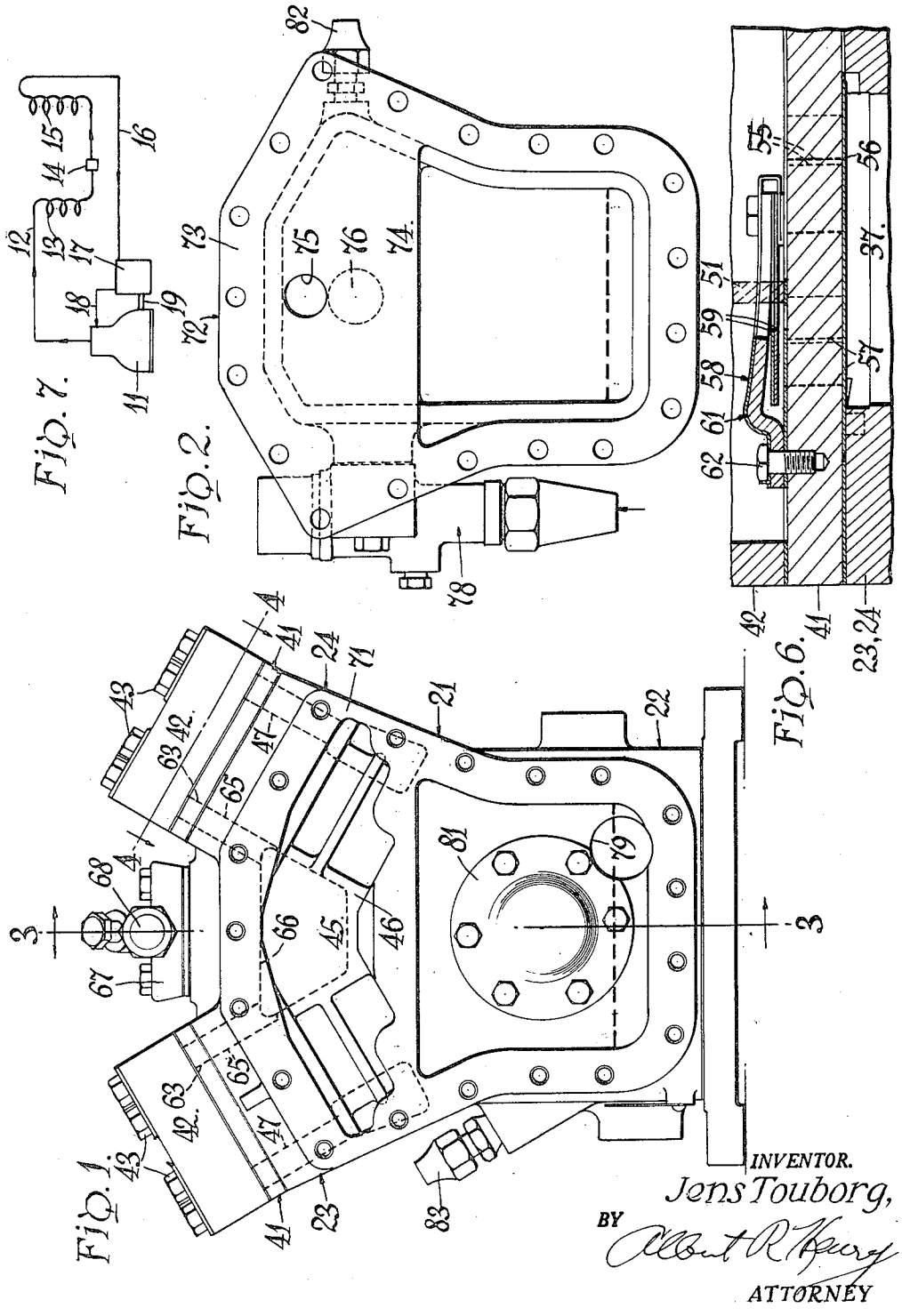
Dec. 22, 1959 J. TOUBORG 2,918,210

COMPRESSOR WITH CRANKCASE OIL SURGE TANK

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COMPRESSOR WITH CRANKCASE OIL SURGE TANK

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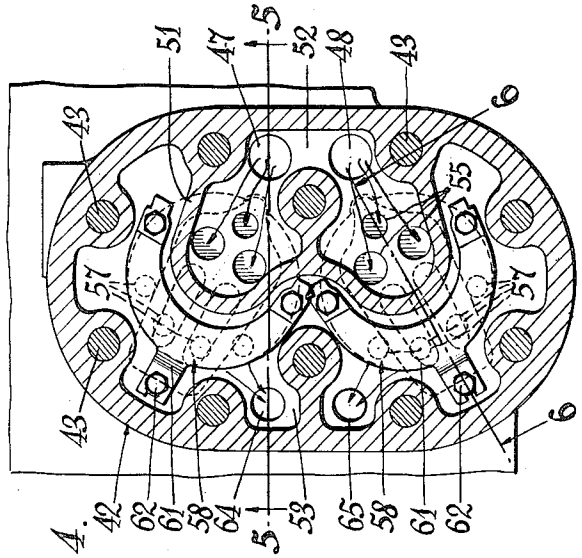


Fig. 4.

