

June 27, 1933.

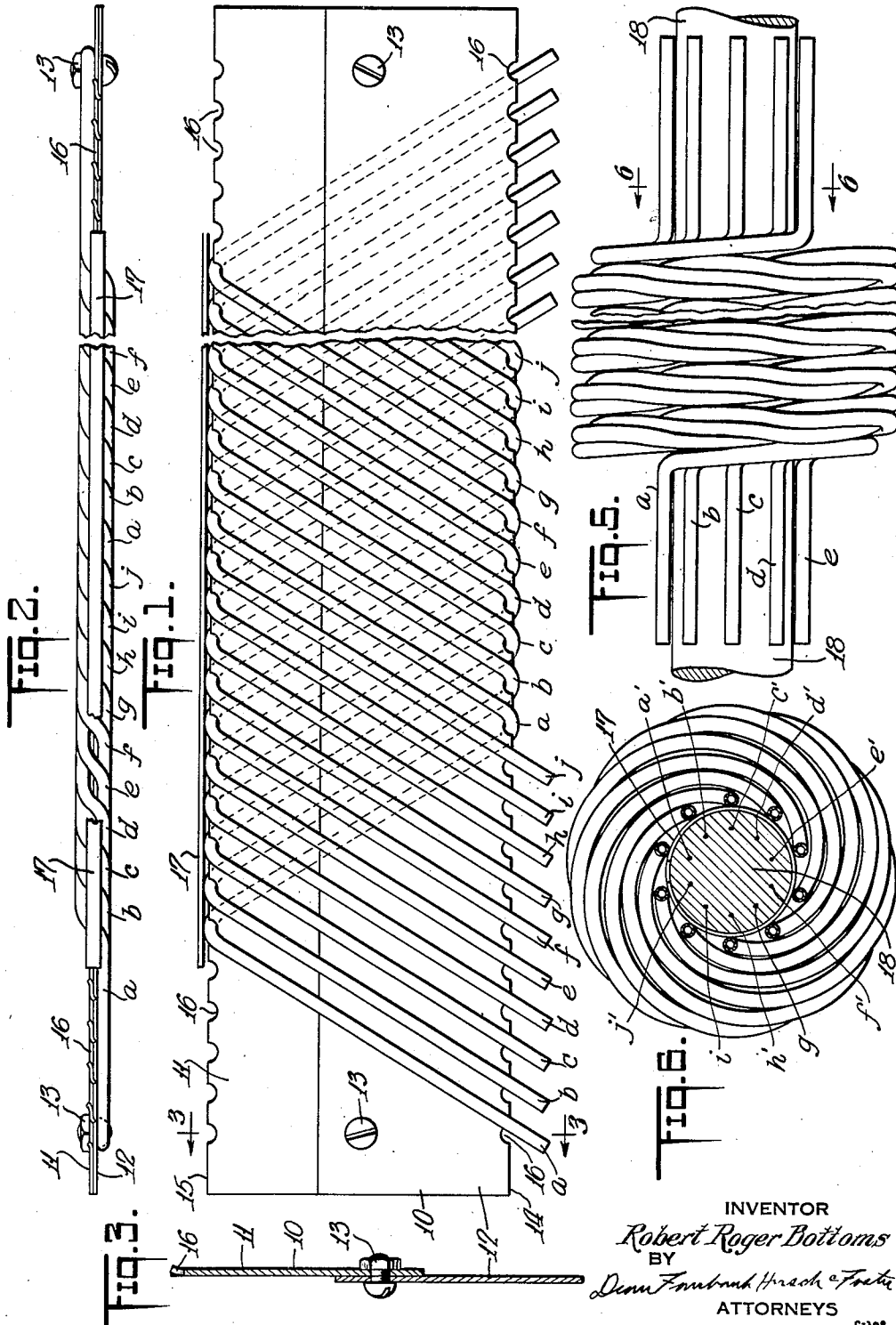
R. R. BOTTOMS

1,915,352

HEAT INTERCHANGER AND PROCESS OF MAKING THE SAME

Filed Oct. 30, 1931

2 Sheets-Sheet 1



INVENTOR
Robert Roger Bottoms
BY
Dean F. Farnham, Hirsch & Foster
ATTORNEYS

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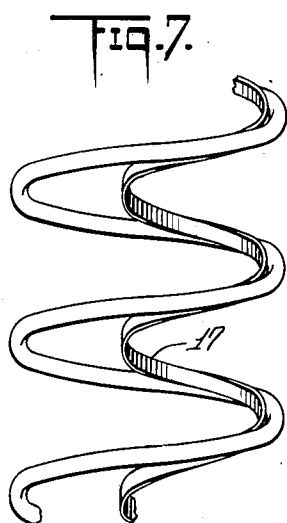
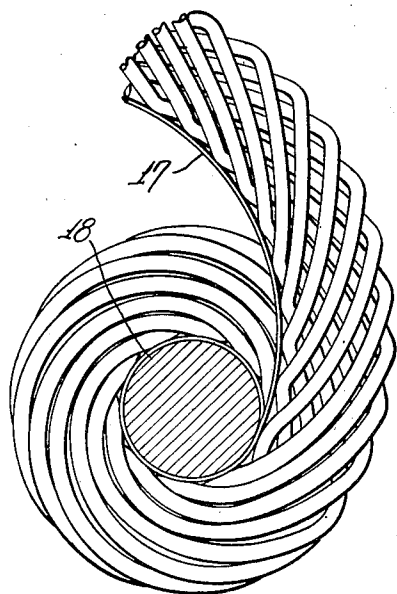


Fig. 4.

