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Percy

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[54] **COOLING SYSTEM**

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[52] **U.S. Cl.** **261/151**, 62/305, 165/160, 261/152, 261/DIG. 11

[51] **Int. Cl.** **B01f 3/04**

[58] **Field of Search** 261/DIG. 11, 111, 151, 261/152, 153, 155, 156; 62/305; 165/160, 176

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Assistant Examiner—Richard L. Chiesa
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[57] **ABSTRACT**

A cooler includes a casing in the form of a tower located over a liquid reservoir. A conduit in an upper part of the tower has discharge nozzles to provide a downward spray of cooling water which precipitates into the reservoir, and a contra air flow produced by means of an induced or forced straight fan mixes with the cooling water in an atmospheric section of the tower, heat exchange contact elements (fill) preferably being provided in this atmospheric section to encourage heat exchange between the water and the air. The cooler is of closed-circuit form, the cooling water being recycled from the reservoir to the discharge nozzles by a return conduit including a pump; and conduits for process liquid extend into the reservoir. A process liquid inlet and a discharge are provided to and from the conduits, and baffle plates are located in the reservoir to direct cooling water over the conduits for heat exchange between the water and the process liquid.

6 Claims, 6 Drawing Figures

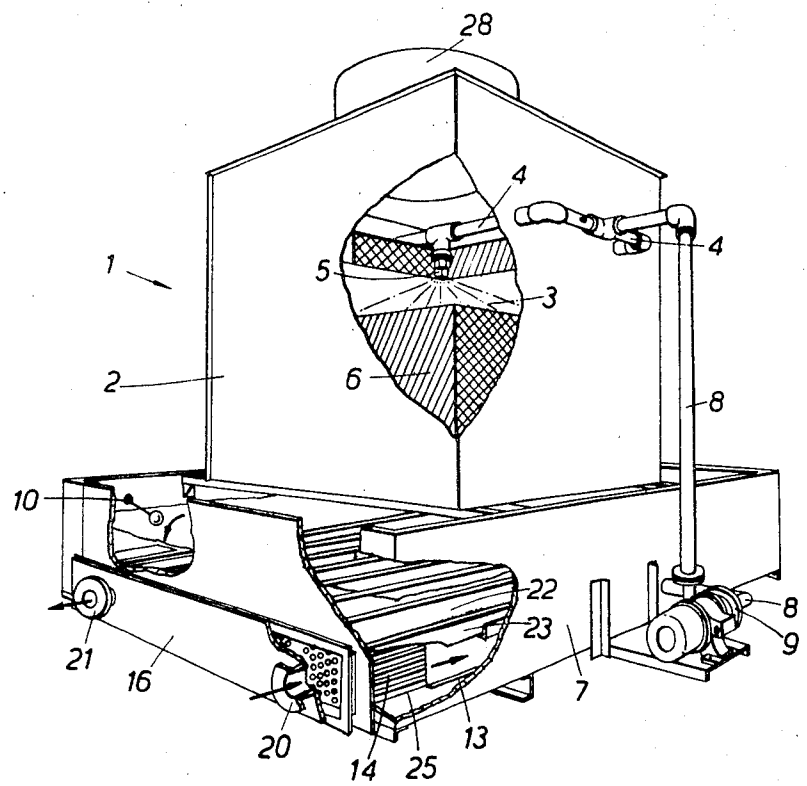


FIG. 1.

