Nov. 4, 1952 A. H. WAKEMAN 2,616,671

PLATE HEAT EXCHANGER

Filed Feb. 16, 1949 2 SHEETS—SHEET 1

Fig. 2.

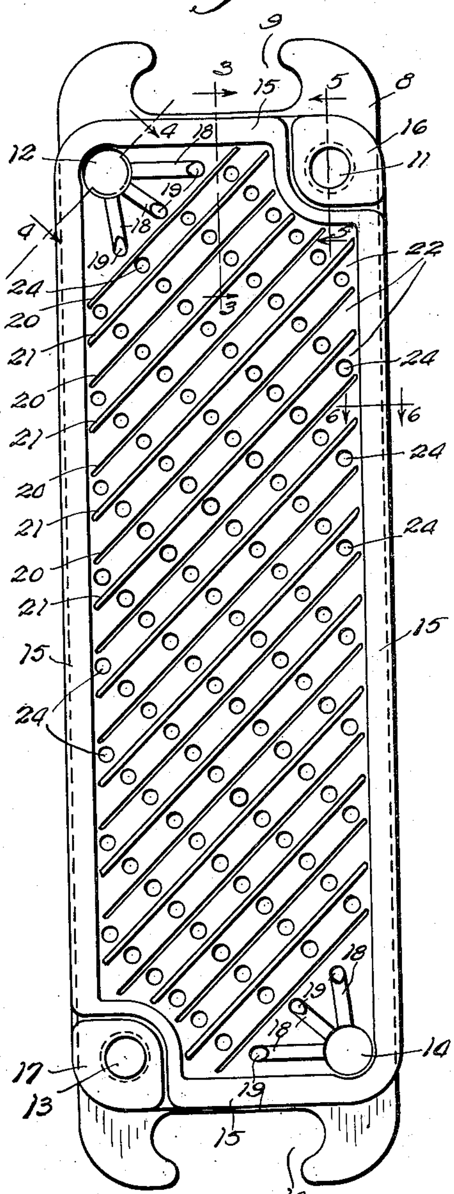


Fig. 1.

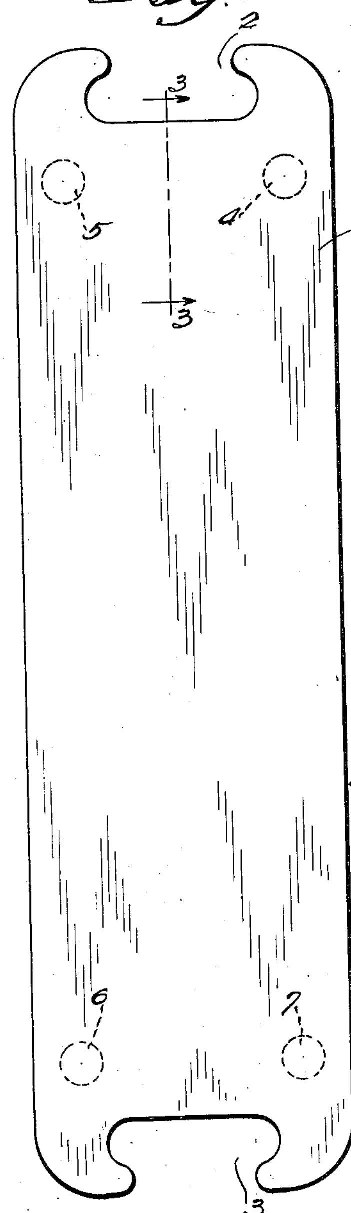


Fig. 3.

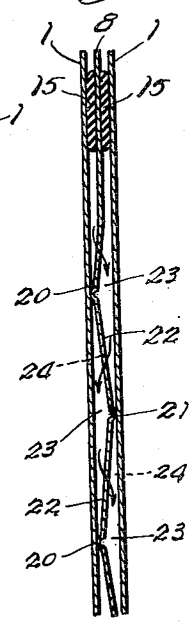
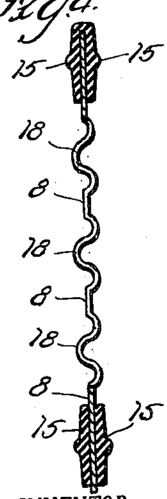


Fig. 4.



