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APPARATUS FOR PURGING FLUIDS FROM
LIQUID COOLING SYSTEMS

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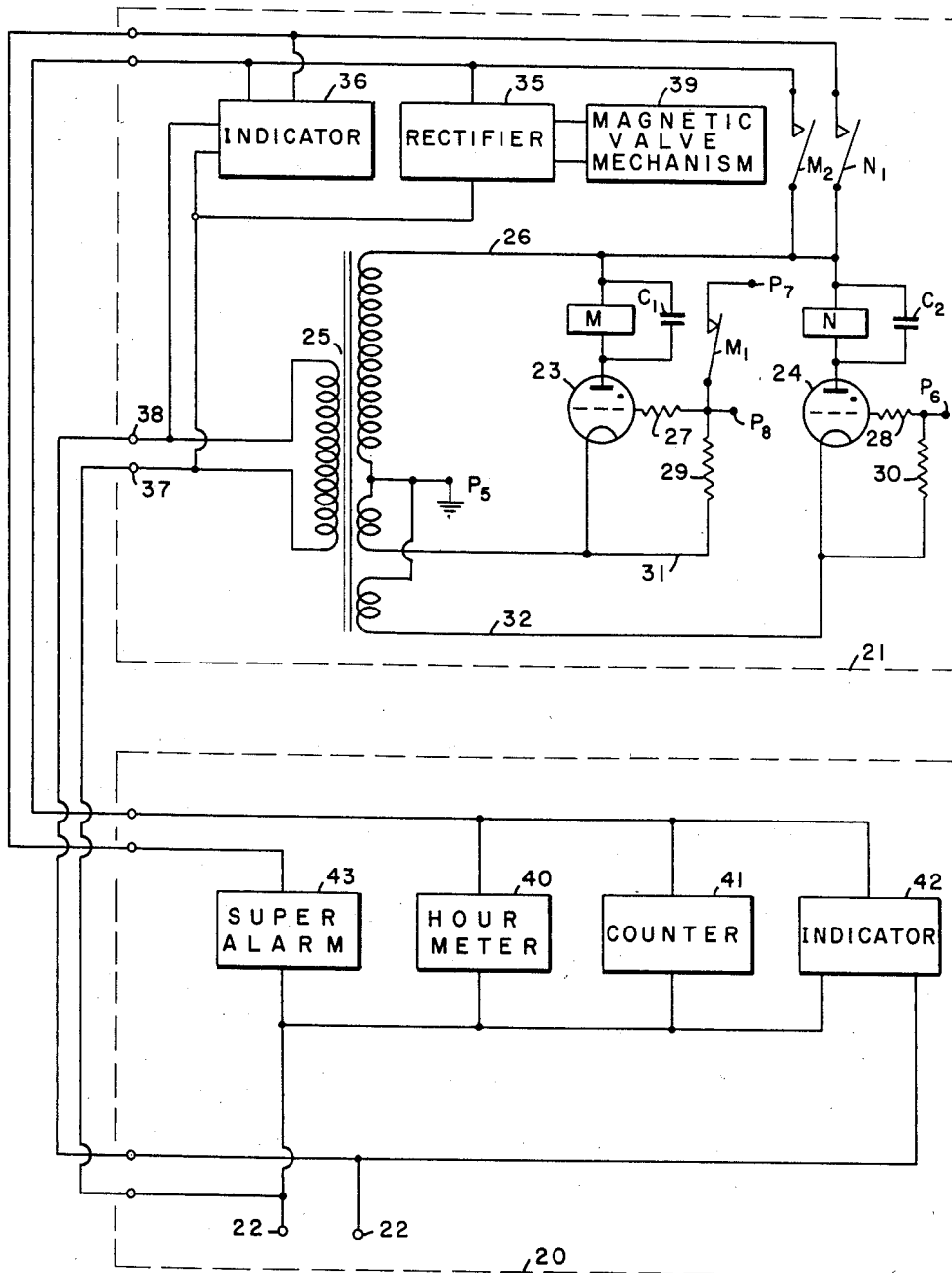


FIG. 2

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APPARATUS FOR PURGING FLUIDS FROM LIQUID COOLING SYSTEMS

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7 Claims. (Cl. 340-242)

This invention relates to industrial plant cooling systems and pertains, more particularly, to continuously operating cooling systems such, for example, as those used in oil refineries, chemical plants and the like.