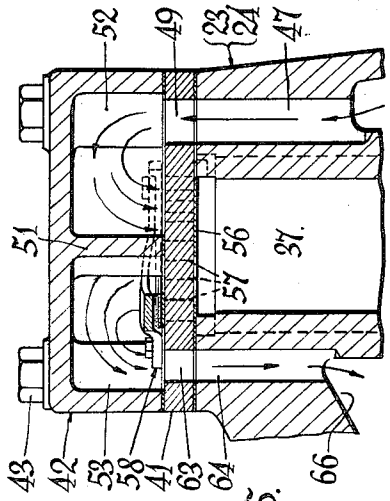


Fig. 5.

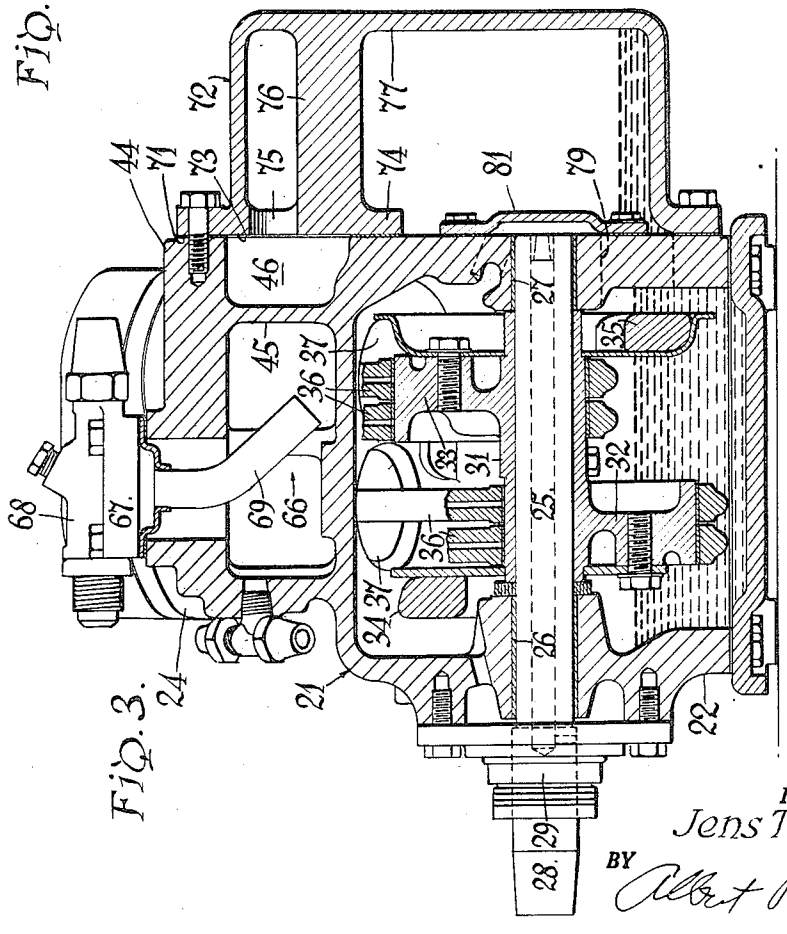


Fig. 3.

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COMPRESSOR WITH CRANKCASE OIL SURGE TANK

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3 Claims. (Cl. 230—206)

This invention relates to a refrigerant compressor having a surge tank connected thereto, wherein a portion of the surge tank is below the normal oil level sought to be maintained in the compressor crankcase, and wherein there is free communication between the crankcase and the lower portion of the surge tank to enable oil to flow therebetween, and to enable refrigerant vapor to escape from the crankcase for return to the suction inlet of the compressor.

