United States Patent [19]

Stover

[11] **3,903,213**

[45] **Sept. 2, 1975**

[54] **COUNTER FLOW, FORCED DRAFT, BLOW-THROUGH HEAT EXCHANGERS**

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[52] **U.S. Cl.** **261/30;** 62/314; 165/122; 261/109; 261/DIG. 11

[51] **Int. Cl.²** **B01F 3/04**

[58] **Field of Search** ...... 261/30, 109, 111, DIG. 11; 165/122, 124; 62/314; 55/233

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[57] **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

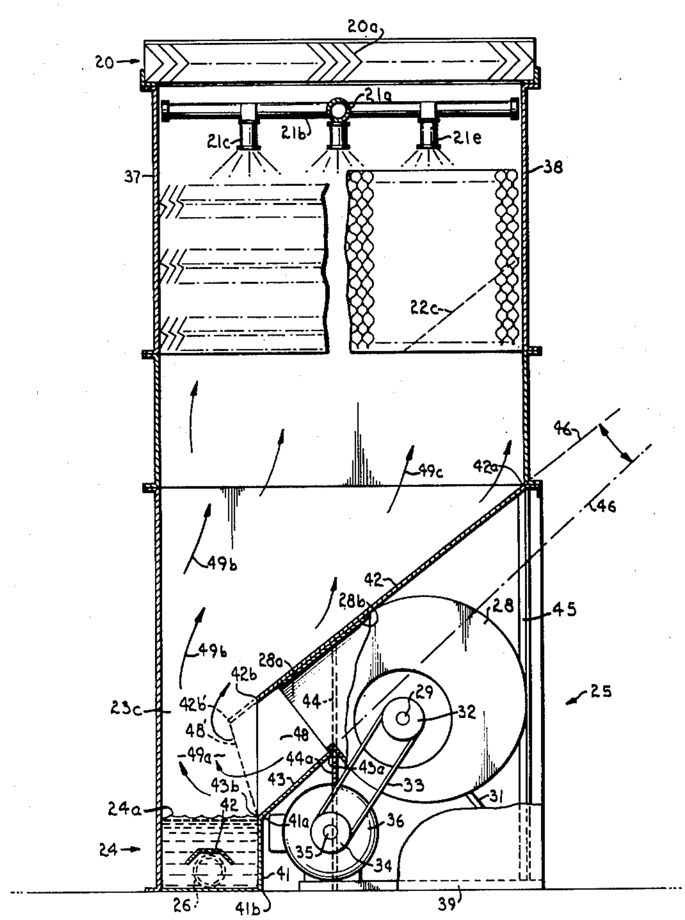

Fig. 1.