Since such plants are usually in continuous operation, it is essential that their cooling systems be capable of continuously circulating the cooling liquid required. However, during its circulation, the cooling liquid frequently becomes contaminated with other fluids which leak into the system such, for example, as oil or gasoline in the case of an oil refinery. Over a period of time, these liquids may foul the pumping apparatus of the system, reduce the heat transfer in the cooling apparatus and otherwise adversely affect the system whereby it becomes necessary periodically to interrupt its operation for overhaul. In addition to the cost of repairs such interruptions may cause a substantial loss in production in cases where it is necessary temporarily to shut down installations normally cooled by the system.

Accordingly, an object of the present invention is to provide a continuously circulating cooling system having new and improved apparatus for purging leakage or foreign fluids from a cooling liquid without interrupting the operation of the cooling system.

A further object of this invention is to provide such an apparatus with means for automatically signaling the presence of leakage fluids in a cooling liquid, signaling the occurrence of an abnormally large amount of leakage into a cooling system, and recording the amounts of liquid purged therefrom.

Further objects and advantages of the present invention will be apparent from the following description taken in connection with the appended drawings in which:

Fig. 1 is a diagrammatic view taken partly in vertical section and illustrating the apparatus of the present invention;

Fig. 2 is a schematic electrical circuit diagram for the apparatus illustrated in Fig. 1, and;

Fig. 3 is a diagrammatic view taken partly in vertical section and illustrating another embodiment of the present invention.

Referring now to the drawings, the embodiment of the present invention is shown, by way of illustration, as comprising part of the cooling water circulation system of an oil refinery. The apparatus shown in Figs. 1 and 2 is constructed and arranged for detecting and purging from the cooling water other liquids which may leak into the system such, for example, as gasoline or oil both of which are lighter than and are immiscible with the cooling water.

The cooling water system of a refinery usually includes a main pair of culverts arranged some ten feet below ground level. One of the culverts is fed with cooling water from a pumping station while the other returns the cooling water to a cooling tower. Preferably, throughout the system, the culvert walls are of concrete, and the culverts are constructed of numbers of separate lengths joined by bituminous material. The main culverts may be octagonal in cross section and have, for example, an

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eight foot diameter. A desired number, for example, four main branch pairs of culverts are also usually provided, each serving a small number of refinery units. These culverts are normally of circular cross section and are four or five feet in diameter.

Figure 1 shows a longitudinal section taken through a main return culvert 1 at a position upstream from the cooling tower. The culvert 1 is provided with a cylindrical vertical manhole 3 which is defined by a casing provided with a number of external flanges which are set in the concrete wall of the culvert 1, or a thickening thereof. A manhole cover 4 is bolted into position, as shown, and forms a watertight seal at the top of the manhole 3. The cover carries four metal probes 5, 6, 7 and 8, which probes pass through water-tight and electrically insulating glands set in the cover. Electrical leads from the probes pass back to a junction box 9 from which a multicore cable 11 passes up to a control apparatus 12 mounted above the ground. One end of a small diameter discharge pipeline 13, for example, a 1½" pipeline, is sealed into the manhole cover 4. The pipeline 13 is connected through valves 14, 15 and 16 to a larger pipeline 17, for example, a 2" line leading to a sump (not shown) for collecting oil or other liquids drawn off from the manhole 3. The valve 14 is hand-operated and is normally kept open. The valve 15 is electrically operated by the control apparatus 12, and the valve 16 is a hand-operated throttle valve, which controls the rate of flow through the discharge line when the valve 15 is opened. Finally, there is provided a pipe 18 including a gas eliminator 19 which is connected in parallel with the valves 14 through 16 for a purpose as subsequently described.

