June 14, 1966 C. F. ROSENBLAD 3,255,816

PLATE TYPE HEAT EXCHANGER

Filed Jan. 2, 1962 3 Sheets-Sheet 1

Fig. 1.

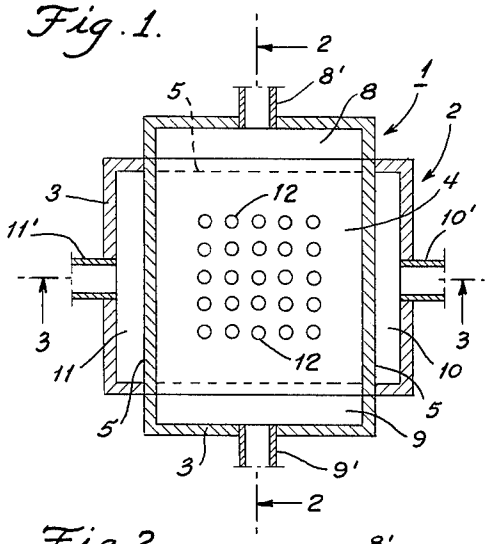


Fig. 10.

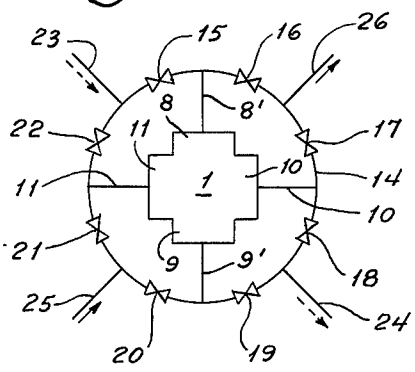


Fig. 2.

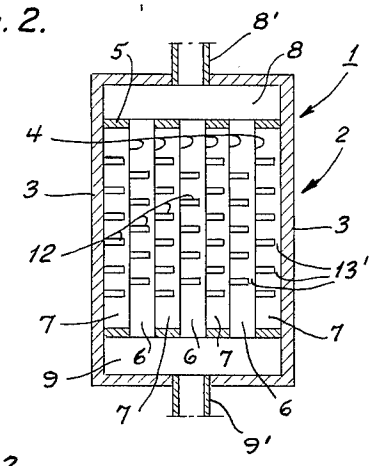


Fig. 4.

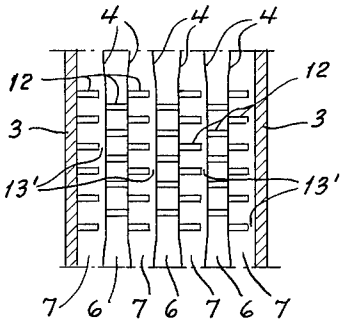


Fig. 3.

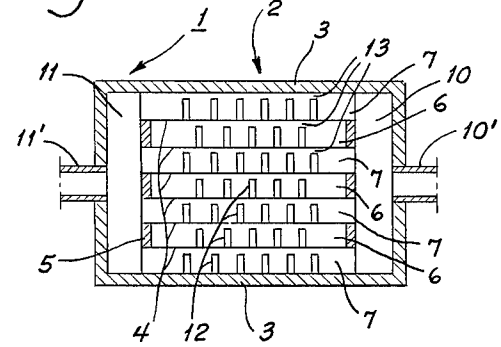
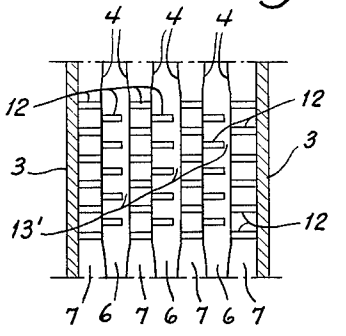


Fig. 5.



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Fig. 6.

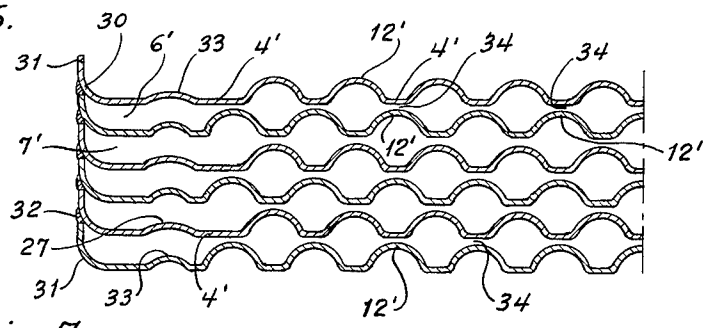


Fig. 7.

