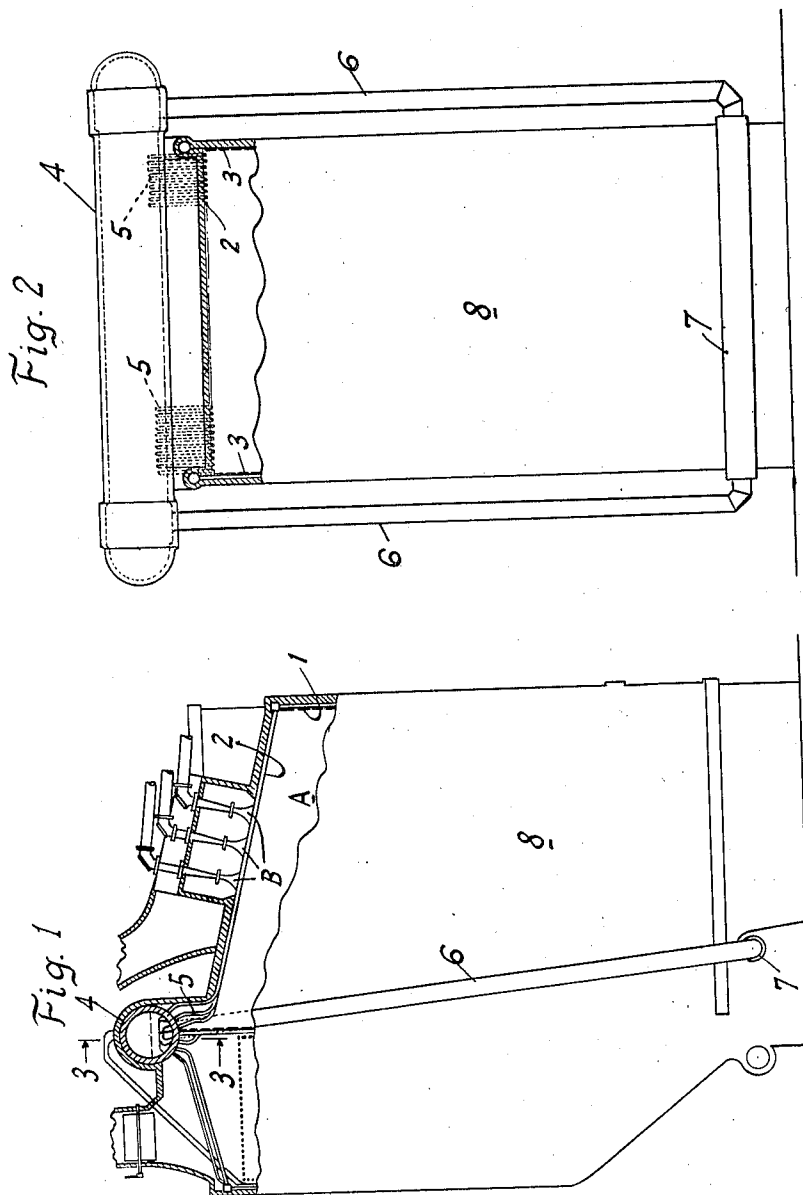


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J. C. HOBBS
FLUID CIRCULATION APPARATUS
Filed July 31, 1940

