COUNTER FLOW, FORCED DRAFT, BLOW-THROUGH HEAT EXCHANGERS

Inventor: Randall S. Stover, 403 W. Windsor Ave., Alexandria, Va. 22302

Filed: Jan. 2, 1974

Appl. No.: 430,168

U.S. Cl. 261/30; 62/314; 165/122; 261/109; 261/DIG. 11
Int. Cl. B01F 3/04
Field of Search 261/30, 109, 111, DIG. 11; 165/122, 124; 62/314; 55/233

ABSTRACT

Improvements in counter-flow, forced draft, blow-through heat exchangers; an improved pan section for such devices; improved baffling for the pan sections of heat exchangers of the type in question.

24 Claims, 7 Drawing Figures
1 COUNTER FLOW, FORCED DRAFT, BLOW-THROUGH HEAT EXCHANGERS

BACKGROUND OF THE INVENTION

Evaporative heat exchange apparatus and gas and liquid contact apparatus in the form of countercflow, blow-through cooling towers are ancient in the art. These devices include fill or contact surface over which water is sprayed, passing downwardly therethrough with a current of air passing upwardly countercflow in direct contact with the liquid. The liquid-gas contact evaporates some of the liquid, reducing the temperature of that remaining. The cooled liquid drops into a collecting sump in the base of the tower. These devices are also referred to as forced draft towers (air blown through the tower from fans at the base) as opposed to induced draft towers (air drawn through the towers by fans overhead).

As early as October, 1901 in the American Electrician (Volume XIII, Number 10, 476) there is shown a countercflow, forced draft, blow-through cooling tower utilizing a propeller fan driving air into the tower through a duct penetrating the wall of the tower and spaced intermediate fill and the sump in the plenum therebetween. The patent to Engalitcheff, Jr., U.S. Pat. No. 3,132,190 issued May 5, 1964 for “Heat Exchange Apparatus” shows the same construction. Commonly, centrifugal fans and propeller fans are interchangeable in such countercflow, blow-through, cooling tower constructions. The Marley Company of Kansas City extensively manufactured and sold such devices in the late 1930’s and early 1940’s with fans both exterior of the tower and interior thereof.

In an effort to minimize the space requirements of a countercflow, blow-through, forced draft tower (positioning centrifugal blowers outside of the tower housing as in Engalitcheff U.S. Pat. No. 3,132,190 takes up additional space), cooling tower makers place the fan or blower under or more or less within the confines of the tower housing, at least partially below the fill. Arrangements of this sort are seen in the patent to Pridham, U.S. Pat. No. 2,082,756, issued June 1, 1937 for “Refrigeration Apparatus”, the patent to Beringer U.S. Pat. No. 2,609,888, issued Sept. 9, 1952 for “Liquid-Gas Contact Apparatus” and the patent to Engalitcheff et al U.S. Pat. No. 3,442,494 issued May 6, 1969 for “Evaporative Heat Exchange Apparatus”. In the latter types of cooling towers and evaporative coolers, the patents to Pridham U.S. Pat. No. 2,082,756 and Engalitcheff et al U.S. Pat. No. 3,442,494 show V-section sumps. The Beringer patent U.S. Pat. No. 2,609,888 shows Y or half Y sump. A construction as in Engalitcheff et al U.S. Pat. No. 3,437,319, issued Apr. 8, 1969 for “Evaporative Heat Exchanger With Air Flow Reversal Baffle” shows a truncated V-section sump.

BRIEF SUMMARY OF THE INVENTION

From the very earliest date (at least 1901, see supra), all countercflow, blow-through, forced draft heat exchangers have had the same basic structural and functional elements, namely: (1) a housing, (2) a fill section or condenser coil positioned in the housing intermediate the upper and lower ends thereof, (3) a sump in the lower portion of the housing below the fill or condenser coil, (4) a plenum or air space between the sump and the heat exchange surface, (5) water distributing means positioned above the contacting or heat exchanging surfaces to flow water downwards therethrough, (6) means for moving air into the plenum above the level of the water in the sump and below the heat exchange contacting surfaces, and (7), usually, eliminator means at the top of the housing above the water distributor means.

The upper portions of countercflow, forced draft, blow-through heat exchangers, both the cooling towers and evaporative condensers, are extremely uniform. That is, necessarily, same is standardized to include (moving upwardly) (1) the upper portion of the plenum under the heat exchange surface, (2) the fill or condenser coil, (3) the water distributor means and (4) the eliminators, if any. The instant improvement and invention does not relate to the configuration of the upper portion of the tower, as this is standard. It is merely noted that, in the case of an evaporative condenser, a standard water distribution system and eliminator arrangement associated with the condenser coil is employed. The basic water distribution system in evaporative condensers is derived from the Beringer U.S. Pat. No. 2,609,888 patent, supra, used without significant variation in the patents to Engalitcheff U.S. Pat. No. 3,146,609, issued Sept. 1, 1964 for “Water Distribution System”; Engalitcheff U.S. Pat. No. 3,290,025 issued Dec. 6, 1966 “Trough System for Evaporative Heat Exchangers” and Engalitcheff et al U.S. Pat. No. 3,378,239, issued Apr. 16, 1968 for “Countercflow Cooling Tower”. Also see Engalitcheff et al application Ser. No. 240,199, filed Oct. 17, 1962 “Evaporative Condenser of Cooler”, abandoned.

