Dec. 23, 1941. R. M. HARDGROVE 2,267,027

FLUID HEAT EXCHANGE APPARATUS

Filed Feb. 8, 1938 3 Sheets-Sheet 1

Fig. 1

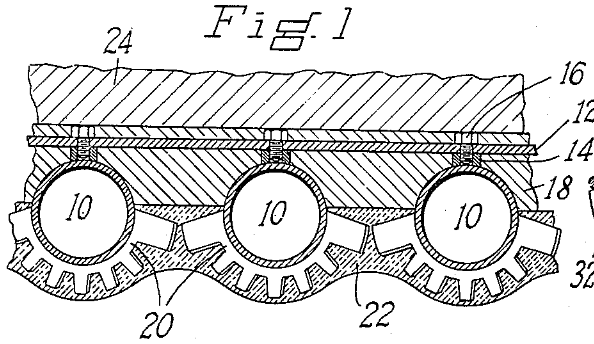


Fig. 4

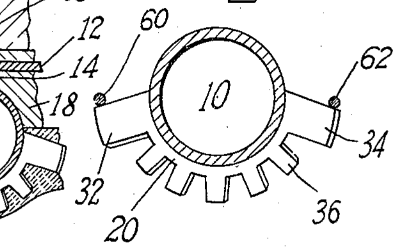


Fig. 3

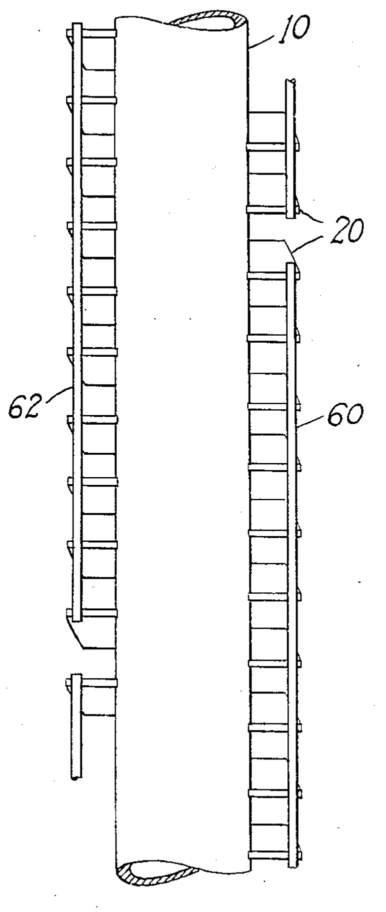
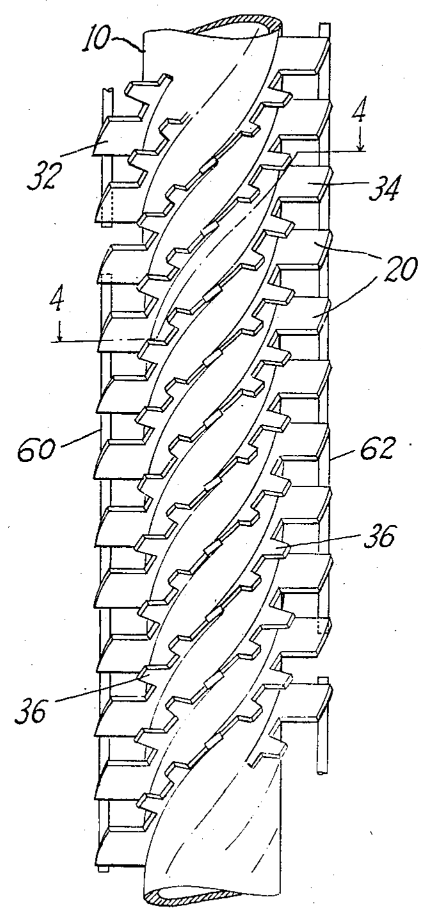


