Jan. 10, 1956 C. N. ROSWELL 2,730,337

HEAT EXCHANGER

Filed April 13, 1953 3 Sheets-Sheet 1

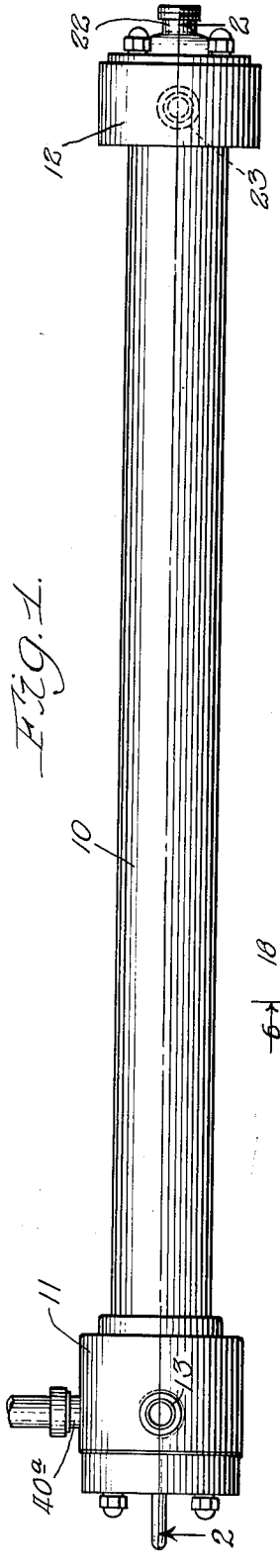


Fig. 1.

