

March 17, 1942.

E. G. BAILEY

2,276,281

FLUID HEAT EXCHANGE APPARATUS

Filed Dec. 21, 1938

3 Sheets-Sheet 1

Fig. 2

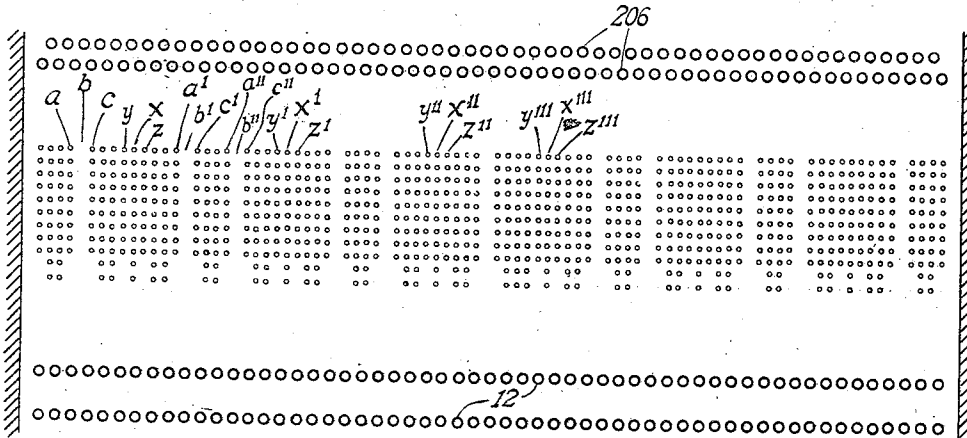


Fig. 1

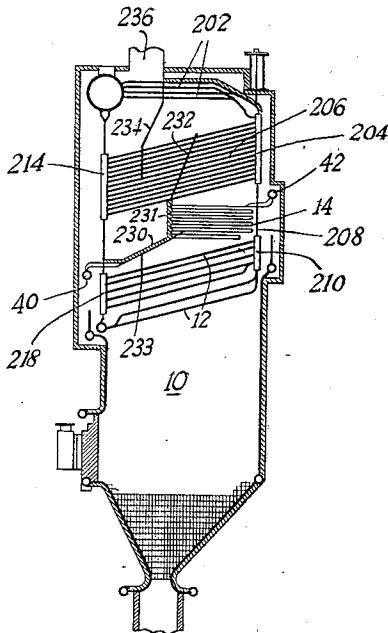
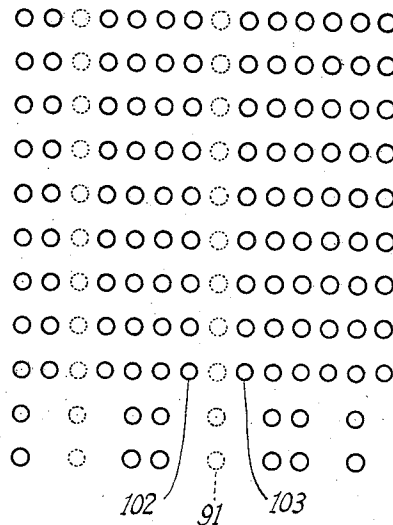


