

[54] **ATMOSPHERIC HEAT EXCHANGERS**

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[22] Filed: **Mar. 15, 1974**

[21] Appl. No.: **451,537**

[52] U.S. Cl. **165/122; 261/DIG. 11; 206/522; 52/2**

[51] Int. Cl.² **F28F 13/06; F28F 13/00**

[58] Field of Search **165/47, 46; 206/30; 150/5; 52/2**

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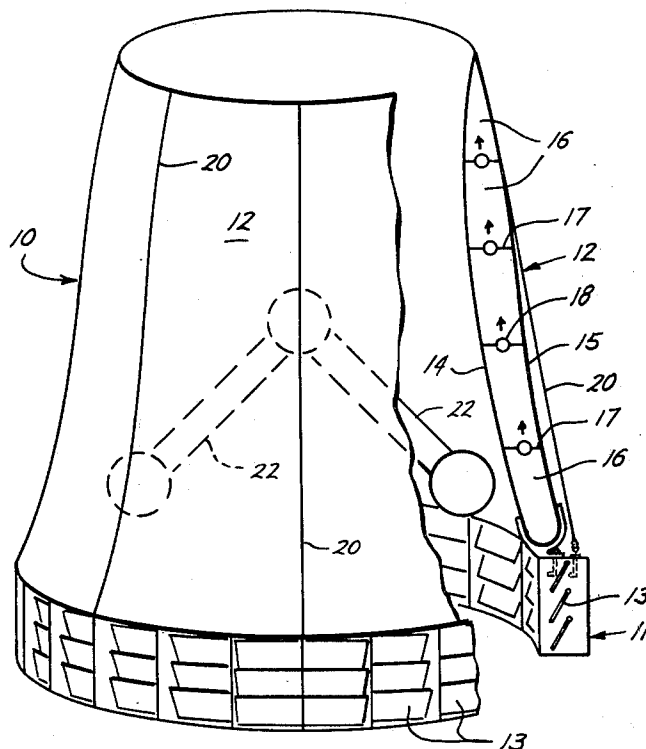
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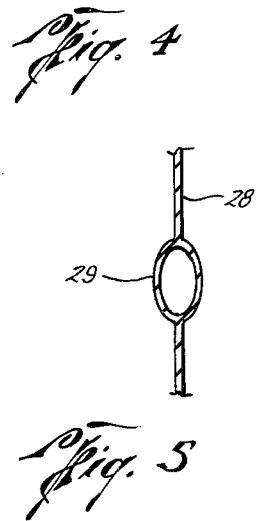
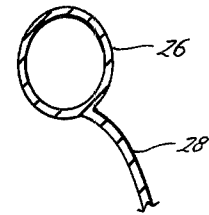
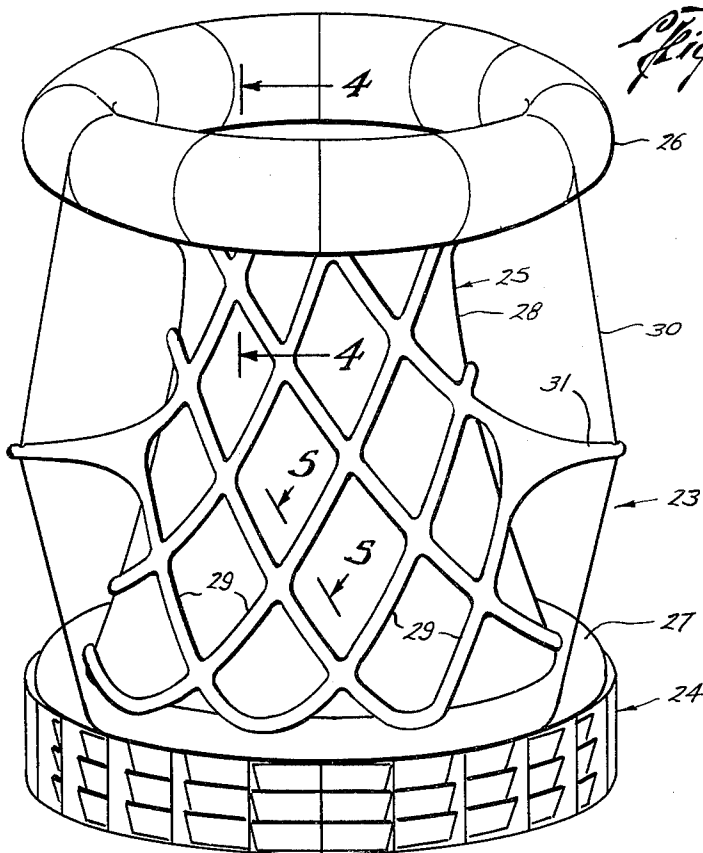