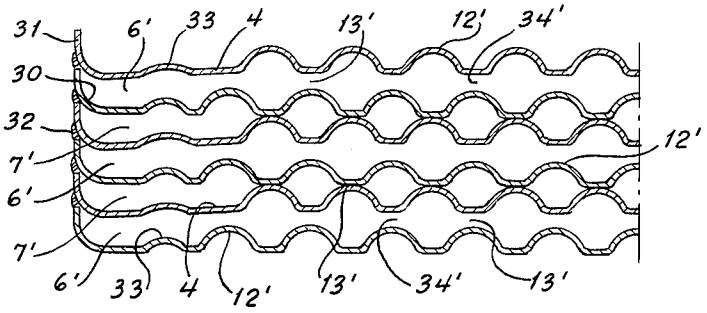


Fig. 8.

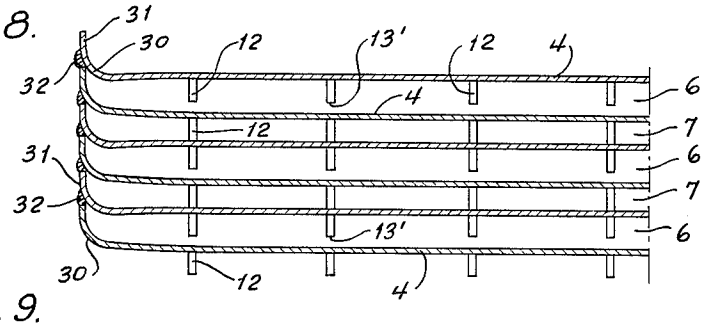
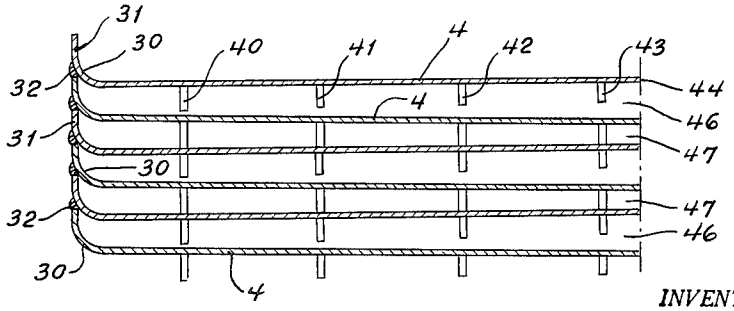


Fig. 9.



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PLATE TYPE HEAT EXCHANGER

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Fig. 11.

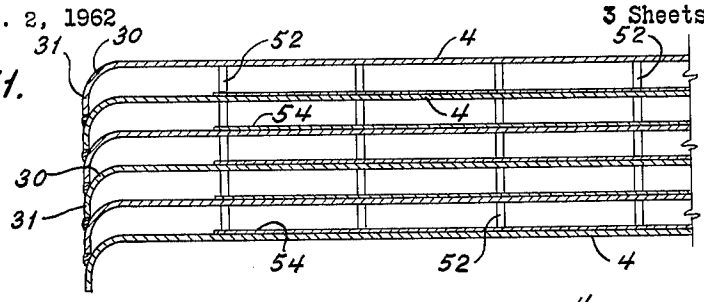


Fig. 12.

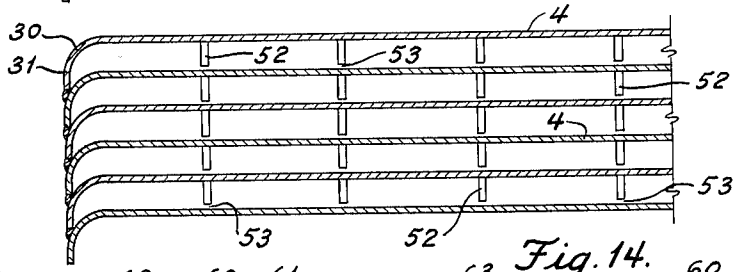


Fig. 13.

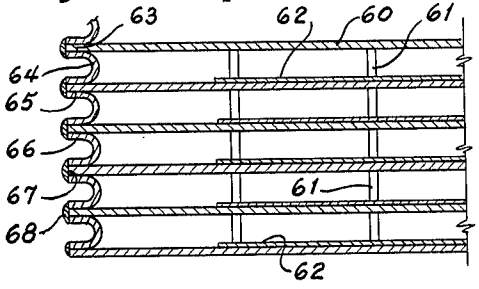


Fig. 14.

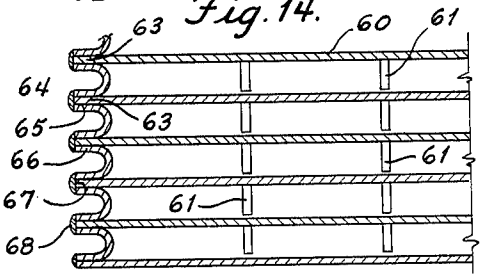


Fig. 15.

