

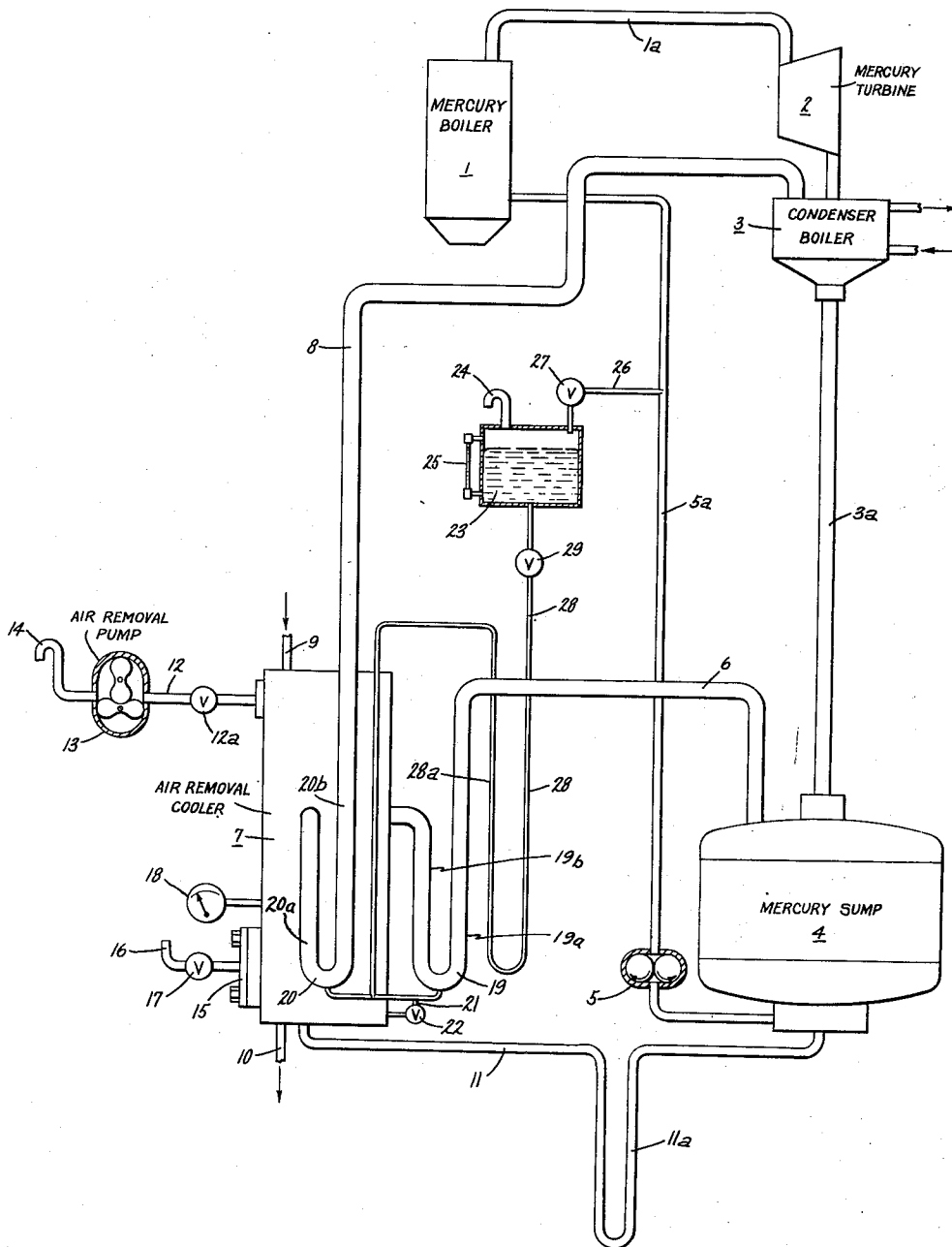
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SHUT-OFF ARRANGEMENT FOR MERCURY VAPOR SYSTEMS

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SHUT-OFF ARRANGEMENT FOR MERCURY
VAPOR SYSTEMSOrla L. Wood, Schenectady, and Harold N.
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This invention relates to mercury vapor power-plants, particularly to an arrangement for disconnecting a component from a mercury vapor system without permitting in-leakage of air into the system and without the necessity for shutting down the entire plant.

