

Nov. 27, 1951

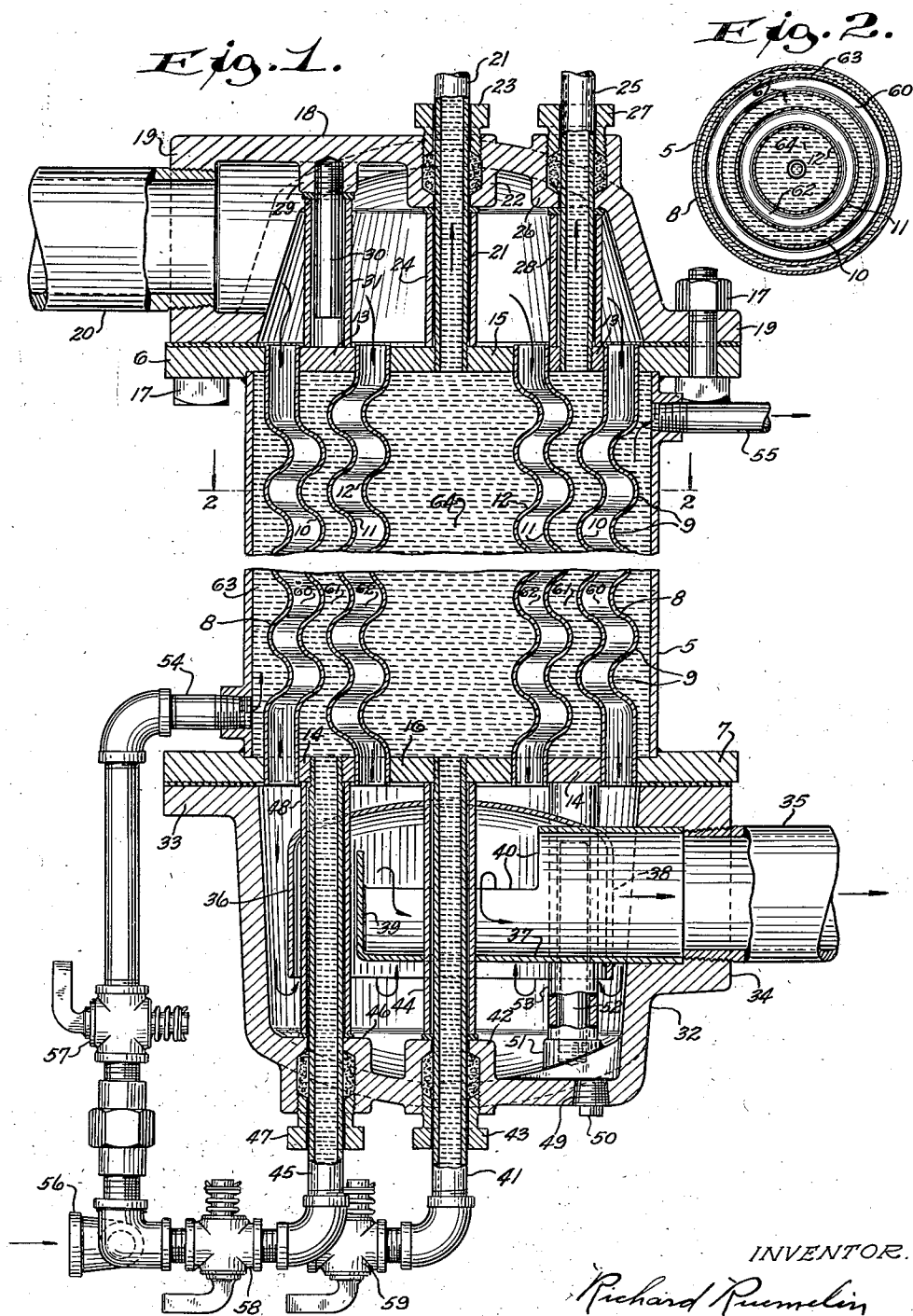
R. RUEMELIN

2,576,309

HEAT EXCHANGER

Filed Jan. 14, 1949

2 SHEETS—SHEET 1



INVENTOR.

Richard Ruemelin

BY *Mossell Mossell*
ATTORNEYS.

