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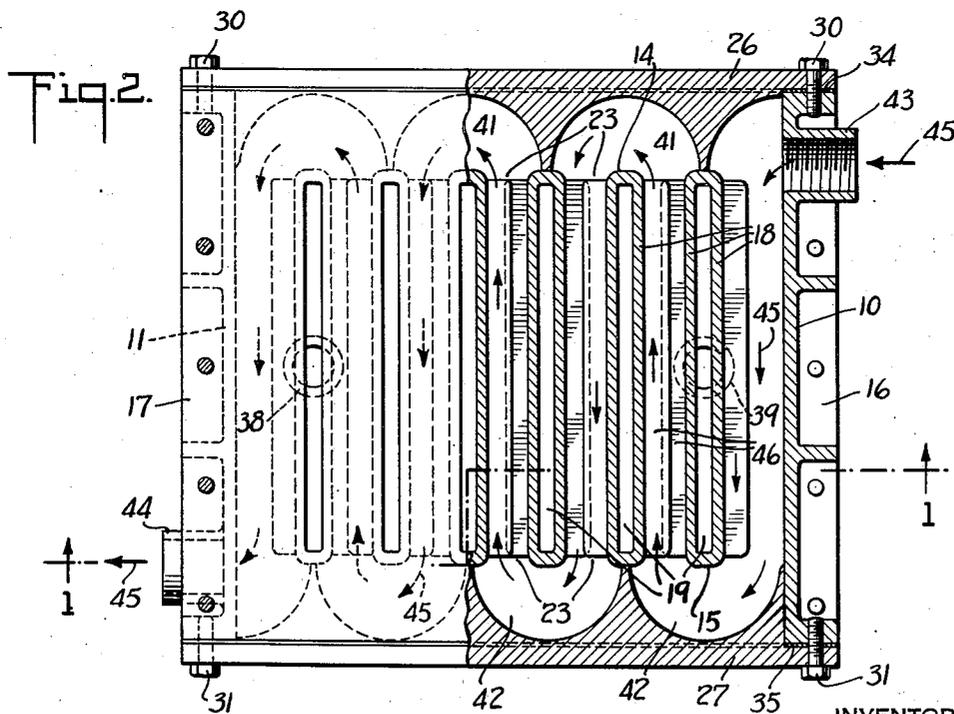
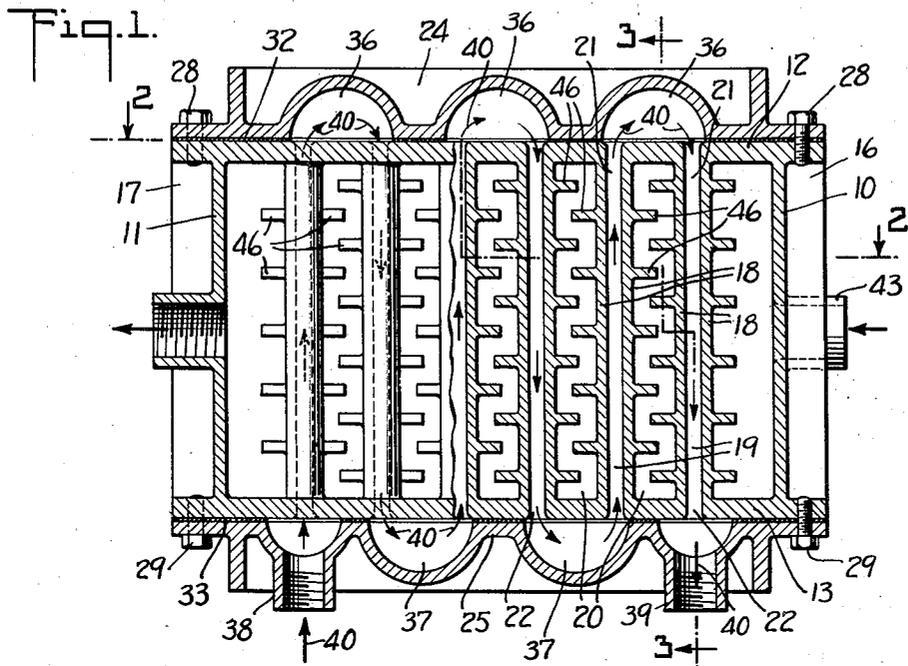
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2,183,956

HEAT EXCHANGE APPARATUS

Filed May 14, 1937

3 Sheets-Sheet 1



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Fig. 3.