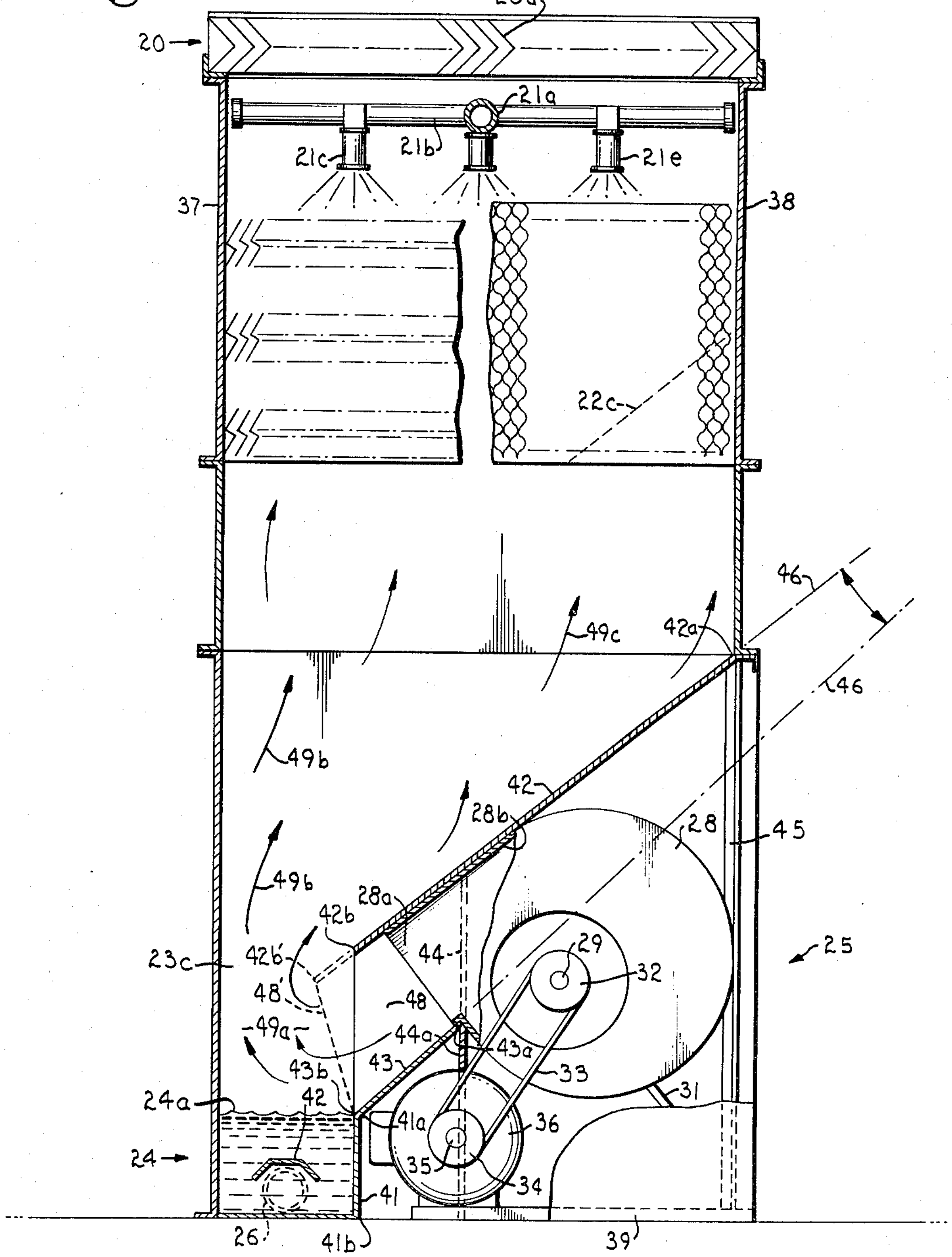
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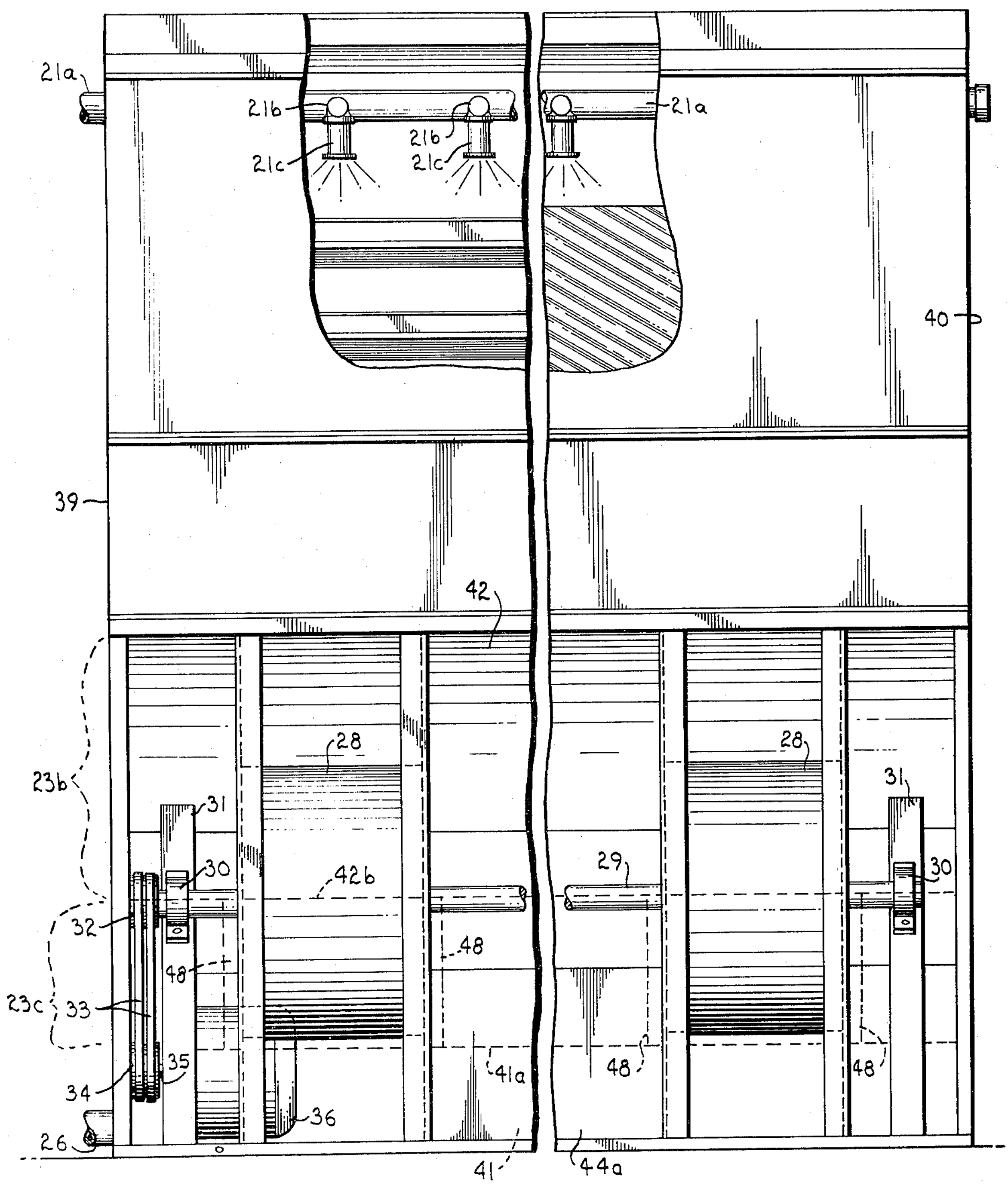
Fig. 2.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44a

