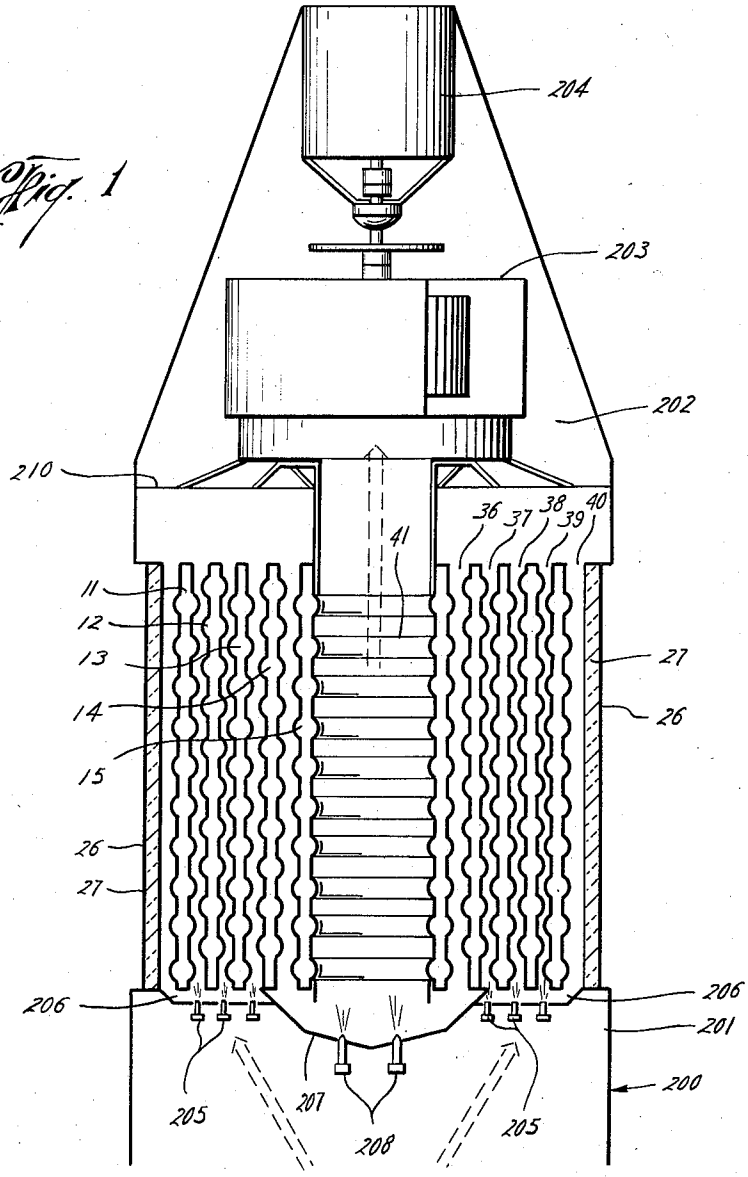
Nov. 25, 1958 L. P. COHEN 2,861,781

HEAT EXCHANGE APPARATUS

Filed May 31, 1955 4 Sheets-Sheet 1

