April 13, 1965 G. WALTER 3,177,936

FLUTED HEAT EXCHANGE TUBE WITH INTERNAL HELICAL BAFFLE

Filed June 5, 1963 2 Sheets-Sheet 1

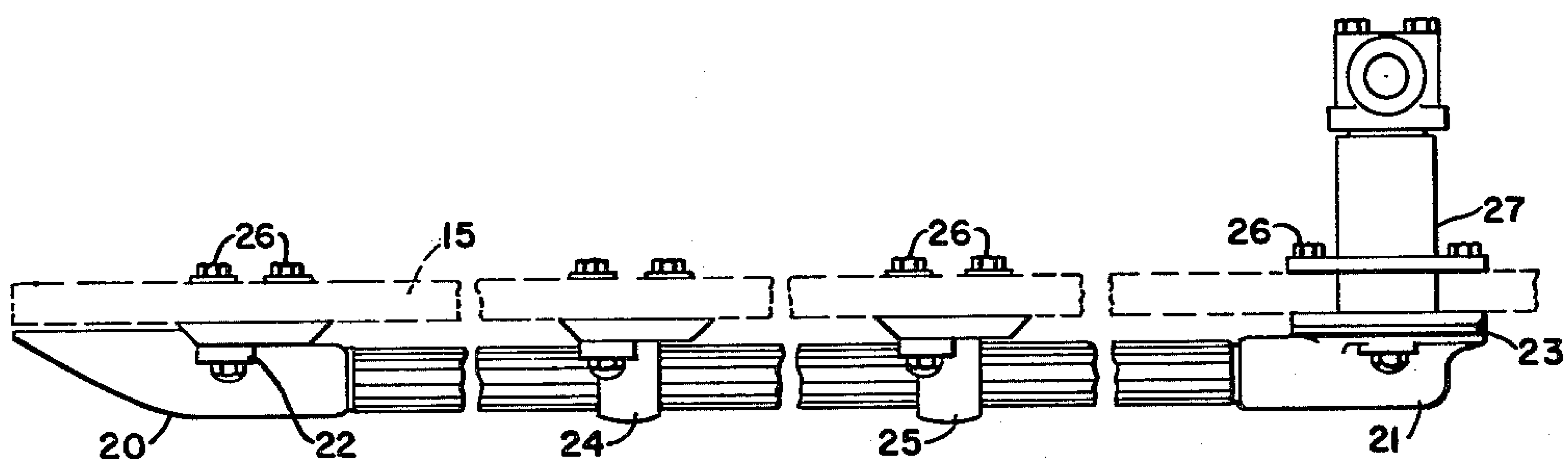

FIG. 1.