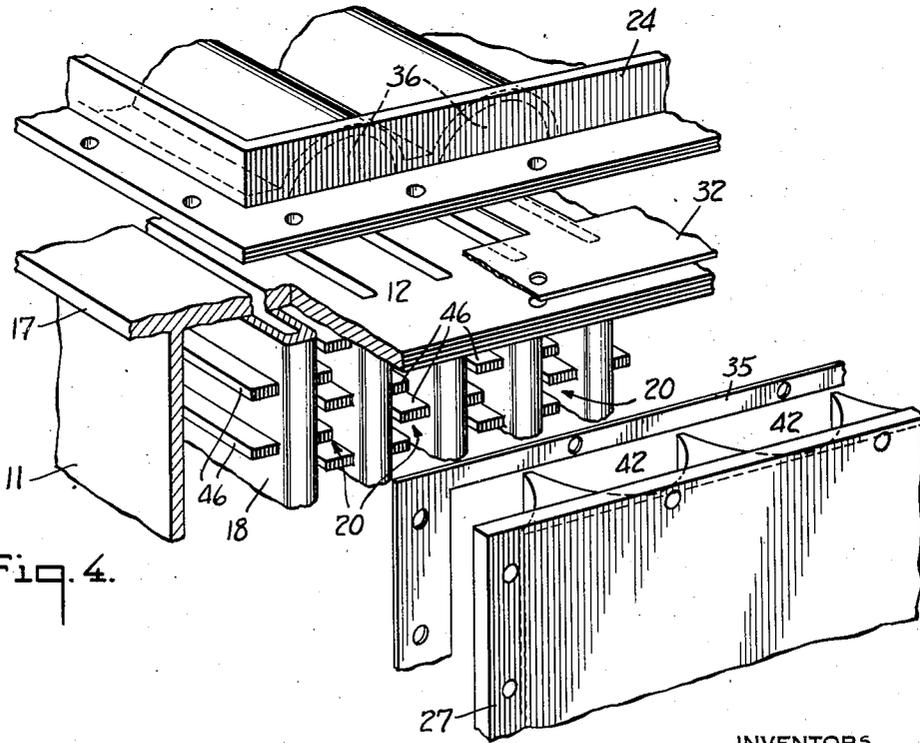
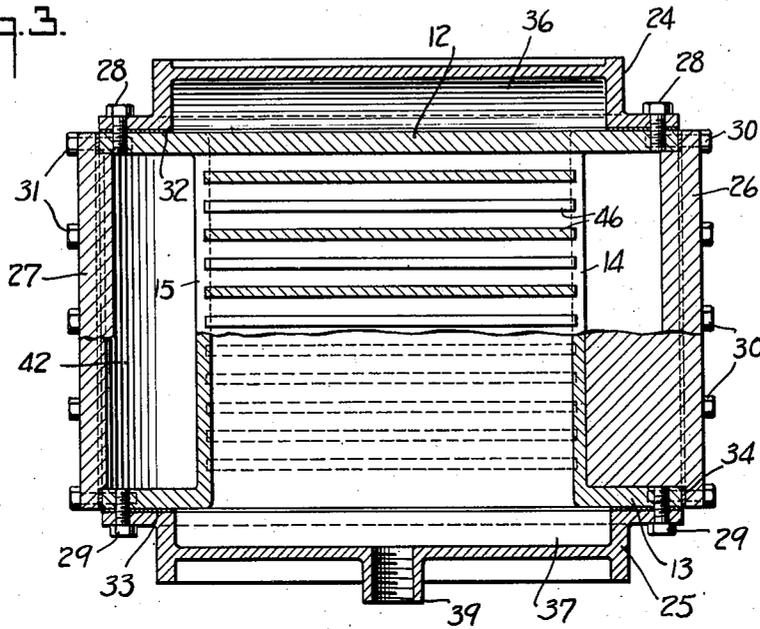


Fig. 4.

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Fig. 5.