Fig. 3.

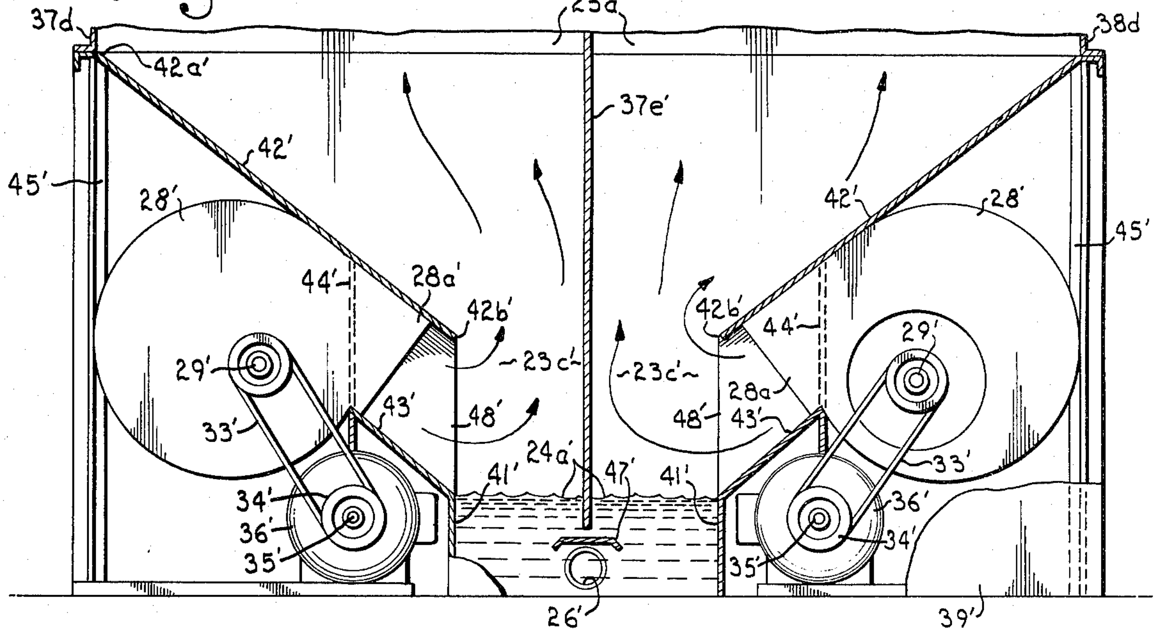
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Fig. 4.

