Dec. 17, 1963 L. MACROW ETAL 3,114,786

GAS AND LIQUID CONTACT APPARATUS

Filed Jan. 14, 1960

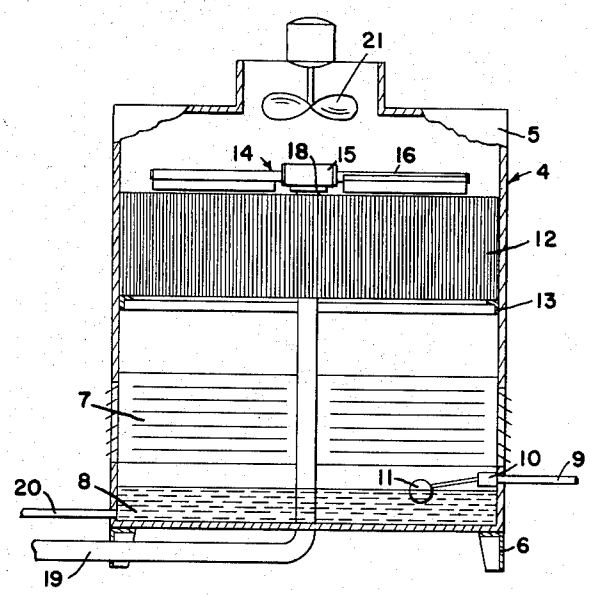


FIG. 1

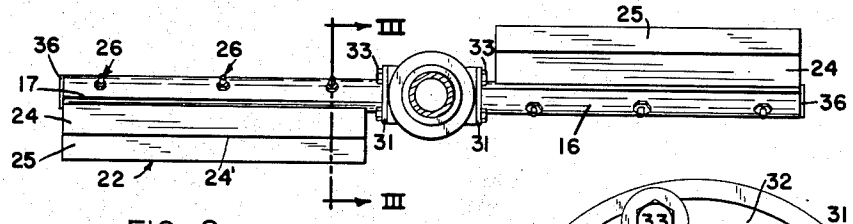


FIG. 2

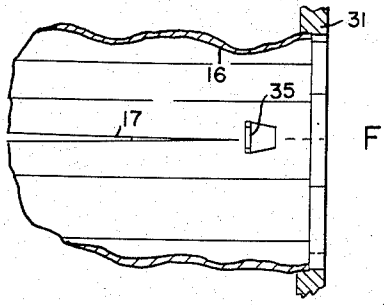


FIG. 4

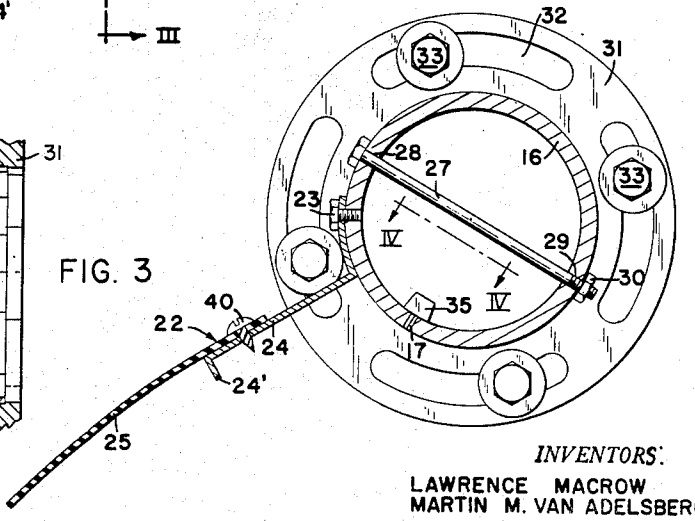


FIG. 3

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3,114,786
Patented Dec. 17, 1963

3,114,786

GAS AND LIQUID CONTACT APPARATUS

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Filed Jan. 14, 1960, Ser. No. 2,491
4 Claims. (Cl. 261—24)

This invention pertains to gas and liquid contact apparatus and more particularly to an improved liquid distribution system for use in such apparatus.

In Munters Patent No. 2,809,818, granted October 15, 1957, there is disclosed cooling tower structure including a packing, means for passing gas through the packing, and a rotary sprayer for distributing water over the packing. The packing may be composed of alternate corrugated and plain sheets attached at their points of contact to provide a plurality of adjacent parallel cells of relatively small cross-sectional areas between the flat an undulating folds of the sheets so that liquid can bridge the walls of the cells by surface tension. Means are provided on the packing to break the bridging of the liquid. The undulating folds of the corrugated sheets provide the spacing of the partition walls of each cell, and the edge portions of the assembled sheets provide a large area through which liquid enters and leaves the packing. The sheets are preferably composed of paper possessing qualities of high moisture absorbency and a large degree of wet strength. The moisture absorbency increases the effectiveness of the packing in heat transfer.

