

Jan. 3, 1956

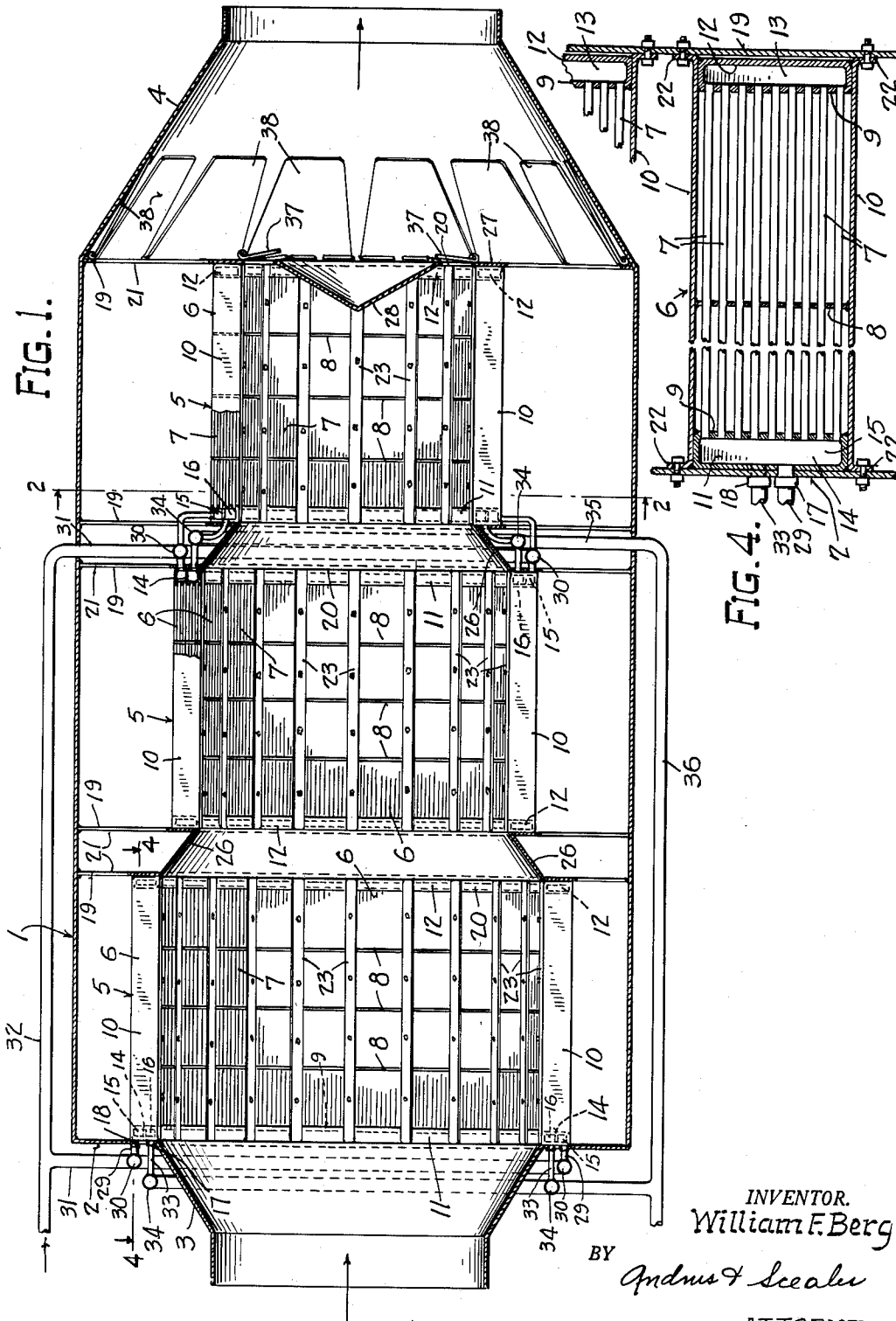
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2,729,432

LARGE CAPACITY HEAT EXCHANGER

Filed Sept. 17, 1952

3 Sheets-Sheet 1



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LARGE CAPACITY HEAT EXCHANGER

Filed Sept. 17, 1952

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FIG. 2.