With respect to a cooling tower heat exchanger, any known or conventional fill, water distribution system, and eliminator means known to the art may be employed, such as disclosed in any of the above listed publications and patents. The fill construction in the patent to Munters U.S. Pat. No. 3,450,393, issued June 17, 1969 for “Gas and Liquid Contact Apparatus” is a very effective and usable fill configuration.

The basic improvement of the instant invention lies in the structural configuration of the pan section for a countercflow, forced draft, blow-through evaporative heat exchanger. The pan sections of such evaporative heat exchangers, whether cooling towers or evaporative condensers, universally contain at least: (1) a sump, (2) a portion of the plenum or air space between the sump and the fill or condenser coil and (3) liquid discharge or some means for moving air into the plenum and up through the fill in countercflow relationship to the water flowing downwardly therethrough. This is typically a centrifugal fan or an axial flow propeller type fan, although other air moving means of conventional known construction may be employed. When the sump is or comprises substantially the entire bottom or a rectangular housing underneath the evaporative heat exchanger condenser coil or fill, it has long been recognized as desirable to provide ducting or rain shields over the outlets of the fans or blowers extending into the plenum between the heat exchange surface in the sump, in order to prevent the intake of water into the fans or blowers (particularly when the fans are off) and also to obtain, in some cases, static regain by shaped ducting, as well as advantages in air distribution. These features are seen in the constructions of the 1940’s of Binks Manufacturing Company of Chicago, Illinois and in the Bulletins of the Marley Company of the late 1930’s and early 1940’s. The Engalitcheff U.S.
3,903,213

Pat. No. 3,132,190 supra, also shows this construction, to say nothing of the 1901 art, also supra.

In later developments with respect to counterflow, forced draft, blow-through heat exchangers, efforts have been made to condense the size of the towers by moving the propeller fans or centrifugal blowers under the fill, typically reducing both the area and volume of the sump and the volume of the plenum space within the heat exchanger housing. In addition to the patents to Pridham U.S. Pat. No. 2,082,756, Beringer U.S. Pat. No. 2,609,888, Engalitcheff U.S. Pat. No. 3,442,494 and Engalitcheff et al U.S. Pat. No. 3,437,319, mentioned above, the patents to Ramsaur et al. U.S. Pat. No. 2,228,484, issued Jan. 14, 1941 for “Unit Evaporative Cooler” and Shelton, U.S. Pat. No. 2,775,310, issued Dec. 25, 1956 for “Cooling Tower” show the positioning of a fan or blower beneath a portion of the housing of a cooling tower or evaporative condenser.

One of the problems of water baffling in sump construction in counterflow, forced draft, blow-through exchangers lies in the fact that, in a V-section pan section, of which the lower portion comprises the water holding sump, it is commonly necessary to have the blower discharge outlet penetrating the inclined baffling wall. This is seen in the patents to Pridham U.S. Pat. No. 2,082,756, Engalitcheff et al U.S. Pat. No. 3,442,494 and Engalitcheff et al U.S. Pat. No. 3,437,319, supra. Yet further, the patent to Schmieg U.S. Pat. No. 2,163,452 “Apparatus for Removing Foreign Material from Air” shows a like configuration where the inclined baffle wall in a counterflow heat exchanger is penetrated by fluid outlet ducting. As previously noted, ducting for the shielding of fan and blower outlets within plenum spaces is common and is additionally seen in the patents to Von Linde, U.S. Pat. No. 2,543,217 “Gas Separating Process and Plant” and Byer U.S. Pat. No. 1,981,589 “Countercurrent Condenser”, issued Nov. 27, 1934.

The instant improvement in the pan section of heat exchangers of the type described lies in the concept of so positioning and mounting conventional air moving means such as a centrifugal fan or axial flow propeller fan under an inclined air baffle as to discharge out from under the end of said baffle. The fan itself is preferably aligned so as to discharge both outwardly and downwardly in the direction aligned with the angle of the baffle. Still further, a lower wall or baffle is provided below the main upper run-off baffle which extends from the discharge of the air moving means inwardly and downwardly therefrom to the sump. This wall or baffle actually may be a continuation of one of the side walls of the tower defining the sump, but, at any rate, connects to the upper edge thereof.

What is then provided underneath the upper portion of the tower (containing the heat exchange surfaces, the water distribution system and the eliminators, if any) are a pair of inwardly and downwardly inclined walls, surfaces or baffles between which air is discharged downwardly and inwardly into the lower part of the plenum of the tower. This discharge is directed at an angle against the surface of the water in the sump with the space between the baffles and inboard of the discharge of the air moving means constituting a part of the plenum below the fill or condenser coil.

Most advantageously, the walls or baffles between which the air moving means discharges or discharge may be either parallel to one another or diverge apart from one another. In the latter case, a static regain effect may advantageously be achieved. Still further, vertical walls or baffles communicating between the two primary baffles (between which the air moving means discharge) may be provided, either parallel to one another or diverging from one another, to precisely control the air flow into the lower part of the plenum above the sump. When such vertical baffles or walls are provided, which diverge from one another, a controlled static regain effect is achieved, even when the primary baffles are parallel with one another.

With the new and advantageous configuration disclosed, the structural elements of the pan section may be varied as desired to achieve numerous desirable space conserving, air flow, water baffling, etc. effects, depending upon the space available for the tower. That is, it is not necessary to entirely recess the propeller fan or centrifugal blowers underneath the towers at all times if the space is not limited. In such case, additional plenum area or space is provided within the tower and, additionally, if desired, additional space or volume for water storage in the sump. In such case, the spacing of the heat exchange surfaces (coil or fill) above the pan section may be reduced and thus the total height of the tower.