Fig. 3



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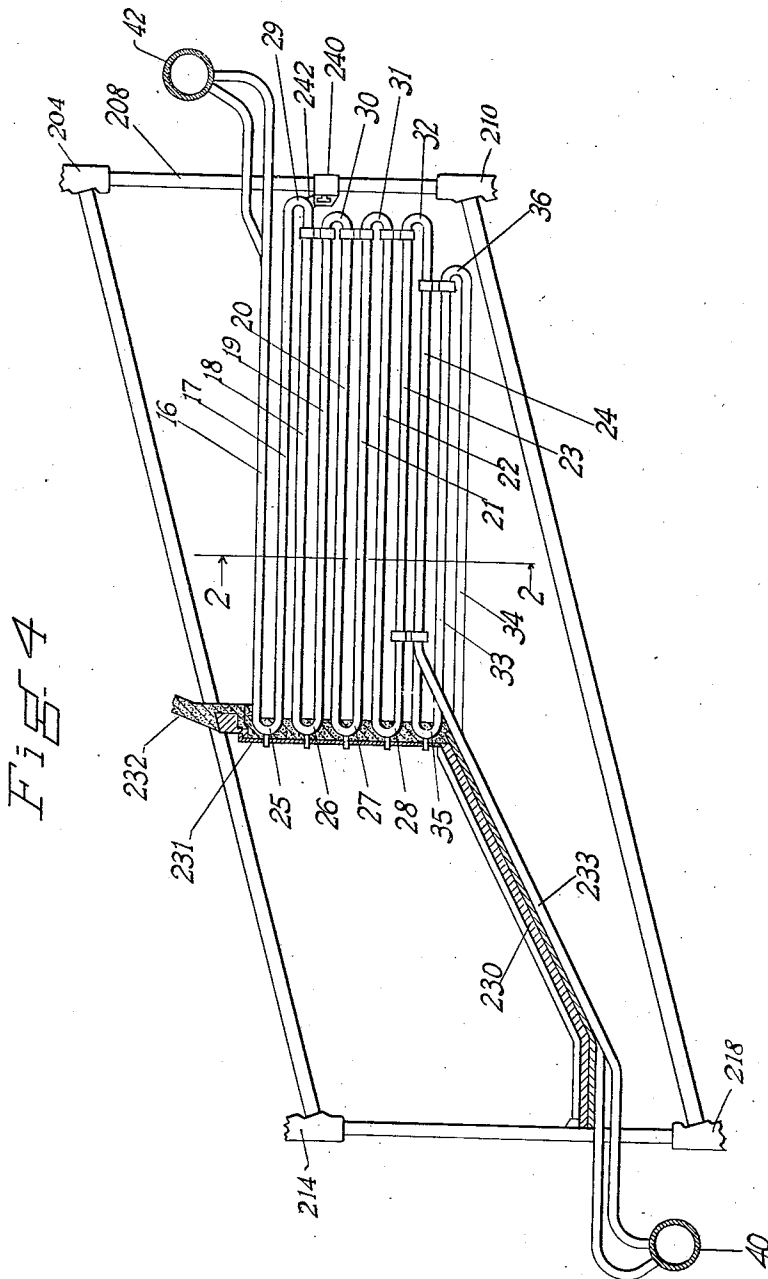
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FLUID HEAT EXCHANGE APPARATUS

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3 Sheets-Sheet 2



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FLUID HEAT EXCHANGE APPARATUS

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3 Sheets-Sheet 3

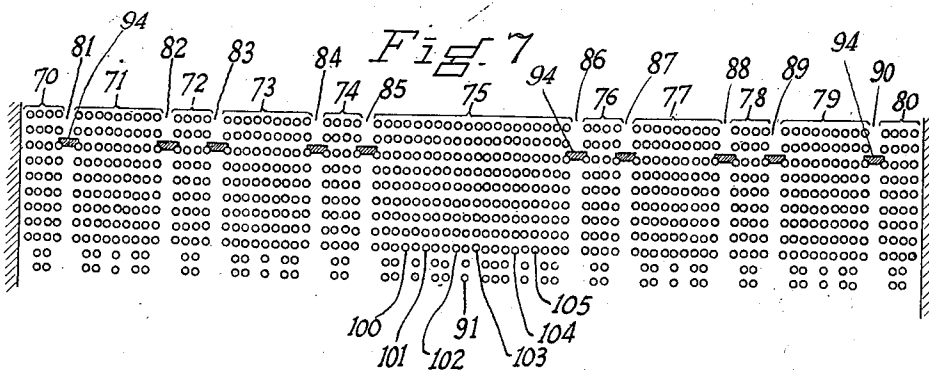
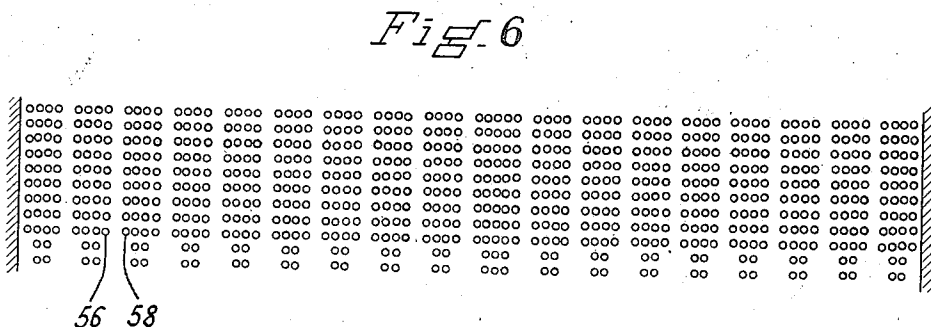
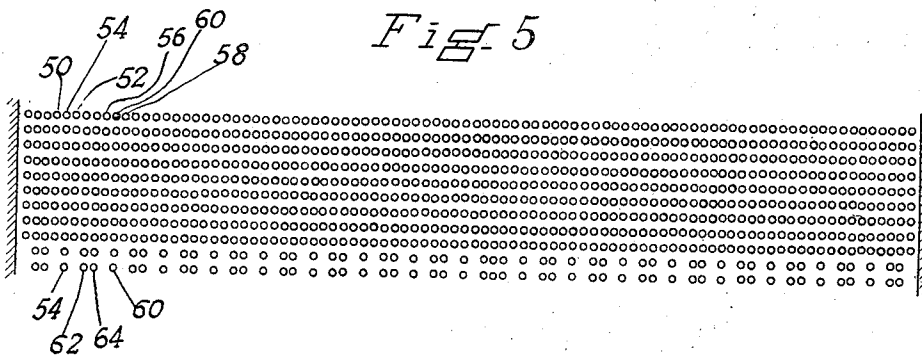
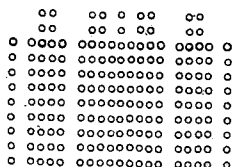