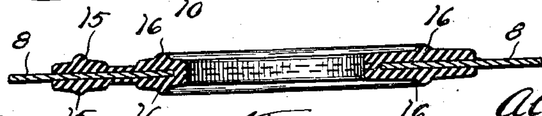


Fig. 5.

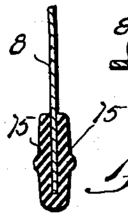


Fig. 6.

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PLATE HEAT EXCHANGER

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2 SHEETS--SHEET 2

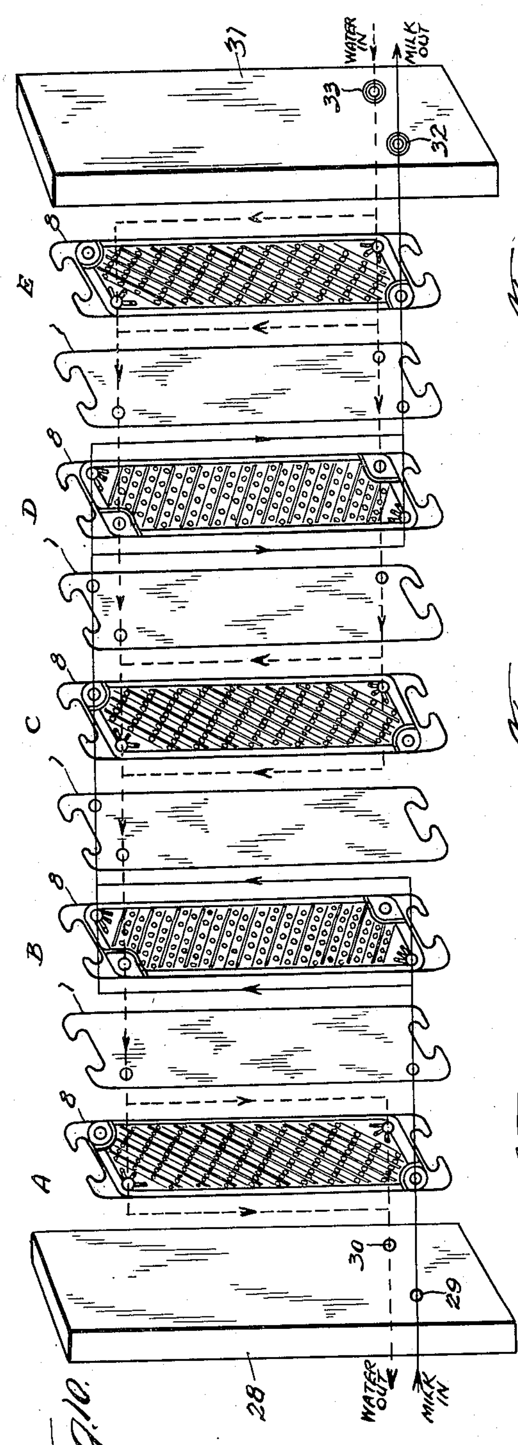

Fig. 10.

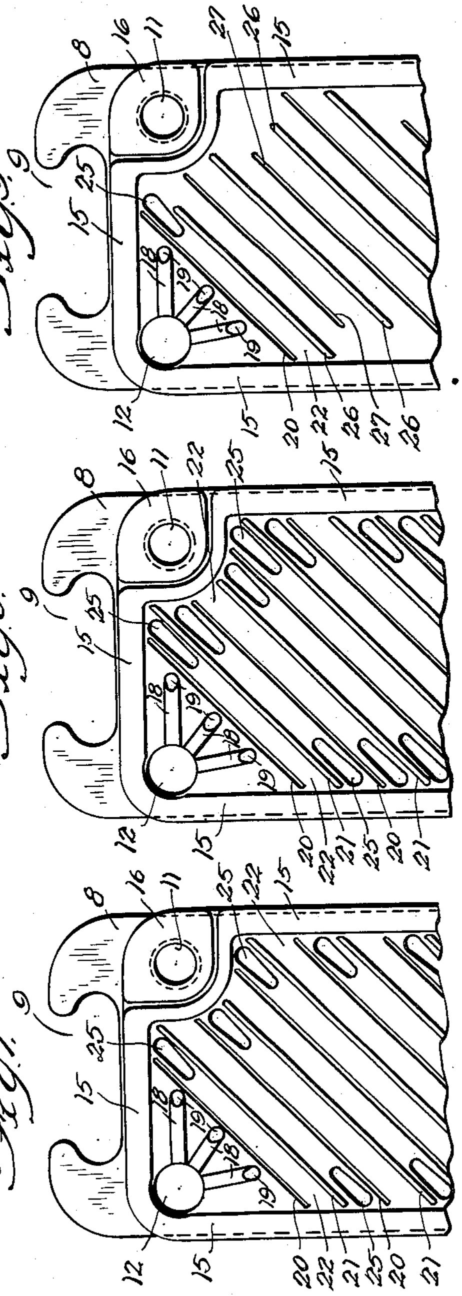

Fig. 7.

