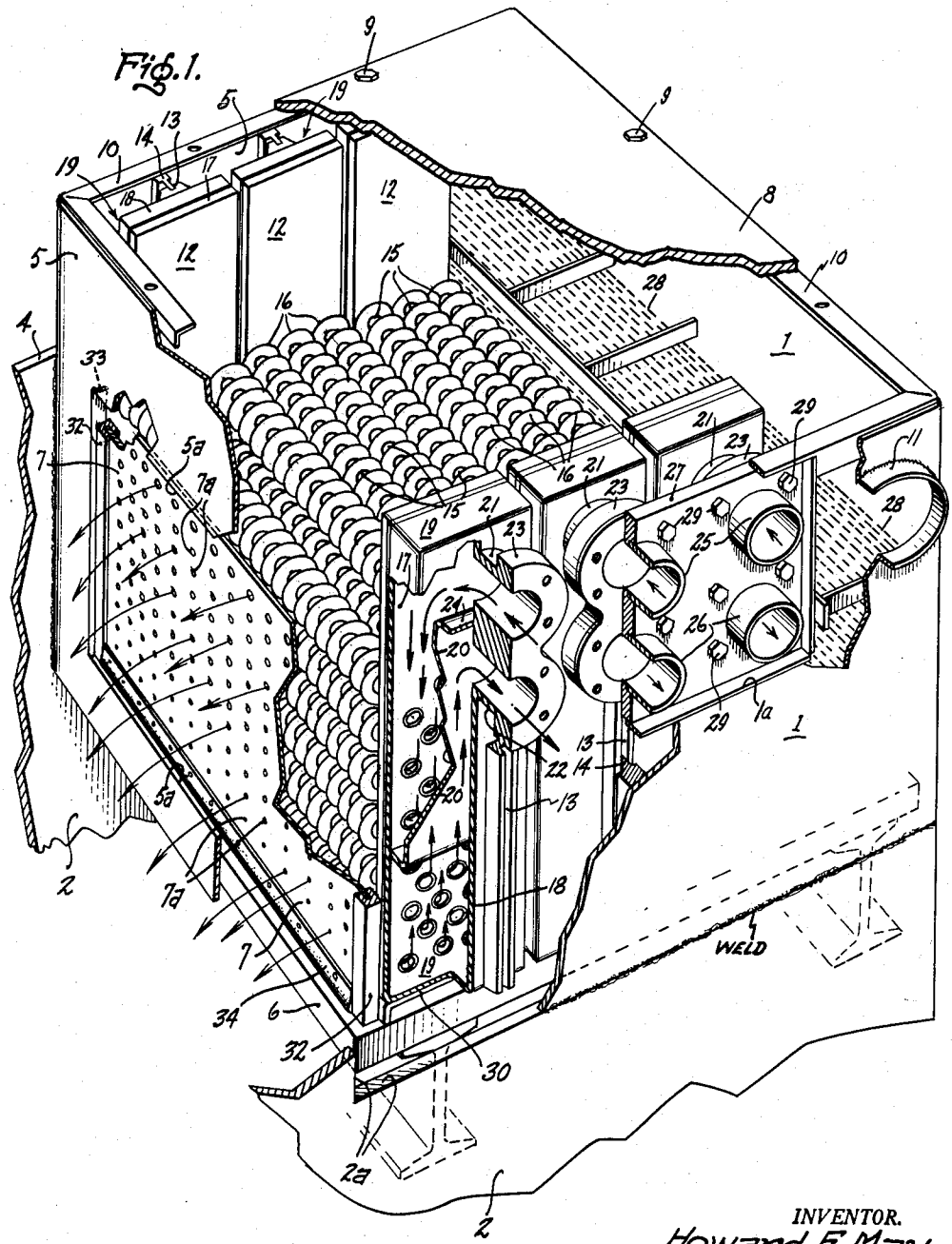
Dec. 31, 1963 H. F. MAY 3,116,134

COMBINATION HEAT EXCHANGER AND DEGASIFIER

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Fig. 1.



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Fig. 2.