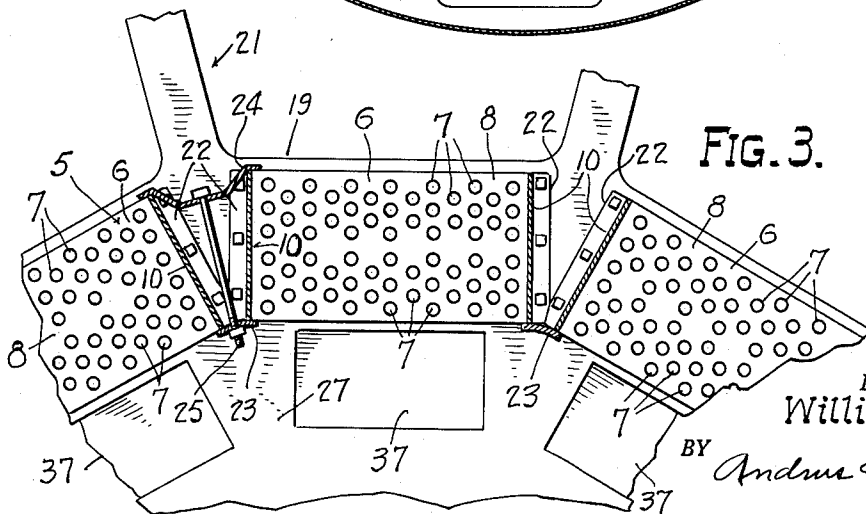
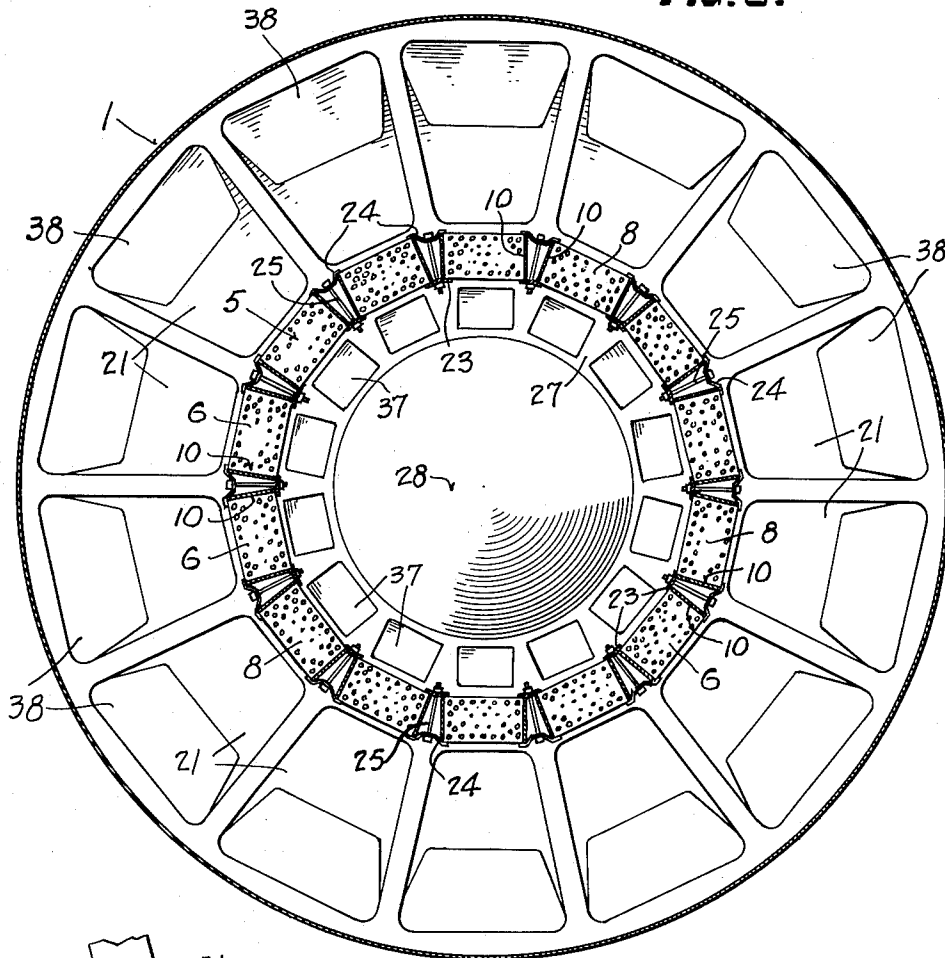


FIG. 3.

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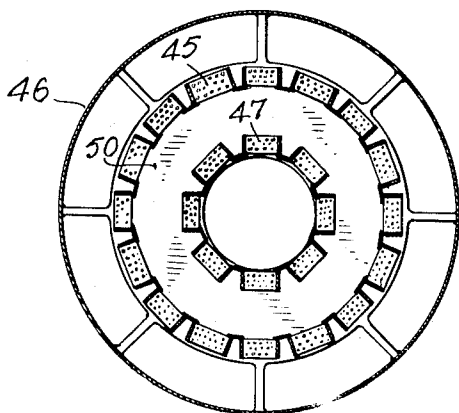
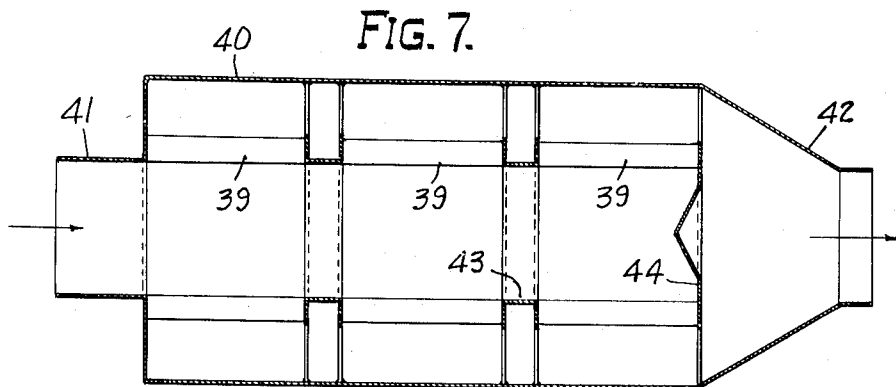
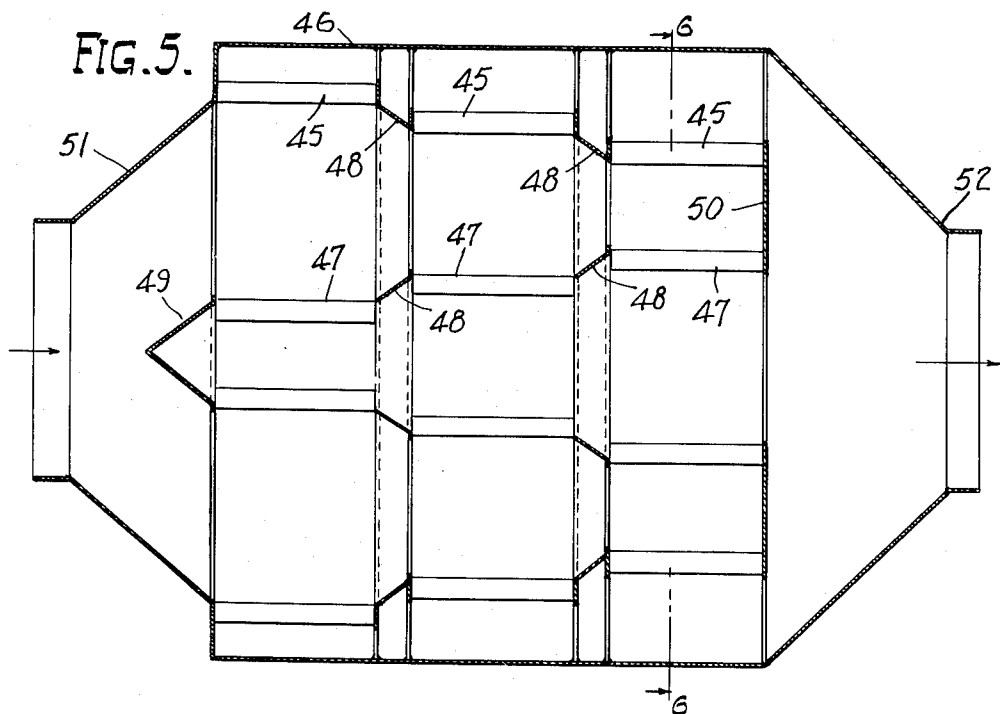
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LARGE CAPACITY HEAT EXCHANGER