One of the few binary fluid cycles which has achieved some commercial success in the power generation field is that employing mercury as the primary liquid and water as the secondary liquid. Mercury is heated in a boiler and the vapor drives a mercury turbine. Spent mercury vapor is condensed in a "condenser-boiler" whence the liquid flows to a sump from which a boiler feed pump withdraws liquid mercury to repeat the cycle. Water is supplied to the condenser-boiler and the resulting steam is used to drive a steam turbine or for other purposes. In such a power plant, it is essential that special precautions be taken to preserve the purity of the mercury. Even though the system is thoroughly cleaned before being put into operation, it is found that the mercury inevitably picks up a substantial amount of dust and other dirt particles; and in spite of the exercise of greatest caution there will be a certain amount of leakage of air into the system with the resulting accumulation of dirt during normal operation of the power plant. This makes it necessary to provide means for continuously removing whatever dust and other dirt particles may accumulate in the system.

One way to effect this continuous removal of dirt from the mercury system is to create a vacuum in the mercury sump sufficient to effect evaporation of some of the mercury, the evaporating vapors serving to carry off the impurities to an "air removal cooler" where the mercury vapor is condensed and the non-condensable gases are drawn off by an air removal vacuum pump. This type of cleaning system is disclosed in United States Patent 2,196,003, issued in the name of O. L. Wood on April 2, 1940, and assigned to the same assignee as the present application.

In connection with such a cleaning system, a further problem arises from the necessity for periodically removing the accumulated impurities from the air removal cooler. It is, of course, highly desirable that this be accomplished without completely shutting down the mercury turbine power plant.

Accordingly, an object of the present invention is to provide an improved mercury cleaning system of the type described having special means for effecting isolation of the air removal cooler

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so that it may be opened and cleaned without shutting down the entire plant.

A further object is to provide an isolating arrangement of the type described which does not depend on mechanical valves to seal the vacuum, yet is capable of positively preventing the entrance of air into the system during the process of isolating and cleaning the air removal cooler.

Other objects and advantages will become apparent from the following description taken in connection with the accompanying drawing in which the single figure represents diagrammatically a mercury turbine power plant having means for isolating the air removal cooler in accordance with the invention.

Generally, the invention is practiced by providing in each vacuum conduit connected to the air removal cooler a U-shaped trap, with special means for filling and draining these liquid seals when it is desired to isolate the air removal cooler.

Referring now more particularly to the drawing, the invention is illustrated as applied to a mercury turbine power plant comprising a mercury boiler 1 supplying motive fluid to a turbine 2, the exhaust from which is condensed in a "condenser-boiler" 3, which also serves the purpose of generating steam for driving a steam turbine or for other purposes.

Liquid mercury collecting in the bottom of the condenser boiler 3, together with dirt particles picked up in the boiler, turbine, etc. is drained to the mercury sump 4, which is sealed air-tight and is capable of having a higher vacuum than that maintained in the condenser-boiler 3. This higher vacuum in the sump is produced by a conduit 6 connected directly to cooler 7, and causes some of the liquid mercury in the sump to flash into vapor and be drawn off to the cooler, carrying with it the dust and other dirt which accumulates on the surface of the liquid mercury in the sump. Thus, the sump serves the double purpose of separating the dirt or dust from the mercury and as a reservoir supplying the boiler feed pump 5, which returns liquid to the boiler 1 through the feed conduit 5a.