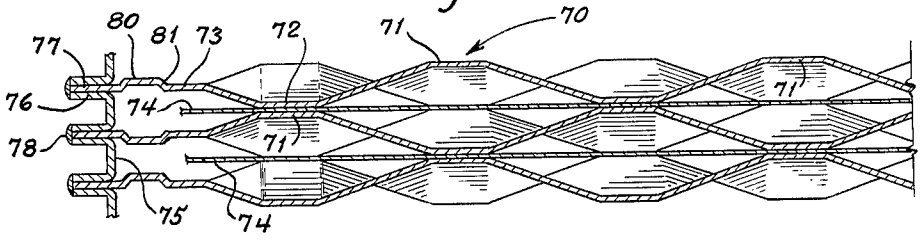
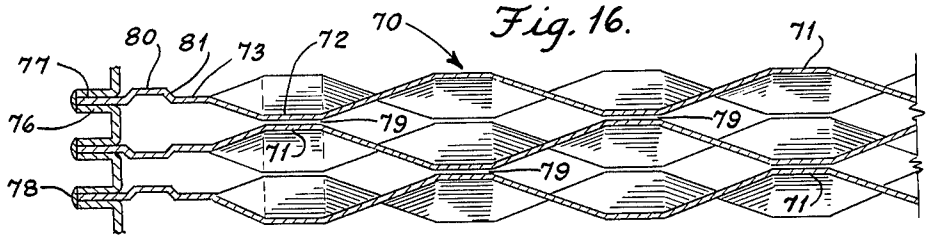


Fig. 16.



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United States Patent Office 3,255,816 Patented June 14, 1966

3,255,816

PLATE TYPE HEAT EXCHANGER

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Filed Jan. 2, 1962, Ser. No. 165,712
5 Claims. (Cl. 165—166)

This invention relates to heat exchange systems involving plate type heat exchangers wherein a package is made up of a multiplicity of spaced heat transmission plates with alternate passages for different heat exchange media therebetween. It also relates to structures for mounting light weight plates in assembled spaced relationship and to methods for protecting the assembled plates from damage during shipping and handling. The invention is also particularly concerned with the provision of controlled deflection of certain of such plates in response to pressure differential between the alternate passages.

This application is a continuation-in-part of my application Serial No. 15,321, filed Mar. 16, 1960, now abandoned, entitled Heat Exchange Systems.

In plate type heat exchangers the plates are commonly spaced apart at their marginal edges either by some means such as strips formed by the upturning of said edges, or separate elements inserted between the plates adjacent the edges. It is also known to space the plates apart throughout their areas by elements known as field spacers distributed in spaced relation over the surfaces. These act to prevent the plates from deflecting, though subject to difference in pressure between their alternate passages. These field spacers commonly consist of protrusions in the form of ridges or bosses, wide at their bases and narrow or rounded at their tops, which protrusions are pressed out of at least one of the plates bordering the passage so as to engage the opposite plate forming each such passage and thereby maintain the desired spaced relationship between all the plates in the package.

The provision of field spacers as just described though advantageous for some purposes at the same time introduce considerable disadvantages. When a heat exchanger so formed is employed for the treatment of fluids containing solid impurities, particularly those of fibrous nature, the impurities collect and stick in and about the contact points when such spacers engage adjacent plates. Such deposits are difficult to remove and the initial or primary ones serve to trap others with the result that a mass of deposits is built up between the plates.

The instant invention is concerned, among other things, with maintaining the advantages of field spacers in plate type heat exchangers while, at the same time, reducing the likelihood of deposits being built up thereat and facilitating the removal of such deposits that develop. Thus the operation of plate type heat exchangers is facilitated.

Generally speaking the invention provides for the field spacers in at least one of the sets of passages between the plates being shaped, or extended, in a manner to allow a certain amount of deflection of adjacent plates toward each other while restricting such deflection to a predetermined extent. Conversely alternate pairs of the plates in response to over pressure provided by the system will deflect away from each other, thereby providing gaps between the field spacers of one plate and the wall of the opposite plate large enough to permit any deposits that have formed to be washed away by fluid passing by. The invention provides various arrangements and constructions of field spacers for achieving its result. It also provides for plates of uniform flexibility, or for alternate sets of flexible plates opposed to relatively rigid plates.

For economy of construction as well as operation it is desirable to make the plates as thin as reasonably possible. This is particularly so having regard to the expensive anti corrosive alloys commonly employed for making them. Thinning down on the material increases the difficulty of making a tight seal around the plate peripheries as well as establishing and maintaining the desired spaced relationship of the plates adjacent their peripheries. Also the necessity arises for protecting the plates against distortion, thus disturbing the desired spaced relationship of them while they are being shipped and handled prior to operating installation. The invention provides solutions for these problems in novel edge spacing and securing arrangements and in methods for protecting the plates against distortion after they are assembled and until the stack of them is ready to be put to use.

It is, accordingly, an object of the invention to improve upon plate type heat exchangers employing field spacers.

Another object is to reduce the likelihood of the build up of deposits in such plate type heat exchangers.

Another object is to provide for the periodic flushing out of deposits built up in the passages of such heat exchangers.

Still another object is to provide effective edge sealing of the plates in a plate heat exchanger.

