

July 29, 1941.

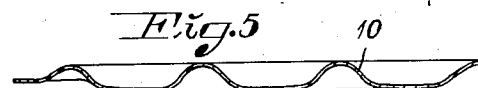
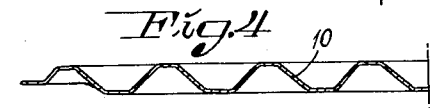
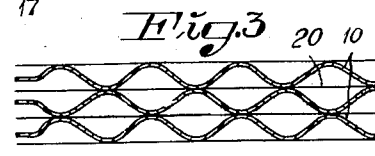
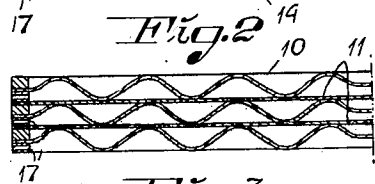
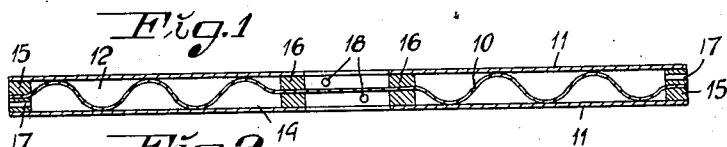
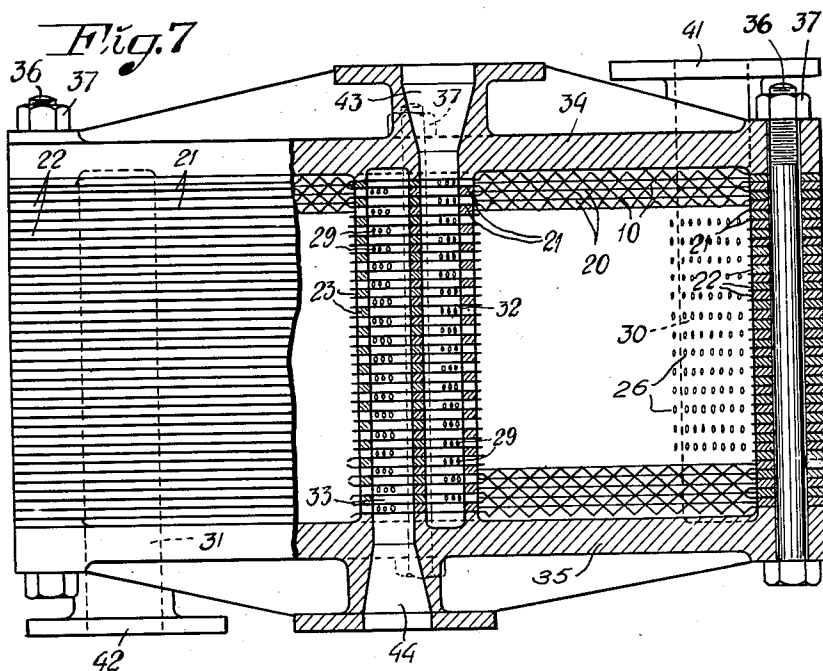
R. A. PERSSON, ET AL

2,251,066

HEAT EXCHANGE APPARATUS

Filed May 19, 1938

2 Sheets-Sheet 1



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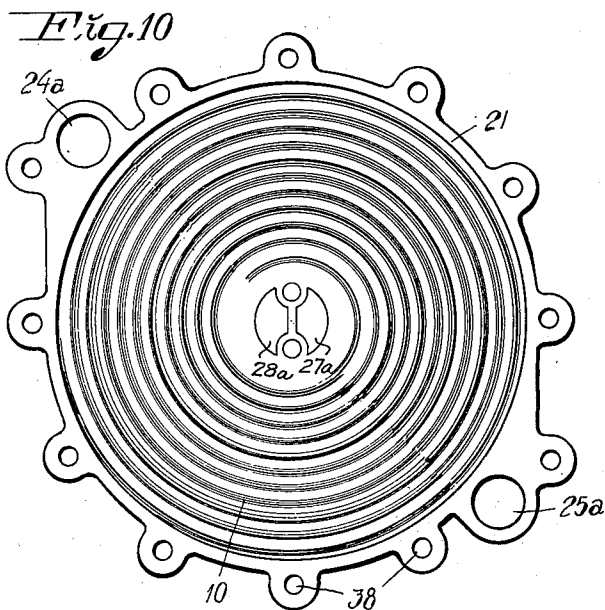
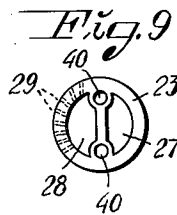
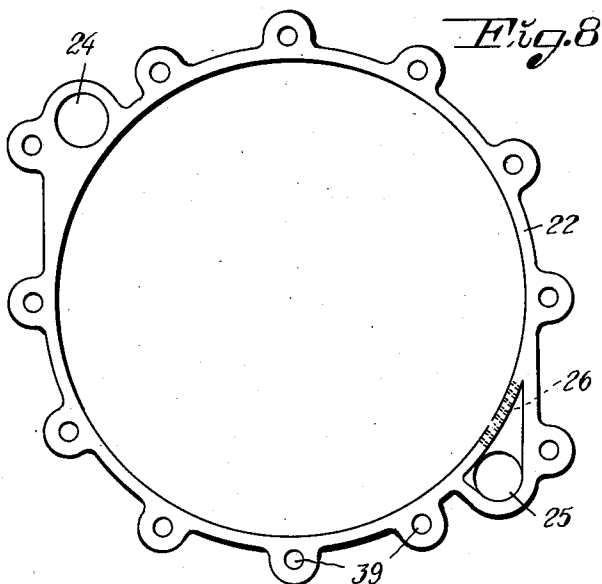
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HEAT EXCHANGE APPARATUS