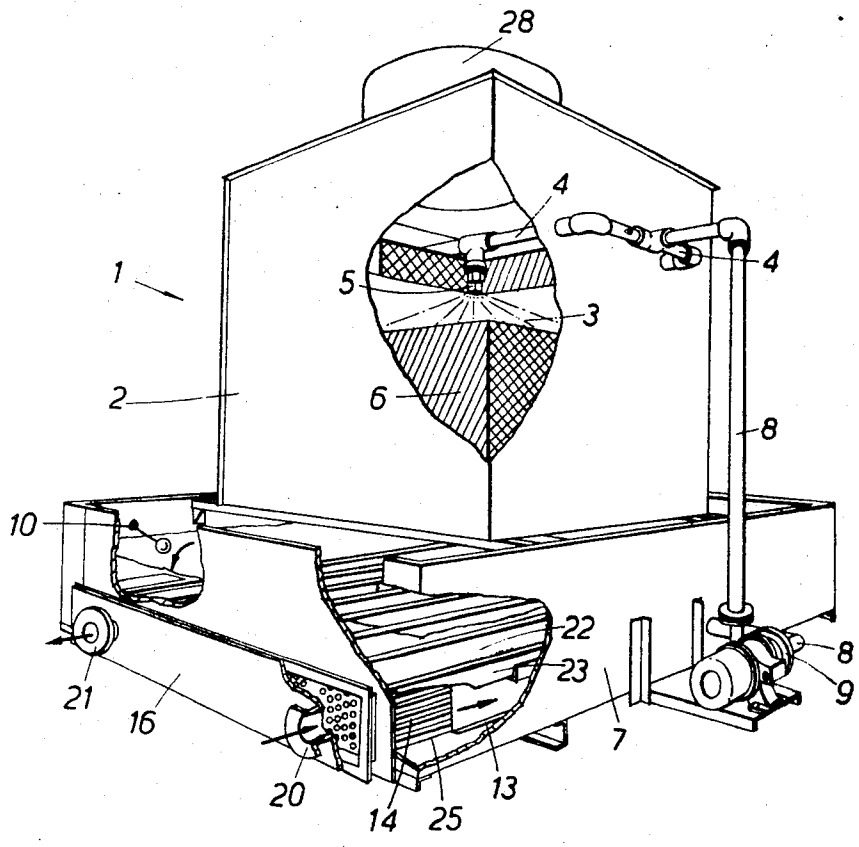
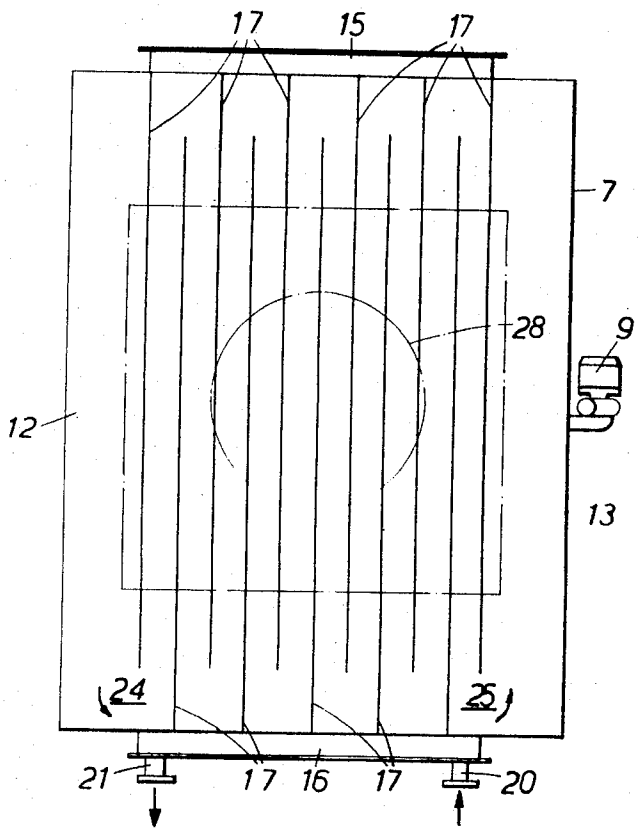


FIG. 2.



