Aug. 26, 1952 S. W. BRIGGS 2,608,269

OIL SEPARATOR

Filed April 6, 1948 2 SHEETS—SHEET 1

Fig.1.

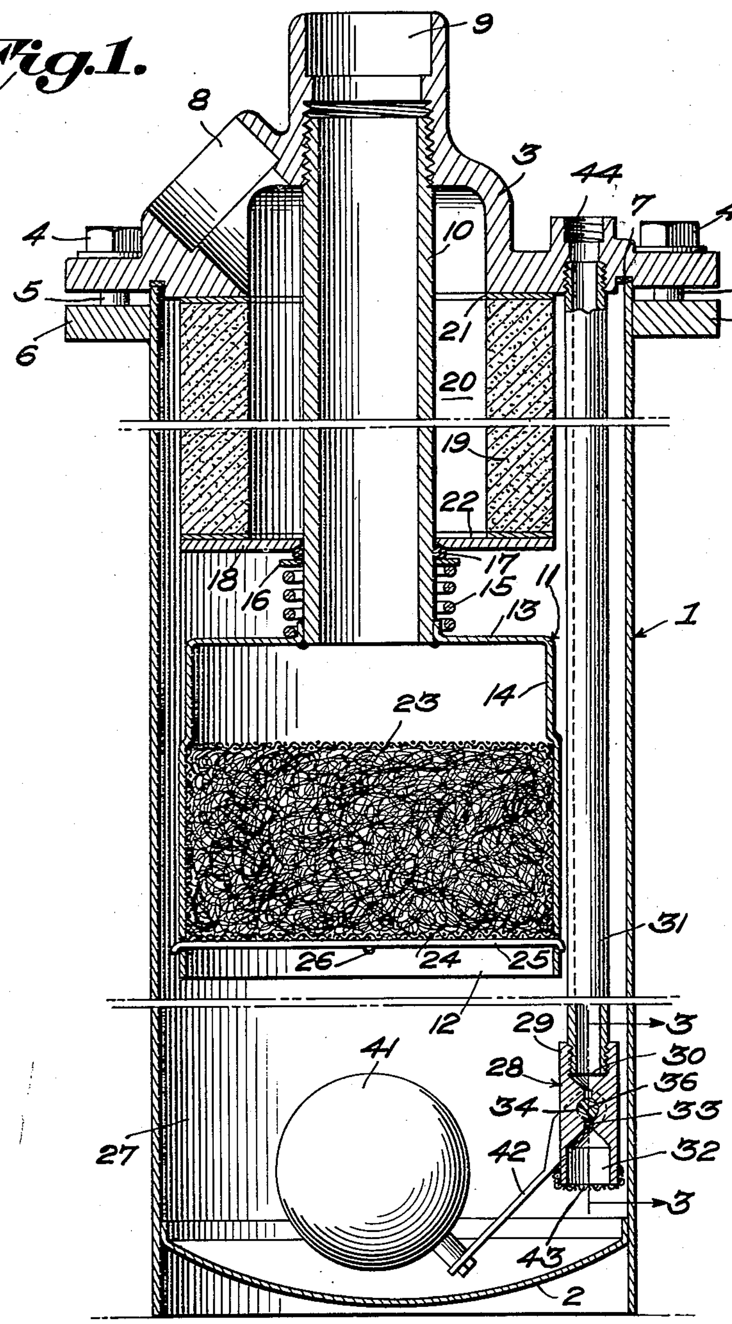

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Fig. 2.

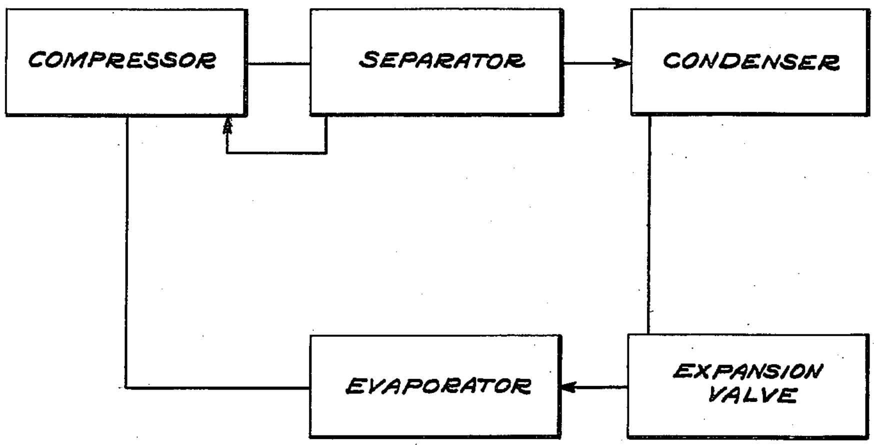


Fig. 3.