Nov. 27, 1951

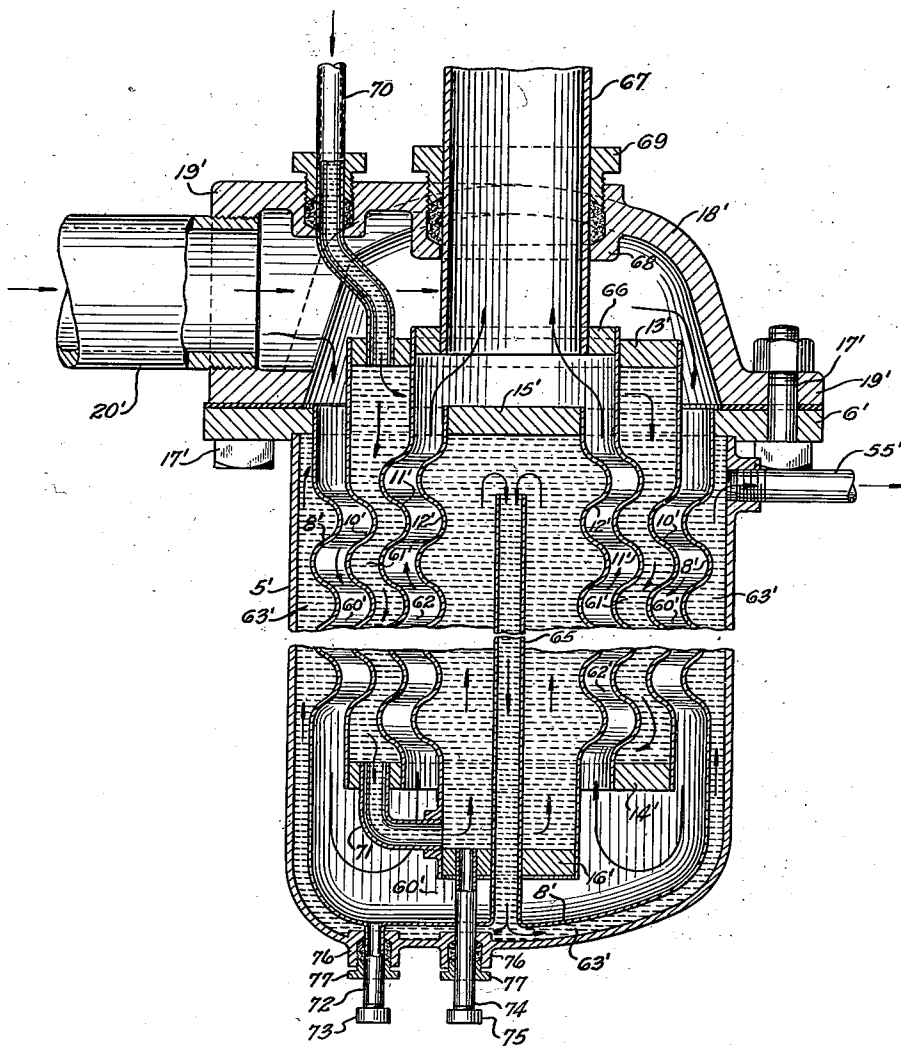
R. RUEMELIN
HEAT EXCHANGER

2,576,309

Filed Jan. 14, 1949

2 SHEETS—SHEET 2

Fig. 3.



INVENTOR.

Richard Ruemelin

BY *Morsell & Morsell*
ATTORNEYS.

UNITED STATES PATENT OFFICE

2,576,309

HEAT EXCHANGER

Richard Ruemelin, Milwaukee, Wis.

Application January 14, 1949, Serial No. 70,970

2 Claims. (Cl. 257-228)

1

This invention relates to improvements in heat exchangers which are particularly well adapted for the drying and cooling of compressed air.

Compressed air is used in various industrial applications such as sand blasting, painting, pneumatic tool operation and the like, and it is important that the compressed air so used be substantially free of moisture. To this end dryers have been heretofore developed which separate excess moisture from the air by means of an air cooling apparatus. The dryers heretofore developed have comprised intricate casings which are not only difficult and expensive to manufacture but, in addition, are difficult to disassemble and clean.

It is therefore a general object of the present invention to provide a heat exchanger adapted to utilize a fluid coolant and having the heat transfer elements thereof made of relatively thin sheet metal.

A further object of the invention is to provide an improved heat exchanger of the type having a plurality of spaced concentric tubular heat transfer elements having annular fluid chambers therebetween.

