Oct. 20, 1970 B. D. MILLER 3,534,564

REFRIGERANT PURIFYING MEANS

Filed Nov. 6, 1968 3 Sheets-Sheet 1

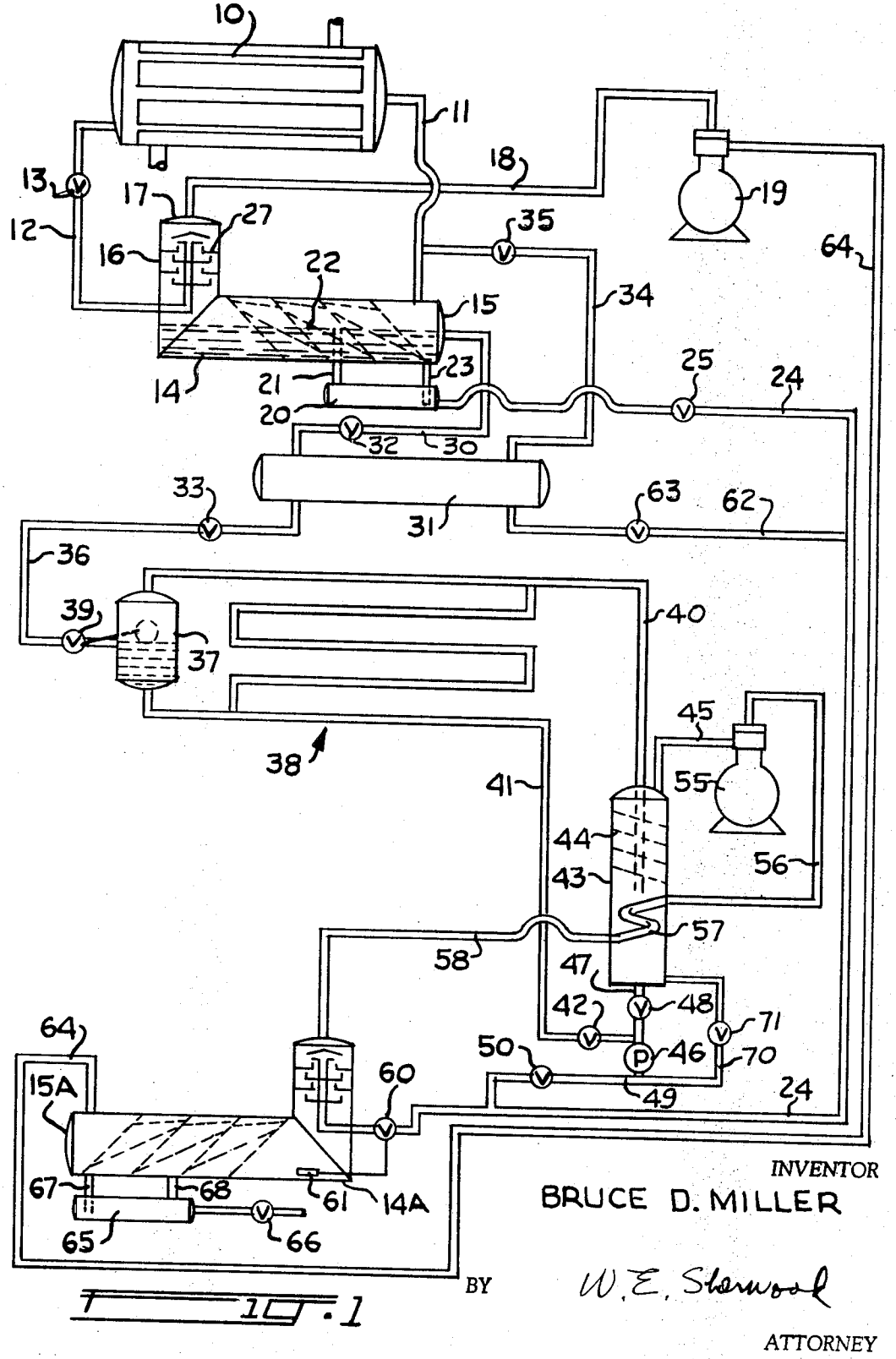


