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(54) INJECTOR TYPE COOLING TOWER

(71) We, BALTIMORE AIRCOIL COMPANY INC., a Corporation organized and existing under the laws of the State of Delaware, United States of America, of Montevideo Road, Jessup, Maryland, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to evaporative heat exchangers. In particular the invention relates to improvements in the heat exchangers of our Application No. 1,299,922. In the said Application we described and claim—
 an evaporative heat exchanger including a longitudinally extending conduit having an axis which extends substantially horizontally, said conduit having an inlet end exposed to atmosphere and an outlet end, means to spray water into the inlet end of the conduit to entrain air through the inlet to flow through the conduit, the outlet end of the conduit communicating with the atmosphere is in effect a cooling tower in the form of an injector wherein water to be cooled functions and with a water collector. This apparatus to pump the air, which cools the water by evaporation. There is a large air-water interface and some of the water which pumps the air is evaporated, and the latent heat for this evaporation is extracted from the remainder of the water which is then collected in a sump on the exhaust side of the injector. The evaporated water saturates the air and this air bearing the extracted heat is exhausted to atmosphere.

The present invention provides in one aspect an evaporative heat exchanger including a longitudinally extending conduit having an axis which extends substantially horizontally, said conduit having an inlet end exposed to atmosphere and an outlet end, means to spray water into the inlet end of the conduit to entrain air through the inlet to flow through the conduit, the outlet end of the conduit communicating with the atmosphere and with a water collector, and in-

cluding mist eliminators to strip water from air passing through the conduit towards the outlet end, the mist eliminators comprising at least two groups of substantially parallel strips spaced apart across the conduit, the strips of one group being substantially vertical and another group of strips being spaced from the one group along the axis of the conduit, such that in use entrained water is stripped from the air flowing down the conduit and flows into the water collector.

The present invention provides in another aspect an evaporative heat exchanger including a longitudinally extending conduit having an axis which extends substantially horizontally, said conduit having an inlet end exposed to atmosphere and an outlet end, means to spray water into the inlet end of the conduit to entrain air through the inlet to flow through the conduit, the outlet end of the conduit communicating with the atmosphere and with a water collector, and including baffle means at the outlet end, said baffle means comprising a plurality of upwardly curved plates extending transversely of the outlet.

The present invention provides in another aspect evaporative heat exchange apparatus including at least two evaporative heat exchangers, each including a longitudinally extending conduit having an axis which extends substantially horizontally, each said conduit having an inlet end exposed to atmosphere and an outlet end, means to spray water into the inlet end of the conduits to entrain air through the inlets to flow through the conduits, and the outlets of the conduits communicating with respective water collectors and with a single central upwardly extending stack open to the atmosphere.

The present invention provides in another aspect evaporative heat exchange apparatus including at least two evaporative heat exchangers, each including a longitudinally extending conduit having an axis which extends substantially horizontally, each said conduit having an inlet end exposed to atmosphere and an outlet end, means to spray water

into the inlet ends of the conduits to entrain air through the inlets to flow through the conduits, the outlet ends each communicating with the atmosphere and with a water collector, wherein the heat exchangers are located one above the other, and the water collector of the upper heat exchanger is connected to the water collector of the lower heat exchanger to pass water thereto, and the apparatus including means to pass water from the lower water collector to the spray means of both heat exchangers.

The present invention provides in another aspect an evaporative heat exchanger including a longitudinally extending conduit having an axis which extends substantially horizontally, said conduit having an inlet end exposed to atmosphere and an outlet end, means to spray water into the inlet end of the conduit to entrain air through the inlet to flow through the conduit, the outlet end of the conduit communicating with the atmosphere and with the water collector, wherein the means to spray water includes a plurality of nozzles arranged across the inlet end, and the heat exchanger including at least one vertically disposed baffle extending downstream of the nozzles and parallel to the axis of the conduit to protect the inlet end and jets of water which, in use, issue from the nozzles from cross winds.

The present invention provides in another aspect an evaporative heat exchanger including a longitudinally extending conduit having an axis which extends substantially horizontally, said conduit having an inlet end exposed to atmosphere and an outlet end, means to spray water to the inlet end of the conduit to entrain air through the inlet to flow through the conduit, the outlet end of the conduit communicating with the atmosphere and with a water collector, and a drip collector located below the spray means to catch drips therefrom.