Fig. 1



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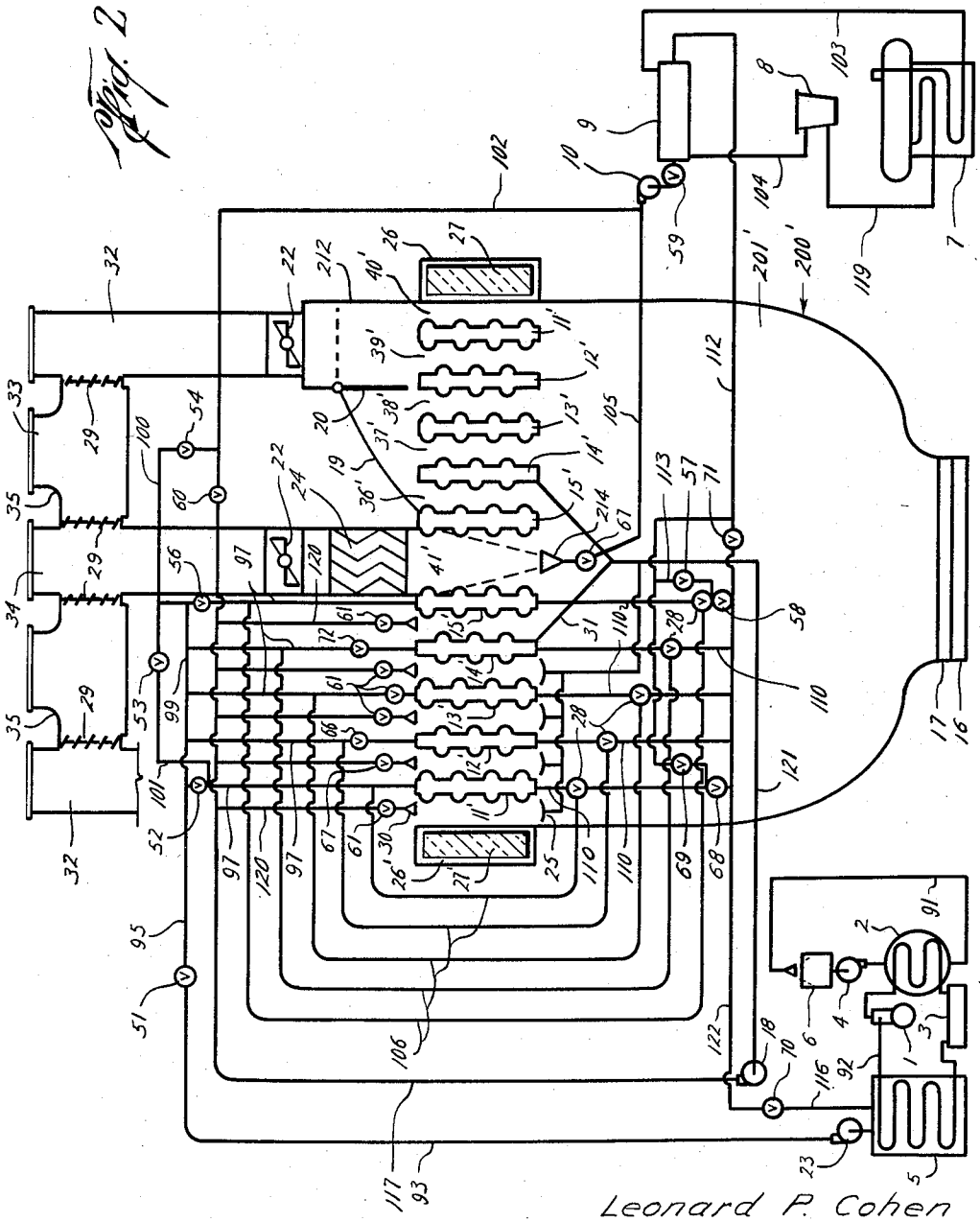
Filed May 31, 1955 4 Sheets-Sheet 2