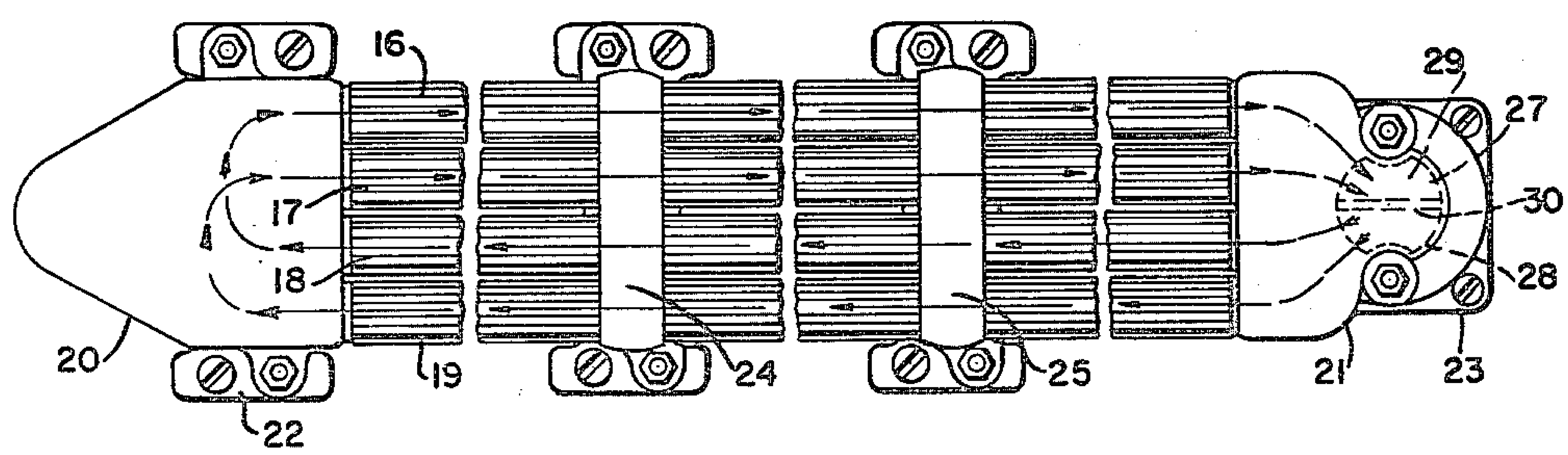

FIG. 2.