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3 Sheets-Sheet 3



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2,729,432

LARGE CAPACITY HEAT EXCHANGER

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Application September 17, 1952, Serial No. 310,075

14 Claims. (Cl. 257—137)

This invention relates to heat exchangers and more particularly to a heat exchanging apparatus capable of handling large volumes of fluid and accurately controlling the temperature thereof.

In many operations, such as wind tunnel experiments, it is essential that the stream of air or gas to be employed therein be thoroughly mixed and have a uniform temperature throughout its cross-sectional area when entering the installation or wind tunnel in order to simulate operating conditions. Experiments have shown that a layer of either hot or cold air that is unmixed with the balance of the air in the stream may travel throughout the complete circulatory system as a stratified layer.

This undesirable stratified condition frequently results from an insufficient heat transfer surface or, when attempting to provide adequate heat transfer surface, resort has been made to a type of heat transfer surface construction which produces an undesirable resistance to flow of air therethrough. It follows that in these circumstances a non-uniform transfer of heat to the air occurs and stratification results. The desired result in a heat transfer apparatus of the type to which this invention is directed is to provide an apparatus which will control the temperature of substantially large volumes of air or other process fluid with equal distribution of the fluid through the heat transfer cores and with a minimum of turn pressure losses, while at the same time providing an apparatus which may be built commercially at a minimum cost.

One object of the present invention is to provide an inexpensive heat transfer apparatus which will uniformly distribute a fluid through the heat transfer surfaces.

Another object is to provide a heat transfer surface in the form of a series of annular banks through which the process fluid will pass radially to provide a uniform transfer of heat without stratification of the fluid.

Another object is to provide a heat transfer unit for processing large masses of air which will maintain the velocity of the air passing through the unit at a constant value so as to minimize pressure loss of the air.

Another object is to provide a heat transfer unit which will accurately control the temperature of large masses of process fluid passing through the unit.

Another object is to provide a heat exchanger having a heat transfer surface in the form of a series of annular banks whereby the face area of the heat exchanger may be increased or decreased by merely adding or removing a bank from the series.

Still another object is to provide a heat exchanger of simple construction wherein the heat transfer surfaces are individually removable from the exchanger for cleaning or repair.

According to the present invention a series of annular heat transfer banks having a structure similar to that described in my copending application, Serial No. 265,253 filed January 7, 1952, and entitled "Barrel Shaped Heat Exchanger," are disposed in an axial end-to-end relation within a generally cylindrical duct to provide a

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central longitudinal passage extending within the banks. Each of the banks is formed of a plurality of longitudinally disposed, circularly spaced core sections which define a passageway for the circulation of a heat transfer medium. Under one embodiment of the invention the diameter of each successive bank is progressively decreased from the inlet end of the duct to the outlet end to provide a heat transfer surface of substantially conical shape.

The air or other fluid to be processed is admitted to the duct and enters the central longitudinal passage, then passes radially through the heat transfer banks, and thereafter passes longitudinally within the annular space between the banks and the duct to an outlet in the duct. A suitable closure plate is secured to the bank of least diameter in the series to close off the central longitudinal passage and prevent the air from passing directly through the banks to the outlet in the duct without passing across the core sections.

To control the temperature of the discharged air the closure plate may be provided with flaps or valves which function to permit a predetermined portion of the air to pass directly through the series of banks without passing across the core sections.

In a second embodiment of the invention a plurality of annular banks having equal diameters are arranged in series, while in a third embodiment one series of decreasing diameter banks are disposed in a concentric relation with a second series of increasing diameter banks.

A particular advantage of the heat exchanger of the present invention is the flexibility provided for increasing the heat transfer face area for any given duct diameter. This may be conveniently accomplished by merely adding another bank to the series and thereby extending the heat transfer face area in the direction of the axis of the duct. This flexibility affords great convenience of construction.

By providing banks of decreased diameter in the direction of air flow the velocities of the air are maintained substantially constant throughout the apparatus. This generally conical arrangement of the annular heat transfer banks provides an extremely effective means of minimizing friction pressure losses of the air passing through the apparatus and providing a uniform distribution of air flow without stratification.

Other objects and advantages will appear in the course of the following description.

In the drawings:

Figure 1 is a vertical section of the apparatus showing the arrangement of annular heat transfer means within the duct;

Fig. 2 is a transverse section of the apparatus taken on line 2—2 of Figure 1;

Fig. 3 is an enlarged fragmentary view of Fig. 2 showing the attachment of core sections to the frame;

Fig. 4 is a fragmentary longitudinal section on the line 4—4 of Figure 1;

Fig. 5 is a schematic longitudinal sectional view of a second embodiment of the apparatus showing a double conical arrangement of the banks;

Fig. 6 is a transverse section taken on line 6—6 of Fig. 5; and

Fig. 7 is a schematic longitudinal sectional view of a third embodiment showing cylindrical banks of the same diameter arranged in tandem.