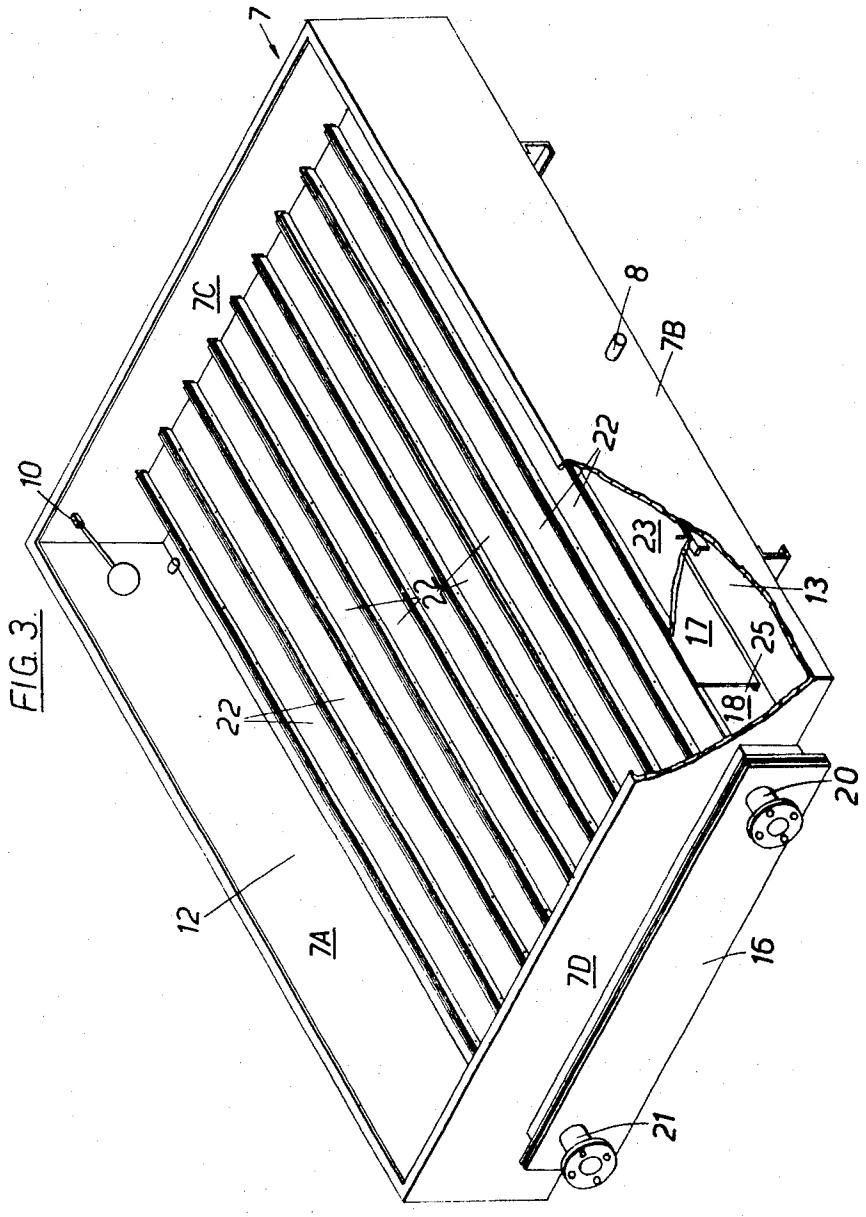


FIG. 3.

FIG. 4.