Heretofore, difficulty has been experienced in maintaining a proper amount of lubricating oil in the crankcase of a compressor, particularly in low temperature refrigeration applications, or where the compressor is shut down for appreciable periods of time. During the normal operation of a compressor-condenser-expander refrigeration machine, some oil from the compressor is forced into the condenser, from where it may flow to the expansion coil, for ultimate return to the suction side of the compressor. This returning oil heretofore has been drained back into the crankcase by means of a bleed port leading from the suction inlet. In many cases, the return of oil is sluggish, and appreciable quantities lodge in the condenser and expansion coil, to create the unsatisfactory operating condition known as oil logging.

Concurrently with this oil flow, refrigerant gas enters the crankcase, either in solution with the returned oil, or by expansion of refrigerant in the evaporator, or by leakage along the cylinder wall and past the piston. A limited amount of refrigerant in the crankcase frequently can be tolerated, but under certain conditions the amount becomes excessive and causes the oil to foam when the compressor is started. The foam is then forced out into the circuit by reason of the pressure of the evaporating refrigerant, and as the foam consists mostly of oil, the compressor is deprived of the proper amount of oil required for lubricating purposes. When a relatively large amount of refrigerant is in the crankcase, for instance, after an overnight shut-down, its vapor may create sufficient pressure, and foam, to discharge substantially all the oil, thus leading to bearing failures, scored or seized pistons, as well as so much oil in the expansion coils that the refrigerating effect is greatly reduced.

Heretofore, numerous designs of oil separators have been proposed, the purpose being to remove most of the oil from the refrigerant, for ultimate return to the crankcase. Some designers have favored the location of the separator between the compressor and condenser, while others have advocated the positioning of the oil separator on the low or suction side of the circuit. Such of these proposals as have come to my attention do not, however, solve the problem of safeguarding the compressor from deleterious loss of oil, caused by the pressure and foaming condition just outlined. For example, with a conventional high side oil trap, the oil draining back to the crankcase is so charged with warm liquid refrigerant that the formation of foam is aggravated. And, as noted, this foaming condition becomes increasingly acute when operating at relatively high compressor speeds, and with low temperature applications.

According to the present invention, provision is made to release refrigerant vapor from the crankcase, thereby to limit the tendency to form foam, and also to provide a conveniently accessible and quiescent zone adjacent the crankcase, into which oil may flow when a high pressure condition exists, and from which the so-displaced oil may return freely to the crankcase when the hydrostatic pressure in such zone exceeds the vapor pressure in the crankcase. Refrigerant entering this zone, or surge tank as it may be called, is free to volatilize therein for return to the compressor inlet port, and, in the absence of the mechanical agitation which exists in the crankcase when the compressor is running, foaming in the surge tank is negligible. The result is to maintain in the crankcase a substantially constant normal oil level when the compressor is running, and the failures due to faulty lubrication are thereby minimized.

A typical embodiment of the invention is illustrated in the accompanying drawing, wherein:

Fig. 1 is an elevation of a refrigerant compressor, with the surge tank removed;

Fig. 2 is an elevation of a surge tank, viewed from the inner face thereof;

Fig. 3 is a section on the line 3—3 of Fig. 1, with the surge tank of Fig. 2 connected directly to the compressor;

Fig. 4 is an enlarged section on the line 4—4 of Fig. 1;

Fig. 5 is a section on the line 5—5 of Fig. 4;

Fig. 6 is an enlarged section on the line 6—6 of Fig. 4; and

Fig. 7 is a diagram of a refrigeration circuit incorporating the present invention.

As shown in Fig. 7, a compressor 11 discharges hot compressed refrigerant into a line 12 leading to a condenser 13, wherein the refrigerant is cooled and liquefied. The refrigerant then flows past a metering element 14, such as an expansion valve or capillary tube, into an evaporator 15, wherein the refrigerant may expand and extract heat from the medium around the evaporator. The expanded refrigerant then flows through a suction line 16, and, according to the present invention, into the upper part of a surge tank 17, which is also connected by a line 18 to the suction port of the compressor 11. The lower portion of the tank 17 is connected by a line or port 19 to the crankcase of the compressor 11, and at a region below the normal oil level therein, that is, when the compressor is running. This oil level is naturally lower than the oil level in the crankcase after the compressor has been idle for a period of time. The line 19 is unrestricted, so that oil may flow back and forth between the crankcase and tank 17, depending upon the pressure conditions therein. Any oil entrained in the refrigerant, and returning from the evaporator 15, may separate by gravity upon entering the tank 17, to join the oil at the bottom thereof.