In operation, the conduit, pipe or culvert 1 is normally filled with cooling water, the pressure being considerably more than sufficient to fill the manhole 3 up to the underside of the cover 4, entrapped air escaping through pipe 18, as will be seen hereinbelow. The water flows quickly and turbulently, the Reynolds number for the flow being high in the turbulent range, i. e., about 2×10^6 . In spite of the rate and turbulence of flow, if any oil, gasoline or other immiscible liquid lighter than water leaks into the cooling water, it separates out and a major proportion collects in the manhole 3 which thus acts as a collection space or tray. This proportion is thought to depend very much on the magnitude of the diameter of the collection space or manhole 3 in relation to that of the main conduit 1. The manhole diameter may be varied according to the size of the conduit and the flow conditions therein. In the case of the conduit and the flow conditions previously described, it has been found that a manhole having a diameter as small as 2' may be used. However, in most cases, the diameter of the manhole should be a substantial proportion of the conduit diameter, and preferably the two diameters should be equal, as shown in the drawings. The efficiency of separation and collection is also thought to depend on the length of the conduit through which the water/oil mixture flows before reaching the manhole.

While the manhole 3 is filled with water, the probes 5 through 8 are electrically connected by a relatively low resistance path through the water, and are all grounded through the permanently earthed probe 5. The control apparatus 12 is arranged to respond to this condition of the probes in such a manner that the valve 15 is closed. It is understood, that, while the use of probe 5 is preferred, it may be removed, the probes 6 through 8 being grounded, in its absence, through the water and the sides of the manhole 3.

As a leakage liquid, for example, oil collects in the top of the manhole 3, the time will occur when the probe 8 lies wholly above the oil-water interface and is thus in-

ulated from the remaining probes, and therefore is no longer grounded. Initially, this has no effect as will be seen from a discussion of the circuit of Fig. 2 hereinbelow. Collection of additional oil in the manhole 3 will eventually cause the interface to move below the tip of the probe 7, thus breaking the electrical connection between that probe and the probes 5 and 6, and hence disconnecting the probe 7 from the ground. The control apparatus 12 is arranged to respond to the removal of the ground from the probe 7 by opening the valve 15, so that the oil is forced out of the manhole 3 through the pipelines 13 and 17 by the pressure within the culvert. The rate of discharge is set to a convenient value by means of the throttling valve 16. As the oil-water interface moves up the manhole 3 again, the re-grounding of the probe 7, which in most cases occurs almost immediately, has no effect on the controller 12, which maintains the valve 15 open until the interface lies just above the tip of the probe 8. When this level is reached, the re-grounding of the probe 8 causes the controller 12 to close the valve 15 again, whereupon, if the leakage persists, the cycle of operation is repeated. Simultaneously with the opening and closing of the valve 15, the controller 12 energizes a warning lamp, or some other alarm device at a suitable control position, so that steps can be taken to trace the leakage. In addition the controller 12 is arranged to operate a counter and an hour-meter which record, respectively, the number of times the valve 15 is opened, and the total length of time for which it is open. With these figures and the known volume of the manhole 3 between the levels defined by the tips of the probes 7 and 8, the total rate of discharge to the sump can be calculated. Alternatively, the counter and hour-meter can be replaced by a flow meter 12a which may be electrically operated by the controller 12 for indicating the volume of fluid discharged through the valve 15.

If, due to a serious leakage, oil or other liquids should collect in the manhole 3 at a rate such that the interface still falls despite the opening of the valve 15, a super-alarm 43 (Fig. 2) is operated by the control apparatus 12 when the interface falls below the tip of the probe 6 thus disconnecting it from earth as well as probes 7 and 8. The super-alarm may take the form, for example, of a light or an audible warning such as a bell or a buzzer sounding at a suitable control position. Additional relief valves (not shown in the drawing) are then opened either manually, or automatically under the control of the apparatus 12, to increase the rate of discharge from the manhole 3, until such time as the leakage is brought under control. It will be appreciated that adjustment of the throttle valve 16 will determine the magnitude of the leakage for which the super-alarm is operated.

If desired, an additional probe (not shown) can be included in such a manner that its tip lies at a level between the tips of the probes 5 and 6. This additional probe can then be combined with the probe 6 and the controller 12, to operate an additional discharge by means of another magnetic valve, when the super-alarm condition occurs, in exactly the same way that the valve 15 is controlled by means of the probes 7 and 8. With this modification the level of the tip of the probe 7 can be made higher, and the throttle valve 16 can be adjusted to give a much slower rate of discharge under normal alarm conditions, so that warning of relatively small leakages will be obtained more quickly.