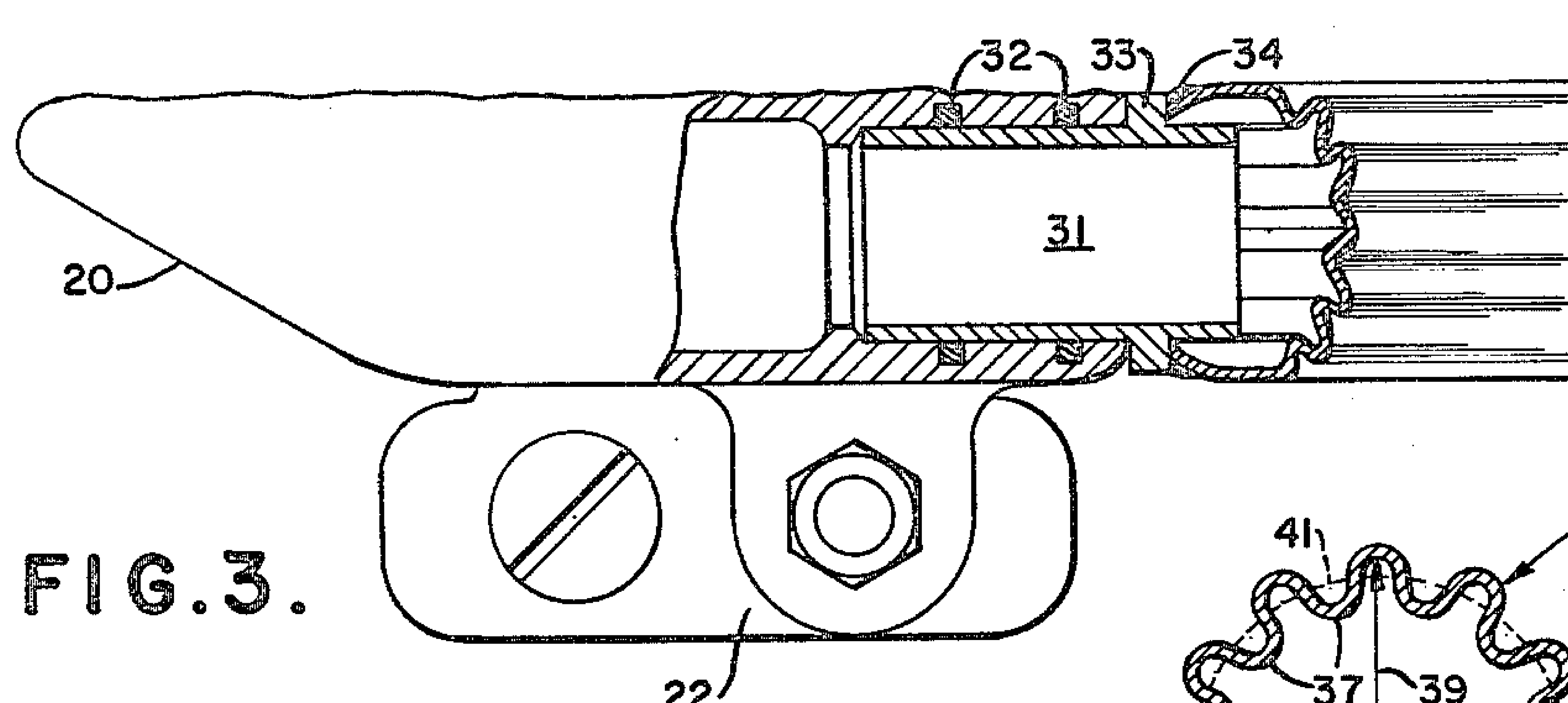

FIG. 3.

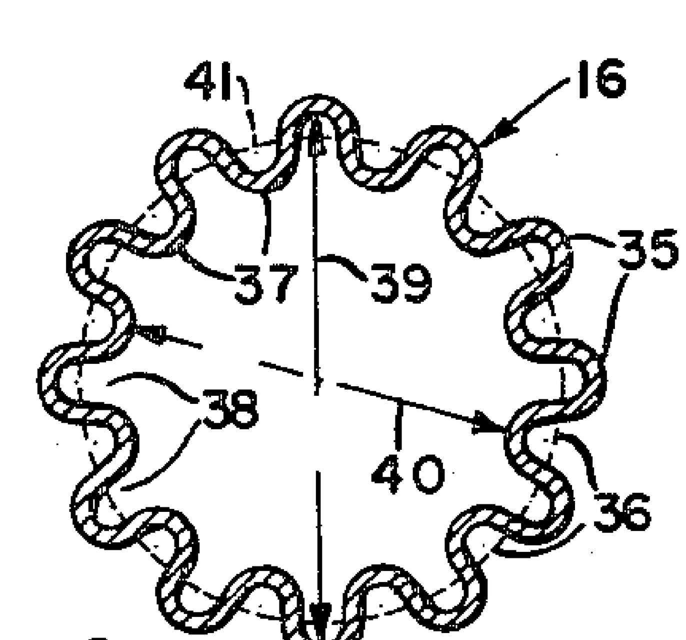

FIG. 4.

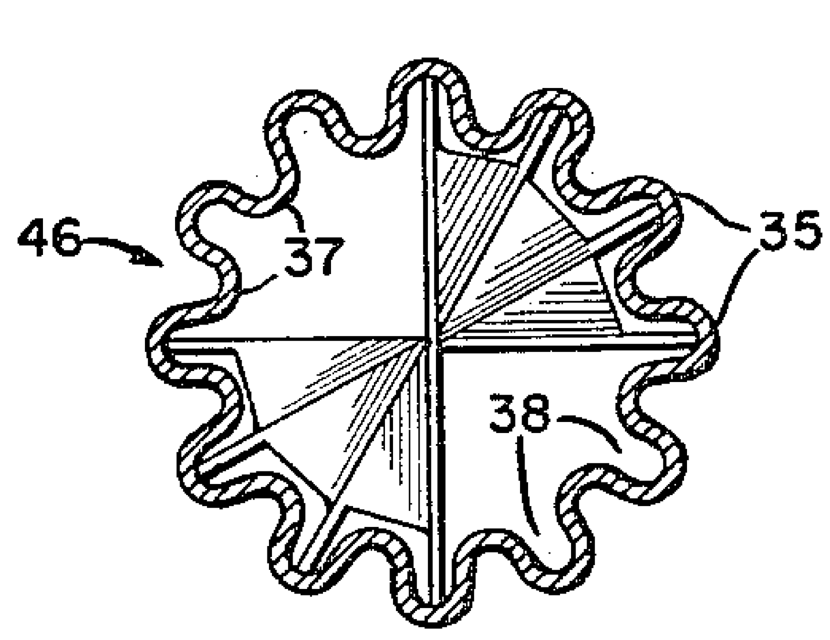

FIG. 5.