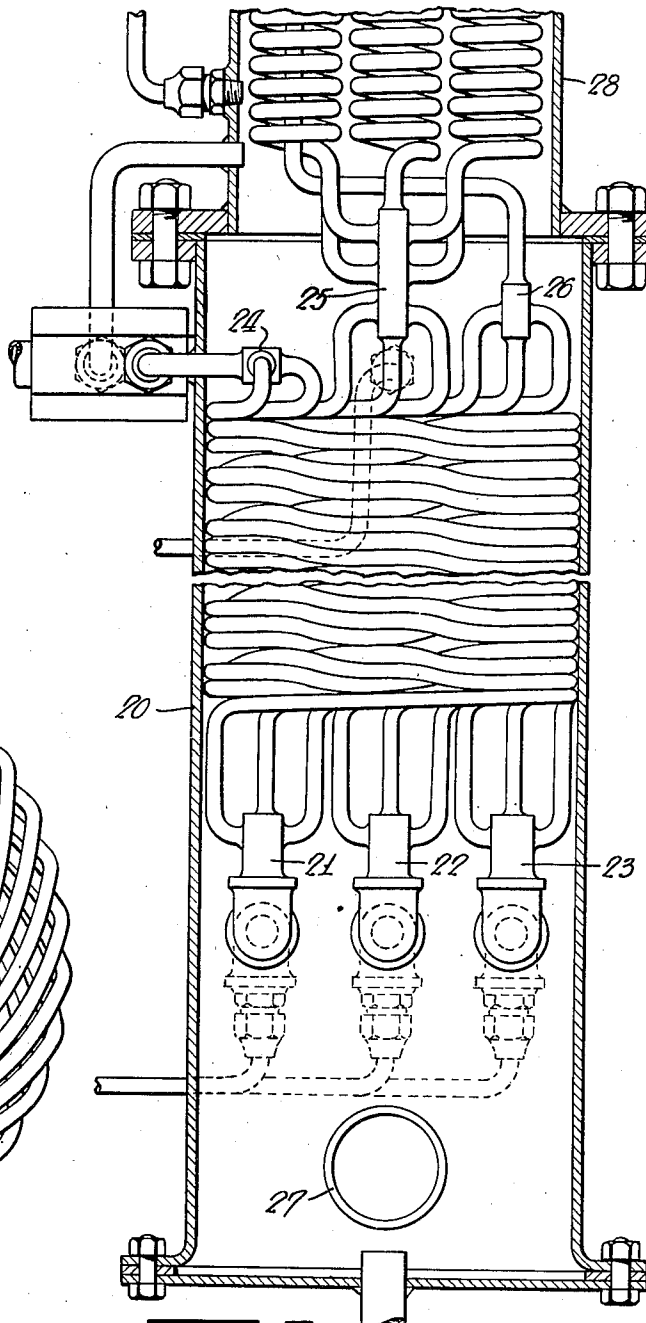


Fig. 8.

INVENTOR

Robert Roger Bottoms

BY

Dean Fairbank Hirsch Foster

ATTORNEYS

C-108

UNITED STATES PATENT OFFICE

ROBERT ROGER BOTTOMS, OF LOUISVILLE, KENTUCKY, ASSIGNOR TO THE GIRDLER CORPORATION, OF LOUISVILLE, KENTUCKY, A CORPORATION OF DELAWARE

HEAT INTERCHANGER AND PROCESS OF MAKING THE SAME

Application filed October 30, 1931. Serial No. 572,037.

This invention relates to certain improvements in heat interchangers of that type in which one or more fluids are passed through coils over which the other fluid is caused to flow.

The main objects of the invention are to secure a more effective nesting of the plurality of coils; to reduce the cost of labor involved in assembling the coils in nested relationship; to provide adequate but comparatively thin passages for the flow of the fluid in contact with the coils; to insure the proper spacing of the coils, and to insure the exposing of each and all of the coils to the contacting fluid to the same extent.

In my improved construction any desired number of coils may be employed and each coil may be for a separate fluid, or all of the coils may be connected in parallel for the same fluid, or they may be connected in parallel in separate groups.

In the accompanying drawings I have illustrated one embodiment of my invention and certain of the steps employed in forming the nested coils, although it will of course be understood that the number of pipes, the relative dimensions, and various other features may be varied within wide limits within the scope of my invention.

In these drawings:

Fig. 1 is a face view of a template with the pipes wound thereon and secured together by a connecting strip.