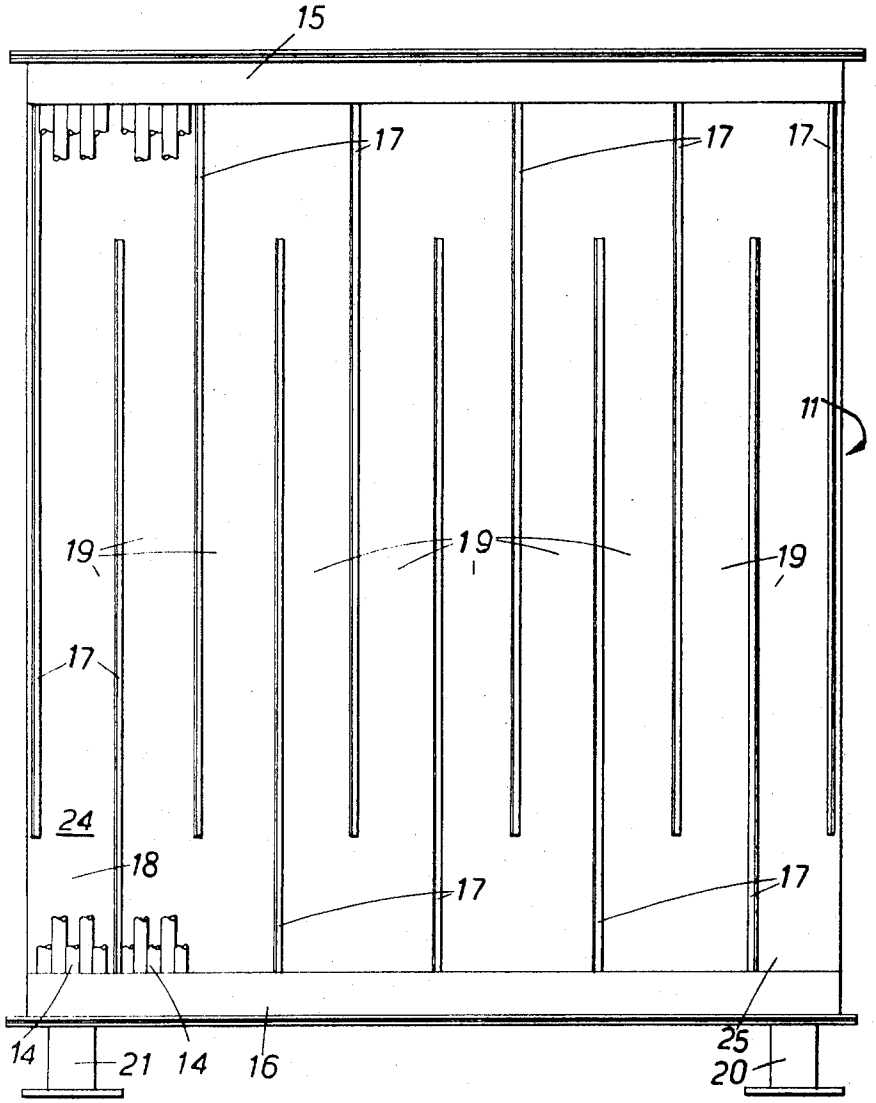


FIG. 5.

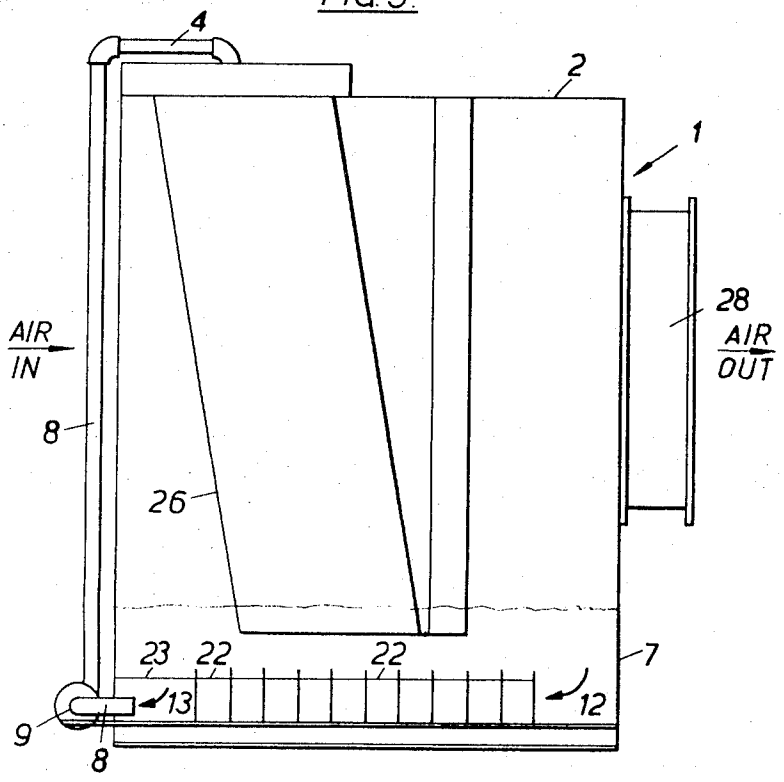
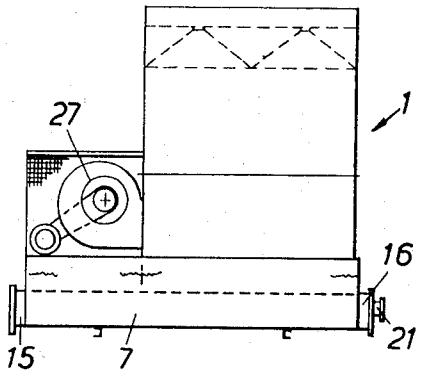