A further object of the invention is to provide an improved apparatus of the class described wherein the relatively thin tubular heat transfer elements are formed with corresponding horizontally extending corrugations which give the annular chambers between said members a zig-zag cross-sectional shape whereby a medium may flow in the form of a ribbon to exchange heat by impingement against the corrugations.

A further object of the invention is to provide a construction wherein, because of the corrugations, expansion and contraction of the heat transfer elements may take place without detrimental results.

A further object of the invention is to provide an apparatus of the class described wherein the smallest diameter portion of each of the tubular heat transfer elements is at least slightly greater than the largest diameter portion of the next adjacent element inwardly thereof, thereby facilitating assembly or disassembly of the apparatus for cleaning or repair.

A further object of the invention is to provide an apparatus of the class described which may have a trap or baffle associated in a novel manner with the air outlet to prevent entrained moisture from being carried out of said outlet.

A further object of the invention is to provide an apparatus of the class described which is compact, strong and durable, which is inexpen-

2

sive to manufacture, which is efficient in operation, and which is otherwise well adapted for the purposes described.

With the above and other objects in view, the invention consists of the improved heat exchanger, and all of its parts and combinations, as set forth in the claims, and all equivalents thereof.

In the drawings accompanying and forming a part of this specification, wherein are shown two embodiments of the invention, and wherein the same reference characters indicate the same parts in all of the views:

Fig. 1 is a fragmentary vertical sectional view of the preferred form of the invention;

Fig. 2 is a transverse sectional view taken along the line 2-2 of Fig. 1; and

Fig. 3 is a fragmentary vertical sectional view of a modified form of the invention.

Referring more particularly to Fig. 1 of the drawing, the numeral 5 indicates a cylindrical outer shell fixed at its upper end to a top ring 6, and fixed at its lower end to a similar bottom ring 7. The major portions of the top and bottom rings 6 and 7 project outwardly from the shell 5 and form attaching flanges. Fixed to the inner surfaces of the top and bottom rings 6 and 7 and spaced inwardly from the inner surface of the shell 5 is a tubular heat transfer element 8 which is preferably concentric with the shell 5 and which is preferably formed with horizontal annular corrugations 9. Positioned concentric with the element 8 are tubular heat transfer elements 10, 11 and 12. The heat transfer elements 10, 11 and 12 are formed with annular horizontal corrugations which preferably correspond with the corrugations 9 of the element 8, as shown in Fig. 1. At their upper ends the inner surface of the element 10 and the outer surface of the element 11 are fixed to a head ring 13. Similarly associated with the lower ends of the elements 10 and 11 is a bottom head ring 14. Fixed to the inner surface of the element 12 at its upper end is a circular headplate 15, and similarly associated with the lower end of the element 12 is a circular bottom plate 16.

Fixed to the upper surface of the upper ring 6, as by bolts and nuts 17, is an upper head 18 having the shape of an inverted bowl and being formed with an attaching flange 19. The head 18 is also formed with an air inlet connection into which is adapted to be threaded an air supply conduit 20. Projecting vertically through a central portion of the head 18 and through the circular plate 15 is a conduit 21. The conduit 21

may have a threaded connection with the plate 15, and the head 18 is preferably provided with a stuffing box 22 and gland 23 sealingly surrounding the conduit 21 as shown. A tubular spacer 24 may be positioned around the conduit 21 to extend between the plate 15 and the stuffing box 22.

A conduit 25 extends vertically through the head 18 and through the head ring 13 as shown. The conduit 25 is associated with the headring 13 and with the head 18 in substantially the same manner as the conduit 21 is associated with the plate 15 and the head 18, having associated therewith a stuffing box 26, a gland 27, and a tubular spacer 28. The interior of the head 18 is also formed with a boss 29 which is tapped to receive a vertically depending stud 30. Surrounding the stud 30 and extending between the boss 29 and the upper surface of the ring 13 is a tubular spacer 31.

Attached, as by bolting, to the lower surface of the lower ring 7 is a lower head 32. The head 32 is substantially bowl-shaped and is formed at its upper margin with an outwardly extending annular attaching flange 33. The head 32 is also formed with an air outlet connection 34 into which is adapted to be threaded an air discharge conduit 35. Positioned substantially concentrically within the head 32, and spaced from the bottom end thereof and from the plate 16, is an inverted bowl member 36 having substantially vertically extending side walls. A horizontally extending conduit 37 within the head 32 is supported at one end in the outlet connection 34 as shown in Fig. 1. The conduit 37 extends through a side wall portion of the bowl member 36, as at 38, and has an inner end wall 39. The upper portions of the inner end of the conduit 37 are cut away as at 40.