Secondly, whether or not the fan or blower is entirely recessed under the tower housing, by varying the sump side wall configuration or the angle of the lower primary baffle, a sump zone of lesser or greater volume and water storage capacity may be provided.

In all cases, not only is there no interruption whatsoever of the primary water baffle, thus eliminating leakage, the discharge of the air moving means (fan or blower) is always fully protected from down falling water and inspiration of water into the fan, either in operation thereof or when same are off, as in winter operation. Sealing problems are a minimum. Air flow characteristics in all portions of the plenum (at fan or blower discharge, immediately above the sump, above the primary upper baffle and into the fill) are at all times optimum or at least as good as any of the prior art configurations.

OBJECTS OF THE INVENTION

An object of the instant invention is to provide improvements in forced draft, blow-through, counterflow cooling towers and evaporative condensers.


Another object of the instant invention is to provide improvements in the pan section of counterflow, forced draft, blow-through cooling towers and evaporative condensers, this section including, conventionally, the fans or blowers, the sump, at least a portion of the plenum and water run-off baffling.

Another object of the invention is to provide improvements in such cooling towers and evaporative condensers utilizing either centrifugal or propeller type fans.
Another object of the invention is to provide improvements in counterflow, forced draft, blow-through cooling towers and evaporative condensers of the type wherein the fans or blowers are positioned under the fill or within the housing thereof in order to minimize the space taken up by the device.

Another object of the invention is to provide novel ways of mounting centrifugal blowers and propeller type fans in blow-through towers and condensers whereby fully obviate any problems of negative pressure with respect to the operation of the fans or blower and further prevent water getting into the fans or blowers, particularly in cooler weather, when the fans may be off.

Another object of the invention is to provide improvements in the pan section of blow-through condensers and towers, which improvements are adaptable to such devices with fans on one side only thereof or fans on both sides thereof (opposed to one another).

Another object of the invention is to provide methods of and means for introducing forced air into the plenum or pan section of blow-through condensers and cooling towers in such manner as to eliminate any possibility of circulated liquid entering the fan while the fan is in operation or off.

Another object of the invention is to provide a novel pan configuration for blow-through condensers and towers wherein a pair of substantially parallel or diverging run-off baffles are provided in said pan section, the fans or blowers discharging into the plenum of the tower therebetween.

Another object of the invention is to provide improvements in run-off baffle structures and configurations used in conjunction with fans of blow-through condensers and towers, as well as in the sump configurations associated therewith, which improvements not only keep circulating water in the tower out of the fan under all conditions, but also produce ducting effects, including static regain, which is desirable, without requiring actual ducting, shields or duct work projecting through the water baffling of the tower in the pan section.

Another object of the invention is to provide improvements in blow-through heat exchangers of the type wherein the fans or blowers are received under the tower housing at least partially under the fill, all of the functional advantages of the prior art being obtainable (including, specifically, the above listed patents) and, additionally, new advantages being provided with respect to simplicity of construction, air flow effects, sump volume, fan or blower placement, size of blower usable with the tower and the like.

Another object of the invention is to provide such improvements in pan section construction of blow-through heat exchangers of the type wherein the fans or blowers are at least partially received beneath the fill of the tower that large fans on only one side of the tower may be employed in double width towers without any loss of cooling efficiency.

Another object of the invention is to provide improvements in methods of and means for mounting fans and blowers in blow-through heat exchangers of the type wherein the fans and blowers are at least partially received within the tower housing underneath the fill, these improvements involving an improved arrangement in water baffling both above and below the discharge of the fans or blowers into the tower, whereby to permit the use of various configurations of sumps, including a true V-sump, a flat bottom V-sump or a Y-sump.

Another object of the invention is to provide improvements in forced draft condensers and towers which may be used in such towers independently of the particular fill configuration, water distribution system and eliminator means employed in such towers.

Another object of the invention is to provide methods of and means for achieving, simultaneously, both a downward flow of air input into counterflow heat exchangers of the type having the fans or blowers at least partially under the fill, and static regain effects without requiring any special ducting configuration or penetration of the conventional inclined baffling under the fill by such ducting.

Another object of the invention is to provide new, simplified, pan section constructions for counterflow heat exchangers of the type having the fans underneath the fill thereof wherein there is full and easy access to both the fans and the drives therefor without minimizing the plenum space in the tower or the sump region thereof.

Other and further objects of the invention will appear in the course of the following description thereof.

In the drawings, which form a part of the instant specification and are to be read in conjunction therewith, embodiments of the invention are shown and, in the various views, like numerals are employed to indicate like parts.

FIG. 1 is an end sectional view of a counterflow forced draft blow-through tower of the type having fans or blowers on only one side thereof.

FIG. 2 is a side view of the device seen in end section in FIG. 1 taken from the right hand side of FIG. 1 looking to the left in the view.

FIG. 3 is an end sectional elevation showing a counterflow forced draft cooling tower with opposed blowers on each side of the tower.

FIG. 4 is an end sectional elevation of a cooling tower of the capacity of that of FIG. 3 (same width of fill), but using large blowers on but a single side of the tower.

FIG. 5 is a fragmentary view of a pan construction as in FIG. 4 but with the baffle walls parallel and non-diverging.

FIG. 6 is a fragmentary plan view of the construction of FIG. 5 showing diverging vertical wall baffles.