The present invention provides in another aspect an evaporative heat exchanger including a longitudinally extending conduit having an axis which extends substantially horizontally, said conduit having an inlet end exposed to atmosphere and an outlet end, means to spray water into the inlet end of the conduit to entrain air through the inlet to flow through the conduit, the outlet end of the conduit communicating with the atmosphere and with a water collector, and including a water conductor connected to the spray means, such that in use some water in the supply passes to the conductor, said conductor being located at least in part in heat exchange relation to at least part of the inlet end of the conduit.

These aspects of the invention may be provided singly or, where appropriate, together.

Certain aspects of the invention make it easier to achieve a heat exchange capacity equal to or greater than that of a conventional counter-current cooling tower with a piece of apparatus far simpler to build and to maintain as well as cheaper to operate. Higher thermal efficiency and low noise level are advantages of the invention.

In some forms of the invention the conduit can have a throat such that there is an expansion zone downstream of the throat. As a preferred feature, it is advantageous to define the conduit as rectangular in cross section with vertical side walls and with upper and lower walls diverging. It is also preferred to provide the nozzles such that they provide fan shaped water sprays. It is a further preferred feature of the invention that, in this case, the long axes of spray cross sections are parallel to vertical side walls of the conduit. The conduit is preferably slightly downwardly inclined from the inlet end to take account of gravitational effects on the sprays of water.

In order that the invention may be more clearly understood, the following description is given, merely by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a view in transverse section of a single module horizontal injection type heat exchanger constructed in accordance with various aspects of the present invention;

Figure 2 is an end view of the apparatus of Figure 1 taken from the intake end thereof;

Figure 3 is a view in horizontal section taken on line 3—3 of Figure 1;

Figure 4 is a view partly in section and partly in side elevation of a single water spray nozzle of the type preferably employed in the present invention showing the spray pattern as seen from the side;

Figure 5 is a view in cross section on the line 5—5 of Figure 4 to show the cross-sectional shape of the spray as it appears close to the nozzle;

Figure 6 is a view in section taken on the line 6—6 of Figure 4;

Figure 7 is a view partly in side elevation and partly in section illustrating in particular the first aspect of the invention;

Figure 8 is a view partly in section and partly in side elevation of heat exchange apparatus according to the aspect of the invention in which two heat exchangers are used one above the other;

Figure 9 is a view in elevation taken at the air inlet end of the apparatus of Figure 8;

Figure 10 is a schematic view in vertical section of heat exchange apparatus according to the invention in the aspect where two or more heat exchangers are arranged to discharge into a common stack;

Figure 11 is a fragmentary view in section

illustrating to an enlarged scale one of the aspects of the invention included in the embodiment of *inter alia* Figure 1;

5 Figure 12 illustrates for reference apparatus shown as described in our Application No. 1,299,922; and

Figure 13 is a fragmentary view in section of the mist eliminators shown *inter alia* in Figures 1 and 3.

10 Referring to Figure 1 in greater detail, the apparatus there shown comprises a cooling tower having an air entry mouth at 10, a throat at 11, and downstream of the throat, a diffusion or expansion region 12. Water to
15 be cooled is supplied through a header 13 to a series of horizontal conduits 14, each provided with nozzles 15 spaced along the length of the respective conduit. Water is sprayed from the nozzles 15, and this action
20 draws air into the mouth 10 of the apparatus. In a manner to be hereinafter more fully explained, the nozzles 15 are so spaced and the spray therefrom is of such shape that a water seal is established across the throat 11.
25 The air which is drawn into the mouth 10 and passes through the throat 11, mixes intimately with the droplets of water. Flow continues through the diffusion region 12. Evaporative cooling takes place because
30 some of the water is evaporated and the heat of vaporization is extracted from the remaining water, which, moving from left to right as seen in Figure 1, falls into the sump 16 from which it is withdrawn through conduit
35 17 to be used. The air exhausts from the tower through a group of mist eliminators 18 which strip out any remaining water entrained thereby so that the substantially droplet free air discharging from the eliminators
40 18 is passed to atmosphere through turning vanes 19. These vanes cause the air to flow upwardly and away from the cooling tower to avoid recirculation of the hot discharged air to the region of the mouth 10. The turning vanes 19 also function to minimize the effect of severe cross winds opposing the air flow through the unit. Should conditions permit, these vanes may be omitted. Should conditions require it, they may be supplemented
45 with a wind deflector such as is shown at 59 in Figure 12.