Still another object is to provide effective edge spacing of the plates in conjunction with such edge sealing.

A further object is to provide methods for protecting the plates in a stack against distortion until the stack is ready to be put into operation.

A further object is to provide for retaining substantial advantages of plate type heat exchangers including field spacers while eliminating the disadvantages thereof.

Further and more detailed objects will be partly obvious and partly be pointed out as the description of the invention taken in conjunction with the accompanying drawing proceeds.

In that drawing:

FIG. 1 is a vertical section of a heat exchanger in accordance with the system of the invention.

FIG. 2 is a section on lines 2—2 of FIG. 1 and looking in the direction of the arrows.

FIG. 3 is a section on line 3—3 of FIG. 1 and looking in the direction of the arrows.

FIG. 4 is an enlarged fragmentary view of the plate assembly of FIG. 2 showing one condition of the plates resulting in a pressure differential between alternate passages.

FIG. 5 is a view similar to FIG. 4 showing the pressure differential reversed as between passages.

FIG. 6 is an enlarged fragmentary transverse sectional view through an alternate form of plate assembly in accordance with the invention showing the plates in relaxed state, or subjected to uniform pressure.

FIG. 7 is a similar view showing the condition of the plates with a pressure differential between the passages.

FIG. 8 is an enlarged transverse sectional view of an assembly of plates in accordance with the showing of FIGS. 1–5 and employing spacer studs of uniform extent throughout and with a pressure differential between alternate passages.

FIG. 9 is an enlarged transverse sectional view of an assembly of plates in accordance with a modified construction, the assembly employing spacer studs which diminish in height from the border of the plates toward the center thereof, the assembly being shown with a pressure differential between alternate passages formed by the plates.

FIG. 10 is a diagrammatic view of a system in accordance with the invention wherein channel switching is provided for the heat exchanger as in FIG. 1.

FIG. 11 is a view similar to FIGS. 8 and 9 but in reverse and showing the inclusion of protective spacer sheets.

FIG. 12 is a similar view of the construction just as the spacer sheets have been removed.

FIG. 13 is a view similar to FIG. 11 but showing a different form of edge spacing and sealing.

FIG. 14 is a similar view with the spacer sheets removed, and

FIGS. 15 and 16 are views respectively similar to FIGS. 13 and 14 but showing plates of modified construction including a wave formation around the peripheries of the plates to enhance the flexibility.

In the description to follow like parts will be indicated throughout by the same reference numerals.

The heat exchanger, generally shown at 1 in FIGS. 1–3, comprises a casing 2 formed with side walls 3 and enclosing therewithin a package of heat exchange plates 4, here shown as square in outline. Though this shape is a desirable one, the invention is not necessarily limited thereto.

The plates 4 as here shown are of thin sheet metal normally flat and arranged in spaced face to face relationship. The spacing of one pair of opposed plates is effected along opposite marginal horizontal edges by a pair of spacer strips 5, while the next pair of opposed plates are similarly spaced by similar strips 5 extending along their opposite marginal vertical edges. This arrangement continues alternately throughout the package so that the set of spaces, or passages, 6 open along their opposed horizontal edges are alternately interspersed with spaces, or passages, 7 open along their opposed vertical edges. The passages 6 are in communication with the chambers 8 and 9 which in turn are in communication with the pipes 8′ and 9′. The passages 7 are in communication with the chambers 10 and 11 respectively in communication with the pipes 10′ and 11′.

As will be apparent to those skilled in the art, the structure just described provides for a cross-current, or cross-flow indirect heat exchanger where one fluid passes through the pipe 8′, chamber 8, passages 6, chamber 9, and pipe 9′, while the other fluid passes through pipe 10′, chamber 10, passages 7, chamber 11, and pipe 11′. The next thing to note in this construction is that uniform field spacers 12 are provided on one side of each plate in a uniform pattern. These field spacers 12, as there shown, are illustrated as pins welded to their respective plates and extending directly laterally therefrom.

As distinguished from prior art teachings, however, the field spacers 12 of the invention do not extend all the way to the opposite plate, but stop short of the same leaving uniform gaps 13 between their ends and the adjacent plate. The gap provided is substantial but in the accompanying drawing it has been somewhat exaggerated and increased in size for the purposes of illustration. Actually the length of the pins and, accordingly, the gap at the ends thereof should restrict the deflection of the plates to a predetermined amount, preferably within the range of about .5 mm. to 3 mm. This would be true irrespective of the dimensions of the plate surface.

Referring now to FIGS. 4 and 5, it will be seen that if the pressure in passages 7 is increased sufficiently over that in passages 6 the plates will deflect as here shown, widening passages 7 and correspondingly reducing the width of the passages 6 until the pins in the passages 6 come into contact with the plate opposed to the ends thereof. Correspondingly it will be apparent that the gaps at the ends of the pins in the passages 7 will have increased from the distance indicated at 13 to the distance 13′.