The rotary sprayer for distributing water over the packing includes a plurality of arms with spaced openings therein. The sprayer subdivides the stream of supply water into droplets which are sprayed over the packing. The heavier droplets discharged from the sprayer contact the top of the packing and flow downwardly therethrough by gravity, however, the smaller droplets discharged from the sprayer may be caught up in the air stream and discharged from the cooling tower. To remove the smaller droplets suspended in the air stream before it leaves the tower, eliminator plates are often provided in the cooling tower over the rotary sprayer.

Previous rotary sprayers required drilling of closely spaced holes in the arms thereof. The diameter of the holes constantly increased from the center of the sprayer to the extremity of the arms. This method of forming the openings in the sprayer arms is costly. Too, the small openings tend to become clogged with foreign matter in use and reduce the efficiency of the cooling tower as a result of unequal wetting of the packing.

The chief object of this invention is to provide gas and liquid contact apparatus in which these disadvantages or defects in prior constructions are obviated.

An object of the invention is to provide gas and liquid contact apparatus including an improved sprayer which assures a uniform distribution of water over the top of the packing.

A further object of the invention is to provide an improved spray arrangement for gas and liquid contact apparatus which obviates the need for eliminator plates.

Another object of the present invention is to provide an improved sprayer for use in gas and liquid contact apparatus which uniformly wets the top of the packing and which is adjustable for various water flow rates, and can therefore equalize density of distribution regardless of the area wetted.

A still further object is to provide an improved sprayer having an elongated slot extending substantially the length thereof that can easily be cleaned.

This invention relates to gas and liquid contact apparatus and includes in combination a casing, a packing in the casing comprised of a series of closely spaced wall members defining cells open at the top and bottom adapted to be moistened from above, the cross-sectional area of each cell being so small that liquid can bridge the walls of the cell by surface tension, and means on the packing for breaking the bridging of liquid, means for passing a gas stream through the packing, and means for distributing a liquid over the packing comprising a sprayer rotatably mounted in the casing above the packing closely adjacent the top thereof, the sprayer including a hub adapted to be connected to a source of liquid, at least one tubular sprayer arm connected to the hub, the ram having a slot therein extending substantially the length thereof, means for adjusting the width the slot, to affect a uniform distribution of liquid over the top of the packing and baffle means connected to the arm extending substantially coextensive with the slot to redirect splashing liquid to the top surface of the packing.

The attached drawings disclose a preferred embodiment of the invention in which:

FIGURE 1 is a sectional view of a cooling tower embodying the present invention;

FIGURE 2 is a bottom view on an enlarged scale of the improved rotary sprayer;

FIGURE 3 is an enlarged transverse sectional view through the sprayer arm taken along the line III—III of FIGURE 2, with parts being omitted;

FIGURE 4 is a sectional view showing the relationship of the deflector to the arm of the water distributor.

Referring to the drawings, there is disclosed in FIGURE 1, a cooling tower employing the present invention. This cooling tower 4 includes a casing 5 mounted on support members 6. Along the lower portion of the casing and extending substantially around the entire casing are suitable louvers 7, which permit air to pass into the lower portion of the casing. In the extreme lower portion of the casing is located a suitable sump 8 wherein water is collected. The water level is maintained at a desired height by means of the supply line 9 in which is connected a suitable valve 10 operated by float 11 in the sump.

Packing 12, preferably of the type disclosed in Munters Patent No. 2,809,818, is mounted above the sump 8 and louvers 7. This packing 12 is supported by suitable means such as rods or angle irons 13 which are secured to the inside of casing 5.

Above the packing is mounted water distributor or rotary sprayer 14. In the preferred embodiment, this water distributor comprises hub 15 and a plurality of arms 16 each having a slot 17 extending substantially the length thereof. These arms are in fluid communication with hub 15 which is rotatably mounted above bearing assembly 18. Each arm 16 has a removable cover 36 on the outer end thereof to permit access to the interior of the arm to clean the same and has a flange 31 connected on the other end thereof. Slots 32 are formed in the flange to permit rotary adjustment of arm 16 with respect to hub 15. Suitable bolts 33 extend through each slot 32 and connect flange 31 to hub 15. Normally each arm is secured to hub 15 so that slot 17 is at an angle to the vertical whereby the reaction of the water leaving slot 17 in arm 16 will rotate the water distributor 14. Rotation of arm 16 with respect to hub 15 will change the angle of discharge of the water leaving the slot from about 5° to 80°. The greater the angle of discharge or more nearly the slot approaches the horizontal, the greater will be the thrust. As a consequence, the distributor 14 will rotate faster.