FIG. 7 is a fragmentary schematic of the top of an evaporative condenser.

FIGS. 1 and 2 (BASIC STRUCTURE)

Referring to FIGS. 1 and 2, therein is shown a counterflow, forced draft, blow-through cooling tower utilizing the improved pan section of the instant invention and employing, in the views shown, centrifugal blowers or fans. Particularly looking at FIG. 1, as previously noted, this tower employs the necessary and conventional elements of cooling towers of this type including (moving from the top of the tower downwardly) and eliminator section generally designated 20, water distribution means generally designated 21, a liquid-gas contact section (in this cooling tower a fill section) generally designated 22, a plenum section or air space below the liquidgas contact zone 22, a sump zone in the bottom of the tower housing generally designated 24 and air forcing means here generally designated 25, the latter positioned so as to discharge above the sump and
below the heat exchanging contact surfaces 22 into the plenum air space 23. The mist eliminators in the zone 20 are conventional and comprise reverse angled metal sheets extending from end to end of the rectangular plan section tower. The water distribution system in zone 21 comprises an inlet conduit 21a, right angled cross arms 21b and nozzles 21c for spraying water downwardly onto the fill sections 22. After use, the water has taken on heat and is recycled or returned to the cooling tower or heat exchanger through conduit 21a into the water distribution system. The air moving means illustrated in FIGS. 1 and 2 for blowing air into the plenum and up through the heat exchange surfaces or fill of the cooling tower seen in FIGS. 1 and 2 comprises one or more centrifugal fans or blowers schematically designated at 28. The centrifugal fans or blowers 28 of FIGS. 1 and 2 are ganged on a single drive shaft 29 which is mounted at the ends thereof in bearings 30 (FIG. 2) on suitable structural angles or beams 31. At one end of shaft 29 there is provided one or more pulleys 32 which are driven by belts 33 which take power from the drive sheaves 34 on the drive shaft 35 of any conventional power source such as electric motor 36.

FIGS. 1 AND 2 (PAN SECTION)

The pan section of the cooling tower of FIGS. 1 and 2 comprises the entire portion of the tower below upper plenum zone 23a. That is, starting from the bottom of the tower, the pan section includes the sump 24, plenum portions 23c and 23b, the water baffling to be described and the air moving means 28, as well as the associated tower wall structure. As previously described, the entire upper section of the tower (above plenum portion 23b) is entirely conventional, whether or not the heat exchanger is an evaporative condenser or closed circuit cooler, all prime surface, or, secondary surface finned cooled. Said otherwise, the improved pan section to be described may be used interchangeably or equally well in an evaporative heat exchanger of either cooling tower or evaporative condenser structure. Also, this pan section can be used if the upper portion serves as another liquid-gas contact device, such as a gas cooler, an air washer, or the like.

Turning first to the overall tower configuration, in the tower of FIGS. 1 and 2, there are two side walls to the tower (which is here shown as basically rectangular in horizontal section) namely, the full side wall 37 (left hand wall in FIG. 1) and 38 (right hand wall in FIG. 1). End walls 39 and 40 are to the left and right in FIG. 2, respectively. End walls 39 and 40 are rectangular in the portion thereof above plenum portion 23b. They may be rectangular and entirely close off the ends of the tower therebelow, but typically are cut away in the portions opposite the blower receiving sections in the tower for access to blowers and motors thereunder. The side walls 37 and 38 may be monolithic. However, alternatively, they may be formed of removable sections as at 37a, b, c, and d and 38a, b, c, and d readily permit construction of towers of the same horizontal sectional area, but different heights. This is conventional. The flanging to permit such upper sectional construction is also visible. If the side walls are sectional then the end walls match and vice-versa.

Turning now to the pan section of the heat exchanger of FIGS. 1 and 2, this has one side wall portion 37e. In the sump configuration shown, the other side wall of
3,903,213

The sump 24 comprises an elongate, short, vertical wall 41 which is sealingly connected at its ends to end walls 39 and 40 and extends upwardly parallel to side wall 37e to its upper edge 41a. The level of the water in the sump at 24a is preferably controlled (by conventional float valve, electrode liquid level control or other new water replenishment means of conventional sort not seen) around of at edge 41a. However, this level may be controlled below edge 41a or slightly thereabove or included baffle or wall 43 to be described.

The lower portion of the side wall 38 below segment 38d is made up of an inwardly extending, downwardly inclined, water baffle or run-off plate 42 which extends from its upper end 42a connecting with the lower edge of wall 38 downwardly and inwardly to its lower end edge 42b. The inward extension of water run-off baffle 42 may be short of the upper edge of wall 41 at 41a, in line therewith or theretop. Preferably, as seen in the view, it extends at least vertically in line with the upper extension or edge 41a of wall 41. (In the single side, small baffle tower shown.)

It must be understood that wall 41 is not necessarily vertical. That is, it may be inclined either to the left or to the right in FIG. 1, as desired. An inclination downwardly to the right in FIG. 1 would provide a greater sump volume, while an inclination downwardly to the left in FIG. 1 would reduce the sump volume.

A second downwardly and inwardly inclined baffle, wall or run-off plate 43 having an upper edge 43a and a lower edge 43b is positioned below run-off plate or baffle 42 and more or less parallel thereto unless a static regain effect is desired to be achieved between baffles 42 and 43. The lower edge 43b of baffle 43 sealingly fits with and joins to the upper edge 41a of wall 41 so that baffle 43 and wall 41 present a continuous wall running from the upper edge 43a of baffle 43 to the lower edge 41b of wall 41. Both wall 41 and baffle 43 extend continuously between and sealingly connect to the end walls 39 and 40 of the tower or heat exchanger.