It will be noted in Figure 1 that the upper defining wall 20 of the diffuser section 12 has a different slope from the lower defining wall
55 21 thereof whereas the sidewalls 22 are vertical, see Figures 2 and 3. This is to take advantage of the effect of gravity on the trajectory of the water streams issuing from the nozzles 15. Because of the effect of
60 gravity, the upper expansion angle, that is, the angle between the horizontal and the upper boundary 20 of the expansion region 12 of the tower, is smaller than the lower expansion angle which is the angle between
65 the horizontal and the lower boundary 21

of the expansion region 12 of the tower. By so disposing the walls 20 and 21 maximum efficiency for the expansion of the air-water mixture is assured as well as maximum
70 air-water contact.

It should be noted that the entrance to the mouth 10 is arranged in bell form to reduce air resistance. The upper wall 23 at the defining edge of the mouth is curved as can be readily seen in Figure 1. A trough 24
75 which defines the lower edge of the bell mouth has a narrow slit in it at 24¹ which runs the full width of the mouth 10 but which is sufficiently narrow as not to interfere with the entering air flow. This trough
80 or gutter 24 is connected at the left end, as seen in Figure 2, to a pipe 25, which is connected to a waste discharge conduit 26.

All evaporative cooling towers require some portion of the recirculating water be
85 discharged or bled to waste in order to prevent excessive accumulation of mineral salts. In the present construction, the lowermost nozzle supply conduit 14, again see Figure 2, is connected by a conduit 27 to the end of
90 the gutter 24 opposite from the end to which the gutter drain 25 is attached. This means that water discharged from the system is warm water, i.e., part of the water being supplied to the tower for cooling and that it
95 flows across the entire bottom of the air admission mouth in order to reach the waste line. Thus, the warm water is in heat exchange relation with the metal of gutter 24 and by conduction, with adjacent metal
100 parts. Furthermore when the tower is shut off and the water from the conduits 14 drains out, some of its falls to the region of the slot 24¹ in the bell mouth trough 24. To ensure that this takes place, there are small
105 projections 28 under each of the nozzles 15, see Figures 1, 4 and 5. The projections 28 may be provided by a single piece of metal extending lengthwise of conduit 14, as shown, or may be provided by individual pieces
110 under each nozzle. In either case the position and length will be chosen to avoid interference with the incoming air flow. These projections 28 function to prevent water from falling outside of the mouth 10 so that
115 ultimately drippage from the nozzles is received somewhere along the length of the slot 24¹.

In winter, during shut off or operation, any water drippage entering the slot 24¹
120 is prevented from freezing because of the heat of the bleed water which is passing through conduit 27 through the gutter 24 to waste conduits 25 and 26. This warm bleed water then prevents freezing when the
125 header water is draining off after shut off. The quantity of water needed to prevent ice formation is very small and may, if desired, be discharged into the sump, without materially affecting the capacity of the tower. 130

The heat exchange effect of the bleed water in gutter 24 is, of course, valuable in winter weather even when the header is not draining after shut off because it keeps the lower part of the throat warm and prevents ice formation.

In addition to the features heretofore described it is to be noted that discharge conduit 26 is connected by an elbow 28¹ to a short conduit 29 which protrudes into the sump area above the level of the water. This short conduit 29 is provided with a dam 30 at one end, the dam being of sufficient height so that water coming from line 25 will not overflow it but, should there be a malfunction in the water level control or stoppage in the main cold water outlet 17, a drain for discharging overflowing sump water is provided. These details are shown in Figure 11.

The sump is provided with the usual strainer screen 31 and with a make-up water spigot 32 controlled by a float 33 in the conventional manner, that is to say, when the water level falls below a pre-determined value the sinking of float 33 opens a spigot 32 and adds make-up water to the system.

In Figures 1, 2 and 3 there is shown a baffle 12a which is used with units of considerable width to prevent cross flowing wind from displacing mist-like droplets of water so that they escape from the air entry end of the unit. While a single baffle is shown, it is intended that the number used be a function of unit width. The baffle 12a extends from a plane tangent to the conduits 14 to somewhat beyond the throat 11, see Figure 1.

If now reference is made to Figures 4, 5 and 6, the construction and function of the various nozzles 15 can be better understood. The discharge opening of each nozzle 15 is such as to produce a spray having, as viewed from the side, the shape illustrated in Figure 4 and as viewed in section the shapes illustrated in Figures 5 and 6. The pipes 14 are so spaced vertically from one another that the upper and lower edges of each spray intersect just about in the throat 11. The nozzles 15 are so spaced in relation to one another along the respective pipes 14 that the side edges of the spray just about touch one another in the throat. See in this regard Figure 2. Air is drawn into the mouth 10 of the conduit in between the various water jets but the seal formed in the throat 11 is so complete that there is no tendency for blow-back of air from downstream of the throat in normal conditions of operation.