Fig. 2



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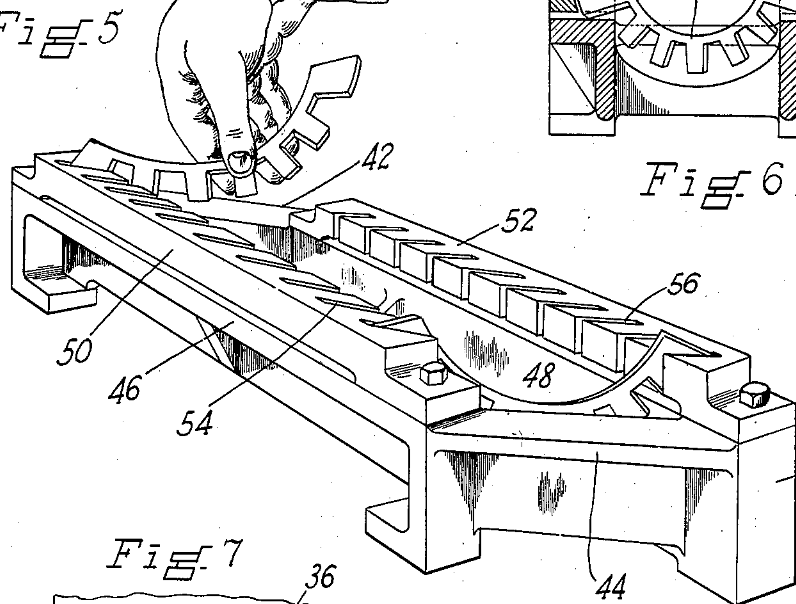
FLUID HEAT EXCHANGE APPARATUS

Filed Feb. 8, 1938 3 Sheets-Sheet 2

Fig. 5



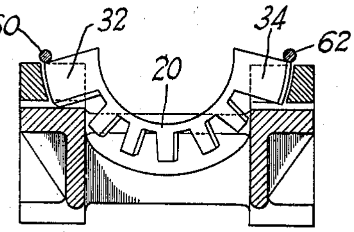


Fig. 6

Fig. 7

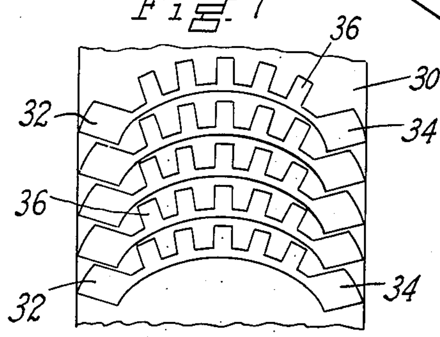


Fig. 9

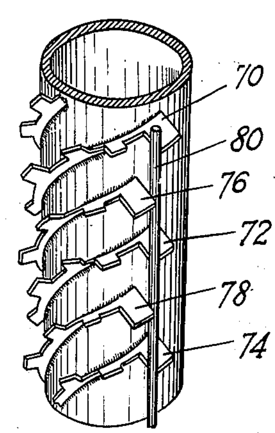
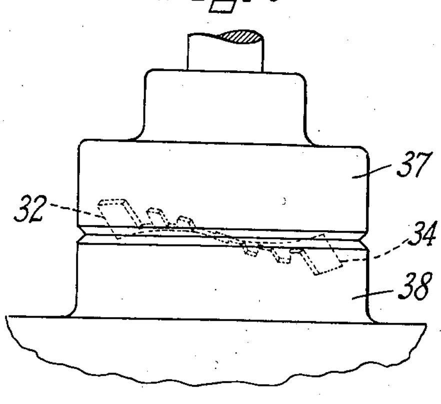


Fig. 8



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FLUID HEAT EXCHANGE APPARATUS

