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EVAPORATIVE HEAT EXCHANGER WITH AIRFLOW REVERSAL BAFFLE

Filed May 20, 1968

Sheet 1 of 3

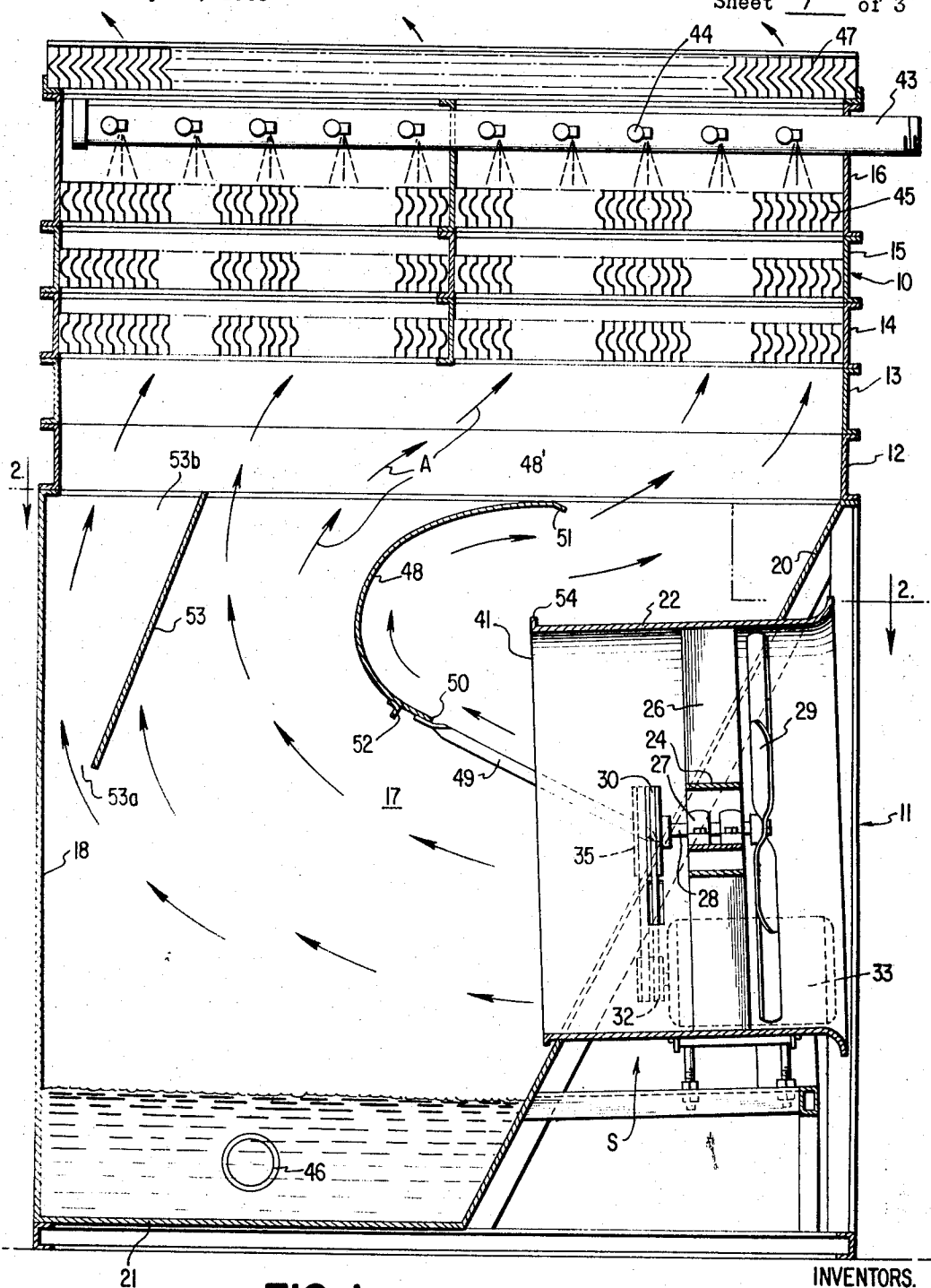


FIG. 1

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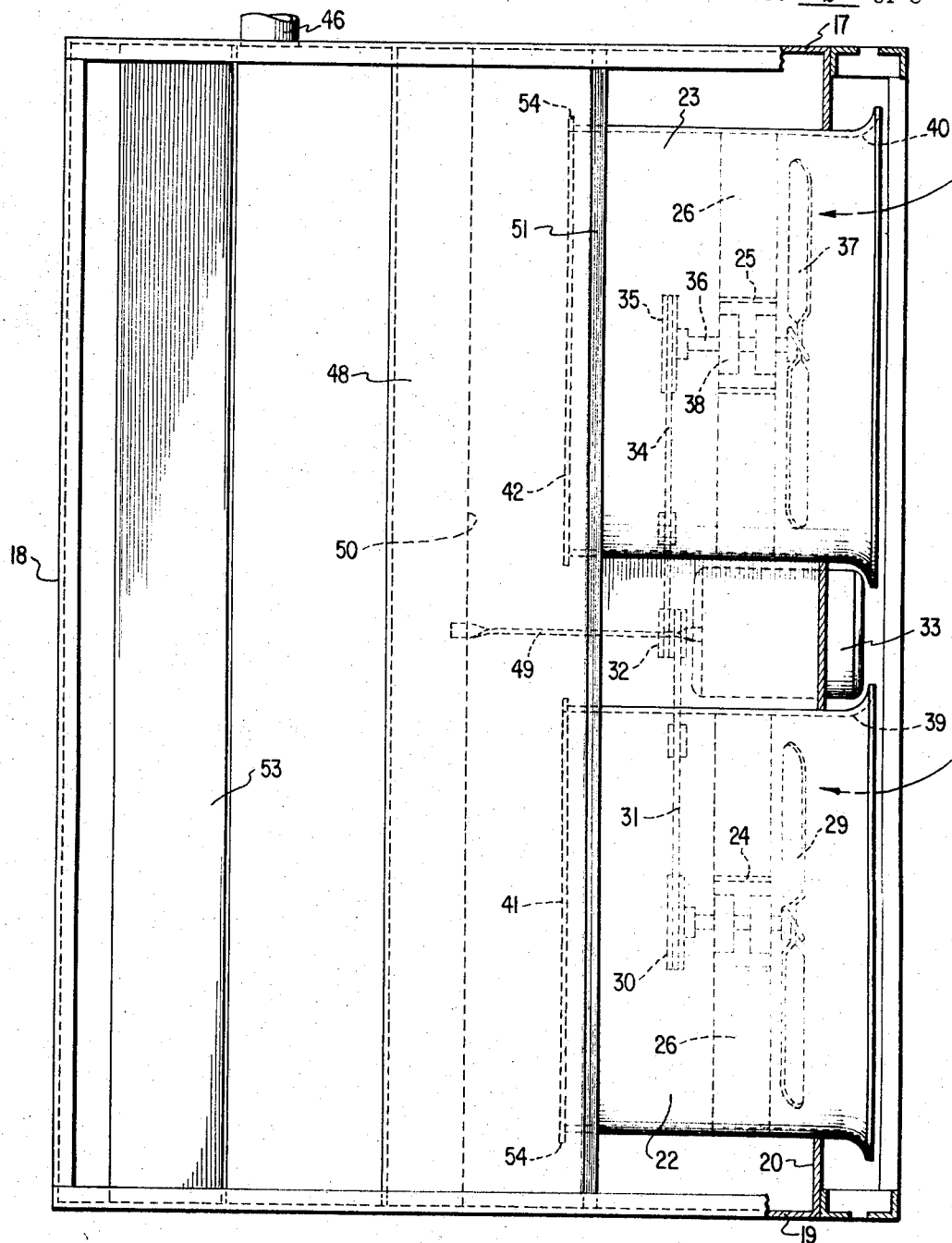