Figs. 1 and 3 illustrate a four-cylinder V-type compressor comprising a main body casting 21 having a crankcase portion 22 and similar cylinder blocks 23 and 24 angularly disposed with respect to each other. A drive shaft 25 is mounted in bearings 26 and 27 in the crankcase portion, and one end 28 extends through a suitable seal 29 for connection to a prime mover, not shown. A sleeve 31, secured to the shaft 25, is formed with opposed eccentrics 32 and 33, to which are secured counterweights and oil slingers 34 and 35. Each eccentric receives the big ends of a pair of like piston rods 36, whose small ends project into cylinders 37 for connection to pistons (not shown) in any conventional manner. Fig. 3 also shows various ports and passageways in the crankcase portion 22, the shaft 25, and the piston

rods 36, by means of which oil contained in the crankcase is distributed to the bearings and cylinder walls, but inasmuch as the details of the internal lubricating system are well known, and do not form a part of this invention, a detailed description is deemed unnecessary.

The cylinder blocks 23 and 24 receive valve plates 41 and cylinder heads 42, retained by bolts 43. The region between the blocks 23 and 24 is occupied by a dome portion 44 of the main casting 21, which portion is internally formed with a wall 45 extending arcuately from a suction inlet region or chamber 46 of the portion 44 toward the blocks 23 and 24. Thus, returning refrigerant vapor is diverted by the wall 45 to the cylinder blocks. Each block is formed with a pair of inlet risers or ducts 47 and 48, which are in registry with ports 49 formed in the valve plates 41 (see Figs. 4 and 5). Each cylinder head 42 is internally formed with an arcuate wall 51 dividing the head into inlet and outlet chambers 52 and 53 respectively. The ducts 47 and 48 and aligned ports 49 communicate with the inlet chamber 52.

Each valve plate 41 is formed with a plurality of apertures 55 in communication with the inlet chamber 52, and with the respective cylinders 37 of each cylinder head 23 or 24 through leaf type inlet valves 56. The valve plate is also formed with an additional series of ports 57, underlying the discharge chamber 53 of the head 42, and also underlying a discharge valve 58 mounted on the plate 41. As is also shown in Fig. 6, each valve 58 is of arcuate or crescent shaped form, and it comprises a plurality of flexible leaves 59 connected to a retainer 61, which in turn is secured to the plate 41 by a screw 62. The discharge chamber 53 communicates through ports 63 in the plate 41 with passageways or ducts 64 and 65 formed in the cylinder head 23 or 24 which terminate in a chamber 66 formed in the mid-portion 44 of the casting 21. The chamber 66 is covered with a cap 67 including an outlet fitting 68, and the cap 67 retains in position an outlet pipe 69 which depends almost to the bottom of the chamber 66. The purpose of this pipe is to prevent the accumulation of oil in the chamber 66, and the pressure of the compressed refrigerant will force such oil up through the pipe and thence into the discharge line leading to the condenser.

Having thus described the general arrangement of a typical refrigeration compressor, attention is now invited to the specific means employed to maintain, during operation of the compressor, a substantially constant oil level in the crankcase 22, and to avoid the adverse effects of foam formation. The main casting 21 is machined and finished on its exterior surface opposite the shaft end 28, to form a pad 71 on which is mounted a surge tank 72 having an inner finished surface 73 to match the pad 71, and an inner depending wall 74 at its upper portion which overlies the inlet region 46 in the dome 44. The wall 74 is formed with a port 75 communicating with the region 46, and a cylindrical reinforcing strut 76 extends between the wall 74 and the outer wall 77 of the tank 72. An inlet port and fitting 78 is provided on a side wall of the tank 72, so that returning refrigerant will enter the tank between the walls 74 and 77, near the top of the tank. The refrigerant vapor may then flow around the strut 76, which may have some effect as a baffle to separate oil particles, and thence through the port 75 into the inlet 46, for return to the compressor cylinders as previously described.

It will be noted that the bottom portion of the tank 72 is below the normal oil level in the crankcase 22, which has been indicated by the broken lines in Figs. 1, 2, and 3. The crankcase is here formed with an aperture or passageway 79, so located as to be partially below, and partially above, the normal operating oil level. This aperture provides free fluid communication between the crankcase and the tank 72, and another potential path of communication, around the end of the shaft 25, is sealed by a plate 81. It will be noted with reference to Fig. 7 that the discharge fitting 68 will be connected to the line 12, the inlet fitting 78 to the line 16, that the port 75 corresponds to the line 18, and that the aperture 79 corresponds to the line 19. While the passageway 79 is of sufficient area to effect its intended purpose, it is not so large that the agitation of the oil in the crankcase is significantly transmitted to the oil in the tank 72. That is, the rotation of the counterweights and oil slinger 34 and 35 churns the oil in the crankcase, but the oil in the tank 72 is comparatively quiescent, and any refrigerant in the tank 72 does not tend to form a foam.