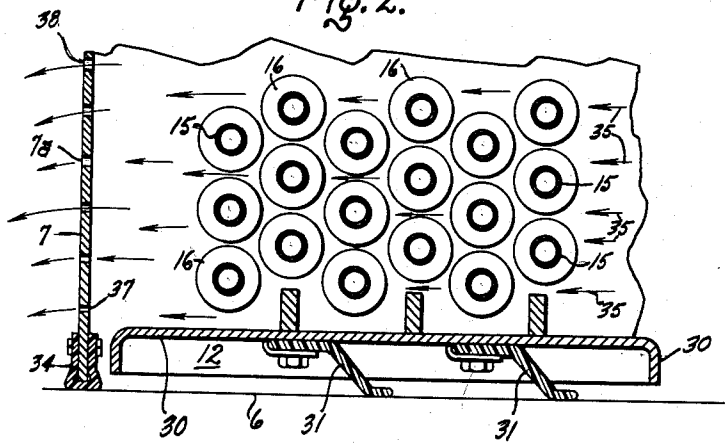
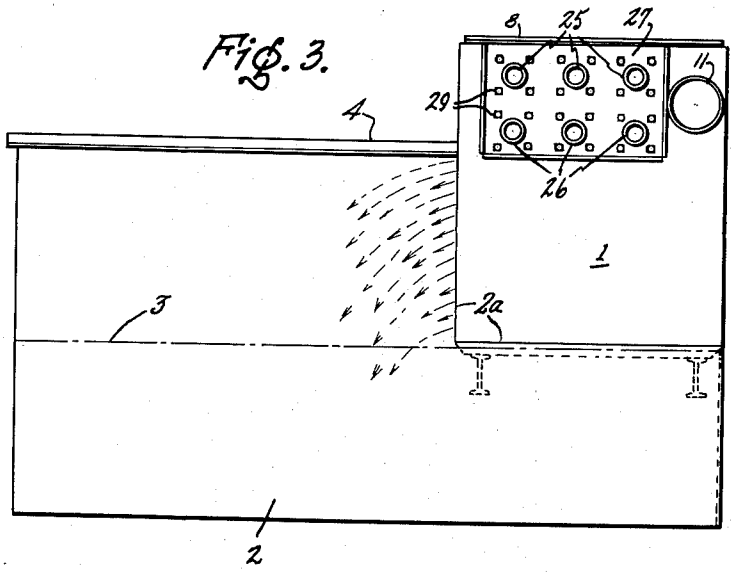


Fig. 3.



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COMBINATION HEAT EXCHANGER AND DEGASIFIER

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This invention relates to an improved arrangement for removing both heat and entrained gases from a liquid. More particularly, it pertains to an improved device for deaerating and cooling a liquid, such as oil, which contains foam or entrained air bubbles.

In a closed cycle lubrication system, such as that customarily used in a steam turbine, the lubricant often passes through a heat exchanger so as to cool the lubricant before it is pumped to the bearings. The exposure of the lubricant to air in the bearings and the agitation occasioned in the bearings, and by the pumping process, result in the entrainment of large quantities of air and water vapor in the form of foam or small bubbles. These bubbles, if allowed to accumulate, will materially reduce the discharge flow of the lubricating pump thus reducing flow to the journal and may even induce pump "cavitation," which can result in both pump and journal failure. Both air and water vapor increase undesirable oxidation of the oil. The reduction of the quantity of entrained air to a tolerable level is quite difficult, especially at high oil flow rates, and often a higher percentage of entrained air is tolerated than is desirable in order to avoid the expensive equipment which would be necessary to remove it.

Accordingly, one object of the present invention is to provide an improved arrangement for both degasifying and cooling a liquid having substantial quantities of entrained gas bubbles or foam therein.

A more specific object is to provide an improved oil cooler and deaerator for a steam turbine lubrication system.

Another object is to provide a cooling and deaerating unit for liquids, which is a complete and compact unit suitable for installation on or in a larger storage tank or sump for the liquid.

Still another object is to provide a gravity flow oil cooler in which heat exchange sections can be readily added or removed to vary the cooling capacity or for cleaning, without shutting down the system.

Generally stated, the invention is practiced by providing a tank with a plurality of finned tubes therein carrying a heat exchange fluid. A side wall portion of the tank is perforated and acts both as a dam to keep the heat exchange section full of liquid and as a means to break up the discharged liquid into numerous small jets for the effective release of air bubbles which have previously been coalesced by the fins on the heat exchanger tubes. The arrangement and size of the holes in the perforated wall portion aids in distributing the flow across the fined tubes, and equalizing the flow rate from top to bottom of the heat exchange sections.