In the case of centrifugal fans or blowers such as are schematically indicated at 28 in FIGS. 1 or 2, some typically has a snout 28a of greater or lesser extension from which the air is discharged. This snout closely and sealingly fits under the upper surface of upper baffle 42 (adjacent end 42b) and the upper surface of wall 43 whereby to discharge air downwardly and inwardly (to the left in FIG. 1) into the plenum zone 23c and particularly that portion thereof which is received between the lower end of upper baffle 42 and the upper surface of lower baffle 43.

In order to ensure that plenum 23 is entirely air sealed, a vertical wall is provided communicating between and fixed at its upper and lower edges, respectively, to the under side of baffle 42 and the upper edge 43a of wall 43. (Vertical wall 44) This vertical wall 44 may be extended downwardly from the upper edge 43a of wall 43 to the ground level or floor, thus operating to support both the lower end and upper baffle 42 and the upper edge 43a of baffle 43. This is seen in the views.

The portion of wall 44 below baffle 43 is designated 44a. Suitable angle supports 45 are provided to removably hold blower housing 28 in position with the upper wall 28b of the blower housing flat against the under surface of baffle 42. Blowers 28 may be of older type with removable cut-off plates (not shown) or have the cut-off point of the blower integral with the housing, as

seen. The snouts of the blowers 28 extend through openings or orifices in the wall 44 with suitable sealing means of rubber or plastic strips, applied plastic sealer compound or both assuring air seal circumferential thereto if required.

As seen by angled lines 46 which are in line with baffles 42 and 43 extended, baffles 42 and 43 preferably diverge inwardly and downwardly from one another. For static regain effects, as is taught in the art, a divergence apart, one from the other of these baffles of 17° is optimum to achieve static regain of the air input to the tower from blower 28. It should be noted that, as previously mentioned, baffles 42 and 43 may extend parallel to one another. In the tower of FIG. 1, this would be accomplished by rotating baffle 43 slightly clockwise around its upper edge 43a. In such case, and if the baffle 43 was extended to connect at the lower end of wall 37e (removing wall 41), then a V-section sump would be present. Alternatively, the wall or baffle 43 extended seen in FIG. 1 would provide a truncated V-section sump. In either of the latter two instances (true V or truncated V section sump) the return water conduit 26 and the anti-air entrainment baffle 47 thereabove (which extends end wall to end wall in the tower in the sump) would be relocated to the left in the view and upwardly.

In order to provide more control of the air flow from the fans or blowers 28 in the zone of plenum portion 23c between the lower end of upper baffle 42 and above lower baffle 43, there optionally may be provided sets of vertical baffles 48 inboard (in the plenum 23) of wall 44. This is to the left in the view of FIG. 1. These baffles may be parallel to one another and closely fit against the side walls of the blower housing (particularly in the snout portions 28a thereof) or, alternatively, they may diverge away from one another from right to left in the view of FIG. 1 and downwardly and inwardly in the plenum portion 23c. This divergence is particularly desirable where baffles 42 and 43 are substantially parallel to one another, whereby the static regain effect is achieved between the vertical baffles 48, rather than the baffles 42 and 43. In the case where the upper and lower baffles 42 and 43 diverge from one another, then the baffles 48 may be in both baffles 42 and 43 (from one another) and 48 (from one another). When baffles 48 are provided, then there is a duct extension from the discharge snout 28a of each of the blowers 28, in effect.

FIGS. 1 AND 2 (OPERATION)

With respect to the operation of the heat exchanger (specifically, a cooling tower) illustrated in FIGS. 1 and 2, the following is noted. First, it is evident, as previously noted, that this is a forced draft, counterflow, blow-through heat exchanger having each and every one of the conventional structural or apparatus parts of same, namely: a housing, a sump in the lower portion of the housing, a plenum air space above the sump, air moving means to drive air into the lower part of the tower housing and, specifically, the plenum, contact surfaces by way of a heat exchanging coil or cooling tower fill, water distribution apparatus above the contact surfaces and mist eliminators thereabove. Likewise, this device functions as a counterflow, blow-through, forced draft heat exchanger in that liquid to be cooled is input in the upper portion of the housing above the contact surfaces, migrating downwardly in
contact therethrough. Liquid falling from the underside of the cooling tower fill falls downwardly through the air plenum, still in counterflow gas-liquid air contact. This water either falls directly into the sump or impacts upon the upper baffle 42 to pass downwardly thereover and fall into the sump. Any liquid which for any reason may, in the plenum zone 23c, be drawn or fall or move to the right under the upper baffle 42 falls on the inclined lower baffle 43 and also goes into the sump.

The cooled liquid in the sump is recycled through conduit 26, via the work to be heat exchanged, to the input conduit 21a at the top of the tower housing. The air blown into the tower through the orifices in the wall 44 between the baffles 42 and 43 by fans 28, as is seen by arrows 49a, blows or blasts from right to left in the view of FIG. 1 downwardly and inwardly into the tower over the surface of the plenum and against the wall 37e. There is a static regain in the zone between the baffles 42 and 43 (and 48, if present), provided either the baffles 42 and 43, or the baffles 48, or both sets, diverge from one another from right to left in the view of FIG. 1.