FIG. 1

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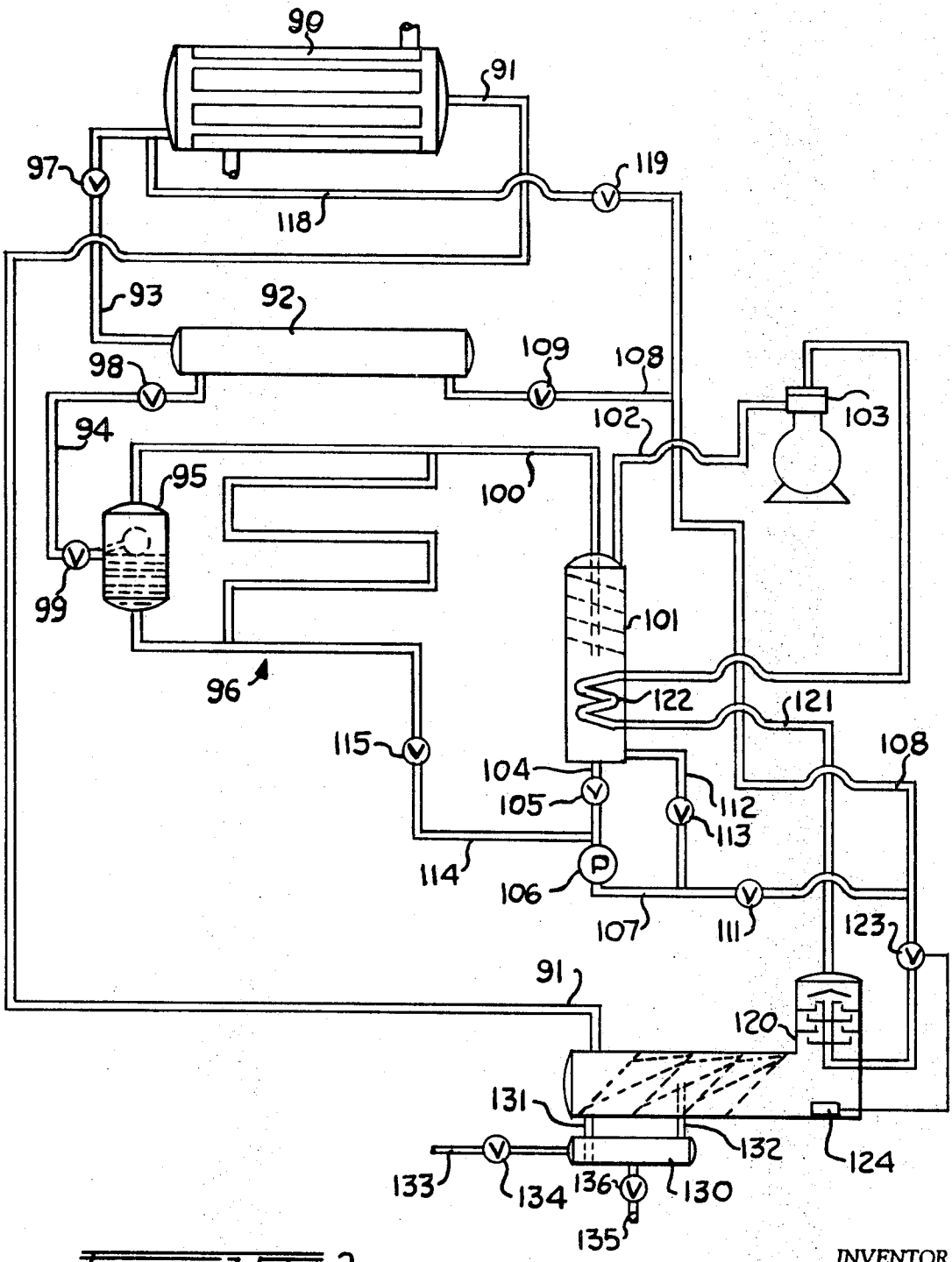