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HEAT EXCHANGE APPARATUS

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6 Claims. (Cl. 257-245)

The present invention relates to heat exchange apparatus of the recuperative type in which the fluids which are to exchange heat are conducted through spiral channels formed by plates separating the fluids.

Heat exchange apparatus of this type are previously known in which plates provided with spiral grooves are arranged one above the other in such manner that two adjacent plates co-operate to form the spiral channels. In this known apparatus each channel communicates not with the adjacent channel but with that following the latter at the periphery as well as at the centre. Consequently, each fluid flows through every second channel from the periphery to the centre and through every second channel from the centre to the periphery.

In another known heat exchange apparatus the channels are formed by heat insulating plates removably mounted in rigid frames and heat conducting plates arranged close to the former plates and fitting fluid-tightly to the frames, either the insulating plates or the heat conducting plates being formed with spirally proceeding ribs. In this apparatus the fluids flow from the periphery towards the centre, then through a central aperture in the heat insulating plate and therefrom along the other surface of said plate back to the periphery.

The principal object of the invention is to provide a heat exchange apparatus of the class described which is compact and simple in construction, allows an easy assembling and disassembling of the apparatus, has satisfactory fluid-tight joints between the different plates and has good heat efficiency.

Another object of the invention is to provide a heat exchange apparatus of the class described in which the fluids flow from an inlet chamber through a plurality of parallel spiral channels to an outlet chamber, said chambers being provided at the periphery and centre of the plates, respectively. The spiral channels may be formed by a plate having a spiral groove extending from the centre to the periphery and an adjacent plate which may be plane or provided with a similarly shaped spiral groove in which latter case the channels are formed by the co-operation of two spiral grooves.

Still another object of the invention is to provide a heat exchange apparatus of the class described in which the plates are separated from each other by distance pieces provided at the centre and/or at the periphery and in which the

inlet and outlet chambers are formed by coinciding apertures in said distance pieces.

These and further objects will be apparent according as the following description proceeds reference being had to the accompanying drawings illustrating by way of example some embodiments of same.

In the drawings:

Fig. 1 is a diagrammatic sectional view of a heat exchange element of an apparatus according to the invention.

Figs. 2 and 3 are similar views of a number of heat exchange elements arranged according to different embodiments.

Figs. 4, 5 and 6 are fragmentary sectional views of three modified forms of spirally grooved plates capable of assembly in either of the ways indicated in Figs. 2 and 3 to form further embodiments of the heat exchange apparatus of the present invention.

Fig. 7 is a view partly in cross section of a constructional form of a heat exchange apparatus according to the invention embodying an arrangement of plates as shown in Fig. 3.

Figs. 8, 9 and 10 are plan views of a peripheral distance ring, a central distance ring and a spirally grooved plate of said apparatus.

In the following description and claims the terms "spiral groove" and "spiral channel" are used to comprise grooves and channels of not only a continuously spiral course but also of an intermittent or in any other way irregular or discontinuous course equivalent to a real spiral course. The terms also comprise a combined helical and screw course of the grooves and channels, for instance of a shape equivalent to that assumed by a spiral spring when its two ends are drawn apart. Consequently, the plates forming the grooves or channels may be either substantially plane or conical.