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FLUTED HEAT EXCHANGE TUBE WITH INTERNAL HELICAL BAFFLE

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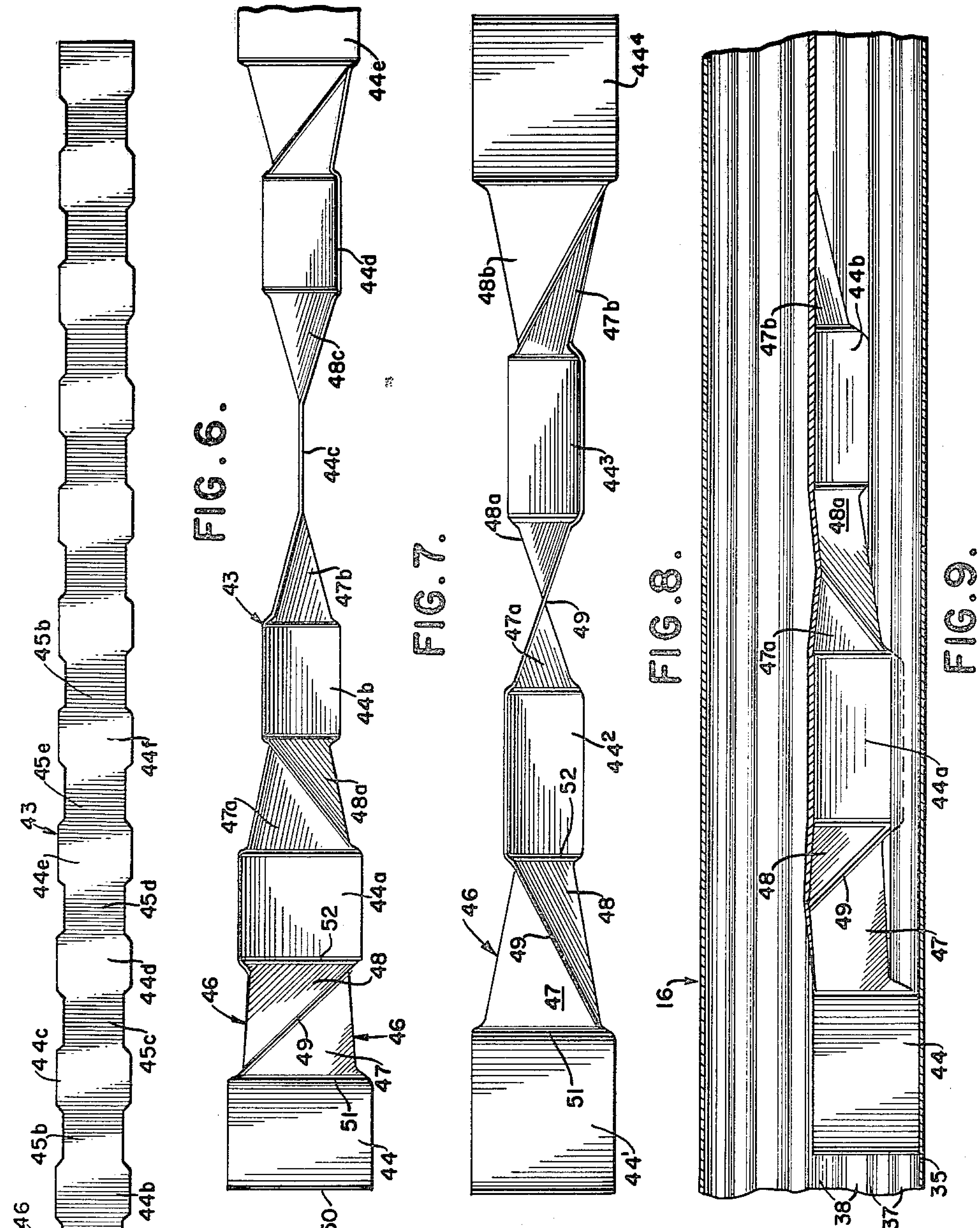

FIG. 6. FIG. 7. FIG. 8. FIG. 9.