Likewise by reversing the application of pressure through the respective passages, the passages 6 may be widened while the passages 7 are reduced in width. This increases the gaps to the extent as shown at 13′ the same as in FIG. 4. It becomes apparent then that the gaps in both sets of passages 6 and 7 can be increased by the proper exertion of pressure in alternate passages and thus fluid flowing through at the time when the gaps are increased will wash out any solid impurities, or fibrous material trapped by the spacers.

When the fluids flowing are normally at the same pressure, whereby the deflection of the plates will not take place, cleaning out of one or the other of the passages may be effected by introducing a pressure exerting means into the line for temporarily increasing the pressure therein. Such may take the form of a pump or a pressure head provided by gravity on a pressure tank. Then a suitable throttle valve may be employed for regulating the pressure in each of the passages.

When one fluid is supplied at a pressure constantly higher than the other fluid, the cleaning out of the passages in the heat exchanger in accordance with the invention may be effected by periodically interchanging the paths of flow of the heat exchanging fluids through the heat exchanger. This practice is known as "channel switching." A system for carrying out such operation is illustrated in FIG. 10 employing the heat exchanger of FIG. 1. First, a pipe, which may be referred to as a circuit pipe 14, is provided to which all of the pipes 8′, 9′, 10′ and 11′ of the heat exchanger are connected. As here shown those connections are at positions 90° apart on the circumference of the circuit pipe. At either side of these connections the valves are provided in the circuit pipe 14, here shown as numbered from 15–22. Between each pair of valves the inlet and outlet pipes for the system are connected to the circuit pipe. Thus inlet pipe 23 is connected between valves 15 and 22, while the opposite outlet pipe 24 is connected between valves 18 and 19. Inlet pipe 25 is connected between valves 20 and 21 and its opposite outlet pipe 26 is connected between valves 16 and 17. It will be readily apparent from the arrangement set forth that various flow combinations can be produced following this system.

As an illustration, it can be assumed that an aqueous solution of pulp waste liquor containing fiber as the impurity is to be heated to boiling point with steam. The steam must be of higher pressure than the liquor so outward deflection of the plates carrying the steam can be expected along with consequent tendency to trap the fiber from the liquor in the passages through which the liquor flows.

Utilizing the system of FIG. 10 and assuming that during the first period the valves 15, 17, 19 and 21 are open while the remaining valves are shut, and assuming the liquor carrying the fibrous material to be supplied through the pipe 25 while the steam will be supplied through the pipe 23, the liquor from the pipe 25 will thus pass around the circuit pipe 14, through the valve 21, through the pipe 11′, the chamber 11, passages 7, the chamber 10, the pipe 10′, the valve 17 and out through the pipe 26. On the other hand, the steam supplied will flow through the pipe 23, around the circuit pipe 14, through the valve 15, the pipe 8′, the chamber 8, through the passages 6, the chamber 9, the pipe 9′, the valve 19 and out through the pipe 24. Thus the plates will deflect, as seen in FIG. 5, whereby the passages 6 enlarge and the gaps 13 at the ends of the pins 12 will be eliminated, or substantially so, in the passages 7. There will accordingly be a tendency for the impurities, such as fiber, to catch and build up about the pins 12 in the passages 7. Initially they serve as cores and as the flow continues a mass of deposits will build up about those cores so long as the plates remain in the position just indicated. Insofar as passages 7 are concerned, this is what would continuously be the condition in the prior art apparatus where plates are fixed in such position so long as the apparatus is operated.

Utilizing the plate and spacer arrangements of the invention, however, in a system providing channel switching as in FIG. 10, this drawback of the prior art can be readily eliminated. All that is necessary is to interrupt and interchange the flow before any considerable amount of impurities has had time to accumulate in the passages 7. To do this, the start is made by shutting valves 15, 17, 19 and 21 and opening the valves 16, 18, 20 and 22. Thus steam will pass from the pipe 23 to the pipe 24 as before, but instead of passing through the valve 15, it will pass through the valve 22, the pipe 11′, the chamber 11,

passages 7, the chamber 10, and the pipe 10'. From there it will pass around the circuit pipe 14, through the valve 18 and out of the pipe 24. The liquor, on the other hand, will be passed from the pipe 25 to the pipe 26 as before, but this time through the valve 20, the pipe 9', chamber 9, passages 6, chamber 8, pipe 8', around the pile 14, through the valve 16 and out through the pipe 26. Thus complete channel switching is effected.

The deflection of the plates will, accordingly, be reversed so that the passages 7 will be increased, opening the gaps 13 out to the width 13'. Thus the deposits formed from the previous liquor flow will easily be loosened up and be washed away by the steam and its condensate as it passes through the passages 7. The switching can be reversed again as soon as deposits start to build up in the passages 6 and this reversal may be effected periodically to keep the liquor passages free from deposit.

