The present invention relates to heat exchangers and more particularly to a heat exchange device of the type wherein heat is transferred from one fluid medium to another and wherein the two fluid media are caused to flow in spiral paths, in their heat exchanging relation, and in the form of their ribbon-like streams.

The heat exchange device comprising the present invention is designed for general use, which is to say that it is capable of a wide variety of uses, either in the form illustrated and described herein, or in a slightly modified form. Heat exchangers constructed in accordance with the principles of the present invention may find application in household and industrial situations as steam water heaters.

The various units are obviously numerous, including heating of laundry water, boiler feed water, or heat treatment of liquid chemicals utilizing steam as the heating medium. Irrespective however of the particular use to which the invention may be put, the essential features thereof are at all times preserved.

According to the present invention, an improved construction is provided whereby the heating medium and the heated medium, which in most instances will preferably be steam and water respectively, may pass through the device in the form of thin ribbons of fluid which are co-extensive with each other and in close relation so that, by their intimacy, a large proportion of the heat carried by the heating medium will be transferred to the heated medium with the transfer taking place rapidly.

The flow of the heating medium is in a direction counter to the flow of the heated medium so that, in the case of steam and water respectively, the steam inlet and water outlet are adjacent each other and, similarly, the steam outlet and water inlet are adjacent each other.

By such an arrangement, steam which has not had an opportunity to dissipate its heat and which therefore is at its highest temperature will come into heat exchange relation with water which already has assimilated much heat so that the water finally leaving the device will have its temperature raised to a very high degree. Likewise, water which has not yet assimilated any heat and which therefore is relatively cool will come into heat exchange relation with steam which already has dissipated some of its heat but which still is at a high temperature differential.

Since the rate of heat transfer between two bodies in contact with each other or otherwise in heat exchange relation is directly proportional to the temperature differential between the two bodies, the arrangement just described will insure that a high and almost constant temperature differential is maintained between the heating medium and the heated medium throughout the entire length of the co-extensive paths provided for the media.

The improved heat exchange device is generally of cylindrical configuration and the two juxtaposed ribbon-like passages for the heating and the heated media are arranged in co-extensive spiral fashion through the device so that heat-transfer areas are provided, thus contributing toward high efficiency for any given size of heat exchanger. If desired, the spiral passages for the heating and the heated media may be formed by the use of a relatively thin elongated strip of sheet metal provided with marginal and/or intermediate rigidifying ribs; the metal sheet being shaped into spiral form and employed as a partition member between concentrically arranged outer and inner shell members.

The heat exchange device as above described is comprised of a minimum number of separate parts of formed and durable construction and capable of withstanding high internal pressures; one which because of its simplicity of construction may be manufactured at a low cost; one which may readily be assembled or dismantled for purposes of cleaning, inspection or repair; and one which otherwise is well adapted to perform the services required of it. These are further desirable features which have been borne in mind in the production and development of the present invention.

The invention is illustrated in certain preferred embodiments in the accompanying drawings wherein:

Fig. 1 is a sectional view taken substantially centrally and longitudinally through a heat exchange device constructed in accordance with the principles of the present invention;

Fig. 2 is a side elevational view on a reduced scale of an insensible partition member constituting one of the elements of the heat exchange device of Fig. 1;

Fig. 3 is a sectional view taken substantially along the line 3—3 of Fig. 1 in the direction indicated by the arrows;

Fig. 4 is a fragmentary sectional view showing a modified construction;

Fig. 5 is a fragmentary sectional view illustrating a further modification;

Fig. 6 is a face view of a partially formed sheet metal blank made according to the scale of Fig. 2, the construction of the cylindrical portion of the partition member shown in said Fig. 2;

Fig. 7 is a sectional view taken on line 7—7 of Fig. 6;

Fig. 8 is a view similar to Fig. 6, illustrating a partially formed blank used in the construction of the cylindrical portion of the corrugated partition member shown, on a larger scale, in Fig. 4;

Fig. 9 is a sectional view taken on line 9—9 of Fig. 8;

Referring now to the drawings in detail and in particular to Figs. 1, 2, 3, 6 and 7: The heat exchanger of the present invention involves in its general organization three main parts or assemblies, namely an outer shell or casing 10, an inner shell 11 and an intermediate partition member or shell 12, the three shells being arranged in spaced concentric relation and being secured together by respective attachment flanges as will be described in detail presently.