FIG. 6.



COOLING SYSTEM

The present invention relates to cooling apparatus including a casing in which heat exchange occurs between a flow of primary liquid discharged from an outlet in the casing and a flow o gas induced to or forced to mix with the primary liquid, particularly but not exclusively wherein the gas has a counterflow or cross-flow relationship with the primary liquid. Such apparatus is hereinafter referred to as cooling apparatus of the type aforesaid.

One known form of cooling apparatus of the type aforesaid is the conventional cooling tower comprising an upright casing with a discharge conduit for primary cooling water in an upper zone of the casing including discharge nozzles to provide a downward spray of primary water, an induction or forced draught fan to create an upward flow of air for mixing with the primary water, and a reservoir at the foot of the casing to receive the primary water. In one arrangement, a coil of process liquid tubes projects into an atmospheric section of the casing and in the path of the primary water spray to provide cooling of the process liquid: and the tower may be of closed-circuit type wherein the primary water is recycled to the discharge conduit from the reservoir. It is an object of the present invention to provide a cooling tower of improved efficiency in comparison with the conventional tower.

According to the present invention there is provided cooling apparatus for cooling a fluid flow, comprising in combination; a vertical casing; a discharge outlet for primary liquid arranged at an upper part of the vertical casing so as to discharge a downward flow of primary liquid within the casing; means for creating an induced or forced draft of gas to mix with the primary liquid within the casing for heat exchange between the gas and the primary liquid; a reservoir for primary liquid at the foot of the vertical casing including vertical baffle means defining a series of parallel culverts within the reservoir; the culverts being arranged for sinuous flow of primary liquid therethrough; an end channel located at one end of the reservoir; an inlet to the reservoir for flow of primary liquid from the end channel into the reservoir for flow therethrough; duct means in the casing for directing primary liquid to said end channel; an outlet for primary liquid from the reservoir; recycling conduit means for recycling primary liquid from the reservoir outlet to the primary liquid discharge outlet; heat exchange conduit means for secondary liquid extending into the culverts so that heat exchange occurs between the primary and secondary liquids in the reservoir; and an inlet to and an outlet from the heat exchange conduit means for secondary liquid.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a pictorial sectional view of a cooling tower according to the present invention:

FIG. 2 shows a schematic plan view of the cooling tower of FIG. 1:

FIG. 3 shows a pictorial view in part section of the cooling water reservoir of the tower of FIG. 1 including a culvert assembly for heat exchange between the cooling liquid and secondary process liquid:

FIG. 4 shows in detail a plan view of the culvert assembly of FIG. 3 prior to fitting in the reservoir of FIG. 3:

FIG. 5 shows a modified form of cooling tower according to the present invention: and

FIG. 6 shows a cooling tower similar to that shown in FIG. 1 but using forced draught fans.