FIG. 2

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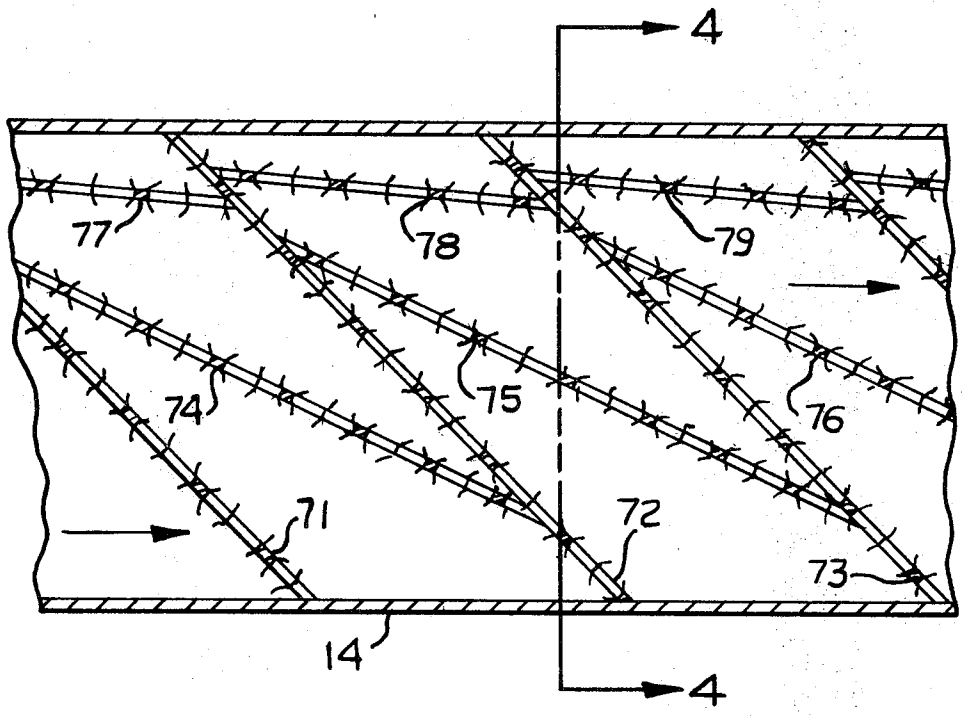


FIG. 3

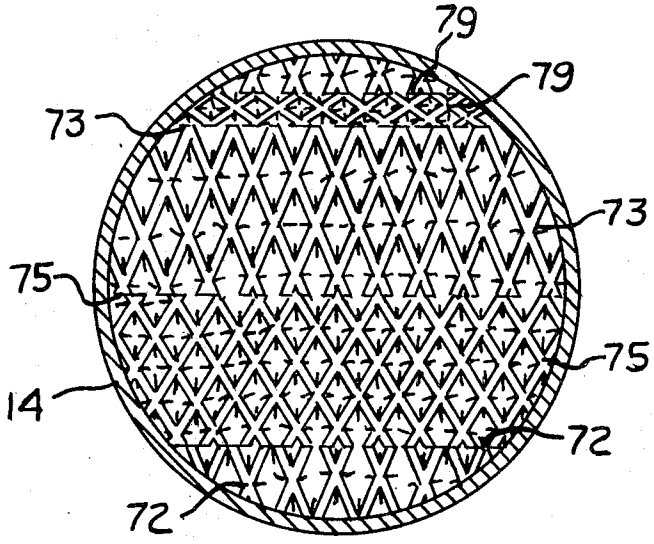


FIG. 4

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REFRIGERANT PURIFYING MEANS

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Int. Cl. F25b 43/02
U.S. Cl. 62—470 15 Claims

ABSTRACT OF THE DISCLOSURE

A refrigeration system with at least one oil-lubricated compressor embodies at least one combined desuperheating and impurity-removing unit in which hot oil-containing gas from a compressor is cooled by direct contact with liquid refrigerant. The unit includes mechanical structure on which viscous oil from the cooled gas deposits and from which it drains into a trap. Embodiments of the invention are disclosed in refrigeration systems employing refrigerants miscible with oil and refrigerants immiscible with oil.