The pipe 18 and gas eliminator 19 are provided, as it has been found that in some circumstances gas, usually mainly air, also collects in the manhole 3 and actuates the controller 12 in exactly the same way as oil. This can lead to undue wear of the control apparatus 12, particularly of the contacts of the relays included in it. The pipe 18 and eliminator 19 permit ordinary quantities of gas to escape from the manhole 3 without affecting the control 12. Should gas collect at a rate greater than can be dealt with by the eliminator 19, the apparatus 12 will be actu-

ated as before, but this should be a relatively rare occurrence.

Referring now to the circuit shown in Fig. 2, the terminals P5, P6, P7 and P8 are connected through the multicore cable 11 (Fig. 1) to the probes 5 through 8, respectively. The apparatus represented by the circuits in the dotted block 20 is preferably situated at a suitable control point, for example, the cooling water pumping station, while the apparatus represented by the circuits in the dotted block 21 is preferably mounted on a frame near the top of the manhole, as indicated in Fig. 1. The power supplies for the whole circuit are derived from A. C. mains across which the terminals 22 are connected.

The electronic relay arrangement includes a pair of thermionic tubes such, for example, as a pair of thyatron tubes 23 and 24, which may conveniently be included in a single envelope. The circuit includes an input mains transformer 25, having three secondary windings, one end of each of which is grounded preferably through the terminal P5. The other ends of the windings are respectively at 230 volts, 14 volts and 14 volts, the windings being arranged so that the voltages at the free ends of the windings are all in phase with one another. The 230 volt line 26 is connected to the anodes of the valves 23 and 24, through the windings of A. C. relays M and N, respectively, capacitors C1 and C2 being connected in parallel with the windings. The 230 volt line 26 is also connected to one side of each of the normally open contacts M2 and N1 of the relays M and N, respectively. One megohm resistors 27 and 28 are connected between the control grids of the tubes 23 and 24 and the terminals P8 and P6, respectively. A 33 kilo-ohm resistor 29 is connected between the control grid and cathode of the tube 23 and a 1 kilo-ohm resistor 30 is connected between the control grid and cathode of the tube 24. The cathodes are connected to the two 14 volt lines 31 and 32 from the transformer 25. The normally closed contact M1 is connected between terminal P7 and P8.

In operation, when the interface is between the tips of the probes 7 and 8 and falling, the terminals P6 and P7 are both at ground potential, due to connection of the probes 6 and 7 through the water to the probe 5. In consequence, the control grids of the valves 23 and 24 are both at ground potential, and a bias voltage is applied to each of the grids of the tubes 23 and 24. This voltage is out of phase with the voltage applied to the anodes, and in consequence the tubes 23 and 24 are both cut-off and the relays M and N remain unenergized. When the interface falls below the level of the tip of the probe 7, terminal P7 is no longer grounded, and the grid voltage of the tube 23 rises to the cathode voltage. The tube 23 then becomes conducting and the relay M is energized, thus opening the contact M1 and closing the contact M2. As described below, the closing of contact M2 causes the opening of the valve 15, and the interface then normally starts to rise again. When the terminal P7 is earthed again there is no effect on the relay arrangement, as the contact M1 is held open until the interface rises above the tip of the probe 8, thus earthing terminal P8 and restoring the bias to the valve 23 and releasing the relay M. The cycle of operation is then repeated.

Under super-alarm conditions, the interface falls below the tip of the probe 6 and removes the ground from terminal P6. The valve 24 then becomes conducting, causing the relay N to operate and close the contact N1. This condition is maintained until the interface rises above the level of the tip of the probe 6 whereupon terminal P6 is again grounded and the valve 24 is cut-off releasing the relay N.