The outer shell or casing 10 is a unitary structure which preferably comprises three main structural parts, namely a cylindrical body part 13, an end cap or closure 14 and a ring member 15 which constitutes the attachment flange whereby the member 10 may be secured to the intermediate partition member 11. The end cap 14 is of cup-shape design and is butt-welded as at 16 at one end of the cylindrical member 13 and provides a closure for this end. The other open end of the part 13 is telescopically received within a central opening 17 of the ring member 15 and is welded thereto as at 18. The part 15 thus constitutes a radial attachment flange for the shell at the open end of the latter. Threaded steam inlet and steam outlet connections in the form of nipples 19 and 20 respectively are provided adjacent the opposite ends of the
shell 18 and, in the assembled device, communicate with steam passages as will be made clear subsequently. The connections 19 and 20 are suitably welded in the respective openings with which they communicate.

The inner shell 11 is comprised of four main parts, namely a cylindrical body part, an inner feed duct 21, a conical closure wall 22 and a closure part 24 in the form of a plate which serves to close one end of the cylindrical part 18 and which extends radially beyond the cylindrical confines of the latter to provide an attachment flange by means of which the inner shell 11 may be secured to the partition member 12. The other end of the inner shell is open. The cylindrical part is secured to the closure part 24 by welding as at 26. Additional details of the inner shell 11 will be set forth presently.

The intermediate partition member 12 consists of three main parts, namely a generally cylindrical part 30, an end closure or cap 31 and a ring member 32 which constitutes a radial attachment flange for the partition member as a whole. The end cap 31 is butt-welded as at 33 to one end of the part 30 and the latter part is welded as at 34 to the ring member 32. The ring member 32 is designed for attachment to the portion 24 of the inner shell 11 and to the ring member 15 of the outer shell 10.

The cylindrical part 30 of the partition member 12 is formed from an elongated strip or blank B of sheet metal such as has been shown in Figs. 6, 7 and 8. In the construction of the part 30, one longitudinal edge 35 of the blank is turned laterally in one direction and the other longitudinal edge 36 thereof is turned laterally in the opposite direction and thereafter the partially formed blank is turned upon itself in the form shown in Fig. 2 so that the edges of adjacent convolutions overlap each other to a slight extent as indicated at 37 in Fig. 1. The blank is pre-cut so that when fashioned into its spiral form as described above, the ends of the tubular member 30 will terminate squarely in respective planes which are perpendicular to the axis of the member 30. It is to be noted that in the vicinity of the laterally turned edge 36, the blank is offset as at 38 (Figs. 1 and 6) so that each convolution of the spirally wound member will constitute a true extension of the adjacent convolution. It will also be noted in this connection that the tapered edge D of the portion of the blank which is welded at 34 is the inner face of the attachment flange 32. The tapered edge C constitutes the portion of the blank which is welded at 33 to the closure cap 31.

The three main parts of the heat exchange device are assembled and nested together in the manner indicated in Fig. 1 with the flange 12 of the outer shell member 10 abutting the flange 32 of the partition member 12 and with the latter flange abutting the portion 24 of the inner shell 11. Anchoring screws 39 serve to secure the flanges 15 and 32 together and similar anchoring screws 40 serve to secure the two flanges 24 and 32. Suitable gaskets 41 may be disposed between the elements 15, 24 and 32.

The transverse width of the laterally turned flange 35 is substantially equal to the radial distance between the cylindrical walls 13 and 30 and the transverse width of the flange 36 is similarly substantially equal to the radial distance between the inner shell 11 and wall 30 so that the cylindrical part of the partition member is centered and supported between the cylindrical walls of the outer and inner shells 10 and 11 respectively.

With the parts 10, 11 and 12 thus assembled, it will be seen that a spiral steam passage 42 exists between the cylindrical walls 13 and 15 and a similar spiral water passage 43 exists between the walls of the shells 11 and 12. These two spiral passages are substantially co-extensive and the outer steam passage 42 communicates with the space 51 existing between the end caps 14 and 31 while the inner water passage 43 communicates with the open end of the inner shell member 11.

The steam inlet connection or nipple 19 communicates with the spiral steam passage 42 at one end thereof while the steam outlet connection 20 communicates with this passage adjacent the other end thereof. Preferably the connections 19 and 20 are disposed on opposite sides of the shell 10 so that when the device is positioned as illustrated in Fig. 1 with the outlet connection 20 facing downwardly, any sludge or mineral deposits that may separate out in the steam passage 42 may be discharged or blown through the steam outlet.

The plate 24 is formed with a threaded opening 45 receiving one end of a water inlet conduit 21. The other end of conduit 21 is provided with a conical element 22 which is slidably fitted within the member 11 so that the members 11 and 21 may expand and contract individually in response to the different temperatures at which they are subjected. In this connection it will be observed that all elements 10, 11, 12 and 21 are secured in fixed relationship only at one end of the structure and therefore may expand and contract individually without imparting stresses to another as a result of such expansion or contraction.