Water spray issuing from any nozzle orifice will expand to some degree in all directions downstream of the nozzle. The amount of expansion in certain directions can be controlled by the design of the orifice. It has been discovered that maximum usage of input energy to pump air in an injector cooling tower is importantly related to the

nozzle orifice and the orientation of the nozzles in relation to one another and in relation to the other parts of the cooling tower. Thus, it is an advantage of the present invention that the expansion of the jets of water is principally in vertical planes since this corresponds to the expansion in the diffusion zone which is brought about by the slope of walls 20 and 21 which define the upper and lower boundaries of the diffuser section. It is preferred for the nozzles to produce fan shaped sprays of water, with the flat sides of the fan shaped sprays parallel and for the nozzles to be arranged such that the divergence of the upper and lower walls of the conduit is the same as the divergence of the upper and lower edges of the fan shaped sprays. One desirable nozzle arrangement is four rows of closely spaced nozzles each of which produces a high velocity, highly atomized spray in fan-shaped pattern. Several features of the design of the nozzle contribute significantly to the air aspiration and the heat transfer action. The spray patterns present at the exit of the nozzles, see Figure 5, are thin sheets of water which have considerable surface area to transfer momentum to the air to start its movement into the throat, yet which present, at the same time, streamlined profiles for air entry. The spray pattern as illustrated in the drawings has also the advantage that it permits filling a rectangular throat such as is shown in Figure 2 without wasting water and energy on the side walls or from the excessive overlapping which would be necessary to produce a seal using conical sprays.

Of course, the nozzles 15 are directed generally horizontally toward the discharge end of the tower so that the major thrust of the water is in the direction that the air is to be moved. Yet, any spray issuing from a nozzle must expand to some extent downstream of the nozzle which produces it. The lateral displacement of water from the flat sides of the sprays is small and in fact is just enough to form a seal between the closely spaced adjacent sprays. The nozzles are such as to limit the sprays in this fashion because any more lateral movement of the water would be wasteful of energy as the forward rather than the lateral movement of the water functions to pump air through the unit. The angle of expansion of the water spray issuing from the nozzles in vertical planes is much greater than the lateral expansion of the sprays. This is desirable because it helps to expand the air-water mixture into the diffusion region which is defined by walls 20 and 21 diverging in the same general direction as the vertical expansion of the sprays. The end result is that the input water energy is directed primarily toward the mist eliminators 18. This, of course, is the optimum pumping direction. In addition-

tion, the other needs of the ejector, such as good air diffusion and streamlining, are met. Thus, the pumping energy put into the water is used to a maximum extent to bring about aspiration of air and entrainment thereof through the apparatus and also to achieve excellent air-water contact and mixing for maximum heat transfer. The efficiency of the air pumping action is appreciated when the quantity of air pumped is considered. Approximately three times the quantity of air is used to achieve the same degree of heat transfer as would be necessary in a conventional counterflow tower. Even with the large increase in required air flow which results in high internal air velocities, this necessary amount of air is pumped with an input energy which is less than that required in many counterflow towers.

In conventional cooling towers, different capacities may be obtained from a given module plan area by changing the amount of wet-deck fill or varying the air quantity through the tower by adjusting the fan speed. Capacity adjustment is obtained in an ejector tower simply by variations in the nozzle sizes to obtain different operating spray pressures. The nozzle pressure determines the quantity of air flow and the degree of air-water contact and hence the amount of heat transfer available. The higher the water pressure is raised the greater is the input energy and hence the greater the amount of air pumped. This in turn makes for finer spray and mixing and heat transfer.

The high flow rate of the air and water makes the job of the mist eliminators very difficult. In Figure 1, there are shown two sets of mist eliminators 18 which are used for what may be called average water flow rates and pressures. In some applications where the nozzle pressure is very low or the water flow rate is less than average a single bank of mist eliminators can function to strip the water droplets from the air. Most often, however, the velocities through the tower are in excess of the capabilities of a single bank eliminator adequately to strip all water from the air. In addition, the velocity of the water leaving the nozzles is very high and impinges on the first set of blades in large quantities. Therefore, the first deck, and a large portion of the second, are completely wetted further to function as conventional wet-deck surface significantly to contribute to the heat transfer in cooling the water and achieve very close approaches between the leaving water temperature and the leaving air temperature. This, of course, is very important in order to obtain maximum heat transfer efficiency particularly with a parallel flow heat exchanger.