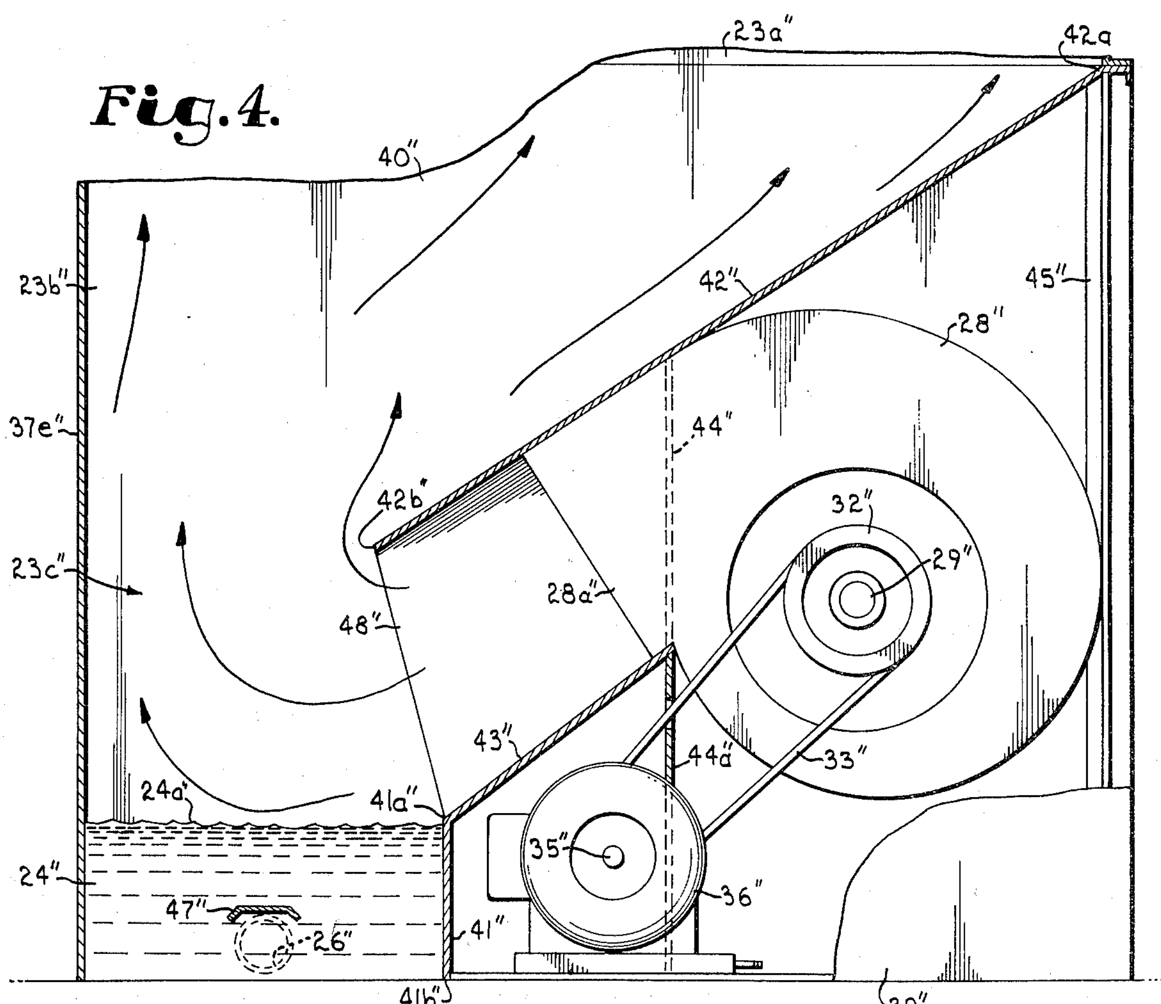
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Fig.5.