Fig. 2 is an edge view of the parts shown in Fig. 1.

Fig. 3 is a transverse section through the template, taken on the line 3—3 of Fig. 1.

Fig. 4 is an end view showing heat interchanger coils in the process of assembly.

Fig. 5 is a side elevation of a portion of the nested coils.

Fig. 6 is an end view of the parts shown in Fig. 5.

Fig. 7 is a somewhat idealized perspective view of portions of one pipe coil and the helical strip attached thereto, and

Fig. 8 is a side elevation through one form of heat interchanger, the casing being shown in section.

In carrying out my invention in one spe-

cific embodiment, there is provided a template 10 which may be made of two separate sheet metal plates 11 and 12 secured together in overlapping relationship by suitable fastening means, such as readily removable bolts 13 disposed adjacent to opposite ends of the template. The width of the template is determined in accordance with the number of pipe coils to be formed, the diameter of the pipes, and the inside as well as the outside diameter of the nested coils in the completed construction. The opposite edges 14 and 15 of the template are parallel, and are each provided with a series of notches 16. These notches are preferably curved and are of a size and curvature dependent upon the diameter of the pipes to be used in making the pipe coils. If there are to be an even number of separate pipe coils in the completed construction, the notches in one edge are disposed directly opposite to those on the other edge, whereas if an uneven number of coils are to be formed, the notches are preferably staggered. The notches are spaced apart lengthwise of the edges to a distance preferably substantially equal to three times the outside diameter of the pipe.