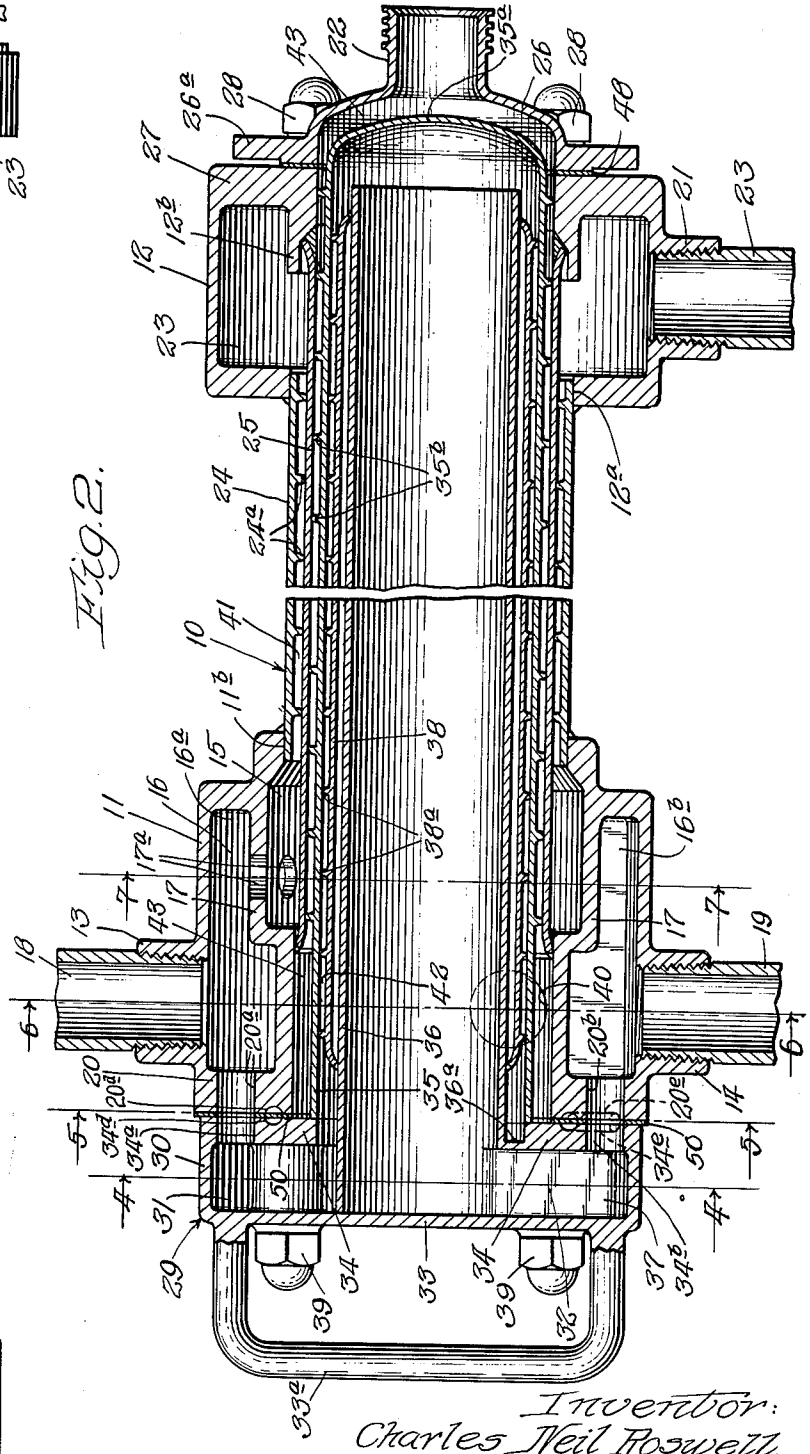


Fig. 2.

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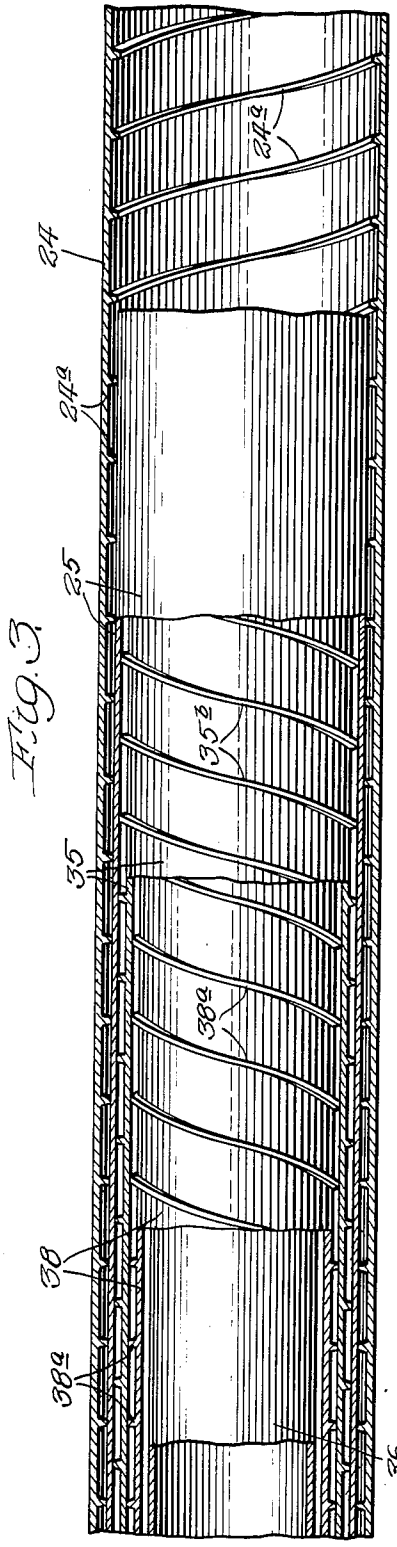


Fig. 3.

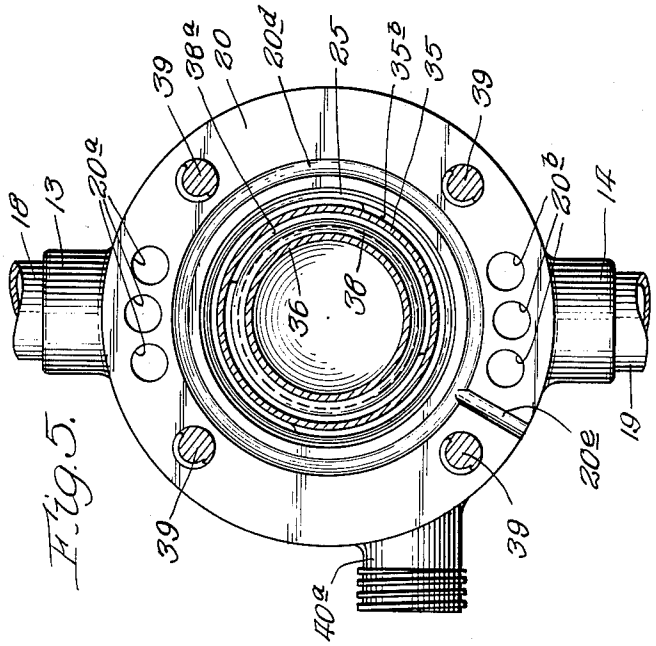


Fig. 5.

