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HELICAL BAFFLE MEANS IN A TUBULAR HEAT EXCHANGER

Filed May 16, 1966

FIG-1

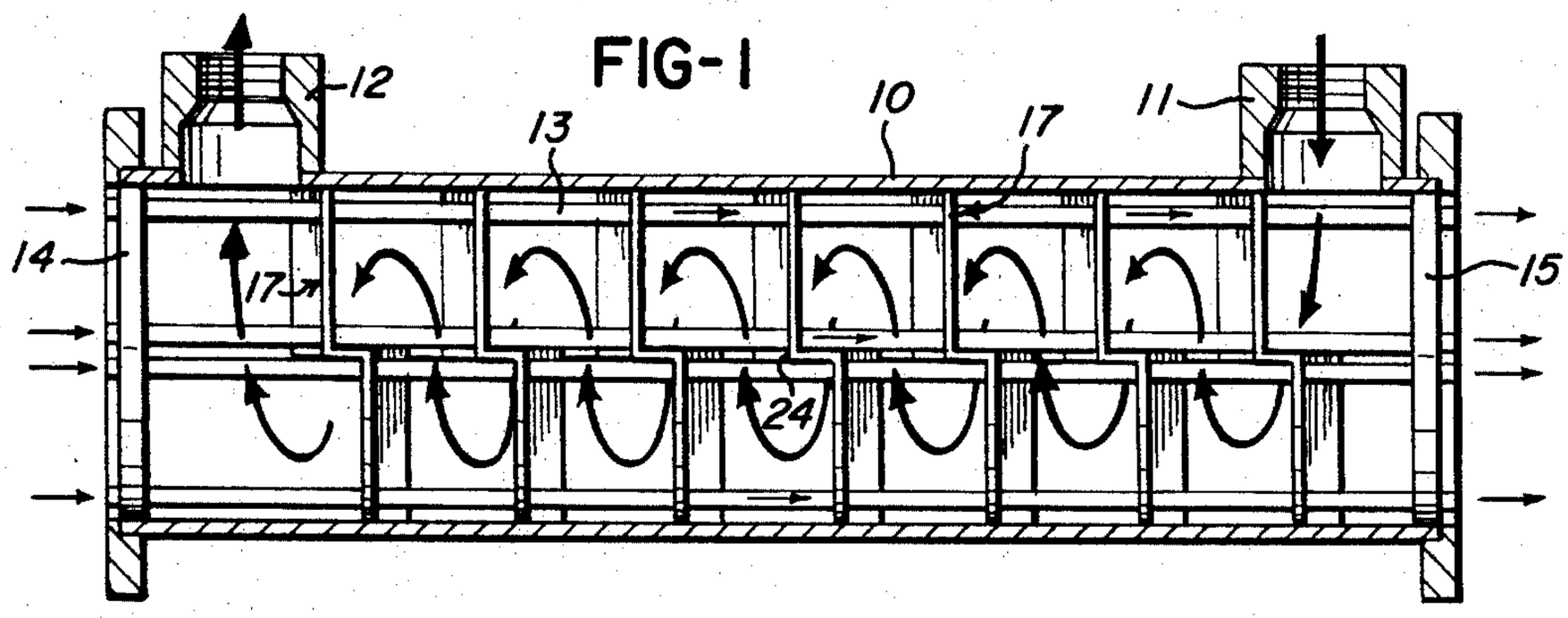


FIG-2

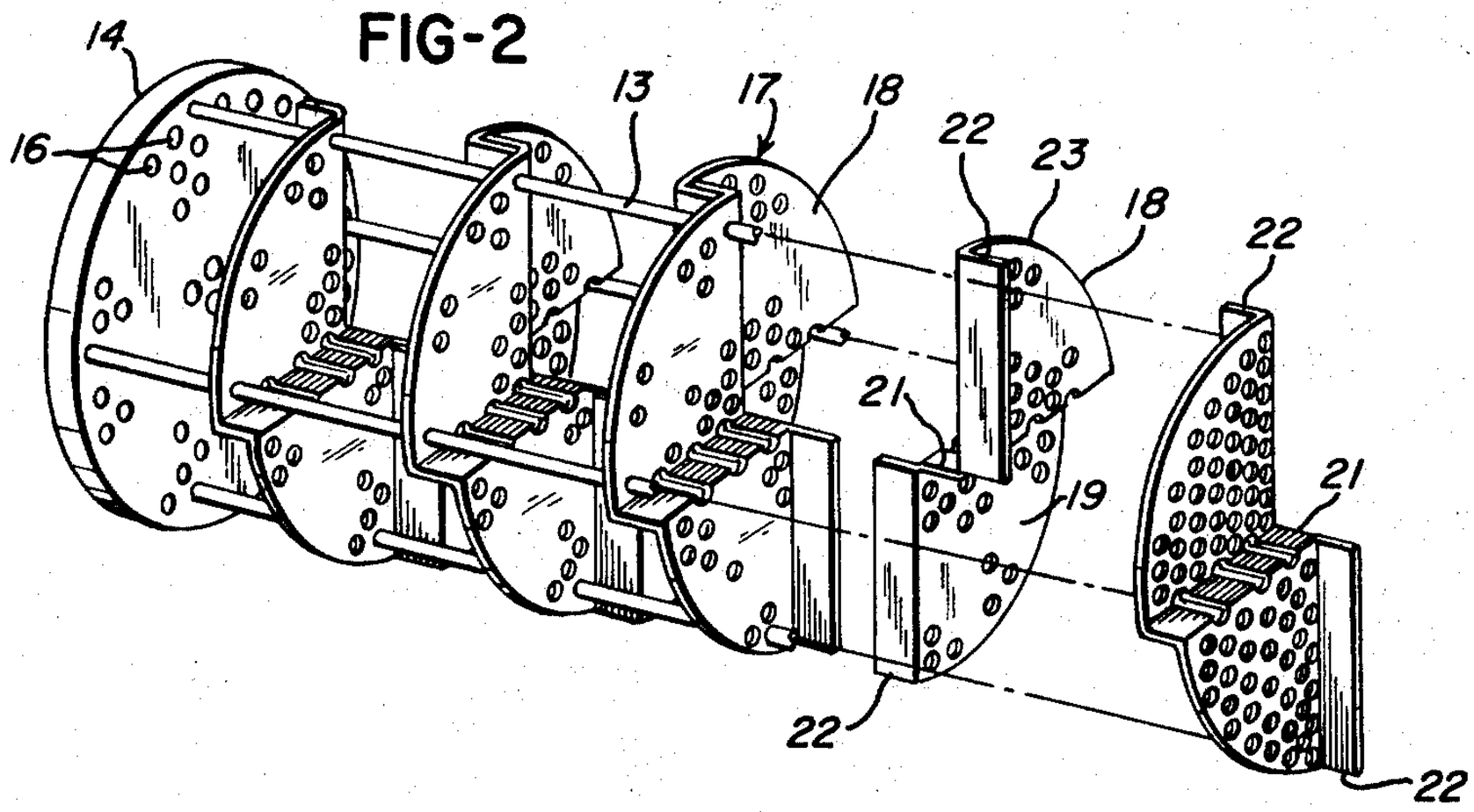


FIG-3

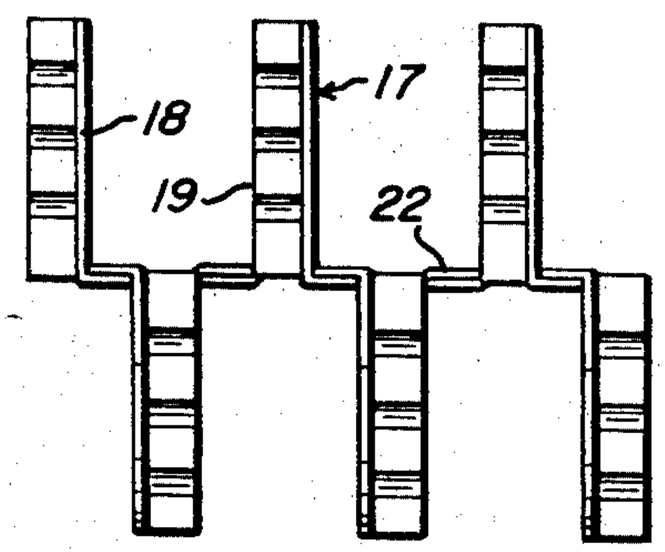
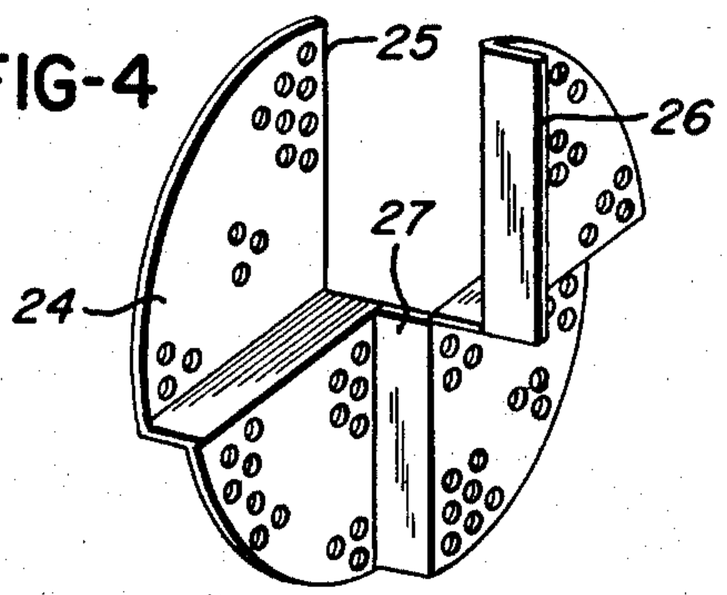


FIG-4



INVENTOR.
MAN SUK LEE

BY J. E. Hennigen

HIS ATTORNEY

United States Patent Office

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HELICAL BAFFLE MEANS IN A TUBULAR HEAT EXCHANGER

Man Suk Lee, Dayton, Ohio, assignor to United Aircraft Products, Inc., Dayton, Ohio, a corporation of Ohio

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ABSTRACT OF THE DISCLOSURE

A tube and shell type heat exchanger wherein the shell side fluid is caused to flow over the tubes in a helical path, baffle means being provided in the form of longitudinally spaced segmental plate elements having flow control surfaces which are perpendicular to the axes of the tubes simplifying installation and removal of the tubes.