The subject matter of the invention is particularly pointed out and distinctly claimed in the concluded portion of the specification. The invention, however, both as to organization and method of practice, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the acompanying drawing in which:

FIG. 1 is a perspective view, partly in section, of a deaerating oil cooler constructed in accordance with the invention;

FIG. 2 is a detailed cross-sectional view taken transversely through the finned tube heat exchangers near the perforated dam member; and

FIG. 3 is an elevation drawing of an oil storage tank showing the disposition of the deaerating oil cooler.

Referring first to FIG. 3 of the drawing, the combination cooling and deaerating tank, shown generally as 1, is welded into a cutout portion of a main tank 2. Main tank 2 is a storage or sump tank for the collection of the cooled and deaerated lubrication oil, which is pumped back into the bearings by a recirculating system (not shown). The level of liquid in the main tank 2 is indicated by dot-dash line 3 near the bottom of the cooling and deaerating tank 1. The bottom of the cooling and deaerating tank 1 is lower than the top 4 of the main tank and near liquid level 3 so that the oil flows by gravity into tank 4 as shown by the arrows. In the embodiment shown, this is accomplished by welding the cooling and deaerating tank 1 into a cutout portion 2a, although the tank 1 could equally well be held inside tank 2 on suitable brackets or mounting supports at the position shown.

Referring now to FIG. 1, tank 1 is made up of generally rectangular side walls 5 forming a rectangular enclosure together with a flat bottom plate 6 welded around the bottom of wall 5. On one end of the tank, a large rectangular opening 5a is blocked by a perforated dam member 7. A cover plate 8 is attached by means of bolts 9 and angle brackets 10 which serves merely to prevent dirt from getting into tank 1. An inlet conduit shown by the pipe stub 11 is attached to wall 5 and serves to conduct a free flow of foam-bearing oil to tank 1.

Disposed in tank 1 are a number of heat exchanger sections 12 mounted to be vertically removable, by means of the vertically grooved members 13 attached on each end of the heat exchangers which receive tongued members 14 attached to the wall 5 of the tank 1.

The heat exchangers utilize, for the active element, a number of parallel tubes 15 having fins 16 and mounted between tube sheets 17. Such finned tube elements are commonly employed in gas-to-liquid heat exchangers because of the large surface area necessary to compensate for the lower heat transfer coefficients of gases. Their use in this liquid-to-liquid heat exchanger is unusual, in that they are found to perform a particular deaerating function in addition to their ordinary role as heat exchanger, as will be pointed out more particularly hereinafter. It is to be particularly noted that the fins 16 are disposed substantially vertical and also are disposed parallel to the liquid flow through the heat exchanger (see FIG. 2).

A channel member 18 is sealed to tube sheets 17 to define manifolds designated generally at 19. A divider 20 secured midway up tube sheet 17 on one end of each heat exchanger and bent so as to extend upward between channel member 18 and tube sheet 17 serves to divide the manifold 19 at one end of each heat exchanger into supply and discharge portions. On the other end of each heat exchanger, there is no divider plate 20. Hence the finned tube heat exchangers constitute a two-pass system with the coolant liquid flowing through half of the finned tubes 15 in parallel in one direction and through the other half in the other direction, entering and discharging at the same end of the heat exchanger.

The upper end of each manifold 19 on the near end of the heat exchanger is provided with an inlet pipe 21 and an outlet pipe 22 attached to a common flange 23. As is indicated, the top portion of divider plate 20 is secured to the web of channel member 18 between pipes 21 and 22 as indicated by numeral 24, thus keeping the fluid entering pipe 21 separated from that discharging at pipe 22.

It will be observed that manifolds 19 extend much higher in the cooling and deaerating tank 1 than do the finned tubes 15, 16. The common flanges 23 are therefore located higher than the top of main tank 4, thus allowing

disconnection of the coolant fittings without draining the oil from the tanks.

The coolant (water in this case) is supplied to pipes 21, 22 by means of sets of coolant supply pipes 25 and discharged through coolant discharge pipes 26, all of which are secured to a common plate 27. Plate 27 fits in a cutout portion 1*a* defined by the cooling and deaerating tank 1, the bottom of which cutout is above the normal operating oil level in cooling tank 1, indicated by the dot-dash line 28. The plate 27 is secured to the common flanges 23 on each heat exchanger element by means of gaskets and bolts 29 so that the conduits communicate.

Referring to FIGS. 1 and 2 of the drawings, it is seen that each of the heat exchangers 12 rests upon a channel member such as 30 supplied with resilient sealing strips 31 which reduces the flow of liquid beneath channel 30.

