

Oct. 29, 1968

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3,407,871

HEAT EXCHANGER

Filed July 25, 1966

2 Sheets-Sheet 1

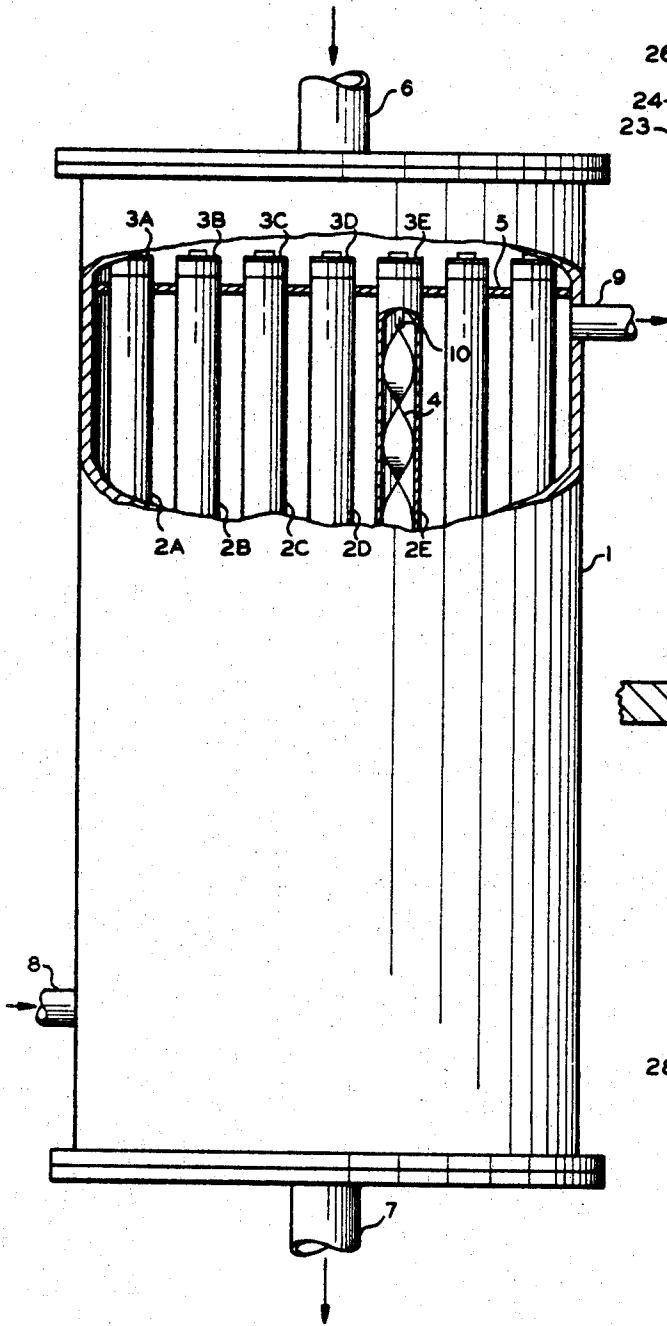


FIG. 1

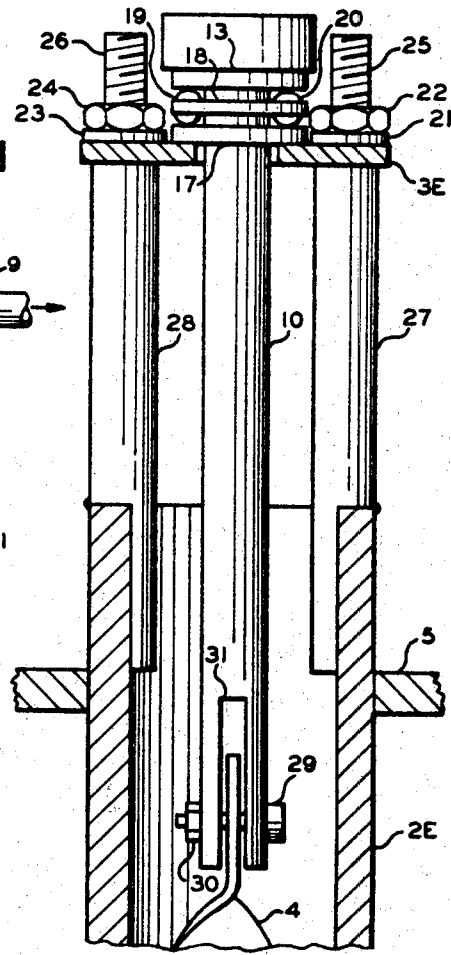


FIG. 2

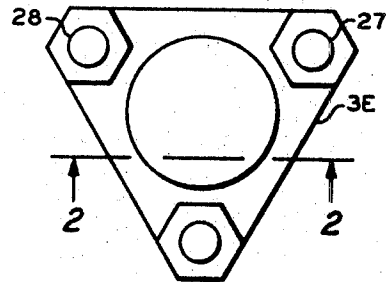


FIG. 3

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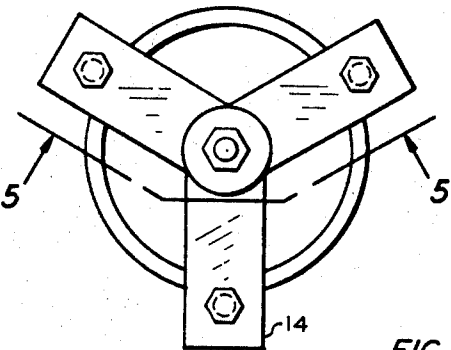


FIG. 4

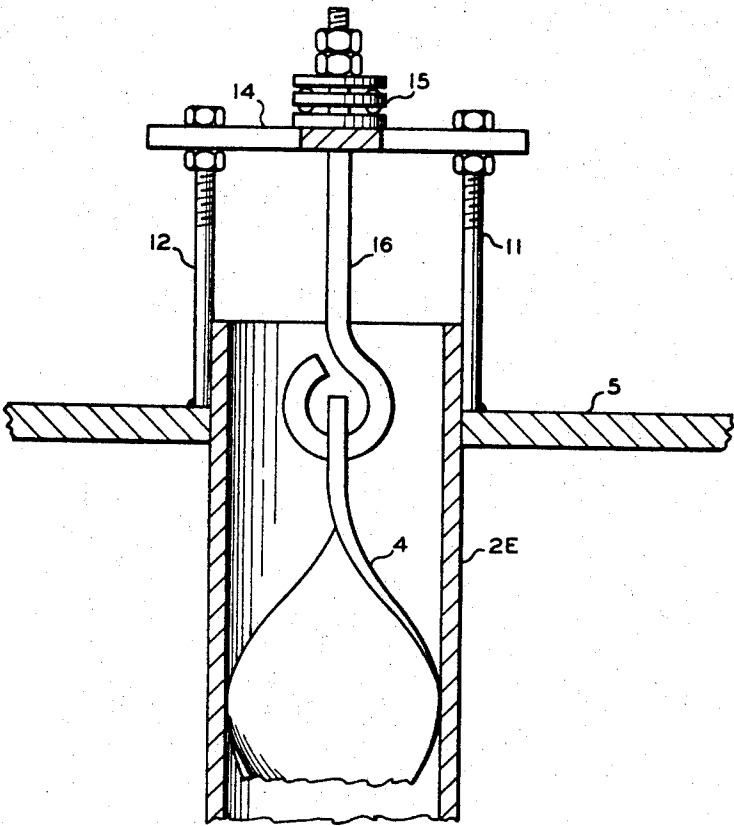


FIG. 5

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3,407,871

HEAT EXCHANGER

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Filed July 25, 1966, Ser. No. 567,471
3 Claims. (Cl. 165-85)

ABSTRACT OF THE DISCLOSURE

Heat exchange apparatus comprising a shell and a plurality of tube elements mounted therein wherein the tube elements contain a twisted strip approximately equal in width to the internal diameter of the tubes, and wherein the strip is freely rotatable within the tube and is under tension during passage of fluid through the tube, and wherein the twisted strip is connected to a readily mountable bearing assembly.

This invention relates to a heat exchange device of improved efficiency.

In another aspect, the invention relates to a heat exchange apparatus comprising at least one conduit enclosing a twisted strip approximately equal in width to the internal diameter of the conduit, the strip rotated by the movement of fluid through the conduit, and the strip rotatably mounted therein such that the strip is under tension during passage of fluid through the conduit.

In another aspect, the invention relates to a heat transfer apparatus comprising at least one conduit and a twisted strip substantially equal in width to the internal diameter of the conduit, and rotatably mounted therein by means of a bearing joined to the twisted strip at its upstream end.

In still another aspect, the invention relates to a heat transfer device comprising a plurality of conduits, means for aligning said conduits in substantially parallel relationship, and for preventing intermixing of process material and heat exchange medium, shell means substantially enclosing the conduit means and the means for aligning them, means for introducing heat exchange medium into said shell means, means for withdrawing said heat exchange medium from said shell means, means for introducing process material into said shell means and said conduit means, and means for withdrawing process material from said conduit means and said shell means.