If desired, motor means may be incorporated in bearing assembly 18. The motor means may comprise a small turbine which rotates the hub and passes water into the arms 16 from whence the water is discharged onto packing 12.

Water is introduced in bearing assembly 18 through

supply or riser pipe 19 from the place where it is used and the cooled water falls in the sump 8 and is conducted from the sump to the place of use.

Suitable fan means 21 are mounted in the upper portion of the casing 5 to draw air through the packing in heat exchange relation with water passing therethrough. The cooled water collects in sump 8 and is discharged therefrom through conduit 20 to the place where it is used. Pump means (not shown) are provided to force the water through conduits 19 and 20.

FIGURE 2 discloses a bottom view of water distributor or rotary sprayer 14. Baffle 22 is suitably secured to arm 16 as for example, by bolt 23, and extends substantially over the length thereof. If desired, baffle 22 may be integrally made from a plate or from sheet metal, however, it is preferred that baffle 22 be made in parts; a first rigid part 24 preferably sheet metal, connected to said arm and a second resilient part 25 as for example, rubber, connected at the rear of the first rigid part by screws 40. Part 24 includes a downwardly bent portion 24' the end of which in normal operation is closely adjacent the top surface of packing 12. Though only two arms are shown connected to the hub 15, it will be apparent that one or more arms may be employed as desired.

Rotary sprayer 14 is mounted closely adjacent the top of packing 12 as seen in FIGURE 3. The tendency for the water to splash and be caught up in the upwardly moving air stream is resisted by baffle 22 which traps the splash water and redeposits it on the top of packing 12. Thus, the necessity for the series of eliminator plates commonly used in cooling tower of this type to remove the splash water from the air stream discharged from the cooling tower is obviated.

Slot 17 is generally tapered towards the hub as best seen in FIGURE 2 to obtain a uniform wetting of the surface of the packing. A progressively greater quantity of water is discharged along the length of each arm. The highest efficiency of evaporative cooling is attained when an equal quantity of water is discharged upon each increment of surface area of packing 12. The width of the slot 17 at a given distance R from the axis of rotation of the sprayer is determined by the following formula:

$$W=\frac{(Dn^2-Dn'^2)\times G\times 2.6137\times 10^{-2}}{\sqrt{Ps+(1.69\times 10^{-4}\times N^2\times R^2)}}$$

where:

W=the width of the slot at point n taken at R distance from the axis of rotation of the sprayer, expressed in inches.

Dn=twice the distance taken from the axis of the supply pipe to point n, expressed in inches.

Dn'=twice the distance taken from the axis of the supply pipe to point n', a minute distance from point n.

G=design flow rate of water in gallons per minute per square foot of top surface of packing 12.

Ps=initial static pressure supplied in supply pipe at entrance to arm 16, expressed in feet of water.

N=desired revolutions per minute of the sprayer.

Adjustment means 26 may be uniformly spaced along the arm 16 to taper slot 17 and to vary the width of slot 17 along the length thereof. The width of the slot at each adjustment means may be calculated from the above formula and the adjustment may be made at the time of fabrication. The slot gradually widens and then narrows somewhat near the extremity of arm 16. By virtue of the unique conformation of slot 17 an equal quantity of water is discharged upon each square inch of surface area of packing 12 regardless of the water flow rate through the sprayer, which may be from one to ten gallons of water per minute per square foot of top surface area of packing 12 depending upon design considerations. Normally when the cooling tower is part of a mechanical refrigerating system, the flow rate may vary from 3 to 8 gallons per minute per square foot of top surface area of packing 12 and when the cooling tower is part of an absorption refrigeration system, the flow rate may vary from 1 to 4 gallons per minute per square foot of top surface of packing 12.

Each adjustment means 26 is preferably comprised of bolt 27 extending through openings 28 and 29 in arm 16 and having external threads on an end thereof and nut 30 having complementary internal threads therein. As is readily apparent, by rotating nut 30 in one direction, the walls of sprayer arm 16 are drawn together narrowing the slot, and by rotating nut 30 in the opposite direction the walls of arm 16 are permitted to move apart widening slot 17. For clarity, only three adjustment means have been shown in each arm. Obviously the number of adjustment means used will be dependent upon the length of arm 16.