It is to be understood that channel switching per se for ordinary cleaning purposes has been previously practiced. The present invention, however, goes beyond the prior practices, combining channel switching with flexible plates in plate type heat exchangers, where the passages between the plates are obstructed to at least some extent by field spacers which tend to catch and retain particles carried by the fluid. Not only does the channel switching of the invention in combination with the flexible plates enable the channels to be enlarged and thus provide more space for the flow of the impurities, but the moving of the spacers away from the opposed plates also acts to break loose the deposits and cause them to go into the steam.

Plate construction where the field spacers are formed out of the plates themselves by means of protrusions in the form of ridges or bosses, are shown in FIGS. 6 and 7. In FIG. 6 the plates are in the stage where the pressure in alternate channels is uniform, while in FIG. 7 the plates are shown as deflected by providing for the flow of a higher pressure medium through the channel 6' than is the case through the channels 7'.

As will be seen, the edges of the plates are curved around at 30 into aligned straight portions 31 and are welded together at 32 so that the straight portions maintain the same alignment from one to the other.

Another element introduced into this modification is the waved portion 33 which surrounds the marginal edges of the plates adjacent their edges. This portion provides a flexing section to allow for the repeated deflection of the plates without overstraining the metal.

The bosses 12', as seen in FIG. 6, come close to the body portion 4' of the opposed plate, leaving gaps 34 therebetween. The width of these gaps is exaggerated out of scale from the rest of the construction for enhancing the illustration. Actually the gap can be as small as .25 mm. in the state where the pressure in adjacent passages is equal. Here is one instance in accordance with the invention where utilization of sheets of material, interposed between and of the right thickness to fill the gaps between the bosses or pins on one plate and the surface or body portion of the adjacent plate becomes significant. In this instance the sheets are employed to establish and maintain the width of the gaps in the course of assembly of the plates. On completion of the package of assembled plates the sheets of spacer material may be dissolved by passing a solvent thereof through the assembly. However, such sheets may be retained in place until actual working installation of the assembly as will be pointed out more fully hereinafter.

FIG. 7 simulates the same condition as FIG. 5 wherein fluid under pressure is passed through the passageway 6' thereby deflecting the plates bordering that passage and bringing together the other pairs of plates. Thus the spaces 34 are expanded to 34' which again are exaggerated out of scale for the purpose of facilitating the illustration.

The construction shown in FIG. 8 is the same as that of FIGS. 1–5 with the exception of the bordering edge formation around the plates and the joining thereof. The edges here are turned in the same manner as shown in the FIGS. 6 and 7, so the turning carries the same reference characters. The plates 4 again carry the studs 12 and where the plates are deflected apart as in the passages 6, the space 13' opens up between the ends of the studs 12 and the surfaces of the opposed plate 4. Here it is to be noted that the studs 12 are all of the same extent, i.e. they are of uniform height throughout the whole of the plate.

In FIG. 9, however, a somewhat different situation exists. Here the plates 4 carry studs which diminish in height from the border of the plate towards the center thereof. These studs are illustrated at 40, 41, 42, and 43. The center of the plate is indicated at the line 44 and it is to be understood that the height of the studs diminish uniformly all over the plate from the border toward the center. Thus when a medium is introduced into the passage 46 of sufficiently greater pressure than the fluid in the passage 47, the plates are deflected apart to a greater extent from their peripheries at 30 towards the center, with the greatest deflection being at the center 44. Again, the showing here is exaggerated for enhancing the illustration, but instead of having deflection within the range of .5 mm. to 3. mm., as in the previous forms, the range here can start with a deflection of .1 mm. at the circumference and increases up to 5 mm. in the center. The deflection is distributed throughout the plate so that stress caused by large deformation at the circumference is protected against.

In the situation where a plate package is made up of a very large number of plates and thus provides a very large number of passages, it might well happen that the pressure within each set of passages becomes unevenly distributed to the individual passages to such a degree as to cause uneven deflection of the plates. Carrying this to the extreme, there is the theoretical possibility that with very flexible plates 4 one of the higher pressure passages will open to such an extent as to close the spacer gaps in all other passages in both sets. In situations where such a contingency may arise, it can be guarded against by the substitution of a relatively stiff plate for one, or more, of the flexible plates. Thus the package will be divided into sections between stiffer plates. This will effectively counteract the tendency of the over-pressure in one passage to close all the spacer gaps as above mentioned. It is also contemplated that the provision of initial gaps, such as 13, could be restricted to one, or the other, set of passages, for instance to the passage 6. Then, as these gaps are closed from greater pressure within the passages 7, gaps would be formed in the passages 7 corresponding to the gaps 13 furnished in the passages 6. The preferable situation, however, is where initial gaps are provided in both sets of passages, for in such instance the deflection effected will of course be twice as large.