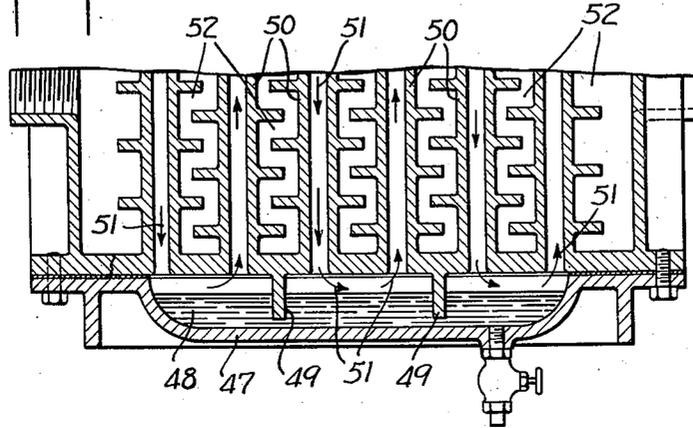
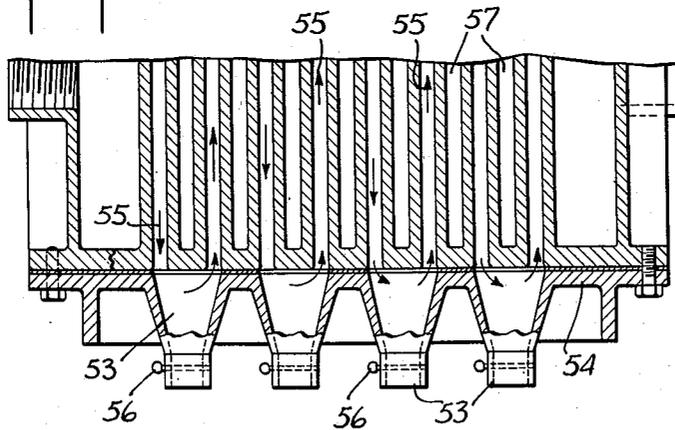


Fig. 6.



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HEAT EXCHANGE APPARATUS

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Application May 14, 1937, Serial No. 142,556

1 Claim. (Cl. 257—245)

Our present invention relates generally to heat-exchange apparatus, and has particular reference to an improved construction.

It is a general object of our invention to provide a heat exchanger of improved structural characteristics, adaptable for use with high efficiency wherever an exchange of heat from one fluid to another is to be effected.

One conventional type of heat-exchange apparatus consists of a group or bundle of tubes, of relatively small diameter, assembled within a shell. One fluid, usually liquid, passes through the tubes, while the other fluid surrounds the tubes and is confined within the shell. This type of apparatus has a number of inherent disadvantages which our present improved heat exchanger obviates. For example, to avoid excessive tube lengths, the bundle is usually divided into several so-called "passes". As a result, the last pass is at a different temperature from the first, and this results in severe strains which, in time, cause tube breakage and tube joint failure. Furthermore, when a heat-exchange apparatus of this type becomes fouled, either from dirt or from precipitation within the passageways, the cleaning procedure requires that the entire bundle of tubes be disconnected and removed from the shell, which is an expensive, time-consuming and cumbersome operation. A further disadvantage lies in the fact that, if leakage develops, one of the fluids becomes contaminated with the other. Not only is it necessary, in order to locate the leak, to remove the entire bundle of tubes and subject them individually to test, but the losses due to spoilage of fluids is considerable.

A heat-exchange apparatus constructed in accordance with our present invention is not beset with any of the foregoing disadvantages. Not only do we avoid the use of multitudinous tubes, but we avoid also any possibility of fluid contamination in case of leakage. Moreover, the present type of heat exchanger is readily cleanable without requiring expensive dismantling procedures.

Of outstanding importance is the fact that our present heat-exchange apparatus may be operated on a pure counterflow principle, with the incoming hot fluid closely adjacent to the outgoing cold fluid. As a result, the maximum rate of heat transfer may be provided for, measured in heat units per hour, per square foot, per degree temperature difference.

On the other hand, if desired, and where conditions require it, the present improved appa-

ratus may be connected to operate on the parallel-flow principle, giving a lower heat transfer constant but a slower rate of temperature change.

Briefly, our present improved structure consists of a substantially rectangular unit comprising a series of flat chambers arranged side-by-side. One set of alternate chambers has closed sides but open tops and bottoms; the intermediate set of chambers has closed tops and bottoms but open sides. Specially constructed closure walls are provided for the top, bottom, and sides of the unit, and these closure walls have return-bend recesses which establish sequential communication between the chambers of each set. As a result, one set of chambers, with its corresponding closure walls, provides an up-and-down sinuous fluid pass; while the other set of chambers, with its closure walls, provides a lateral sinuous fluid pass. One pass thus forms a fluid passageway in the form of a flat ribbon folded upon itself, and the other fluid pass forms a fluid passageway in the form of a second flat ribbon folded upon itself, the sections of the second passageway interweaving, as it were, with the sections of the first passageway, so that the entire unit is filled with the two fluids, these fluids being separated only by the thin walls of the material used.