Fig. 8



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FLUID HEAT EXCHANGE APPARATUS

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13 Claims. (Cl. 122—235)

This invention relates to fluid heat exchange apparatus, and it may be considered as exemplified in a superheater.

In the operation of power steam boilers which generally deliver superheated steam to steam turbines, the temperature of the superheated steam must be held within certain limits, and this result is often difficult of accomplishment on account of many influences which tend to change the superheat from a desired value. As a consequence, control means are frequently provided for correcting departures from the desired steam temperature.

The need for controlling the superheat in a power steam boiler may arise in several different ways. It may result from changing load conditions, or from the necessity of supplying steam to power equipment which presents widely different demands. It may also result from changes in fuels or fuel conditions. The extent to which the heat absorbing surfaces of the boiler become slagged or otherwise fouled is also an example of altered operating conditions which may change the superheat from a value which was previously suitable to a new and undesired value so that control of superheat is necessary.

Means including desuperheaters, and apparatus bypassing a portion of the heating gases have been suggested for accomplishing the control of superheat within the narrow range of temperature variations caused by changes in boiler load, fouling of boiler surface, and other conditions previously referred to.

On occasion, however, it is necessary to make changes in the superheat temperature beyond the limits of the control apparatus being used, or in other words, to modify the range of temperature over which the control will be applicable, and in still other cases where control might not be employed it may become necessary to increase or decrease the range of superheat temperature resulting from a specific superheater installation. Such changes as these require the adjustment of the superheating surface, which must be increased or decreased depending on the nature of the change desired, and it is desirable to be able to make such adjustment without extensive changes to the structures involved.

It is an object of my invention to meet these conditions of increasing or decreasing superheat ranges in boilers by superheater surface adjustment which modifies the range of resulting superheat temperatures which range may, or may not, be subsequently subjected to control.

My invention provides a superheater of such a

character that some tubes may be removed, or additional tubes added, with assurance that the superheat will be altered as desired without incurring such undesirable results as the local overheating of some of the tubes.

In one form my invention contemplates the removal of one or more of a plurality of flat return bend coils which collectively present a bank of tubes extending across the flow of furnace gases. The coils are arranged with their tube axes in planes generally parallel to gas flow with the straight tube portions of each coil uniformly spaced. If, in such a tube bank, one coil is removed, a wide gas lane is formed. This results in increased gas flow through the wide lane and increased heat transfer to the straight tube portions of each coil marginal to that lane, and while such heat transfer is mainly due to convection, in some instances, the removal of a coil may also cause an increase in heat transfer by radiation.

My invention further provides for increased heat absorption in the marginal tubes to prevent their overheating, and, to accomplish this result, the superheater is provided with marginal tubes which have flow capacities per unit of heat absorbing ability greater than those of the non-marginal tubes. Accordingly, the marginal coils may be shorter than the other coils, or the tube diameter of the marginal coils may be greater.