Referring to FIGS. 1 and 2, a cooling tower 1 includes a casing 2 wherein a downward spray of heated primary cooling water 3 is cooled by an upflow of cooling air, a water spray discharge conduit 4 including discharge nozzles 5 being provided at the top of the casing 2. Contact bodies (fill) 6 are provided in the casing to facilitate heat transfer between the primary water 3 and the air, and the cooled primary water 3 precipitates into a reservoir 7 located at the foot of the casing 1. A recirculation pipeline 8 including a pump 9 recycles the primary water 3 from the reservoir 7 to the discharge conduits 4 in the casing; and the water level in the reservoir 7 is maintained constant by feed water discharge 10 controlled through a float actuated valve (not shown) compensating for primary water loss through evaporation.

A funnel 28 is located at the top of the casing 2 for the discharge of air from the tower 1 and this funnel 28 may house an induction fan (not shown) to assist the air flow.

Referring more particularly to FIGS. 3 and 4, a culvert heat-exchange assembly 11 (FIG. 4) is located within the reservoir 7 so as to provide side passage 12, 13 (FIG. 3) between the assembly 11 and side walls 7A, 7B of the reservoir 7. The heat-exchange assembly 11 comprises a parallel series (FIG. 4) of tube bundles 14 (ten in FIG. 4) adapted to extend through the reservoir 7 between a pair of headers 15, 16 located at opposed sides 7C, 7D of the reservoir 7, and a parallel series of vertical baffle plates 17 are mounted in staggered relationship on a base plate 18 of the assembly to form a culvert 19 for each of the tube bundles 14 and to direct primary water longitudinally over the tubes of the bundle 14. The header 16 includes an inlet 20 and an outlet 21 for secondary process liquid and a series of top plates 22 (FIG. 3) is fastened over the baffle plates 17, the plates 22 together with an end cover 23 over the side passage 13 forming a false bottom in the reservoir and such that primary liquid is directed to the side passage 12 subsequent to entry to the culvert assembly 11 via inlet 24. The primary liquid is discharged into the side passage 13 via outlet 25 whence it is passed to outlet conduit 8 and the tube-header arrangement 14, 15, 16 is such that the liquid flow in one tube bundle 14 is contra to that in the adjacent tube bundle(s) 14: and the primary water is directed in counterflow over the tubes of each bundle 14 for efficient heat transfer between the primary water and secondary process liquid. By the use of secondary liquid in the above described heat exchanger arrangement, cooled uncontaminated liquid can be supplied to installations for example, generators, refrigeration plant, as otherwise would not be the case if the primary water were delivered direct to such installations, since the primary water is liable to contamination by air impurities and concentration of dissolved salts. The arrangement also provides for efficient heat transfer, by virtue of the multiplicity of tube bundles 14 and water to liquid heat transfer.

In one example, primary water at 73°F precipitates into the reservoir while secondary water at 95°F is supplied to the tube bundles; and the outlet temperatures are respectively 86°F, 80°F for primary/secondary water flows of 90/78 gallons per minute (gpm) respec-

tively, but other water flow and temperature values are of course possible and the specification of the heat-exchange assembly **11** (number of tubes, tube lengths etc.) to provide these values is readily calculable using known heat transfer formulae.

Modifications are of course possible in the above described apparatus. In particular while the primary water and secondary liquid are described as having counterflow, it would be possible to have other forms of flow, for example at least partial parallel flow. It may be desirable to circuit the secondary liquid twice per culvert so that there may in fact be a combination of parallel/counterflow between the primary water and secondary liquid in each culvert.

Further, instead of the primary water and air having a counterflow relationship, it would be possible for them to have other flow relationships. For example, FIG. **5** shows a tower **1** having inclined fill **26** for the mixing of the primary water and air flows and arranged for horizontal air flow so as to provide a crossflow relationship between the primary water and the air. Also, referring to FIG. **6** a forced draught fan (or fans) **27** is used in addition to or as an alternative to the induced draught fan. Whereas in the described embodiment, the primary water was discharged vertically downwards, it would be possible to have cooling apparatus according to the present invention where the primary water is sprayed horizontally or at an angle inclined to the horizontal; and it will be understood that the reservoir **7** and culvert heat-exchange assembly **11** could be arranged and orientated differently from that described but still satisfying the present invention.