Optional extension of baffle 42 over sump 24 is seen in FIG. 1 with end 42b' of baffle 42 extended further downwardly and inwardly and the vertical baffles 48 extended as seen at 48'. This gives additional duct effect between the baffles 42, 43 and 48 when same are employed in combination.

It should be pointed out that additional lower plenum portion 23c volume may optionally be provided by moving the blowers 28 upwardly and to the left in the view of FIG. 1 so that a portion of the blower housing protrudes outside the line of wall 38 extended vertically downwardly. When space considerations are not absolutely critical, this configuration will enable either moving the lower ends of baffles 42 and 43 to the right in the view of FIG. 1, whereby to widen (in end view) the plenum portion 23c to the left of the baffles and improve air distribution or, alternatively, if the baffles are left with their same downward and inward (to the left in FIG. 1) extension, then a considerably longer controlled duct is provided from the blower discharges 28a on the outside of the baffles 42, 43 and 48. This permits the desired, controlled, maximum static regain potential to be achieved.

The provision of the upper baffle 42, particularly if extended to 42b' also see FIG. 4), as also the lower cooperating baffle 43 and baffles 48 (if employed) obviate and do away with any hazard or effects of negative pressure as discussed in the Engaltichoff U.S. Pat. No. 3,132,190 (if present) particularly see column 4, lines 37 through column 5, line 7, Independently of the cause, or whether it is restricted to a particular type of blower, such as that employing a removable cut-off, drawing of water into the discharge snout 28e of centrifugal fans or back into the blades of propeller fans is very undesirable, particularly in cooler weather, with a possibility of a vapor freezing on the fan wheel or wheels or propeller blades or fan accessories.

One of the basic purposes of the instant invention is to introduce air into the plenum or pan section through the vertical wall 44 and between the baffles 42 and 43 (and 48 if present) in such a way as to totally eliminate any possibility of circulated liquid in the heat exchanger entering the fan either while same is in operation or not in operation. By rotating (from horizontal discharge) and locating a standard fan housing under a run-off baffle as baffle 42 to an angle of 30°-45° (45° shown) and also positioning same with respect to an angled lower run-off baffle. Another achieved purpose of the described baffle-wall configuration is to achieve a marked, effective static regain effect downstream of the fan or blower discharge without requiring duct work which projects into the plenum through a vertical side wall or, for that matter, through an angled, run-off water baffle. The former is seen in the 1901 forced draft cooling tower disclosure of Worthington, supra, and the Engaltichoff U.S. Pat. No. 3,132,190, supra. The latter is typically seen in the Engaltichoff U.S. Pat. No. 3,442,494, supra.

The air, moving upwardly out of the plenum section 23c and on recoil impact from the wall 37e moves into section 23b from left to right in the view of FIG. 1 as indicated by the arrows 49a. As the air then moves upwardly into the plenum section 23a out of the expanding plenum section 23b above the baffle 42, more or less uniform air distribution is achieved (depending upon the volume of plenum section 23a) and the air passes into the under side of the fill section 22. The predominantly upward movement of the air in plenum section 23b is indicated by the substantially vertical arrows 49c. This upward air movement in plenum sections 23b and 23a is counterflow to the falling water droplets from the fill section (or heat exchanging coils of an evaporative condenser). The air then passes upwardly through the fill in intimate gas-liquid direct heat exchanging contact with the water, thereafter passing through the air distribution apparatus zone and thence through the mist eliminator section 20.

It should be understood that the mist eliminators may be anamalch up of the same material (in lesser depth) as the fill with respect to the material 22b.

The upper wall or run-off baffle 42 necessarily projects downwardly and inwardly beyond the blower snout, not only to function as a rain shield, but in order to provide a top side air containing chamber. Wall 44a is relieved, where necessary, to permit positioning of motor 36 where shown in FIGS. 1 and 2. Under certain circumstances, it is desirable that the water level be kept at the minimum depth feasible without causing cavitation, on start-up particularly, because of increased weight in the tower with a greater water volume therewithin.

Another factor of significance with respect to either absence of vertical walls 48 between baffles 42 and 43 or outward divergence thereof at a considerable angle lies in the fact that this construction results in very considerably less resistance and back pressure with respect to the air forced into the tower plenum as compared to a confined duct, per se. This lessened resistance enables the further extension of the lower end of baffle 42 downwardly past the blower discharge snout 28a without hindering air distribution or air flow in the tower to any considerable degree.

It is understood that the centrifugal fan scrolls or housings, in side view, constitute an Archimedes curve and not a circle, but the fans illustrated are shown schematically.

Traditionally, as is well known in ancient prior art, the centrifugal fans are spaced apart from one another a full fan housing width, at least, in order to obtain sufficient air in the side inlets of the centrifugal fans and, additionally, permit the lateral removal of the blower wheels. This arrangement also results in the blower
housings being spaced at least one-half a housing width from the end walls 39 and 40 (FIG. 2). This blower spacing is discussed in the Engalitcheff et al U.S. Pat. No. 3,442,494, but is not novel to that patent.

FIG. 3 — DOUBLE WIDTH TOWER

Refrerring next to FIG. 3, therein is shown the well known opposed blower configuration in counterflow, forced draft, blow-through cooling towers. This is a double width tower, as seen in the end view of FIG. 3 and, actually, is equivalent, exactly, to two towers of the configuration of FIG. 1 placed opposite one another with walls 37 made common to one another, this wall stopped short of the bottom of the double width sump for water communication thereunder. A double width tower of this type is seen in FIG. 2 of the Engalitcheff et al U.S. Pat. No. 3,442,494.