The shape of the eliminators is appreciated from reference to Figures 3 and 13.

The illustrated configuration provides a

very effective eliminator with a very low air resistance as compared to conventional sharp break mist eliminators. Because the eliminator is wet, the surfaces function also as wet-deck. Both of these features importantly contribute to the thermal efficiency of the apparatus. Note that the eliminators are so mounted as to leave the bottom edges open for free discharge of water into the sump 16, see Figure 1.

Under temperature conditions that permit very large quantities of water to be used, it may be that two units of mist eliminators such as are shown in Figure 3 will not be adequate to strip the entrained water from the airstream. It should be noted that as the water rate is increased the energy input is proportionally increased thereby resulting in a significantly higher air flow rate as well. An arrangement for handling large volumes of water is shown in Figure 7. This figure illustrates an injection type cooling tower basically similar to that shown in Figure 1 except for the mist eliminators. In Figure 7 there are three banks of mist eliminators 34, 35 and 36. In cross section each of these is of the same shape as is shown in Figure 13. Because of the effect of gravity on the flowing water in the diffusion zone 12, it is evident that by the time the water is in the region of the mist eliminators there is more water per unit volume near the bottom of the tower than at the top. Even so, the velocity of the water at the time it reaches the first eliminator 34 is such that if that eliminator were used alone a considerable volume of water would go through it but would thereafter assume a trajectory with a much larger gravity component. To prevent the velocity of the water from driving some of it even through three banks of eliminators, banks 35 and 36 are disposed at an angle to the vertical such as to define a space triangular in vertical section between the first bank of eliminators 34 on the one hand and the second and third on the other. Thus water which passes through eliminator 34 is considerably decelerated as it enters eliminators 35 and 36. The combined effect of gravity and the sloping eliminator channels is to provide a path to the sump through which the remaining component of horizontal energy in the water is dissipated so that the water will fall for recovery into the sump.

It is important to note that the mist eliminators 34, 35 and 36 are made of long strips having straight edges connected by a curved central portion and are thus of the same shape as eliminators 18. Again see Figure 13. These are nested also as shown in Figure 13 and each has at least two spacing tabs extending therefrom and touching the next adjacent strip to maintain a predetermined spacial relationship therebetween. In the position of the mist eliminators shown in

Figure 7 a great deal of water actually channels vertically downwardly through the mist eliminators. There is so much water, however, that even three banks would not be adequate in the situation of Figure 7 if it were not for the fact that space is allowed between bank of eliminators 34 and banks 35 and 36. Great quantities of water fall in this region such that the water flowing from the channels of bank 36 actually represents the last of the entrained water so that mist elimination is complete.

These eliminators, of course, function as fill in the ordinary sense that fill is used in cooling towers. The mist eliminators shown in Figure 1 also so function, and it has been found that this fill contributes very importantly to the efficiency of the unit.

The basic units which have been heretofore described may be arranged in various ways to work with one another where the load requirements are such as to require a multiple unit. One way that the units may be combined is shown in Figures 8 and 9. In this instance the lower unit is basically similar to the unit of Figure 1. Another unit 37 similar to it is placed above it and pipes 38 are arranged along the opposite side walls 22 of the region above the sump 16 for connecting a small sump 39 with sump 16 therebelow. The small sump 39 functions with the upper unit but is structurally a part of the lower one.

Another difference between the upper unit of Figures 8 and 9 and the basic module of Figure 1 is that the trough 40 at the lower bell mouth of the upper unit, although it is similar in structure and function to trough 24, discharges differently. It is fed from the hot water line 14 feeding the lowest row of nozzles but, instead of discharging to waste, it discharges through a pipe 41 into the upper sump 39, the amount of water not being enough materially to affect efficiency. The hot water bleed for the system is the same as that shown in Figure 1 associated in Figure 8 with the lower of the two units. The sump water level control shown in the lower unit of Figures 8 and 9 is differently positioned from the arrangement shown in Figure 1. In Figures 8 and 9 the sump is defined by two end walls 42 and 43 as well as side walls 22. The upper edge of end wall 42 is spaced below the bottom 21 of the diffusion region 12 thus defining an access space at 44. A partition 45 extends from wall 21 with its lower edge below the normal water level of the sump. The float 33 and the spigot 32 are located between the partition 45 and the end wall 42. Since the wet region of the cooling tower is above the wall 21 and to the right of partition 45 as seen in Figure 8, an operator may adjust the float system without getting wet even though the tower is operating. He simply reaches through ac-

cess space 44 and makes the necessary adjustments. The strainer screens are also accessible through access space 44. Except for the differences in the location of the make-up water controls, the hot water bleed and the interconnection of the sump, the upper unit 37 of Figures 8 and 9 is the same as the lower unit which in turn is the same as the unit shown in Figure 1. The construction of the lower unit of Figures 8 and 9 may, if desired, be used alone in lieu of the Figure 1 arrangement.