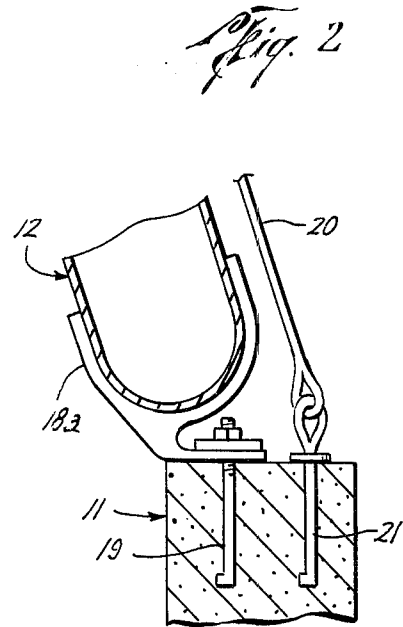
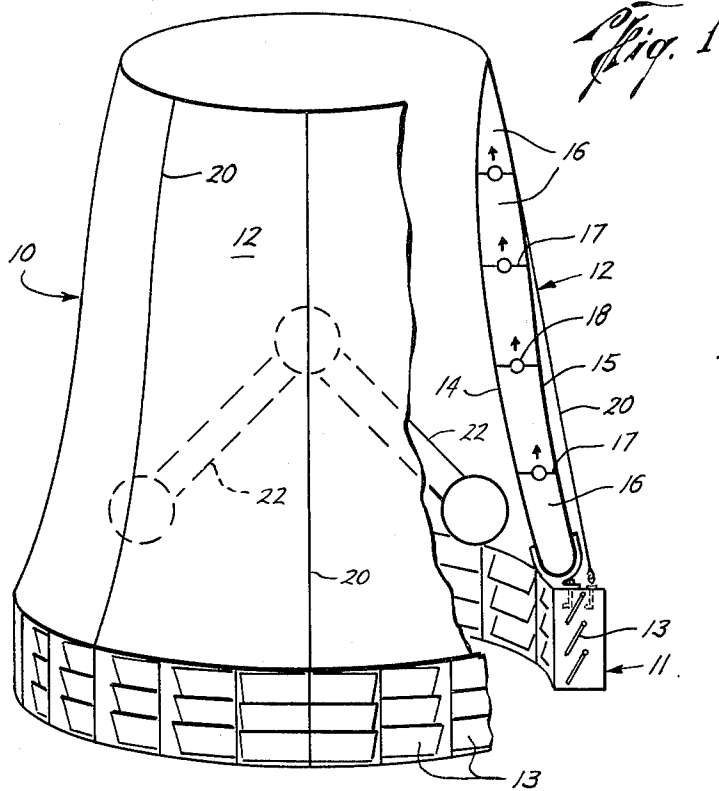
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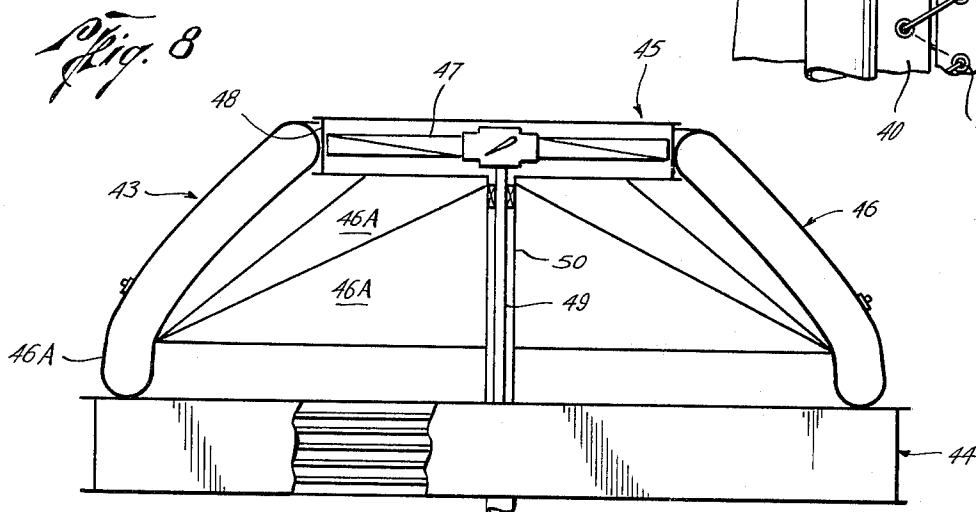
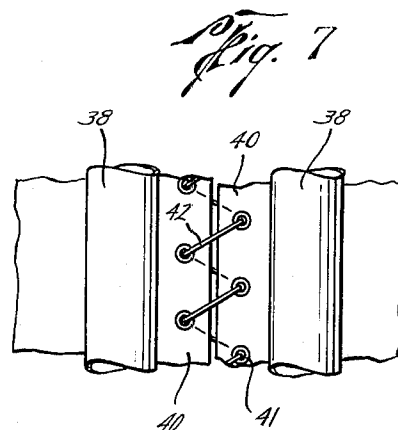
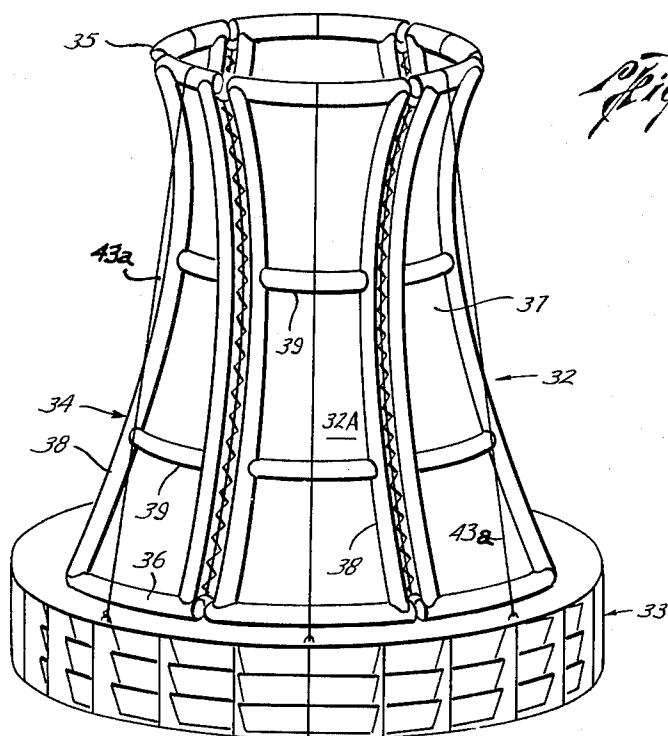
ABSTRACT