Fig. 8.

Fig. 9.

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PLATE HEAT EXCHANGER

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1 Claim. (Cl. 257—245)

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The invention relates to heat exchangers of the type wherein a group of thin metal plates are assembled in face to face spaced arrangement defining thin passages therebetween for the separated flow of two fluids in heat exchange relation, the supporting structure for the plates being adapted for the ready separation of the plates to permit cleaning of the surfaces contacted by the fluids.

An object of the invention is to provide an improved construction in a plate heat exchanger in which the novel form and arrangement of the plates contribute a considerable betterment in heat exchange efficiency and a reduction in cost of maintenance.

The invention employs two series of sheet metal plates arranged in alternate face to face relation. The plates of one series have plane surfaces on both sides and are without gaskets or other attachments. These plates function only as heat exchange plates between the flowing streams of the two fluids of different temperatures. The plates of the other series are positioned alternately between the plates of the first series and serve in part as carrier for the marginal and port enclosing gaskets defining the flow areas between the heat exchange plates. That portion within the marginal gasket of each plate of the second series lies within the stream of fluid flowing between the two adjacent heat exchange plates and does not function as a heat exchange plate. The inner portions of the second series of plates are formed with offset corrugations alternately extending frontwardly and rearwardly of the marginal planes of the plates, the corrugations serving as spacers between the adjacent heat exchange plates.

The inclined sides of the offset corrugations are provided with multiple perforations through which the flowing stream of fluid may pass back and forth from one side to the other of the spacer plate. The corrugations are preferably inclined to the longitudinal axis of the plate, and effect the spreading of the stream of liquid across the flow area between the marginal gaskets. The flow channels defined by the corrugations, and the perforations connecting opposite adjacent channels, together effect a maximum of intermixing and turbulence in the fluid stream with a minimum of pressure drop due to flow resistance. Such turbulence of flow materially increases the efficiency of the transfer of heat between the fluids of different temperatures flowing along opposite surfaces of the respective heat exchange plates.

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A further advantage resides in the fact that the corrugated spacer plates are not subject to temperature differences on opposite sides of the plates and therefore there is no tendency for the precipitation and "baking on" to the plates of solids carried by the fluids flowing over them. Such precipitation is difficult to remove from the depressions formed by the corrugations. In contrast, the heat exchange plates, upon which such precipitation may occur, have flat smooth surfaces throughout which greatly facilitate the scrubbing and removal of such "baked on" precipitation deposits.

Other objects and advantages will be apparent in the following description of a preferred embodiment of the invention adapted to the treatment of edible liquids and illustrated in the accompanying drawings. Referring to the drawings:

Fig. 1 represents a front view of one of the heat exchange plates.

Fig. 2 is a front view of one of the gasket carrying spacer plates with the preferred arrangement of corrugations and perforations.

Fig. 3 is an enlarged cross sectional view of a portion of an assembly of one of the spacer plates between two of the heat exchange plates taken on the plane of the lines **3—3** in Figs. 1 and 2.

Fig. 4 is an enlarged cross sectional view of a corner portion of a spacer plate showing the structure adjacent an open port and taken on the line **4—4** in Fig. 2.

Fig. 5 is an enlarged cross sectional view of a corner portion of a spacer plate showing the structure adjacent a gasketed port and taken on the plane of the line **5—5** in Fig. 2.

Fig. 6 is an enlarged cross sectional view of a marginal portion of a spacer plate and gasket taken on the plane of the line **6—6** in Fig. 2.

Figs. 7, 8 and 9 respectively represent partial front views of spacer plates showing modifications of the arrangement of the corrugations and perforations.

Fig. 10 is a somewhat diagrammatic view of an assembly of plates and supporting headers shown in separated relation and indicating the lines of flow of the liquids.