The parts of each tower half being the same as those parts described in FIGS. 1 and 2, identical parts in the tower of FIG. 3 are numbered the same, but primed. The structural configuration of each side of the pan section, save for the changes noted being identical to a tower of the configuration in FIGS. 1 and 2, the parts and their operation will not be here redescribed.

FIG. 4 — DOUBLE WIDTH LARGE BLOWERS

Refrerring to FIG. 4, therein is shown an end vertical section of part of a modified construction (or pan section for an evaporative condenser, closed circuit cooler or cooling tower) which embodies the same principles and structures, but permits the use of large fans on only one side of the tower. The tower is of a double width (FIGS. 3 and 4 show towers of the same width). Assuming that, for example, the tower of FIG. 1 is 4½ feet wide, then pan sections of the same structure used in opposition to one another in FIG. 3 would give a double width of 9 feet. Thus it may be seen that the single width and double width towers of FIG. 1 and 3 employ relatively smaller fans. A tower of the construction of FIG. 3 having the same number of the like size fans on each side thereof as on the tower side of the structure of FIG. 1 would have double the capacity. FIG. 4 thus puts larger fans on only one side with a double width. The sump of FIG. 4 is double width with respect to FIG. 1 and the same width as that in FIG. 3, without a dividing wall.


Other than the dimensions and fan capacity referred to, the structure of FIG. 4 has the same parts arranged in the same way as FIGS. 1 and 2. The upper part of the tower may be a cooling tower, closed circuit cooler, or an evaporative condenser. As another difference, the full line showing the upper baffle here is extended over the sump which may be readily utilized in this configuration without impedance to air flow because of the additional sump width (which gives greater lower plenum width).

In the showing of the pan sections of FIGS. 1, 3 and 4 it should be understood that it is not necessary that the baffles or walls 48, 48' and 48" extend to the end of the upper and lower baffles 42 and 43, etc.

The parts of the towers of FIGS. 1 and 4 (the lower portion of FIG. 1) being the same except for the above noted differences, like parts in FIG. 4 the same or identical to like parts in the lower portion of FIG. 1 are numbered the same, but double primed and will not be described as the operation thereof is the same.

In the case of cold weather operation (fan off), where the water fall from the fill is unopposed by air blown from the fans, in many counterflow, blow-through, cooling towers, evaporative condensers or close circuit coolers, there is steam flow back through the fans with the problem of water freezing on the fans. This is no problem in the instant unit as the weight of the cold air column between the baffles opposes warm air and steam outflow from the tower.

Additionally, with the orientation of the fans shown in the instant improvement, it is not necessary to use devices of the sort seen in the U.S. Pat. No. 3,572,657 to Bradley, issued Mar. 30, 1971 for "Water Baffle".

FIGS. 5 AND 6 — PARALLEL MAIN BAFFLES

FIG. 5 is a fragmentary view of a pan construction like that of FIG. 4 in every way, but having the main baffle walls parallel to the one another, rather than diverging from one another away from the fan outlets.

This being the only difference between the structures of FIGS. 4 and 5, the parts of FIG. 5 which are seen and are the same as those of FIG. 4 are numbered the same, but triple primed. To repeat, the only difference between the showings of FIGS. 4 and 5 is that walls 43', 43", and 42' of FIG. 5 are parallel to one another, rather than diverging from one another as is the case in FIG. 4 with respect to walls or baffles 42' and 43'.

The FIG. 6 is a fragmentary plan view of the construction of FIG. 5 showing diverging vertical baffles 48'" and optional non-diverging same. The non-diverging baffles are designated 48a" in the view of FIG. 6. Even with the parallel main baffles 42'" and 43" in FIG. 5, if the diverging wall baffles 48'" are provided, static regain is provided.

FIG. 7 is a fragmentary side schematic view of the top of an evaporative condenser having side walls 50 and 51 with eliminators 52 at the top thereof. Input pipe 53 connects to header 54 with cross arms 55 having sprays thereon. A coil 56 substitutes for the fill of FIGS. 1 and 2 (cooling tower). Refrigerant is input through line 56a and taken out through line 56b. The showing of FIG. 7 is to indicate that the pan section of the previous figures can be employed with the conventional heat exchange means other than cooling towers such as evaporative condensers and closed circuit coolers. Thus, the pan sections of the lower portion of FIG. 1 or FIGS. 3 or 4 may be employed with the upper portion of the vessel or device of FIG. 7.

From the foregoing, it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth together with other advantages which are obvious and which are inherent to the apparatus.