In the specific form illustrated in the drawings, the interchanger includes ten separate nested pipe coils. In making such an interchanger ten separate pipes *a, b, c, d, e, f, g, h, i, and j* are wrapped around the template in parallelism, so that each pipe will pass diagonally across one side of the template and then diagonally across the opposite side, the angle being such in respect to the width of the pipe that successive turns for each pipe on one edge of the template will be ten inches apart. The length of the template will depend upon the length of the nested pipe coils to be formed. When the pipes have been wrapped around the template, as shown in Fig. 1, they are all connected together along one edge of the template by a metallic strip 17. This strip is comparatively narrow and in any event it is preferable to make it of a width not greater than the total thickness of the template and the pipes wound thereon. The strip may be secured in any suitable manner, as for instance by brazing or soldering

on the area of the strip connected to each bend, and should be as small as reasonably possible to insure adequate holding together of the parts. After the pipes have thus been bent to loop form and all of the loops along one edge connected together by the strip 17, the template is removed. As the template cannot be directly slipped out endwise by reason of the engagement of the pipes in the notches, the fastening means 13 are removed or released so that the two plates 11 and 12 may slide in respect to each other to narrow the effective width of the template and permit the narrowed template to be slipped out, or the two plates to be slipped out separately.

The product in this state will comprise a series of pipes in loop form, and all of the pipes connected along one edge by the strip, so that the product may be referred to as a ribbon of fixed length at one edge, and freely expendible or contractible along the opposite edge by a bend of the ribbon in its own plate.

One end of the strip is then attached to a mandrel and the strip is wound around the mandrel in helical form, and with the ribbon extending out radially from the mandrel. The circumference of the mandrel is preferably substantially equal to the width of one edge of the template measured by ten notches on the latter if ten pipes are employed. With a larger or smaller number of pipes the circumference of the mandrel will be correspondingly varied.

In Fig. 4 I have shown an end view of the partly assembled construction showing a cylindrical mandrel 18 with the ribbon partially wrapped therearound, and with the strip 17 defining the edge of fixed length of the ribbon closely following the surface of the mandrel. As the ribbon is wrapped around the mandrel the bends of the pipes which are attached to the strip will straighten out, and the pipes at these points will become curved somewhat in the opposite direction, and the ribbon will become narrower, and the bends at the outer edge of the ribbon will also tend to straighten out. When the wrapping has been completed the ribbon will be in helical form on the surface of the mandrel, and of a diameter equal to the outside diameter of the mandrel, while each complete loop of each pipe will take on a substantially circular form, and each pipe will become a helical coil with the circumference of the coil approximately equal to double the diagonal distance across the template.

By making the mandrel of the size above referred to in respect to the notch spacing on the template, each pipe will become a helical coil of a diameter somewhat larger than that of the diameter of the helix formed by the strip, and each pipe coil will be connected to the strip at one point in each complete turn of the pipe, and the connecting

points will be parallel to the axis of the mandrel along the surface thereof. The center line of each pipe coil will be at the side of the axis of the mandrel diametrically opposite to the line of the points at which the successive turns of that pipe coil are attached to the successive turns of the strip. As each coil is attached to the strip at a different point along the length of the latter, and therefore at a different point around the circumference of the mandrel, the separate pipe coils will be readily distributed around the mandrel and equally spaced. After the pipe coils have thus been formed in nested relationship they are mounted in a suitable casing and connected up to the desired source of supply and delivery of the fluids to be treated. Merely as an example I have shown in Fig. 8 a heat interchanger embodying such nested coils.

The mandrel is either left in place or is replaced by a solid block or tube closed at its ends so that no fluid may flow through the center of the nested coils in the completed apparatus. The nested coils are enclosed within a suitable casing 20, and the ends of the separate pipes properly connected up. In Fig. 8 the lower ends of the pipes are divided into groups and connected to separate headers 21, 22 and 23, while the upper ends are likewise brought together in groups and connected to headers 24, 25 and 26. Thus three different fluids may be passed through the three different groups of tubes. The fluid which is to be passed into heat interchanging relationship with the fluid or fluids in the pipe coils is caused to flow axially through the casing. As illustrated, the casing is provided with an inlet 27 at the lower end thereof, and at the upper end is connected to a separate casing 28 which may contain coils connected in series with one or more of the nested coils in the body of the heat interchanger.