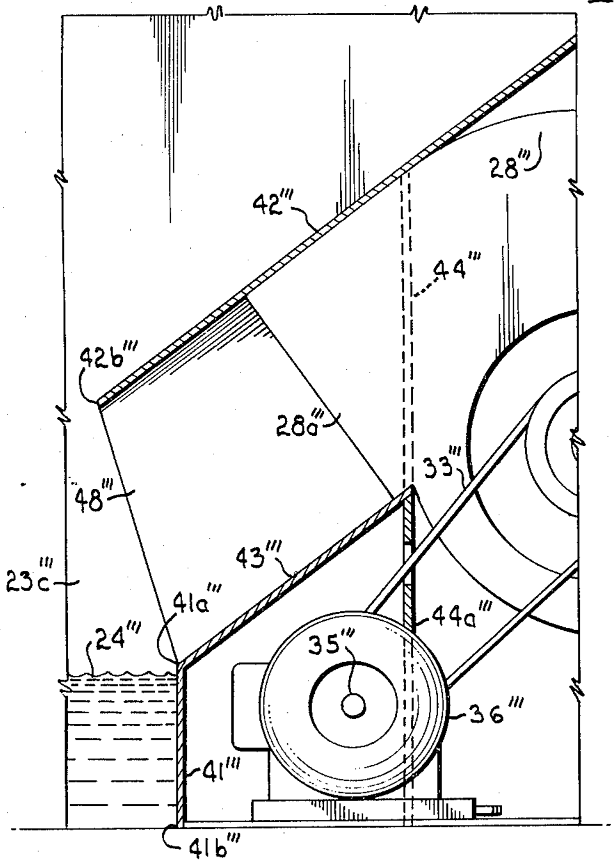


Fig. 7.

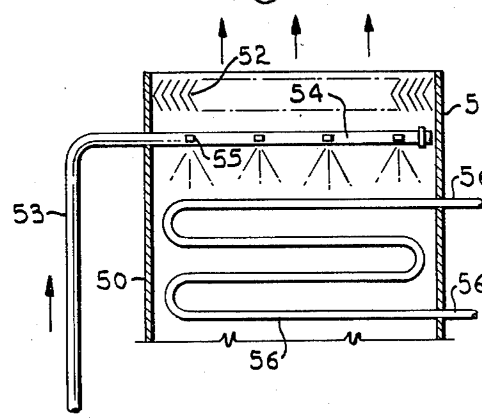
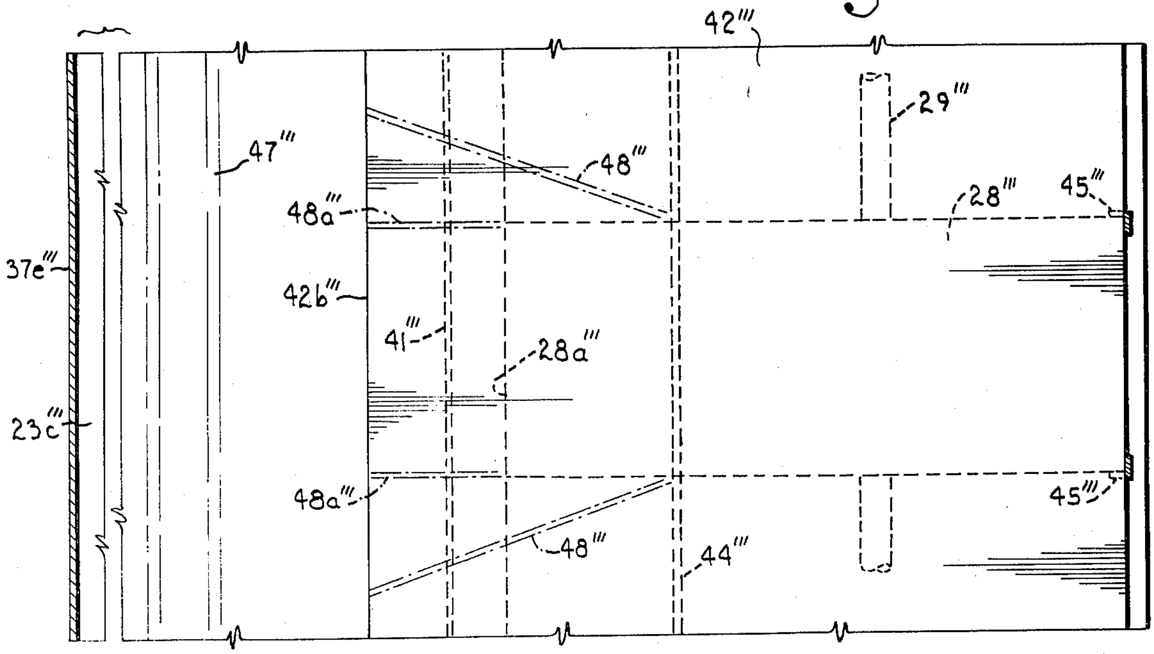


Fig. 6.



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 counterflow, 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 counterflow 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 counterflow, 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 the 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 counterflow, 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 counterflow, 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 counterflow, 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 down therethrough, (6) means for moving air into the plenum above the level of the water in the sump and below the heat exchanging contact surfaces, and (7), usually, eliminator means at the top of the housing above the water distributor means.

