Nov. 4, 1930. B. L. NEWKIRK 1,780,683

METHOD AND APPARATUS FOR HEAT REMOVAL BY MERCURY

Filed Aug. 4, 1927

Fig. 1

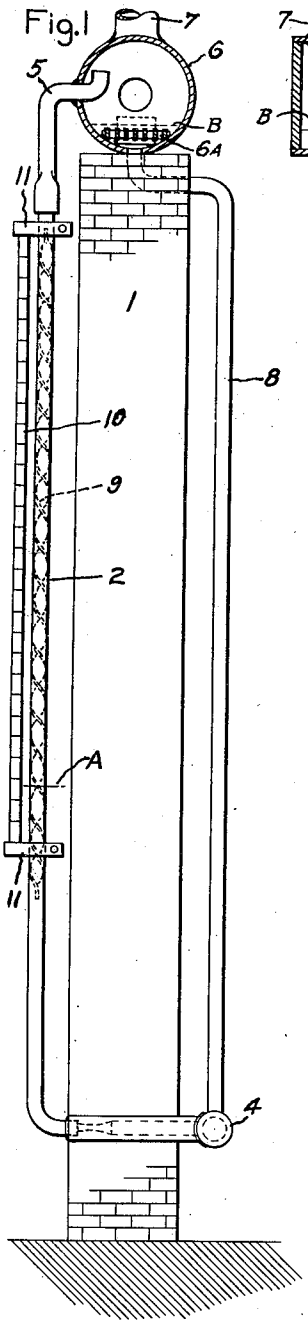


Fig. 2

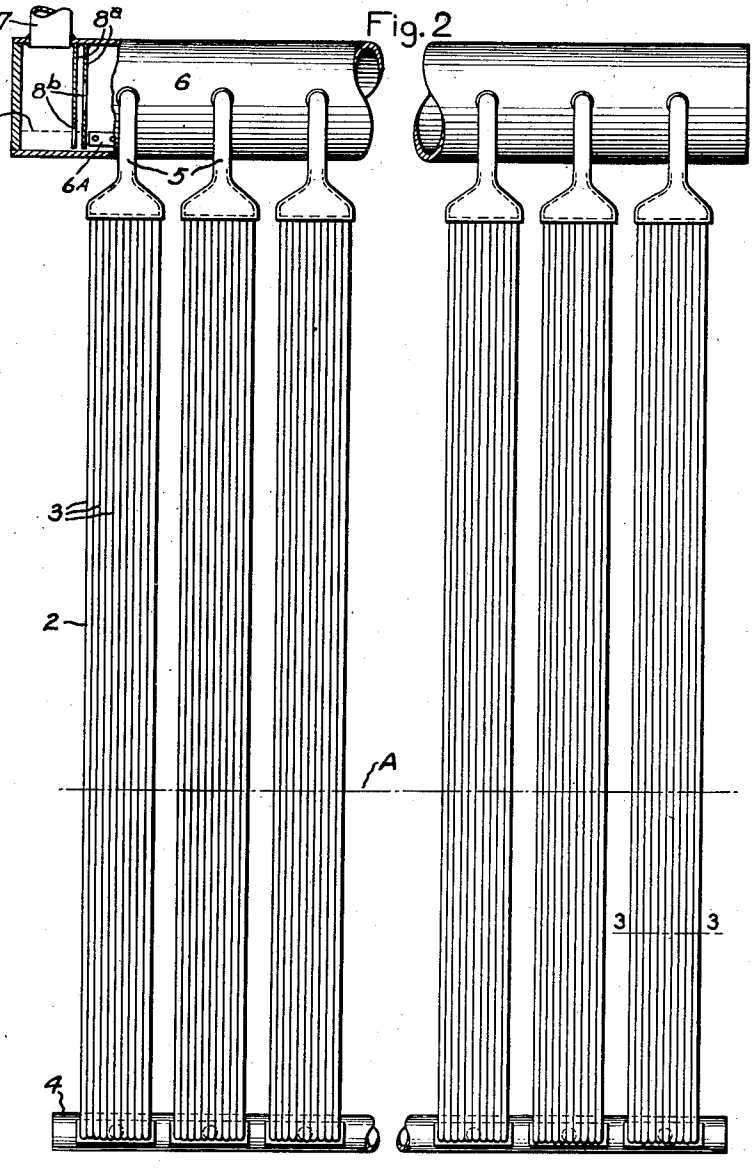


Fig. 4

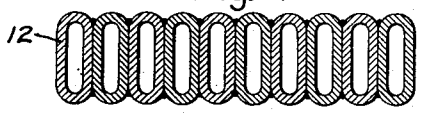
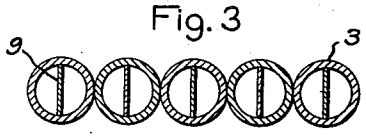


Fig. 3



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UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR HEAT REMOVAL BY MERCURY

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In connection with apparatus, such as boilers, for the removal of heat by mercury, that is to say, in connection with boiler apparatus for vaporizing mercury, it is essential, for known reasons, to reduce to a minimum the amount of mercury required for operation. On the other hand, however, it is essential that sufficient mercury be provided to remove adequately the heat from the wall of the boiler tube or other container which is exposed to the fire or the hot gases, or otherwise the tube or other container will be burned or distorted.