FIG. 2

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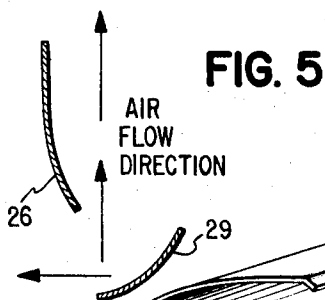
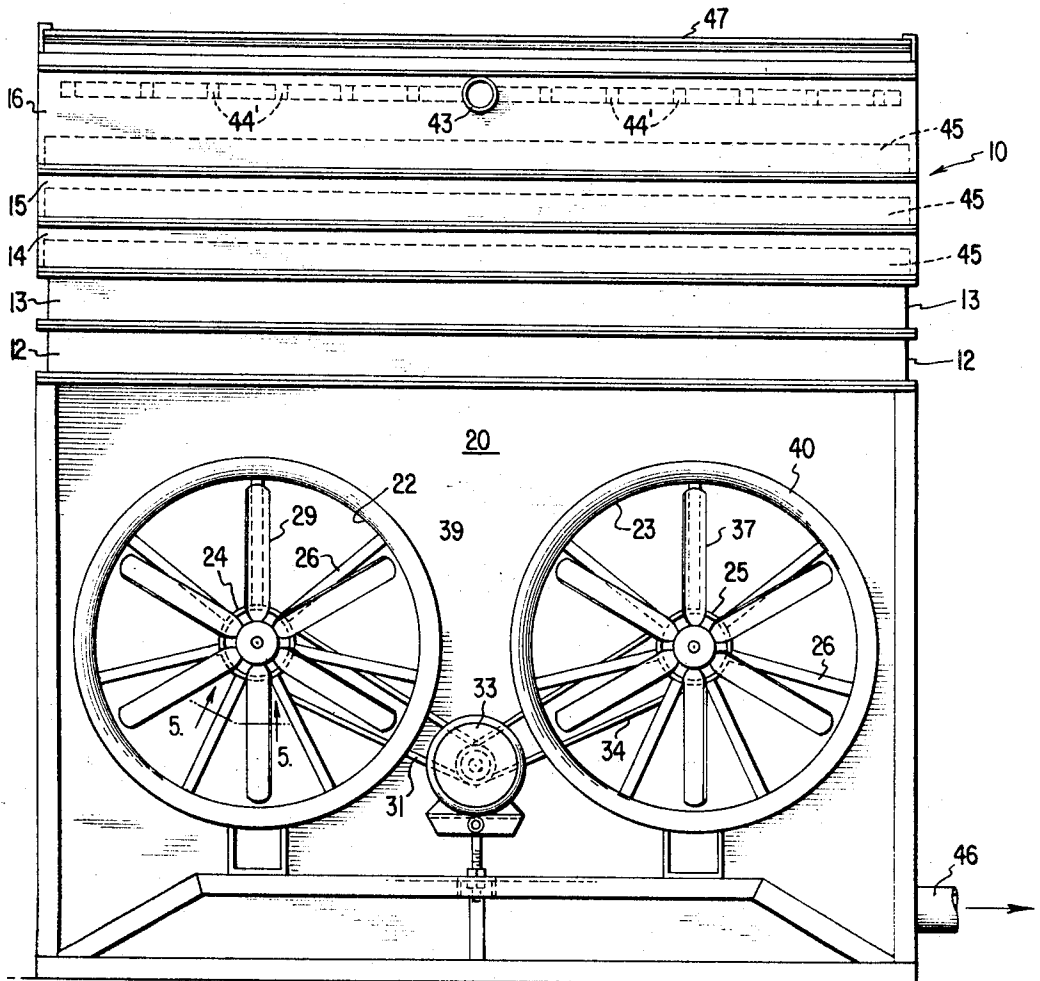


FIG. 3

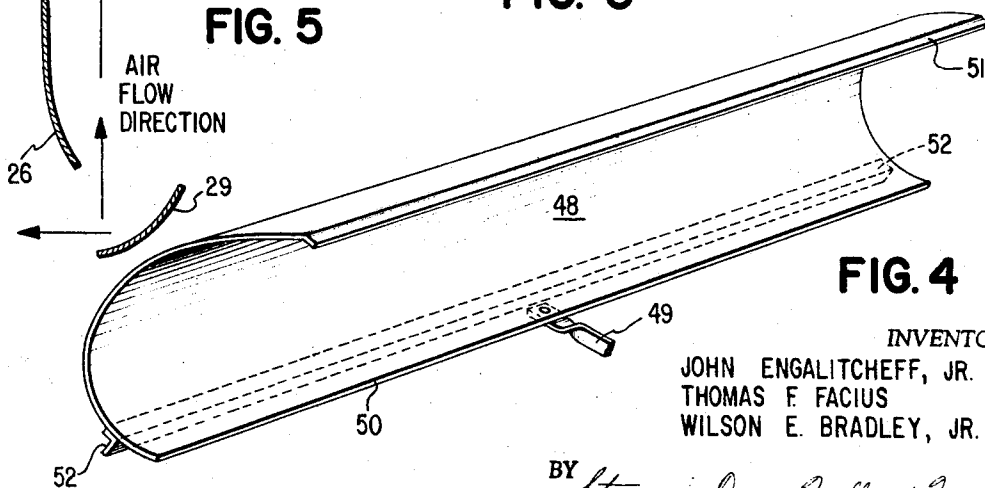


FIG. 4

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## EVAPORATIVE HEAT EXCHANGER WITH AIR-FLOW REVERSAL BAFFLE

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Continuation-in-part of application Ser. No. 711,772, Mar. 8, 1968. This application May 20, 1968, Ser. No. 730,574