The special perforated dam member 7 fits at either side in a grooved member 32 which is welded to a tab 33 bent in at either side of the rectangular opening 5*a*. The bottom edget of perforated dam 7 is fitted with a U-shaped resilient sealing member 34 which, when acted upon by the weight of plate 7, prevents the flow of liquid beneath the plate. Thus all of the liquid to be cooled and deaerated is constrained to flow through the small holes 7*a* in plate 7 in a plurality of small jets.

It should be noted that holes 7*a* are arranged so that they decrease in cross-sectional area from top to bottom of the dam member 7. This is to compensate for the pressure difference due to the liquid height, so as to achieve uniform flow velocity over finned tubes 15 in all parts of the tank. An equivalent effect can be obtained by keeping the hole size uniform and varying the vertical spacing between holes. In this case the vertical spacing would gradually decrease when going from the bottom of the tank to the top. This is effectively the same thing as having larger holes at the top. The proper selection of the cross-sections and spacing of holes 7*a* is within the scope of one skilled in the art given the physical properties of the liquid and the flow velocity desired.

The operation of this cooling and deaerating arrangement is as follows, referring particularly to FIGS. 1 and 2. The hot, foam-containing liquid (such as lubricating oil from steam turbine bearings) enters tank 1 by means of conduit 11 and leaves tank 1 through perforations 7*a* in the perforated dam member 7. The cooling liquid, preferably water, enters through the inlet pipes 25 in a two-pass flow through the finned tubes 15 and is discharged through conduits 26. Thus the oil enters from the right as indicated by the arrows 35 in FIG. 2 and flows from right to left to exit through perforations 7*a*, while the large fins 16, which are arranged both vertically and parallel to the flow, transfer heat from the lubricating oil to the cooling water in the tubes 15.

The size and spacing of holes 7*a* in plate 7 are carefully selected with reference to the rate of flow and the known density and viscosity of the liquid so as to obtain a desired normal level 36 in the tank. As previously mentioned, the hole size also decreases toward the bottom of the tank. The plate 7 acts to hold the level 36 constant, since as the level of the liquid rises, the increased pressure head causes the flow through perforations 7*a* to increase, thus tending to lower the liquid level to its former value.

The fins 16 are designed to have a much larger surface area than would be required for only the heat exchange function. The reason for this is that the fins perform the dual function of (1) cooling the oil, and (2) commencing the deaeration process by "scrubbing" the liquid as it impings upon the sharp edges of the fins and passes parallel to the surface of the fins. This causes entrained gases to separate and coalesce to form bubbles. Since the fins are disposed vertically, any bubbles of such size as would tend to escape from the liquid are not impeded from rising immediately to the surface of the liquid. On the gas which does not escape directly, the fins perform the action of coalescing very small bubbles into larger bubbles so

that they will be able to escape more quickly after passing through the perforations 7*a* in plate 7.

The perforations or orifices 7*a* serve to break up the total liquid flow into a number of small jets of liquid discharging into air. These small jets have a much larger ratio of surface area to volume than does the large mass of oil contained in the tank. Thus as the liquid passes through the perforations, the coalesced air bubbles readily escape from the surface of the jets and the liquid falls into the main tank 2 in a cooled and almost completely deaerated state. It appears that the changing pressure and velocity relations of the air and liquid, as the mixture passes through the orifices, may also have an influence on the separation of the gas from the liquid.

The plate 7 serves also to distribute the flow past the finned tubes 15, 16. As noted previously, the size and distribution of the orifices are selected so as to provide essentially uniform axial velocity of liquid from top to bottom of the tank. It will be observed that the perforated dam and the finned tubes act in combination to accomplish the deaeration. Furthermore, the finned tubes cool the oil, while the dam retains the liquid at a substantially constant level and provides a uniform flow velocity over the finned tubes. Thus the two components act in concert to perform the dual function of cooling and deaerating.

Although in the preferred embodiment, the perforated dam member 7 is in the side wall of tank 1 it would be possible also to use imperforate side walls and to place the perforations in the bottom of tank 1. In this case the size and distribution of the perforations would be uniform. The action in regulating the liquid level and in producing a number of small jets from which coalesced bubbles can escape would, however, be essentially the same.