2,316,765

2 Sheets-Sheet 1



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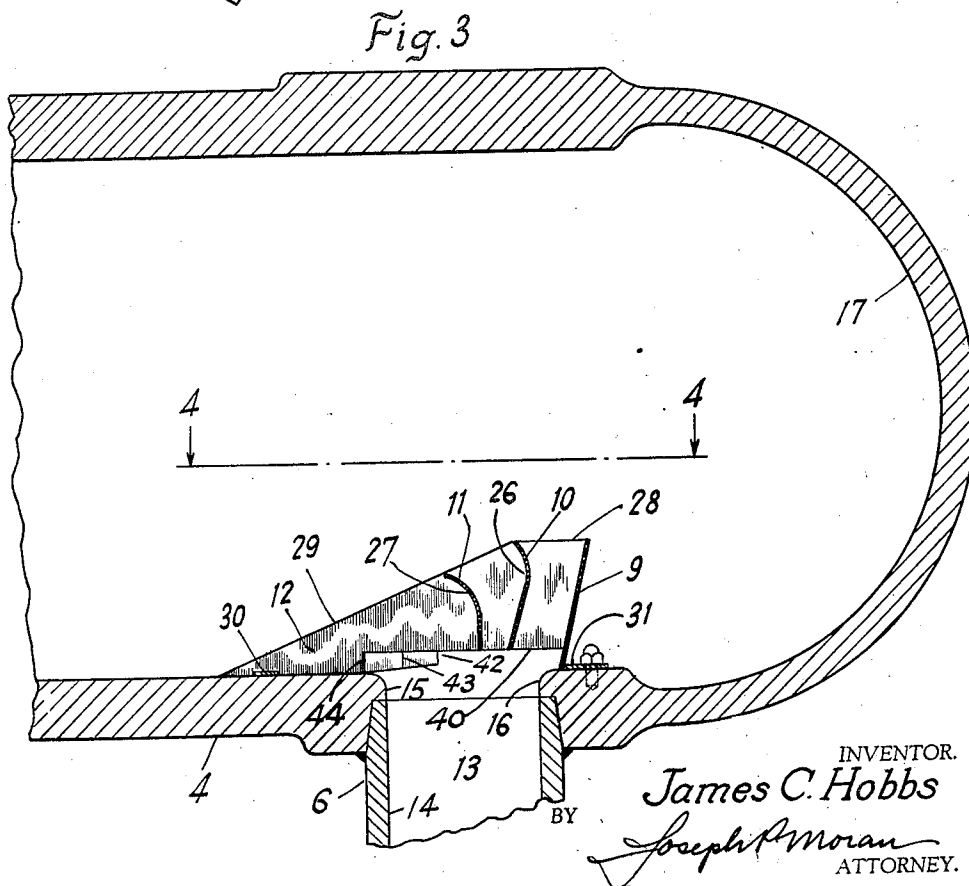
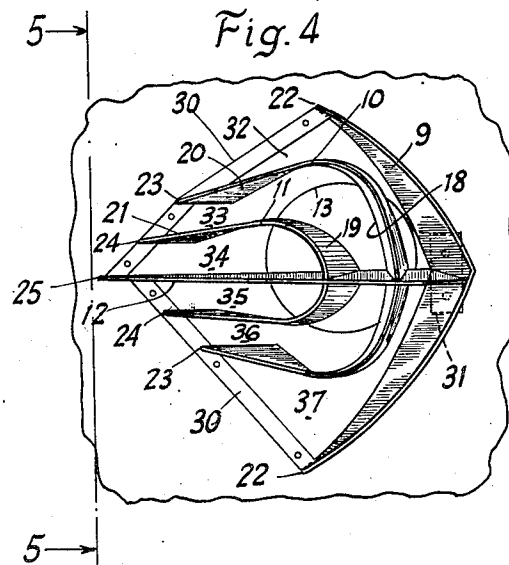
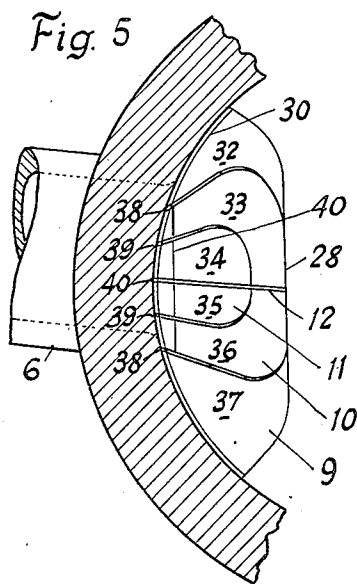
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FLUID CIRCULATION APPARATUS

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2 Sheets-Sheet 2



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FLUID CIRCULATION APPARATUS

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Application July 31, 1940, Serial No. 348,840

11 Claims. (Cl. 122-406)

The present invention relates in general to fluid circulation apparatus and in particular to such apparatus as is adapted for improving the characteristics of fluid flow in a natural circulation boiler.