Int. Cl. F28c 1/02

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7 Claims

### ABSTRACT OF THE DISCLOSURE

A blow-through evaporative heat exchanger having an axial flow fan in the lower portion and a surface presenting means in the upper portion to receive fluid to be cooled. The fan ducting projects into the lower portion through an inclined wall, the axial flow fan being located in the ducting and the fan drive motor under the inclined wall so that there is no projection beyond the tower side wall. A baffle reverses part of the air issuing from the fan ducting to promote even airflow through the surface presenting means.

This application is a continuation-in-part of application Ser. No. 711,772 filed Mar. 8, 1968.

The invention relates to evaporative type heat exchangers of the blow-through (forced draft) counterflow type in which air flows countercurrent to the fluid to be cooled or condensed. Although this description is chiefly concerned with evaporative heat exchangers of the cooling tower type, it should be understood that its features and concepts could be adapted to all blow-through evaporative heat exchangers, such as evaporative condensers, liquid coolers, gas coolers, etc.

A conventional type "blow-through" cooling tower has a cooling region which is provided with a wet deck surface section over which water is gravitated to spread and so to present a large surface to counterflowing air. A small portion of the gravitating water is evaporated and the heat of vaporization is extracted from the remainder, which is collected in a sump from which it is withdrawn for use. The counterflowing air is provided by one or more fans which introduce air into a pan section plenum which is located above the sump but below the wet deck or fill section. An example of the type of equipment just described is to be found in Engalitcheff Patent No. 3,132,190.

In prior art blow-through evaporative heat exchangers, particularly of the axial flow, propeller fan type, there has been a problem caused by the fact that the incoming air is given direction and velocity in the fan duct and so tends to flow straight across the plenum from the point of entry. Thus, the wet deck region above the portion of the sump plenum opposite the point of air entry tends to get too much air and the region just above the air entry tends to get too little. If discharge vanes are used to increase the efficiency of the fan system, the resulting straightening of the air issuing from the ducts tends to aggravate this problem of getting even distribution across the fill or wet deck section. In the past, the width of plenum served by each fan has been kept narrow in an effort to mitigate the air distribution problem. Generally, this width was limited to the approximate diameter of the fan. Furthermore, the prior art has experienced difficulty in protecting the fans from water both when the fan is operating and when the system is operated on water alone, as may be the case under some conditions of load and/or weather.

It is an object of the present invention to overcome the

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foregoing disadvantages and to provide for a high efficiency, axial flow fan which may be used with quite wide plenums with excellent uniformity of air distribution across the fill or wet deck section.

The present invention not only provides novel means for uniformly distributing air in the plenum of a blow-through evaporative heat exchanger, but also protects the fan region from water regardless of whether or not the fan is operating.

The evaporative heat exchanger of the present invention is more efficient, compact and lightweight than prior art units. The fan and drive motor form an integral part of the pan and sump. There is no substantial extension or protrusion of the fans or fan ducting beyond the cooling tower side wall. The fan and drive arrangement are located within the fan ducting which projects into the plenum of the cooling tower. Thus, there is no substantial projection beyond the superstructure of the cooling tower.

Other objects and advantages of this invention will be apparent on consideration of the following detailed description of a preferred embodiment thereof in conjunction with the annexed drawings wherein:

FIGURE 1 is a view in vertical section taken near one end of a cooling tower of the evaporative type and showing the air fan and ducting constructed and arranged in accordance with the teachings of the present invention;

FIGURE 2 is a view in horizontal section taken along the line 2—2 of FIGURE 1;

FIGURE 3 is a view in side elevation of the unit of FIGURE 1 as it would be seen from the right side of that figure;

FIGURE 4 is a perspective view of an air distribution baffle forming a part of the present invention; and

FIGURE 5 is a fragmentary view in section taken along the line 5—5 of FIGURE 3.