Heretofore, it has been the practice to mount twisted strips rotatably in heat exchange tubes in such a manner that the force of material passing through the tubes rotates the strips but also tends to compress or buckle the strips. It is an object of this invention to provide a twisted strip heat exchange device in which the force of fluid passing therethrough rotates the strip and also places the tape (or strip) in tension. It is also an object of the invention to prevent binding of the tape against the tube or conduit wall during passage of material through the tube or conduit. Another object of the invention is to permit the use of longer and thinner strips (or tapes) in heat exchange devices, thus making the device more economical.

Other aspects, objects and the several advantages of this invention will be apparent to one skilled in the art from a reading of the disclosure, appended claims and the drawings.

The invention comprises a heat transfer apparatus comprising at least one conduit, having a twisted, rotatably mounted strip therein approximately equal in width to the internal diameter of the conduit such that the strip is under tension during passage of material through the conduit. Generally, a heat exchange device will comprise a plurality of conduits, each of which houses a twisted strip substantially equal in width to the internal diameter

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of the conduit and rotatably mounted therein by means of a bearing joined to the strip at its upstream end. However, the bearing need not be mounted outside the inlet end of the tube, but can be mounted inside of the tube or elsewhere. In any instance, the function of the invention is accomplished when the strip (or tape), which is adapted to fit closely within the tube, undergoes tension during the passage of material through the conduit. Though the strip has been described as "twisted," it is apparent from the drawings that a helical configuration is preferred because rotation of the strip is best effected by this shape.

The invention can best be understood by referring to the drawings in which FIGURE 1 shows the invention embodied in a once through heat exchanger;

FIGURE 2 shows a suitable mounting and a connection means for the strip;

FIGURE 3 shows the top view of a mounting plate for a twisted strip;

FIGURE 4 shows an alternate embodiment of a mounting for a twisted strip; and

FIGURE 5 shows an alternate connection between the twisted strip and the mounting plate thereof.

In FIGURE 1, shell means 1 houses a plurality of conduits 2A, 2B, 2C, 2D, 2E, and so on. A portion of conduit 2E is cut away, showing the twisted strip 4 rotatably mounted therein, and joined to mounting plate 3E through connection means 10. Tube sheet 5 holds the conduits in substantially parallel alignment and prevents process material from mixing with the heat exchange medium, which enters through conduit 8 and exits via line 9. Process material enters the shell means via line 6, flows into the conduits between the mounting plate and the conduit end, and passes through the conduits and out of the shell means via line 7. As the process fluid flows through the conduits, the twisted strips 4 are caused to rotate. The edges of the strips come in close proximity to the walls of the conduits but do not actually touch or scrape the walls. Actual contact of the twisted strips with the walls would result in binding of the strip and cessation of the rotation. Clearance between the strip edges and the conduit walls is in the range of 0.005 to 0.25 inch, depending on the process fluid, its viscosity, solids content, etc. With the small clearance specified and the strip in tension during rotation, the strip will tend to seek the center of the conduit, thereby avoiding contact with the conduit walls. In contrast, if the strip is in compression as in the case when only a downstream bearing is used, the strip will bind, contact the conduit wall, and stick.

As the twisted strip rotates, the thickness of the stagnant layer of fluid on the conduit walls is decreased, thereby increasing heat transfer rates. Fluid velocity at the conduit walls is also increased which eliminates fouling of the conduit walls with permanent deposits. High heat transfer rates are thus maintained for indefinite periods without the usual shutdown and clean-up periods required for other exchangers.

FIGURE 2 shows an elevated cross-sectional view of conduit 2E, twisted-tape 4, and mounting plate 3E. The tape is mounted atop the plate by means of lower bearing surface 17, race 18, which contains ball bearings 19 and 20, and other bearing surface generally indicated 13. Plate 3E is spaced from the end of conduit 2E by support rods 27 and 28 which are machined down to a smaller diameter and threaded at the upper ends as indicated by 25 and 26. At the other ends, the rods are machined as shown so as to slip inside conduit 2E. This construction method permits easy insertion of the twisted-tape assembly into the heat exchanger tubes of an existing exchanger in a commercial plant. It is merely necessary to remove the closure cap from the upstream end of the exchanger and insert a twisted-tape assembly into the end of each tube. No modifi-

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cation of the exchanger is required. Heat transfer in an existing exchanger is thus quickly and cheaply increased several fold.