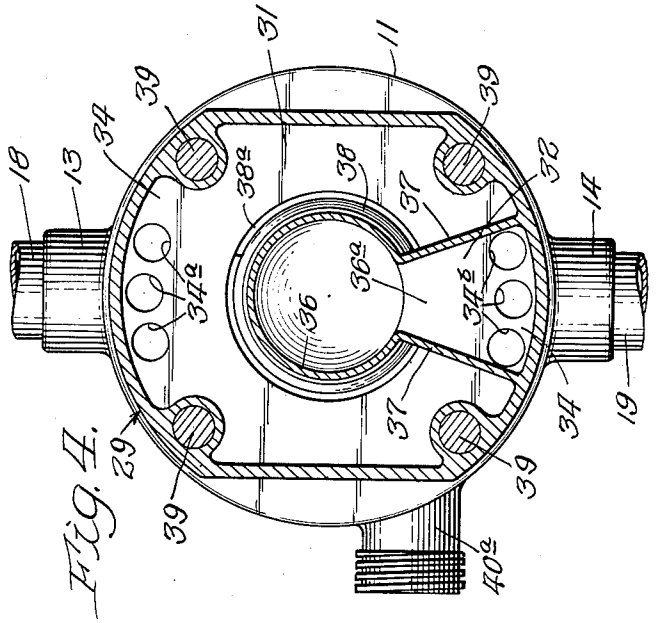


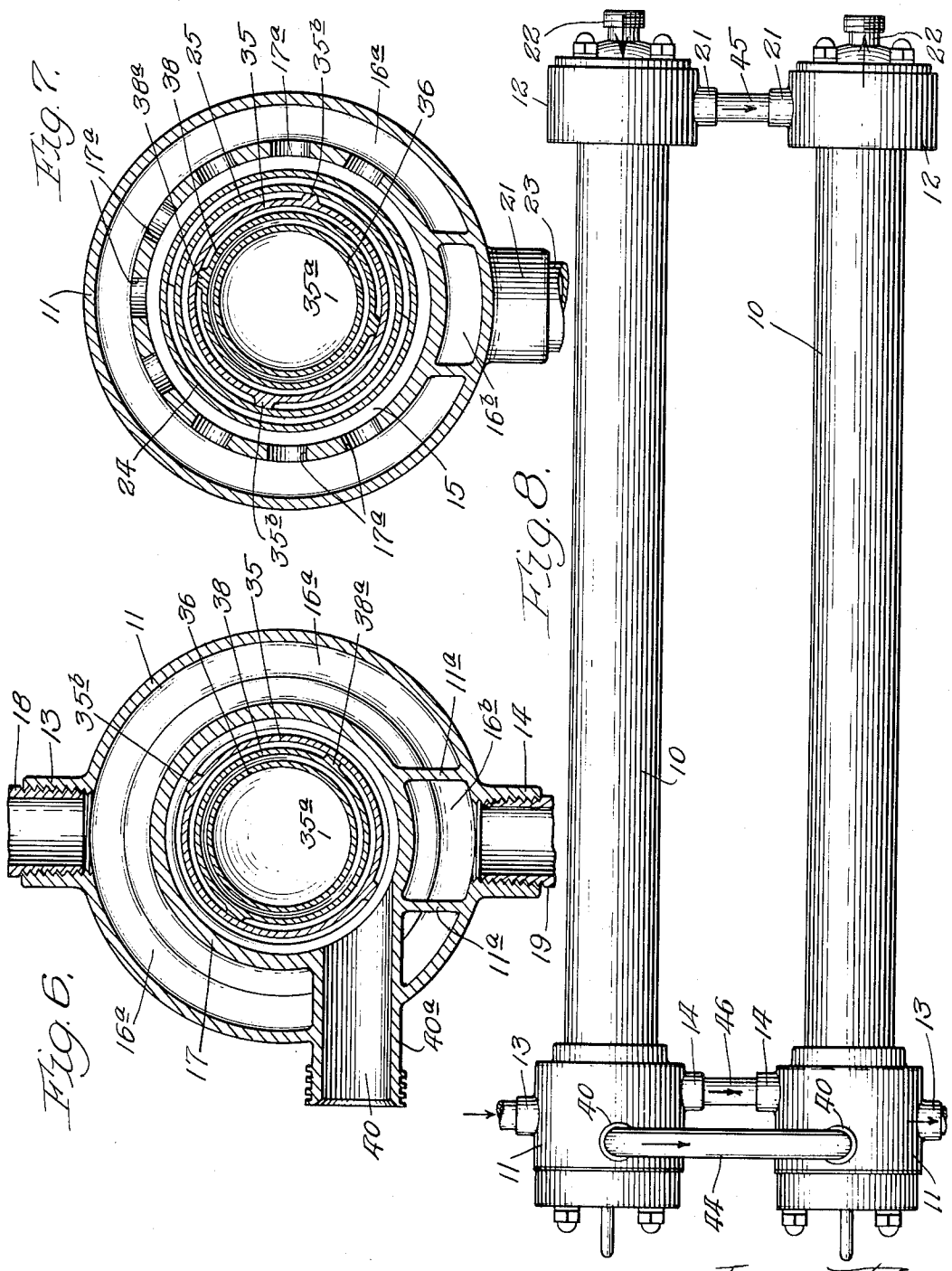
Fig. 4.