BACKGROUND OF THE INVENTION

The disadvantages of the presence of oil and other impurities on heat-exchange surfaces of refrigeration systems have long been recognized and many proposals have been advanced for solving, or at least reducing, this problem. In my earlier Pat. No. 2,149,358 a system for removing oil by passing the entire amount of refrigerant as a gas through a filter type of oil trap is disclosed. One method involves the desuperheating of the refrigerant gas so as to convert any impurity carried thereby as a fog or mist into a liquid state whereby a separation based upon the different specific gravities of the impurity and the refrigerant may be carried out. The Pottenger Pat. No. 2,618,132 illustrates this procedure using a direct contact of hot, impure refrigerant gas with a reflux of a portion of the purer refrigerant liquid. Another arrangement, for example, in which the hot gas is cooled by heat-exchange with condenser fluid, but without contacting the purer refrigerant liquid, is disclosed in Miller Pat. No. 3,021,689 and still anohter arrangement, in which a separating means is built into a condenser, is illustrated by Kocher Pat. No. 3,274,796.

The internal structure of a desuperheating and separator unit and the location of the unit with respect to other elements of a complete refrigeration system is important in effecting the maximum economy of operation of the system. Any such unit which is complex in construction may present difficulty in instrumentation control of the overall system, as well as being expensive to install and to service. Moreover, a unit which might have merit when used with a refrigerant such as ammonia which is immiscible with oil, may be found to be unsuitable for use with a refrigerant such as Freon which is miscible with oil. It is these and other difficulties encountered in the removal of impurities from refrigeration systems which it is a purpose of this invention to overcome.

SUMMARY

The refrigeration system of the invention, depending upon the number of stages of compression of the refrigerant gas, employs one or more desuperheating and impurity-removing units. The unit is simple in construction, has no moving parts and comprises an entry section receiving hot, oil-laden refrigerant gas and a cool refrigerant liquid which are brought into contact with each other with a resulting increase in viscosity of the oil and a cooling of the gas and a vaporizing of at least a portion of the refrigerant liquid. Communicating with the

entry section is an exit section containing stationary, mechanical means on which viscous oil passing from the entry section deposits and with such means having a construction which breaks any bubbles of gas received from the entry section. Purified refrigerant passing from the exit section under the prevailing pressure conditions in the system recirculates through the system and remains relatively pure until it once more reaches an oil-lubricated compressor.

Oil which is carried into the exit section, either by refrigerant gas or by refrigerant liquid or by both, is deposited on the mechanical means, which preferably includes apertured baffles having sharp edges, deposits on such baffles and is led into an oil trap from which it is removed as desired. Control of the operation of the system is exerted by conventional valves and by conventional pump and compressor regulating means. By arranging the elements of the refrigeration system so as to operate a one-stage compression system with a single combined desuperheating and impurity-removing unit operating with its exit section in substantially dry condition the invention makes possible the use of Freon, ammonia, or other evaporative types of refrigerants. Moreover, by arranging such elements so as to operate a two-stage compression system having two such units with the exit section of the second unit containing both refrigerant liquid and refrigerant gas and the first such unit operating with its exit section in substantially dry condition, the invention makes possible a highly efficent use of ammonia as a refrigerant.

Among the objects of the invention are the provision of an improved refrigeration system which may employ refrigerants which are oil-miscible or oil-immiscible, or water soluble or substantially water insoluble; and improved combined desuperheating and impurity-removing unit for use with refrigeration systems; and an inexpensive, reliable mechanical gas-bubble-breaking and impurity-collecting structure for use in refrigeration equipment.

These and other objects and advantages of the invention will become more apparent as the description proceeds and when considered in conjunction with the accompanying drawings in which:

FIG. 1 is a diagrammatic view of a two-stage compression refrigeration system employing the invention.

FIG. 2 is a diagrammatic view of a one-stage compression refrigeration system employing the invention.

FIG. 3 is a longitudinal sectional view to a larger scale of an intermediate portion of the gas-bubble-breaking and impurity-collecting structure, and

FIG. 4 is a sectional view of the structure taken on line 4—4 of FIG. 3.

Referring now to FIG. 1, a refrigeration system employing the invention and operating under typical conditions hereinafter disclosed for purposes of illustration and not of limitation, includes a conventional tube and sheet condenser **10** to which a conduit **11** leads ammonia gas at a temperature of about 106° F. and at a pressure of about 185 p.s.i.g. From the condenser refrigerant liquid passes through conduit **12** having a check valve **13** opening into the entry section of a second combined desuperheating and impurity-removing unit. This unit may take various forms without departing from the invention, but a preferred form comprises a generally horizontal tubular exit section having a circular wall **14** closed at one end by a head **15** and joined at the other end to and in open communication with an entry section having a generally vertically extending tubular wall **16** closed at its top by a head **17**. The entry section serves essentially as a desuperheater for oil-laden, hot refrigerant gas supplied through conduit **18** from the oil-lubricated high pressure com-