In accordance with the invention disclosed in the above-identified patent to Wood 2,196,003, the dirt or dust is removed from the mercury sump 4 by way of a vacuum conduit 6 communicating with the air removal cooler 7 as described above. Similarly, air and entrained gases separating in the condenser-boiler 3 may be drawn off to the air removal cooler 7 by a vacuum conduit 8. It will be appreciated that

the cooler 7 has tubes (not shown) through which is circulated a coolant such as water, admitted through inlet 9 and drained through conduit 10. The cooling action thus produced on the mercury vapor and "non-condensable" gases in the cooler 7 effects condensation of the mercury, which falls to the bottom of cooler 7 and is drained through the return conduit 11 having a U-seal 11a. The remaining uncondensed gases are drawn off through conduit 12 having a valve 12a to the air removal vacuum pump 13, which discharges to atmosphere through a suitable vent 14. To provide access for cleaning the cooler 7, a removable clean-out door 15 is provided. This carries an atmospheric vent 16 having a manually controlled bleed valve 17. A vacuum gauge 18 is located convenient to the valve 17 so that the operator can bring the air removal cooler to atmospheric pressure at a desired rate, and so that the access opening cover 15 will not be removed until the pressure inside the cooler 7 is atmospheric.

In accordance with the invention, each vacuum line connected to the cooler 7, specifically the vapor draw-off conduits 6, 8, are provided with U-seals 19, 20 respectively. During normal operation, these U-seals are kept free of condensed liquid by a gravity drain conduit 21 having branches connecting the lowermost portion of each U-seal with the interior of the cooler 7, or with some other portion of the system to which the sealing liquid can drain when the manual shut-off valve 22 is opened. It will be obvious that the arrangement of the U-seals and the sump 4 must be such that in normal operation the liquid level in the sump never rises high enough to enter the U-seals from the cooler 7.

The means for filling the liquid U-seals comprises an elevated supply tank 23 containing liquid mercury maintained at atmospheric pressure by the vent 24. A gage glass 25 or equivalent liquid level indicating means shows the level of mercury in the reservoir 23. The mercury used to seal the vacuum conduits 6, 8 is returned to the reservoir 23 by a return conduit 26 communicating with the boiler feed conduit 5a, and containing a valve 27. Sealing liquid is supplied from reservoir 23 by way of a conduit 28 containing a valve 29. This conduit 28 may conveniently be connected to the branched drain conduit 21 as clearly shown in the drawing. It is to be noted that the supply conduit 28 is provided with a U-seal 28a.

The manner in which this system is employed to positively isolate the air removal cooler 7 without using any mechanical valves in the vacuum conduits will be seen from the following.

When it is desired to clean out the air removal cooler 7, the seal drain valve 22 is closed, and the seal liquid supply valve 29 opened so that liquid mercury flows from the reservoir 23 through conduit 28 to fill the U-seals 19, 20, until the shorter legs 19b, 20a, are filled and liquid begins to overflow into the cooler 7. The air removal pump valve 12 is then closed and the bleed valve 17 opened to slowly admit air from the atmosphere to cooler 7. As the pressure in cooler 7 builds up to atmospheric, the liquid mercury in the U-seals 19, 20 rises in the comparatively long right-hand legs 19a, 20b, until the height of the mercury column in these legs is sufficient to balance the vacuum existing in the mercury system during normal operation. This mercury column in the U-seal legs 19a, 20b, thus preserves the normal vacuum in the mercury

sump 4 and the condenser-boiler 3, and the mercury vapor power plant can continue to operate while the clean-out door 15 is removed and the accumulated dirt removed from cooler 7. Similarly, the U-seal 11a seals the drain conduit 11.

To put the air removal system back into service, the clean-out door cover 15 is replaced and the bleed valve 17 closed. The vacuum pump valve 12a is then opened and the pump 13 brings the air removal cooler 7 down to the normal vacuum on the system. The valve 29 is then closed and the seal drain valve 22 opened so that the liquid in the U-seals 19, 20 flows into the cooler 7 through drain conduit 21. This, of course, means that the total amount of mercury in the system has been increased by the amount employed to seal the traps 19, 20. In order to return the amount of working fluid to its normal value, valve 27 is opened and mercury from the boiler feed conduit 5a permitted to flow back into reservoir 23 until the level therein, as indicated by gage 25, returns to its previous normal value.