My invention will be described with reference to the accompanying drawings which disclose preferred embodiments.

In the drawings:

Fig. 1 is a vertical section of a steam boiler in which the illustrative superheater is employed;

Fig. 2 is a vertical section through a superheater such as that shown in Fig. 1 or Fig. 4, and it may be considered as taken on the line 2—2 of Fig. 4;

Fig. 3 is a partial vertical section through the superheater, illustrating on an enlarged scale the removal of a long superheater coil from a position between shorter tubes;

Fig. 4 is a partial vertical section on an enlarged scale illustrating the two kinds of coils employed in the illustrative superheater;

Fig. 5 is a vertical section showing the superheater installed complete in such a manner that it includes the maximum number of coils and maximum amount of heat absorbing surfaces in the illustrative arrangement;

Fig. 6 is a vertical section showing the superheater provided with the minimum number of coils so as to present a minimum of fluid heat absorbing surfaces;

Fig. 7 is a vertical section through the superheater presenting an amount of heating surface intermediate the total surfaces of the arrangements indicated in Figs. 5 and 6; and

Fig. 8 is a vertical section indicating a portion of a superheater having a modified arrangement of coils, with both long coils and short coils having their lowermost loops in line, transversely of gas flow.

My superheater consists of flat coils of tubes disposed in parallel planes in the direction of gas flow, the gases of the boiler shown in Fig. 1 of the drawings flowing from the furnace 10 across the bank of steam generating tubes 12 and then across the coils of the superheater 14.

Each flat coil is formed of straight tube sections such as those indicated by the numerals 16-24, inclusive, in Fig. 4 of the drawings. These sections are connected in series by the return bends 25-32, inclusive. Some of the coils involve the additional straight tube sections 33 and 34 which have connected thereto the return bends 35 and 36. The latter coils are the longer and they present more heating surface than the first coils. Both kinds of coils have their corresponding ends connected to the header 40 and their opposite ends communicating with the outlet header 42 for the passage of steam to the latter from a common source.

The superheater is set so that the furnace gases sweep its tubes transversely, the direction of gas flow being substantially parallel to the planes of the flat coils. These coils are spaced apart so that gas flow lanes are provided between the tubes. Also, in the illustrative structure, the superheater tube banks formed by the coils extend all the way across the gas pass from end to end and from side to side.

The tube bank of the illustrative superheater is characterized by a particular arrangement of the flat coils and more particularly by the arrangement and spacing of the short coils relative to the long coils. For example, in the arrangement of coils indicated in Fig. 5 of the drawings, the short coils will be seen to be arranged in pairs (with the exception of the two end coils) with a single long coil between the coils of the pairs. Thus, the coils 50 and 52 of one pair have the long coil 54 disposed between them, and the short coils 56 and 58 of the next pair have the long coil 60 arranged between them. This arrangement is repeated many times throughout the superheater tube bank with adjacent sets of these long and short coils separated by two or more adjacent long coils such as the coils 62 and 64.

Assuming that all of the coils are of the same diameter, and that the coils join common inlet and outlet headers, each short coil will have a greater steam flow than a long coil because frictional resistance is less.

While, on the one hand, this will result in the absorption of less heat by these short coils when the superheater has its full complement of tubes, on the other hand, when a long coil is removed from its position between a pair of short coils and a wide lane is thus provided for increased gas flow therethrough the short coils will absorb more heat per unit of length than the remaining long coils. The greater amount of steam passing through these short coils because of the lower frictional resistance to steam flow will prevent overheating of the metal of the coils. It is for this reason that this particular arrangement of long and short coils is important.

Assuming that the maximum amount of superheating surface, as indicated in Fig. 5 of the drawings, is not desired in the installation, such long coils as the coils 54 and 60 may be omitted throughout the width of the bank, as indicated in Fig. 6 of the drawings. With this arrangement a minimum amount of superheating surface is provided, and overheating of the short coils (such as the coils 56 and 58) flanking wider gas lanes will be prevented because of the reduced heat absorbing surface and the increased steam flow.