In boilers of the natural circulation type, operating at high capacities and high rates of heat absorption, it is essential that a maximum differential in hydraulic head be maintained between the downflow and upflow sections of the fluid circulatory system. In certain types of modern boilers, the number of downcomers is limited and individual downcomers are of large diameters to accommodate the quantity of water required for the high rates of steam generation. Such downcomers may conveniently be connected to an elevated steam and water drum of the boiler at its ends, and be disposed exteriorly of the boiler setting where they are shielded from the heat of the furnace. Under certain conditions, a disturbance may be set up in the water within the drum which will cause a vortical action in water entering the downcomers; the result being a reduction in the effective hydraulic head in the downflow section of the system and thereby an impairment of the boiler circulation.

In order to improve flow conditions in such a system, and in accordance with contemporary practice, it is proposed to divide the liquid flowing longitudinally of the drum into a plurality of streams, and to direct each stream toward a predetermined unit area or division of the total flow area of the drum outlet passage.

Heretofore, such streams have represented predetermined proportionate divisions of the total flow of liquid for a substantially constant level condition, and have been directed toward similarly proportionate divisions of the total outlet area. However, with varying levels of liquid within the drum, there are produced variations in the cross sectional areas of individual streams so that the desired equality or proportionate relation is not maintained at different levels, particularly in horizontally disposed cylindrical drums, unless suitable provision is made, for example, as disclosed in the present application.

Therefore, as an object of the invention, it is proposed to make allowance for variations in liquid level within the drum, so that for all levels throughout the normal operating range of levels, each stream represents a substantially constant proportion of the total flow of liquid and is discharged through a correspondingly proportionate division of the total outlet area; the streams and outlet divisions being either equal

or unequal in their individual cross-sectional areas.

The foregoing objects and others are made more apparent by the description which follows, and by the accompanying drawings in which:

Fig. 1 is a side elevation, partly in section, indicating a type of boiler favorable to utilization of the invention;

Fig. 2 is an end elevation of Fig. 1, partly in section;

Fig. 3 is an enlarged fragmentary section of Fig. 1 taken along line 3-3;

Fig. 4 is a fragmentary plan of parts shown in Fig. 3;

Fig. 5 is an end section of Fig. 4.

Figs. 1 and 2 indicate a boiler of the natural circulation type capable of generating vapor at high rates and at high pressures and temperatures; for example, such a boiler may have steam generating capacities of several hundred thousand pounds of steam per hour, and operate at pressures in excess of 2000 lb. per square inch. In the boiler shown, an associated furnace chamber A is fired by suitable means such as fuel burners B, and a large proportion of the vapor generating surface is incorporated in the furnace walls and therefore subjected to intense heat of radiation from the burning fuel. The furnace heating surface may include a plurality of groups of tubes, such as the front wall tubes 1, the roof tubes 2 and the side wall tubes 3, suitable connections being provided so that the vapor generated within these tubes, together with unvaporized liquid, is discharged into the horizontally disposed cylindrical drum 4 through a plurality of connectors 5 which are arranged at relatively close spacings in one or more rows throughout a major intermediate portion of the drum length. The unvaporized water, together with the additional quantity of make-up water required for steam generation, is supplied from the elevated drum 4 through connections which include the downcomers 6 and the distributing header 7, the downcomers having their upper ends connected to opposite end portions of the drum 4 beyond the intermediate location at which liquid enters the drum through the connectors 5.

The downcomers 6 preferably extend downwardly from the drum exteriorly of the boiler setting 8 and have their lower ends connected to the distributing header to which the lower ends of the upflow generating tubes are connected. A level of water may be maintained in the upper drum 4 at approximately the hori-

zontal center line as indicated but certain conditions of operation might make it desirable to maintain a level either below or above the center line position.

In the circulatory system as thus described, the tubes forming the upflow section derive their total supply of liquid, either directly or indirectly, from a lower header such as 7, and all such tubes discharge their total content of heated liquid, or liquid and vapor mixed, into a common upper drum such as 4.