Filed Feb. 8, 1938 3 Sheets-Sheet 3

Fig. 12

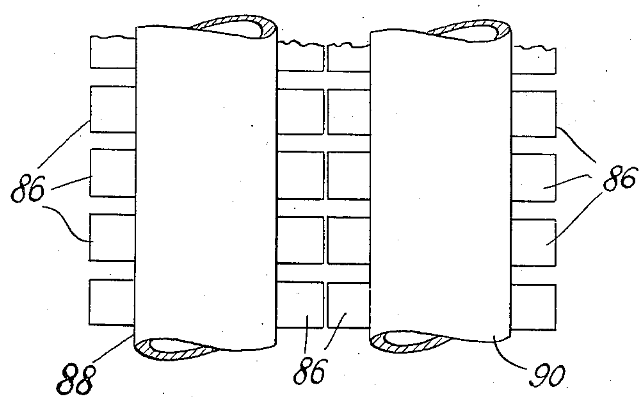


Fig. 11

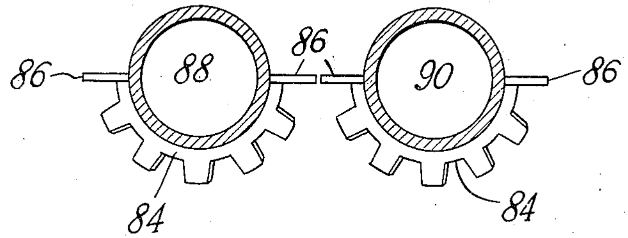
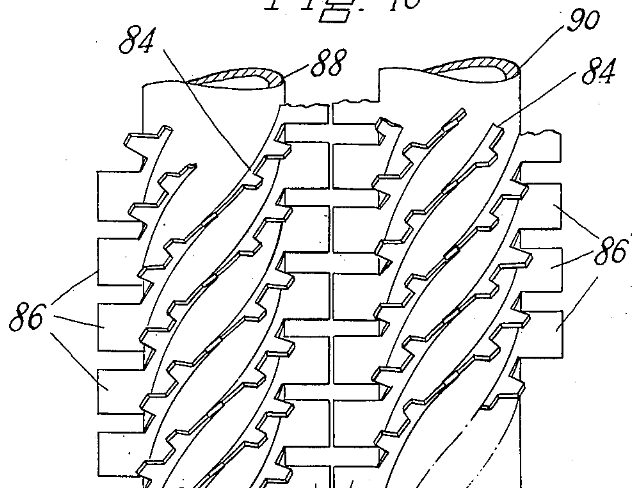


Fig. 10



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Patented Dec. 23, 1941

2,267,027

UNITED STATES PATENT OFFICE

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FLUID HEAT EXCHANGE APPARATUS

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Application February 8, 1938, Serial No. 189,313

2 Claims. (Cl. 257—262)

This invention relates to tubular elements and methods of manufacturing the same. It also relates to improvements in furnace structures in which the tubular elements are used.

It is an object of the invention to provide a novel and practical furnace construction which may be advantageously employed in the walls of high temperature furnaces such as the furnaces of modern steam boilers.

More specifically, an object of the invention is to provide a furnace boundary structure employing tubes with toothed metallic strips helically arranged and welded to the tubes so as to extend outwardly therefrom. This forms advantageous means for anchoring a refractory covering on the tubes and for simultaneously protecting the refractory from overheating during the operation of the furnace at high rates. It also reduces to a high degree the tube stresses caused by the local heating resulting from welding operations. This reduction in tube stresses is important because it eliminates costly stress relieving operations which may be necessary with other arrangements of simillar elements.

The invention will be more clearly understood, and other objects of the invention will appear, from the following description which relates to an embodiment of the invention selected for the purposes of illustration. This embodiment of the invention is indicated in the accompanying drawings, in which:

Fig. 1 is a partial transverse section of a furnace boundary structure including the illustrative tubes and refractory material covering the furnace faces of the tubes and the tube projections formed by the strips.

Fig. 2 is a front elevation of the illustrative tube structure, particularly showing the relationship of the helical strips to the tubes.

Fig. 3 is a rear elevation of the tube shown in Fig. 2.

Fig. 4 is a transverse section of the illustrative tube structure.

Fig. 5 is an isometric view illustrating a jig and a method of assembly of the strips in the jig.

Fig. 6 is a transverse vertical section through the jig with one of the strips in its operative position therein.

Fig. 7 indicates one way in which the strips may be struck or stamped out of a larger strip, or metal plate.

Fig. 8 is a combined elevation and phantom view illustrating the two parts of the forming dies and the formation of the strip resulting from the operation of the dies.

Fig. 9 is a view in the nature of a perspective view showing a modified tube structure.

Fig. 10 is a front elevation of stud tubes with the studs formed from strips similar to the strips indicated in the other figures, but having the end studs bent so that they form a barrier or closure between the adjacent wall tubes at positions in, or adjoining, the center plane of the tubes.

Fig. 11 is a view in the nature of a transverse section of the embodiment indicated in Fig. 12 of the drawings.

Fig. 12 is a fragmentary view in the nature of an elevation of a modified form of the invention.

When the illustrative tube structure is employed in a furnace boundary construction such as that indicated in Fig. 1 of the drawings the tubes 10 are held in boundary forming alignment by securement to the support 12. As shown, there are internally threaded metallic pads 14 welded to the sides of the tubes so as to receive the cap screws 16 extending through openings in the support.

Between the support and the tubes insulating material 18 is placed, and a highly refractory material is installed in a semi-plastic condition over the furnace sides of the tubes and the strips 20 to form the refractory layer 22. This refractory material is mechanically anchored in position by the tubes and the projections of the strips. It is also thermally maintained by the heat transfer through the strips and their projections to the cooler fluid within the tubes. Externally of the insulating layer 18 is another insulating layer 24 which operates to minimize heat losses.

In the manufacture of the tube structure used in the illustrative furnace construction metal strips of the outlines indicated in Fig. 7 are first stamped out of, or struck from, a larger metal strip or plate 30. Fig. 7 indicates five of the tube strips as being struck from the illustrative portion of the strip 30. Each tube strip is preferably curved as shown, and is formed with two relatively large end projections 32 and 34 and a number of separate intermediate projections 36 spaced from each other and spaced from the end projections 32 and 34.