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HEAT EXCHANGER

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2,730,337

HEAT EXCHANGER

Charles N. Roswell, Chicago, Ill.

Application April 13, 1953, Serial No. 348,186

14 Claims. (Cl. 257—246)

This invention relates to a heat exchanger of the type adapted continuously to cool or heat a flowing fluid.

In my copending application, Serial No. 167,221, filed June 9, 1950, now abandoned, of which the present application is a continuation-in-part, I have described and claimed a heat exchanger employing an outer casing, a heat exchange medium tube telescopically received into this casing through one end thereof and having the outer surface of the tube spaced from the inner surface of the casing to provide a substantially annular chamber therebetween, releasable attaching means fastening the tube to the casing in a predetermined relative position, the casing including a heat exchange medium port and a product port adjacent to this one end and cooperating wall sections on the casing and on the tube directing the medium from the medium port into the interior of the tube and directing the product from the product port into the chamber.

A heat exchanger of the above type has many advantages over previous types of exchangers. Thus, it is quite compact for its capacity and is so constructed that the telescoping part may be easily withdrawn to expose surfaces contacted by the product for easy cleaning. All these advantages and others are explained in more detail in the above mentioned copending application.

In the present heat exchanger I have invented a device in which the product flows continuously in an annular path and the heat exchange medium, which may be steam when the product is intended to be heated, flows at opposite sides of this annular path and countercurrently thereto. These heat exchangers are quite versatile in that they can be used to heat or cool a product, the product and medium may be introduced from either end and a plurality of exchangers may be interconnected and operated in banks if such is desired. Furthermore the exchanger is relatively simple to construct, is easy to disassemble for cleaning and to reassemble, and has a very high capacity as the product is run through the exchanger in a relatively thin film, at a high rate and preferably in a helical path.

One of the objects of this invention therefore is the provision of a heat exchanger comprising an outer casing having a first heat exchange medium port and a first product port adjacent to one end thereof and a second heat exchange medium port and a second product port adjacent to the other end thereof, a heat exchange medium conduit tube telescopically received into the casing through this one end and having an outer wall of the tube spaced from an inner wall of the casing to provide a substantially annular product chamber, both product ports normally communicating with the chamber to direct a product therethrough, releasable attaching means fastening the tube in the casing in a predetermined position, cooperating wall sections on the casing and tube directing the medium into the tube in a passage along the inner surface of the tube's outer wall and between these medium ports countercurrently to the flow of product in the chamber, and wall sections in the casing directing the medium between the

medium ports in a passage along the outer surface of the casing inner wall countercurrently to the flow of product in the chamber.

Other and more specific objects of the invention will be apparent from the following description of one embodiment of the invention and from the appended claims.

Of the drawings:

Figure 1 is a side elevational view of a heat exchanger embodying the invention.

Figure 2 is a sectional elevation taken substantially along the line 2—2 of Figure 1.

Figure 3 is a fragmentary elevational view, partially broken away for clarity of illustration, showing the midportion of the heat exchanger between the end headers.

Figure 4 is a sectional elevation taken substantially along the line 4—4 of Figure 2.

Figure 5 is a sectional elevation taken substantially along the line 5—5 of Figure 2.

Figure 6 is a sectional elevation taken substantially along the line 6—6 of Figure 2.

Figure 7 is a sectional elevation taken substantially along the line 7—7 of Figure 2.

Figure 8 is a side elevational view illustrating how a pair of the heat exchangers may be interconnected in a bank.

The heat exchanger illustrated in the drawings comprises an outer casing 10 including a first header 11 at one end thereof and a second header 12 at the other end. This first header is provided with a first heat exchange medium port 13 and a second heat exchange medium port 14. The header 11 is divided into a first hollow section 15 and a second hollow section 16 adjacent to each other. The first hollow section describes a chamber while the second hollow section 16 is divided by substantially parallel bottom walls 11*a* into a pair of chambers 16*a* and 16*b*. The chamber 16*a* is connected to the chamber 15 by a series of arcuately arranged holes 17*a* in an annular wall 17 that divides the chamber 15 from the chambers 16*a* and 16*b*. As can be seen in Figure 2 the outer end of this wall 17 has a diameter somewhat less than that of the inner end of this wall.