It will be understood that certain features and sub-combinations are of utility and may be employed with reference to other features and sub-combinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.
1. A pan section for a counterflow, forced draft, blow-through evaporative heat exchanger, comprising:
   a pair of opposed, parallel, vertical, spaced-apart walls defining the pan section end walls,
   one side wall of the pan section formed of a vertical wall connecting at its end edges to one end edge of each end wall and extending the length thereof at right angles thereto,
   a first downwardly and inwardly inclined continuous upper side wall baffle connected at its end edges to said end walls and continuously extending from the opposite edges thereof downwardly and inwardly thereof, but stopping short of the vertical side wall,
   a second downwardly and inwardly inclined continuous lower side wall baffle connected at its end edges to the said end walls and positioned below said first baffle and continuously extending substantially parallel thereto,
   the outboard side edge of said second, lower, side wall baffle positioned substantially inboard of the outboard side edge of the first upper side wall baffle;
   a sump side wall below said second baffle and connected at its upper edge to the lower inner edge thereof running continuously the length of said pan section and connecting at the end edges thereof to said end walls, whereby to define with said vertical side wall the side walls of a sump,
   a bottom wall extending continuously between the end walls of the pan section and connected at its end edges thereto and with its side edges to the bottom edges of the pan section vertical wall and sump side wall,
   at least one fan means for forcing air between said side wall baffles positioned substantially under the upper baffle and largely outboard of the lower baffle and discharging downwardly and inwardly between said baffles over the lower baffle and sump,
   and intermediate and outboard portions of the upper and lower baffles, respectively, closely fitting the discharge of the fan means
   means sealing the space between the baffles except where said air is forced therebetween positioned outboard of the lower baffle,
   whereby the space between the baffles, over the sump and above the upper baffle forms a plenum zone in said pan section.

2. A pan section as in claim 1 wherein the means for forcing air between the baffles comprises one or more centrifugal blowers with the line of flow of air from each blower extending substantially parallel to the line of extension of the upper baffle.

3. A pan section as in claim 1 wherein the means for forcing between the baffles comprises one or more axial flow propeller fans.

4. A pan section as in claim 1 wherein the baffles extend parallel to one another.

5. A pan section as in claim 4 including additional vertical diverging baffles positioned on each side of the discharge of each air forcing means between the baffles.

6. A pan section as in claim 1 wherein the baffles diverge from one another inwardly.

7. A pan section as in claim 6 including additional vertical baffles positioned on each side of the discharge of each air forcing means between the baffles extending substantially parallel to one another.

8. A pan section as in claim 1 wherein the sump side wall adjacent the baffles is a substantial continuation of the lower baffle whereby the sump in end section is of substantial V-configuration.

9. A pan section as in claim 8 wherein the sump is of truncated V-section with a flat bottom.

10. A pan section as in claim 8 wherein the sump is of true V-section.

11. A pan section as in claim 1 wherein the sump side wall next to the baffles is substantially vertical whereby the sump, in end section, is of substantial rectangular configuration making a half Y with the lower baffle.

12. A pan section as in claim 1 wherein the upper baffle extends inwardly over the sump zone.

13. A pan section for a counterflow, forced draft, blow-through heat exchanger comprising
   a pair of opposed, parallel, vertical, spaced-apart walls defining the pan section end walls;
   a first pair of upper symmetrical, opposed, spaced apart, downwardly and inwardly inclined continuous side wall baffles connected at their end edges to the said end walls and continuously extending from the side edges of said end walls downwardly and inwardly thereof, but stopping short of one another centrally of said pan section;
   a second pair of lower symmetrical, opposed, spaced apart, downwardly and inwardly inclined continuous side wall baffles connected at their end edges to said end walls and positioned below said first pair of baffles and continuously extending in substantial parallelism therewith;
   the outboard side edges of the said second lower side wall baffles positioned substantially inboard of the outboard side edges of the first upper side wall baffles;
   at least two sump side walls positioned below said second baffles and connected at their upper end edges to the lower inner edges thereof and running continuously the length of said pan section and connected at the end edges thereof to said end walls whereby to define therebetween the side walls of a sump;
   a bottom wall extending continuously between the end walls of the pan section and connected at its end edges thereto and with its side edges to the bottom edges of the sump side walls;
   at least one fan means for forcing air between the upper and lower continuous side wall baffles on each side of the heat exchanger, each said means positioned substantially under an upper baffle and largely outboard of the adjacent lower baffle and discharging downwardly and inwardly thereof over the adjacent lower baffle and said sump;
   intermediate and outboard portions of the adjacent upper and lower baffles, respectively, closely fitting the discharge of the fan means,
   and means sealing the space between adjacent upper and lower baffles outboard of the latter except where said air is forced therebetween, whereby the space between the upper and lower baffles, over the sump and above the upper baffles forms a plenum zone in said pan section.
14. A pan section as in claim 1 wherein the means for forcing air between the baffle pairs comprise one or more centrifugal blowers with the line of flow of air from each blower extending substantially parallel to the line of extension of the first baffle thereover.

15. A pan section as in claim 1 wherein the means for forcing air between the baffle pairs comprise one or more axial flow propeller fans.

16. A pan section as in claim 1 wherein the two members of each pair of baffles extend parallel to one another.

17. A pan section as in claim 16 including additional vertical diverging baffles positioned on each side of the discharge of each air forcing means between the baffles of each pair.

18. A pan section as in claim 1 wherein the two members of each pair of baffles diverge from one another inwardly.

19. A pan section as in claim 7 including additional vertical diverging baffles positioned on each side of the discharge of each air forcing means between the baffles of each pair.

20. A pan section as in claim 1 wherein the sump side walls are substantial continuations of the lower two baffles of the opposed pairs thereof, whereby the sump in end section is of substantial V-configuration.

21. A pan section as in claim 20 wherein the sump is of truncated V-section with a flat bottom.

22. A pan section as in claim 20 wherein the sump is of true V-section.

23. A pan section as in claim 1 wherein the sump side walls are substantially vertical, whereby the sump in end section is of substantial rectangular configuration making a Y with the opposed lower baffles.

24. A pan section as in claim 1 wherein the upper one of each said pair of baffles extends inwardly over the sump zone.