In fabrication, the heat exchange plates and the spacer plates preferably are blanked from flat sheet metal in identical form. A heat exchange plate, indicated by the numeral **1** in Fig. 1, comprises the blanked plate formed with outwardly constricted endward openings **2** and **3** by which the plate is supported. Port openings **4**, **5**, **6** and **7** are selectively provided in the plate as required by the selected arrangement of liquid flow passages in a heat exchanger of specified capacity.

A gasket carrying spacer plate, indicated at 8 in Fig. 2, is of identical marginal form with the heat exchange plate 1, including endward support openings 9 and 10. Corner port openings 11, 12, 13 and 14 are provided in every spacer plate and are positioned for registry with such of the port openings 4, 5, 6 and 7 as are provided in the adjacent heat exchange plates in an assembled heat exchanger.

The spacer plate 8 is provided with marginal gaskets 15 secured on both sides of the plate 8 in back-to-back registry with each other. The outer lateral portions of the gaskets 15 preferably are joined outwardly of the edges of plate 8 as shown in Fig. 6. The gaskets 15 form a continuous enclosure of the inner surface area of each side of the plate including the diagonally opposite ports 12 and 14, but excluding the ports 11 and 13. The ports 11 and 13 are enclosed respectively by supplemental gaskets 16 and 17 on both sides of the plate and preferably joined inwardly of the metal edges of the port openings as shown in Fig. 5. The gaskets are secured to the plates without grooves in the latter.

Extending inwardly from the port opening 12 are three like radial corrugations 18 formed in the plate 8 and ending in perforations 19. As shown in cross section in Fig. 4, the corrugations 18 extend both sides of the normal plane of the plate 8 and serve as spacer supports for the adjacent surface of the heat exchanger plates when assembled therewith. The corrugations 18 and their terminal perforations 19 also facilitate equal distribution of liquid flow from the port 12 along both sides of the plate 8. Identical corrugations and perforations formed about the port are given like reference numerals.

A series of angularly disposed offset parallel corrugations are formed in the area of the plate 8 enclosed by the gasket 15 and between the ends of the radial corrugations 18 extending from the ports 12 and 14. As appearing in Fig. 2, the angular corrugations comprise alternate rib portions 20 formed in the sheet metal and extending rearwardly of the normal plane of the plate 8, and interposed alternate rib portions 21 extending frontwardly of the normal plane of the plate 8. Intermediate portions 22 of the plate 8 join the spaced parallel rib portions 20 and 21 and present substantially flat alternately inclined surfaces forming wide shallow flow channels 23 (Fig. 3) on both sides of the plate 8. Multiple spaced perforations 24 are provided in each of the intermediate portions 22, the perforations 24 preferably being arranged in cross alinement in angular relation to the rib portions 20 and 21.

Fig. 3 illustrates the positional relation of the spacer plate corrugations to the adjacent heat exchange plates. The ribs 20 and 21 contact the heat exchange plates when the assembled plates are pressed together in operating position, thereby supporting the heat exchanges plates against diaphragmatic movement by the pressure of the flowing liquids. The linear contacts of the ribs with the heat exchange plates also confine the streams of liquid flowing in the shallow channels 23. The perforations 24 permit the passage of liquid from front to back and reverse across the successive channels 23.

Referring to Fig. 2, and considering the port opening 12 as opposite the port of entry 5 for the liquid, the flowing liquid passes on both sides of the corner portion of the plate 8 within the gasket 15 and traversed by the radial corrugations 18, the rearward flow emerging through the perforations 19 to the front side of the first rearwardly extending rib portion 20. The liquid flows over the latter and through the first row of perforations 24 into the first channel 23 rearward of the first frontwardly extending rib portion 21. Thence the liquid flows through the second row of perforations 24 into the second channel 23 frontward of the second rearwardly extending rib portion 20. The liquid flow thus continues progressively downward and to the right through the successive alined perforations 24 to the right hand side portion of the gasket 15 where the flow is diverted downwardly to the left linearly through the channels 23.

Except for the end portions of the plate adjacent the port openings, the several cross alined series of perforations 24 are arranged so that for each series ending at the right hand side of the plate in one of the channels 23, another alined series of perforations begins at the left hand side of the plate in the opposite end of the same channel. Thus the liquid flow which is diverted from the right side of the plate linearly through a channel 23 finds a compensating outlet at the other end of the channel. Slight flow clearance between the ends of the ribs 20 and 21 and the gasket 15 avoids any dead pockets at the ends of the channels 23. The flowing liquid passes over the exit corner portion of the plate 8 and out through the port 7 opposite the port 14.