Referring to the drawings there is shown a heat transfer apparatus comprising a generally cylindrical external duct 1 or casing having an inlet end into which air or other fluid to be processed is admitted and an outlet end from which the processed fluid is discharged. An annular plate 2 having an axial opening therein is secured edgewise to the inner surface of duct 1 adjacent the inlet end thereof and an inlet fitting 3 of cone shape is weld-

ed within the axial opening of plate 2. A generally conical discharge fitting 4 is secured to the outlet end of duct 1.

A series of annular heat transfer banks 5, substantially as described in my copending application Serial No. 265,253 filed January 7, 1952, are disposed axially of and within duct 1. The air or other fluid to be processed is adapted to pass radially through the annular banks 5 with the temperature of the air being changed as it passes therethrough. Banks 5 extend from adjacent the inlet end of duct 1 to adjacent the outlet end thereof with the number and size of the banks employed depending on the operation involved. As shown in Figure 1 three such banks 5 are employed within duct 1.

The forwardmost bank 5 in the series, adjacent the inlet end of the duct 1, has an inner diameter substantially equal to the axial opening in plate 2, and the hollow interior of the bank registers therewith. The diameter of each succeeding bank from inlet end to outlet end is progressively smaller with the rearwardmost bank in the series, adjacent the outlet end of the duct, having the least diameter.

Each bank 5 comprises a plurality of circularly spaced longitudinally disposed core sections 6 which define a passageway for the circulation of a heat transfer medium. The core sections 6 are all of the same size so that the number of core sections in any one bank depends upon the diameter of that bank. It follows that the forwardmost bank having the largest diameter will be formed of the greatest number of core sections 6, while the rearwardmost bank having the least diameter will contain the smallest number of core sections.

Core sections 6 include a cluster or bundle of longitudinally disposed finned tubes 7 within which a heat transfer medium, such as water, is adapted to flow. Tubes 7 may be constructed of any material which has generally high thermal conductivity properties and which is able to withstand corrosive attack from the particular fluids employed in the apparatus.

To support tubes 7 over their length, each core section 6 is provided with a plurality of transverse, longitudinally spaced support plates 8 which are formed with a plurality of suitable openings to receive tubes 7.

The ends of tubes 7 are secured to header plates 9. Plates 9 are generally rectangular in shape and are provided with a plurality of suitable openings within which the respective ends of tubes 7 are secured by welding, brazing, soldering or the like.

The sides of each core section 6 are enclosed by side plates 10 which are welded to the respective header plates 9 and to support plates 8. Side plates 10 serve to seal off the space between core sections 6 to the passage of air and direct the air radially outward through the sections.

To distribute the heat transfer fluid to and from tubes 7, a generally rectangular header box 11 is secured to the outer face of one of the header plates 9. A second header box 12 is secured to the outer face of the other header plate 9 and defines a return chamber 13.

A rib 14 is disposed within each header box 11 and divides the same into an inlet chamber 15 and an outlet chamber 16. A pair of pipe fittings 17 and 18 disposed at the inner and outer faces of header 11, respectively, establish communication between chambers 15 and 16 and a suitable heat transfer fluid circulating system.

Water enters inlet chamber 15 via fitting 17 and passes longitudinally through the portion of tubes 7 registering with chamber 15 to return chamber 13 and thereafter returns to outlet chamber 16 in the portion of tubes 7 registering with chamber 16. By employing additional ribs similar to rib 14 within headers 11 and 12 the number of passes of the water through each core section may be increased as desired.

Each annular bank 5 is supported by a frame which includes a pair of annular spaced supporting plates 19,

similar in structure to plate 2, which are longitudinally disposed within duct 1 and secured edgewise by welding or the like to the inner surface of duct 1. Plate 2 serves as one of the pair of supporting plates for the forwardmost bank, adjacent the inlet end of duct 1.

Each of the supporting plates 19 is provided with an axial opening 20 aligned with the axial opening in plate 2 and through which the air or other process fluid is adapted to pass. Each of the supporting plates 19 is also provided with a plurality of circularly spaced, generally rectangular peripheral openings 21 through which the air passes in traveling to the outlet fitting 4 after having passed radially across the heat transfer banks 5.

The axial opening 20 in the first plate 19 is of the same diameter as that in plate 2 while the axial openings 20 in the following pairs of plates 19 supporting successive banks 5 are of equal diameter and the peripheral openings 21 in the same pairs of plates are all of equal size. However, as the banks 5 are progressively smaller in diameter from inlet to outlet the axial openings 20 in successive pairs of plates 19 are correspondingly smaller in diameter than in the pair of plates supporting the previous bank of core sections. The peripheral openings 21 in each pair of plates are increased in size over the openings 21 in the pair of plates supporting the previous bank of core sections. Thus the peripheral openings 21 in the plates 19 supporting the bank 5 of least diameter adjacent the outlet end of the duct are largest in size.

Core sections 6 of each bank 5 are secured lengthwise between the respective supporting plates 9, intermediate the peripheral openings 21 and the axial openings 20 in the plates, by flanges 22 of the side plate 10.

To seal off the space between core sections to the passage of process fluid or air, a plurality of longitudinal sealing strips 23 are disposed across the inner longitudinal edges of adjacent core sections 6. Strips 23 are attached to a plurality of longitudinally spaced, generally U-shaped brackets 24 which are disposed between the outer longitudinal edges of adjacent core sections 6. The U-shaped web portion of the brackets 24 extends within the V-shaped space between adjacent core sections 6, and the flanges of the brackets 24 bear against the outer longitudinal edges of core section side plates 10. Bolts 25 extend inwardly through aligned openings in brackets 24 and the corresponding sealing strip 23 and are engaged adjacent the inner surface of the strip 23 by suitable nuts.