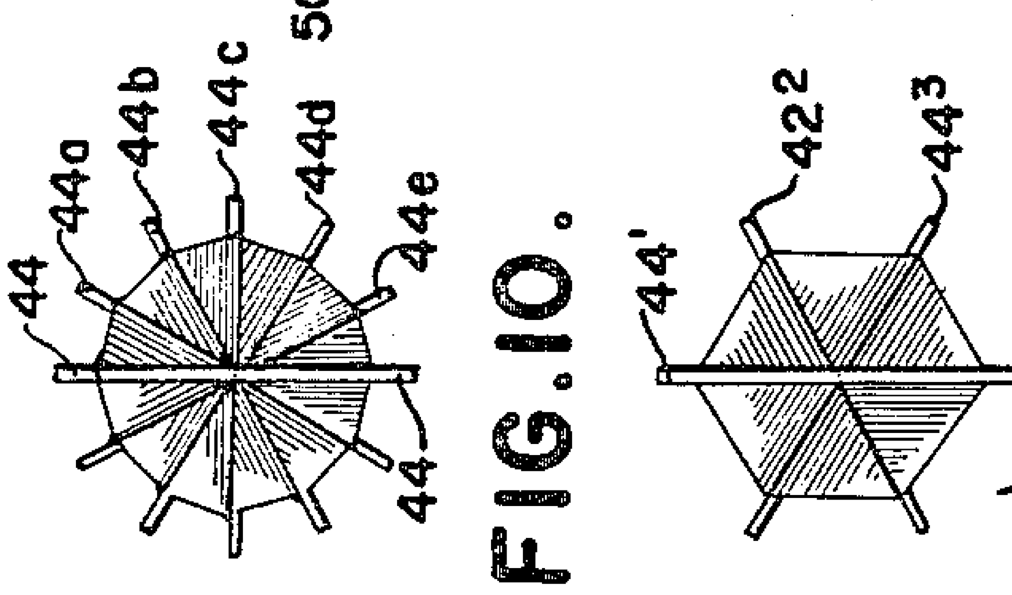

FIG. 10. FIG. 11.

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FLUTED HEAT EXCHANGE TUBE WITH INTERNAL HELICAL BAFFLE

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1 Claim. (Cl. 165—179)

The present invention relates to marine heat exchanger for engine coolant, and has for an object, among other objects and purposes, to provide a novel heat exchange unit for use in such engine cooling devices and systems as disclosed in my prior Patents 2,258,526, granted October 7, 1941, and 2,415,154, granted February 4, 1947.

Those prior patents provided keel cooling systems for marine engines in which heat exchangers were affixed beneath the hull of a boat involving closed fresh water cooling systems to protect the marine engines from the contamination and corrosion of raw water.

With the development of more powerful engines and fast power boats, the length of cooling tubes necessary to provide sufficient heat exchange for these engines, when installed in fast but comparatively short boats, is becoming prohibitive to fit available lengths beneath the boats, which reduced lengths also have raised problems of fastening conventional long cooling tubes to the keel or other portions of the bottoms of the boats.

In order to increase the rate of heat exchange experiments have been made with commercially available finned cooling tubes with the purpose to decrease the lengths of the cooling tubes while at the same time increasing the heat exchange capacity of the tubing.