The space 25 contains a body of water which enters through the loose connection between the closure 22 and the member 11. This non-circulating body of water in the space 25, therefore, functions as an insulating body to prevent the incoming water in conduit 21 from cooled hot water at the outlet end of the structure. The plate 24 is also formed with an opening 46 for the reception of an element 47 in a web 48 formed integrally with the ring member 32. The water inlet leads into the inner shell 11 through its closed forward end 24 and the central cylindrical chamber of the inner shell constitutes a pre-heating chamber from which a spiral of a spiral as shown in Fig. 2 so that the edges of adjacent convolutions overlap each other to a slight extent as indicated at 37 in Fig. 1. The blank is pre-cut so that when fashioned into its spiral form as described above, the ends of the tubular member 30 will terminate squarely in respective planes which are perpendicular to the axis of the member 30. It is to be noted that in the vicinity of the laterally turned edge 36, the blank is offset as at 38 (Figs. 1 and 6) so that each convolution of the spirally wound member will constitute a true extension of the adjacent convolution. It will also be noted in this connection that the tapered edge D of the portion of the blank which is welded at 34 is the inner face of the attachment flange 32. The tapered edge C constitutes the portion of the blank which is welded at 33 to the closure cap 31.

The three main parts of the heat exchange device are assembled and nested together in the manner indicated in Fig. 1 with the flange 12 of the outer shell member 10 abutting the flange 32 of the partition member 12 and with the latter flange abutting the portion 24 of the inner shell 11. Anchoring screws 39 serve to secure the flanges 15 and 32 together and similar anchoring screws 40 serve to secure the two flanges 24 and 32. Suitable gaskets 41 may be disposed between the elements 15, 24 and 32.

The transverse width of the laterally turned flange 35 is substantially equal to the radial distance between the cylindrical walls 13 and 30 and the transverse width of the flange 36 is similarly substantially equal to the radial distance between the inner shell 11 and wall 30 so that the cylindrical part of the partition member is centered and supported between the cylindrical walls of the outer and inner shells 10 and 11 respectively.

With the parts 10, 11 and 12 thus assembled, it will be seen that a spiral steam passage 42 exists between the cylindrical walls 13 and 15 and a similar spiral water passage 43 exists between the walls of the shells 11 and 12. These two spiral passages are substantially co-extensive and the outer steam passage 42 communicates with the space 51 existing between the end caps 14 and 31 while the inner water passage 43 communicates with the open end of the inner shell member 11.

The steam inlet connection or nipple 19 communicates with the spiral steam passage 42 at one end thereof while the steam outlet connection 20 communicates with this passage adjacent the other end thereof. Preferably the connections 19 and 20 are disposed on opposite sides of the shell 10 so that when the device is positioned as illustrated in Fig. 1 with the outlet connection 20 facing downwardly, any sludge or mineral deposits that may separate out in the steam passage 42 may be discharged or blown through the steam outlet.
perature differential is maintained between the heating body and the heated body of liquid and this high temperature differential is maintained through the entire length of the spiral passages 42 and 43 to render high heat transfer at any given point in the system.

Referring now to the modification illustrated in Fig. 4, the outer and inner shells of this modified construction are identical with the outer and inner shells of Fig. 1. Therefore, the like parts are designated as having the same reference characters plus an exponent "a." The intermediate partition member 30a is somewhat different in construction than the embodiment shown in Figs. 1, 2 and 3. The sheet metal blank B' (Figs. 8 and 9) employed in the construction member 12a is formed with two pairs of corrugations 60, 61 and 62, 63 which extend lengthwise of the sheet metal blank B'. The corrugations 60 and 62 are pressed outwardly from the plane of one face of the sheet and the corrugations 61, 63 are pressed outwardly from the other side of the sheet metal blank. When the blank B' is wound into spiral form the margin of the sheet adjacent the outer-flanged edge 35a overlaps the offset portion 38a formed along the flanged edge 36a. The corrugations function as additional rigidification for the partition so that the partition will be capable of withstanding relatively high pressures without danger of objectionable distention. The corrugations terminate with tapered ends 64 and preferably stop short of the end portion 65 of the sheet. Consequently when the blank B' is coiled into a spiral to form a cylinder the tapered end portions 65 form ring portions 67 at opposite ends of the partition member 12a, whereby the heating medium and the liquid being heated will pass into the spaces between the several corrugations. The corrugations 61, 63 extend into the passage 42a and provide stiffening ribs which bear against the inner surface of the outer shell 10a. The corrugations 60, 62 extend into the passageway 43a and provide stiffening ribs which seat against the outer cylindrical surface of the inner shell 11a.