Fig. 2



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HEAT EXCHANGE APPARATUS

Filed May 31, 1955 4 Sheets-Sheet 3

Fig. 3

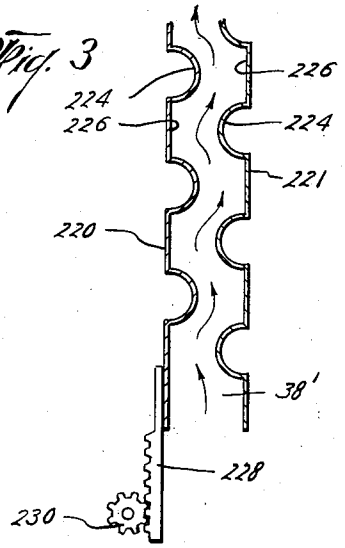


Fig. 4

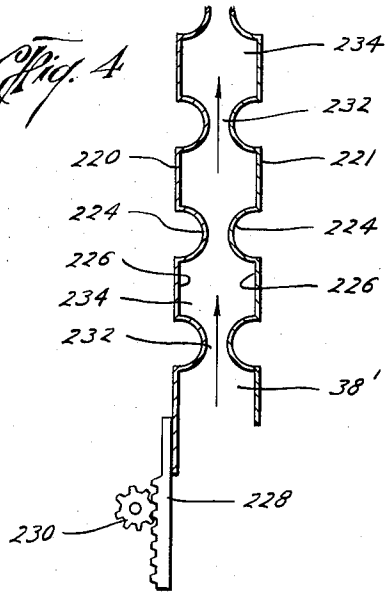
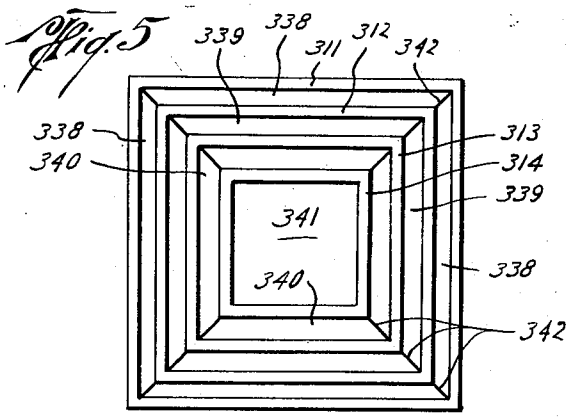


Fig. 5



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HEAT EXCHANGE APPARATUS

Filed May 31, 1955 4 Sheets-Sheet 4

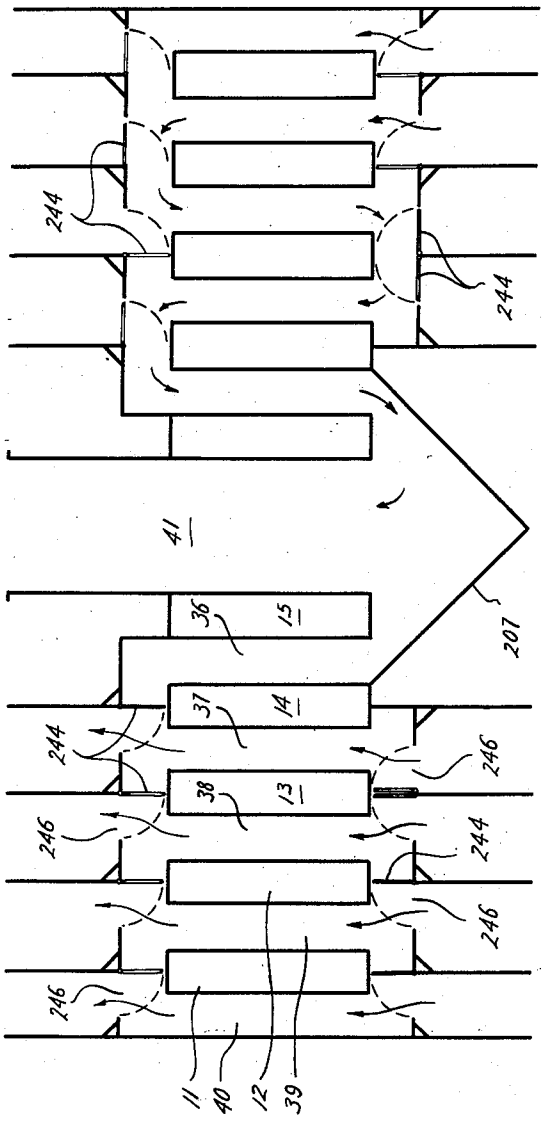

Fig. 6

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2,861,781

HEAT EXCHANGE APPARATUS

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Application May 31, 1955, Serial No. 512,049

3 Claims. (Cl. 257—243)

This invention relates to heat exchange apparatus and more particularly to improved apparatus for use in carrying out any of numerous different processes in which an exchange of heat occurs between fluids.

The invention is capable of wide application wherever an exchange of heat between fluids is to be accomplished, such as in air conditioning and humidifying or dehumidifying and in processes involving the condensation of vapors or evaporation of liquids.