Extending upwardly through the lower head 32, conduit 37, bowl member 36, and plate 16, is a conduit 41. The head 32 is provided with a stuffing box 42 and with a gland 43 sealingly surrounding the conduit 41. A tubular spacer 44 surrounds said conduit and extends from the stuffing box 42 to the lower surface of the plate 16. Extending vertically through the head 32, bowl member 36, and ring 14, is a conduit 45. The head 32 is provided with a stuffing box 46 and with a gland 47 sealingly surrounding the conduit 45, and a tubular spacer 48 surrounds the conduit and extends between the stuffing box 46 and the lower surface of the annular plate 14. The conduits 41 and 45 may respectively have a threaded connection with the plates 16 and 14. The lower head 32 is formed with a drain opening 49 which may be closed with a plug 50. The head 32 may also be formed with a boss 51 which is tapped to receive an upstanding stud 52. A tubular spacer 53 may surround the stud 52 and extend between the boss 51 and the annular plate 14, as shown.

Threaded into a lower side wall portion of the casing 5 is a conduit 54, and threaded into an upper side wall portion of said casing is a preferably diametrically oppositely positioned conduit 55. An inlet connection 56 leads from a suitable source of cold water under pressure. Through suitable branch connections the inlet 56 communicates with shutoff valves 57, 58 and 59. As shown in Fig. 1, the valve 57 communicates with the conduit 54, the valve 58 communicates with the conduit 45, and the valve 59 communicates with the conduit 41. The conduits 21, 25 and 55 may communicate with a common discharge conduit (not shown).

It will be noted from the drawing that the size

of the heat transfer elements 8, 10, 11 and 12, and the corrugations therein are such that the smallest diameter portion of any one of said elements is slightly larger than the largest outer diameter portion of the next inwardly adjacent element. The corrugations in the heat transfer elements and the spacing between said elements provide annular chambers 60, 61 and 62 having serpentine vertical cross-sectional shapes and having substantially the same thickness. In addition to the chambers 60, 61 and 62, there is an annular chamber 63 between the casing 5 and the element 8, and there is a central chamber 64 within the element 12 and the end plates 15 and 16.

In operation, cold water under pressure enters the inlet connection 56, and the valves 57, 58 and 59 being normally open, said water flows into and fills the chambers 63, 61 and 64. Hot compressed air enters the upper head 18 through the conduit 20 and connection 19, and passes down through the annular chambers 60 and 62, where it is cooled by the cold water flowing upwardly through the chambers 63, 61 and 64. Simultaneously with the cooling of the air, the cold water is heated by the air. The heated water flows out of the conduits 21, 25 and 55. As the air is cooled during its passage through the chambers 60 and 62, its saturation point is correspondingly reduced, with the result that moisture is condensed from the air. This moisture is deposited on the heat transfer elements and flows down the inner surfaces of the chambers 60 and 62 and collects in the bottom of the lower head 32 from which it may be periodically drained by the removal of the plug 50. If desired, the drain hole 49 may communicate with a drain pipe and with a drain trap in the manner disclosed in Fig. 1 of my Patent No. 1,899,988. Upon leaving the chambers 60 and 62 the cooled air travels downwardly around the bowl member 36 and then flows upwardly within said bowl and out through the conduits 37 and 35, entering said conduits via the cutaway portion 40. The inverted bowl member 36 and the conduit 37 combine to form a trap or baffle system which prevents any entrained moisture within the lower head 32 from passing out of the conduit 35. If desired a separate trap inserted in a portion of the line 35 may be used instead of a trap within the apparatus.

The improved air drier is very easily disassembled and reassembled. To disassemble the apparatus, all that is necessary is to disconnect the conduits 21, 25, 41 and 45 from the water inlet and discharge systems and to loosen the glands 23, 27, 43 and 47. The head 18 may then be unbolted and lifted off the casing 5 and off of the conduits 21 and 25. With the head 18 off, the unit composed of the conduit 21, element 12, end plates 15 and 16, and conduit 41, may be lifted out. As this is done, the conduit 41 slides through the gland 43. Due to the fact that the smallest inner diameter portion of each of the elements is larger than the largest outer diameter portion of the element next inwardly adjacent, the element 12 can pass freely upwardly through the element 11. Upon removal of the abovementioned unit, a second unit consisting of the upper and lower rings 13 and 14, elements 10 and 11, and conduit 45, can be lifted out in the same manner and for the same reasons as the first unit. Removal of the abovementioned units not only facilitates cleaning or repair thereof, but also affords complete access to the interior of the remainder of the apparatus for any purpose. When desired, the

5

lower head 32 may be easily and quickly removed by unbolting it from the lower plate 7.