While it is true that, during normal operation, some air may leak into cooler 7 through the mechanical valve 17, any such leakage air will be directly expelled by pump 13. During the process of isolating cooler 7 and cleaning the dirt therefrom, the cooler is entirely isolated from the vacuum parts of the system by liquid-filled U-seals, no mechanical valves being present to introduce the possibility that dirt may prevent the valves from seating tightly and thereby permit air to enter the system.

It will be seen that the invention provides a mechanically simple arrangement for effectively sealing the vacuum lines of a mercury vapor powerplant in order that one component thereof may be removed from the system for cleaning or other maintenance purposes.

While only one embodiment of the invention has been described specifically herein, it will be apparent to those skilled in the art that many substitutions of equivalents and modifications may be made. It is, of course, desired to cover by the appended claims all such changes as fall within the true spirit and scope of the invention.

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

1. In a mercury vapor powerplant having in series a boiler feed pump, mercury boiler, turbine, condenser-boiler, and mercury sump maintained under vacuum by a second pump for removing non-condensable gases from the system and an air removal cooler connected in series between the vacuum pump and the condenser-boiler and between the vacuum pump and the sump respectively, the combination of means for isolating the air removal cooler from the vacuum portions of the system comprising a first conduit for drawing off non-condensable gases from the condenser-boiler and including a first U-section, a second conduit for drawing off non-condensable gases from the sump and including a second U-section, the lowermost portion of said U-sections being above the bottom of the air removal cooler and connected thereto by a gravity drain conduit, first shut-off valve means in said drain conduit, an elevated mercury reservoir vented to atmosphere and connected by a seal supply conduit to said drain conduit between the shutoff valve and the U-sections, said seal supply conduit including a third U-section and a second shutoff valve between the third U-section and the reservoir, a seal liquid return conduit for bleeding mercury from the boiler feed pump back to said reservoir,

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third valve means in said seal liquid return conduit, and valved vent means for bringing the air removal cooler up to atmospheric pressure, whereby the air removal cooler may be isolated from the condenser-boiler and sump by closing said first drain valve and opening the seal liquid supply valve to fill all three U-sections, after which said valved vent may be opened to break the vacuum in the air removal cooler, the cooler being returned to service by closing the seal liquid supply valve and opening the drain valve to empty the first and second U-sections into the cooler after which the quantity of mercury in the system may be restored to normal by opening said third valve to admit mercury from the feed pump to the seal liquid reservoir.

2. In a mercury vapor powerplant having in series a boiler feed pump, mercury boiler, turbine, condenser-boiler, and a mercury sump maintained under vacuum by a second pump for removing non-condensable gases from the system and an air removal cooler connected in series between the vacuum pump and sump, the combination of means for isolating the air removal cooler from the sump comprising a conduit for drawing off non-condensable gases from the sump and including a U-section with one leg connected to the air removal cooler, a gravity drain conduit connecting the lowermost portion of said U-section with the air removal cooler, first shut-off valve means in said drain conduit, an elevated mercury reservoir vented to atmosphere and connected by a conduit for supplying sealing liquid to the U-section, the seal supply conduit having a second U-section and a second shutoff valve, and valved vent means for bringing the air removal cooler up to atmospheric pressure, whereby the cooler may be isolated from the sump by closing the gravity drain valve and opening the seal liquid supply valve to fill said U-sections, after which the valved vent may be opened to break the vacuum in the air removal cooler, the cooler being returned to service by closing the seal liquid supply valve and opening the gravity drain valve to empty the first U-section into the cooler.