The chamber 16*a* is operatively connectable to a pipe 18 by means of the port flange 13. This pipe 18 is for conducting heat exchange medium into or out of the exchanger. The chamber 16*b* is connected by means of the port 14 to a pipe 19.

The outer side of the chambers 16*a* and 16*b* are defined by a transverse wall 20. This wall which is annular shaped is provided with upper openings 20*a* leading from the upper portion of chamber 16*a* and lower openings 20*b* leading from lower chamber 16*b*.

The second header 12 at the other end of the casing 10 includes a second heat exchange medium port 21 and the second product port 22. The header 12 is hollow with the hollow portion describing a chamber 23 of annular shape connected through the heat exchange medium port 21 to a pipe 23.

Extending between the headers 11 and 12 is an outer enclosing shell 24 of generally cylindrical shape. This shell 24 has one end attached to the concentric circular openings 12*a* in the header 12 and the other end attached to similar openings 11*b* in the first header 11. As can be seen from Figure 2, the shell 24 has its interior in communication with the chambers 23 and 15.

Located inwardly of the shell 24 and substantially concentric thereto is an inner enclosing shell 25. This shell is spaced from the outer shell 24 and also extends between the headers 11 and 12. This second shell 25 has its ends extending beyond the ends of the outer shell 24. One end of this inner shell is connected to an inwardly extending annular flange 12*b* that defines a portion of the inner wall of the chamber 23. The other end of shell 24 is at-

tached to the annular wall 17 adjacent to the extreme outer end of the chamber 15. With this arrangement the space between the shells 24 and 25 defines a heat exchange medium passage which communicates with heat exchange medium chamber 15 and heat exchange medium chamber 23.

The product port 22 is in the form of a center threaded flange that forms a part of an end cap 26. This end cap 26 is held in place on the outer wall 27 of the header 12 by means of a plurality of spaced bolts 28.

The heat exchanger includes a heat exchange medium conduit tube 29 telescopically received into the casing 10 through the end thereof defined by the header 11. This tube is provided with an outer hollow section 30 of annular shape divided into a first chamber 31 and a second chamber 32. The assembly of these two chambers covers the entire annular section. This annular section is defined by an outer end wall 33 and an inner wall 34. The wall 34 is provided with a plurality of upper openings 34*a* adapted to communicate with the openings 20*a* in the manner illustrated in Figure 2. The lower portion of the wall 34 within the chamber 32 is provided with similar openings 34*b* adapted to communicate with the openings 20*b* also in a manner illustrated in Figure 2.

Extending inwardly from the wall 34 and substantially concentric thereto is a cylinder or outer wall 35 closed at its inner end as illustrated at 35*a*. This inner end is spaced inwardly from the end cap 26 while the cylinder 35 is spaced inwardly from the enclosing shell 25 to provide a product space within the interior of the exchanger.

Positioned inwardly of the cylinder 35 and substantially concentric therewith is an inner shell section 36. This section extends to a point short of the end 35*a* of the cylinder 35 and is open at this inner end. The outer end of the shell section 36 is attached to the end wall 33 of the hollow section 30 except for a bottom portion that is turned down at a flange 36*a*. This flange 36*a* is positioned between the side walls 37 defining the chamber 32 and this portion of the end of section 36 is cut away so that the chamber 32 communicates with the interior of the hollow shell section 36.

In order to insulate the interior of the section 36 there is provided an enclosing closely spaced jacket 38 on the outer surface of the section 36. The space between this jacket and the shell is evacuated so as to create a heat insulating covering for the shell 36. The space between the jacket 38 and the cylinder 35 provides an inner heat exchange medium passage that communicates at one end with the chamber 31 and thus with the chamber 16 and at the opposite end with the interior of the shell 36. Thus, this passage also communicates through the interior of the shell 36 to the chamber 32 and to the chamber 16*b*.

The heat exchange conduit tube 29 which is removable to expose the surfaces contacted by the product, the outer surface of the cylinder 35 and the inner surface of the inner enclosing shell 25, is removably fastened within the outer casing 10 in a predetermined manner as illustrated so that the openings 34*a* communicate with the openings 20*a* and the openings 34*b* communicate with the openings 20*b*. The releasable fastening means includes four bolts 39 in the embodiment shown. In order to aid in removing the conduit tube 29 from the exchanger the outer wall 33 is provided with a handle 33*a*.

In order to secure maximum heat transfer the various medium and product passages are preferably provided with helically arranged guide means directing the medium and product in helical paths. As illustrated in the drawings this guide means comprises helically arranged ridges 24*a* on the inner surface of the outer enclosing shell 24, helically arranged ridges 35*b* on the outer surface of the cylinder 35 and helically arranged ridges 38*a* on the outer surface of the jacket 38. Each set of helical ridges is in the form of a double helix as illustrated in Figure 3, that is, each has a double pitch.