The invention has for an important object the provision of heat exchange apparatus whose capacity may be varied throughout a wide range without altering the over-all size of the apparatus.

Another object of the invention is to provide heat exchange equipment wherein the heat exchange surfaces may be adjusted relative to each other to regulate the cross-sectional area of the flow-way through the equipment and also to vary the path of flow and to increase or decrease the turbulence of fluid passing therethrough.

A further object of the invention is the provision of heat exchange apparatus wherein the heat exchange surfaces are constructed to form a multiplicity of flow-ways, which may be easily arranged in series or in parallel relation, to adapt the apparatus to different conditions of use, without changing the over-all dimensions of the apparatus.

Another object of the invention is to provide heat exchange apparatus including a plurality of heat exchange surface elements or tanks adapted to arrange one within another to form passageways for the flow of fluids therethrough, the elements being mounted for relative movement in directions normal to the axes of the elements to vary the distances between the heat exchange surfaces.

A further object of the invention is the provision of heat exchange apparatus of the type referred to, wherein the surface elements are designed to form between them passageways shaped to cause the fluids to flow in circuitous or tortuous paths, thereby increasing the turbulence of the fluids, and also having means for adjusting the relative positions of the elements to vary the shape of the passageways to regulate the turbulence of the fluids.

Another object of the invention is to provide heat exchange apparatus which is designed to secure the effective control of droplet separation from gaseous or vaporous fluids.

A further object of the invention is the provision of heat exchange apparatus having heat transfer surface portions, which are shaped to provide a series of orifices and expansion chambers, and which are mounted for relative movement to permit the adjustment of the sizes of the orifices to increase or decrease the pressure and velocity effects exerted on fluids flowing through the apparatus, and which may also be adjusted to provide a circuitous path with a minimum of pressure and velocity effect on such fluids.

A still further object of the invention is to provide heat exchange equipment of simple construction and compact

design, which is easily adapted to use for numerous different purposes and whose capacity is adjustable to meet widely varying conditions.

The above and other important objects and advantages of the invention may best be understood from the following detailed description, constituting a specification of the same, when considered in conjunction with the annexed drawings, wherein—

Figure 1 is a central, vertical, cross-sectional view illustrating a preferred embodiment of the invention;

Figure 2 is a fragmentary diagrammatic view illustrating the manner in which the apparatus may be used and including flow diagrams of the hot and cold fluid supply systems employed in conjunction therewith;

Figure 3 is a fragmentary cross-sectional view on an enlarged scale illustrating details of construction of a preferred form of the heat exchange surface elements of the invention, and the manner in which the elements are rendered adjustable, the elements being shown in one position of adjustment;

Figure 4 is a view similar to that of Figure 3 showing the heat exchange surface elements in another position of adjustment;

Figure 5 is a view illustrating a modified form and arrangement of the heat exchange surface elements of the invention;

Figure 6 is a fragmentary, schematic view illustrating adaptation of the invention and showing the manner in which the apparatus may be used for widely different purposes.

Referring now to the drawings in greater detail the apparatus of the invention includes a number of cylindrical vessels or tanks **11**, **12**, **13**, **14** and **15** arranged one within another in radially spaced relation to provide passageways **36**, **37**, **38**, **39** and **40** between them. The interiors of the tanks are connected in communication with sources of heating or cooling mediums by suitable piping to be disclosed hereinatfer, whereby heat may be transferred to or from the fluid in the passageways. The tanks are enclosed in a casing or housing, generally indicated at **200**, which may be provided with suitable insulation, indicated at **27**, located within the wall **26** which surrounds the outermost tank **11**.

The casing is formed with a portion forming an inlet chamber **201**, the spaces between certain of the tanks opening at their inlet ends into the inlet chamber. The casing is also provided with an outlet portion **202** within which blower mechanism is suitably supported, which includes the fan or blower housing **203**. A plate **210** forms the bottom of the outlet portion **202**, which plate has a central opening through which the inlet of the blower housing **203** is connected in communication with the outlet end of the passageway **41**, and within housing **203** a fan or blower of conventional construction is located. Suitable means, such as an electric motor **204** is provided connected to the fan in the housing **203** by which the fan is driven in the usual manner.