Reference is hereby made to copending patent applications Ser. No. 706,004, filed Feb. 16, 1968, entitled, "Wet Deck Fill Section," and Ser. No. 706,003, filed Feb. 16, 1968, entitled, "Evaporative Heat Exchange Apparatus," both assigned to the assignee of the present invention. Disclosures of both of these applications are incorporated herein by reference.

In FIGURE 1 of the drawings there is illustrated a preferred embodiment of the present invention which is comprised of an upper region 10 (in which the water is cooled) and a lower or sump region 11 (in which the cooled water is collected). The upper region 10 is rectangular in plan (see FIGURE 2) and is made up of a number of modular frames 12, 13, 14, 15 and 16 superimposed in vertical registry together to define four vertical side walls about as described in detail in the aforementioned copending patent application Ser. No. 706,004. The lower or sump region 11 of the cooler shown in FIGURE 1 is trapezoidal as it appears in the plane of the section of FIGURE 1 and is defined by three vertical walls 17, 18 and 19, an inclined or sloping wall 20 and a bottom wall 21. The walls 17, 18 and 19 lie roughly in vertical registry with the corresponding walls of the modular units 12—16 thereabove (see FIGURE 2). Because of the use of the sloping wall 20, the area at the bottom of the sump region 11 is less than the area in successive horizontal planes thereabove. Mounted in the sloping wall 20 are two circular fan ductings 22 and 23 horizontally spaced apart, each containing a central hub 24 and 25, respectively, from which there extend seven radial vanes 26. The shape of the radial vanes 26 can be seen in FIGURE 5. Within the hub 24 there are located shaft bearings 27 which accommodate a fan shaft 28. To the right of the hub 24 as viewed in FIGURE 1, there is located a six-bladed propeller air fan 29 keyed to the shaft 28, and at the opposite end of the shaft 28 there is located a sheave

30 connected by belt 31 to a double sheave 32 of an electric motor 33 located between ducting 22 and ducting 23. A belt 34 connects sheave 32 to sheave 35 which is keyed to a shaft 36 which drives a propeller fan 37 similar in all respects to the fan 29. Bearings 38 for the shaft 36 are located within hub 25. The fans 29 and 37 are thus both driven by the motor 33 and, because of the arrangements of the belts and sheave, are driven at the same direction and at the same speed. Air flows into the ducts 22 and 23 through mouths 39 and 40, respectively, which are flared for about 90 degrees in arc to reduce turbulence in an outer annular region of the ducting with resulting increase in fan efficiency. The air issues from the mouths 41 and 42 of the ducts 22 and 23, respectively, and flows generally as indicated by the arrows of FIGURE 1.

Sloping wall 20 and walls 17 and 19 define a space S (see FIGURE 1). This space lies below and, except for small offsets, in vertical registry with the side walls of the upper portion 10. The space S, as can be seen by reference to FIGURES 1 and 3, accommodates the portions of the ducts 22 and 23 which are external of the wall 20 and any parts within those ducts which are external of the wall 20. The space also accommodates motor 33, the effect being that none of the fan mechanism projects beyond the plane of the righthand margin of the tower as it is seen in FIGURE 1.

Water to be cooled is supplied through a manifold 43 and is distributed through a large number of spray nozzles 44 sufficient to cover the area of the modular units 12-16, inclusive. The water falls by gravity through the cooling region 10 and this region contains a large number of wet deck surface sections in the form of mutually spaced sheet metal elements 45. The structure of these elements and the manner in which they are disposed within the modular units which hold them forms a part of the invention of copending application Ser. No. 706,004. For purposes of this case it will suffice to say that these elements provide a very large surface for water-air contact so that the water flowing by gravity through modular units 16, 15 and 14, respectively, is partially evaporated by the counterflowing air. The heat of vaporization is extracted from the remaining water which gravitates into the bottom of the sump from which it is withdrawn through a conduit 46 to a point of use. After a heat load has been transferred to this water, it is returned for recooling through manifold 43. Water to make up evaporation losses is supplied to the bottom of the sump through a float control valve, not shown. It is contemplated that some of the water will be periodically drained off to prevent undue concentration of mineral contaminants in the water.

At the top of the unit as shown in FIGURES 1 and 3 there are mist eliminators 47. Mist eliminators of this type are also shown in copending application Ser. No. 706,004. Their function is to prevent the air from entraining and carrying water outside of the cooling tower.