Like reference numerals have been used throughout to identify like parts. It is, of course, understood that the advantage of having a connection between sump 39 and sump 16 is that the recirculation through a heat load to the spray nozzles takes place from the lower sump only.

Instead of the arrangement of Figures 8 and 9, it is also possible to face two units such as are shown in Figure 1 toward one another or radially arranged around a central stack. This is shown by way of example in Figure 10 where there is a tapering air discharge stack 46 having a partition 47 dividing it into a left side 48 serving a unit 49 such as is shown in Figure 1 and a right side 50 serving a unit 51 such as is shown in Figure 1.

In Figure 12 a horizontal water flow arrangement such as is described in our Patent No. 1,299,922 is depicted. There is a flared mouth portion 52 defining a rectangular air inlet at 53, the short dimension of which is shown in Figure 12. Lengthwise of the air inlet at 53 there extends a water supply pipe 54 from which there extend a line of mutually spaced nozzles 55 arranged centrally of the ejector walls. The ejector also includes a throat portion 56 of rectangular cross section and a diffuser portion 57. The outlet end of the diffuser is provided with mist eliminators 58 and with a wind deflector 59 to prevent natural air currents from opposing the left to right air flow through the ejector as illustrated.

The ejector pictured in Figure 12 is tilted downwardly at a slight angle in the direction of flow to prevent water from running out of the throat down the inlet and dripping to the floor. The water-air mixture entering the diffuser maintains enough directional energy to expand fully and fill the upper section of the diffuser even though this requires the mixture to travel "uphill".

In the system of Figure 12 the cooled water is recovered in a sump 60 which forms part of the lower wall of the diffuser portion 57. The usual water make-up and withdrawal systems are included but not illustrated.

The term injector as used in the claims hereof is intended to define the pumping of air by water jets regardless of whether or not the throat is restricted.

**WHAT WE CLAIM IS:—**

1. An evaporative heat exchanger including a longitudinally extending conduit having an axis which extends substantially horizontally, said conduit having an inlet end exposed to atmosphere and an outlet end, means to spray water into the inlet end of the conduit to entrain air through the inlet to flow through the conduit, the outlet end of the conduit communicating with the atmosphere and with a water collector, and including mist eliminators to strip water from air passing through the conduit towards the outlet end, the mist eliminators comprising at least two groups of substantially parallel strips spaced apart across the conduit, the strips of one group being substantially vertical and another group of strips being spaced from the one group along the axis of the conduit, such that in use entrained water is stripped from the air flowing down the conduit and flows into the water collector.

2. Apparatus according to claim 1 wherein the said another group is downstream of the said one group.

3. Apparatus according to claim 2 wherein the space between the groups is triangular with its apex uppermost when regarded in a vertical cross section including the axis of the conduit.

4. Apparatus according to claim 3 including a further group of strips adjacent and parallel to said other group of strips.

5. Apparatus according to claim 1, 2, 3 or 4 wherein each strip is elongate, having flat margin portions connected by a curved central portion.

6. Apparatus according to any preceding claim including on each strip at least two spacing tabs extending therefrom and touching the next adjacent strip to maintain a predetermined spacial relationship therebetween.

7. An evaporative heat exchanger including a longitudinally extending conduit having an axis which extends substantially horizontally, said conduit having an inlet end exposed to atmosphere and an outlet end, means to spray water into the inlet end of the conduit to entrain air through the inlet to flow through the conduit, the outlet end of the conduit communicating with the atmosphere and with a water collector, and including baffle means at the outlet end, said baffle means comprising a plurality of upwardly curved plates extending transversely of the outlet.

8. Evaporative heat exchange apparatus including at least two evaporative heat exchangers, each including a longitudinally extending conduit having an axis which extends substantially horizontally, each said conduit having an inlet end exposed to atmosphere and an outlet end, means to spray water into the inlet end of the conduits to entrain air through the inlets to flow

through the conduits, and the outlets of the conduits communicating with respective water collectors and with a single central upwardly extending stack open to the atmosphere.