The downcomers 6 as shown are circular conduits of relatively large internal diameter to provide adequate flow area for the quantity of liquid which is continuously returned to the lower part of the upflow section at a rate necessary to maintain the desired high rate of vapor generation. The flow area provided by any downcomer is greater than the flow area of any tube discharging into the drum, but for practical considerations the total downflow area is only a fraction of the combined flow area of all such discharging tubes. The total flow area afforded by the downcomers may also represent only a fraction of the transverse cross section of the normal liquid content of the drum.

The location of such downcomers relative to the entrances for liquid into drum 4 throughout its central portion requires that the liquid attain a high velocity of flow longitudinally of the drum in its approach to a downcomer, and an accelerated velocity as the direction of flow is changed and the liquid enters the downcomer. Such conditions have been found to be conducive to the formation of a vortex in the body of liquid above and within the downcomer, and thus there is a two-fold effect on the extent of hydraulic head available for maintaining circulation; first a loss due to the acceleration of velocity at the entrance, and second, a loss due to the formation of the vortex. The vortex under certain conditions may be hollow and penetrate to a considerable distance below the upper surface of the liquid within the drum, and in some instances may actually extend within the downcomer; in such cases the effect of the vortex is accentuated and the hydraulic head further reduced due to the presence of vapor or gas in the downflow section of the system.

Figs. 3, 4 and 5 illustrate in detail a form of apparatus which in accordance with the objects of the invention has been devised for the purpose of counteracting or entirely preventing the vortical action in the downflow section of a fluid circulatory system. The structure as shown which is known as a vortex inhibitor, comprises a nested arrangement of arched plates or vanes 9, 10, 11 and a flat division plate or vane 12 assembled in a generally horizontal position within the drum 4 adjacent the entrance to the water outlet 13 which includes in this instance the passage 14 provided by the downcover 6 and the aligned outlet opening 15 in the drum wall having a rounded peripheral edge 16. It will be noted that the flow axis of the outlet 13 is inclined to the vertical in order to provide a direct path of flow to the distributing header 7 by eliminating bends in the downcomer 6. The end of the drum is closed by a spherical head 17 providing drum space beyond the downcomer connection, and the arrangement of parts is the same for the opposite end of the drum except that the vortex inhibitor faces in the opposite direction.

The outer arched vane 9 and the arched por-

tions 18, 19 of vanes 10, 11 respectively are of generally conical formation relative to a horizontal base plane tangent to the inner wall of the drum, the arched portions of vanes 10, 11 merging into inclined flat plate portions 20, 21 toward their leading edges. The bottom edge of the outer vane 9 is shaped to provide a close fit with the inner wall of the drum and so positioned longitudinally of the drum as to embrace the entire perimeter of the drum outlet 13; the intermediate vane 10 and the inner vane 11 extending across the entrance to outlet 13. The leading edges 22 of the outer vane 9 extend forwardly to approximately the center line of the drum outlet while the leading edges 23, 24, 25 of the vanes 10, 11 and division plate 12, extend forwardly of the drum outlet at successively varying distances. The intermediate vane 10 and the inner vane 11 are curved inwardly at their upper edges as at 26, 27, from one side of the division plate to the other through an angle of approximately 180 deg. where the vanes are faired into the flat portions 20, 21. The heights to which the plates extend within the drum are determined by the horizontal plane 28, containing an upper edge portion of the outer vane 9 and division plate 12, and the inclined plane 29 which contains the leading edges of all plates. The vanes 9, 10, 11 and division plate 12 are suitably assembled and the leading edges of the plates rigidly supported by flat bars 30 which are bent to lie against the drum wall, the bars being secured to the drum at intervals. A further support is provided by a clip 31 welded to the outer vane 9 and bolted to the drum.