A heat interchanger of the character above described may be used for the treatment of a wide variety of fluids, and in various different industries. The particular construction illustrated may be employed in connection with the liquefaction of gaseous mixtures and the separation of the liquid into its constituents in the desired degree of purity.

For instance, the gas to be treated may pass through the casing and to the liquefier and three separate rectified constituents pass through the three separate groups of coils to absorb the heat of the incoming gas and become warmed up to the temperature of the incoming gas at its point of entry.

In my improved construction it will be noted that each pipe coil has a portion thereof adjacent to the wall 20 of the casing, and has a portion adjacent to and in contact with the inner helical strip 17. In the ideal condition no two adjacent pipe sections will be parallel, as no two pipe coils have the same axis; and thus there will be free passage

through the nested coils for the fluid circulating over the coils. The distribution of the spacing is substantially uniform throughout the entire series of nested coils, and each and every coil is subjected to the treating fluid to the same extent. Any tendency of the fluid to flow through the casing nearer to one side than to the other, or along any particular path, will act upon all of the coils uniformly. Furthermore all of the pipe coils are of the same diameter and the total length of pipe of each coil is the same as that of the others.

In the completed construction the axes of all of the coils are distributed along the central axis of the interchanger, and all of the coil axes are within all of the coils.

In Fig. 6 the axes of the several coils *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i* and *j* are indicated by the points *a'*, *b'*, *c'*, *d'*, *e'*, *f'*, *g'*, *h'*, *i'* and *j'*. As the diameter of each coil extends from one side of the center of the two concentric walls of the casing approximately to the side of the outer wall of the casing at a diametrically opposite point, and as all of the coil axes are inside of all of the coils and are around the axis of the helix of the strip, it will be noted that the diameter of each coil is more than half the diameter of the mass of nested coils.

As the pipes in being bent may not bend entirely uniformly, it is of course to be understood that where I have referred to the pipes and the strip as being arranged in helical form, I mean approximately helical and not as a perfect helix. The member 18 which I have designated as a strip is preferably of thin flat material, but may be of any desired cross-section, and I therefore do not desire to be limited to any particular cross-sectional form in designating this member as a strip.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. The method of forming a plurality of nested coils, including wrapping a plurality of pipes in parallel and in spaced relationship around a flat template, securing a strip to each pipe along one series of turns thereof, and parallel to one edge of said template, removing the template and wrapping the strip around a mandrel.

2. The method of forming a plurality of nested coils, including wrapping a plurality of pipes in parallel and in spaced relationship around a template, securing a strip to all of the pipes at each turn thereof along a line parallel to the template, removing the template, and wrapping the strip in helical form around a cylindrical mandrel.

3. The method of forming a plurality of nested coils, including forming a ribbon of a strip and a series of pipes bent to zigzag form, and each having each alternate bend

thereof attached to the strip with the pipes in substantially parallel planes, and wrapping the ribbon around a mandrel with the strip in contact with the mandrel and the ribbon projecting out substantially radially therefrom.

4. The method of forming a plurality of nested pipe coils, including bending a plurality of pipes to zigzag form, the separate pipes having substantially parallel runs in the same plane, securing said pipes together along one of the two series of bends to form a ribbon, and wrapping the ribbon around a mandrel with one edge in contact therewith and the opposite edge spaced therefrom.

5. The process of forming a heat interchanger, which includes forming a series of loops in each of a series of pipes, attaching each loop of each pipe to a flexible strip, the successive loops of each pipe being attached at points on the strip so spaced lengthwise of the latter that between said spaced points one loop of each of the other pipes may be attached, whereby the attached points are in a straight line and are in a series of groups, and each group includes an attachment to one loop of each pipe, and wrapping said strip around a mandrel to form a helix whereby each loop is bent to substantially circular form around the mandrel, and each pipe is formed into a coil of larger diameter than that of the helix formed by the strip.