It will also be noted that all of the strip projections diverge outwardly away from the base of the strip which connects the projections.

The material from which the tube strips are formed is preferably steel and the rolled steel plate or strip 30 is of adequate thickness, preferably not exceeding the wall thickness of the tube.

When the tube strips are stamped out of the plate **30** as indicated in Fig. 7, they may be flat, and it is the next step in the illustrative method to form the strips in such a way that they may be helically arranged on a tube and have their bases fitted closely against the tube surface. This operation may be carried out in dies such as those indicated in Fig. 8. The upper part **37** of these dies is preferably movable, and will be herein referred to as the hammer. The lower part **38** is preferably fixed, and will be described as the anvil. The operative faces of the hammer and the anvil are somewhat similar, both having similar projections and indentations toward opposite ends of their strip receiving portions.

When one of the flat strips resulting from the operation indicated in Fig. 7 of the drawings is placed in proper position upon the anvil **38**, and when the hammer **37** is caused to move against the face of the anvil, the strip and its projections are brought to the positions indicated in dotted lines in Fig. 8. The outer end of the projection **34** is forced downwardly into a shaping cavity in the anvil **38** and the outer end of the projection **32** at the opposite end of the strip is forced upwardly into an indentation in the face of the hammer **37**. The spaced projections between the end projections **32** and **34** are brought to the intermediate positions indicated in the dotted lines and the base of the strip is formed to such a curvature that it may be closely fitted against a cylindrical tube and arranged in a helical manner thereon.

As a part of the illustrative method, the tube strips resulting from the forming operation indicated in Fig. 8 of the drawings may be shop assembled into groups. For example, ten of these spiral tube strips can be assembled in the jig **40**, shown in Fig. 5. This jig includes end rails **42** and **44** obliquely related to parallel side rails **46** and **48**. Secured to the latter are the removable strip spacers **50** and **52**. These spacers are provided with strip receiving notches **54** and **56** spaced from each other, and otherwise so related, as to produce the desired spacing of the strips and their projections, in the finished tube structure. Different elements **50** and **52** with different arrangements of notches may be provided, if different spacings of the tube strip projections are desired.

The tube strips are placed in the jig as indicated in Fig. 5 of the drawings. As many strips may be placed in position as there are pairs of notches in the jig, or only half that number of tube strips may be placed if a wider spacing of the tube projections is desired.

After the desired group of tube strips in the jig **40** is complete, metallic rods **60** and **62** may be held in contact with the end projections **32** and **34** and tack-welded to the strips. Thereafter, the entire assembly may be lifted from the jig. It is maintained as an operative unit or assembly until such a time as it is to be placed in its final operative position against a tube and welded thereto. The jigging operation may take place in the shop and the assemblies of tube strips packed and shipped to the site of the final installation.

To further minimize and distribute tube stresses alternate tube strips such as the strips **70**, **72**, and **74** (see Fig. 9) may be end-wise offset with reference to the intermediate strips **76** and **78** during the jigging operation, and before the strips are welded to the rods **80**. In this event, the end projections of the intermediate strips **76** and **78** have their end surfaces in contact with the rods **80** while the end projections of the strips **70**, **72**, and **74** have their inner surfaces in contact with and welded to the rod. Alternatively, long and short strips may be used, the short strips having corresponding ends related to the rods **80** as indicated in Fig. 9, and the long strips arranged with reference to those rods in the same manner as the strips **70**, **72**, and **74**. If necessary, the jig may be modified to meet the conditions of either one of these embodiments of the invention.

In the completion of the illustrative tube structures the above described strip assemblies may be welded to plain cylindrical tubes in the field or in the shop with the use of flame or arc welding equipment. Each assembly is held against the side of the tube which will ultimately be the furnace side. It is then tack-welded to the tube at a number of distributed positions, and then the welder can proceed with the welding of each strip, forming a continuous weld along one side thereof. He can proceed thus from one strip to the other without any further jigging of the strips or loss of time in locating the strips in their proper places. This eliminates the necessity of taking extra time in the field to lay out spacing on the tubes.

After the tubes are completed they may be arranged as indicated in Fig. 1 of the drawings and covered by the highly refractory layer **22** which is preferably solidly tamped into position around the strips, their projections, and the tubes.

The practice of this invention results in a reduction of the cost of stud tubes and it affords a method of procedure which permits plain tube water walls to be converted into stud tube constructions, in the field. No injury or impairment of the tubes results from the practice of the method. The strips may be made of stampings of sheet metal, and the cost thus further reduced. Each strip is of such shape and length that it matches the face of the plain cylindrical tube along a line defined by a part of a helix.