The closure walls, with their return-bend recesses, may be either permanently or removably mounted with respect to the unit, depending upon requirements. Or, certain of the closure walls may be permanently mounted while the others are removable. Wherever a closure wall is removably secured to the unit, it is capable of removal independently of the other walls, whereby independent access may be had to the chambers which it interconnects.

We achieve the foregoing objects and advantages, and such other objects and advantages as may hereinafter appear or be pointed out, in the manner illustratively exemplified in the accompanying drawings, wherein—

Figure 1 is an elevational cross-sectional view through a heat-exchange apparatus constructed in accordance with our present invention, this view being taken substantially along the line 1—1 of Figure 2;

Figure 2 is a plan cross-sectional view taken substantially along the line 2—2 of Figure 1;

Figure 3 is a cross-sectional view taken substantially along the line 3—3 of Figure 1;

Figure 4 is a fragmentary exploded view, with

parts broken away, of one corner portion of the apparatus;

Figure 5 is a fragmentary elevational cross-sectional view, showing a modification; and

5 Figure 6 is a view similar to Figure 5, showing a further modification.

The parts of the apparatus are preferably made of metal, although any suitable material may be used, depending upon the fluids to be 10 handled and the temperatures involved. Where the parts are made of metal, they may be cast in one piece or in sections, and those parts which are permanently united may be integrated with one another by autogenous welding or otherwise. 15 No claim is made herein for the use of any particular material, nor for any particular mode of manufacture or assembly, and the details of manufacture are, therefore, not referred to herein.

20 Referring now to Figures 1-4, we have illustratively shown an integral or integrated main unit of substantially rectangular shape defined by the end closure walls 10 and 11, the top and bottom walls 12 and 13, and the side walls 14 and 25 15. The end wall 10 is preferably provided with the peripheral flange 16, and the end wall 11 with a similar peripheral flange 17.

Extending transversely across the unit are the spaced parallel walls 18. The spacing of the 30 walls 18 from one another will depend upon requirements. If two similar fluids are to pass through the apparatus, the walls 18 should usually be spaced by equal amounts so that the cross-sectional area of one ribbon-like passage- 35 way is substantially the same as the cross-sectional area of the other. On the other hand, where one fluid is a liquid while the other is a gas, the ribbon-like passageway for the gas might have to be of greater cross-sectional area, 40 in which case the walls 18 would be correspondingly spaced. If a condensing vapor is passing through the apparatus, it would be desirable to have the ribbon-like passageway of progressively narrower cross-sectional area.

45 In the illustrated construction, which is merely an example, we have arranged the walls 18 in such spaced relationship that a series of relatively narrow chambers 19 are alternated with a series of narrow, yet slightly wider, chambers 20.

50 The main rectangular unit thus comprises a series of flat chambers 19 and 20 arranged side by side. In accordance with our invention, the chambers 19 have closed sides (as shown most clearly in Figure 2), but they are open at the 55 top (as indicated by the reference numeral 22). The intermediate chambers 20 are, on the other hand, closed at their tops and bottoms (as indicated most clearly in Figure 1), but they are open at the sides (see reference numerals 23 in Figure 2).

The apparatus is completed by the top closure wall 24, the bottom closure wall 25, and the side closure walls 26 and 27.

In the apparatus herein illustrated, each of 65 these walls happens to be shown as a removable wall mounted independently of the other walls; but, as hereinbefore pointed out, this is not absolutely essential and one or more, or even all, of these closure walls may, depending upon 70 requirements, be secured to the unit in a permanent irremovable manner.

75 Merely by way of example, we have shown the wall 24 secured in position by means of studs or bolts 28 passing through the peripheral flanges 16 and 17. We have shown the bottom wall 25

similarly secured by means of bolts or studs 29, and the side walls 26 and 27 similarly secured by means of bolts or studs 30 and 31, respectively. This manner of removably mounting these walls is, however, in itself also a matter of choice, and 5 any other suitable or desired securing arrangement, such as special quick-opening clamps or devices, may be employed.