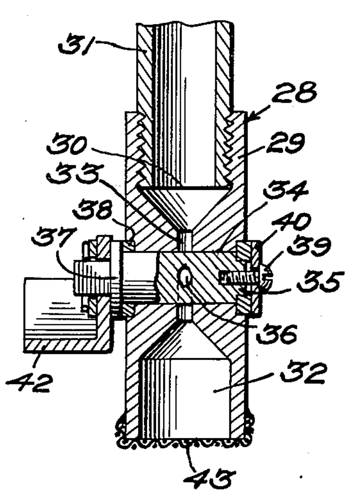
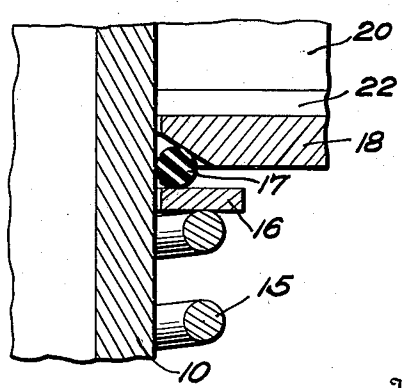


Fig. 4.



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Patented Aug. 26, 1952 2,608,269

UNITED STATES PATENT OFFICE

2,608,269

OIL SEPARATOR

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Application April 6, 1948, Serial No. 19,264

6 Claims. (Cl. 183—42)

1

This invention relates to apparatus for the removal of entrained liquid from gases and more particularly for the separation of oil from a refrigerant.

In the usual refrigeration apparatus the refrigerant is compressed to a relatively high pressure in a reciprocating or rotary compressor. The compressed refrigerant in a substantially gaseous condition is then introduced into a condenser which removes the heat of compression and condenses the refrigerant. The cooled, condensed refrigerant is throttled through an expansion valve which lowers its temperature and is then introduced into an evaporator in which it absorbs heat from the material to be cooled. The gaseous refrigerant from the evaporator is returned to the compressor to repeat the cycle.

The heat given up by the material to be cooled and the heat introduced into the cycle by the compression of the refrigerant must be removed from the refrigerant in the condenser. In order to reduce the cost and size of the apparatus, it is highly desirable to have a high rate of heat transfer in the condenser. The refrigerant discharged from the compressor, however, is generally contaminated with entrained oil which coats the heat transfer surfaces in the condenser and reduces its heat transfer capacity. The presence of a film of oil on the heat transfer surfaces of the condenser may reduce its capacity as much as 25%.

The oil separators heretofore available have not removed oil from the refrigerant completely enough to prevent the formation of an oil film in the condensers. It has, therefore, been necessary to over-design the condenser capacity to make allowance for the low rate of heat transfer. Furthermore, the separators of the prior art have not removed water from the refrigerant and hydrolysis of the refrigerant with serious corrosion of the refrigeration equipment has resulted. Moreover, the separators heretofore available generally fail by by-passing refrigerant from the separator directly back to the crankcase of the compressor. It is then not possible to pull the vacuum on the evaporator and the pressure and temperature in the evaporator are increased.

It is an object of this invention to remove entrained and dissolved oil from the refrigerant discharged from a compressor of a refrigerating machine prior to the cooling of the refrigerant.

It is also an object of this invention to remove traces of water from the refrigerant and oil in a refrigerating machine.

Another object of this invention is to remove impurities such as gums and carbon from the lubricating oil used in the compressor of a refrigerating machine.

2

A further object of this invention is to provide apparatus for the efficient separation and separate discharging of liquids and gases from mixtures thereof.

Still another object of this invention is to provide means for discharging separated oil without passing gaseous refrigerant directly from the separator to the compressor.

With these and other objects in mind which will become apparent in the following detailed description of the invention, this invention resides in a porous adsorbent block through which the refrigerant discharged from the compressor must pass before entering the condenser of a refrigerating machine. Provision is made to direct the flow of the refrigerant to aid the separation of droplets of liquid from the gaseous refrigerant passing through the oil separator. While this invention is described for the separation of lubricating oil from refrigerants, it will be appreciated that the apparatus is efficient for the separation of liquids from gases generally, and is particularly efficient in the separation of liquids from gases which are substantially insoluble in the liquids.