Superheaters installed with the arrangement of coils indicated in Fig. 2 provide for either increasing or decreasing superheat adjustment as may be desired. In the event that the superheat temperature is too high, then the same procedure is followed as previously described in connection with Figs. 5 and 6 in that the long elements $x, x', x'',$ etc., between the shorter elements of the pairs $y, y', y'',$ etc., may be removed, thus forming additional wide lanes having marginal tubes shorter than the non-marginal tubes. On the other hand, should the superheat temperature be too low and an increase be desired, then long elements similar to $x, x',$ etc., can be installed in the wide lanes $b, b', b'',$ etc., already provided and bounded by shorter marginal tubes $a, a', a'',$ etc., which are similar to the marginal tubes $y, y', y'',$ etc. This illustrates the flexibility of the superheater arrangement and its ability to accomplish a permanent adjustment readily, without major changes to the structure, and yet in such a manner as to insure the safety of all superheater elements, with reference to overheating.

The superheater illustrated in Fig. 7 is similar to that of Fig. 2 previously described with the exception that baffle tile 94 are installed in the wide gas flow lanes 81-90, inclusive. These baffle tile 94 modify the full effect of the wide gas flow lanes 81-90 by imposing obstructions to gas flow and necessitating the flow of gas over the tubes of the superheater and consequently increasing the heat absorption over what it would be with open wide gas flow lanes. Selective use of these baffle tile not only provides for a partial adjustment of resulting superheat temperature without resorting to addition or removal of the long superheater elements, but, also, as previously stated, is a modifying influence upon the main adjustment feature of tube addition or removal.

Fig. 1 shows the superheater in an inter-deck position between the banks of steam generating tubes 12 and 206, the furnace gases passing over the bank 206 in three passes. The steam generating tubes are connected by the downtake headers 214, 218 with their associated nipples, and the uptake headers 204, 210 with the associated nipples 208.

Gases from the furnace 10 pass upwardly over the tubes of the bank 12 and thence upwardly through a first gas pass which terminates at a position below the horizontal circulators 202. This gas pass above the bank of tubes 12 is defined by the baffles 230, 231, and 232.

The baffle 230 preferably extends along the inclined portions 233 of the superheater coils adjacent the header 40, and the baffle 231 is employed to support the return bends 25-38, inclusive, of the superheater coils. Above the baffle 231 the baffle 232 extends across the tubes of the upper bank.

After passing over the bank of tubes 206 in the first gas pass the furnace gases pass down-

wardly through a second pass between the baffles 232 and 234, and then upwardly around the lower end of the baffle 234 to the exit 236.

The ends of the superheater coils adjacent the header 42 may be supported by the uptake nipples 208, as indicated in Fig. 4 of the drawings. In this case, the members 240 are secured in position on the nipples so as to co-operate with lugs 242 rigid with the return bends 29 of the superheater loops.

While the invention has been shown and described with reference to certain specific embodiments thereof, it is to be understood that it is not limited to all of the details of those embodiments. They may be modified, and other means to carry out the invention may be employed, within the spirit and scope of the sub-joined claims.

I claim:

1. In a steam boiler, a superheater including a plurality of groups of parallel flat tubular coils of different lengths extending across a gas pass with the coils disposed in planes generally parallel to the direction of gas flow, means connecting the inlet ends of the coils of a group to a common source of steam, means connecting the outlet ends of the coils of a group to a common outlet chamber, the spaces between the long and short coils of a group being uniform and narrower than the spaces which separate the groups, and baffles obstructing the wider spaces between the groups.

2. In fluid heat exchange apparatus, spaced tubular units of different heat absorption characteristics conducting a fluid at one temperature across a flow of fluid at another temperature so as to effect fluid heat exchange by convection, some of the units having steam flow capacities per unit of heat absorbing ability greater than the remainder, and means for supporting said units in an arrangement wherein the units of greater flow capacity are arranged in pairs with the space between the units of the pairs greater than the spaces between the units of lesser flow capacity and the units next adjacent thereto.

3. In a steam boiler, a superheater having short and long flat tubular coils arranged in planes substantially parallel to the general direction of gas flow over the coils, means for connecting the short and long coils to a common source of steam to be heated, the superheater being installed with the coils arranged in widely spaced groups of uniformly and narrowly spaced coils and with each group including a plurality of long coils disposed between two short coils, and baffles closing the wide spaces between the groups.