In operation, refrigerant may be charged into the system through a service fitting 82, and oil is supplied to the compressor crankcase through a fitting 83. It is not necessary, as has been deemed heretofore, to measure the amounts of refrigerant and oil with exactitude, and in fact an excess of oil can be tolerated, as the excess will flow to the tank 72. When the compressor is running, vapor pressure in the crankcase, caused by volatilization of refrigerant from the crankcase oil, or by leakage of refrigerant past the pistons, may displace sufficient oil into the tank 72 to partially uncover the port 79. The vapor may then readily escape into the tank, for return to the system by flow through the port 75. Any foam which might be formed is similarly displaced, and, in the relatively quiet zone in the tank, it may volatilize and so return to the system. There is a continuous balance of pressures between the tank 72 and the suction side of the compressor, and the crankcase, and the oil is always free to flow from one to the other, in response to changes in pressure.

In oil separators with which I am familiar, the object has been to return all the oil to the crankcase as quickly as possible. According to the present invention, the object is rather to provide for the free venting of vapor in the crankcase into a quiet zone, so that foam formation is practically forestalled, and the displacement of the oil, in either direction, is a consequence of this action. In actual tests of the invention, a circular peep hole or sight glass, three-quarters of an inch in diameter, was provided at the normal operating oil level, through which it was observed that the oil level varied only slightly, and that foam formation was readily minimized.

It will, of course, be understood that the invention is not limited to the particular compressor shown in the drawing, but that it may be applied to other designs. Accordingly, it is intended that the invention should be accorded a scope commensurate with that expressed in the following claims.

I claim:

1. The combination with a refrigerant compressor having a crankcase adapted to receive a charge of oil, a cylinder above the crankcase, a crankshaft in the crankcase having oil slingers thereon arranged to dip into said charge of oil when the crankshaft is rotating to splash oil upwardly in the crankcase toward the cylinder, and a valved refrigerant inlet port communicating with a suction line at an elevation above the normal operating oil level in the crankcase, of a surge tank connected to the compressor and having a lower end disposed below the normal operating oil level in the crankcase, said surge tank having port means at the upper end thereof freely communicating with said inlet port and suction line, the upper portion of the surge tank being out of direct communication with the crankcase, the lower portion of the surge tank having an open passageway communicating with the crankcase, said passageway being so located as to be partially below and partially above the normal operating oil level in the crankcase, said crankshaft being located entirely without said surge tank and said surge tank being characterized by the absence of all moving parts therein which would tend to agitate the oil in the surge tank whereby said surge tank provides a quiescent chamber wherein the oil is not subject to substantial agitation and said passageway permitting free flow of oil

between said surge tank and said crankcase when the compressor is operating whereby refrigerant vapor may displace oil from the crankcase into the surge tank and flow freely through the portion of said passageway above the normal operating oil level in the crankcase to said port means.

2. The combination set forth in claim 1 wherein said port means comprises a pair of ports one communicating freely with said refrigerant inlet port and the other communicating freely with said suction line, said suction line communicating with said inlet port through the upper portion of the surge tank.

3. A piston-in-cylinder refrigerant compressor comprising a main body having a crankcase at a low portion thereof and a cylinder portion above the crankcase, said crankcase housing a crankshaft for operating pistons in the cylinder portion and being adapted to contain a body of oil having a normal level under operating conditions, said crankshaft having a plurality of oil slingers thereon which rotate with the crankshaft and which, when the crankshaft is rotated, dip into said body of oil to splash oil upwardly in the crankcase toward said cylinder portion, a valved suction inlet chamber formed in the main body and communicating with the cylinder portion, said main body being formed with an exterior finished surface around said inlet chamber and the crankcase, a surge tank secured to said finished surface, said surge tank having a wall overlying the inlet chamber, an aperture formed in said wall and constituting a port between the interior of the tank and said inlet chamber, said surge tank having a low portion adjacent the crankcase and an upper portion out of direct communication with the crankcase, said body at said crankcase being formed with an open passageway which provides free fluid communication between the crankcase and the surge tank, said passageway being so located as to be partially below and partially above the normal operating oil level in the crankcase, said crankshaft being located entirely without said surge tank and the surge tank being characterized by the absence of all moving parts therein which would tend to agitate the oil in the surge tank whereby said surge tank provides a quiescent chamber wherein the oil is not subject to substantial agitation, and an inlet connection in the surge tank above said passageway to admit refrigerant vapor and entrained oil from an extraneous point into the surge tank and compressor.

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