To accomplish the objective of efficiently cooling large volumes of water, the distribution of the air across the cross section of the modular units 14, 15 and 16 is very important. To this end there is provided a baffle 48 the shape of which can best be understood by reference to FIGURE 4 and the position of which is best understood by reference to FIGURE 1. This baffle is held by suitable brackets, not shown, from end walls 17 and 19 of the sump section 11, and midway of its length there is a strap 49 which extends to the portion of the wall 20 which overlies the motor 33. The baffle 48 presents to the air issuing from the ducts 22 and 23 a curved face extending more than 90 degrees in arc. This face is shaped almost like the cross section of a clam shell. The lower edge 50 of the baffle 48 projects into the upper portion of the generally cylindrical air stream issuing from the ducts 22 and 23. The upper edge 51 of the baffle 48 lies above the top of the ducts 22 and 23 and, in fact, lies to the right of the mouths 41 and 42 of the ducts as they are seen in FIGURE

1. On the outside curve of the baffle 48 near the lower edge 50 there is located a small L-section baffle 52.

To the left of the baffle 48, as viewed in FIGURE 1, there is another baffle 53. This baffle extends substantially from the wall 17 to the wall 19 across the upper region of the plenum. Baffle 53 is a flat sheet of material disposed at an angle to the vertical so as to define with wall 18 a space generally triangular in cross section with a narrow air ingress slot 53a at the bottom and a wider air egress slot 53b at the top.

Attention is directed to the fact that the inner curved or concave face of the baffle 48 functions to cause the air which is blown against it (flowing from right to left as viewed in FIGURE 1) to reverse direction, that is, to flow from left to right as shown in FIGURE 1 as it leaves the baffle between the top edge 51 and the top outer surface of the ducts 22 and 23. This reversal of flow is to insure that the wet deck area 10 above the ducts 22 and 23 receives an adequate supply of air. Furthermore, the air tends also to follow the outer surface of the baffle 48, which also makes a contribution to evenness of air distribution. See, for example, the arrows A in FIGURE 1. It is important to note that because baffle 48 bends for more than 90 degrees, the upper region 48' thereof acts to prevent the large quantities of water falling from the fill section from contacting the inner or concave surface of the baffle. Thus, air issuing from the ducts 22 and 23 sweeps around the baffle 48, undergoing a complete reversal of direction while the upper portion 48' of the baffle at the same time keeps the concave face of the baffle dry. Keeping the inner or concave face of the baffle 48 dry has the effect of preventing any drainage of water into the fan ducts from the lower inner face of the baffle. The baffle 52 is also a water protection device which prevents water flowing on the outside of the baffle 48 from getting into the fan ducts. The L-section baffle 52 causes the water to break away from the outer surface of baffle 48 and to fall more or less vertically in a region considerably beyond the mouths of the air duct. The location of the baffle 52 on the outer surface of baffle 48 is such that its lower edge of said baffle 52 will not project into the airstream and so disturb the airflow over said outer surface.

Equipment of the type here described is adaptable to use under a wide variety of conditions of heat load. It is also intended to operate under varying conditions of weather. Under some conditions, it is possible to operate at fairly long intervals without using the air fans. These will include situations when the ambient is at a low temperature or when the heat load is low, or both. Another way to operate is to cycle the air fans, causing them to go on when the water temperature in the sump rises to a predetermined level and to go off again when a desired low water temperature is reached. When the fan is not operating, it is especially vulnerable to the water falling from the section 10. Here, however, another advantage of the present invention can be appreciated. When the air fans are not operating, the bend at the upper end portion 51 of the baffle 48 performs an important function. If it were not there some of the water falling on the upper portion 48' of the baffle 48 would tend to go around the end 51 and then to flow down the inside or concave face of the baffle and into the fan ducts. However, the bent portion 51 causes the water to fall straight down from its end and thus to fall on the outside of the cylindrical ducting 22 and 23. The ducts 22 and 23 are provided with lips at 54 which dam the water enough to cause it to flow off the cylinders by moving around circumferentially rather than by falling off the end of the cylinder and possibly getting into the duct. It is to be noted that ducts 22 and 23 slope slightly downwardly from right to left as viewed in FIGURE 1. This has the added feature that if any mist does get into the duct, the duct is self-draining.