In the drawings we have shown the possible use of gaskets 32 and 33, respectively, for the 10 walls 24 and 25, and gaskets 34 and 35, respectively, for the walls 26 and 27. However, in many cases, gaskets are preferably not employed at all, the joint being a pure metal-to-metal abutment, such as a ground joint. 15

In accordance with our invention, the top and bottom walls 24 and 25 (whether removably or permanently mounted) are provided with the return-bend recesses 36 and 37, respectively, which 20 establish sequential communication between the chambers 19. This is illustrated most clearly in Figure 1, and it will be observed that the recesses 36 are staggered with respect to the recesses 37. Thus, the left-hand chamber 19 of Figure 1 is in communication with the adjacent 25 chamber 19 through the first recess 36; this second chamber 19 is in communication with the third chamber 19 by means of the first recess 37; and so on. Accordingly, a sinuous up-and-down fluid pass is provided, this pass being in the 30 form of a relatively flat ribbon doubled back-and-forth upon itself.

Preferably, the inlet and outlet for this fluid pass are provided on the bottom wall 25, but this arrangement is not absolutely essential. We 35 have, for illustrative purposes, shown a fluid inlet 38 and a fluid outlet 39, and the sinuous travel of a fluid is indicated by the arrows designated 40.

Similarly, the side walls 26 and 27 (whether removably or permanently mounted) are provided 40 with return-bend recesses 41 and 42, respectively, these recesses establishing sequential communication between the intermediate chambers 20, as shown most clearly in Figure 2. Again, the recesses 41 are staggered with respect 45 to the recesses 42, so that a lateral sinuous fluid pass is provided in the form of a relatively flat ribbon doubled back-and-forth upon itself. A fluid inlet 43 for this fluid pass is preferably 50 mounted in the end closure wall 10, and a corresponding fluid outlet 44 is mounted in the opposite closure wall 11, the sinuous path of travel of the second fluid being indicated by the arrows designated 45 in Figure 2.

Preferably, at least one set of chambers is 55 provided with ribs 46. We have illustratively shown the wider chambers 20 provided with these ribs, and it will be noted that these ribs project into the chambers 20 from the opposite walls of these chambers, and preferably in 60 staggered relation. It should be noted that these ribs are arranged parallel to the flow of fluid in the chambers 20, and thus these ribs may serve to prevent eddying of the fluid and to guide it more smoothly through the ribbon-like passage- 65 way. If desired, the ribs may be of heat-conductive material to facilitate the exchange of heat from one fluid to the other.

The uses to which the present apparatus may be put will be obvious to those skilled in the art; 70 but, in general, where counterflow is desired, it will be understood that one fluid is caused to pass from the inlet 43, sinuously through the horizontal chambers 20, and ultimately out of the outlet 45; while the second fluid is caused to 75

pass upwardly through the inlet 38, sinuously up-and-down through the chambers 19, and ultimately out of the outlet 39. An almost perfect counterflow is thus provided for, and because of the flat nature of the chambers 19 and 20 an extremely efficient transfer of heat, from one fluid to the other, is effected. The ribs 46 may assist not only in guiding the fluid flow, but also in efficiently transferring the heat from one fluid to the other.

Where parallel-flow is to be effected, one or the other fluid is directed through its passageway in the opposite direction from that described in the preceding paragraph.

Of outstanding importance is the fact that even where the closure walls are removable, leakage, wherever it may develop, will not contaminate either fluid with the other, barring, of course, the unlikely development of an actual break in the walls of the unit 10. For example, if the gasket 32 (or the corresponding metal joint where no gasket is used) were to develop a leak, the fluid passing from the inlet 38 to the outlet 39 would in no event leak into the chambers 20 but would find its way to the outside of the unit 10 through the joint between the closure 24 and the unit 10. Similarly, any other like type of leakage would result, in the worst case, in having one or the other fluid escape to the outside, where it would be immediately discoverable.

In the case of repairing such a leak, the procedure would be extremely simple, and would require the discontinuance of flow of only one of the fluids. The other fluid flow could remain unimpaired and uninterrupted. This highly important advantage is due to the structural arrangement of the parts whereby, for example, the closure wall 24 might be removed and the gasket renewed by merely discontinuing the flow of fluid into the inlet 38, and without disturbing in the least the flow of fluid into the inlet 43.