Mounting plate 3E in FIGURE 2 is held in place by washers 21 and 23 and hex nuts 22 and 24. Plate 3E may be secured to rods 27 and 28 by other means such as welding, press-fit, etc. The bearing assembly is connected to the twisted-tape 4 by means of shaft 10 which contains slot 31 in the end thereof. Tape 4 is fastened to shaft 10 by bolt 29 and hex nut 30 as shown in FIGURE 2 or by use of a cotter pin or other suitable means.

FIGURE 3 shows a top view of mounting plate 3E, to which threaded rods 27 and 28 are secured. FIGURE 4 shows an alternative embodiment of the mounting plate, which is shown in the alternative mounting embodiment of FIGURE 5.

FIGURE 5 shows conduit 2E mounted in tube sheet 5. Mounting plate 14 is spaced from the end of the conduit by threaded bolts 11 and 12, and twisted-tape 4 is joined to bearing 15 through eyebolt 16. Bolts 11 and 12 may be welded to tube sheet 5 or threaded and screwed into holes in said tube sheet. From this drawing, it is apparent that any means can be used to join the tape to the bearing means.

It is clear that the concept of the invention is not limited to the type of heat exchanger shown in FIGURE 1. The shell and conduit means could be horizontally oriented, and U-shaped conduits could be employed. The number of conduits used is optional, and, though countercurrent flow of process streams is preferred, it is not necessary. Similarly, any suitable type of thrust bearing and/or connection between the bearing and the twisted-tape can be used. The bearing can be either ball or flat type, and can consist of a nylon or Teflon washer between two flat metal washers. The bearing could also be spherical, conical and so on. The connector between the bearing and the tape, as shown, can be an eyebolt, but can also be a flexible cable, a slitted and threaded rod and so on.

The bearing plate illustrated in the drawings is shown for illustrative purposes only. The plate could be of unit construction, could take on various shapes as dictated by cost and pressure drop through the pedestal or plate, and could be bolted or screwed to the tube or tube sheet if necessary. Generally, however, the force of the flowing material on the tape, and in turn, on the pedestal or plate will hold the plate firmly against the exchanger tube sheet. Further, one bearing plate could very well be used for three, four, or more tubes for triangular or square pitch respectively.

Reasonable modification and variation are possible within the spirit and scope of the invention, the essence of which is a heat transfer apparatus comprising at least one conduit, a twisted strip approximately equal in width to the internal diameter of the conduit, said strip being rotatably mounted in the conduit, whereby said strip is rotated under tension by passage of material through said conduit.

I claim:

1. A heat exchanger apparatus comprising, in combination:

- (a) shell means having means for introducing heat exchange medium into and withdrawing same from said shell means and means for introducing process mate-

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rial into and withdrawing same from tube elements disposed within said shell,

- (b) a plurality of tube elements arranged in substantially parallel relationship within said shell means,
- (c) a tube sheet means extending across said shell means and connected to said tubes at their inlet end for aligning said tubes in substantially parallel relationship and for preventing intermixing of process material and heat exchange medium,
- (d) a removable head connected to said shell at the tube sheet end of said shell means,
- (e) a twisted strip approximately equal in width to the internal diameter of said tubes rotatably mounted in said tubes whereby the strip is rotated under tension by passage of material through said tube elements, said twisted strips being rotatably mounted within said tubes by being connected to a bearing assembly joined to said twisted strip and mounted on the upstream or inlet end of the tubes, and
- (f) a bearing assembly comprising

- (1) a first bearing plate spaced from the end of the heat exchange tube so as to permit entry of fluid through the inlet end of the tube and cause rotation of said twisted strip upon passage through the tube,
- (2) a race containing ball bearings which bear on said first bearing plate,
- (3) a second bearing plate housing said ball bearings between it and the first bearing plate so as to provide free rotation of the second bearing plate upon the ball bearings between the two plates,
- (4) a shaft connected to said second bearing plate and the end of the twisted strip within the tube element within the tubes, and
- (5) support legs connected to said first bearing plate at one end and at the other end mounted onto the ends of the tubes, thereby permitting the insertion of a twisted tape assembly into the heat exchange tubes in an existing heat exchanger by merely removing the heat exchanger head from the upstream end of the exchanger and inserting a twisted tape and bearing plate assembly onto the ends of the tubes.

2. An apparatus according to claim 1 wherein the support legs mounted on the tube sheet are machined so as to slip onto the ends of the tube to facilitate said easy insertion of the twisted tape assembly into the heat exchanger tubes.

3. An apparatus according to claim 1 wherein the support legs for said bearing assembly are welded to the tube sheet.

References Cited

UNITED STATES PATENTS

2,070,427 2/1937 Faumce ----- 165—95

FOREIGN PATENTS

347,904 5/1931 Great Britain.

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