To prevent the flow of air radially between adjacent banks 5 a plurality of generally conical rings 26 are secured within the axial openings 20 of plates 19 in adjacent frames. Rings 26 serve as baffles and direct the air longitudinally through the hollow interior of the series of annular banks 5.

An end plate 27 is secured within the axial opening 20 of the rearwardmost supporting plate 19. End plate 27 is formed with a central conical portion 28 which serves to direct the air entering the rearwardmost bank radially outwardly through core sections 6 of that bank.

In order to distribute a heat transfer medium, such as water, to the core sections 6 in an economical manner, the core sections of alternate banks are positioned in an opposite relation to those in intermediate banks. That is, rather than having the headers 11 of all core sections 6 facing forwardly of the duct 1, core sections 6 in alternate banks face rearwardly of the duct so that headers 11 of adjacent banks are juxtaposed and face each other. With this positioning one distributing conduit may service core sections 6 in adjacent banks. As seen in Figure 1 the header 11 of the forwardmost bank faces forwardly, the header 11 of the intermediate bank rearwardly, and the header 11 of the rearwardmost bank, forwardly.

A conduit 29 connects the inlet fitting 17 of each of the headers 11 to ring-like inlet manifold 30 and serves to conduct a heat transfer medium such as water from the manifold to the inlet chamber 15 of each header 11. The inlet manifold 30 for the forwardmost bank 5 is disposed

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on the exterior of duct 1, and conduit 29 extends through a suitable opening in plate 2 to establish connection between fitting 17 and inlet manifold 30. The inlet manifold 30 for each successive pair of banks 5 is disposed outwardly of the corresponding baffle ring 26 connecting the banks.

A conduit 31 extends radially outward from each inlet manifold ring 30 and provides communication between the ring and a suitable external pipe 32 which is in turn connected to a source of heat transfer fluid. In the case of the inlet manifolds 30 disposed within duct 1, the conduit 31 extends outwardly through a suitable aperture in the duct to effect the connection with pipe 32.

A discharge conduit 33 connects the discharge fitting 18 of each core section 6 to a ring-like discharge manifold 34 and communicates with outlet chamber 16 of each header 11. As in the case of the inlet manifold 30, the discharge manifold 34 associated with the forwardmost bank 5 is disposed outside of the duct 1 and the discharge conduit extends through a suitable opening in plate 2 to make the connection. The discharge manifold 34 associated with the successive pairs of banks 5 is disposed between the adjacent banks outwardly of the baffle ring 26.

A radial conduit 35 establishes communication between the respective discharge manifolds 34 and an external return pipe 36 in a manner similar to that employed with conduit 31. Return pipe 36 extends longitudinally of duct 1 and serves to return the heat transfer fluid to the source thereof for recirculation.

The air or other fluid to be processed, meaning heated or cooled depending on the operation, enters duct 1 via inlet fitting 3. A portion of the air entering the hollow interior of the forwardmost annular bank is directed radially outward across the core sections 6 of that bank. Heat is transferred between the air and the heat transfer fluid within the core sections as the air passes across the same. The air which passed across the core sections then flows longitudinally within the annular space between the banks 5 and duct 1, through peripheral openings 21 in the series of supporting plates 19 and is discharged from the duct through outlet fitting 4.

The portion of the air which did not pass radially across the core sections 6 of the forwardmost bank passes through the axial openings 20 in plates 19 into the hollow interior of the second bank in the series. Here again a portion of the air is directed radially outwardly through the core sections of the second bank with the remaining air passing longitudinally into the next succeeding bank.

This procedure is continued through the series of banks until the air enters the rearmost bank and there the end plate 27 directs the remaining air outwardly across the core sections 6 of that bank and hence through openings 21 in the rearmost supporting plate 19 to outlet fitting 4 from which the air is discharged.

By arranging the annular banks in a series with the diameters of the banks progressively decreasing from the inlet end to the outlet end of the duct, the quantity of air passing longitudinally through the series of annular banks decreases progressively from the forwardmost bank to the rearwardmost bank. As the quantity of air passing longitudinally decreases from bank to bank by virtue of a portion of the air being turned outwardly through the core sections wherein it is processed, the quantity of air in the annular space between the banks and the duct 1 increases progressively from the inlet to the outlet end of the duct so that the quantity of processed air which is discharged from the duct in a given period is equal to the quantity of unprocessed air entering the duct in that period.

The apparatus is designed so that the greatest heat transfer face area is at the inlet end of the duct where the greatest quantity of unprocessed air is available. On the other hand at the outlet end of the duct where the quantity of unprocessed air within the banks is at a minimum, the heat transfer surface is likewise at a minimum.

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By decreasing the diameter of each successive bank from inlet to outlet end of the duct the longitudinal velocities of the air are substantially constant throughout the unit except for the change in volume consequent upon the change in temperature of the air. The particular arrangement of the heat transfer surfaces provides for a minimum frictional pressure drop in the air being processed as well as providing an extremely uniform distribution of air through the core sections without stratification of the air into layers of different temperatures.

To control the temperature of the process fluid being discharged through outlet fitting 4 a valving arrangement is provided to permit any desired amount of the entering fluid to pass directly through duct 1 without passing across the core sections 6 of the series of annular banks 5. This may be accomplished by providing end plate 27 with a plurality of generally rectangular circumferentially spaced openings which may be closed off by a corresponding number of adjustable hinged flaps 37 or valves. The flaps 37 when open, permit air to pass longitudinally through the annular banks from the inlet end of the duct to the outlet end.