The contacts M2 and N1 govern the operation of the remainder of the control apparatus and the alarm apparatus. In the apparatus near the manhole 3, closure of the contact M2 connects the 230 volt line 26 to a rectifier 35 and an indicator circuit 36. The rectifier 35 is already connected to terminal 37, one of a pair of

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A. C. mains input terminals 37 and 38. Thus, when the contact M2 closes, an A. C. voltage is applied to the rectifier 35, which then provides a D. C. output voltage, which voltage is applied to the mechanism 39 for operating the magnetic valve 15. The indicator 36, which may consist simply of three lamps, is connected to the terminals 37 and 38, one of the lamps lighting to indicate whether the circuit is alive or not. It is also connected to the leads from the contacts M2 and N1, and the second and third lamps are connected across these leads and the lead to the terminal 37 so that these lamps light when those contacts M2 and N1, respectively, close, thus indicating operation of the magnetic valve 15 and the super-alarm condition.

At the cooling water pump house, there is provided an hour-meter 40, a counter 41, an indicator 42, and a super-alarm 43, each of which is connected to one of the A. C. mains input terminals 22. The units 40, 41 and 42 are connected to the contact M2 and hence to the 230 volt A. C. line 26 when the contact M2 closes. The super-alarm is connected to the contact N1 and hence also to the line 26 when the contact N1 closes. The hour-meter 40 registers the time during which the contact M2 is closed, and the counter 41 the number of times it closes. The indicator 41 preferably includes two lamps one of which is lit as long as the circuit is alive, while the other lights when the contact M2 is closed, thus indicating when the magnetic valve 15 is open. The super-alarm 43 includes a warning device, for example, an electric bell which rings as long as the contact N1 is closed, i. e., as long as the interface is below the tip of the probe 6.

It will be appreciated that while particular control and alarm circuits have been described they may be varied to make the circuitry simpler, if desired, or more complex if it is required to affect closer control, without departing from the spirit of this invention.

The arrangement described above has been tested under a variety of conditions, and has been found effective in preventing at least a major proportion of any leakage from reaching the cooling tower. Apart from that aspect of its operation, the warning provided of any leakage has been found to be extremely useful in the general operation of the refinery.

To exercise closer control and to facilitate the tracing of leaks, similar arrangements can be provided at other strategic points in the cooling water system, particularly, for example, in each of the branch conduits just upstream of the point where they each join the main conduit.

If liquids heavier than water are apt to leak into the cooling water system, provision should be made for trapping them in a collection space such, for example, as a well or sump disposed below the bottom of the water conduit. If the heavier liquids have relatively high electrical resistances, the purging apparatus may be employed in the manner previously described.

In cases where it is desired to purge either a heavier or lighter relatively low electric resistance liquid from a relatively high resistance cooling liquid, for example, the purging of water from an oil stream, it is necessary to modify the apparatus. Fig. 3 illustrates an embodiment suitable for this purpose. Except for minor changes, the arrangement is the same as that previously described.

Since water is heavier than oil the collection space 53 is disposed below the bottom of the culvert or conduit 51, and the discharge line 63 is passed around the outside of the culvert to the surface of the ground where it is connected to the pipe 18 and the pipeline 17 in a manner similar to that shown in Fig. 1. The same number of probes may be used, it being understood that the grounded probe 55 can be omitted, as previously noted, without affecting the circuitry. The probes 56 through 58 are electrically connected through the junction box 59 and the cable 61 to the terminals P6 through P8, respectively (Fig. 2). Since the collection space is normally filled with the cooling liquid which in this case

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is oil, the tubes 23 and 24 are normally conducting and the relays M and N are normally energized. Thus by changing the mechanical connections of the contacts M2 and N1, so that all of the contacts M2, M1 and N1 are normally open when the valves 23 and 24 are conducting, the circuitry can be made to operate the discharge valve 15 and the remainder of the apparatus in the same sequence and in response to the collection of corresponding amounts of the leakage liquid as in the embodiment previously described.