The modification shown in Fig. 5 is the same as that shown in Fig. 4 except that the corrugations 68, 69 instead of being arranged in spaced apart groups such as shown at 60, 61 and 62, 63 of Fig. 4 are connected to provide a sinuous configuration extending transversely the major portion of the width of the sheet. The sinuous configuration of the corrugations 68, 69, in addition to providing maximum reinforcement for the partition member to provide an increased heat transfer area for contact with the heating source and the heated media. Inasmuch as the construction of Fig. 5 is distinguished from Fig. 4 only by the form and number of the corrugations 68, 69 the corresponding parts do not require further description.

I claim:

1. A heat exchange device comprising an outer cylindrical casing open at one end and closed at the other, an inner cylindrical shell open at one end and provided with a closure for the other and telescopically received within said casing in spaced relation to the walls thereof to provide a relatively narrow cylindrical space between said shell and said casing, an intermediate thin wall cylindrical partition member open at one end and closed at the other and telescopically received within said outer casing and encompassing said inner shell and with its closed end adjacent the open end of said inner shell and the closed end of the outer shell, the walls of said partition member being spaced from the walls of said outer casing and said inner shell and dividing said relatively narrow cylindrical space into a heating fluid passageway and a heated fluid passageway, a closure flange secured to said partition member and interposed between the open end of the outer casing and the end closure for the inner shell for closing the ends of said passageways adjacent the open end of said outer casing, means defining a heating fluid inlet leading into the heating fluid passageway, means defining an inlet for the heated fluid passageway adjacent one end of the outer casing and defining the outer surface of the outer casing defining an outlet from said heating fluid passageway, and means defining an outlet from said heated fluid passageway.

2. A heat exchange device according to claim 1 characterized in that the partition is composed of portions having overlapped edges and in that the inner surface of the partition member is provided at said overlapped edges with an inwardly projecting reinforcing rib and the outer surface of the partition member is provided at said overlapped edges with an outwardly projecting reinforcing rib.

3. A heat exchange device according to claim 2 characterized in that the outwardly projecting rib engages the inner wall of the outer casing and the inwardly projecting rib engages the outer wall of the inner shell.

4. A heat exchange device according to claim 3 characterized in that the overlapped portions of the partition member constitute a band of helical configuration and in that the outwardly projecting rib and the inwardly projecting rib extend in the same helical direction and define helical ribbon-like paths at opposite sides of said partition, whereby the heating and heated fluids are passed in intimate heat exchange relationship.

5. A heat exchange device according to claim 4 characterized in that the outer surface of the inner shell is provided with a channel defining a branch passageway connecting the heated fluid passage with the heated fluid outlet.

6. In a heat exchange device of the character described having inner and outer tubular shells arranged in nested relation and having concentric cylindrical walls spaced a slight distance from each other and defining therebetween an annular space, a partition member disposed within said annular space and dividing the same into outer and inner fluid passageways arranged in heat exchange relationship, said partition member comprising an elongated strip of sheet metal coiled progressively in spiral fashion about a longitudinal axis with one longitudinal edge region overlapping the opposite longitudinal edge region and with the opposite sides of the strip arranged in the face-to-face contact, the extreme outside overlapping edge region of the strip being turned radially outwardly and the extreme inside overlapping edge region of the strip being turned radially inwardly to provide outer and inner dividing flanges of spiral configuration within said annular space, the combined radial extent of said dividing flanges being substantially equal to the radial width of said annular space whereby the free edges of the flanges will engage the outer and inner surfaces of the inner and outer shells respectively and serve to center the partition member within said annular space.

7. A heat exchange device according to claim 6 characterized in that one of the overlapped edges of the metal strip is offset out of the plane of the strip a distance substantially equal to the thickness of the overlapped edge of the strip.

8. A heat exchange device according to claim 7 characterized by the provision of a plurality of corrugations pressed outwardly from the planes of the opposite sides of the metal strip and extending lengthwise thereof to provide reinforcements extending lengthwise of the strip.

9. A heat exchange device according to claim 8 characterized in that the corrugations assume a spiral configuration when the said strip is wound into said longitudinal axis.

10. A heat exchange device according to claim 9 characterized in that the adjacent corrugations engage the inner wall of the outer casing and the outer wall of the inner shell, respectively.

11. A heat exchange device according to claim 10 characterized in that the said corrugations connect with each other to provide a sinuous configuration in cross-section transversely of the strip.
12. A heat exchange device according to claim 11 characterized in that each end of the said strip is formed with a diagonal edge extending from one longitudinal edge to the other.

13. A heat exchange device as defined in claim 1 characterized by the provision of an inlet duct extending lengthwise within the inner shell through a body of water contained in said inner shell and provided with a closure fixed thereto slidably fitted in the inner shell to retard the outflow of water from said body contained in the inner shell.