The spacer plates 8, in assembly with the heat exchange plates 1, provide flow conditions which produce highly efficient heat transfer between the liquids flowing in heat interchange relation. The shallow channels 23 provide thin wide passages along the surfaces of the heat exchange plates through which the liquid flows at high velocity under pressure normal to heat exhangers of this type. The linear flow of liquid through the channels is subjected to multiple interjections of higher velocity cross streams flowing through the series of perforations 24 with the effect of producing high turbulence in the flowing liquid throughout the flow area of the plates. The channels are formed on both sides of the plate 8 in overlapping relation, thus doubling the channel flow capacity over that of one side of an imperforate plate. The series of multiple perforations establish cross flow between the channels on opposite sides of the plate and provide for full utilization of the flow capacity of the space between the adjacent two heat exchange plates without any laminar channeling or short circuiting. The resultant turbulence of flow throughout the flow area of the plates gives a high factor of heat exchange.

A modification of the spacer plate 8 is shown in Fig. 7 which is similar in all respects to the preferred structure shown in Figs. 2 to 6 inclusive except as to the arrangement of the perforations and the resultant flow characteristics. As shown in Fig. 7, the perforations comprise elongated openings or slots 25 positioned at the alternate ends of the successive intermediate portions 22 of the channel forming corrugations. In this arrangement, the liquid entering through the port 12 flows through the uppermost slot 25 into the rearward channel underlying the first forwardly extending rib portion 21, and thence downwardly to the lower end of that channel and through the second slot 25 into the frontward channel overlying the second rearwardly extending rib portion 20. The liquid then flows upwardly through the latter channel to the third slot 25 and therethrough to the next rearward channel. The liquid thus passes back and forth across the plate progressively through the successive channels on both sides of the plate to the exit port. This modification provides a maximum of linear flow in the passage of the liquid from the entry port to the exit port.

Another modification of the spacer plate 8 is shown in Fig. 8 which is similar to the modification shown in Fig. 7 except that the slots 25 as arranged in Fig. 8 produce a reversal of linear flow direction in successive pairs of channels, one frontward channel and one rearward channel, instead of reversing the flow direction in successive single channels as shown in Fig. 7. The arrangement shown in Fig. 8 increases the liquid flow capacity at like pressure over that shown in Fig. 7.

A further modification of the spacer plate 8 is shown in Fig. 9. In this arrangement a slot 25 is provided in the first intermediate portion 22, whereby the flow of liquid from the inlet port 12 is divided and directed over both the front and the rear surfaces of the plate 8. The frontwardly extending rib portions 26 terminate at alternate ends substantially spaced from the gasket 15, thereby providing flat interconnecting flow passages between the successive frontward channels at alternate sides of the plate 8 and causing the liquid to flow right and left through the successive channels over the front surface of the plate 8. Likewise, the rearwardly extending rib portions 27 terminate at alternate ends substantially spaced from the gasket 15, and provide the same right and left flow passage through the successive rearward chanenls over the rear surface of the plate 9. The two surface streams are again merged through a similarly positioned slot 25 (not shown) at the outlet port end of the plate 8.

In illustration of the operating arrangement of the heat exchange plates and the spacer plates assembled in a heat exchanger, Fig. 10 shows in somewhat diagrammatic representation the essential elements in a simple heater or cooler adapted to the treatment of milk or other edible liquid with hot or cold water as the heating or cooling medium. The plates are shown separated in order to indicate the interrelation of the plate surfaces and the flow paths of the two liquids passing thereover in heat interchange relation, it being understood that in actual operation the plates are closely assembled under pressure between two terminal headers.

As shown in Fig. 10, a flat faced terminal header 28 is provided with liquid flow openings 29 and 30 respectively adapted for outward connection with a milk supply pipe and a water discharge pipe (not shown). An opposite flat faced terminal header 31 is similarly provided with liquid flow openings 32 and 33 likewise respectively adapted for outward connection with a milk discharge pipe and a water supply pipe (not shown). The spacer plates 8 and the heat exchange plates 1 are alternately positioned in face to face relation between the two headers 28 and 31 with their corner ports severally in alinement, and with the bottom corner ports in alinement with the header liquid openings 29, 30, 32, and 33.