In addition, the valving arrangement may include a plurality of generally rectangular shaped hinged flaps 38 disposed to close off and regulate the flow of air through openings 21 in the rearmost supporting plate 19.

Flaps 37 and 38 may be operated by any desired means. It may be preferred to operate corresponding radial flaps 37 and 38 together. That is, as flaps 37 in end plate 27 are opened to allow fluid or air to by-pass core sections 6, flaps 38 are closed to reduce the flow of air through the core sections. Conversely, as the openings in end plates 27 are closed by flaps 37, flaps 38 are opened and air will be directed across core sections 6.

The arrangement of the core sections 6 in the form of an annular bank provides a maximum heat transfer face area for a given diameter duct. By use of the annular configuration of the core sections the face area for a duct of given diameter is substantially greater than if the heat transfer surface were installed frontally to the direction of air flow or in a herringbone pattern. The heat transfer face area may be conveniently increased or decreased in the present apparatus by merely adding or removing a bank from the series and thereby extending or decreasing the heat transfer face area in the direction of the axis of the duct. This unusual feature of the invention makes it possible to add heat transfer face area to the apparatus by merely adding a section to the length of the duct and adding a bank to the series without the costly operation of having to scrap the original duct and replace it with one of increased diameter, as is necessary when increasing the face area of frontal or herringbone arrangements.

The present heat transfer apparatus provides for the convenient independent removal of core sections 6 from the respective banks 5. After the fittings 17 and 18 are disconnected by merely unfastening bolts 25 and flanges 22 the core sections may be withdrawn inwardly from their resting position between supporting plates 19 to the hollow interior of the bank 5 and hence removed from the duct via inlet fitting 3. The separate removal of any core section 6 for cleaning or repair without disturbing the remaining core sections is highly advantageous, for by merely inserting a substitute core section or a plug in the position of the removed section the operation of the apparatus may continue without a lengthy shut down for repair.

A second embodiment of the invention, shown schematically in Fig. 7, provides a heat transfer surface that is substantially cylindrical rather than conical as in the first embodiment. The annular heat transfer banks 39, corresponding to banks 5 of the first embodiment, are all formed with equal diameters and are disposed longitudinally of the duct 40 and secured therein in a manner similar to that employed in the first embodiment.

The air of other process fluid enters inlet fitting 41 and is directed radially outward through the heat transfer banks 39. The processed air then flows longitudinally in the annular space between the banks 39 and the duct 40 and is discharged from the duct through outlet fitting 42.

Baffle rings 43 and end plate 44 which are similar in construction and function to baffle rings 26 and end plate 27 of the first embodiment, serve to prevent the radial flow of air between banks and to prevent the longitudinal flow directly from inlet to outlet respectively.

The embodiment of the invention shown schematically in Fig. 5 illustrates a double conical arrangement of the heat transfer banks. One series of annular banks 45, corresponding in construction and function to banks 5 of the first embodiment, are disposed longitudinally of and within duct 46 with the banks 45 progressively decreasing in diameter from the inlet end of the duct to the outlet end. A second series of annular banks 47 are disposed concentrically within the first series. However, the diameter of each bank 47 in the second or inner series progressively increases from inlet to outlet. Thus the heat transfer surface may be taken to be made up of two cones, the inner cone having its apex adjacent the base of the outer cone at the inlet end of the duct.

Baffle rings 48 connect adjacent banks in each series and prevent the radial flow of air between the banks. A conical end cap 49 is secured across the forward end of the bank 47 of smallest diameter in the inner series to prevent the longitudinal entry of air between the banks 47. An annular end plate 50 is secured between the rearward end of the smallest diameter bank 45 of the outer series and the rearward end of the largest diameter bank 47 in the inner series. Plate 50 serves to seal off the annular space between banks and directs the air radially outwardly or inwardly from the space through the outer and inner series of banks.

The air or other process fluid enters duct 46 through inlet 51 and passes into the annular space between the outer series of banks 45 and the inner series of banks 47. The air then passes both radially inwardly and outwardly through the respective banks 47 and 45. The air which passes through the outer banks 45 travels longitudinally within the annular clearance between the banks 45 and the duct 46 to the outlet 52, while the air which passes through the inner banks 47 flows longitudinally within the hollow interior of the banks 47 to the outlet 52.

The double conical arrangement of annular heat transfer banks results in an apparatus having an extremely large heat transfer face area for a given size duct. As is the case with the first embodiment, the longitudinal velocities of the air within this unit are substantially constant and the frictional pressure loss of the air is minimized. The air is uniformly distributed to the heat transfer surfaces to provide a uniformly processed discharge air without evidence of stratification.

In each embodiment the air was described as entering the inlet end of the duct and passing radially through the banks. However the direction of flow may be reversed in any of the described embodiments so that the air may enter the so-called outlet end of the duct and pass radially through the banks in a direction opposite to that previously described.

Various embodiments of the invention may be employed within the scope of the accompanying claims.

I claim:

1. A heat transfer apparatus for controlling the temperature of substantially large volumes of fluid passing therethrough, which comprises a longitudinally extending duct having an inlet and outlet end, a series of annular heat transfer banks disposed axially of each other within said duct and having a longitudinal central passage therethrough, said banks being spaced radially inwardly of the duct to provide an outer passage between the banks and the duct, each said bank comprising a plurality of independently removable longitudinally disposed core sec-

tions arranged in a substantially circular shape to form each annular bank with said core sections defining separate flow paths for a fluid and a heat transfer medium, means to introduce fluid into the central passage of said duct and to flow a portion of the fluid axially through the central passage of the banks and to flow another portion of said fluid radially through the core sections of each of said banks to said outer passage and thence longitudinally of the duct to said outlet, and means to supply a heat transfer medium to each core section and to withdraw the same from said core section.