The above cooling tower according to the present invention has the following advantages:

i. A higher concentration of impurities can be tolerated in the cooling water due to the washing action of the water in the culverts. The atmospheric section i.e. the mixing zone of the primary water and air determines the permissible impurity level:

ii. Water distribution problems over the tubes are minimised due to the straight tubes/culvert combination:

iii. Easy accessability to the tube bundle for cleaning or maintenance:

iv. The straight tube/box header arrangement allows several process fluids to be cooled at the same time.

The design of the above cooling tower according to the present invention is such that the maximum temperature driving force is maintained between the cooling and process liquids. Unlike the conventional designs of closed circuit cooling towers there is no appreciable fall-off in cooling of the process liquid. For equal duty i.e. gpm cooled through a given range, theoretical analysis indicates overall heat transfer co-efficients which lie between 2 and 2.5 times that for the conventional tower.

I claim:

1. Cooling apparatus for cooling a fluid flow, comprising in combination; a vertical casing; a discharge outlet for primary liquid arranged at an upper part of the vertical casing so as to discharge a downward flow of primary liquid within the casing; means for creating an induced or forced draft of gas to mix with the primary liquid within the casing for heat exchange between the gas and the primary liquid; a reservoir for primary liquid at the foot of the vertical casing including vertical baffle means defining a series of parallel culverts within the reservoir; the culverts being arranged for sinuous flow of primary liquid therethrough; an end channel located at one end of the reservoir; an inlet to the reservoir for flow of primary liquid from the end channel into the reservoir for flow therethrough; duct means in the casing for directing primary liquid to said end channel; an outlet for primary liquid from the reservoir; recycling conduit means for recycling primary liquid from the reservoir outlet to the primary liquid discharge outlet; heat exchange conduit means for secondary liquid extending into the culverts so that heat exchange occurs between the primary and secondary liquids in the reservoir; and an inlet to and an outlet from the heat exchange conduit means for secondary liquid.

2. Cooling apparatus for cooling a fluid flow, comprising in combination; a vertical casing; a discharge outlet for primary liquid arranged at an upper part of the vertical casing so as to discharge a downward flow of primary liquid within the casing; means for creating an induced or forced draft of gas to mix with the primary liquid within the casing for heat exchange between the gas and the primary liquid; a reservoir for primary liquid at the foot of the vertical casing including vertical baffle means defining a series of parallel culverts within the reservoir; the culverts being arranged for sinuous flow of primary liquid therethrough; an end channel located at one end of the reservoir; an inlet to the reservoir for flow of primary liquid from the end channel into the reservoir for flow therethrough; a roof for the culverts receiving the downward flow of primary liquid and directing the primary liquid to said end channel; an outlet for primary liquid from the reservoir; recycling conduit means for recycling primary liquid from the reservoir outlet to the primary liquid discharge outlet; heat exchange tubes for secondary liquid extending into the culverts so that heat exchange occurs between the primary and secondary liquids in the reservoir; and an inlet to and an outlet from the tubes for secondary liquid.

3. Cooling apparatus as claimed in claim **2,** wherein the tubes are in the form of tube banks each bank extending through a respective culvert of the reservoir so that the primary liquid is directed along a tube bank in a culvert.

4. Cooling apparatus as claimed in claim **3,** wherein the culverts are arranged to direct the primary liquid in counterflow to the secondary liquid in the tube banks.

5. Cooling apparatus as claimed in claim **4,** wherein a parallel series of tube bundles extend between headers at opposed sides of the reservoir, with the arrangement such that secondary liquid flows in counterflow in alternate tube bundles, and the inlet and outlet for secondary liquid are provided on the headers.

6. Cooling apparatus as claimed in claim **5,** wherein an outlet passage for primary liquid is provided at an end of the reservoir opposite to said end channel, the outlet passage and said end channel extending parallel to the culverts.

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