In a similar manner, an excellent opportunity for cleaning and inspection is always readily obtainable where one or more of the closure walls are removable. If it is desired, for example, to inspect or clean the chambers 20, it is merely necessary to discontinue the flow of fluid into the inlet 43, and to remove the closure walls 26 and 27. The passages 29 are then completely exposed, and the insertion of a perfectly straight brush or similar tool is a relatively simple matter. The inspection and cleaning of the passages 19 is equally feasible by merely removing the closure walls 24 and 25. Even where the closure walls are permanently mounted, access for cleaning or inspection may be easily provided for by simply arranging closable access openings at strategic points, preferably in alignment with the passages to be cleaned or inspected.

The apparatus is extremely compact and lends itself readily to assembly with other similar pieces of apparatus, in groups, either in series, in multiple, or in series-multiple, by use of manifolds.

In Figure 5 we have shown a modification in which the lower closure wall 47 is constructed to accommodate a liquid 48, and in which ribs 49 project downwardly into this liquid at proper points, so that a liquid seal is provided. If desired, the walls 50 may, themselves, be extended downwardly into the liquid to accomplish the same purpose. The path of fluid flow through the up-and-down ribbon-like passageway is indicated by the arrows 51; and it will be understood that the other fluid flows, as hereinbefore de-

scribed, through the lateral ribbon-like passageway 52.

In Figure 6, the construction is modified by constructing the return-bend recesses 53 of the lower closure wall 54 in the form of hoppers, in which solid or liquid particles of matter may collect, as in the case where a gas such as flue gas is caused to pass through the up-and-down ribbon-like passageway, as shown by the arrows 55. Openable doors 56 or the like permit withdrawal of the collected matter when desired. The other fluid, as before, travels through the lateral ribbon-like passageway 57.

The constructions of Figures 5 and 6 illustrate the wide field of possible utility for the present apparatus. For example, it may be used for heating air for combustion, utilizing for this purpose the heat from products of combustion. In such a case, the arrangement of removable closure walls, or suitable access openings, in conjunction with the side-by-side arrangement of flat chambers, permits the surfaces to be kept clean at all times and at the same time provides an improved means for cleaning flue gases or the like, since the velocity of the gases in the downward passes of the up-and-down ribbon would cause the solids or other entrained matter to impinge upon the surface of the liquid seal (or to collect in the hoppers of Figure 6), thus removing them from the gas.

The present apparatus may also find utility in the field of air-conditioning, where, for example, air to be transported into a conditioned room is raised or lowered in temperature, or purified, or humidified.

In the case of a hot-air furnace, the employment of the present apparatus, by providing for a highly efficient transfer of heat, may result in making this type of furnace equal in efficiency to a steam-heating or similar system, a result which is not at present attainable in the present state of the art of making hot-air heaters.

Furthermore, and merely by way of example, the present type of apparatus, with the walls between the passageways made extremely thin, could be used as an economizer for brick kilns and in combination with furnaces of all kinds, such as blast furnaces, open hearth steel furnaces, and the like.

In general, it will be understood that changes in the details, herein described and illustrated for the purpose of explaining the nature of our invention, may be made by those skilled in the art without departing from the spirit and scope of the invention as expressed in the appended claim. It is, therefore, intended that these details be interpreted as illustrative, and not in a limiting sense.

Having thus described our invention, and illustrated its use, what we claim as new and desire to secure by Letters Patent is:

In a heat-exchange apparatus, a substantially rectangular unit formed in one integral piece and comprising a series of flat chambers arranged side by side, one set of alternate chambers having closed tops and bottoms but open sides, the intermediate set of chambers having closed sides but open tops and bottoms, a unitary closure wall for one side of the unit provided with recesses establishing communication between successive pairs of the first-named chambers, a unitary closure wall for the opposite side of the unit provided with recesses also establishing communication between successive pairs of said chambers, the latter recesses being staggered rel-

ative to the first-named recesses, whereby said chambers are connected in succession to define a side-to-side sinuous fluid passage; a unitary closure wall for the top of the unit provided with recesses establishing communication between successive pairs of said intermediate chambers, a bowl-shaped closure wall for the bottom of the unit, a body of liquid in said wall, projections on the unit extending down into said liquid to define liquid-sealed recesses which establish communication between successive pairs of said inter-

mediate chambers, said liquid-sealed recesses being staggered relative to the recesses in the top closure, whereby said intermediate chambers are connected in succession to define an up-and-down sinuous fluid passage; and means for removably mounting each closure wall on said unit independently of the other closure walls, whereby independent access may be had to the chambers of either fluid passage.

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