2.

Referring to FIGURE 1 of the drawings, a compressor 2 discharges compressed refrigerant through a line 4 to an oil separator and muffler unit 6. From unit 6 the oil is returned to the crank case of the compressor through an oil outlet structure 7 and a line 8, and the compressed refrigerant flows through a line 10 to a condenser 12 where it is condensed. The liquid refrigerant flows to a receiver 14, from which it flows through a line 15, the liquid circuit of a heat interchanger 16, a line 17 and an expansion valve 18 to an evaporator 20. The refrigerant is evaporated in the evaporator and is returned to the compressor through a line 21, the gas circuit of heat interchanger 16, and a line 22.

The oil separator and muffler unit 6 has a cylindrical steel shell 24 formed by a central portion 26 to which end bells or heads 28 and 30 have been welded. Welded in head 28 is the refrigerant inlet connection formed by a pipe 32 which is rigidly supported by the head and projects axially into the shell. Pipe 32 carries a screen assembly 34 formed by a cylindrical screen 36 mounted at its right-hand end upon a plate or disc 38 which is welded to and closes the end of pipe 32. The screen is

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soldered to a peripheral flange 39 on the disc, so as to provide a rigid annular support. Similarly, the left-hand end of the screen is soldered to and supported by the flange 37 upon an annular plate 40 which surrounds pipe 32 and is welded thereto. Pipe 32 is provided with spaced openings 42 throughout the extent of the cylindrical screen, thus to deliver the incoming gas in radial streams flowing outwardly toward the screen in a uniform manner to be discussed more fully below.

Positioned to the right of screen unit 34 is a baffle plate 44 which has an opening 46 concentric with a nozzle 48 which is welded to the plate. Two additional openings 50 and 52 are provided in plate 44 which are smaller in size than opening 46. As will be discussed below, the refrigerant gas and the accompanying oil flow through these openings.

Directly to the right of the nozzle 48 is the hemispherical vane cup 54 of vane assembly 53 (see FIG. 2) formed by a cup 54 rigidly mounted upon the upper free end of a swinging arm 56. The lower end of arm 56 is welded to a bracket 58 which is pivoted by a pin 60 to a fixed bracket 62. Bracket 62 has a pair of spaced upstanding ears 63 between which the bracket 58 is supported and guided during the swinging movement of arm 56. Vane assembly 53 is biased by gravity toward the full-line position shown but, as will be more fully discussed below, it is swung upwardly and held in the broken-line position by the flow of gas through nozzle 48. However, even in the broken-line position, the center of gravity of the vane is at the left of its pivot axis, so that the vane assembly returns to the full-line position whenever the flow of refrigerant gas stops.

The vane assembly acts as a valve operating unit for a needle valve 59 of the oil outlet assembly 7. Valve 59 is formed by a movable valve body or member 74 which is positioned within a cylindrical valve chamber 71 of a stationary valve member 70. Valve member 70 has a cylindrical valve bore 72, the upper end of which forms a valve seat 73, against which the conical lower end 75 of the movable valve body 74 seats. Thus, when the vane assembly 53 is in the full-line position shown, the valve member 74 is seated so that the valve is closed. However, when the vane assembly is moved to the broken-line position, valve member 74 is lifted and the valve is opened so that fluid may flow downwardly through the annular passageway around valve member 74, and thence through the valve bore 72. The upward movement of valve member 74 is limited by a stop bracket 78 welded to the base of bracket 62, and the two brackets are both welded to the top of a cylindrical valve casing 64.

Valve member 70 is held by a press fit in the upper end of bore 80 of valve casing 64, and the valve casing has an annular flange 66 welded to it. Surrounding the entire valve assembly 59 is a cylinder 67 which is welded at its upper end to the shell 24 concentric with an opening in the shell, thus forming an oil well or sump 69. Welded to the lower end of cylinder 67 is an annular flange 68 to which flange 66 is clamped by a plurality of bolts 65, there being a fluid-tight seal 81 between the flanges. The lower end of casing 64 is threaded, and is provided with a fitting 79, to which the oil return line 8 is connected.