Mercury vapor has a very low specific heat, and only a moderate density when used at the low pressures now employed in known mercury vapor boilers. It is, therefore, a poor agent for the removal of heat from any surface. On this account it has been considered necessary heretofore in the design of mercury boilers, so to construct them that always there would be liquid mercury washing the walls from which any considerable amount of heat was to be removed.

This has been a limiting factor in reducing the amount of mercury required in the operation of mercury vapor generating apparatus.

The object of my present invention is to provide an improved method and apparatus whereby the amount of mercury required in a mercury vapor generating apparatus for its safe operation may be still further reduced, and for a consideration of what I believe to be novel and my invention, attention is directed to the accompanying description and the claims appended hereto.

I have found that a mixture of mercury liquid and mercury vapor which mixture is predominantly vapor by volume is a fairly good agent for the removal of heat from the walls of a container, such as a boiler tube, it being substantially better than mercury vapor although not as good as liquid mercury. According to my invention, therefore, I create a mixture of mercury liquid and mercury vapor, which mixture is predominantly vapor by volume, and utilize such mixture in the removal of heat from the boiler tube or other container. The mixture is in the form of mercury vapor through which is distributed globules of liquid mercury. By predominantly vapor by volume, I mean mixtures wherein the percentage of liquid by volume is comparatively small. For example, I have found mixtures wherein the volume of liquid to vapor was of the order of 1½% to 2% satisfactory. It is to be understood, however, that these figures are given only by way of example and are not to be taken as limitations for my invention.

In construction a mercury vapor generating apparatus embodying my invention, I preferably so arrange it that those portions of the heating surfaces which must transmit large amounts of heat are cooled by liquid mercury, the remaining surfaces being cooled by a mixture of mercury liquid and mercury vapor.

In carrying out the invention I use preferably also means to separate the minute liquid globules from the vapor before passing the vapor on to a turbine or other apparatus. This can be accomplished by centrifuging or by causing the mixture to sweep over a surface of liquid mercury, preferably so that the stream of the mixture changes direction in such manner that the globules of liquid tending more than the vapor to move in straight lines, strike a surface of liquid mercury and coalesce with it.

As one means of carrying out my invention I may employ a mercury container in the form of a long tube of comparatively small bore. By a long tube I mean a tube of the order of ten feet or more in length, and by a tube of comparatively small bore I mean a tube having an inside diameter of the order of 0.4 of an inch. For example I have found a tube ten feet long and having an inside diameter of 0.38 of an inch satisfactory. I then supply liquid mercury under suitable pressure to the lower end of the tube. With this arrangement, the intense heat applied to the lower portion of the tube causes vigorous ebullition and effects the formation of a mixture of mercury vapor and mercury liquid in the tube above the mercury liquid therein depressing the level of the liquid in the tube. This mixture, sweeping along the walls of the upper portion of the tube, serves to remove the heat therefrom and vaporize some of the globules of mercury in the mixture.

By the above described arrangement, I am enabled to reduce substantially the amount of mercury required in a mercury vapor generating apparatus, the proportion of liquid by volume in the working mixture being extremely small.

I may with advantage employ a special means or device in the tube or container to break up the liquid into small globules and to cause this mixture to sweep past or aaginst the surfaces to be cooled. For example, in the case of a long tube of small bore, I may use a twisted or helical strip in the tube which extends from a point in the vicinity of the top of the tube to a point below the liquid level in the tube. This serves to give the rising column of liquid and vapor a whirling motion which breaks up the liquid, and causes the liquid particles to make numerous contacts with the surfaces to be cooled.