Fig. 3 shows a modified form of the invention and is of the double pass type. The parts of the modified form of the invention which are analogous to like parts in the preferred form of the invention are designated by the same reference characters primed. In the modified form of the invention there is an outer cylindrical shell or casing 5' having an open upper end and having its bottom end closed as shown. There is an end ring 6' fixed to the upper end of the shell 5', and fixed to the end ring 6' is an upper head 18' which is formed with an air inlet connection 19'. Positioned within and concentric with the casing 5', and having its upper end fixed to the inner surface of the end ring 6', is a heat transfer element 8' which has its lower end closed by a bottom wall, as shown. Projecting upwardly from a central portion of the bottom wall of the element 8', and opening through said wall, is a conduit 65.

Positioned concentrically within the tubular heat transfer element 8', and preferably in substantially equally spaced relationship, are tubular heat transfer elements 10', 11' and 12'. The heat transfer elements 8', 10', 11' and 12' are preferably formed with corresponding horizontally extending annular corrugations which impart to the annular chambers 60', 61' and 62' a zigzag shape in vertical section, as in the preferred form of the invention. The upper and lower ends of the element 12' are sealed respectively with a circular upper plate 15' and with a circular lower plate 16'. A headring 13' sealingly connects the inner surface of the upper end of the element 10', and the outer surface of the upper end of the element 11'. A ring 66 is sealingly connected to the inner surface of the upper end of the element 11', and sealingly connected to the inner surface of the ring 66 is an upwardly projecting air outlet conduit 67 which extends through the head 18'. The head 18' is provided with a suitable stuffing box 68 and with a gland 69 sealingly surrounding the air outlet conduit 67.

Extending downwardly through the head 18' and through the ring 13', and communicating with the annular chamber 61' is a cold water inlet conduit 70. Threaded into the casing 5' and communicating with the chamber 63' is a water outlet conduit 55'. Communicating between the lower end of the chambers 61' and 64' is a conduit 71. Extending upwardly through the bottom wall of the casing 5' and opening through the bottom wall of the element 8' is a condensate drain pipe 72 which may have its lower end closed with a cap 73. Extending upwardly through the bottom wall of the casing 5', through the bottom wall of the element 8' and through the circular plate 16' is a drain pipe 74 which may have its bottom end closed with a cap 75. The bottom wall of the casing 5' may be provided with suitable stuffing boxes 76 and with glands 77 sealingly surrounding the pipes 72 and 74.

In operation, cold water enters the apparatus through the conduit 70 and flows downwardly into and through the annular chamber 61'. This water flows from the bottom of the chamber 61' through the conduit 71 and into the chamber 64', through which it then flows upwardly to enter the upper end of the conduit 65. The water then flows downwardly through the conduit 65 and enters that portion of the chamber 63' between the bottom walls of the casing 5' and the element 8'. The water then flows outwardly and upwardly in the chamber 63' and passes

6

out the conduit 55'. Hot compressed air which enters the apparatus through the air inlet conduit 20' and through the connection 19' flows into the head 18'. The air then flows downwardly through the chamber 60', and, upon passing out of the bottom end of the chamber 55, said air flows inwardly and upwardly, as indicated by the arrows, into the lower end of the chamber 62'. The air, upon flowing out of the upper end of the chamber 62', enters the air outlet conduit 67 through which it leaves the apparatus.

As in the preferred form of the invention, the cooling effect of the water causes moisture to be condensed from the air flowing through the apparatus. This moisture will flow downwardly and will collect on the inner surface of the bottom wall of the element 8', from which it may be drained through condensate drain conduit 72. The drain conduit 74 provides means for emptying the chambers 61' and 64' when necessary.