If desired each adjustment means may be comprised of a bolt extending through a hole in arm 16 at one side of slot 17, said bolt having threads on the other end thereof adapted to be screwed into a threaded hole in arm 16 on the other side of the slot. Turning the bolt in one direction would draw the walls of the arm closer together narrowing the slot and turning the bolt in the opposite direction would permit widening of the slot.

Water discharged from the portion of the slot adjacent supply pipe 19 would have an outward force component and thus the packing surface adjacent supply pipe 19 might not be uniformly moistened. To assure that the packing surface immediately adjacent supply pipe 19 is moistened, a deflector plate 35 is fixed in each arm about one-half inch from the beginning of slot 17.

The arm may be fabricated from a length of standard pipe or tube having a slot cut therein or from a flat sheet rolled so that the opposite ends are closely adjacent one another to form a slot.

An advantage of the improved rotary sprayer is the ease of cleaning the tapered slot. By inserting a narrow knife-like tool in the slot adjacent the hub and drawing said tool toward the end of arm 16, the slot can be readily cleaned. Further, cover 36 may be removed to facilitate cleaning the inside of each arm 16.

In operation, water is pumped through supply pipe 19 to hub 15. The reactive force of water issuing from tapered slot 17 rotates the sprayer 14 and effects a uniform distribution of water over the surface of packing 12. Deflector plate 35 directs a small portion of water flowing in arm 16 onto the surface of packing 12 adjacent pipe 19 to assure wetting said surface. The water flows downwardly by gravity through the cells formed by the closely spaced wall members of packing 12 and forms a film on the wall members. Fan means 21 causes air to be drawn through louvers 7 into casing 5 and up through packing 12 in counterflow relation to the water to effect evaporative cooling thereof. This is done at the cost of evaporating approximately two percent of the water passed through the packing. The cooled water collects in sump 8 and is removed therefrom through conduit 20 to the place where it is used.

Water issuing from slot 17 strikes the surface of the packing and splashes. In the absence of baffle 22 the splash water would be picked up in the air stream and discharged from the cooling tower. This would necessitate drawing more water through supply line 9 and would increase the operational costs of the cooling tower. Part 24 is initially adjusted so that the lower tip of bent portion 24' is approximately one-half inch from the surface of packing 12. Most of the splash water is deflected back to the packing surface by part 24 and portion 24'. The remainder of the splash water is redirected to the packing surface by resilient part 25 which can trail on the top of packing 12. Because of the upwardly moving air stream, part 25 contacts the surface of packing 12 only lightly or flutters adjacent the surface of packing 12 as the distributor 14 rotates.

While we have described a preferred embodiment of

the invention, it will be understood that the invention is not limited thereto since it may be otherwise embodied within the scope of the claims.

We claim:

1. In a gas and liquid contact apparatus, the combination of a packing, means for passing a gas stream through said packing, liquid supply means, and means for distributing the liquid over said packing to flow therethrough in contact with the gas stream passing therethrough, said distributing means comprising a sprayer rotatably mounted above said packing adjacent the top thereof, means for rotatably mounting said sprayer, said sprayer including a tubular arm having a slot therein extending substantially the length thereof and placed in the lower portion thereof to discharge liquid from the arm toward the packing, said liquid supply means communicating with the interior of said tubular arm, and adjustment means for tapering the width of said slot toward the axis of rotation of the sprayer whereby the liquid discharged from said slot is uniformly distributed over the top of the packing, said adjustment means including a plurality of bolt means spaced from each other longitudinally of the arm for adjusting the width of the slot.

2. A gas and liquid contact apparatus according to claim 1 in which baffle means are provided extending substantially coextensive with the slot therein to redirect splashed liquid onto the top of said packing, said baffle means including a resilient part adapted to trail said arm closely adjacent the top of said packing to substantially confine liquid discharged from said slot to the top surface of said packing.

3. Gas and liquid contact apparatus according to claim 2 in which the baffle means include a plate secured to said arm having a downwardly bent portion the end of which in operation is adjacent the top surface of the packing.

4. Gas and liquid contact apparatus according to claim 1 in which a deflector plate is provided in the arm adjacent the slot and proximate the axis about which the arm rotates to assure that the packing most proximate the axis about which the arm rotates is moistened.

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