The condition of universal applicability by means of the use of flame or arc welding equipment is met by the fact that each strip has a long continuous edge throughout which the weld metal can be deposited as easily as if it were a straight line. This ease of welding is also a primary factor contributing to the low cost of the illustrative stud tube construction.

The avoidance of injury to the tube by the welding of the strips is met by the helical shape of the welded joint, by the limited length of each strip, and by the serrations which separate the projections of the strip. The serrations also contribute to the avoidance of injury during the operation of a furnace in which the invention is employed. Continuous welds at right-angles to the longitudinal axis of the tubes, or continuous welds parallel to the longitudinal axis of the tubes set up more local tube stresses. These excessive stresses may be relieved by heat treatment but this adds expense and is sometimes impractical when tubes are provided with studs. In operation, the outer edges of an ordinary strip (when welded to the tube) are hotter than the inner edges which have tube wall temperature, and thus expand more. A continuous plain strip or fin, will thus stress the tube during operation, and this stress is cumulative with reference to the stresses imposed by the welding, but the strip of this invention, being serrated on its outer edge, does not create such additional stresses.

Fig. 10 of the drawings indicates an embodiment of the invention in which the helical strips **84** have their end projections or studs **86** bent so that they will form a substantial barrier or closure between the tubes **88** and **90**. The relationship of these ends to the tubes and the remainder of the strips is particularly well indicated in Fig. 11 of the drawings. With such a construction, the high temperature side of the wall defined by the tubes **88** and **90** is on the side of the tubes toward which the studs extend. The opposite sides of the tubes may, in some circumstances, be the outside wall of the furnace, or when a division wall is formed by the illustrated construction, the opposite sides of the tubes may be merely sides of a zone of lower temperature than that exposed to the studded side. In the latter event, bare metal on the low temperature sides of the tubes **88** and **90** may be exposed to the furnace gases at the side of the furnace or gas pass.

Fig. 12 of the drawings is an outside elevation of the wall which is indicated in Figs. **10** and **11**. It will, of course, be understood that reference to the embodiment of the invention indicated in Figs. 11 and 12 with ceramic refractory material is associated with the tubes and the studs in the same manner as above described with reference to the other illustrative embodiments of the invention.

The highly refractory material of the layer **22** is held in place firmly because of the shape of the spaces between the helical faces of adjacent strips, which, being warped surfaces around the tubes provide no zone of parallel or outwardly diverging planes, and resist the withdrawal of the interposed refractory. Furthermore, the refractory being positioned as it is, on the opposite sides of a single strip, and extending across the spaces of the serrations is held by the strip because the latter is not a flat surface, but rather a warped surface.

It is to be appreciated that, although the invention has been described with reference to the details of particular embodiments thereof, that it is not limited to those details, but is rather of a scope commensurate with the scope of the sub-joined claims.

The invention having been described in accordance with the requirements of the Revised Statutes and particularly sec. 4888, what is claimed as the invention is:

1. In a tubular structure adapted for use in fluid heat exchange apparatus, a metallic tube, and spaced metallic strips extending over one side of the tube only and secured thereto in good heat exchange relationship, the strips being formed with spaced outwardly extending teeth and being arranged along lines in the nature of helices enclosing the tube, the ends of each strip having wide teeth which are arranged at an angle to the strip and are aligned longitudinally of the tube so as to present structures in the nature of interrupted longitudinal fins along opposite sides of the tube, each fin-like structure being adapted to co-operate with a similar structure on an adjacent and similar tube to present a backing against which refractory material may be molded, the amount of metal affording heat transfer paths in an annular zone adjacent the tube and the bases of the teeth being greater than the amount of heat transfer metal afforded by the teeth exteriorly of that zone.

2. In a tubular structure adapted for use in fluid heat exchange apparatus, a metallic tube, and spaced metallic strips extending over one side of the tube only and secured thereto in good heat exchange relationship, the strips being formed with spaced outwardly extending teeth and being arranged obliquely to the longitudinal axis of the tube, the ends of each strip having wide teeth which are arranged at an angle to the strip and are aligned longitudinally of the tube so as to present structures in the nature of interrupted longitudinal fins along opposite sides of the tube, each fin-like structure being adapted to co-operate with a similar structure on an adjacent and similar tube to present a backing against which refractory material may be molded, the amount of metal affording heat transfer paths in an annular zone adjacent the tube and the bases of the teeth being greater than the amount of heat transfer metal afforded by the teeth exteriorly of that zone.

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