With reference to the drawings, reference numeral 10 designates a circular plate provided with a groove proceeding spirally from the periphery to the centre of the plate, and 11 circular grooveless plates arranged on opposite sides of plate 10 and bearing on the top of and the bottom of the crests and troughs of the groove thereof so as to form two spiral channels 12 and 14 extending on both sides of the plate 10 from the periphery to the centre thereof. Distance pieces 15 and 16 are provided between the plates 10 and 11 at the periphery and centre thereof, said pieces having apertures 17, 17 and 18, 18 communicating with the two channels 12 and 14 and serving for the introduction and discharge of the fluids.

According to Fig. 1 the one fluid is introduced, for instance, through the one peripheral aperture 17 and passes through the spiral channel 12 confined by the corrugated plate 10 and the upper plane plate 11, proceeding successively towards the centre and escaping through one of the central apertures 18. The other fluid enters the apparatus through another central aperture 18 and passes through the spiral channel 14 confined by the corrugated plate 10 and the lower plane plate 11 and escapes through another peripheral aperture 17.

The plate 10 may consist of a material of good heat conducting properties such as iron, stainless steel, copper, lead or the like but it is also possible to use a material of inferior heat conducting properties, for instance an artificial composition such as Bakelite, since in comparison with the total resistance to heat transmission the heat conductive power of the material is not very important and since in view of the constructional features of the present apparatus the plates can be made very thin and be assembled by a simple clamping means. Similarly the plates 11 may consist of a heat conducting material or of a heat insulating material such as asbestos, compositions of asbestos and rubber or the like. The spiral groove of the plate 10 may be produced by any known method such as pressing or rolling or the plate may be moulded, for instance by press-moulding.

To provide a heat exchange apparatus of sufficient capacity a plurality of elements according to Fig. 1 are combined as shown in Fig. 2. Here a number of identical corrugated plates 10 are piled the one above the other in unturned relationship so that the crests and the troughs of the plates coincide and plane plates 11 are provided between two adjacent corrugated plates.

When every second of a pile of identical corrugated plates 10 is turned through an angle of 180° in relation to the adjacent plates plane intermediate plates may be omitted. Such an arrangement is shown in Fig. 3. Here the bottom of the troughs of the spiral groove of one plate bears on the top of the crests of the groove of the adjacent plate so as to form a spiral channel 20 which is confined by two corrugated plates 10 and closed in transverse direction by the bearing surface or line between the plates. By arranging the plates in this manner the combined unit becomes more stable and the shape of the channels more suitable from point of view of flow. If in the arrangement shown in Fig. 3 plane intermediate plates are used the angle of displacement of the corrugated plates 10 need not, evidently, be 180° but any other angle may be used, spiral channels closed in transverse direction being formed in any case, but in the case of identical plates 10 no other angle of displacement of the plates than approximately 180° can be used without the aid of intermediate plates 11.

With regard to the shape and size of the grooves of the plates 10 or of the channels formed by said plates with or without the aid of intermediate plates 11 several embodiments may be conceived adapted to the working conditions under which the apparatus is to operate. The top of the crests and the bottom of the troughs may be arc-shaped or otherwise rounded-off as shown in Figs. 1 to 3 or they may be rectilinear as shown in Fig. 4 in order to procure a larger bearing surface between the corrugated plates. On one or both surfaces the cross sectional area of the spiral groove may be equal and constant through-

out the length of the groove as shown in Figs. 1 to 4 but it is also possible to provide the plates with a corrugation forming grooves of different cross sectional areas on opposite surfaces of the plates. Such plates are shown in Figs. 5 and 6.

According to Fig. 5 the cross sectional area of the groove is constant throughout the whole length thereof but is greater on one surface of the plate 10 than on the other. Such plates may be used when the quantity of flow of the one heat exchanging fluid is greater than that of the other, said firstmentioned fluid being thereby conducted through the channel of the greater cross sectional area in order to attain approximately the same speed of the fluids which may be desirable from point of view of good heat exchange.

According to Fig. 6 the groove on the upper surface of the plate 10 has a cross sectional area decreasing continuously from the periphery towards the centre, whereas the cross sectional area of the groove on the lower surface of the plate is approximately constant throughout the whole extension of the plate. It may be observed that when the grooves on one or both surfaces of the plates 10 have varying cross sectional area and no intermediate plane plates are used, the plates 10 cannot be identical but must be shaped in suitable manner so as to secure abutment between the top of the crests of one plate and the bottom of the troughs of the adjacent plate. This form of plates 10 may be used at advantage in such cases where heat is to be exchanged between a gas or vapour such as super-heated steam, and a liquid, the gas being conducted through the channel of gradually decreasing cross sectional area to compensate the decrease in volume due to the temperature fall whereby an at least approximately constant speed of the gas or vapour is attained. When using super-heated vapour as heat delivering fluid which vapour condenses during its passage through the apparatus, the cross sectional area of the grooves of the plates 10 should first decrease in the direction of flow of the vapour in order to compensate the decrease in volume due to the temperature fall of the vapour and that due to the condensation thereof, the cross sectional area of the groove being then constant when conducting solely condensed water. Evidently, the conditions should be reversed, when vapour is to be generated. In case of two liquids of different quantities of flow per unit of time, the liquid of the greater quantity of flow may preferably be conducted from within and outwards. If steam is the one heat exchanging fluid it may be conducted from outside and inwards.