Fitting 79 has a central bore 86, and the upper end of the fitting has an enlarged top bore 88 in which is positioned an orifice plate or disc 82 and a screen 92. Screen 92 has a mounting ring 90 and is domed shape, so as to provide a very substantial screen surface for the flow of oil or other fluid into the center of the screen to the zone 83 above the orifice disc 82. Orifice disc 82 has an orifice 84 through which the fluid flows from zone 83 to the zone or space 85 formed by bore 86. Orifice 84 operates in accordance with the principles described in

the introduction of a standard orifice at pages 3-62 of "Mechanical Engineers' Handbook" (1958 edition) by Leon S. Marx. Specifically, orifice 84 is an opening of such shape and construction as to pass oil freely, but restrict passage of gas, as will be explained more fully below. Mounting ring 90 of screen 92 is snugly received in bore 88, so that it and the orifice disc are held properly in place, and yet they may be removed for servicing or replacement by merely removing the fitting 79. The entire oil outlet structure 7 may be removed for inspection and servicing by merely removing the bolts 65 and withdrawing the vane assembly down through the cylinder 67.

It has been pointed out above that the refrigerant gas passes to the right from unit 6 through line 10 to the condenser 12. Accordingly, line 10 is connected to a pipe 89 which is welded into an opening in end bell 30. The open end of the pipe 89 is enclosed by a screen unit 91 formed by a cylindrical screen 93 mounted at the right upon a flanged disc 94 welded to pipe 89. A flange disc 94 is similarly fixed to the cylindrical screen at the left.

The compressed refrigerant and oil therefore enters pipe 32 and is diverted radially outwardly through the openings in the pipe, and then through screen 36. There is a very substantial reduction in the velocity of the gas and there are changes in the direction of flow, so that the sound waves transmitted from the compressor are absorbed and cancelled by interference. The flow is then diverted in an annular stream to the right beyond plate 38, but this flow is also interrupted by the baffle plate 44. The flow through opening 46 and nozzle 48 is directed against the vane cup 54, so as to move the vane to the broken-line position of FIGURE 2, thus to open the needle valve. There is additional flow through the openings 52 and 50, but there is still sufficient flow through nozzle 48 to move the vane to the wave opening position, and to hold the valve open during the entire time that the compressor is operating. The refrigerant gas is then again diverted to an annular stream as it approaches the cylindrical screen 93, and it flows radially inwardly through this screen and then axially again through pipe 89.

During this flow, the oil is effectively separated from the gas, and it collects at the bottom of shell 24 and flows into the oil well or sump 69. The oil separation results from the sudden reduction in the velocities and changes in directions during the flow along the path outlined above. The oil droplets do not change directions of movement readily, and the changes in the velocities tend to cause the oil droplets to join to form larger drops and to be collected in drops and films upon the screen and baffle surfaces. Thus, all of the oil which is entrained with the gas is completely separated, and remains in the unit 6 while the oil-free gas flows onto the condenser.

It has been indicated above that the initial reduction in the velocity of flow and the changes in the direction of flow cause interference and cancelling of the sound waves. Further sound-reducing effects result from the changes in the direction of the flow and the velocities at the baffle plate 44 and at the outlet screen unit 9. It has been found that the pulsations from the compressor are absorbed within this unit. The substantial volume of gas within the unit provides a very effective cushioning means, so that the above results are accomplished in a minimum space and in an efficient manner.

The oil which is separated by the unit flows immediately through the oil outlet structure 7 and the oil return line 8 back to the crankcase of the compressor. This structure 7 has sufficient flow capacity to handle the maximum amount of oil which is apt to be delivered with the gas from the compressor. The needle valve 74 is held open during the entire time that the compressor is operating, with the result that it is unnecessary for oil to accumulate within the unit 6. However, even though the structure 7 will handle the maximum amount of oil which is

apt to be delivered, and it may be that a substantially lesser quantity of oil is actually delivered, the maintaining of the needle valve in its open position has no undesirable effect. In other words, this valve is maintained open, even though no substantial amount of oil is present, and therefore the high-pressure compressed gas within shell 24 is connected through the assembly 7 to the oil return line 8, and there is a tendency for this gas from the "high side" to flow through the oil return line to the "low side" of the compressor. However, while orifice 84 permits the free flow of the oil at the maximum return rate anticipated, this orifice prevents any significant flow of refrigerant gas, even though no substantial amount of oil is present.

Referring to FIGURE 3, it is assumed that the zone 83 above the orifice 84 is at the "high side" pressure P_h , whereas the zone 85 beneath the orifice is at the "low side" pressure P_l . With these pressure conditions, and with oil filling zones 83 and 85, the oil flows at a rapid rate through the orifice. However, when no oil is present so that the zones are occupied by refrigerant gas, the differences in pressure create a "pressure shock" or "baffle shock" condition, so that no significant amount of gas flows through the orifice. In other words, the orifice itself acts as an open valve for the oil, but acts as a substantially closed valve for the gas.