There are disclosed cooling towers and air coolers each having a housing through which air is caused to flow, the housing including a substantially upright conduit having a lower end which is anchored against upward movement, and cell means thereabout which, upon inflation, is adapted to be pneumatically tensed and to lift the conduit into erected position.

6 Claims, 9 Drawing Figures







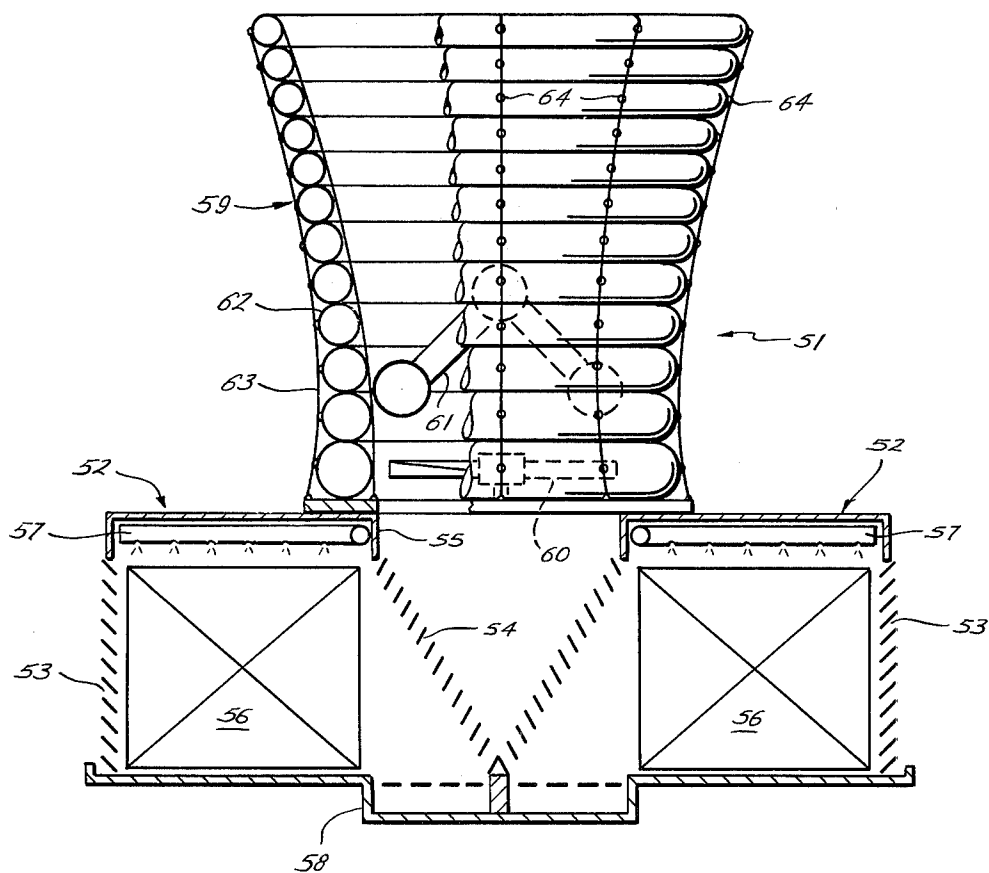


Fig. 9

ATMOSPHERIC HEAT EXCHANGERS

This invention relates to improvements in atmospheric heat exchangers wherein air is caused to flow through a housing in direct or indirect contact with another fluid medium to be cooled.

One type of heat exchanger contemplated by this invention comprises a cooling tower in which the housing includes a large, tall chimney or stack having an open lower end to permit air to be drawn upwardly there-through. In an evaporative type tower, water to be cooled may be sprayed onto a packing arranged across the stack, so that the water is cooled by direct contact with the air. On the other hand, in a dry type tower, steam or other medium to be cooled may instead be passed through tube bundles arranged about the lower open end of the stack, or across an intermediate part of the stack itself, and thus in indirect heat exchange relation with the air.

The stacks may comprise different shapes, such as cylindrical, conical or hyperbolic, and air may be caused to flow upwardly therethrough by natural draft or by fans. In any event, in order to obtain enough air flow to cool a large quantity of water, the stack may be of considerable size — e.g., 400 feet high and 200 feet in width. As will be appreciated, therefore, the erection of such a stack with conventional materials, such as wood, concrete or steel, is extremely expensive and time consuming. Also, of course, such stacks are susceptible to extreme weather conditions, such as tornadoes and earthquakes, which might destroy or seriously damage them, are quite heavy and thus require substantial foundations, and, depending on the material from which they are made, may be subject to corrosion. Still further, due to their hard surfaces, they reinforce noise, which may create an environmental problem.

In a so-called induced draft, cross flow type of cooling tower, packing is arranged between the side inlets to and a top opening in a housing, and air is drawn through the packing and out the top opening by means of a fan mounted in a ring above the top opening. The housing may also include a chimney or stack extending upwardly from the top opening and of a size and shape to provide a desired plume effect for the exhaust. Although not as large and expensive to construct as those previously described, such stacks are nevertheless subject to many of the same problems, as well as those which arise as a result of vibrational noise.