This invention relates to tube and shell heat exchangers, that is, to heat exchangers comprised of a tube bundle installed in a shell for flow of a first fluid through the tubes and for flow of a second fluid over and around the tubes, the fluids being segregated and a transfer of heat taking place through the tube walls. Although not so limited, the invention has special reference to compact forms of heat exchangers having high density cores comprised of a large number of closely spaced apart tubes.

Tubular heat exchanger cores customarily incorporate baffles. These make possible a maximum use of available pressure drop and are usually arranged to effect repeated crossing and re-crossing of the tube bundle by the described second fluid for optimum heat transfer effect. In the past this has been done by installing in the tube bundle a series of separated, longitudinally spaced apart baffles which enforce a serpentine flow of fluid over the tubes between shell openings defining an inlet and an outlet. Such a baffling arrangement has certain disadvantages, as when portions of the provided heat transfer surface may be by-passed by the flowing fluid. More uniform flow at different flow rates is possible in a helical flow path with possibly superior heat transfer efficiency. However, the installing of baffle means to obtain a helical flow has heretofore been impractical, particularly in high density cores.

The advantages of such a construction have not been seen to outweigh the difficulties of fabrication, including the forming of the helix and the installation in the baffle means of large numbers of closely spaced tubes.

In accordance with the instant invention, however, generally new and improved results are achieved with helical baffle means and problems of fabrication are simplified or eliminated. The provision of a heat exchanger core having helical baffle means so characterized is an object of the invention.

Another object of the invention is to provide helical baffle means wherein openings in the baffles accommodating heat exchanger tubes are aligned for easy insertion and withdrawal of such tubes.

A further object of the invention is to construct a helical baffle means as described with steps interposing restrictions in the path of movement of the flowing fluid over the tubes in such manner that the flow intermittently is restricted.