The upper portions of counterflow, 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 "Counterflow 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 usuable fill configuration.

The basic improvement of the instant invention lies in the structural configuration of the pan section for a counterflow, 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) at least the discharge or some means for moving air into the plenum and up through the fill in counterflow 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.

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. 2,843,217 "Gas Separating Process and Plant" and Byer U.S. Pat. No. 1,981,989 "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, first, 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 is to provide improvements in counterflow, forced draft heat exchangers of the blow-through type as seen in the patents to Beringer, U.S. Pat. No. 2,609,888, issued Sept. 9, 1962 for "Liquid-Gas Contact Apparatus" and Engalitcheff et al U.S. Pat. No. 3,442,494, issued May 6, 1969 "Evaporative Heat Exchange Apparatus". (Also Engalitcheff et al U.S. Pat. No. 3,437,319, issued Apr. 8, 1969 for "Evaporative Heat Exchanger with Air Flow Reversal Baffle".)

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 to 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 input conduit **21***a*, right angled cross arms **21***b* and nozzles **21***c* for spraying water downwardly onto the fill section or condenser coil therebelow. The patent to G. W. Meek U.S. Pat. No. 3,533,560 issued Oct. 13, 1970 for "Cooling Tower Spray Nozzle" details a typical liquid header system with spray nozzles.

The fill configuration employed in a cooling tower utilizing the improved sump may be of any conventional fill construction, such as those shown in the patents listed above or, indeed, any other conventional fill, of plastic, wood, metal, fiberglass, etc. Two different conventional fills are shown in FIGS. **1** and **2.** To the left in FIGS. **1** and **2,** there is (**22***a*) seen a W type of fill configuration to permit use of light guage galvanized steel, wherein there are a plurality of discreet, separate sections **22***a* of curved or angled metal sheets (much like the eliminator blades **20***a* positioned adjacent one another). On the other hand, on the right hand side of FIG. **1** there is seen fill material of the type seen in the Munters U.S. Pat. No. 3,450,393 patent, supra, involving a monolithic block of corrugated thin sheets composed of a plastic material such as polyvinyl chloride. Block **22***b* extends continuously the height and breadth of the fill section, if same is used. Conventional means for supporting the fill within the housing or tower are employed as will now be described.

Immediately below the fill section there may be provided, with respect to the plenum zone **23,** an upper plenum zone **23***a* of an area (in horizontal section) precisely that of the fill section thereabove. The purpose of such preferred and optimal upper plenum zone **23***a* is to provide, insofar as possible, equal air distribution across the lower portion of the fill for optimum heat exchange efficiency within the fill. In the event that the height of the tower is critical and it is not feasible (with the depth of fill desired in the tower or required) to provide a zone **23***a*, then, alternatively, in the view of FIG. **1,** the fill section may bottom immediately at the top of the fill section **23***b*. However, in such case, the right hand side of the fill section, in FIG. **1,** will, in such case, to achieve reasonably uniform air distribution across the bottom surface of the fill, necessarily be relieved or removed in the right hand side thereof such as indicated by the angled dotted line **22***c* in the right hand of the fill section in FIG. **1.**

The plenum section **23***b* is that plenum section (in the view of FIG. **1**) which is to the left of the upper inclined water baffle **42** (to be described) and thereabove to the top of said upper inclined water baffle. The plenum area **23***c* is that zone of plenum **23** which is immediately above the sump, extending upwardly to the bottom or lower edge of the upper inclined water baffle (to be described) and includes the zones between the two inclined water baffles also to be described.

In the sump zone **24,** (where the cooled water is received after input to the tower through the water distribution system, gas-liquid contact in the fill and passage down through the plenum **23**) in the modification of FIGS. **1** and **2,** the water level **24***a* is typically maintained at the top of the rectangular sump (rectangular in end vertical section as seen in FIG. **1**). As in conventional counterflow, forced draft blow-through cooling tower operation, a withdrawal conduit **26** is provided adjacent the lower level of the sump zone **24.** From conduit **22,** through any conventional suitable external piping or conduit (not seen) and driven by a pump (also not seen) the cooled water is withdrawn from the sump zone **24** and passed to a point of use or work. After use, the water has taken on heat and is recycled or returned to the cooling tower or heat exchanger through conduit **21***a* 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 **23***a*. That is, starting from the bottom of the tower, the pan section includes the sump **24,** plenum portions **23***c* and **23***b*, 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 **23***b*) is entirely conventional, whether or not the heat exchanger is an evaporative condenser or closed circuit cooler, all prime surface, or, secondary surface finned coiled. Said otherwise, the improved pan section to be described may be used interchangably 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 **23***b*. 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 **37***a*, *b*, *c*, and *d* and **38***a*, *b*, *c*, and *d* to 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 **37***e*. In the sump configuration shown, the other side wall of 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 **37***e* to its upper edge **41***a*. The level of the water in the sump at **24***a* 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 **41***a*. However, this level may be controlled below edge **41***a* or slightly thereabove or inclided baffle or wall **43** to be described.