An atmospheric heat exchanger of this type may also comprise an air cooler wherein the housing through which the air is to flow includes a transition or plenum connecting a ring in which a fan rotates with a tube bundle. The fan may be arranged above the bundle so as to induce air flow therepast, or may be arranged below the bundle so as to force air flow therepast. In either case, conventional plenums are expensive, susceptible to breakdown and high noise levels, and, since they are heavy, require expensive supporting structure.

Thus, in any event, the housings of the heat exchangers of the type contemplated by this invention include conduits which, depending on the type of exchanger, may be expensive and time consuming to construct, susceptible to destruction or damage by severe weather conditions, unduly heavy, subject to corrosion, prone to breakdown and expensive repairs, subject to high vibrational and noise levels, and so heavy as to require relatively massive structural support.

It is therefore the primary object of this invention to provide atmospheric heat exchangers of this type having such conduits which may be constructed with a minimum of time and expense, which are of relatively light weight and which are not subject to frequent repairs and/or vibrational noise.

Another object is to provide such heat exchangers wherein the conduit may be disassembled or knocked down with a minimum of time and effort in the event of threatening weather conditions.

Still another object is to provide such heat exchangers which are not subject to corrosion.

These and other objects are accomplished, in accordance with the preferred embodiments of the invention, by an atmospheric heat exchanger in which a conduit of the type above described has a lower end which is anchored against upward movement, and cell means thereabout which, upon inflation, is adapted to be pneumatically tensed and to lift said conduit into erected position. Conversely, the cell means may be deflated to permit the conduit to collapse, which is especially helpful when it comprises a stack for a cooling tower which might otherwise be damaged by severe weather.

During use, the air flowing upwardly through the conduit assists in maintaining the conduit in its upright position. Also, the conduit is inexpensive to manufacture and quickly and easily erected. Furthermore, the inflatable cell means is divided into portions which are so arranged that malfunction of one or more of them will not interfere with operation of the conduit as a whole. Still further, the conduit is made of a plastic material which is not only lightweight, but also invulnerable to noise or rust, and preferably reinforced with fiberglass, metal wires, etc.

In the drawings, wherein like reference characters are used throughout to designate like parts:

FIG. 1 is a perspective view of a cooling tower having a hyperbolic stack, which is broken away in part and constructed in accordance with one embodiment of this invention;

FIG. 2 is an enlarged detailed sectional view illustrating the manner in which the lower end of the stack is anchored;

FIG. 3 is a perspective view of a cooling tower having a hyperbolic stack constructed in accordance with another embodiment of this invention;

FIG. 4 is a sectional view of the stack of the tower of FIG. 3, taken at 4—4 in FIG. 3;

FIG. 5 is another sectional view of the stack, taken at 5—5 in FIG. 3;

FIG. 6 is a perspective view of a cooling tower having a hyperbolic stack constructed in accordance with still another embodiment of this invention;

FIG. 7 is an enlarged view of part of the stack of the tower shown in FIG. 6;

FIG. 8 is a cross-sectional view of an air cooler having a plenum constructed in accordance with this invention; and

FIG. 9 is a side view, partly in section, of an induced draft, cross flow type cooling tower having a stack or chimney constructed in accordance with this invention.

Referring now to the details of the above-described drawings, the cooling tower illustrated in FIG. 1, and indicated in its entirety by reference character 10, includes a circular base 11 and a stack 12, which is hyperbolic in shape, anchored to and extending upwardly

from the base. The base 11 may be 200 feet in diameter and 30 to 40 feet tall, and has a plurality of adjustable louvers 13 mounted therein to permit ambient air to flow into the lower end of the stack. The stack 12 may rise up to 400 feet above the base.

The stack includes inner and outer walls 14 and 15 of lightweight plastic material and walls 17 of similar material extending horizontally between the inner and outer walls to divide the stack into individual, separately inflatable cells 16 which are arranged vertically adjacent one another from the upper to the lower end of the stack. Regulating check valves 18 are provided in each dividing wall to permit the cells to be inflated sequentially, preferably from the bottom up, thus avoiding the necessity of separately filling each cell. For this latter purpose, one or more check valves (not shown) may be provided in one of the lowermost cells.