When using solely corrugated plates 10 or when using such plates in combination with plane intermediate plates 11, the plates may be spaced by suitable distance pieces. Said distance pieces may preferably be formed in such manner as to serve simultaneously as packings between the plates. To secure a good tightening packing material may be provided between the distance pieces and the plates, for instance engaging grooves in the distance pieces or the plates securing a good tightening effect when the plates are compressed or clamped together in the manner to be described. Such distance pieces may be provided at the periphery and/or at the centre of the plates.

The heat exchanging apparatus shown in Figs. 7 to 10 comprises solely spirally grooved circular plates 10 of a number adapted to the desired capacity of the apparatus, whereas no intermediate plane plates 11 are used. At their

periphery and centre the plates are formed with plane portions 21, and provided between the plates are peripheral and central distance rings 22 and 23 having substantially plane surfaces bearing on the plane portions 21 of the plates. Each peripheral distance ring 22 is provided with diametrically opposed openings 24 and 25 (see Fig. 8), of which opening 24 has unperforated walls, whereas the wall of opening 25 is provided with lateral holes 26. Corresponding peripheral apertures 24a, 25a are provided in the plates 10 (see Fig. 10). Similarly each central distance ring 23 has two openings 27 and 28 and lateral holes 29 in the wall of the latter opening 28 (see Fig. 9). Corresponding central apertures 27a, 28a are provided in the plates 10.

The plates 10 are piled one above the other separated by the peripheral and central distance rings 22 and 23 in such manner that every second plate 10 as well as every second distance ring 22 and 23 are turned through an angle of 180° in relation to the adjacent plate and distance ring. As described with reference to Fig. 3 the top of the crests of the grooves of one plate 10 will thereby bear on the bottom of the troughs of the grooves of the adjacent plate causing spiral channels 20 to be formed confined by two plates 10 and closed in transverse direction by the bearing surface or line of the plates. Each channel communicates at its periphery by the holes 26 with the opening 25 and at its centre by the holes 29 with the opening 28 and on account of the distance rings 22, 23 being turned through 180° two separate channel systems will be formed each comprising every second channel between the plates and each having a peripheral inlet or outlet chamber 30 and 31 formed by the coinciding openings 24, 25 and 24a, 25a and a central inlet or outlet chamber 32 and 33 formed by the coinciding openings 27 and 28. The pack of plates 10 and distance rings 22 and 23 are kept together between end covers 34, 35 by bolts 36 and nuts 37 passing through coinciding holes 38 in the plates 10, holes 39 and 40 in the distance rings 22 and 23 as well as corresponding holes in the end covers 34, 35. The end covers 34, 35 have peripheral passages 41, 42 coinciding with the peripheral chambers 30, 31 and central passages 43, 44 coinciding with the central chambers 32, 33, said passages serving as inlets and outlets for the fluids. The thickness of the distance rings 22, 23 should be such that, when the pack is clamped together by tightening the bolts 36, a certain compression of the plates 10 is allowed so as to secure good tightening at the bearing surfaces or lines of the plates and to eliminate short-circuiting of the various channels. In order to facilitate said compression of the plates the distance rings 22, 23 may consist of relatively soft material such as hard rubber. In order to increase the fluid-tight fit between the plates, for instance between the crests and bottoms of the corrugated plates, every second plate may consist of a material which is softer than that of the other plates. The harder material may, for instance, consist of stainless steel and the softer one of, for instance, lead.

The operation of the apparatus is as follows: The one heat exchanging fluid is introduced for instance through the peripheral inlet 41 and chamber 30 and passes through the holes 26 in the distance rings 22 into the one channel system flowing in a tortuous path through the spiral channels of said system and out through the central chamber 33 and outlet 44. Another fluid

is introduced for instance through the central inlet 43 and the central chamber 32 and passes through the holes 29 into the second channel system flowing in a similar tortuous path through the helical channels of said second system. In this arrangement the fluids flow in countercurrent to each other through the apparatus, but evidently one may also operate on the parallel flow principle in which case the two fluids are introduced either both through a peripheral inlet 41 or 42 and escape through a central outlet 43, 44 or vice versa.