4. In a fluid heater, a bank of tubes extending across the path of high temperature furnace gases, and means connecting the tubes to form a plurality of long and short flat coils connected to a common source of fluid and extending in the direction of gas flow, the short coils being arranged in pairs with the spacing between the individual short coils being at least twice as great as the spacing between each short coil and an adjacent long coil.

5. In fluid heat exchange apparatus, a bank of tubes arranged across the path of a heat exchange fluid, the tubes being arranged in long and short rows parallel to the general direction of flow of the fluid, means connecting the tubes of each row together for the series flow therethrough of a fluid of different temperature, and means for connecting the long and short rows to a common source of fluid, the short rows be-

ing arranged in pairs with the space between the rows of each pair being at least twice the spacing of the long rows from the immediately adjacent rows.

6. A superheater including two kinds of spaced heating elements extending across a gas pass and arranged with the inter-element gas flow lanes or spacings of different widths transversely of gas flow, the heating elements of one of said kinds being disposed in positions marginal to the wider spaces and having steam flow capacities per unit of heat absorbing ability greater than those of the elements of the other kind.

7. In a steam boiler, a superheater having short and long flat tubular coils arranged in planes substantially parallel to the general direction of gas flow over the coils, and means for connecting the short and long coils to a common source of steam to be heated, the superheater being installed with the coils arranged in widely spaced groups of uniformly and narrowly spaced coils and with each group including a plurality of long coils disposed between two short coils.

8. In fluid heat exchange apparatus adapted to the heating of a fluid in a single phase, a plurality of heat absorbing units arranged transversely of a pass of the heating fluid and subject to different mass flows of that fluid, said units consisting of similarly formed tubular conduits connected for series flow therethrough, the units being arranged for parallel flow between common inlet and outlet chambers, some of the units having steam flow capacities per unit of heat absorbing ability greater than the remainder, the units of greater flow capacity being disposed in the zones of greater mass flow.

9. In fluid heat exchange apparatus adapted to the heating of a fluid in a single phase, a plurality of heat absorbing units arranged transversely of a pass of a heating fluid and subject to different mass flows of that fluid, said units consisting of a plurality of substantially parallel tube lengths connected at their ends for series flow therethrough, the units being arranged for parallel flow between fluid inlet and outlet chambers, some of the units having steam flow capacities per unit of heat absorbing ability greater than the remainder, the units of greater flow capacity being disposed in the zones of greater mass flow.

10. In a steam generator, a furnace including steam generating wall tubes connected into boiler circulation, means for firing the furnace, means forming a gas pass leading from the furnace, and a steam heater including a plurality of spaced heat absorbing units arranged transversely of the gas pass and subject to different degrees of gas mass flow, said units consisting of similarly formed tubular conduits connected for series flow therethrough, the units being arranged for parallel flow between a common inlet and a common outlet, some of the units having steam flow capacities per unit of heat absorbing ability greater than the remainder, the units of greater flow capacity being disposed in the zones of greater mass flow.

11. In a steam generator, a furnace including steam generating wall tubes connected into boiler circulation, means for firing the furnace, means forming a gas pass leading from the furnace, steam generating tubes connected into the boiler circulation and forming a screen extending across the path of the furnace gases, and a steam heater including a plurality of heat absorbing units arranged transversely of the gas pass at a

position rearwardly of the screen tubes and subject to different mass flows in the pass, said units consisting of a plurality of substantially parallel tube lengths connected at their ends for series flow therethrough, the units being arranged for parallel flow between a common fluid inlet and a common outlet, some of the units having steam flow capacities per unit of heat absorbing ability greater than the remainder, the units of greater flow capacity being disposed in the zones of greater mass flow.

12. In a heat exchanger, spaced fluid conducting tubes forming a bank and disposed in a transverse zone and in groups across the flow of a fluid, said zone or bank of tubes being characterized by inter-group positions at which the mass flow of said fluid is appreciably higher than

at other positions, the tubes at the positions of higher mass flow having flow capacities per unit of heat transfer ability higher than those of the tubes at positions of lower mass flow.

13. In a method of equalizing heat absorption between the fluid heat exchange streams of a convection system involving separate and enclosed streams, said system being characterized by zones of different mass flow of an external heat exchange fluid flowing over and around said streams, the provision of additional fluid streams of greater flow capacity per unit of heat transfer ability and the disposal of such additional streams in the zones of greater mass flow of the external fluid.

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