If desired, the annular cells 16 may be divided by vertical walls into horizontally adjacent cells. Also, and as described in connection with the tower of FIG. 6, the stack may be formed of a plurality of vertically divided sections releasably connected to one another along their side edges by suitable means. In any event, because of the separate, horizontally adjacent cells, the stack would retain its erected position even though individual cells may become deflated.

The stack 12 is anchored to base 11 by suitable means, such as that shown in FIG. 2, wherein the lower end of the stack is attached to boots 18a, which are in turn secured to base 11 by means of spaced-apart anchor bolts 19. Also, cables 20 extend downwardly from the upper end of the stack by means of anchor bolts 21. The cables are of equal length and are held taut by inflation of the cells of the stack, thereby helping to maintain the stack upright.

The fluid medium to be cooled may be introduced across the stack in such a manner as to be in direct or indirect heat exchange relation with the air flowing upwardly therethrough. For example, as shown diagrammatically in FIG. 1, steam may be circulated through tube bundles 22 mounted across an intermediate portion of the stack. Alternatively, of course, the fluid to be cooled may be sprayed onto suitable packing mounted across the stack, in generally the same manner shown in FIG. 9. Also, the cooling tower may be a natural draft type, or a mechanical draft type in which air is either forced or induced to flow through the stack by one or more fans, as well known in the art.

In the erection of the tower, the lower end of the stack 12 and the cables 20 are connected to the base 11 and the cables are laid out about stack 12 in deflated condition. Then, air, preferably supplemented by helium or another medium which is lighter than air, is introduced into the cells of the stack so as to pneumatically tense them and lift the conduit into the position of FIG. 1, with restraint being provided by the taut cables. Although the stack is flexible intermediate its upper and lower ends, it will, when so pneumatically tensed and securely anchored to the base, withstand considerable winds.

The cooling tower embodiment of FIGS. 3 to 5, indicated in its entirety by reference character 23, is similar to that above described in that it also includes a louvered base 24 and a hyperbolic stack 25 anchored to and extending upwardly therefrom. However, the volume of the cells of the stack 25 is substantially reduced, so that substantially less inflating gas is required and

erection time is considerably reduced. Thus, as compared with the stack of FIG. 1, it comprises upper and lower inflatable rings or annular cells 26 and 27 and an intermediate portion 28 comprising a single flexible wall of hyperbolic shape. When inflated and pneumatically tensed, the cell 26 at the upper end of the stack holds the single sheet of plastic material forming the single wall in a taut position. The cells 26 and 27 may be separately inflated, or may be connected together by suitable valves to permit them to be inflated in sequence.

The single sheet or ply forming the single wall of the intermediate portion may also carry elongate, inflatable cells 29 extending diagonally and criss-crossing each other, as shown in FIG. 3. When inflated, they provide additional support for the stack in general, and the flexible intermediate portion thereof in particular. If desired, they may also provide fluid communication between the upper and lower cells 26 and 27, thereby enabling the cells to be inflated sequentially in much the manner described in connection with stack 12.

The stack 25 is anchored to base 24 in any suitable manner, such as that described above in connection with the tower 10 of FIG. 1. Thus, as illustrated in FIG. 2, cables 30 may extend downwardly from the upper ring or cell 26 to anchor bolts on the base. As shown in FIG. 3, the cables may be guided and tensioned by means of inflatable struts 31 extending out from the sides of the intermediate portion of the stack.

The separately inflatable rings or annular cells 26 and 27 may be formed as separate, inflatable bags having their end walls joined to the end walls of adjacent bags to form horizontally adjacent cells therein. As an alternative, horizontally adjacent cells may be formed within a large annular bag having air-tight partitions or walls thereacross, or the opposite walls of the large bag can be pinched together by sewing or clamping.

The cooling tower shown in FIGS. 6 and 7, and indicated in its entirety by reference character 32, includes, similarly to those above described, a base 33 and a stack 34 of hyperbolic configuration anchored to and extending upwardly therefrom. In this embodiment of the invention, the stack 34 is also similar to the stack 25 above described in that it comprises inflatable rings or annular cells 35 and 36 at its upper and lower ends, respectively, and a flexible intermediate portion 37 which includes a single wall extending between such rings.