The plates thus formed and arranged subdivide the longitudinally flowing body of water within the drum into a plurality of streams, and provide a corresponding number of stream-lined passages, 32, 33, 34, 35, 36, 37, through which the streams are directed to their respective proportionate cross sectional areas of the downflow passage. The bottom edges 38, 39, 40, of the flat portions 20, 21 of vanes 10, 11, and of the division plate 12, are preferably arranged parallel to the longitudinal axis of the drum and are spaced horizontally at equal distances transversely of the drum, the division plate being arranged substantially parallel to the downcomer axis and the flat portions being inclined inwardly toward the downcomer entrance. The vanes which extend across the entrance to the downcomer, namely, the arched vanes 10, 11 and the division plate 12, may be cut away along their bottom edges to a level indicated by the plane 40 on a convenient radius intersecting the plates at 42, 43 and 44 respectively.

The reference to the arched vanes 9, 10, 11 having portions of generally conical formation does not imply that these vanes must necessarily have a contour of a geometric conical shape; a major consideration being to provide a contour of surface which will afford substantially uniform flow areas at the entrances to the various passages, and that the passages will be maintained of the same proportionate areas throughout their lengths. A further consideration is that passages of a given proportionate area will discharge to downcomer cross sectional areas of substantially the same proportionate relation, and where the area of a passage changes from its area at the entrance to a different area at the outlet, the change in area is made gradually. These same relations are preferably maintained for different water levels within the drum; for example, if the

passages are of substantially equal areas at one level, a change in level would increase or decrease the passage areas but would not substantially affect the equality relation.

While the foregoing description is made with reference to a specific embodiment of the invention, it is to be understood that variations may be made in the form of apparatus without departing from the spirit of the invention.

I claim:

1. In combination, an elevated drum having inlet and outlet means for liquid at horizontally spaced locations, a conduit extending downwardly from said drum for conducting liquid discharged through said outlet means under conditions conducive to the formation of a vortex, and means for directing liquid into said outlet means with a minimum turbulence and loss of velocity head comprising upwardly extending plates forming passages having entrances for liquid arranged transversely of said drum in advance of said outlet, said plates being formed and arranged to divide the approaching body of liquid into a plurality of streams of substantially the same proportionate cross-sectional areas for different levels of liquid within said drum.

2. In combination, an elevated drum having inlet and outlet means for liquid at horizontally spaced locations, said outlet means including a conduit of circular cross section extending downwardly from said drum, said outlet means having sufficient flow capacity for conducting liquid therethrough at a rate contributing to vortical movement of said liquid, and means for discharging liquid from said drum through said conduit while inhibiting vortical action in the discharging liquid comprising a plurality of arched vanes in nested arrangement forming passages having entrances for liquid arranged transversely of said drum in advance of said outlet, said vanes having upstream end portions formed and arranged to divide the approaching body of liquid into a plurality of streams of substantially the same proportionate cross-sectional areas for different levels of liquid within said drum.

3. In combination, an elevated drum having inlet and outlet means for liquid at horizontally spaced locations, said outlet means including a conduit of circular cross section extending downwardly from said drum, said outlet means having sufficient flow capacity for conducting liquid therethrough at a rate contributing to vortical movement of said liquid, and means for discharging liquid from said drum through said conduit while inhibiting vortical action in the discharging liquid comprising arched vanes in nested arrangement forming passages having entrances for liquid forwardly of said outlet means, said vanes having portions extending longitudinally of the drum in advance of said outlet means and arranged at an inclination to the vertical.

4. In combination, an elevated drum having inlet and outlet means for liquid at horizontally spaced locations, said outlet means including a conduit of circular cross section extending downwardly from said drum, said outlet means having sufficient flow capacity for conducting liquid therethrough at a rate contributing to vortical movement of said liquid, and means for discharging liquid from said drum through said conduit while inhibiting vortical action in the discharging liquid comprising arched vanes in nested arrangement forming passages having entrances

for liquid forwardly of said outlet means, said vanes having rearward arched portions of generally conical formation and connected forward longitudinally extending portions arranged at an inclination to the vertical.

5. In combination, an elevated drum having inlet and outlet means for liquid at horizontally spaced locations, said outlet means including a conduit of circular cross section extending downwardly from said drum, said outlet means having sufficient flow capacity for conducting liquid therethrough at a rate contributing to vortical movement of said liquid, and means for discharging liquid from said drum through said conduit while inhibiting vortical action in the discharging liquid comprising arched vanes in nested arrangement forming passages having entrances for liquid forwardly of said outlet means, one of said arched vanes embracing the downstream margin of said outlet means, said nested vanes being inclined to the vertical throughout their lengths and defining a plurality of flow passages for liquid approaching and entering said outlet means.