In the drawings:

Figure 1 is a vertical sectional view of the oil separator of this invention.

Figure 2 is a schematic flow sheet of refrigerating apparatus showing the location of the oil separator in the apparatus.

Figure 3 is a detailed sectional view of a float operated valve for discharging the separated oil from the separator; and

Figure 4 is a sectional view illustrating in detail the closure means to prevent the refrigerant from by-passing the adsorbent block.

As is best illustrated in Figure 2, the oil separator of this invention is preferably installed between the compressor and condenser of a refrigerating machine.

Referring to Figure 1, the oil separator of this invention is illustrated in a casing 1 having a base 2 integral therewith and a domed cover 3 closing its upper end. Cover 3 is secured to casing 1 by means of nuts 4 engaging studs 5 which extend upwardly from a flange 6 attached to the upper end of the casing 1. A gasket 7 on the upper rim of casing 1 prevents leakage between the casing and the cover.

An inlet 8 and an outlet 9 are provided in cover 3 for the flow of the refrigerant through the oil separator. An outlet tube 10 communicates with outlet 9 which is substantially centrally located in the cover and extends downwardly therefrom into the casing 1. Outlet tube 10 opens downwardly in a container 11 secured to its lower end. Container 11 occupies substantially the full cross-sectional area of the casing and is also open at its lower end 12. The upper end 13 and walls 14 of the container are imperforate, thereby forcing the fluid passing through container 11 to enter its open lower end 12 and leave through the outlet 10.

Upper end 13 of container 11 provides a surface on which a helical spring 15 surrounding the outlet tube 10 rests. Helical spring 15 is in a compressed condition during the operation of the oil separator and bears against a washer 16 which is slidable along the outer surface of outlet tube 10. Washer 16 engages a sealing ring 17 of compressible material which closes the openings between the outer surface of outlet tube 10 and a plate 18 slidable on tube 10.

A porous adsorbent tubular block 19 having a central bore 20 is supported by plate 18 which urges the block against the lower surface of the cover 3 of the oil separator. Outlet tube 10 passes through the central bore of the adsorbent block 19. Flow of the refrigerant past the ends of the adsorbent block is prevented by gaskets 21 and 22 at the upper and lower ends of the block, respectively. The central bore 20 of the alumina block communicates with the inlet 8 of the oil separator.

Adsorbent block 19 is preferably of activated alumina bonded with a suitable inorganic binder. An adsorbent material prepared according to the invention described in my copending application filed on July 9, 1948 and having Serial No. 37,971 entitled "Bonded Filter Medium" in which the alumina is bonded with Portland cement is highly satisfactory. Porous, adsorbent blocks bonded with aluminum phosphate or sodium silicate binders are also satisfactory. In some instances it may be desirable to provide a porous mass of activated silica gel; however, generally alumina is preferred since it does not decrepitate on contact with water.

A strainer 23 enclosed in a wire mesh cover 24 is supported by wires 25 and 26 in the lower end of container 11. The strainer 23 occupies the full cross-sectional area of container 11 to prevent by-passing of the refrigerant around its sides. As mentioned above, the container 11 is of large diameter to provide a conduit having a large cross-sectional area through which the refrigerant may pass at a very low velocity.

In the preferred form, the strainer 23 consists of a mass of fine copper wool which, while of an open nature to provide a large free space, also provides an extremely large surface over which the refrigerant passes. In certain instances, such as when the refrigerant is corrosive to copper, it will, of course, be necessary to provide a strainer of finely divided material which is resistant to the corrosive effects of the refrigerant. If ammonia is the refrigerant, steel wool may be used in strainer 23.

The lower end of the casing 1 below the strainer 23 serves as a well 27 for the collection of oil separated from the refrigerant. A float operated valve, indicated generally by 28, is provided to control the discharge of the oil from the well in casing 1.

Float operated valve 28 consists of a body 29 drilled and tapped at 30 at its upper end for

connection with a discharge tube 31. Discharge tube 31 is securely attached to the cover 3 and supports the valve 28 within the casing of the separator. Body 29 is also drilled to form an opening 32 at its lower end. A passage 33 of small diameter connects the drilled openings 30 and 32.

Referring to Figure 3, a conduit 34 extends horizontally across the valve for the reception of a valve stem 35. A port 36 passes through the stem 35 in alignment with passage 33 to allow flow through the valve when the valve stem is in the open position. Conduit 34 is machined to close tolerances to allow stem 35 to rotate therein and also to serve as a valve seat preventing flow through the valve when port 36 does not communicate with passage 33.