Still another object of the invention is to present a generally new baffle means comprised of a plurality of component elements cooperating with one another to define a helix and being individually in a mutually supporting relation to tubes of the tube bundle.

Other objects and structural details of the invention will appear from the following description, when read

in connection with the accompanying drawings, wherein:

FIG. 1 is a partly diagrammatic view of a tube and shell heat exchanger, the shell being shown in longitudinal section with the core therein in side elevation;

FIG. 2 is a fragmentary view in perspective of the core of FIG. 1, a portion of the core being exploded to show details of baffle elements;

FIG. 3 is a detail view of a series of related baffle elements comprising the baffle means; and

FIG. 4 is a detail view of a modified form of baffle elements.

Referring to the drawings, a heat exchanger in accordance with the invention may comprise a shell **10** near respectively opposite ends of which are bosses **11** and **12** respectively for the inlet and outlet of a flowing fluid. The ends of the shell are open for flow therethrough of another fluid. The two fluids achieve a segregated, heat transfer relation within the shell **10**, the heat transfer surface being afforded by tubes **13**. These have their ends mounted in header plates **14** and **15** which are suitably perforated, as indicated at **16** in FIG. 2, to receive and pass the tubes with a comparatively close fit. A large number of closely spaced apart openings **16** provide for a large number of tubes **13**. For simplicity and clarity of illustration most of such openings are not here shown, and only a few tubes **13** are shown.

The header plates **14** and **15** have a peripheral bearing in the shell **10** and may be joined thereto in a leak proof manner. The fluid described as entering one end of the shell **10** and flowing longitudinally thereof to and through the opposite end is compelled to do so by flowing through the tubes **13**. The fluid entering the shell **10** by way of inlet **11** and exiting by way of outlet **12** moves through the shell exteriorly of the tubes **13**. The interior wall surface of the tubes **13** is thus contacted by one fluid of one temperature while the exterior wall surfaces of the tubes are contacted by another fluid at a different temperature. Heat transfer through the tube walls occurs, the fluid of higher temperature yielding up some of its heat to the fluid of lower temperature. As heretofore seen, in order to make optimal use of the heat transfer surface the fluid flowing exteriorly of the tubes is baffled to move repeatedly in a generally cross flow relation to the tubes. Such baffling is accomplished in accordance with the instant invention by helical baffle means **16**. Along with the tubes **13** and header plates **14** and **15** the baffle means **16** comprises the core of the heat exchanger. Conventionally the core is separately assembled and installed as a unit in the shell **10**.

The baffle means **17** achieves its extended character by a succession of angularly displaced steps. A perfect helix baffle is possible. It presents manufacturing difficulties, however, and affords no means by which the holes to accommodate the tubes **13** may be aligned in successive flights and may be round properly to receive the round tubes. Also, as will hereinafter more clearly appear, a perfect helix baffle does not provide the intermittent flow restriction of the present invention. Accordingly, the baffle means **17** has a stepped configuration and includes in the main segmental lands **18** disposed to lie in planes perpendicular to the axes of the tubes **13**.

Considering the baffle construction in greater detail, in the illustrated instance of FIGS. 1, 2 and 3, the baffle means is comprised of a plurality of formed plate-like elements **19**. Each element **19** is comprised of a pair of lands **18** which may be considered as occupying a side-by-side relation offset in a longitudinal sense by a wall or ledge **21** which unitarily joins the two lands at their adjacent edges. Opposite edges of the respective lands have turned over extremities **22** which project oppositely of one an-

other out of and at right angles to the planes of their respective lands. The bent over extremities **22** of each element **19** are in a common plane and define what may be considered one side edge of the element. The opposite side edge is defined by a curved periphery **23** conforming to and adapted substantially to seat against the interior surface of the shell **10**.