2. A heat transfer apparatus for controlling the temperature of substantially large volumes of fluid passing therethrough, which comprises a longitudinally extending duct having an inlet and outlet end, a series of annular heat transfer banks disposed axially of each other within said duct and having a longitudinal central passage therethrough with said banks being spaced radially inwardly of the duct to provide an outer passage between the duct and the banks, each said bank comprising a plurality of independently removable longitudinally disposed core sections arranged in a substantially circular shape to form each annular bank said core sections defining separate flow paths for a fluid and a heat transfer medium, means to introduce fluid into the central passage of said duct, means closing off the outlet end of the central passage through the duct to effect flow of a portion of the fluid axially through each bank and discharge said portion radially through the core sections of the last bank to the outer passage and then to the outlet end of the duct, and said closure means in addition effecting radial flow of a second portion of the fluid through the core sections of each bank ahead of the last bank of the series to the outer passage and then to the outlet end of the duct, wall means in said duct directing the radially discharged fluid longitudinally to the outlet end of the duct, and means to supply a heat transfer medium to each core section and to withdraw the same from said core section.

3. A heat transfer apparatus for controlling the temperature of substantially large volumes of fluid passing therethrough, which comprises a longitudinally extending duct having an inlet and outlet end, a series of annular heat transfer banks disposed axially of each other within said duct and having a longitudinal central passage therethrough with said banks being spaced inwardly of the duct to provide an outer passage therebetween, each said bank comprising a plurality of independently removable longitudinally disposed core sections arranged in a substantially circular shape to form each annular bank, said core sections defining separate flow paths for a fluid and a heat transfer medium, means to introduce fluid into the central passage of said duct, means closing off the outlet end of the central passage through the duct to effect flow of a portion of the fluid axially through each bank and discharge said portion radially through the core sections of the last bank to the outer passage and then to the outlet end of the duct, and said closure means in addition effecting radial flow of a portion of the fluid through the core sections of each bank ahead of the last bank of the series to the outer passage and then to the outlet end of the duct, means to adjust the closure means to open the same a varying amount for discharge of a portion of the fluid directly through the closure means, wall means in said duct directing the radially discharged fluid longitudinally through said outer passage to the outlet end of the duct, and means to supply a heat transfer medium to each core section and to withdraw the same from said core section.

4. A heat transfer apparatus for controlling the temperature of substantially large volumes of fluid passing therethrough, which comprises a longitudinally extending duct having an inlet and outlet end, a series of annular heat transfer banks disposed axially of each other within said duct and having a longitudinal central passage therethrough with said banks being spaced inwardly of the duct to provide an outer passage therebetween, each said bank

comprising a plurality of longitudinally disposed core sections arranged in a substantially circular shape to form each annular bank, said core sections defining separate flow paths for a fluid and a heat transfer medium, and each said bank being of lesser diameter from the inlet end to the outlet end of said duct, means to introduce fluid into the central passage of said duct and to flow a portion of the fluid axially through the central passage of the banks to the outlet end of the duct and flow another portion of said fluid radially through the core sections of each of said banks and thence longitudinally of the duct to said outlet, and means to supply a heat transfer medium to each core section and to withdraw the same from said core section.

5. A heat transfer apparatus for controlling the temperature of a fluid passing therethrough, which comprises a duct having an inlet end and an outlet end, a series of frames disposed axially of said duct and extending substantially from the inlet end to the outlet end thereof, said frames being continuously connected at their outer peripheries with the inner surface of said duct, a plurality of longitudinally disposed circularly spaced heat transfer core sections carried by each frame, each core section defining a passageway for the circulation of a heat transfer medium, means for removably securing each core section to the corresponding frame to permit independent removal of the core section for cleaning and repair, baffle means secured between adjacent frames to prevent the radial passage of fluid between said adjacent frames, and second baffle means secured across the last frame in the series to effect flow of the fluid radially through the core sections to change the temperature of the fluid as the same passes in contact with the core sections.

6. A heat transfer apparatus for controlling the temperature of a fluid passing therethrough, which comprises a duct having an inlet end and an outlet end, a series of frames disposed axially of said duct and extending substantially from said inlet end to said outlet end, said frames being continuously connected at their outer peripheries with the inner surface of said duct, a plurality of longitudinally disposed circularly spaced heat transfer core sections carried by each frame and arranged thereon in the shape of an annular bank, said banks decreasing in diameter from one end of the duct to the other end of said duct, means for removably securing each core section to the corresponding frame to permit independent removal of the core section for cleaning and repair, closure means to close off the outer end of the frame of least diameter to the longitudinal passage of fluid to cause said fluid to pass radially through said core sections to change the temperature of the fluid as the same passes in contact with said core sections, and baffle means associated with adjacent frames to prevent the radial passage of fluid between adjacent frames.

7. In a heat transfer apparatus for controlling the temperature of a fluid passing therethrough, a substantially cylindrical duct having an inlet end and an outlet end, a series of substantially annular heat transfer banks of tubes disposed within said duct in an end-to-end relation to provide a central longitudinal passage within said banks, said banks being inwardly spaced from said duct to provide an outer passage between said banks and the duct, and said banks progressively decreasing in diameter from one end of said duct to the other end of said duct to provide said central longitudinal passage with a progressively decreasing cross sectional area and said outer passage with a progressively increasing cross sectional area, and means to introduce fluid into said central passage and flow the same radially through said banks to said outer annular passage with the temperature of the fluid being changed as the same passes in contact with said banks.