I claim as my invention:

1. Apparatus for purging a foreign liquid from the predominant liquid flowing in a conduit, the liquids being immiscible with each other and having different electrical resistances, said apparatus comprising in combination: means defining a collection space having an opening in communication with the conduit and arranged to trap the foreign liquid flowing therein, said collection space being normally filled by the predominant liquid flowing through the conduit, a fluid discharge conduit in communication with said space, a normally closed electrically operated valve in said conduit, first and second electrodes disposed at different levels in said space and normally immersed in the predominant liquid therein, said first electrode becoming immersed in the foreign liquid when a predetermined small amount thereof has collected in the space and said second electrode becoming immersed in the foreign liquid when a larger predetermined amount has collected in the space, an electrical circuit including said electrodes and relay means electrically connected thereto, the arrangement of said electrodes forming interlock means for said relay means, said circuit being in a first operative condition when both electrodes are in contact with the predominant liquid and in a second operative condition when both electrodes are immersed in the foreign liquid, and electrical control means energized by the output of said circuit for opening said valve when said electrical circuit is in one of said operative conditions and for closing said valve when said electrical circuit is in the other operative condition.

2. Apparatus for purging a foreign liquid from the cooling liquid flowing in a conduit of a cooling system, the liquids being immiscible with each other and having different electrical resistances, said apparatus comprising in combination: means defining a collection space in communication with the conduit through an opening substantially as large as the cross-section of the conduit, said collection space being normally filled with the cooling liquid flowing through the conduit and being arranged to trap by gravity the foreign liquid carried thereby, a fluid discharge conduit in communication with said space, a normally closed electrically operated valve in said conduit, first and second electrodes disposed at different levels in said space and normally immersed in the cooling liquid therein, said first electrode becoming immersed in the foreign liquid when a predetermined small amount thereof has collected in the space and said second electrode becoming immersed in the foreign liquid when a larger predetermined amount has collected in the space, an electrical circuit including said electrodes and relay means electrically connected thereto, the arrangement of said electrodes forming interlock means for said relay means, said circuit being in a first operative condition when both electrodes are in contact with the cooling liquid and in a second operative condition when both electrodes are immersed in the foreign liquid, and electrical control means energized by the output of said circuit for opening said valve when said electrical circuit is in said second operative condition and for closing said valve when said electrical circuit is in said first operative condition.

3. Apparatus for purging a foreign liquid from the cooling liquid flowing in a conduit of a cooling system, the liquids having different electrical resistances and the foreign liquid being lighter than and immiscible with the

cooling liquid, said apparatus comprising: means defining a collection cavity in an upper portion of a wall of the conduit, said cavity having an opening in communication with the conduit, the cooling liquid being under sufficient pressure normally to fill said cavity, said opening extending across the top of the conduit and having a diameter substantially as large as that of the conduit whereby said cavity is arranged to trap by gravity the foreign liquid floating on the cooling liquid, a fluid discharge conduit in communication with said cavity, a normally closed electrically operated valve in said conduit, first and second electrodes disposed at different levels in said cavity and normally immersed in the cooling liquid therein, said first electrode becoming immersed in the foreign liquid when a predetermined small amount thereof has collected in the cavity and said second electrode becoming immersed in the foreign liquid when a larger predetermined amount has collected in the cavity, an electrical circuit including said electrodes and relay means electrically connected thereto, the arrangement of said electrodes forming interlock means for said relay means, said circuit being in a first operative condition when both electrodes are in contact with the cooling liquid and in a second operative condition when both electrodes are immersed in the foreign liquid, and electrical control means energized by the output of said circuit for opening said valve when said electrical circuit is in said second operative condition and for closing said valve when said electrical circuit is in said first operative condition.

4. Apparatus for purging a foreign liquid from the cooling liquid flowing in a conduit of a cooling system, the liquids having different electrical resistances and the foreign liquid being heavier than and immiscible with the cooling liquid, said apparatus comprising: means defining a collection space in a lower portion of a wall of the conduit, said cavity having an opening in communication with the conduit whereby the cavity is normally filled with cooling liquid, said opening extending across the bottom of the conduit and having a diameter substantially as large as that of the conduit whereby said cavity is arranged to trap by gravity the foreign liquid carried by the cooling liquid, a fluid discharge conduit in communication with said cavity, a normally closed electrically operated valve in said conduit, first and second electrodes disposed at different levels in said cavity and normally immersed in the cooling liquid therein, said first electrode coming in contact with the foreign liquid when a predetermined small amount thereof has collected in the cavity and said second electrode coming in contact with the foreign liquid when a larger predetermined amount has collected in the cavity, an electrical circuit including said electrodes and relay means electrically connected thereto, the arrangement of said electrodes forming interlock means for said relay means, said circuit being in a first operative condition when both electrodes are immersed in the cooling liquid and in a second operative condition when both electrodes are in contact with the foreign liquid, an electrically operated alarm, and electrical control means energized by the output of said circuit for opening said valve and operating said alarm when said electrical circuit is in said second operative condition and for closing said valve when said electrical circuit is in said first operative condition.