presor **19**, and which gas may enter the unit at a temperature in excess of 200° F. and at a pressure of about 185 p.s.i.g. As will be understood, during this desuperheating action a portion of the refrigerant liquid entering from conduit **12** is vaporized and the oil carried into the unit by the incoming gas is increased in viscosity. Any conventional gas and liquid contact structure may be employed in the entry section, such as the diagrammatically illustrated tray structure **27** which permits the liquid to cascade downwardly and to contact the gas in a concurrent flow and without producing an excessive amount of foam. In any event, however, a certain amount of oil-containing fog, mist, or foam results and as will later appear, the interior constructions of the exit section of the unit is such as to break any oil-containing gas bubbles and to remove their oil or other impurities from the refrigerant before it leaves the unit.

Attached to the underside of wall **14** is an oil trap **20** in open communication with the exit section of the unit and having one leg **21** extending from the top of the trap to a distance of about four inches within that exit section. A second leg **23** extends from the bottom of wall **14** to near the bottom of trap **20**. A conduit **24** controlled by shutoff valve **25** leads from the oil trap to a first desuperheating and impurity-removing unit similar to the above-described unit and operating in the manner later to appear.

As will now be noted, the desuperheating which has occurred in the unit has so reduced the temperature of the refrigerant gas that a differential of only about ten degrees exists between the liquid refrigerant, indicated at the level **22**, and leaving the distal end of the unit through a conduit **30**, and the gaseous refrigerant leaving that unit through conduit **11**. The liquid refrigerant is then directed into a receiver **31** having the customary upstream and downstream shutoff valves **32**, **33**, and with a pressure equalizing conduit **34** connected to conduit **11** and having a check valve **35** therein opening from the receiver.

With valve **33** opened, liquid refrigerant then passes through conduit **36** into a chamber or header **37** for the evaporator **38**. A liquid level control, such as a float controlled valve **39**, assures adequate supply of refrigerant which upon vaporization passes as a gas from the evaporator into conduit **40** at a pressure of about 0 p.s.i.g. and at a temperature of about −28° F. A conduit **41** controlled by shutoff valve **42** also is connected to the evaporator and serves as a means for purging the evaporator of liquid and any collected impurities, as when the system is shut down. Cold gas which may contain droplets of liquid is directed through conduit **40** to near the lower end of a conventional knock-out tank **43** and in which inclined screens **44** are disposed to trap drops contained in the gas rising toward outlet conduit **45**. Any such liquid collected in the bottom of tank **43** is removed therefrom by pump **46**, which is fed through conduit **47** controlled by a valve **48**, and which feeds into conduit **49** controlled by valve **50** and thence into conduit **24**. Pump **46** also serves to purge liquid from the evaporator when valve **42** is opened. In addition, a by-pass conduit **70** having a suitably loaded relief valve **71** therein opening into the tank connects conduit **49** with the tank.

The cold, liquid-free gas entering conduit **45** is compressed by an oil-lubricated booster compressor **55** to a pressure of about 40 p.s.i.g. and its temperature is raised accordingly. The hot gas is then directed through conduit **56** into a heat-exchanger **57** inside the knock-out tank and then is fed through conduit **58** into the entry section of the first desuperheating and impurity-removing unit. The amount of refrigerant liquid supplied for gas-liquid contact in the entry section of this first unit preferably is so regulated that no refrigerant liquid collects in the exit section of that unit and all such liquid supplied to the unit is vaporized in the entry section. Accordingly, a thermostatic controlled conventional valve **60** in conduit **24** regulates the liquid supplied to the unit and is responsive to a thermostat **61** located near the bottom of wall **14A**. Liquid refrigerant mixed with oil contained in trap **20** of the second unit together with any liquid refrigerant supplied from pump **46**, and supplemented by any refrigerant passing from pump **46**, and supplemented by any refrigerant passing from the receiver through conduit **62** connected under control of valve **63** to conduit **24** upstream from valve **60**, serves to provide the necessary desuperheating of the gas entering the unit through conduit **58**.