As is also true in the preferred form of the invention, the smallest inner diameter portion of each of the tubular heat transfer elements of the modified form is slightly larger than the largest outer diameter portion of the tubular heat transfer next adjacent element inwardly thereof. It is apparent, therefore, that during assembly or disassembly of the modified form of the apparatus, the heat transfer elements thereof may be readily placed in position within or removed from one another as desired. The improved apparatus is relatively inexpensive to manufacture because of the fact that sheet metal is employed in the heat transfer elements rather than expensive castings which have been common heretofore. The improved apparatus is efficient in operation and is particularly easy to disassemble and clean, the latter feature materially reducing the cost of maintenance of the improved apparatus.

Due to the corrugations, heat exchange takes place very efficiently because of impingement against the corrugations of the medium flowing in the exchanger.

It is obvious that the apparatus is suitable for use with any gases or liquids, and is suitable for a variety of uses such as in an air dryer, still or water heater.

Various changes and modifications may be made without departing from the spirit of the invention, and all of such changes are contemplated, as may come within the scope of the claims.

What I claim is:

1. In an air drier, a substantially cylindrical outer shell having an open upper end and a closed lower end, a first tubular heat transfer element within said casing having a closed lower end and having an open upper end, the upper margins of said element and said casing being sealingly connected, said element having its side and end walls spaced from and adjacent the side and end walls of the casing to form a cup-shaped first fluid chamber therebetween; a second tubular heat transfer element spaced concentrically within said first element and having open ends; a third tubular heat transfer element spaced concentrically within said second element and having open ends, said second and third elements being sealingly connected at their upper and lower margins to form a second fluid chamber therebetween; a fourth tubular heat transfer element spaced concentrically within said third element and having its upper and lower ends closed to form a third fluid chamber there-

7

in, there being a first annular air chamber between said first and second elements and a second annular air chamber between said third and fourth elements; a head for closing the upper end of said casing; an air inlet communicating with the upper end of said first air chamber, said first and second air chambers having communication at their lower ends; an air outlet leading from the upper end of said third element and communicating with the upper end of said second air chamber; a fluid connection between the lower ends of said second and third fluid chambers; a conduit projecting upwardly from the end wall of said first element and through the lower end of said third fluid chamber to adjacent the upper end thereof to provide communication between said first and third fluid chambers; a fluid inlet communicating with the upper end of said second fluid chamber; and a fluid outlet communicating with the upper end of said first chamber, said tubular heat transfer elements having sidewall portions formed with corrugations which impart to said air chambers and said second fluid chamber a serpentine shape in vertical section, and said elements being of such diametrical dimensions that each may be removed from the adjacent elements by coaxial relative movement.

2. In an air drier, a substantially cylindrical outer shell having an open upper end and a closed lower end, a first tubular heat transfer element within said casing having an open upper end, the margins of which are sealed to the upper margins of said casing, and having a closed lower end, said element having its side wall and end wall spaced from and adjacent the side and end walls of the casing to form a cup-shaped first fluid chamber therebetween; a second tubular heat transfer element spaced concentrically within said first element and having open ends; a third tubular heat transfer element spaced concentrically within said second element and having open ends, said second and third elements being joined at their upper and lower margins to form a second fluid chamber therebetween; a fourth tubular heat transfer element spaced concentrically within said third element and having its upper and lower ends closed to

8

form a third fluid chamber therein, there being a first annular air chamber between said first and second elements and a second annular air chamber between said third and fourth elements; a head for closing the upper end of said casing; an air inlet in said upper head and communicating with the upper end of said first air chamber, said first and second air chambers having communication at their lower ends; an air outlet projecting through said upper head and connected to the upper end of said third element and communicating with the upper end of said second air chamber; a fluid connection between the lower ends of said second and third fluid chambers; a conduit projecting upwardly from the end wall of said first element and through the lower end of said third fluid chamber to adjacent the upper end thereof to provide communication between said first and third fluid chambers; a fluid inlet communicating with the upper end of said second fluid chamber; and a fluid outlet communicating with the upper end of said first chamber, said tubular heat transfer elements having sidewall portions formed with corrugations which impart to said air chambers and said second fluid chamber a serpentine shape in vertical section, and said elements being of such diametrical dimensions that each may be removed from the adjacent elements by coaxial relative movement.

RICHARD RUEMELIN.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
342,871	Hocking	June 1, 1886
983,913	Lovekin	Feb. 14, 1911
1,005,442	Lovekin	Oct. 10, 1911
1,899,988	Ruemelin	Mar. 7, 1933

FOREIGN PATENTS

Number	Country	Date
19,332	Denmark	Sept. 25, 1914
158,483	Great Britain	Feb. 10, 1921