

PATENT SPECIFICATION

(11) 1 299 922

DRAWINGS ATTACHED

1 299 922

- (21) Application No. 38288/72 (22) Filed 30 Jan. 1970
 (62) Divided out of No. 1 299 921
 (31) Convention Application No. 826 638 (32) Filed 21 May 1969
 (31) Convention Application No. 869 798 (32) Filed 27 Oct. 1969 in
 (33) United States of America (US)
 (45) Complete Specification published 13 Dec. 1972
 (51) International Classification F28C 3/08
 (52) Index at acceptance F4K 12A1



(54) EVAPORATIVE HEAT EXCHANGERS

(71) We, BALTIMORE AIRCOIL COMPANY INC., a SCorporation organized and existing under the laws of the State of Delaware, United States of America, of
 5 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, or be particularly described in and by the following statement:—

10 This invention relates to evaporative heat exchangers and more particularly to exchangers of the type which are used for cooling water for air conditioning, and various other
 15 industrial purposes.

Conventional cooling towers have heretofore involved certain critical moving parts such as an air moving device, normally a conventional fan for pumping air to contact the large water
 20 surface. In addition, conventional equipment also requires a separate water pump for circulation of water to the tower distribution system. These pumps and fans are run by separate motors and they have separate and different horsepower requirements. Generally they
 25 are located in separate equipment areas thereby requiring extensive electrical wiring and controls. Furthermore, most cooling towers use a plurality of fans requiring several motors.
 30 The fans have to be protected against undue exposure to moisture and a certain amount of maintenance, such as bearing lubrication and repair, is necessary.

Our copending Application No. 4721/70
 35 (Serial No. 1299921) describes and claims an evaporative heat exchanger in which water to be cooled is sprayed into a conduit and entrains air through the conduit inlet to extract heat from the water.

40 The present invention provides 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
 45 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.

More particularly, the present invention provides 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 conduit having a throat between the inlet and the outlet ends, the outlet end of the conduit communicating with the atmosphere and with a water collector.

Still more particularly, the invention provides a heat exchanger including a longitudinally extending conduit of rectangular cross-section having an axis which extends substantially horizontally, said conduit having an inlet end exposed to atmosphere and an outlet end, mean to spray water into the inlet end of the conduit to entrain air through the inlet to flow through the conduit, the conduit having a throat between the inlet and the outlet ends, the outlet end of the conduit communicating with the atmosphere and with a water collector.

In some preferred embodiments the conduit is slightly downwardly inclined from the inlet end to the outlet end thereof.

Mist eliminators may be provided across the outlet end of the conduit to assist stripping water still entrained in the air.

When atomized water is sprayed into the conduit thereby inducing an air flow, the velocity of the water relative to the air is high, and the mixing between the two fluids is excellent. This results in a high heat transfer between the air and water.

While it is possible to use constant cross-section conduits it has been found that better results may be achieved if the conduit has a throat, and it can suitably be in the form of a venturi.

In order that the invention may more readily be understood, the following description is given, merely by way of example, reference

[Price 25p]

being made to the accompanying drawings wherein:—

Figure 1 is a vertical section of one form of apparatus according to the invention; and

5 Figure 2 is a detail in section of the mist eliminators.

The conduit of the apparatus of Figure 1 has an axis which is slightly downwardly inclined from an inlet to an outlet. The conduit illustrated is in fact of rectangular cross-section, although this is not essential, and has a flared mouth portion 84 defining a rectangular air inlet at 85, the short dimension of which is shown in the Figure. Lengthwise of the air inlet at 85 there extends a water supply pipe 10 15 86 from which there extend a line of mutually spaced nozzles 87 arranged centrally of the conduit walls. The conduit illustrated also includes a throat portion 88 of rectangular cross-section and a diffuser portion 89, and is thus in the form of a venturi, although this is not essential. The outlet end of the diffuser portion is provided with mist eliminators 90 and with a wind deflector 91 to prevent natural air currents from opposing the left to right air flow through the conduit as illustrated. 20 25

The conduit pictured in Figure 1 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 portion maintains enough directional energy to expand fully and fill the upper section of the diffuser portion even though this requires some of the mixture to travel "uphill." 30 35

In the system of Figure 1 the cooled water is recovered in a sump 92 which forms part of the lower wall of the diffuser portion 89. The usual water make-up and withdrawal systems provided in evaporative exchangers are included but not illustrated. 40

The water atomizing nozzles 87 are so designed as to cause the water to spread in atomized form in the throat 88. The spray may in particular be conical or fan shaped. The length of the throat and the shape of the spray produce a prolonged high velocity contact between air sucked into the inlet 85 and water issuing from the nozzles. Best results are achieved if the sprays impinge one on others so as to spray water over substantially the whole of a cross-section of the conduit. This ensures maximum entrainment of air. 45 50

The water which is pumping the air moves at velocities much greater than the air with the result that there is considerable relative movement between the air and water with resulting good mixing. This mixing causes evaporation of some of the water and the heat of vaporization is taken from the remaining water which falls into the sump region in a cooled condition. 55 60

Mist eliminators 90 are provided and prevent entrainment of water through the outlet from the conduit. The shape of these elimina-

tors can be seen by reference to Figure 2, from which it may be seen that each mist eliminator comprises a fill unit made up of a plurality of parallel spaced apart fill pieces in the form of elongate strips, each having two planar margin portions connected by a curved central portion. The spaced relationship of the fill pieces is maintained by at least two spacing tabs attached to each fill piece to contact the adjacent fill piece. The surfaces of the mist eliminators become coated with water and may remain water loaded during operation of the equipment. The air flow across the water loaded surfaces causes evaporation enough to make a significant contribution to the total heat exchange. The mist eliminators also serve to remove mist from the water-air mixture which impinges upon them so that air escaping through the outlet is substantially free of entrained droplets. 70 75 80 85

The above described embodiment is also described in our copending Application No. 4721/70 (Serial No. 1299921).