A mixture of mercury liquid and mercury vapor, as described, is effective as an absorber of heat because any introduction of heat into a quantity of the mixture vaporizes some of the liquid but does not increase the temperature of the mixture. The presence of the globules of liquid gives the mixture a property which may be described as that of an infinitely great specific heat, in that the introduction of a comparatively large amount of heat into the mixture may take place without raising the temperature to any appreciable extent. For example, a quantity of the mixture at 100 pounds pressure and containing 90 percent liquid by weight could absorb without increase in temperature about eight hundred times as much heat as would be required to raise the temperature of an equal volume of mercury vapor alone (i. e. without liquid globules) fifty degrees F. Such a mixture, however, (being at 100 pounds per sq. in. absolute pressure and consisting of 10% vapor and 90% liquid by weight) would fill a volume over fifty times as great as it would if it were all liquid. It follows, therefore, that by the use of a mixture of this sort I accomplish two important results in that first I provide a substance which is very much superior to mercury vapor alone as an agent to remove heat from a surface, and second I provide a substance which is very much superior to the mercury liquid alone in its capacity to cover and remove heat from a large surface because of the relatively large volume of the mixture.

These two properties of the mixture, viz: capacity to absorb a large amount of heat without increase in temperature and, large volume compared with that of the liquid, render this mixture very useful in reducing substantially the quantity of mercury liquid required in the operation of a mercury vapor generator.

In the drawing, wherein I have shown my invention applied to a wall screen for a furnace, Fig. 1 is an end view of a furnace wall provided with a wall screen; Fig. 2 is a face view of the construction shown in Fig. 1, the protective refractories for the wall screen being omitted; Fig. 3 is a detail sectional view on a larger scale taken on line 3—3, Fig. 2; and Fig. 4 is a sectional view of a modification.

Referring to the drawing, 1 indicates a furnace wall and 2 indicates generally a wall screen in front of it. The wall screen comprises a number of sets of tubes, each set being made up of long tubes 3 of comparatively small bore, the individual tubes of each set being welded or otherwise fastened together. At their lower ends the sets of tubes communicate with a liquid supply conduit 4 and at their upper ends they communicate through conduits 5 with a vapor drum 6. B represents the level of liquid mercury in drum 6. The ends of conduits 5 are turned upward so that the vapor enters the drum at an angle with the radial direction whereby centrifuging action results. 7 indicates a conduit through which mercury vapor may be drawn off from drum 6. Circulation of liquid from drum 6 to supply conduit 4 is effected by means of a pipe 8 which connects the lower portion of drum 6 to supply conduit 4. 6A indicates a grid to prevent the liquid mercury from being washed away from the entrance to the pipe 8 by the blast from conduit 5. The line A indicates an approximate normal level of mercury liquid in tubes 3 when boiling is in progress, the portion of the tubes below the line A containing mercury liquid while the portion above the line A contains a mixture of mercury liquid and mercury vapor. It will be understood that the liquid level in the tubes 3 may vary to a considerable extent, the line A indicating, as stated above, what may be considered an approximate normal level for satisfactory operation. In drum 6 is a baffle 8^a provided with openings 8^b through which the vapor flows to conduit 7.

The level of liquid is maintained at A by the back pressure of the mixture of vapor and liquid in the tube above level A. The location of the level A in any tube 3 depends upon the amount of heat being transferred by that tube. If a small amount of heat is being transferred, the level is high, but when the heat transfer is near the capacity of the tube, level A is near the bottom of the tube. The hydrostatic pressure due to difference in level between level B in drum 6 and level A is required to drive the vapor and entrained liquid out of the tube.

In each tube is a twisted strip 9 which extends from a point in the region of the upper end of the tube to a point below the liquid level in the tube for giving a whirling motion to the rising column of liquid and vapor.

In using a wall screen of the type shown, care is necessary to design and operate the

furnace so that the tubes shall not become overheated above the liquid line A. To this end it is desirable that a large proportion of the total wall area of the furnace be covered by the screen, otherwise heated refractories may radiate an excessive amount of heat to the tubes. It is important also not to push the furnace and boiler too hard by burning too much coal in a given furnace space. Finally where the service is too severe to permit the use of tubes unprotected above the liquid level A, refractories may be added and supported from the tubes themselves, in accordance with any known method so as to protect the tubes. Such refractories are indicated at 10 in Fig. 1, the same being supported by suitable brackets 11 carried by the tubes.

In Fig. 4 I have shown a modification wherein the tubes 12, corresponding to the tubes 3 of Figs. 1 to 3 are flat instead of round, this being a construction which in some cases may be desirable.

A mercury vapor generating apparatus built in accordance with my invention has not only the advantage that it utilizes a smaller amount of mercury, but also the additional advantage that by the use of long tubes, the required amount of heating surface can be introduced into a generator with fewer parts to be handled in manufacture and with fewer joints. In this connection it will be understood that the minimizing of the number of joints is a matter of considerable importance from a practical standpoint in that it serves to reduce the danger of leakage.

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

1. The method of transferring heat in a mercury vapor generating apparatus which comprises generating an intimate mixture of mercury vapor and finely divided mercury liquid which is predominantly vapor in volume but not in weight, and passing such mixture along the heated surface to absorb heat therefrom.