Means is provided for spraying a suitable liquid, such as water, into certain of the passageways, as by means of the nozzles **205**, suitably supported on cross members **206** beneath the lower ends of the tanks, in position to direct sprays of water upwardly into the passageways. A drip pan **207** is located in the inlet chamber **201** beneath the tanks **14** and **15**, and through which additional nozzles **208** are extended, whereby liquid may be sprayed into the passageway **41**. The drip pan also serves to close off the lower ends of the passageways **36** and **41** from the inlet chamber **201**.

It will be apparent that by this construction and arrangement of the apparatus, air may be drawn into the inlet chamber **201** by operation of the blower, and such air may pass upwardly through passageways **37**, **38**, **39**

and 40 to be deflected downwardly by the plate 210 through passageway 36, whence the air flows upwardly through passageway 41 and into the blower housing 203 to be conducted therefrom to any desired location.

It will be appreciated that any number of tanks may be provided and that the flow of air, or other fluid through the passageways may take place in any desired sequence to accomplish the required heat exchange effect.

Figure 2 illustrates the arrangement of an apparatus in greater detail, the heating and cooling systems by which a heating medium or coolant is supplied to the tanks being shown diagrammatically. The tanks and nozzles are shown with the piping connections applied thereto in the left hand half of Figure 2, while in the right hand half of the figure these connections have been omitted for greater clarity.

As seen in Figure 2 the apparatus has cylindrical vessels or tanks 11', 12', 13', 14' and 15', constructed and arranged in the manner as the tanks 11, 12, 13, 14 and 15, previously described, and between which passageways 36', 37', 38', 39' and 40' are formed, the innermost tank 15' having a passageway 41' therethrough. The casing 200' may be provided with a wall portion 26' surrounding the outermost tank 11' and which is provided with suitable insulation, as indicated at 27'.

The casing has an inlet opening provided with louvers of conventional design, as indicated at 16 and which may also be provided with a filter 17 of usual construction.

Passageways 37', 38', 39' and 40' open at their lower ends into the inlet chamber 201' of the casing, and passageways 38' and 39' are in communication at their upper ends with the upper end of passageway 36'.

Beneath the lower ends of the tanks 14' and 15' a drip pan 31 is located which closes off the lower ends of passageways 36' and 41' from the inlet chamber. A baffle 19 extends across the upper ends of passageways 36', 37' and 38' above the upper ends of those passageways in position to direct the upward flow of fluid therefrom toward the upper end of passageway 36'. A hood 212 is provided in the casing above the upper ends of passageways 39' and 40' in position to receive fluid discharged therefrom, and is connected in communication with discharge ducts 32. The hood may be provided with deflecting dampers such as that indicated at 20 along one side thereof, which may be moved to one position, as shown in dotted lines, to close off communication between the passageways and the ducts 32, or to another position to permit the upward flow of fluid from passageways 39' and 40' into the ducts.

The ducts 32 are connected in communication with plenum chambers 35 through openings provided with mixing dampers such as those indicated at 29.

The passageway 41' is connected at its upper end in communication with a main supply duct 34 within which eliminator plates indicated at 24 are located, and which also is in communication with the plenum chambers 35 through openings likewise provided with mixing damps 29.

Suitable blowers or fans 22 may be positioned in the ducts 32 and 34 whereby fluid may be moved therethrough.

Spray nozzles 30 are positioned to direct a spray of liquid into the passageways 36', 37', 38', 39', and 40' and a nozzle 214 is also disposed to direct a spray of liquid into the passageway 41' above the drip pan 31. Suitable drip pans 25 may also be located beneath the passageways 37', 38', 39' and 40' to catch liquid therefrom to be returned to the source of supply.

With the arrangement illustrated in Figure 2, as thus far described, it will be seen that air, or other fluid may enter the inlet chamber 201' to pass upwardly through passageways 37' and 38' and downwardly through passageway 36' from whence the fluid flows upwardly through passageway 41' and out through the duct 34. Air may also pass upwardly through passageways 39' and 40', and

when the dampers 20 are in the position shown, will pass out through ducts 32.