The stack 34 is further similar to the stack 25 in that the single wall 37 of the intermediate portion carries elongate, inflatable cells which assist in the support of the intermediate portion upon erection of the stack. Thus, as shown in FIG. 6, these elongate cells include cells 38 which extend vertically from the upper ring 35 to the lower ring 36, and cells 39 which extend laterally or horizontally between adjacent vertical cells 38.

More particularly, the stack 34 is shown to be made up of vertically separated sections 32A each having means for releasable connection to an adjacent section. Each such section includes a pair of vertical elongate cells 38 connected at their upper and lower ends to a portion of the upper and lower rings 35 and 36 and at intermediate portions by a pair of cells 39. More particularly, the pair of vertical cells 38 are disposed near the side edges of each stack section 32A, and the horizontal cells 39 are substantially equally spaced apart from one another and the upper and lower rings 35 and 36.

As best shown in FIG. 7, the side edges of each stack section 32A have flanges 40 extending out from the outer sides of adjacent vertical cells 38. Holes 41 are provided in the flanges to receive laces 42 which permit the side edges of the adjacent sections 32A to be laced together. Obviously, other means, such as zippers, may be used for releasably connecting the adjacent side of these sections to one another.

The stack 34 is also anchored to the base 33 in a manner similar to that previously described in connection with stacks 12 and 25. Thus, the lower ring portion of each section 32A is anchored to the base in the manner illustrated in FIG. 2, and a cable 43a extends from the upper ring 35 of such section to an anchored position on the base 11, as also best shown in FIG. 2. As will be understood, sections 32A may be simultaneously or sequentially inflated, and, for this purpose, the elongate vertical cells 38 provide a means by which the upper and lower ring portions may be fluidly communicated with one another.

The air cooler shown in FIG. 8, and indicated in its entirety by reference character 43, comprises a tube bundle 44 extending across a base at its lower end, a fan assembly 45 at its upper end, and a conduit providing a plenum or transition 46 extending vertically between the tube bundle and fan assembly. As well known in the art, the fan assembly comprises a fan 47 rotatably mounted within a fan ring 48, and the plenum extends continuously from the rectangular outer edge of the tube bundle 44 to the circular outer side of the fan ring 48 so as to confine air for flow upwardly through the tube bundle and out the fan ring. As indicated diagrammatically in FIG. 8, the fan 47 is rotatable on a shaft 49 which extends vertically upwardly through the tube bundle and plenum, and a bearing 50 in which the shaft is mounted provides suitable support for holding the fan ring 48 in the elevated position shown above the tube bundle 44.

As illustrated diagrammatically in FIG. 8, the plenum 46 is made up of a plurality of separately inflatable, vertically separated sections 46A. Depending on the size of the plenum, each section may comprise an individual cell extending vertically from its lower end adjacent the tube bundle 44 to its upper end adjacent the fan ring 48. Alternatively, each inflatable section may be divided into a plurality of horizontally and/or vertically arranged cells. In any event, the adjacent edges of the plenum sections 46 are releasably connected together in any suitable manner, such as that described above in connection with the stack 34 of cooling tower 32. As well known in the art, since the tube bundle is rectangular in plan, and the fan ring 48 is circular in plan, the flexible sections of the plenum must be so formed and shaped as to provide the desired transition.

The cooling tower shown in FIG. 9, and indicated in its entirety by reference character 51, is of a different type than the cooling towers previously described - namely, an induced draft, cross flow type. The housing of a cooling tower of this latter type includes a water cooling chamber 52 at each opposite side of a base thereof, each such chamber having an air inlet 53 in the outer side thereof and an air outlet 54 on the inner side thereof leading to a central opening 55 common to each chamber.

As well known in the art, packing indicated diagrammatically at 56 is contained within each chamber 52 beneath a sprayhead 57. Water which is sprayed onto

the packing by means of the heads 57 will, upon trickling through the packing and into the collection chamber 58, be cooled by means of air which is drawn through the chambers. Thus, as previously described, this type of cooling tower cools water by direct contact therewith.