In assembling the baffle means, one of a pair of elements **19** in substantially face to face relation is rotated to achieve the laterally offset reversely disposed position illustrated by the exploded elements at the right hand end of FIG. 4. Moved in a relatively approaching direction, corresponding turned over extremities **22** are caused to interfit with one another and in limiting against respective lands **18** interrupt such relative approaching motion. While a pair of elements **19** is held so positioned, as for example by clamp means applied to the interfitting extremities **22**, other plate elements of appropriate rotary displacement are caused to approach and engage the assembled pair of frame elements at opposite ends thereof. The result is to extend the baffle means and this action is continued until a baffle means of desired length is achieved. The assembly results in a continuous helix formed of angularly displaced lands **18** interconnected either by integral walls **21** or by interfitting extremities **22** which are at right angles to the walls **21** and serve the same purpose. Ledges **21** and interfitting extremities **22** provide steps longitudinally spacing the lands **18** of individual plate elements and of corresponding lands of adjacent elements. A helical flow path is formed having its entrance end at the inlet **11** and its exit at the outlet **12**. The fluid in flowing through such path has a swirling motion in generally cross flow relation to the tubes **13** and is conducted from the inlet **11** to the outlet **12** in a number of turns appropriate to the heat rejection requirements, the allowed flow rates and pressure drops and other data pertinent to a particular heat exchanger.

In considering flow through the helical path as described it will be seen that the baffle construction intermittently enforces a flow restriction where the ledges **21** of adjacent flights of the helix or where the interfitting bent over extremities **22** of adjacent flights are aligned with one another. A passage **24** (FIG. 1) is defined at these locations of reduced cross sectional area as compared to the area immediately preceding and immediately beyond the such locations. Fluid encountering a passage **24** and an interposed step at the location of such passage has its flow constricted. The flow into the space beyond the passage, which space may be considered an expansion chamber, occurs under increased velocity conditions producing random flow and turbulence. A higher heat transfer rate through the tube walls results. Additionally, in advance of the passage **24** the restricted fluid breaks up in the corner of the step, producing eddies and turbulence in a manner to obviate pools or locations of low flow.

The individual plate elements may be circular in form as shown in FIG. 4, rather than semi-circular as in FIGS. 1 to 3. Thus, a plurality of circumferentially off-set lands **24** are positioned to occupy the quadrants of a circle. The circular configuration is split in one-half portion of the element and extremities are bent over to define opposite projections **25** and **26**. These correspond to the projections **22** of the plate elements **19** and are similarly adapted to interfit with corresponding projecting portions of companion elements. The remaining lands or quadrants of the circular plate element are joined by integral connecting walls **27** disposed at right angles to the lands **24** and achieving a longitudinally offset relation of the several such lands.

The lands **18** and **24** may be described as defining surfaces, each baffle means providing a succession of longitudinally spaced, angularly displaced such surfaces.

It will be evident that other modifications in the instant heat exchanger structure are possible within the spirit and concept of the invention as contained in the accompanying drawings and in the foregoing description, and in accordance with the claims to follow.

What is claimed is:

1. A core for a tubulous heat exchanger, including a plurality of tubes arranged in a bundle of parallel tubes for flow through the tubes of a first fluid and for flow over and around the tubes of a second fluid, heat transfer between the fluids occurring through the tube walls, and baffle means in the form of longitudinally spaced baffle elements in said tube bundle directing the flow of said second fluid, said baffle elements providing a succession of longitudinally spaced angularly displaced surfaces, said surfaces being interconnected at adjacent edges and adjacent elements being interconnected to define a helix forming a helical flow path for said second fluid, said surfaces being disposed substantially perpendicular to the longitudinal axes of said tubes and having openings receiving said tubes, said surfaces each conforming to a quadrant of a circle, the connected adjacent edges of said surfaces defining walls disposed angularly of said surfaces.

2. A core for a tubulous heat exchanger, including a plurality of tubes arranged in a bundle of parallel tubes for flow through the tubes of a first fluid and for flow over and around the tubes of a second fluid, heat transfer between the fluids occurring through the tube walls, and baffle means in said tube bundle directing the flow of said second fluid, said baffle means providing a succession of longitudinally spaced angularly displaced surfaces, said surfaces being interconnected at adjacent edges to define a helix forming a helical flow path for said second fluid, said surfaces being disposed substantially perpendicular to the longitudinal axes of said tubes and having openings receiving said tubes, said baffle means being formed of plate-like elements, each comprised of a plurality of lands in offset parallel relation to one another and interconnected at adjacent edges by relatively angularly disposed portions, other angularly disposed portions projecting oppositely from each element to achieve interengaging relation with corresponding projecting portions of adjacent elements, said lands defining said surfaces.