Following this desuperheating, the refrigerant gas passes through the exit section of the first unit and emerges into conduit **64** at a pressure of about 40 p.s.i.g. and at a temperature of about 30 to 40° F. Conduit **64** is connected to the high pressure compressor **19** and after being compressed therein to a pressure of about 185 p.s.i.g. and again reading a temperature in excess of 200° F. the gas passes into the described second unit.

The exit section of the first unit thus is operated in essentially dry condition, and an oil trap **65** attached to the bottom of wall **14A** receives impurities only in liquid form and which impurities may periodically be drawn off by opening of a drain valve **66**. The trap, moreover, is in open communication with the exit section by means of legs **67**, **68**.

Referring now to FIGS. 3 and 4, the invention includes a baffling structure which may be assembled in a suitable jig, prior to installation in the exit section of the unit. This structure comprises a first set of rough expanded metal members, three of which are indicated at **71**, **72**, **73** mounted at a uniform angle of about 45° to the direction of flow is indicated by the arrows and at a uniform spacing. The generally parallepiped apertures in the members are characterized by their sharp edges and by the presence of the burrs formed during the metal expanding operation. A second set of similar baffles, of which **74**, **75**, **76** are shown, disposed at an angle of about 25° to the direction of flow are welded at their confronting edges to the adjacent baffles of the first set. A third set of similar baffles, of which **77**, **78**, **79** are shown, disposed at an angle of about 5° to the direction of flow are welded at their confronting edges to the adjacent baffles of the first set. The relative locations of the axes of the apertures in the several sets of baffles are not necessarily identical and preferably are different, but each baffle in each set slopes toward the bottom of the circular wall in which the structure is employed. The third set of baffles are located nearest the upper side of the circular walls **14**, **14A** of the units. Upon being assembled, the structure is moved endwise into the tubular exit section prior to the welding of the diagonal seam joining the exit and entry sections and, prior to the affixing of the heads **15**, **15A** to the exit sections. Upon being positioned therein the endmost baffles of the first set are welded at their peripheries to the inner wall of the exit section. As an example, in one commercial installation employing the invention the first set of baffles comprised fifteen baffles and a commensurate number of baffles of the second and third sets were used, thus providing a strong reinforced structure with all baffles sloping downwardly.

As will now be apparent, any mist, fog, foam or bubbles of gas formed during the gas-liquid contact in the entry section must pass through numerous apertures in the baffling structure in order to reach the distal end of the unit. In so doing, the individual particles pass sharp edges and burrs on the baffles and this baffling structure serves efficiently to break bubbles and to coalesce the mist or fog in the gas and to release the oil carried thereby. The oil, of course, is viscous after having been subjected to the gas desuperheating step and will flow gradually down the baffles to the bottom of the walls **14**, **14A** whereupon it collects in the oil trap. A similar action occurs when water vapor is present and is desuperheated prior to reaching the baffles.

Although the above described refrigeration system employs, for example, a refrigerant such as ammonia which

is lighter than the viscous oil and is immiscible therewith, the system as shown in FIG. 2 indicates the usage of the invention with a refrigerant which can be heavier than viscous oil and which can be miscible therewith. In this embodiment, a condenser **90** receives from conduit **91** a relatively pure refrigerant gas, such as Freon, which in a typical installation may be at about a temperature of 90° F. and at a commensurate pressure depending upon the formula of the refrigerant being used. The liquid refrigerant from the condenser passes into receiver **92** through conduit **93** and is passed from the receiver through conduit **94** into the chamber or header **95** of the evaporator **96**. The customary upstream and downstream shutoff valves **97**, **98** for the receiver, as well as the control valve **99**, serve to regulate the supply to the evaporator. Vaporized refrigerant gas passes from the evaporator through conduit **100** into a knock-out tank **11** and liquid-free gas moves from the top of this tank through conduit **102** to the intake of the compressor **103**.