The lower portion of the side wall **38** below segment **38***d* is made up of an inwardly extending, downwardly inclined, water baffle or run-off plate **42** which extends from its upper end **42***a* connecting with the lower edge of wall **38** downwardly and inwardly to its lower end edge **42***b*. The inward extension of water run-off baffle **42** may be short of the upper edge of wall **41** at **41***a*, in line therewith or therepast. Preferably, as seen in the view, it extends at least vertically in line with the upper extension or edge **41***a* of wall **41**. (In the single side, small blower 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 **43***a* and a lower edge **43***b* 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 **43***b* of baffle **43** sealingly connects with and joins to the upper edge **41***a* of wall **41** so that baffle **43** and wall **41** present a continuous wall running from the upper edge **43***a* of baffle **43** to the lower edge **41***b* 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**, same typically has a snout **28***a* of greater or lesser extension from which the air is discharged. This snout closely and sealingly fits between the under surface of upper baffle **42** (adjacent end **42***b*) and the upper surface of wall **43** whereby to discharge air downwardly and inwardly (to the left in FIG. **1**) into the plenum zone **23***c* 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 insure 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 **43***a* of wall **43**. (Vertical wall **44**) This vertical wall **44** may be extended downwardly from the upper edge **43***a* of wall **43** to the ground level or floor, thus operating to support both the lower end and upper baffle **42** and the upper end **43***a* of baffle **43**. This is seen in the views. The portion of wall **44** below baffle **43** is designated **44***a*. Suitable angle supports **45** are provided to removably hold blower housing **28** in position with the upper wall **28***b* 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 **43***a*. In such case, and if the baffle **43** was extended to connect at the lower end of wall **37***e* (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 **23***c* 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 **28***a* 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 **23***c*. 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** (fron one another. When baffles **48** are provided, then there is a duct extension from the discharge snout **28***a* 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 poriton 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 **23***c*, 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 **21***a* 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 **49***a*, blows or blasts from right to left in the view of FIG. **1** downwardly and inwardly into the tower over the surface of the sump and against the wall **37***e*. 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 **42***b*′ 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 **23***c* 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 **23***c* 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 **28***a* outboard of the termini 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 **42***b*′ (also see FIG. **4**), as well as 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 Engalitcheff 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 **28***a* 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 Engalitcheff U.S. Pat. No. 3,132,190, supra. The latter is typtically seen in the Engalitcheff U.S. Pat. No. 3,442,494, supra.

The air, moving upwardly out of the plenum section **23***c* and on recoil impact from the wall **37***e* moves into section **23***b* from left to right in the view of FIG. **1** as is indicated by the arrows **49***a*. As the air then moves upwardly into the plenum section **23***a* out of the expanding plenum section **23***b* above the baffle **42,** more or less uniform air distribution is achieved (depending upon the volume of plenum section **23***a*) and the air passes into the under side of the fill section **22.** The predominantly upward movement of the air in plenum section **23***a* is indicated by the substantially vertical arrows **49***c*. This upward air movement in plenum sections **23***b* and **23***a* 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 made up of the same material (in lesser depth) as the fill with respect to the material **22***b*.

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 **44***a* 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 reistence enables the further extension of the lower end of baffle **42** downwardly past the blower discharge snout **28***a* 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

Referring 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 numberd 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

Referring 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 doubel 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.

This configuration of tower readily permits the employment of axial flow propeller fans with a double width tower as seen in the Engalitcheff et al U.S. Pat. No. 3,437,319 "Evaporative Heat Exchanger with Air Flow Reversal Baffle", issued Apr. 8, 1969.

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'''** 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''**.

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 **48*a*'''** 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 **56*a*** 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 subcombinations are of utility and may be employed with reference to other features and subcombinations. 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.

I claim:

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 lowr 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.

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