In accordance with this embodiment of the present invention, the housing of the cooling tower 51 also includes a stack or chimney 59 which extends upwardly from the top opening 55 in the water cooling chamber 52 to a height for creating the desired plume effect. Normally, a fan 60 will be mounted within the lower end of the stack just above the top opening 55 for inducing air flow across the packing and thus up through the stack 59. As also illustrated diagrammatically in FIG. 9, the cooling tower is of a type in which banks of tube bundles 61 are mounted within and arranged across the stack above the fan 55, thereby rendering the cool air useful in not only cooling the water from the sprayheads 57, but also cooling a medium circulating through the tube bundles 61.

The stack preferably flares upwardly from its lower end to its upper end, and is comprised of a plurality of vertically adjacent, horizontally disposed inflatable rings or annular cells 62. More particularly, each ring may be secured to adjacent cells in some manner, or separated therefrom but anchored to the top of the water cooling chamber 52 by means of cables 63 which extend upwardly along the inner side of the cells, over the cell at the upper end of the stack, and then downwardly along the outer side of the cells. As indicated diagrammatically in FIG. 9, the ends of each cable are secured to the top of chamber 52, and intermediate portions thereof are guided along the outer sides of the cells by passing through rings 64 attached to the outer sides of the cells.

As shown, the cables are of such extent that they will permit each of the cells, including the cell at the lower end of the stack, to be fully inflated before the cables are drawn taut. At the same time, when the cables are taut, they help to maintain the erect or upright position of the stack.

As previously described in connection with the other embodiments, each ring may be divided by vertically extending walls into individual, horizontally adjacent cells. Also, when the vertically adjacent cells 62 are connected to one another, they may also permit fluid communication from one to the other, thereby permitting sequential inflation of the cells, in the manner previously described in connection with other embodiments of this invention.

Although the entire stack is shown to be made up of inflatable cells, it will be appreciated that it may instead be partly of conventional construction and partly of inflated cells. This may be especially useful in increasing the plume height of an existing stack.

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 without 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 apparatus of this 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.

This invention having been described, What is claimed is:

1. An atmospheric heat exchanger, comprising a housing including a base having air inlet means and air outlet means, and a substantially upright conduit which is anchored at its lower end to the base, said lower end of the conduit having air inlet means in fluid communication with the air outlet means of the base and said upper end of said conduit having air outlet means so that air passing through the base is caused to flow upwardly through the conduit, said conduit having inflated cell means thereabout which pneumatically tenses said conduit and maintains its upper end in upright position, and means extending across the housing for introducing a fluid medium to be cooled into the path of air flowing therethrough.

2. An atmospheric heat exchanger of the character defined in claim 1, wherein said conduit comprises a plurality of vertically separated, releasably connected sections, and the cell means includes a portion at the upper end of each conduit section.

3. A cooling tower, comprising a housing including a base having air inlet means and air outlet means, and a substantially upright conduit defining a stack which is anchored at its lower end to the base, said lower end of the stack having air inlet means in fluid communication with the air outlet means of the base and said

upper end of said stack having air outlet means so that air passing through the base is caused to flow upwardly through the stack, said stack having inflated cell means thereabout which pneumatically tenses said stack and maintains its upper end in upright position, and means extending across the housing for introducing a fluid medium to be cooled into the path of air flowing therethrough.

4. A cooling tower of the character defined in claim 3, wherein said conduit includes a portion intermediate its upper and lower ends which is hyperbolically shaped upon erection of said stack.

5. A cooling tower of the character defined in claim 3, including a fan mounted for rotation within the lower end of the stack.

6. An air cooler, comprising a housing including a lower end providing a base having air inlet means and air outlet means, an upper end having air inlet means and air outlet means, and a substantially upright conduit providing a plenum which is anchored at its lower end to the base, said lower end of the plenum having air inlet means in fluid communication with the air outlet means of the base and said upper end of said plenum having air outlet means in fluid communication with the air inlet means of the upper end of the housing, so that air passing through the base is caused to flow upwardly through the plenum, said plenum having inflated cell means thereabout which pneumatically tenses said plenum and maintains its upper end in upright position, and a tube bundle extending across one end of the housing for introducing a fluid medium to be cooled into the path of air flowing therethrough.

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