9. Apparatus according to claim 8 including at least one partition in the stack to isolate the respective outlet ends.

10. Apparatus according to claim 8 or 9 including vanes in the outlet ends to direct air upwardly in the stack.

11. Evaporative heat exchange apparatus including at least two evaporative heat exchangers, each including a longitudinally extending conduit having an axis which extends substantially horizontally, each said conduit having an inlet end exposed to atmosphere and an outlet end, means to spray water into the inlet ends of the conduits to entrain air through the inlets to flow through the conduits, the outlet ends each communicating with the atmosphere and with a water collector, wherein the heat exchangers are located one above the other, and the water collector of the upper heat exchanger is connected to the water collector of the lower heat exchanger to pass water thereto, and the apparatus including means to pass water from the lower water collector to the spray means of both heat exchangers.

12. An evaporative heat exchanger including a longitudinally extending conduit having an axis which extends substantially horizontally, said conduit having an inlet end exposed to atmosphere and an outlet end, means to spray water into the inlet end of the conduit to entrain air through the inlet to flow through the conduit, the outlet end of the conduit communicating with the atmosphere and with a water collector, wherein the means to spray water includes a plurality of nozzles arranged across the inlet end, and the heat exchanger including at least one vertically disposed baffle extending downstream of the nozzles and parallel to the axis of the conduit to protect the inlet end and jets of water which, in use, issue from the nozzles from cross winds.

13. An evaporative heat exchanger including a longitudinally extending conduit having an axis which extends substantially horizontally, said conduit having an inlet end exposed to atmosphere and an outlet end, means to spray water to the inlet end of the conduit to entrain air through the inlet to flow through the conduit, the outlet end of the conduit communicating with the atmosphere and with a water collector, and a drip collector located below the spray means to catch drips therefrom.

14. Apparatus according to claim 13 wherein the spray means include a plurality of nozzles each having a drip guide associated therewith to direct drips therefrom into the collector.

15. Apparatus according to claim 13 wherein the spray means includes a plurality of nozzles arranged in at least one horizontal row and including a strip fixed to and extending below the nozzles of a row to direct drips therefrom into the drip collector.
16. Apparatus according to claim 13, 14 or 15 wherein the drip collector is a gutter extending across the lower edge of the air inlet at least below the spray means to catch drips therefrom, and including a discharge from the gutter.
17. An evaporative heat exchanger including a longitudinally extending conduit having an axis which extends substantially horizontally, said conduit having an inlet end exposed to atmosphere and an outlet end, means to spray water into the inlet end of the conduit to entrain air through the inlet to flow through the conduit, the outlet end of the conduit communicating with the atmosphere and with a water collector, and including a water conductor connected to a water supply means connected to the spray means, such that in use some water in the supply passes to the conductor, said conductor being located at least in part in heat exchange relation to at least one part of the inlet end of the conduit.
18. Apparatus according to claim 17 wherein the water conductor is in heat exchange relation to at least part of the lower edge of the inlet.
19. Apparatus according to claim 16 and claim 17 or 18 wherein the water conductor includes said gutter.
20. Apparatus according to claim 17, 18 or 19 including a waste water discharge to which said water conductor is connected.
21. Apparatus according to any one of claims 1 to 6 and 11 to 20, including baffle means at the outlet end of the or each conduit, said baffle means comprising a plurality of upwardly curved plates extending transversely of the or each outlets.
22. Apparatus according to any preceding claim except claims 1 to 6 and claim 21 when appendent thereto, and including in the or each conduit mist eliminators to strip water from air passing through the conduit towards the outlet end, the mist eliminators comprising at least two groups of substantially parallel strips spaced apart across the conduit, the strips of one group being substantially vertical and another group of strips being spaced from the one group along the axis of the conduit, such that in use entrained water is stripped from the air flowing down the conduit and flows into the collector.
23. Apparatus according to claim 22 wherein the said other group is downstream of the said one group.
24. Apparatus according to claim 23 wherein the space between the groups is triangular with its apex uppermost when viewed in a vertical cross section including the axis of the conduit.
25. Apparatus according to claim 24 including a further group of strips adjacent and parallel to said other groups of strips.
26. Apparatus according to claim 22, 23, 24 or 25 wherein each strip is elongate having flat margin portions connected by a curved central portion.
27. Apparatus according to any one of claims 22 to 26 including on each strip at least two spacing tabs extending therefrom and touching the next adjacent strip to maintain a predetermined spacial relationship therebetween.
28. Apparatus according to any preceding claim, except claims 13 to 16 and 19 and any one of claims 20 to 27 when appendent thereto, including a drip collector located below the spray means of the or each conduit to catch drips therefrom.
29. Apparatus according to claim 28 wherein the spray means include a plurality of nozzles each having a drip guide associated therewith to direct drips therefrom into the collector.
30. Apparatus according to claim 28 wherein the spray means includes a plurality of nozzles in at least one horizontal row and including a strip fixed to and extending below the nozzles of a row to direct drips therefrom into the drip collector.
31. Apparatus according to claim 28, 29 or 30 wherein the collector is a gutter extending across the lower edge of the air inlet at least below the spray means to catch drips therefrom, and including a discharge from the gutter.
32. Apparatus according to any one of the preceding claims, except claims 17 to 20 and any one of claims 21 to 31 when appendent thereto, and including for the or each conduit a water conductor connected to a water supply means connected to the spray means, such that in use some water in the supply passes to the conductor said conductor being located at least in part in heat exchange relation to at least part of the inlet end of the conduit.
33. Apparatus according to claim 32 wherein the water conductor is in heat exchange relation to at least part of the lower edge of the inlet.
34. Apparatus according to claim 31 and claim 32 or 33 wherein the water conductor includes said gutter.
35. Apparatus according to claim 32, 33 or 34 including a waste water discharge to which said water conductor is connected.
36. Apparatus according to any preceding claim, except claim 12 and any one of claims 21 to 35 when appendent thereto, wherein the means to spray water includes a plurality of nozzles arranged across the inlet end of the or each conduit, and the apparatus