The invention has been found to result in a highly effective and compact arrangement for removing both heat and entrained gas from a liquid. With the particular embodiment shown, that of a lubricating oil deaerator and cooler, the invention has resulted in a marked improvement over previous arrangements. When amounts of air up to 16% by volume have been introduced into inlet conduit 11 during experimental testing of the device, the apparatus has successfully removed all but about 1% of the entrained air in the oil.

The added feature of removable heat exchange elements, with inlet and outlet connections disposed above the operating liquid level, allows the heat exchanger sections to be disconnected and removed for cleaning without disturbing the cover of the main oil tank, and without even shutting down the machine.

These and many other advantages will be apparent to those skilled in the art, and while there has been described what is at present considered to be the preferred embodiment of the invention, it will be understood that still other modifications may be made; and it is intended to cover in the appended claims all such modifications which fall within the true spirit and scope of this invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A gravity-flow liquid cooler and degasifier comprising a tank having at least one vertical perforated wall portion defining a plurality of spaced orifices over a substantial vertical height of the wall portion, inlet conduit means supplying a free flow of liquid containing entrained gas into a portion of the tank spaced from said perforated wall portion, and a plurality of tubes having extended surface fins disposed between the inlet conduit means and the perforated wall portion with the fins arranged substantially vertically and substantially parallel to the fluid flow from the inlet portion of the tank to said perforated wall portion, and means for circulating a coolant through said finned tubes, whereby the perforated wall portion acts both to regulate the velocity of the liquid over the finned tubes and as orifice plate means to discharge the liquid in a plurality of discrete spaced

jets from the surface of which jets entrained gases readily escape into the ambient atmosphere upon passing through the orifices.

2. A gravity-flow liquid cooler and degasifier comprising a substantially rectangular tank having a perforated discharge plate member forming a substantial portion of one vertical end wall thereof, inlet conduit means supplying a free flow of liquid containing entrained gas into said tank adjacent the opposite end wall thereof, a plurality of tubes with extended surface fins disposed in said tank between the perforated discharge plate member and the inlet conduit means, said finned tubes being disposed transversely in the tank with the fins substantially vertical and substantially perpendicular to said end walls so as to be disposed generally parallel to the flow of liquid horizontally from the inlet end of the tank to the discharge plate end so as to create minimum turbulence in the liquid, means circulating coolant through said finned tubes, whereby the fins cool the liquid and tend to coalesce entrained gas bubbles, while the perforated end plate serves to regulate the velocity of flow of the liquid over said finned tubes and to discharge the liquid in the form of spaced discrete jets into the ambient atmosphere from the surface of which jets entrained gases readily escape, and reservoir means disposed below said perforated plate member to collect the cooled and deaerated jets of liquid.

3. A gravity-flow liquid cooler and degasifier in accordance with claim 2 in which the discharge plate member has uniformly spaced perforations forming orifices the aggregate effective area of which per unit area of the plate member progressively increases from the bottom to the top of the plate member, whereby increasing level of liquid in the tank brings into operation orifices of increasing aggregate effective area per unit area of the plate member whereby the inverse relation between aggregate effective orifice area at a particular height on the plate member and the hydraulic head of the liquid in the tank acting on the orifices at that height tends to equalize the rate of discharge over the perforated area of the plate member and thereby tends to render uniform the horizontal velocity of the liquid past the finned tubes throughout the vertical cross section of the tank.

4. A gravity-flow liquid cooler and degasifier comprising:

a first substantially rectangular horizontally disposed tank having a first end portion forming an inlet chamber and at the opposite end a second discharge chamber portion,

inlet conduit means connected to discharge a free flow of hot liquid containing entrained gas into said first inlet chamber end portion,

a plurality of heat exchange tubes disposed transversely in the portion of the tank intermediate said inlet and discharge end portions and having extended surface fins disposed substantially vertical and generally parallel to the flow of liquid horizontally through the tank from the inlet end to the discharge end portion thereof, whereby the fins create minimum turbulence and present minimum obstruction to the flow of liquid,

the end wall of said second discharge chamber portion of the tank having a plurality of spaced orifices distributed uniformly over a substantial portion of the vertical height thereof to discharge the liquid into the ambient atmosphere as spaced discrete jets,

means for circulating a coolant through said finned tubes, whereby the liquid is cooled and the extended surface fins coalesce small entrained gas bubbles into larger bubbles which are free to rise to the top of the tank or are released into the ambient atmosphere from the surface of said jets upon passage of the liquid through said orifices,

and reservoir means disposed below said first tank to collect the degasified jets of liquid.

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