5. Apparatus for purging oil from a cooling water conduit of a cooling system, said apparatus comprising: means defining a collection cavity in an upper portion of a wall of the conduit, said cavity having an opening in communication with the conduit, the cooling water being under sufficient pressure normally to fill said cavity, said opening extending across the top of the conduit and having a diameter substantially as large as that of the conduit whereby said cavity is arranged to trap by gravity the oil floating on the cooling water, a fluid discharge conduit in communication with said cavity, a normally closed electrically operated valve in said discharge con-

duit, first and second electrodes disposed at different levels in said cavity and normally immersed in the water therein, said first electrode becoming immersed in the oil when a small predetermined amount thereof has collected in the cavity and said second electrode becoming immersed in the oil when a larger predetermined amount has collected in the cavity, an electrical circuit including a thyatron tube, said electrodes being normally connected to the grid of said tube in such manner that the tube is non-conductive when both electrodes are in contact with the cooling water, and control means energized by the output of said thyatron tube for opening the discharge valve when both electrodes are immersed in oil and for closing the discharge valve when both electrodes are in contact with cooling water.

6. Apparatus for purging oil from a cooling water conduit of a cooling system, said apparatus comprising: means defining a collection cavity in an upper portion of a wall of the conduit, said cavity having an opening in communication with the conduit, the cooling water being under sufficient pressure normally to fill said cavity, said opening extending across the top of the conduit and having a diameter substantially as large as that of the conduit whereby said cavity is arranged to trap by gravity the oil floating on the cooling water, a fluid discharge conduit in communication with said cavity, a normally closed electrically operated valve in said discharge conduit, first and second electrodes disposed at different levels in said cavity and normally immersed in the water therein, said first electrode becoming immersed in the oil when a small predetermined amount thereof has collected in the cavity and said second electrode becoming immersed in the oil when a larger predetermined amount has collected in the cavity, a third electrode connected to ground and disposed in said cavity in continuous contact with the cooling water, said third electrode extending past the levels of said first and second electrodes, an electrical circuit including said three electrodes, control means in said circuit electrically connected to said valve for opening the valve in response to the increase in electrical resistance between said second and third electrodes when the second electrode is immersed in oil and for closing the valve in response to a decrease in electrical resistance between the first and third electrodes when the first electrode is in contact with water in said cavity, and means for venting vapor from said cavity.

7. Apparatus for purging a foreign liquid from the cooling liquid in a conduit of a system, the liquids being immiscible with each other and having different electrical resistances, said apparatus comprising in combination: means defining a collection space having an opening adapted to communicate with cooling liquid in the conduit and arranged to trap the foreign liquid carried thereby, said collection space being normally filled by the cooling liquid flowing through the conduit, a fluid discharge conduit in communication with said space, a normally closed electrically operated valve in said conduit, first and second electrodes disposed at different levels in said space and normally immersed in the cooling liquid therein, said first electrode becoming immersed in the foreign liquid when a predetermined small amount thereof has collected in the space and said second electrode becoming immersed in the foreign liquid when a larger predetermined amount has collected in the space, an electrical circuit including said electrodes, said circuit being in a first operative condition when both electrodes are in contact with the cooling liquid and in a second operative condition when both electrodes are immersed in the foreign liquid, electrical control means energized by the output of said circuit for opening said valve when said electrical circuit is in one of said operative conditions and for closing said valve when said electrical circuit is in the other operative condition, a third electrode disposed in said space and adapted to become

immersed in the foreign liquid when a maximum pre-determined amount thereof has collected in said space, an electrically operated alarm, electrical circuit means including said third electrode and said alarm and operative for energizing said alarm when said third electrode is immersed in the foreign liquid, and means for recording the number of times said valve is opened and the period of time it remains open.

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