The similar spacer plates 8 are alternately reversed in their front and rear surface relation to the adjacent heat exchange plates 1, thus crossing the rib portions of the spacer plate corrugations in contact with opposite sides of each heat exchange plate. The alternate reversal of the spacer plates 8 also reverses the lateral position of the gasket enclosed ports 11 and 13 (indicated in Fig. 2), thus providing for the alternating through flow of the respective streams of milk and water for the separated passage of the two liquids over opposite surfaces of the heat exchange plates 1. The port openings 4, 5, 6 and 7 (indicated in Fig. 1), are selectively provided, or omitted, in the several heat exchange plates 1, in such arrangement with the registering ports in the spacer plates 8 as to direct the streams of milk and water upwardly, across and downwardly through their respective alternate passages between the several heat exchange plates.

The several flow passages between the heat exchange plates (endwardly including the terminal headers) are indicated in Fig. 10 by the letters A to E inclusive. The flow path of the milk through the passages and through the plate port openings is diagrammatically indicated by continuous lines with arrows indicating direction of flow. The flow path of the water is similarly indicated by broken lines. The milk stream enters through the opening 29 in the header 28, crosses passage A through the gasketed lower port in the spacer plate in passage A and through the registering port in the first heat exchange plate toward the lower port opening in the spacer plate in passage B, thence flowing upward through passage B, across passage C, downward through passage D, and across passage E to the milk discharge opening 32 in the header 31. The counter flow water stream enters through the opening 33 in header 31 and is divided, one portion flowing upward through passage E and across passage D into passage C while another portion crosses passages E and D and enters the lower end of passage C, thence flowing upwardly through passage C and merging with the first portion, the merged water stream then crossing passage B and flowing downward through passage A to the water discharge opening 30 in the header 28. The respective streams of milk and water flowing through the indicated passages in alternate sequence are in substantially constant heat interchange relation through the heat exchange plates which separate the streams. The marginal gaskets carried by the spacer plates, when compressed between the flat surfaces of the heat exchange plates, define the flow areas in the several passages from the open entry ports to the open exit ports. The corner gaskets enclosing the cross flow ports effect a seal against intermixing of the liquids.

The heat exchange and spaced plates of the present invention are adapted for assembly in a heat exchanger comprising any of the conventional combinations of heating, cooling and regenerating sections, by the use of intermediate headers between sections in accordance with well known practice.

I claim as my invention:

In a plate heat exchanger, a series of sheet metal heat exchange plates having plane surfaces an arranged in parallel face to face spaced relation forming a series of fluid flow passages between the surfaces of adjacent plates, each of said heat exchange plates having port openings for the inflow and outflow of fluid to and from said flow passages, the port openings to alternate flow passages being serially interconnected to provide for the separated flow through said passages of two streams of fluid in heat interchange relation by conduction through said heat exchange plates, and a series of sheet metal spacer plates having like dimensions with said heat exchange plates and interposed therebetween within said flow passages, the marginal portions of said spacer plates having plane surfaces spaced equally from the surfaces of the adjacent heat exchange plates and having port openings in register with the port openings in the adjacent heat exchange plates, each of said spacer plates having a series of parallel spaced corrugations formed in its central portion inwardly of its plane marginal portion and arranged transversely of the flow passage between said inflow and outflow port openings, said corrugations being offset alternately into opposite contact with the surfaces of the adjacent heat exchange plates and thereby defining a succession of oppositely overlapping shallow flow channels underlying said corrugations along the surfaces of the adjacent heat exchange plates, each of the intermediate portions of the spacer plate between said corrugations having a plurality of spaced perforations successively interconnecting said flow channels whereby a fluid flowing through said flow passage is subjected to a tortuous course repeatedly

changing from one surface to the other of said spacer plate in alternating contact with the adjacent heat exchange plates, each of said spacer plates having a continuous gasket secured on each side of its plane marginal portion, said gaskets normally having sealing contact with the adjacent heat exchange plates and defining the lateral boundary of said flow passage and communicating port openings, said spacer plates having other gaskets sealing the cross connecting ports between adjacent alternate flow passages

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
Re. 20,139	Pick	Oct. 20, 1936
1,313,730	Pease	Aug. 19, 1919
1,458,128	Curran	June 12, 1923
2,221,937	Astle	Nov. 19, 1940
2,314,966	Astle	Mar. 30, 1930

FOREIGN PATENTS

Number	Country	Date
505,698	Great Britain	May 16, 1939