The assembly shown in FIGS. 11 and 12 is generally similar to that of FIG. 8, though in this instance the assembly is shown in reversed position and with the spacer pins extending from the body 4 of the plates in the same direction as the downturned straight edge portion 31 of the plates, instead of in the opposite direction as in FIG. 8. The spacer pins in this instance are designated by the reference character 52. The body portions 4 of the plates are curved at 30 the same as in the previous forms and the downturned straight portions 31 are welded at 32 to the opposed outer surface of the adjacent plate just where the curve 30 merges into the straight portions 31. Thus the straight portions 31 of the various plates are in alignment. Inasmuch also as the curved portions 30 and the straight downturned portions 31 are the same in each instance, the welding at the same position in each instance effects the desired accurate spacing of the respective plates at

their edges. Accurate as this may be, however, it is also important to assure that uniform gaps, as illustrated at **53** in FIG. 12, will be provided throughout the assembly between the ends of the spacer pins **12** and the opposed faces of the adjacent plates **4**. This is accomplished in accordance with the invention by interposing a sheet **54** between the pin ends and the surface of the opposed plate. By effecting the assembly in the manner shown in FIG. 11, that is with the straight portions **31** turned downwardly, the sheets of spacer material **54** may merely be laid on the upper face of each plate **4**. Then the next plate is positioned thereover with the ends of its pin **52** seated on the sheet of material **54**. This is continued throughout the stack until the complete height of the assembly or package is created, with the welds **32** being made at the appropriate time.

Initially when, as previously pointed out, the sheets **54** serve to establish the proper spacing between the ends of the pins **52** and the opposed surface of the adjacent plate **54** in order to assure that the gap **53** (see FIG. 12) is of the desired extent. As an example, a gap of .5 mm. between each of pins and opposed plate would appear to be adequate. Thus when the gaps in alternate passages are closed up the spaces at the ends of the pins in the remaining passages would be 1 mm.

Besides establishing proper spacing for the initial assembly, the sheets **54** also perform another important function. This is to protect the package of plates when assembled from distortive actions during shipment or in the course of installation of assembly. So long as the sheets **54** are in position throughout the package the plates **4** cannot flex toward or away from each other. The package can, accordingly, be shipped from the manufacturer to the place where it is to be installed and the installation can be effected without any concern about distortion of the plates. This is of particular significance when the economics of making the plates as thin as possible is taken into consideration.

Once the installation is completed and before the assembly is put to use, it is first necessary to dispose of the sheets **54**. This can be done in various ways depending upon the material out of which such sheets are made. If, for instance, the sheets are merely made of paraffin, that can be melted by the application of hot water which is kept flowing until removed.

Another readily water soluble material is polyglycol marketed by the Carbide & Carbon Chemical Corporation under the trade name of "Carbowax." This can be obtained in sheet form or could advantageously be employed as small cup-like member secured over the ends of the spacer pins **52** in a friction fit. Otherwise the sheets may be made of a suitable synthetic plastic material soluble in a chemical fluid not injurious to the metal of the assembly. Such chemical can be run through the assembly in order to dissolve and clean out the sheet material. Once the sheet material is removed, the assembly of plates in the heat exchanger is ready to be put to use as is seen from the showing in FIG. 12. Thus this aspect of the invention provides a novel method for shipping and handling thin plate heat exchangers while protecting the plates from injury.

It, of course, is understood that alternate passages or channels will in the normal operation of heat exchangers be connected with alternate media in known manner as illustrated in FIGS. 1–5 and **10**.

Where the sheets or plates of the heat exchanger are made of thin metal, difficulties arise in the proper spacing of the plates around their periphery and also in the forming of tight pressure proof joints at those peripheries. The forming of the tight joints is a problem because the welding of thin metal without burning any of it away is always difficult. How these factors are taken care of in accordance with the invention is illustrated in FIGS. 13–16 of the accompanying drawing. In FIG. 13 the plates **60** equipped with spacer pins **61**, are shown as having the initial spacing between their principal body portions established by means of a sheet of spacer material **62** within each channel or passage in the same manner as described with respect to the material **54** of FIG. 11. At their perperipheries **63** the plates **60** are assembled at a predetermined distance apart by means of the U-shaped spacer bars **64**. These spacer bars have the U's thereof extending within the space between the plates **60** and have the ends **65** of their straight side portions **66** aligned with the free end edges **67** of the plates **60**. Thus in all positions except those at the opposite ends of the stack there is a straight portion **66** on either side of the edge portion **63** of the plates. Any welding effected here, as illustrated at **68**, thus extends across from the end **65** of one of the U shaped spacers **64** to the end **65** of the next one and includes between those ends the free end edges **67** of the plates **60**. Effective welds may accordingly be made without burning away the material of the plates **60**, thin though it may be. Even though some burning did take place it would be of no consequence, since a tight joint is made by the bridging of the weld **68** from the end of one U-shaped spacer to the end of the adjacent one on the other side of the plate **60**.

By means of end securing as just described, thinner material for the plates **60** than has heretofore been thought possible can now be put to use. In fact, corrosion resistant steel alloy as thin as 0.6 mm. can be employed.

FIG. 14 shows the construction of FIG. 13 with the spacer sheets **62** removed. Here, as in the form of FIGS. 11 and 12, it is merely necessary to make the spacer sheets, or cups over the pin ends, of material soluble either in hot water or some chemical which will not attack the metal of the plates or pins.