Liquid collected in tank **101** is withdrawn through conduit **104** controlled by valve **105** and forced by pump **106** into conduit **107**. This conduit **107** connects with conduit **108** leading from receiver **92**. Shut-off valve **109** in conduit **108** upstream from the connection with conduit **107**, as well as a shut-off valve **111** in conduit **107**, are provided. A conduit **118** for supplying liquid refrigerant as needed leads from the conduit **93** near the condenser to the conduit **108** downstream from valve **109** and has therein a shut-off valve **119**. In addition, a bypass conduit **112** having a suitably loaded relief valve **113** therein opening into the tank **101** connects conduit **107** with the tank downstream from the pump. A conduit **114** controlled by shutoff valve **115** is connected to the evaporator and to conduit **104** and serves as a means for purging the evaporator when it is shut down. The pump thus may draw refrigerant from the evaporator when valve **115** is opened.

A single combined desuperheating and impurity-removing unit of the type described has an entry section **120** into which oil-laden gas under pressure is reecived through conduit **121** from the compressor. Included in this conduit is a heat-exchanger **122** within tank **101** and which serves to provide an initial amount of desuperheating of the gas before it reaches that entry section. Conduit **108** under control of a conventional thermostatic valve **123** supplies to the entry section for cascading movement in contact with the hotter gas an amount of liquid refrigerant which will be substantially completely vaporized before leaving that entry section. A thermostat **124** located near the bottom of the exit section of the unit serves to regulate the setting of valve **123**.

During the final desuperheating in the entry section the viscosity of oil contained in the gas will increase and such oil whether carried as gas fog, mist, foam, or bubbles will move with the gas into the exit section and into contact with the described baffling structure located therein. As the gas stream moves through the exit section, liquid removed therefrom will drain down the sloping baffles and be collected in oil trap **130** which has legs **131**, **132** in open communication with the exit section of the unit. A conduit **133** connected to the trap and controlled by valve **134** provides for removal of the collected oil which optionally may be restored to the compressor **103** for reuse by a suitable means (not shown) or may be removed from the system. Also connected to trap **130** is a drain conduit **135** controlled by shut-off valve **136** and through which water may be separately drained from the trap. Purified refrigerant gas leaving the distal end of the exit section of the unit enters conduit **91** for recirculation into the condenser.

As will now be apparent, the desuperheating and impurity-removing unit embodying the invention, is equally adaptable for use with systems in which the exit section is operated without liquid refrigerant therein as shown in FIG. 2, or in which liquid refrigerant accumulates therein, as disclosed in the high-pressure stage of FIG. 1. The oil traps attached to the exit sections are so arranged that upon any rapid lowering of pressure within the exit section no substantial amount of oil already collected in such trap will leave the trap.

In view of the above disclosure, it will be noted that the several objectives of the invention are achieved and other advantageous results obtained.

What is claimed is:

1. A refrigeration system comprising in combinations, an oil-lubricated compressor, a condenser, a receiver for relatively pure refrigerant liquid cooled in said condenser, an evaporator, and a separate combined desuperheating and impurity-removing unit; said unit including an entry section into which hot, oil-containing gas from said compressor and cool relatively pure refrigerant liquid are brought into contact thereby to desuperheat said gas and to increase the viscosity of said oil, an exit section communicating with said entry section and containing a stationary mechanical structure on which oil collects and which breaks bubbles and coalesces mist and fog in the gas prior to exit of gas from said unit, said unit including means for effecting concurrent flow of the respective fluids from the entry section into and through the exit section of said unit; an oil trap connected to said exit section and receiving viscous oil draining from said structure, means for passing relatively oil-free gas from said exit section to said condenser, means for passing gas from said evaporator to said compressor, means for supplying liquid refrigerant from said receiver to said evaporator, and means for supplying refrigerant liquid to said entry section of said unit.

2. A refrigeration system comprising in combination, an oil-lubricated compressor, a condenser, a receiver for relatively pure refrigerant liquid, an evapoartor, and a separate and single combined desuperheating and impurity-removing unit; said unit including an entry section into which hot, oil-containing gas from said compressor and cool, relatively pure refrigerant liquid from said receiver are brought into contact thereby to desuperheat said gas and to increase the viscosity of said oil, an exit section communicating with said entry section and containing a stationary, mechanical structure on which oil collects and which breaks bubbles and coalesces mist and fog in the gas prior to exit of gas from said unit, said unit including means for effecting concurrent flow of the respective fluids from the entry section into and through the exit section of said unit; an oil trap connected to said exit section and receiving viscous oil draining from said structure, a conduit passing relatively oil-free gas from said exit section to said condenser, means for passing gas from said evaporator to said compressor, means for supplying liquid refrigerant from said receiver to said evaporator, a conduit passing liquid refrigerant from said condenser to said receiver, a conduit passing hot gas from said compressor to said entry section, and a conduit passing cool liquid from said receiver to said entry section.