It is therefore seen that the arrangement provides for the separation of the oil from the gas and the collection of the oil in the well 69 in an efficient and dependable manner. The oil then flows through the open needle valve down through the valve bore 72 to bore 80, where it flows through screen 92 to the zone 83. The oil is then discharged through the orifice 80 and line 8. It has been pointed out that the screen presents a substantial amount of surface so that there is no substantial danger of stoppage of flow by accumulations.

The size of orifice 84 in any particular refrigeration system is determined by taking into consideration the various factors, including the size or refrigeration capacity of the system and the head pressure or "high side" pressure which is related directly to the type of refrigerant which is to be used in the system. If the orifice is too small, it will not permit all of the oil to return to the compressor and, if the orifice is too large, the "pressure shock" or "baffle shock" condition will not be created, and therefore the full advantage of the invention will not be obtained. For one particular self-contained refrigeration system of one-ton capacity, the orifice size (i. e., diameter) is .0117 inch when the refrigerant is F-12, and is .009 inch when the refrigerant is F-22. The following are additional illustrative examples of the orifice sizes:

2-ton unit, 0.16 inch for F-12 and .126 inch for F22;
5-ton unit, .026 inch for F-12 and .02 inch for F-22;
10-ton unit, .038 inch for F-12 and .28 inch for F-22;
30-ton unit, .0635 inch for F-12 and .052 inch for F-22;
and,
100-ton unit, .0935 inch for F-22.

The head or "high side" pressures in these illustrative systems are of the order of 125 pounds per square inch when the refrigerant is F-12, and are of the order of 225 to 230 pounds per square inch when the refrigerant is F-22. The "low side" pressures vary widely, depending upon the evaporator temperatures. However, the "pressure shock" or "baffle shock" condition referred to above is always created in a particular system and with a particular head pressure, even though there is a wide variation in the downstream or "low side" or suction pressure. Hence, the same orifice sizes are used for the various systems, even though the particular applications or installations require different evaporator temperatures.

It has been pointed out above that the baffle plate 44 has two openings 52 and 54, above and below the nozzle opening 46. The invention contemplates that these openings will be omitted when the rate of gas flow is not

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greater than can be handled by the nozzle, or that additional openings will be provided when desirable. The openings are positioned at the extreme periphery of the baffle when special circumstances make that desirable. In the illustrative embodiment, the nozzle 48 extends at an angle to the horizontal, so that it is tangential to the arc of movement of cup 54. Under some circumstances, this nozzle extends horizontally.

While the needle valve and vane assembly here shown have proven very satisfactory, it is contemplated that other structures may be used. One such structure is in the form of a vane mounted to pivot around a vertical axis and arranged to open a valve when swung axially around that axis by the action of the flowing gas. With such an arrangement, the vane is spring biased to a rest position in front of the nozzle, and is moved from this position by the action of the flowing gas, so as to open the valve, as in the illustrative embodiment.

In the illustrative embodiments of the invention, the fixed orifice provides the "pressure shock" or "baffle shock" which prevents any substantial flow of refrigerant from oil separator back to the compressor. The invention contemplates the use of other equivalent mechanisms or elements in place of the fixed orifice. For example, other orifices or nozzles may be used with advantageous results for some systems and for some conditions of operation.

As many possible embodiments may be made of the mechanical features of the above invention and as the art herein described might be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter hereinabove set forth, or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

We claim:

1. In a refrigeration system which includes a compressor and a condenser, and wherein oil is discharged from the compressor with the compressed refrigerant gas, a unit connected to receive the compressed gas and oil from the compressor and to separate the oil from the gas and deliver the gas to the condenser, and an oil return assembly through which the separated oil flows to the compressor and including a thin wall having an orifice therethrough which is of sufficient size to readily pass oil at the normal rate of discharge from the compressor and which creates a "pressure shock" condition when gas flows therethrough whereby it passes no significant amount of refrigerant gas when oil is not present.

2. A refrigeration system as described in claim 1, which includes a valve in series with said orifice which is opened automatically during the period of operation of the refrigeration system.

3. A refrigeration system as described in claim 2, wherein said valve is normally biased toward its closed position and valve opening means which is operated by the flowing of refrigerant gas from the compressor.