Valve stem 35 may be held in place within the body 29 of the valve by any suitable means. In the form illustrated, a washer 37 engages a gasket 38 in a recess in the body 29 to fix the position of the stem within the body of the valve. The stem is held in place by means of a bolt 39 engaging a washer 40. Bolt 39 is screwed into the end of stem 35. A float 41 is connected by means of an arm 42 to the stem 35 and rotates the stem as the level of the liquid in the well 27 changes.

A screen 43 is held in place across the lower end of the valve body 29 to prevent the entrance of any fluid particles which might accumulate in the well 27. The openings in screen 43 should preferably be about ¼ the size of passage 33 to prohibit the entrance of any particles large enough to bridge across the passage 33 and prevent flow through the valve. Discharge tube 31 extends vertically from the upper end of valve body 29 and communicates with a discharge opening 44 in the cover 3.

The compressor of the refrigerating machine is generally started by some thermostatically controlled device associated with the object or material to be cooled. After the compressor has been standing for awhile, its crankcase is under a relatively high pressure caused by the refrigerant dissolved in the lubricant; consequently, as the compressor starts to run, large slugs of oil are discharged with the refrigerant. At this time a foam may be discharged from the compressor to the separator. After the compressor has operated for a short period, a fine mist of lubricant is generally present in the refrigerant passing from the compressor to the oil separator.

The velocity of the oil-laden refrigerant entering the inlet 8 of the oil separator is immediately reduced by the large volume of the central bore 20 of the adsorbent block to precipitate a large part of the oil. The refrigerant and the oil then pass through the porous adsorbent block and are discharged from its outer surface. If any foam is present, it is broken by contact with the surface of the adsorbent block 19. Similarly, any fine mist of liquid is deposited and coalesces on the surfaces of the passages within the block as the refrigerant follows an extremely tortuous path therethrough. The liquid phase, which is largely oil but also contains some refrigerant, sweats from the outer surface of the porous block 19 and drops from its lower edge in the form of large drops of liquid which are easily separated from the gaseous phase.

If an adsorbent porous block of the type described hereinbefore is employed, a number of advantages in addition to the breaking of the foam and separation of mist from the gaseous phase are gained. An activated alumina block, for example, will effectively remove traces of moisture from the refrigerant and oil. The removal of moisture prevents the hydrolysis of the refrigerant, which in the case of certain refrigerants, such as Freon-12, results in serious corrosion. If the refrigerant is sulphur dioxide, the presence of moisture results in the formation of corrosive sulphur-containing acids. In addition, the removal of moisture eliminates any possibility of moisture freezing in the expansion valve and thereby preventing proper operation of the refrigeration apparatus.

An activated alumina block also effectively removes any gums and carbon from the lubricant. In many refrigeration machines the crankcase compressor is sealed and the lubricant remains in service for years. It is, therefore, highly desirable that means be provided to remove impurities from the lubricant. While only a relatively small portion of the lubricant is discharged from the compressor with the refrigerant, the thorough treatment of that portion of the lubricant is sufficient to prevent the accumulation of gum and carbon in the crankcase of the compressor.

The refrigerant discharged from the outer surface of the adsorbent block 19 and the liquid dropping from its lower end pass downwardly in the casing. The large volume of container 11 results in the gas flowing downwardly at an increased velocity. As the gas passes the lower end 12 of container 11, its direction of flow is changed which tends to throw particles of mist from the gas into well 27. The large drops of liquid will, of course, fall readily into the well 27 and accumulate there.

After passing the lower edge 12 of container 11, the gaseous phase changes its direction of flow and then passes upwardly at a low velocity through the screen 23. The very large surface and the extremely large number of very small passages in the copper wool within the strainer insures contact of any mist with the surface of the strainer. The last traces of the mist are deposited on the strainer, coalesce, and drop into the well 27. Oil-free refrigerant is discharged from the top of strainer 23 into outlet tube 10.

The liquid phase collected in the well 27 will contain some refrigerant. In the case of Freon-12, for example, which is completely miscible with lubricating oil, a relatively high concentration of refrigerant may be in the liquid collected in well 27. This refrigerant continually evaporates from the surface of the collected liquid and passes through strainer 23 to the outlet of the separator with the main body of refrigerant.