3. In a mercury vapor plant having in series a boiler feed pump, a mercury boiler for generating mercury vapor under pressure, a mercury vapor energy consumer, a condenser-boiler and a mercury sump maintained under vacuum by a second pump for removing non-condensable gases from the system, and an air removal cooler connected in series between the vacuum pump and the sump, the combination of means for isolating the air removal cooler from the sump comprising a vacuum conduit for drawing off non-condensable gases from the sump and including a U-seal section, the lowermost portion of said U-seal being above the bottom of the air removal cooler and connected thereto by a gravity drain conduit, first shut-off valve means in said drain conduit, a mercury reservoir located substantially above the level of the air removal cooler and vented to atmosphere, a seal liquid supply conduit for conducting liquid from said reservoir to the lowermost portion of said U-seal, said seal supply conduit including a second U-seal and a second shut-off valve between the second U-seal and the reservoir, a seal liquid return conduit for bleeding mercury from the high pressure side of the system back to the seal liquid reservoir, third valve means in the seal liquid return conduit, and valved vent means for bleeding air into said cooler for bringing the pressure therein up to atmospheric, whereby the air removal cooler may

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be isolated from the mercury sump by closing said first drain valve and opening the seal liquid supply valve to fill said U-seal sections, after which said valved vent may be opened to break the vacuum in the air removal cooler, the cooler being returned to service by closing the seal liquid supply valve and opening the drain valve to empty the first U-seal into the cooler, after which the quantity of mercury in the system may be restored to normal by opening said third valve to admit mercury from the high pressure portion of the system to the seal liquid reservoir.

4. In a thermal energy transfer and conversion system having hydraulic circuits filled with a vaporizable liquid the purity of which must be carefully preserved by continuously removing dirt therefrom during normal operation, said hydraulic circuits including a liquid sump maintained under a substantial vacuum by an air removal pump and having an air removal cooler in series between the pump and sump, the combination of means for isolating the air removal cooler from the sump comprising a vacuum conduit for drawing off non-condensable gases from the sump and including a U-seal section, the lowermost portion of U-seal being above the bottom of the air removal cooler and connected thereto by a gravity drain conduit, first shut-off valve means in the drain conduit, a liquid reservoir located substantially above the level of the air removal cooler and vented to atmosphere, a seal liquid supply conduit for conducting liquid from said reservoir to the lowermost portion of the U-seal, the seal supply conduit including a second U-seal and a second shut-off valve, and valved vent means for bleeding gas into the cooler for bringing the pressure therein up to atmospheric, whereby the air removal cooler may be isolated from the sump by closing the gravity drain valve and opening the seal liquid supply valve to fill said U-sections, after which the valved vent may be opened to break the vacuum in the air removal cooler, the cooler being returned to service by closing the seal liquid supply valve and opening the drain valve to empty the first U-seal into the cooler.

5. In a thermal energy transfer and conversion system having hydraulic circuits filled with a vaporizable liquid the purity of which must be carefully preserved by continuously removing dirt therefrom during normal operation, said hydraulic circuit including a liquid sump maintained under a substantial vacuum by an air removal pump and having an air removal cooler in series between the pump and sump, the combination of means for isolating the air removal cooler from the sump comprising a vacuum conduit for drawing off non-condensable gases from the sump and including a U-seal section, a drain conduit communicating with the lowermost portion of the U-seal, first shut-off valve means in said drain conduit, a source of liquid located substantially above the level of the U-seal, a sealing liquid supply conduit for conducting liquid from said reservoir to the U-seal, the seal supply conduit including a second U-seal and a second shut-off valve, and valved vent means for bleeding gas into the cooler to bring the pressure therein up to atmospheric, whereby the air removal cooler may be isolated from the sump by closing the drain valve and opening the seal liquid supply valve to fill said U-seals, after which the valved vent may be opened to break the vacuum in the air removal cooler, the cooler be-

ing returned to service by closing the seal liquid
supply valve and opening the drain valve.

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