In order to provide a second product connection in the

product space between the cylinder 35 and the shell 25 and end cap 26, the end of the space opposite the product port 22 is in communication with a product port 40. This product port is formed by pipe member 40*a* extending laterally of the first header 11 and having its inner end joined to the wall 17 as shown in Figure 6.

The end cap 26 is provided with an annular flange 26*a* through which the bolt 28 extends. This flange is sealed to the header 12 by means of an annular gasket 48 to produce a fluid-tight seal. The opposite end of the exchanger is provided with a similar annular gasket 50 between the wall 34 and the wall 20. The bolts 39 extend through this gasket and the gasket is cut away so that it does not interfere with the medium flow through the aligned openings 20*a* and 34*a* and 20*b* and 34*b*.

In order to detect leakage in the system there is provided a pair of annular leak detecting grooves 20*d* and 34*d* in the walls 20 and 34, respectively, separated by the gasket 50. Each groove 20*d* and 34*d* communicates with the exterior of the heat exchanger through radially arranged auxiliary grooves 20*e* and 34*e*, respectively, likewise separated by the gasket 50. Any leakage through or around the gasket 50 will cause the product or heat exchange medium, as the case may be, to leak into the channel 20*d* or 34*d* and to then flow from the open end of channel 20*e* or 34*e*, respectively, so that it can be readily detected.

With the heat exchanger assembly as shown in the drawings, the heat exchange medium may pass through the pipe 18, into the chamber 16, through the openings 17*a* into the chamber 15 and through the annular space 41 between the shells 24 and 25. In this annular space the medium is directed in a helical path by reason of the double pitch helical ridges 24*a*. From this space 41 the medium passes into the chamber 23 and out the medium port 21.

Another portion of the heat exchange medium passes from the chamber 16 through the aligned openings 20*a* and 34*a* into the chamber 31 and from here into the annular space between the jacket 38 and the cylinder 35 that defines the heat exchange medium passage 42. The medium flows to the right as viewed in Figure 2 in helical paths to the inner end of the shell 36. The medium then reverses its flow and flows back through the interior of the shell 36 to the front end or toward the wall 33. From this front end the medium flows downwardly through the chamber 32, through the aligned openings 34*b* and 20*b* and into the chamber 16*b*. From this chamber the medium flows outwardly through the medium port 14. Thus, in both the heat exchange medium passages 41 and 42 the medium flows concurrently from left to right as viewed in Figure 2.

While the heat exchange medium is flowing as described above, the product to be heated or cooled is introduced through the product port 22 into the product passage 43 between the cylinder and end cap 35 and 35*a* and the inner shell 25 and end cap 26. This product flows in a helical path from right to left as viewed in Figure 2 or countercurrently to the heat exchange medium. The product which is either heated or cooled during its passage through the container then flows out through the product port 40.

As can be seen from the above description the product can be flowed through the heat exchanger in either direction. Thus, it may be introduced through port 22 and withdrawn through port 40 or may be introduced through port 40 and withdrawn through port 22. Similarly the heat exchange medium may be flowed in either direction as desired. Thus, it may be introduced through port 13 and withdrawn through ports 14 and 21 or may be introduced through ports 14 and 21 and withdrawn through port 13. With this flexibility the medium and product may flow concurrently or countercurrently. However, the heat exchanger of this invention is specifically designed for countercurrent flow in order to secure more efficient heat transfer.

In the embodiment shown in Figure 8 a pair of heat exchangers are connected together for series flow in a multiple unit operation. The internal construction of each exchanger is the same as that previously described. Here the product can be introduced into the product port 22 in the upper exchanger. The product then flows through the exchanger as previously described and out through the product port 40. From this port the product flows downwardly through a pipe 44 and into the lower heat exchanger through its product port 40. The product then flows back in the opposite direction through the full length of the lower heat exchanger and out the lower product port 22.

The heat exchange medium in this embodiment can be introduced through the medium port 13. From here the medium flows to the right in the upper heat exchanger as shown in Figure 8 and out the medium port 21. From the port 21 in the upper heat exchanger the medium flows through the pipe 45 and into the port 21 in the lower heat exchanger. From here the medium flows to the left in the lower heat exchanger as shown in Figure 8 and then flows out the medium port 13 in the lower heat exchanger.