If desired the dampers 20 may be moved to the position indicated in dotted lines, whereupon air passing through passageways 39' and 40' will be directed into passageway 36' along with the air from passageways 37' and 38' to pass upwardly through passageway 41' and out through duct 34.

It will, of course, be understood that the passageways may be arranged in numerous other ways to secure the most efficient heat transfer to meet any particular conditions, the arrangements illustrated herein being intended by way of example only.

The invention, as illustrated in Figure 2 also includes suitable sources of supply for heating medium or coolant and the piping arrangement and means whereby the flow of the same to and from the apparatus is controlled. The means for supplying heating medium is shown at the right hand of Figure 2 and includes a steam generator 7, or other similar heat source, which is connected by a pipe 119 to a steam trap 8 of conventional design, from whence the steam flows by way of pipe 104 to a hot water converter 9. The steam may return to the generator 7 from the converter by way of pipe 103. The hot water converter 9 has an outlet pipe 102 into which a pump 10 is connected and which is provided with a valve 59. The pipe 102 leads to each of the spray nozzles 30 by way of branch pipes 120 each of which is under the control of a separate valve 61, there being also a valve 60 which controls the flow of water to all of the spray nozzles 30. Water may also flow from pump 10 through pipe 105 to the nozzle 214 to supply a spray of hot water into the passageway 41' under the control of a valve 67.

The heating medium is also supplied to the tanks through pipe 102, and pipes 100 and 101 which lead to branch pipes 97 connected to the tanks, the pipes 100 and 101 being provided with valves 54 and 53, respectively, for controlling the flow therethrough, and valves being provided for each branch pipe whereby the flow therethrough may be separately controlled. The heating medium may return from the tanks to the converter 9 through pipe 112 and branch pipes 110, each of which is under the control of a three-way valve 28. A by-pass pipe 106 is connected to each of the pipes 97 of the tanks and also to each of the three-way valves 28, whereby fluid may be by-passed around any of the tanks as desired.

By the above described piping arrangement it will be apparent that heating medium may be supplied to the tanks and spray nozzles in any desired manner, using all or any number of the tanks and nozzles, and that the supply of heating medium may be very closely controlled to meet any particular conditions.

A pipe 121 is connected by suitable branch pipes to each of the drip pans 25 located beneath the passageways 37', 38', 39' and 40' and is also connected to the drip pan 31 beneath passageways 36' and 41', and this pipe 121 leads to a pump 18 whose discharge outlet is connected by a pipe 117 leading to spray nozzles 30 through branch pipes 120 and to spray nozzle 214 through pipes 102 and 105, whereby water received in the drip pans may be recirculated through the nozzles if desired.

A suitable coolant, such as chilled water, may be supplied to the tanks, as by means of the equipment shown on the left hand of Figure 2 wherein a refrigerant compressor is indicated at 1 which is connected in communication with a condenser 2 from whence the refrigerant passes to a receiver 3, to be supplied to a water chiller indicated at 5. From the chiller 5 refrigerant is returned to the compressor 1 through a pipe 92.

Chilled water is supplied from the chiller 5 to the tanks 11', 12', 13', 14' and 15' through a pipe 93 under the control of a valve 51, by a pump 23, the pipe 93

being connected to the branch pipes **97**. The water is returned from the tanks to the chiller **5** through a pipe **122** which is connected to the branch pipes **110**.

It will be apparent that by this piping arrangement coolant may be circulated through any or all of the tanks, as desired, whereby the apparatus may be effectively used to meet any cooling conditions required.