As the level of the liquid collected in well 27 rises, float 41 will be lifted and turn stem 35 until port 36 communicates with passage 3. The liquid in well 27 will then enter through the lower end of the valve body 29 and pass through passage 33 and port 36 to the discharge tube 31. The liquid discharged through tube 31 and opening 43 is returned to the crankcase of the compressor.

It will be noted that a float operated valve is provided in which the stem and seat of the valve are in sliding contact. In this manner the lodging of a solid particle between the stem and seat is prevented. In separators employing float operated needle valves, for example, a solid particle may lodge in the needle valve. As the liquid level falls, the valve is held open by the solid particle and eventually gas is returned from the oil separator to the crankcase of the compressor. The compressor is then not able to pull a vacuum on the evaporator and the capacity of the refrigerating machine is reduced.

The refrigerant passing from outlet 9 to the condenser is virtually oil-free. Any oil present will be dissolved by the refrigerant and will not collect in the condenser to form a film on its surfaces. This effective removal of the oil from the condenser surfaces allows the capacity of the condenser to be increased. It is not necessary to make allowances for an oil-film on the surface of the condenser when they are designed. The removal of the oil-film allows reductions of as much as 25% in the area of the heat conducting surface of the conductor with corresponding savings in the cost of the equipment.

While the oil separator comprising this invention has been described in detail in relation to specific forms of the invention, it is to be understood that the concept of this invention is not limited to those specific forms, but is limited only by the scope of the appended claims.

I claim:

1. Apparatus for the separation of oil from a refrigerant discharged from the compressor of a refrigerating machine comprising a casing having an inlet and an outlet, an outlet tube extending into said casing from the outlet, a tubular bonded adsorbent block having a central bore surrounding said outlet tube, the central bore of the block communicating with the inlet, a container mounted on the outlet tube, a strainer supported in the container, resiliently actuated closure means preventing by-passing of the adsorbent block and directing the refrigerant through said block and strainer to the outlet, and means for discharging the separated oil from the casing.

2. Apparatus for the separation of oil from a refrigerant discharged from the compressor of a refrigerating machine comprising a casing having an inlet and an outlet, an outlet tube extending into said casing from the outlet, a tubular bonded adsorbent block having a central bore surrounding said outlet tube, the central bore of the block communiucating with the inlet, a container mounted on the outlet tube, a strainer of cooper wool supported in the container, resiliently actuated closure means preventing by-passing of the adsorbent block and directing the refrigerant through said block and strainer to the outlet, and means for discharging the separated oil from the casing.

3. Apparatus for the separation of oil from a refrigerant discharged from the compressor of a refrigerating machine comprising a casing having an inlet and an outlet, an outlet tube extending into said casing from the outlet, a tubular activated bonded alumina block having a central bore surrounding said outlet tube, the central bore of the block communicating with the inlet, a container mounted on the outlet tube, a strainer supported in the container, resiliently actuated closure means preventing by-passing of the adsorbent block and directing the refrigerant through said block and strainer mass to the outlet, and means for discharging the separated oil from the casing.

4. A separator for the separation of oil entrained in a refrigerant comprising a casing having an inlet and an outlet in the upper end thereof, an outlet tube extending from the outlet

into the casing and opening downwardly therein, an adsorbent block positioned within the casing intermediate the inlet and the opening of the outlet tube, a well in the lower end of the casing to receive the liquid coalesced in the adsorbent block through which the refrigerant discharged through the porous block passes to the outlet tube, and a float operated valve to discharge liquid from the well.

5. A separator for the separation of oil entrained in a refrigerant comprising a casing having an inlet and an outlet in the upper end thereof, an outlet tube extending from the outlet into the casing and opening downwardly therein, a metallic wool strainer having a large cross-sectional area mounted on the lower end of the outlet tube, a porous adsorbent block positioned within the casing intermediate the inlet and the opening of the outlet tube, a well in the lower end of the casing to receive the liquid coalesced in the adsorbent block through which the refrigerant discharged from the block passes, and a float operated valve to discharge liquid from the well.

6. Apparatus for the separation of liquid from gas in which the liquid is entrained comprising a casing having an inlet and an outlet in the upper portion thereof, a porous block mounted within the casing, means within the casing for directing the gas directly from the inlet through

the porous block whereby liquid entrained in the gas is coalesced, said casing having a well in the lower portion for collecting liquid separated from the gas, a strainer mounted within the casing above the well whereby coalesced droplets of liquid drop into the well, conduit means directing the gas emerging from the porous block through the strainer to the outlet, and means for discharging the oil from the well.

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