6. In combination, an elevated drum having inlet and outlet means for liquid at horizontally spaced locations, said outlet means including a conduit of circular cross section extending downwardly from said drum, said outlet means having sufficient flow capacity for conducting liquid therethrough at a rate contributing to vortical movement of said liquid, and means for discharging liquid from said drum through said conduit while inhibiting vortical action in the discharging liquid comprising arched vanes in nested arrangement forming passages having entrances for liquid forwardly of said outlet means, one of said arched vanes embracing the downstream margin of said outlet means, said nested vanes being inclined to the vertical throughout their lengths and defining a plurality of flow passages for liquid approaching and entering said outlet means, said flow passages having cross sectional areas at their entrances different from their cross sectional areas adjacent said outlet means.

7. In a fluid circulatory system including an elevated drum, said drum having inlet and outlet means for liquid at horizontally spaced locations requiring horizontal flow of liquid through said drum for discharge through said outlet means under conditions conducive to the formation of a vortex, a fluid-directing device assembled adjacent said outlet means including an outer arched member embracing the downstream margin of said outlet means, an inner arched member nested within said outer arched member and extending across the entrance to said outlet means, a division plate extending longitudinally of said drum in intersecting relation with said nested members, said division plate extending forwardly of said outlet means a greater distance than the leading edges of said arched members.

8. In a fluid circulatory system including an elevated cylindrical drum having inlet and outlet means for liquid at longitudinally spaced locations requiring horizontal flow of liquid within said drum for discharge through said outlet means under conditions conducive to the formation of a vortex, said outlet means having its axis of flow directed downwardly from said drum, means for inhibiting vortical action in liquid flowing into and through said outlet means comprising upright plates formed and arranged

to divide the approaching body of liquid into a plurality of streams and to provide passages for directing said streams toward different cross-sectional areas of said outlet means, said plates being so disposed in relation to the vertical as to maintain a substantially constant proportionate relation between the cross-sectional areas of said streams at varying levels of liquid within said drum.

9. In a fluid circulatory system including an elevated cylindrical drum having inlet and outlet means for liquid at longitudinally spaced locations requiring horizontal flow of liquid within said drum for discharge through said outlet means under conditions conducive to the formation of a vortex, said outlet means having its axis of flow directed downwardly from said drum, means for inhibiting vortical action in liquid flowing into and through said outlet means comprising upright plates formed and arranged to divide the approaching body of liquid into a plurality of streams and to provide passages for directing said streams toward different cross-sectional areas of said outlet means, said plates having portions adjacent the entrances to said passages so disposed in relation to the vertical as to provide a substantially equal distribution of liquid to all passages at varying levels of liquid within said drum.

10. In a fluid circulatory system including an elevated cylindrical drum having inlet and outlet means for liquid at longitudinally spaced locations requiring horizontal flow of liquid within

said drum for discharge through said outlet means under conditions conducive to the formation of a vortex, said outlet means having its axis of flow directed downwardly from said drum, means for inhibiting vortical action in liquid flowing into and through said outlet means comprising upright plates having portions arranged in spaced relation transversely of said drum for dividing the approaching body of liquid into a plurality of streams, certain plates having portions curved horizontally to form arches in nested arrangement adjacent said outlet means for directing said streams toward different areas of said outlet means, said plates extending upwardly within said drum to progressively higher levels in a downstream direction.

11. In combination with an elevated drum having horizontally spaced inlet and outlet means for liquid, a downcomer extending downwardly from said outlet means, said outlet means and said downcomer each having sufficient flow capacity for the discharge of liquid from said drum at a rate contributing to vortical flow into said downcomer, and means for directing liquid received through said inlet means toward and into said downcomer comprising spaced plates extending longitudinally of the direction of flow of said liquid and arranged edgewise of said outlet means whereby multiple paths are provided for liquid flowing toward and into said downcomer, said plates having downwardly converging portions.

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