In the embodiment shown in Figs. 7 to 10, the channels for each of the fluids are all arranged in parallel in relation to the inlet and outlet. Evidently, it is possible to connect the channels in each of the systems in such manner that a group of channels will be connected in series to another group of channels of the system. This may, for instance, be effected by arranging the openings and the holes in the distance rings in a corresponding manner.

In Figs. 7 to 10 the cross sectional area of the grooves is constant throughout their whole length and equal on opposite surfaces of the plates, and no intermediate plane plates are present. It is to be observed, however, that any of the embodiments shown in Figs. 1, 2 and 4 to 6 and any other combination of plates having grooves of varying cross section or of different shape on opposite surfaces of the plates as well as any combination of such plates with intermediate plane plates may be used. It is also possible to combine two or more heat exchange apparatus such as illustrated in Figs. 7 and 8 or apparatus modified in any respect within the scope of the invention, in which case a fluid which in the first apparatus passes from within and outwards in a following apparatus may pass from outside and inwards to compensate the greater resistance against flow from outside and inwards.

Evidently it is also possible to provide two or more spiral grooves in each plate 10, which grooves may communicate with common inlet and outlet chambers provided by the plates 10 themselves or by the distance pieces 22, 23, or said inlet and outlet chambers may form connecting members outside the plates.

What we claim is:

1. Heat exchange apparatus comprising a serial group of plates identical as to form and size and each provided with a spiral groove extending between the periphery and the centre of the plate, alternate plates being turned about their central perpendicular through an angle of 180° in relation to each other, said plates being shaped to form walls for enclosing said grooves so as to form two groups of alternating spiral passages, openings in the central and peripheral portions of said plates, means including identically shaped peripheral and identically shaped central separate distance pieces positioned between adjacent plates disposing said spiral passages into groups of alternating passages, the passages of one of said groups being separated, in radial as well as in axial direction, from the passages of the other group by a single wall, said distance pieces also having openings coinciding with those of said plates to form central and peripheral fluid collecting chambers, and apertures in said distance pieces connecting the passages of each group in parallel between one of said central chambers and one of said peripheral chambers, every other central distance piece being turned about its axis through an angle of 180° in relation to the

adjacent central distance piece and every other peripheral distance piece being turned about its axis through an angle of 180° in relation to the adjacent peripheral distance piece.

2. In heat exchange apparatus, the combination of a series of substantially circular plates of identical shape and size disposed in superimposed relation, each of said plates having spirally arranged corrugations forming channels in both sides thereof extending between the periphery and the central portion of the plate, the lower apex portion of the corrugation in an upper plate abutting the upper apex portion of the corrugation in a lower adjacent plate, each pair of abutting plates forming a spiral passage from the periphery to the central portion of said plates for the conduction of a fluid, a plurality of more than two abutting plates forming groups of alternating passages for the conduction of a different heat exchanging medium in each group, a first fluid collecting chamber at the periphery and a second fluid collecting chamber at the central portion of said series of plates, said chambers communicating with all passages of one of said groups, a third fluid collecting chamber at the periphery and a fourth fluid collecting chamber at the central portion of said series of plates, said third and said fourth chamber communicating with all passages of another of said groups, the passages of one group being separated from the passages of the other group in the axial as well as in the radial direction by a single thickness of said plates.

3. Heat exchange apparatus comprising at least one series of substantially circular plates disposed in co-axial relation, each plate of said series of plates having identically located peripheral

and central openings and having spirally arranged corrugations forming channels in both sides thereof extending between the periphery and the central portion of said plate and communicating with one of said peripheral and one of said central openings, the apices of said corrugations having identical courses in said series of plates, every two consecutive plates of said series of plates being turned about their common central axis to cause the apices of the corrugations of the sides facing each other of said consecutive plates to coincide as viewed parallel to said axis and at the same time to cause said peripheral and said central openings to register with each other.

4. Heat exchange apparatus comprising a series of coaxial corrugated metal plates assembled under compression in contact with one another wherein the material of every alternate plate is soft in relation to that of each adjacent plate.

5. In a plate heat exchange apparatus, a series of coaxial metal plates, at least every second of which is corrugated and made entirely of lead.

6. Heat exchange apparatus as defined in claim 3 including a pair of distance pieces positioned between the peripheral and central portions, respectively, of each two consecutive plates, each of said distance pieces having at least two axial openings therein adapted to coincide with the openings in said plates, all peripheral distance pieces being identical in shape and size and all central distance pieces being identical in shape and size, the openings in each of said distance pieces being symmetrically disposed about the axis thereof.

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