4. A refrigeration system as described in claim 1 which includes, a nozzle through which compressed refrigerant flows during the operation of the system, a pivoted vane which is biased toward a rest position in the path of gas flowing through said nozzle and which is swung away from said rest position by the action of the flowing gas, and a valve in series flow relationship to said orifice and mechanically connected to said vane and so related as to be in its closed position when said vane is in its rest position and which is moved to the open-valve position by the swinging of said vane.

5. A refrigeration system as described in claim 4, wherein said valve is a needle valve above and co-axially positioned with respect to said orifice, and a dome-shaped screen mounted above said orifice and beneath said valve.

6. A refrigeration system as described in claim 5, wherein said vane is in the form of an arm pivoted at its lower end and having a cup at its upper free end, and

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pivot means mounted adjacent said valve and providing the mounting for said vane.

7. A system as described in claim 1, wherein said unit includes structure which simultaneously separates the oil from the refrigerant gas and muffles the noise and pulsations of the compressor.

8. Apparatus as described in claim 7, wherein said unit includes a cylindrical shell, means to receive the compressed refrigerant with the accompanying oil from the compressor and to subject the flowing stream to a sudden change in direction with a reduction in pressure, refrigerant gas outlet means which subjects the gas to a change in direction as it passes from the unit to the condenser, and means to direct refrigerant gas through said nozzle.

9. A refrigeration system as described in claim 1, wherein said unit comprises a cylindrical shell having an inlet connection at one end through which refrigerant and the accompanying oil is received from the compressor and having a refrigerant outlet connection at the opposite end.

10. A refrigeration system as described in claim 9, which includes an oil sump at the bottom of said shell and having said orifice positioned beneath it whereby oil is collected in the sump and discharged through the orifice, a normally closed valve within said sump above and upstream with respect to said orifice whereby oil does not flow to said orifice when said valve is closed and whereby the opening of the valve provides an open passageway from the shell to the orifice, and a valve opening assembly comprising a nozzle and a movable vane having a rest position to which it is biased in the path of fluid flowing from said nozzle opening and movably mounted to be moved from said rest position by the action of the fluid, said vane being mechanically connected to open said valve by its movement from its rest position.

11. A refrigeration system as described in claim 10, wherein said orifice is of the order of .009 inch to .0935 inch in diameter.

12. A refrigeration system as described in claim 1, wherein said unit includes a shell, means forming an oil sump into which the oil flows from said shell, said orifice being positioned at the bottom of said sump and having a diameter of the order of .009 inch to .0935 inch, respectively, for refrigeration systems of the capacity of the order of one ton to one hundred tons.

13. A refrigeration system as described in claim 1, which includes, an oil return line through which the oil flows to the compressor, and a normally closed valve in the oil return circuit which is opened automatically by the operation of the refrigeration system.

14. In the art of refrigeration, the steps of, discharging refrigerant with accompanying oil from the compressor to an oil separating zone, successively changing the flow and pressure conditions in the flowing stream to separate the oil from the refrigerant, passing the oil-free refrigerant to a condensing zone, and discharging the oil from the oil separating zone through an orifice of such size that gas flowing therethrough produces a "pressure shock" condition whereby no significant amount of refrigerant gas flows through the orifice, even when no oil is flowing.

15. An oil separator and muffler which is adapted to be connected to receive compressed refrigerant flowing from a compressor and to separate the oil from the refrigerant and to return the oil for reuse by the compressor which comprises, means forming a cylindrical chamber having an inlet at one end thereof and an outlet at the other end thereof, a vane which is normally urged in the path of said jet stream in a direction counter to the flow thereof whereby the jet stream moves the vane from the position toward which it is urged, a normally closed valve which has an oil discharge opening within the zone where oil tends to accumulate within said chamber and which is opened by the movement of said vane from the posi-

tion toward which it is urged, and means to restrict flow from said valve.

16. Apparatus as described in claim 15, which includes a muffler and oil separator which comprises a cylindrical member having radial openings therein through which the gas passes and screen means surrounding said cylindrical member, the above-mentioned means including means directing the flowing refrigerant gas in a jet stream.

17. Apparatus as described in claim 15, wherein said vane comprises a member mounted upon a swinging arm and biased by gravity towards said position.

18. Apparatus as described in claim 15, wherein said chamber includes an oil sump within which said valve is

positioned and wherein said means restricting flow comprises an orifice which passes oil at the normal rate of discharge from the compressor and which passes no significant amount of refrigerant gas when no oil is present.

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