tus includes at least one vertically disposed baffle in the or each conduit extending downstream of the nozzles and parallel to the axis of the conduit to protect the inlet ends and jets of water which, in use, issue from the nozzles from cross winds.

37. Apparatus according to any preceding claim, except claims 8 to 10 and any one of claims 22 to 36 when appendent thereto, including an upwardly extending air deflector plate positioned to protect the outlet end of the or each conduit from external air currents.

38. Apparatus according to any one of the preceding claims including a throat in the or each conduit between the inlet and outlet ends.

39. Apparatus according to any one of the preceding claims wherein the or each conduit is slightly downwardly inclined from the inlet to the outlet end.

40. Apparatus according to any preceding claim, wherein the means to spray water includes a plurality of nozzles and wherein the nozzles are disposed so that, in use, water spraying from each nozzle impinges against the water spraying from at least one adjacent nozzle, the water spraying from at least some nozzles contacting the inner walls of the conduit, such that water is sprayed over substantially an entire cross section of the conduit and such that air is entrained by the sprayed water to flow through the conduit.

41. Apparatus according to claim 40 wherein the nozzles are located side by side in one or more rows.

42. Apparatus according to claim 41 wherein the rows are horizontal.

43. Apparatus according to claim 40, 41 or 42 wherein the or each nozzle is adapted to spray a fan shaped spray of water.

44. Apparatus according to claim 43 wherein the nozzles are arranged such that, in use, the flat sides of the fan shaped sprays are parallel.

45. Apparatus according to any preceding

claim wherein the or each conduit is rectangular in cross section.

46. Apparatus according to claim 45 wherein side walls of the or each conduit are vertical.

47. Apparatus according to claim 45 or 46 wherein the side walls are in cross section less long than the bottom and top walls.

48. Apparatus according to claim 44 and claim 46 or 47 wherein the flat sides of the fan shaped sprays are parallel to the side walls.

49. Apparatus according to claim 46, 47 or 48 wherein the upper and lower walls of the conduit diverge in the downstream direction thereof.

50. Apparatus according to claim 44 and claim 49 wherein the nozzles are arranged such that the divergence of the upper and lower walls of the conduit is the same as the divergence of the upper and lower edges of the fan shaped sprays.

51. An evaporative heat exchanger constructed and arranged substantially as hereinbefore described with reference to and as illustrated in Figures 1 to 6, 11 and 13 of the accompanying drawings.

52. An evaporative heat exchanger constructed and arranged substantially as hereinbefore described with reference to and as illustrated in Figures 4 to 7, 11 and 13 of the accompanying drawings.

53. Evaporative heat exchange apparatus constructed and arranged substantially as hereinbefore described with reference to and as illustrated in Figures 8 and 9 of the accompanying drawings.

54. Evaporative heat exchange apparatus constructed and arranged substantially as hereinbefore described with reference to and as illustrated in Figure 10 of the accompanying drawings.

J. A. KEMP & CO.,
Chartered Patent Agents,
14 South Square, Gray's Inn,
London, WC1R 5EU.

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