A further modification is illustrated in FIGS. 15 and 16. Here the heat exchanger plates **70** are embossed outwardly at **71** and inwardly at **72** with respect to a central plane **73**. The depths of these embossings are such that with the plates properly assembled in a package or stack the downward embossings **72** of one plate **73** and the upward embossings **71** of the adjacent plate, when in relaxed position as seen in FIG. 16, closely approach each other merely leaving the allowable small gap between them for cleaning purposes as previously pointed out. Here, again, a sheet of spacer material **74** is positioned between each pair of plates in the assembly of the same and until they are put to use. Alternately, separated out shaped spacer members with the hole therein closed by a spacer membrane of desired thickness may be mounted over each projection.

In the form of FIGS. 15 and 16, abrupt rectangular edge spacer members generally designated **75** are positioned between the edges of the respective plates, spacer members **75** being of U cross section and having their sides **76** lying parallel to and in engagement with the edge portions **77** of the plates **70**. Tight edge joints are accordingly achieved by welding at **78** to join the free ends of the sides **76** and the free ends of the portions **77**.

The spacer members **75** exactly space the edges of the plates **70** from each other while spacing of the main bodies of the plates is initially achieved as already pointed out by means of the spacer sheet **74**. Again, as shown in FIG. 16, gaps of the desired dimension are left between the embossments of opposed plates once the spacer sheets **74** are dissolved away. Such gaps are shown here at **79**.

Another important feature of the construction of FIGS. 15 and 16 is the formation created by the offset portions **80** in the portions of the plates **70** between their embossed areas and the edges **77** thereof. These wave formations extend along the peripheries of the plates and due to the offset resulting from the short side portions **81**, provide a protection against fracture of the plates at this position due to the flexing. Such flexing may form variations in pressure and the passage of obstructions arising during the course of a single use, as well as the differences re-

sulting from channel switching. By the inclusion of such wave formations for the same purpose as shown at **33** in FIGS. 6 and 7 thinner plates may be used with assurance that they will not fracture due to flexing during the life of the heat exchanger.

An alternative method to that involved in the employment of spacer sheets, such as shown at **54**, **62** and **74**, or separate spacer elements, is the placing of one of the two channel systems, made up of one of the alternate sets of spaces between plates, of the exchanger under gaseous, or other fluid, pressure sufficiently higher than that prevailing in the other channel system to cause the plates bordering said one channel system to flex apart until the spacer members come into contact with opposed plates throughout the stack. The gas under the higher pressure is sealed in to maintain such contact of spacers and plates and to protect such plates against damage until the installation is completed.

Though in the foregoing description and accompanying drawing the invention has been described and illustrated as applied to one particular type of plate-heat exchanger, it is to be understood that such showing and description is for illustrative and not for limiting purposes, but rather is to serve as an example and to provide a clear understanding of the invention. From such it is to be understood that anyone skilled in the art might readily apply the construction of the invention or employ the method thereof for other types of plate heat exchangers.

Speaking more generally, it is to be understood that since certain changes in carrying out the above method and certain modifications in the product which embodies the invention without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. A heat exchange system including a plate heat exchanger formed as a package of a plurality of flexible heat transmission plates of thin sheet metal, said plates, when in relaxed condition having the base portion thereof substantially flat, said plates being arranged in spaced parallel face to face relation providing interspaces therebetween, a first group made up of every other one of said interspaces constituting a passage for one heat exchanging fluid and the remaining interspaces forming a second group constituting a passage for another heat exchanging fluid, means fixedly connecting the marginal edges of the plates together so that such marginal edges are spaced a uniform distance apart, means between each successive pair of said plates providing a set formed of a multitude of spacers, said spacers extending laterally with respect to the plane of the base portion thereof and one set of said spacers being distributed in each of said passages between the plates, said spacers in one of said groups of passages being formed to permit adjacent plates bordering said one of said groups of passages to deflect toward each other under pressures in the other of said groups of passages greater than that in said one group and said spacers being adapted to restrict such deflection to a predetermined amount, said spacers in one of said groups of passages always leaving a space between the free ends thereof and the adjacent opposed plate, said spacers of each of said sets decreasing in height from the periphery of the set toward the center of the set.

2. A heat exchange system as in claim **1**, said group of passages carrying the fluid of higher pressure providing a clear passage for fluids and solid impurities therein between the free ends of said spacers and the surface of the plate opposed thereto.

3. A heat exchange system according to claim **1** in which at least one of said plates in said package is relatively stiff and substantially rigid under such abnormal pressure conditions.

4. A heat exchange system according to claim **1** in which certain of said plates are relatively stiff with respect to others, said stiff plates being separated by at least one flexible plate.

5. A heat exchange system according to claim **1** in which said spacers are pins welded at one end to the surface of said plates and extending laterally with respect thereto.

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