3. A core for a tubulous heat exchanger, including a plurality of tubes arranged in a bundle of parallel tubes for flow through the tubes of a first fluid and for flow over and around the tubes of a second fluid, heat transfer between the fluids occurring through the tube walls, and baffle means in said tube bundle directing the flow of said second fluid, said baffle means providing a succession of longitudinally spaced angularly displaced surfaces, said surfaces being interconnected at adjacent edges to define a helix forming a helical flow path for said second fluid, said surfaces being disposed substantially perpendicular to the longitudinal axes of said tubes and having openings receiving said tubes, said baffle means being formed of plate-like elements, each comprised of a succession of angularly displaced longitudinally spaced apart parallel lands, said lands defining said surfaces, said succession of lands terminating at its ends in portions projecting oppositely of one another substantially at right angles to said lands whereby each element may be joined to adjacent elements to form continuing baffle means as described.

4. A core according to claim **3**, characterized in that at least one of said elements is circular in configuration providing four lands as described defining the quadrants of a circle.

5. A core according to claim **3**, characterized in that at least one of said elements is semi-circular in configuration having two lands as described in a side-by-side relation.

6. A core for a tubulous heat exchanger, including a plurality of tubes arranged in a bundle of parallel tubes for flow through the tubes of a first fluid and for flow over and around the tubes of a second fluid, heat transfer

between the fluids occurring through the tube walls, baffle means in said tube bundle directing the flow of said second fluid, said baffle means providing a succession of longitudinally spaced angularly displaced surfaces, said surfaces being interconnected at adjacent edges to define a helix forming a helical flow path for said second fluid, said surfaces being disposed substantially perpendicular to the longitudinal axis of said tubes and having openings receiving said tubes, and steps in said baffle means resulting in longitudinally spaced lands defining said surfaces, correspondingly positioned lands defining a flow path therebetween, said flow path having on account of said steps alternating portions of greater and lesser flow restriction.

7. A core for a tubulous heat exchanger, including a plurality of tubes arranged in a bundle of parallel tubes for flow through the tubes of a first fluid and for flow over and around the tubes of a second fluid, heat transfer between the fluids occurring through the tube walls, and baffle means in said tube bundle directing the flow of said second fluid, said baffle means providing a succession of longitudinally spaced angularly displaced surfaces, said surfaces being interconnected at adjacent edges to define a helix forming a helical flow path for said second fluid, said surfaces being disposed substantially perpendicular to the longitudinal axes of said tubes and having openings receiving said tubes, said baffle means being comprised of a helix made up of a succession of lands parallel to one another to define said surfaces, adjoining lands being connected to one another along adjacent marginal edges by steps approximately at right angles to said lands, said steps narrowing said flow path at the locations thereof to provide for alternate restriction and expansion of the fluid flowing through said path.

8. A tubulous heat exchanger, including a cylindrical shell, perforate header plates in spaced relation to one another in said shell, fluid flowing tubes extending between and opening through said header plates, inlet and outlet openings in said shell for flowing a fluid through said shell over and around said tubes, and perforate baffle means intermediate said inlet and outlet openings through which said tubes extend, said baffle means having the form of a helix having an outer edge substantially in contact with said shell and being comprised of a succession of lands parallel to one another and approximately at right angles to the axis of said shell, successive lands being angularly displaced from one another and interconnected by steps approximately parallel to the axis of said shell, said steps interposing restrictions to flow in the helical flow path defined by said baffle means.

9. A tubulous heat exchanger according to claim **8**, characterized in that said baffle means is comprised of a succession of like elements, each element comprising a plurality of lands as described and terminating in portions of relatively opposite projection disposed approximately at right angles to said lands and cooperating with like portions on adjacent elements to define steps as described.

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ROBERT A. O'LEARY, *Primary Examiner.*

A. W. DAVIS, *Assistant Examiner.*