2. In a boiler for the transfer of heat to mercury for generating mercury vapor, the method which comprises utilizing an intimate mixture of mercury vapor and finely divided mercury liquid as a heat absorbing agent, said mixture being predominantly vapor in volume but not in weight.

3. In the generation of mercury vapor the method which comprises generating first an intimate mixture of mercury vapor and finely divided mercury liquid, which is predominantly vapor by volume but not by weight, using this mixture to absorb heat and then separating the vapor from the liquid.

4. In the generation of mercury vapor the method which comprises generating first an intimate mixture of mercury vapor and finely divided mercury liquid which is predominantly vapor by volume but not by weight, using the mixture to absorb heat and then separating the vapor from the liquid by centrifuging.

5. In a process for generating mercury vapor the method which comprises generating first an intimate mixture of mercury vapor and finely divided mercury liquid which is predominantly vapor by volume, using the mixture to absorb heat and then separating the vapor from the liquid by changing the direction of motion of the mixture.

6. In a mercury vapor generating apparatus the combination of means for generating an intimate mixture of mercury vapor and finely divided mercury liquid, and means for supplying heat to said mixture.

7. In a mercury vapor generating apparatus, the combination of means for generating an intimate mixture of mercury vapor and finely divided mercury liquid, a heated surface, and means for effecting the passage of said mixture into contact with said heated surface.

8. In a mercury vapor generating apparatus, the combination of means for generating an intimate mixture of mercury vapor and finely divided mercury liquid, and means for supplying heat to said mixture, said first-named means comprising tubes of substantial length and comparatively small bore.

9. In a mercury vapor generating apparatus, the combination of means for generating an intimate mixture of mercury vapor and finely divided mercury liquid, said means comprising tubes of substantial length and comparatively small bore, means for supplying heat to said tubes, and means for supplying liquid mercury to said tubes.

10. In a mercury vapor generating apparatus, the combination of means for generating an intimate mixture of mercury vapor and finely divided mercury liquid, said means comprising substantially vertical tubes of substantial length and comparatively small bore, means for supplying heat to said tubes, and means for supplying liquid mercury to said tubes.

11. In a mercury vapor generating apparatus, the combination of means for generating an intimate mixture of mercury vapor and finely divided mercury liquid, said means comprising substantially vertical tubes of substantial length and comparatively small bore, means for supplying heat to said tubes, means for supplying liquid mercury to said tubes, and means associated with said tubes to aid in effecting generation of said mixture.

12. In a mercury vapor generating apparatus, the combination of means for generating an intimate mixture of mercury vapor and finely divided mercury liquid, said means comprising substantially vertical tubes of substantial length and comparatively small bore, means for supplying heat to said tubes, means for supplying liquid mercury to said

tubes, and means for separating the vapor from the mercury liquid after the mixture has passed out of said tubes.

13. In a mercury vapor generating apparatus, the combination of means for generating an intimate mixture of mercury vapor and finely divided mercury liquid which is predominantly vapor in volume but not in weight, said means comprising tubes of substantial length and comparatively small bore, means for supplying heat to said tubes, and means for supplying liquid mercury to said tubes.

14. In a mercury vapor generating apparatus, the combination of means for generating an intimate mixture of mercury vapor and finely divided liquid mercury, said means comprising tubes of substantial length and comparatively small bore, means for supplying heat to said tubes, means for supplying liquid to said tubes, and means in said tubes for imparting a whirling motion to the moving column of mercury liquid and mercury vapor in the tubes.

15. In a mercury vapor generating apparatus, the combination of means for generating an intimate mixture of mercury vapor and finely divided mercury liquid, said means comprising substantially vertical tubes of substantial length and comparatively small bore, means for supplying heat to said tubes, means for supplying liquid mercury to the lower ends of said tubes, and means in said tubes for imparting a whirling motion to the rising column of mercury liquid and mercury vapor in the tubes.

16. In a mercury vapor generating apparatus, the combination of a furnace wall, means in front of said wall for generating an intimate mixture of mercury liquid and mercury vapor, said means comprising tubes of substantial length and comparatively small bore, means for supplying heat to said tubes, and means for supplying liquid mercury to said tubes.

17. In a mercury vapor generating apparatus, the combination of a furnace wall, means in front of said wall for generating an intimate mixture of mercury liquid and mercury vapor, said means comprising substantially vertical tubes of substantial length and comparatively small bore, means for supplying liquid mercury to said tubes, and means in front of the upper portions of said tubes for protecting such portions from intense heat.

In witness whereof, I have hereunto set my hand this 3d day of August, 1927.

BURT L. NEWKIRK.