Figures 3 and 4 are enlarged fragmentary views illustrating a preferred form of wall structure of the tanks, and adjusting means employed therewith, whereby the passageways may be varied to control the turbulence of fluid passing therethrough, to vary the path of the fluid, and also to vary the pressure and expansion effect on the fluid in its progress through the passageways. In Figures 3 and 4 the numerals **220** and **221** designate adjacent walls of two tanks, such, for example, as the tanks **12'** and **13'** shown in Figure 2, which form between them the passageway **38'**. The walls **220** and **221** are preferably formed with alternate circumferential crest and trough portions **224** and **226**, respectively, and the tanks are mounted for relative axial movement by means of any suitable mechanism such as the rack **228** and pinion **230** associated with the wall **220**. The walls are constructed so that the crests **224** of one wall may be moved to positions opposite the troughs **226** of the other wall, as seen in Figure 3, to form a tortuous passageway of substantially uniform width, whereby the turbulence of the fluid may be greatly increased to secure a maximum heat transfer effect. Similarly the walls may be moved to position the crests **224** of one wall opposite the crests of the other wall, as seen in Figure 4, to form a series of restrictions **232** and expansion chambers **234** whereby the fluid will be subjected to alternate compression and expansion in flowing through the passageway.

It will be apparent that by the provision of walls formed in this manner, the areas of the heat exchange surfaces are substantially increased, and by mounting the tanks for relative movement the positions of the crests and troughs of the walls may be adjusted to produce any desired degree of turbulence in the fluid flowing through the passageways or to provide any desired compression and expansion effect.

By this means the apparatus is rendered capable of very accurate control to meet exacting conditions and may be quickly adjusted to accommodate sudden changes.

Figure 5 illustrates a further modification of the invention wherein the tanks **311**, **312**, **313** and **314** may be of rectangular or similar shape in cross section, and the spaces between the tanks may be divided by longitudinally extending divider plates **342** located at the corners to provide a large number of passageways **338**, **339**, **340**. By this construction the path of flow of the fluid through the passageways may be varied to suit varied conditions or several different fluids may be treated in the same apparatus.

Figure 6 is a diagrammatic view illustrating one way in which the apparatus may be provided with dampers which are operable to vary the path of the fluid through the passageways. In this form of the invention the same tanks **11**, **12**, **13**, **14** and **15** may be employed as previously described, arranged in the same manner to provide the passageways **36**, **37**, **38**, **39** and **40**. A separate damper **244** is provided in the casing beyond the end of each passageway which is operable to open and close a corresponding opening **246** in the casing. The dampers may be moved to the positions shown at the left hand of Figure 6 to permit the flow of fluid in the same direction through all of the passageways, or to the positions shown at the right hand of Figure 6 to cause the fluid to flow in one direction through one passageway and in the opposite direction in the next passageway. By suitably adjusting the dampers various paths of flow may be established to accommodate different conditions under which the apparatus is to be used.

In other respects the structure and operation of this form of the invention may be like that of the form previously described in connection with Figure 1 of the drawings.

It will thus be seen that the invention provides heat exchange apparatus which is capable of many applications and is easily adapted without substantial changes in structure for various different uses such as air conditioning, deaerating, spray drying, evaporating condensing and as a cooling tower.

While the invention has been disclosed herein in connection with certain specific embodiments of the same, it will be understood that these are by way of illustration only and that numerous changes can be made in the construction and arrangement of the various parts without departing from the spirit of the invention or the scope of the appended claims.

Having thus clearly shown and described the invention, what is claimed as new and desired to secure by Letters Patent is:

1. In heat exchange apparatus a plurality of tubular, hollow-walled, receptacles arranged one within another in spaced apart relation to form passageways of tubular shape between the receptacles, said receptacles being movable axially relative to each other, and means on the receptacles extending into the passageway and movable with the receptacles into and out of positions to form a restriction in the passageway.

2. In heat exchange apparatus a plurality of tubular, hollow-walled, receptacles arranged one within another in spaced apart relation to form passageways of tubular shape between the receptacles, said receptacles being movable axially relative to each other, and spaced parallel projections formed on the receptacles extending into the passageway and movable with the receptacles into and out of positions to form spaced apart restrictions in the passageway.

3. In heat exchange apparatus a plurality of tubular, hollow-walled, receptacles arranged one within another in spaced apart relation to form passageways of tubular shape between the receptacles, said receptacles being movable axially relative to each other, the walls of said receptacles having trough-like portions forming axially spaced, peripherally extending, substantially parallel projections extending into the passageways and movable with the receptacles into and out of positions to form restrictions in said passageways.

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