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. 90 95

2. 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 conduit having a throat between the inlet and the outlet ends, the outlet end of the conduit communicating with the atmosphere and with a water collector. 100 105 110

3. A heat exchanger according to claim 1 or 2, wherein the conduit is rectangular in cross-section.

4. An evaporative heat exchanger including a longitudinally extending conduit of rectangular cross-section 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 conduit having a throat between the inlet and the outlet ends, the outlet end of the conduit communicating with the atmosphere and with a water collector. 115 120 125

5. A heat exchanger according to any one of the preceding claims, wherein the conduit is slightly downwardly inclined from the inlet end to the outlet end thereof.

6. A heat exchanger according to any one 130



being made to the accompanying drawings wherein:—

Figure 1 is a vertical section of one form of apparatus according to the invention; and

5 Figure 2 is a detail in section of the mist eliminators.

The conduit of the apparatus of Figure 1 has an axis which is slightly downwardly inclined from an inlet to an outlet. The conduit 10 illustrated is in fact of rectangular cross-section, although this is not essential, and has a flared mouth portion 84 defining a rectangular air inlet at 85, the short dimension of which is shown in the Figure. Lengthwise of the air 15 inlet at 85 there extends a water supply pipe 86 from which there extend a line of mutually spaced nozzles 87 arranged centrally of the conduit walls. The conduit illustrated also includes a throat portion 88 of rectangular cross-section and a diffuser portion 89, and is thus 20 in the form of a venturi, although this is not essential. The outlet end of the diffuser portion is provided with mist eliminators 90 and with a wind deflector 91 to prevent natural air currents from opposing the left to right air flow 25 through the conduit as illustrated.

The conduit pictured in Figure 1 is tilted downwardly at a slight angle in the direction 30 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 portion maintains enough directional energy to expand fully and fill the upper section 35 of the diffuser portion even though this requires some of the mixture to travel "uphill."

In the system of Figure 1 the cooled water is recovered in a sump 92 which forms part 40 of the lower wall of the diffuser portion 89. The usual water make-up and withdrawal systems provided in evaporative exchangers are included but not illustrated.

The water atomizing nozzles 87 are so designed as to cause the water to spread in atomized form in the throat 88. The spray may 45 in particular be conical or fan shaped. The length of the throat and the shape of the spray produce a prolonged high velocity contact between air sucked into the inlet 85 and water issuing from the nozzles. Best results are 50 achieved if the sprays impinge one on others so as to spray water over substantially the whole of a cross-section of the conduit. This ensures maximum entrainment of air.

The water which is pumping the air moves 55 at velocities much greater than the air with the result that there is considerable relative movement between the air and water with resulting good mixing. This mixing causes evaporation of some of the water and the heat 60 of vaporization is taken from the remaining water which falls into the sump region in a cooled condition.

Mist eliminators 90 are provided and prevent 65 entrainment of water through the outlet from the conduit. The shape of these elimina-

tors can be seen by reference to Figure 2, from which it may be seen that each mist eliminator comprises a fill unit made up of a plurality of parallel spaced apart fill pieces in the form of elongate strips, each having two planar margin portions connected by a curved central 70 portion. The spaced relationship of the fill pieces is maintained by at least two spacing tabs attached to each fill piece to contact the adjacent fill piece. The surfaces of the mist 75 eliminators become coated with water and may remain water loaded during operation of the equipment. The air flow across the water loaded surfaces causes evaporation enough to make 80 a significant contribution to the total heat exchange. The mist eliminators also serve to remove mist from the water-air mixture which impinges upon them so that air escaping through the outlet is substantially free of entrained droplets. 85

The above described embodiment is also described in our copending Application No. 4721/70 (Serial No. 1299921).

WHAT WE CLAIM IS:—

1. An evaporative heat exchanger including 90 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 95 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.

2. An evaporative heat exchanger including 100 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 105 water into the inlet end of the conduit to entrain air through the inlet to flow through the conduit, the conduit having a throat between the inlet and the outlet ends, the outlet end of the conduit communicating with the atmosphere and with a water collector. 110

3. A heat exchanger according to claim 1 or 2, wherein the conduit is rectangular in cross-section.

4. An evaporative heat exchanger including 115 a longitudinally extending conduit of rectangular cross-section 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 120 end of the conduit to entrain air through the inlet to flow through the conduit, the conduit having a throat between the inlet and the outlet ends, the outlet end of the conduit communicating with the atmosphere and with a 125 water collector.

5. A heat exchanger according to any one of the preceding claims, wherein the conduit is slightly downwardly inclined from the inlet end to the outlet end thereof.

6. A heat exchanger according to any one 130

- 3 of the preceding claims and including an air deflector to protect the outlet from external air currents.
- 5 7. A heat exchanger according to any one of the preceding claims, wherein a mist eliminator is located across the outlet end of the conduit.
- 10 8. A heat exchanger according to claim 7, wherein the mist eliminator includes a wet deck fill unit comprising a plurality of fill pieces lying in substantially parallel spaced relation, each fill piece being an elongate strip having two flat margin portions connected by a curved central portion.
9. A heat exchanger according to claim 8, 15 wherein each fill piece has at least two spacing tabs extending therefrom and touching the next adjacent piece to maintain a predetermined spacial relationship therebetween.
- 20 10. A heat exchanger constructed and arranged substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1972.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from
which copies may be obtained.