A separate portion of the heat exchange medium flowing in through the upper heat exchanger port 13 flows the full length of the upper heat exchanger and then back through the interior of the shell 36 as previously described in detail. After making this complete double flow the heat exchange medium flows out the port 14 in the upper heat exchanger, through a pipe 46 and into the port 14 in the lower heat exchanger. Thus with this connection, only one inlet for a medium, the medium inlet 13 in the upper heat exchanger and only one medium outlet, the port 13 in the lower heat exchanger is provided for all the heat exchanger medium. The other port 14 in the upper and lower heat exchangers is used to connect the medium passages in the two heat exchangers. Similarly the assembly shown in Figure 8 has only one product inlet port and one product outlet port. The other product ports of both exchangers are used to interconnect the product spaces.

As can be seen the heat exchanger of this invention is extremely versatile in operation and is readily dismantled for cleaning or repair, where such repair is necessary. Furthermore it may be used with a heating medium, such as steam, to heat the product or may be used with a cooling medium, such as cooling water, to cool the product. The exchanger is useful for heating or cooling any fluid material but has been found particularly useful in pasteurizing milk, fruit juices and other fluid food products. The use of the helices of plural pitch is very important in increasing the flow path, creating turbulence to give better heat transfer, creating turbulence to prevent solids deposition from the fluid being heated and creating turbulence to prevent scorching of products that are easily subject to scorching. Furthermore the exchanger of this invention permits obtaining countercurrent flow through a number of units so that when the product and medium pass from one unit to another the flow for each is simultaneously and automatically reversed as is illustrated in Figure 8. Thus, several units may easily be arranged in series, in parallel, or in series-parallel.

One very important feature of this invention is providing the several internal sections of free floating construction. Thus the cylinder 35 and the jacketed shell 36 are fastened at one end only so that the other end of each is relatively free for expansion and contraction when subjected to temperature changes. Furthermore the shells 24 and 25 are relatively thin so that expansion and contraction under temperature changes here is not serious.

Having described my invention as related to certain embodiments thereof, it is my intention that the invention be not limited by any of the details of description unless otherwise specified but rather be construed broadly within the spirit and scope as set out in the accompanying claims.

I claim:

1. A heat exchanger, comprising: an outer casing having a first heat exchange medium port and a first product port adjacent to one end and a second heat exchange medium port and a second product port adjacent to the other end thereof; a heat exchange medium conduit tube removably telescopically received into said casing through said one end and having an outer wall of the tube spaced from an inner wall of the casing to provide a substantially annular product chamber, both product ports normally communicating with said chamber to direct product therethrough; releasable attaching means fastening the tube in said casing in a predetermined position; cooperating wall sections on said casing and tube directing said medium into said tube in a passage along the inner surface of said tube outer wall and between said medium ports in one general direction only from one end of the tube to the other when in contact with said outer wall inner surface; and wall sections in said casing directing said medium between said medium ports in a passage along the outer surface of said casing inner wall.

2. The heat exchanger of claim 1 wherein helically arranged guide means are provided in said medium passages directing said medium in helical paths.

3. A heat exchanger, comprising: an outer casing including a first header at one end having a first heat exchange medium port and a first product port therein; a second header at the other end including a second heat exchange medium port and a second product port therein; an outer enclosing shell forming a part of said casing extending between said headers; an inner enclosing shell forming a part of said casing with the sides of said inner shell spaced inwardly of the outer shell to provide a heat exchange medium passage therebetween; a heat exchange medium conduit tube telescopically received into said casing through said one end and having an outer wall of the tube spaced from an inner wall of the casing to provide a substantially annular product chamber, both product ports normally communicating with said chamber to direct product therethrough; releasable attaching means fastening the tube in said casing in a predetermined position; cooperating wall sections on said casing and tube directing said medium into said tube in a passage along the inner surface of said tube outer wall and between said medium ports countercurrently to the flow of product in said chamber; and wall sections in said casing directing said medium from one medium port to the other through said casing medium passage countercurrently to the flow of product in said chamber.

4. The heat exchanger of claim 3 wherein said first header is provided with a pair of chambers communicating with each other, the first chamber communicating with said casing medium passage and the second chamber communicating with said first medium port and with said tube passage.

5. The heat exchanger of claim 3 wherein said first header is provided with a pair of annular hollow sections adjacent to each other, the first hollow section describing a first chamber communicating with said casing medium passage, the second hollow section being divided into a second chamber and a third chamber, the second chamber communicating with the first chamber and with the first medium port and with the interior of said tube, and the third chamber communicating with a third heat exchange medium port and with the interior of said conduit tube.

6. The heat exchanger of claim 3 wherein said second header is provided with a hollow section describing a chamber, the chamber communicating with the casing medium passage and with said second medium port.