3. A system as defined in claim **2** including a liquid knockout tank receiving cold refrigerant gas from said evaporator and collecting at the bottom of said tank the liquid present in the cold gas, and a conduit supplying a liquid-free gas from said tank to the intake of said compressor.

4. A system as defined in claim **3** including a heat exchanger contained in said tank, said conduit for passing gas from said compressor to said entry section being arranged to pass the gas through said heat exchanger.

5. A system as defined in claim **3** including pumping means connected to said tank and to said conduit passing liquid to said entry section and adapted to pass to said entry section the liquid collected in said tank.

6. A refrigeration system comprising in combination, a high-pressure oil-lubricated compressor, a booster oil-lubricated compressor, a condenser, a receiver, an evapo-

rator, and first and second desuperheating and impurity-removing units; each of said units having an entry section into which hot, oil-containing gas and cool refrigerant liquid are brought into contact and an exit section communicating with the entry section and containing a stationary, mechanical structure on which oil collects and which breaks bubbles and coalesces mist and fog in the gas prior to exit of gas from the exit section, first and second oil traps connected to the respective exit sections and receiving viscous oil draining from the respective structures, first and second conduits passing hot gas under pressure respectively from the booster and high-pressure compressors to the entry sections of the respective first and second units, a third conduit passing liquid refrigerant from said condenser to the entry section of said second unit, a fourth conduit passing gas from the exit section of said second unit to said condenser, a fifth conduit passing liquid refrigerant from said receiver to the entry section of said first unit, means for supplying relatively oil-free liquid refrigerant from said receiver to said evaporator, means for passing gas from said evaporator to the booster compressor, and a sixth conduit passing gas from the exit section of said first unit to said high-pressure compressor.

7. A system as defined in claim **6** wherein said means for passing gas from said evaporator to said booster compressor includes a liquid knock-out tank receiving cold refrigerant gas from said evaporator and collecting at the bottom of said tank the liquid present in said cold gas, and a conduit supplying liquid-free gas from said tank to the intake of said booster compressor.

8. A system as defined in claim **7** including a heat exchanger contained in said tank and through which heat exchanger said first conduit passes.

9. A system as defined in claim **7** including pumping means connected to said tank and to said fifth conduit and adapted to pass to the entry section of said first unit the liquid collected in said tank.

10. A system as defined in claim **6** including a seventh conduit connected to said second oil trap and to said fifth conduit and adapted to recirculate into the system refrigerant liquid collected in said second oil trap.

11. For use in the removal of oil from a refrigerant circulating in a refrigeration system, a combined desuperheating and oil-removing unit comprising an entry section and an exit section communicating therewith, gas and liquid contact means disposed in said entry section and

adapted to bring hot refrigerant gas and cool refrigerant liquid into intimate contact with simultaneous desuperheating of said gas and increase in viscosity of oil carried thereby, a mechanical structure having apertured downwardly sloping surfaces disposed in said exit section and adapted to break bubbles and to coalesce mist and fog contained in the gas passing across said structure, and an oil trap connected to said exit section and receiving oil draining from said structure.

12. Apparatus as defined in claim **11** wherein said structure comprises a series of spaced apertured inclined baffles extending completely across said exit section transversely thereof and connected to each other by a second series of apertured inclined spaced baffles, each of the corresponding baffles of said second series being attached at its ends to adjacent baffles of said first series and inclined at a lesser angle to the direction of flow through said exit section than the baffles of said first series.

13. Apparatus as defined in claim **12** wherein said structure includes a third series of apertured inclined spaced baffles each of the corresponding baffles of said third series being attached at its ends to adjacent baffles of said first series and inclined at a lesser angle to the direction of flow through said exit section than the baffles of said second series, the baffles of said third series being disposed above the corresponding baffles of said second series.

14. Apparatus as defined in claim **11** wherein said entry section is generally vertical and said exit section is generally horizontal.

15. Apparatus as defined in claim **13** wherein the apertures in each of said first, second and third series of baffles are provided with sharp edges.

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U.S. Cl. X.R.

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