6. A heat interchanger including a coil comprising a helically disposed strip, a plurality of helical pipe coils, each of larger diameter than the strip coil, and having the same pitch, each pipe coil having each turn thereof secured to the strip coil and the several pipe coils being secured to the strip coil at separate spaced points around the strip coil.

7. A heat interchanger including a series of nested helical pipe coils of substantially the same diameter, the same pitch, and the same direction of turn, and having separate parallel axes arranged at spaced points around a circle, all of said axes being encircled by all of said coils, and the entire series of coils presenting substantially cylindrical inner and outer peripheries.

8. A heat interchanger including a casing having annular concentric spaced walls and a series of helical pipe coils, all of said coils having the same pitch and the same direction of turn, and each pipe coil being eccentric in respect to said casing and disposed closely adjacent to said inner wall at one point and adjacent to the outer of said walls at a diametrically opposite point, the axes of the several coils being at spaced points around the axis of said casing.

9. A heat interchanger including a helically disposed strip and a plurality of helically disposed pipe coils of larger diameter and eccentric thereto, each turn of each pipe

coil being secured to a corresponding turn of the strip.

10. A heat interchanger including a helically disposed strip, a plurality of helical pipe coils of substantially the same diameter and each of larger diameter than that of the helix of said strip and eccentric in respect thereto, the axes of the pipe coils being distributed around the axes of the strip helix, and each pipe coil having each turn thereof secured to a corresponding turn of the helical strip.

11. A heat interchanger including a series of nested helical coils of the same diameter, the same pitch and the same direction of turn, and having their axes substantially parallel and distributed around and spaced from a central axis of the interchanger.

12. A heat interchanger including a series of nested helical coils of the same diameter, the same pitch and the same direction of turn, and having their axes substantially parallel and distributed around and spaced from a central axis of the interchanger, all of said axes being within all of said coils.

13. A heat interchanger including a series of nested helical coils of the same diameter, the same pitch and the same direction of turn, and having their axes substantially parallel and distributed around and spaced from a central axis of the interchanger, and the outside diameter of the interchanger being less than twice the diameter of each pipe coil.

14. A heat interchanger including a series of nested helical coils of the same diameter, and having their axes substantially parallel and distributed around and spaced from a central axis of the interchanger, and means secured to each turn of each pipe for holding successive turns against relative axial movement and holding all of said coils against relative lateral movement.

15. A heat interchanger including a series of nested helical coils of the same diameter, the same pitch and the same direction of turn, and having their axes substantially parallel and distributed around and spaced from a central axis of the interchanger, and means secured to each turn of each pipe for holding successive turns against relative axial movement, and holding all of said coils against relative lateral movement.

16. An article of manufacture adapted for use in forming a heat interchanger, including a metal strip, and a plurality of parallel pipes bent to approximately zigzag form with each alternate bend of each pipe secured to said strip, whereby the strip may be bent to form a helix of one predetermined radius and thereby form the pipes into helical form, but of larger radius.

17. An article of manufacture adapted for use in forming a heat interchanger, including a metal strip, and a plurality of parallel pipes bent to substantially zigzag form with

each alternate bend of each pipe secured to said strip, the distance between the points of attachment of the strip to any one pipe along the strip being substantially equal to the desired internal diameter of the heat interchanger, and being a multiple of the distance between the points of attachment of the strip to adjacent bends of separate pipes, and the distance along the pipe between successive points of attachment of each pipe being substantially equal to the circumference of each coil to be formed.

18. An article of manufacture adapted to be used in the manufacture of a heat interchanger, including a metal strip, and a plurality of pipes, each bent to substantially zigzag form and each alternate bend secured to said strip, the points of attachment of the several pipes being spaced apart to a distance materially less than the distance between the points of attachment of a single pipe.

Signed at Louisville, in the county of Jefferson, and State of Kentucky, this 24 day of October, A. D. 1931.

ROBERT ROGER BOTTOMS.