7. A heat exchanger, comprising: an outer casing including a first header at one end having a first heat exchange medium port and a first product port therein; means in the first header defining a pair of annular hollow sections adjacent to each other, the first hollow section describing a first chamber and the second hol-

low section being divided into a second chamber and a third chamber, the second chamber communicating with the first chamber and with the first medium port; a second header at the other end of said casing including a second heat exchange medium port and a second product port therein; means in the second header defining a hollow section describing a chamber communicating with said second medium port; an outer enclosing shell as a part of the casing extending between the headers; an inner enclosing shell with sides spaced inwardly of the outer shell to provide a heat exchange medium passage therebetween, said first chamber and said second header chamber communicating with said casing medium passage to direct the medium therethrough; a heat exchange medium conduit tube telescopically received into said casing through said one end and having an outer wall of the tube spaced from said inner enclosing shell to provide a product chamber therebetween, both said product ports normally communicating with said chamber to direct product therethrough, said second chamber communicating with one end of the interior of the tube and said third chamber communicating with the other end of the interior of the tube and with a third heat exchange medium port to direct medium through said tube; releasable attaching means fastening the tube in said casing in a predetermined position; and cooperating wall sections on said casing and tube for directing said medium through said tube countercurrently to the product flow.

8. The heat exchanger of claim 7 wherein the heat exchange medium passages in the casing and in the tube and the product passage are each provided with helically arranged guide means directing said medium and product in helical paths.

9. A heat exchanger, comprising: an outer casing having a first heat exchange medium port and a first product port adjacent to one end and a second heat exchange medium port and a second product port adjacent to the other end thereof; means defining a heat exchange medium passage between said medium ports; means defining a product passage between said product ports; a heat exchange medium conduit tube removably telescopically received into said casing through said one end, the tube having an outer end and an inner end and an outer wall closed at said inner end and spaced from an inner wall of the casing to provide an annular product chamber, and an inner shell section within said outer wall spaced inwardly thereof and open at the inner end to provide an annular heat exchange medium passage between said tube wall and tube shell section; releasable attaching means fastening the tube in said casing in a predetermined position; cooperating wall section on said casing and tube directing said medium through said tube medium passage countercurrently to the product flow in said product passage, the product passage communicating at opposite ends thereof with said product ports.

10. The heat exchanger of claim 9 wherein said tube includes a header from which said outer wall and said inner shell section extend, and means forming an annular hollow section in the tube header around the outer end of the inner shell section, the annular hollow section being divided into a first chamber communicating with said first medium port and with said tube annular medium passage and a second chamber communicating with the interior of said inner shell section and with a third heat exchange medium port whereby said medium is directed through said first medium port, through said tube header first chamber, through said tube medium passage, through said tube and through said third medium port.

11. The heat exchanger of claim 10 wherein the inner shell section of said tube is provided with insulating means insulating the interior of said shell section from said tube annular medium passage.

12. The heat exchanger of claim 9 wherein said tube annular medium passage is provided with helically arranged guide means directing said medium in a helical path.

13. A heat exchanger, comprising: an outer casing including a first header at one end having a first heat exchange medium port and a first product port therein; means in the first header defining a pair of annular hollow sections adjacent to each other, the first hollow section describing a first chamber and the second hollow section being divided into a second chamber and a third chamber, the second chamber communicating with the first chamber and with the first medium port; a second header at the other end of said casing including a second heat exchange medium port and a second product port therein; means in the second header defining a hollow section describing a chamber communicating with said second medium port; an outer enclosing shell as a part of the casing extending between the headers; an inner enclosing shell with sides spaced inwardly of the outer shell to provide a heat exchange medium passage therebetween, said first chamber and said second header chamber communicating with said casing medium passage to direct the medium therethrough; a heat exchange medium conduit tube telescopically received into said casing through said one end, the tube having an outer end and an inner end and an outer cylindrical wall closed at said inner end and spaced from said inner enclosing shell to provide an annular product chamber, and an inner cylindrical shell section within said outer wall spaced inwardly thereof and having an inner end, said inner end of said inner shell being open at the inner end to provide an annular heat exchange medium passage between the tube wall and tube shell section; insulating means on said tube shell section insulating the interior of said shell section from said tube annular medium passage; releasable attaching means fastening the tube in said casing in a predetermined position; a header forming a part of the tube from which said outer wall and said inner shell section extend; and means forming an annular hollow section in the tube header around the outer end of the inner shell section, the annular hollow section being divided into a first chamber communicating with said first medium port and with said tube annular medium passage and a second chamber communicating wtih the interior of said inner shell section and with a third heat exchange medium port whereby said medium is directed through said first medium port, through said tube header first chamber, through said tube medium passage, through said tube and through said third medium port.

14. The heat exchanger of claim 13 wherein the heat exchange medium passages in the casing and in the tube and the product passage are each provided with helically arranged guide means directing said medium and product in helical paths.

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