The cooling tower of the present invention is capable of operating with different average velocities of air flowing through the fill section 10. It has been found, for example, that at velocities of about 500 feet per minute or lower, the baffle 48 is entirely adequate by itself to produce good air distribution across the entire fill section 10. On the other hand, at high velocities such, for example, as about 600 feet per minute, a small portion of the air has a tendency to channelize along the plane of the wall 18 and to flow upwardly through that portion of the region 10 at velocities even great enough so that some water is entrained and carried through the mist eliminators in a local region just to the right of the plane of wall 18 as seen in FIGURE 1. To prevent this and to equalize the airflow, the baffle 53 is used. It functions to cause a diffusion effect on the air flowing upwardly between the slot 53a and the slot 53b. This effect decelerates the air along the wall 18 and, thus, even at high average air velocities across the fill section 10, good air distribution thereacross is maintained.

It will be observed that an effect of the sloping wall 20 is to reduce the water inventory of the system. It also permits locating the blower motor 33 and the fans substantially within a vertical projection of the rectangular plan of the wet deck section 10 of the unit. Furthermore, the gradual increase in cross section of the plenum between the water level and the first modulus 12 permits a measure of static pressure recovery in the vertical direction of movement of the fans.

FIGURE 3 is a front view of a multiple fan unit showing how multiple fans can be driven from a single motor which is located in the area provided under slanted wall 20. It should be understood that such evaporative cooling apparatus can be built to a desired capacity by joining similar units together in either an end-to-end relationship so as to extend the type of arrangement shown in FIGURE 2, or by placing similar units "back-to-back," so that a mirror image of FIGURE 1 would be placed on the left side thereof. In large installations, the use of both "back-to-back" and end-to-end combination is available.

What is claimed is:

1. Evaporative heat exchange apparatus comprising surface presenting means to receive fluid to have heat evaporatively extracted therefrom, means above said surface presenting means to flow liquid therethrough by gravity, walls defining a sump region below said surface presenting means, ducting having a mouth discharging into said region, a fan for blowing air through said ducting and out of said mouth into said region, an elongated baffle member presenting to the discharge mouth of said ducting a concave face extending in arc more than 90 degrees, the lower edge of said baffle projecting into said air stream issuing from said ducting mouth and the upper edge thereof terminating in a horizontal plane above the horizontal plane of at least the portion of said ducting that defines the mouth thereof.

2. The apparatus of claim 1, wherein said ducting is substantially cylindrical and said fan is of the axial flow propeller type and is located within the cylindrical ducting.

3. The apparatus of claim 1, wherein one of said walls defining said sump region is inclined so that said sump region has a cross-sectional area smaller at the bottom than at the top and wherein said ducting projects through said inclined wall and said axial flow fan is driven by a motor located substantially within the space under said inclined wall.

4. The apparatus of claim 1, wherein the upper edge of said baffle is located above and overlapping the top edge of the portion of said ducting that defines the mouth to distribute air issuing from said ducting backwardly and upwardly toward that part of the surface presenting means located above said ducting.

5. The apparatus of claim 1 further comprising a baffle spaced from the sump-defining wall opposite the wall through which the ducting projects, said baffle defining with said opposite wall a space the cross-sectional area of which progressively increases in the direction of the surface presenting means.

6. An evaporative heat exchange apparatus comprising a tower, the upper portion thereof having surface presenting means to receive fluid to have heat evaporatively extracted therefrom and water distribution means to circulate water over said surface presenting means, the lower portion thereof having a water-receiving sump, a region between said surface presenting means and the top of the water level of said sump, an inclined wall defining one side of said lower portion, a duct projecting through said inclined wall into said region, an axial flow fan within said duct, a fan motor located under said inclined wall for driving said fan to pump air through said duct into said region, an elongated baffle having in cross section a curvature of more than 90 degrees and presenting its concave face to the air issuing from said duct, said baffle having its axes horizontal and perpendicular to the air stream issuing from said ducting, the lower edge of said baffle projecting into said air stream and the upper edge of said baffle located substantially above and overlapping the top edge of said ducting whereby to distribute air from said ducting over that part of the surface presenting means located above the part of said ducting which projects into said region.

7. The apparatus of claim 6, further comprising a baffle defining with the wall opposite the inclined wall of said lower portion a space the cross-sectional area of which progressively increases in the direction of said upper portion.

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U.S. Cl. X.R.