8. A heat exchange apparatus for controlling the temperature of substantially large volumes of fluid passing therethrough, which comprises a generally cylindrical duct having an inlet end and an outlet end, a series of

annular heat transfer banks disposed longitudinally of and within said duct from adjacent the inlet end of the duct to adjacent the outlet end thereof, said banks being radially spaced inwardly of the duct to provide a passage between the duct and the bank, each bank comprising a plurality of longitudinally disposed core sections arranged in generally circular shape to form each annular bank and adapted to separate flow of fluid and heat transfer medium therethrough, said banks progressively decreasing in diameter from one end to the other end of the duct to form a heat exchange surface of generally conical shape, means for introducing a fluid into said duct and directing said fluid radially through said core sections, and means to flow a heat transfer medium through each core section.

9. A heat exchange apparatus for controlling the temperature of substantially large volumes of fluid passing therethrough, which comprises a generally cylindrical duct having an inlet end and an outlet end, a series of annular heat transfer banks disposed longitudinally of and within said duct from adjacent the inlet end of the duct to adjacent the outlet end thereof, said banks being spaced radially inwardly of the duct to provide a passage between the duct and the banks, each bank comprising a plurality of longitudinally disposed core sections arranged in generally circular shape to form each annular bank and adapted to separate flow of fluid and heat transfer medium therethrough, said banks progressively decreasing in diameter from one end to the other end of the duct to form a heat exchange surface of generally conical shape, means associated with the bank of least diameter to prevent longitudinal passage of fluid through the entire series of banks and to direct the fluid radially across said core sections, means associated with adjacent banks to prevent radial passage of fluid between said banks, and means to flow a heat transfer medium through the core sections of each bank.

10. A heat exchange apparatus for controlling the temperature of substantially large volumes of fluid passing therethrough, which comprises a generally cylindrical duct having an inlet end and an outlet end, a series of annular heat transfer banks disposed longitudinally of and within said duct from adjacent the inlet end of the duct to adjacent the outlet end thereof, said banks being spaced radially inwardly of the duct to provide a passage between the duct and the banks, each bank comprising a plurality of longitudinally disposed core sections arranged in generally circular shape to form each annular bank and adapted to separate flow of fluid and heat transfer medium therethrough, said banks progressively decreasing in diameter from one end to the other of the duct to form a heat exchange surface of generally conical shape, baffle closure means associated with the bank of least diameter to prevent longitudinal passage of fluid through the entire series of banks and to direct the fluid radially across said core sections, valve means attached to said closure means for partially opening the same for controlling the temperature of the outlet fluid by permitting a portion of said fluid to pass longitudinally through the series of heat transfer banks to said outlet end without passing across said core sections, and means to flow a heat transfer medium through the core section of each bank.

11. In a heat exchange apparatus for controlling the temperature of substantially large volumes of fluid passing therethrough, a pair of heat exchange surfaces of generally conical shape, said surfaces being concentrically disposed with relation to each other with the apex of one of said surfaces being disposed adjacent the base of the other of said surfaces, and each of said surfaces comprising a plurality of longitudinally disposed core sections arranged in generally circular shape to form said surfaces and adapted to separate flow of fluid and heat transfer medium therethrough, means associated with the bases and apices of each surface to cause air directed through said apparatus to pass over the core sections in said sur-

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faces, and means to flow a heat transfer medium through said banks.

12. A heat exchange apparatus for controlling the temperature of substantially large volumes of fluid passing therethrough, which comprises a duct having an inlet end and an outlet end, a heat transfer surface disposed longitudinally within said duct and comprising an outer annulus spaced inwardly of the duct to provide a passage therebetween and an inner annulus, each annulus comprising a series of banks formed of a plurality of longitudinally disposed independent core sections arranged in generally circular shape to form each annulus and adapted to separate flow of fluid and heat transfer medium therethrough, said banks of the outer annulus progressively decreasing in diameter from the inlet to the outlet end of the duct and said banks of the inner annulus progressively increasing in diameter from the inlet end of the duct to the outlet end of said duct, means associated with the banks of least diameter of each annulus to prevent the passage of fluid longitudinally through the entire series of banks of each annulus and to change the direction of travel of the fluid to radial flow through the banks, and means to supply a heat transfer medium to the banks of each annulus and to effect passage of the medium therefrom.

13. A heat exchange apparatus for controlling the temperature of substantially large volumes of fluid passing therethrough comprising a generally cylindrical duct having an inlet end and an outlet end, a series of annular heat transfer banks disposed longitudinally of and within said duct from adjacent the inlet end of the duct to adjacent the outlet end thereof, said banks being spaced radially inwardly of the duct to provide a passage between the duct and the banks, each bank comprising a plurality of independently removable longitudinally disposed core sections arranged in generally circular shape to form each annular bank said core sections defining separate flow paths for a fluid and a heat transfer medium,

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said banks having substantially equal diameters to form a heat transfer surface of generally cylindrical shape, means for introducing the fluid into said duct and directing the same radially through said core sections, and means to flow a heat transfer medium through the core sections of each bank.

14. A heat transfer apparatus for controlling the temperature of a fluid flowing therethrough, which comprises a duct having a fluid inlet end and a fluid outlet end, a plurality of substantially annular heat transfer banks disposed longitudinally of and within said duct from adjacent the outlet end to adjacent the inlet end, said banks being spaced radially inwardly of the duct to provide an annular passage between the duct and the banks, each bank being formed of a plurality of longitudinally disposed core sections having an inlet header and a return header and having a plurality of tubes extending therebetween, said tubes defining a passageway for the circulation of a heat transfer medium, said inlet headers of successive pairs of banks being disposed to face each other, means disposed between inlet headers of adjacent banks to supply a heat transfer medium to the tubes of same and to effect withdrawal of the medium therefrom, a plurality of supporting members inter-connecting said duct and each of said headers for removably supporting said banks within the duct, baffle means inter-connecting adjacent supporting members to prevent the flow of fluid radially between adjacent banks, and means to introduce a fluid into the duct and to flow the same across the tubes of the core sections to change the temperature of said fluid.

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