However, while such finned cooling tubes increase the outside surface area, the inside surfaces remain plain and round or cylindrical so that as a whole such tubes have been found insufficient to provide sufficiently increased external surface cooling area to the fresh water inside the tubes. Furthermore, this available tubing has fins formed in a thread-like fashion which, when fastened to the bottom of the hull, are at right angles to the flow of the external cooling water over the tubes with the result that the flow over the external surfaces of the tubes is not desirably efficient since some of the particles of the water surrounding the fins are carried with the tubing at a reduced surface friction which diminishes the heat exchange.

It is the object and purpose of the invention to overcome the above difficulties by the development of a new form of tubing which admits of shorter length and smaller diameter while developing greater heat exchange capacity.

It is another object of the invention to provide fluted tubing in which the flutes on the tubing run lengthwise relatively to the movement of the tubes with the boat through the sea or other cooling water, thereby resulting in an efficient flow of this cooling water over the surface of the tubing.

A further object of the invention is to provide tubing of the smaller diameter referred to so that the same neatly fits to the bottom of the boat offering little drag or resistance to the speed of the boat.

A still further object of the invention is to provide in such a tubing a baffle or mixing device so constructed and arranged as to agitate the engine coolant water while flowing through the tubes in a manner to cause all of the engine coolant water flowing through the tubes to move toward and from the inner surfaces of the cooling tubes for good heat exchange.

A still further object of the invention is to provide a novel form of baffle or mixing device that partitions the tubes into at least two stream passages of a tortuous or serpentine form for increasing the paths of the coolant water longitudinally from end-to-end of the tubes, which

paths are in effect therefore longer than the lengths of such tubes.

With the foregoing and other objects in view, the invention will be more fully described hereinafter, and will be more particularly pointed out in the claim appended hereto.

In the drawings, wherein like symbols refer to like or corresponding parts throughout the several views:

FIGURE 1 is a side elevational view of an improved marine heat exchanger for engine coolants constructed in accordance with the present invention and shown as applied to a boat hull or keel indicated in broken lines.

FIGURE 2 is a bottom plan view of the same.

FIGURE 3 is an enlarged sectional view through one of the headers and one of the novel tubes showing a preferred form of tube mounting.

FIGURE 4 is a cross-sectional view taken through a preferred form of tubing.

FIGURE 5 is a view similar to FIGURE 4, showing a preferred form of baffle or mixing device installed in the tube.

FIGURE 6 is a side elevational view of a blank from which a form of baffle or mixing device may be constructed in any desired length to accommodate the selected length of tubing.

FIGURE 7 is a partial side elevational view of a form of baffle or mixing device which may be constructed from such blank.

FIGURE 8 is a side elevational view of another form of baffle or mixing device in a completed stage.

FIGURE 9 is a fragmentary longitudinal sectional view of a tube taken on an enlarged scale and illustrating the application of the baffle or mixing device to the internal structure of the tube.

FIGURE 10 is an end elevational view of the baffle according to FIGURE 7, taken from the left end thereof.

FIGURE 11 is an end elevational view of the form of baffle shown in FIGURE 8, taken from the left end thereof.

Referring more particularly to the drawings, **15** in FIGURE 1 designates the hull or keel of a boat, and **16**, **17**, **18** and **19** designate a cooling unit of four heat exchange tubes constructed in accordance wtih the preferred form of the invention.

These tubes are fitted at their opposite ends into terminal header fittings **20** and **21** which are affixed to the boat by end supports **22** and **23**. Intermediate clamps **24** and **25** embrace the tube assembly and are also connected by bolts **26** or other fastenings beneath the keel or hull **15** of the boat so that the tubing and headers are exposed externally to the sea or other water.

A stem or stand pipe rises through the hull **15** from one of the headers **21**. In this stand pipe are chambers **28** and **29** separated by a partition **30**. One of these chambers, for instance the chamber **28**, receives hot water from the engine water jacket, which hot water is circulated through certain of the tubes from the header **21** to the header **20** and thereupon in a return flow through other tubes back to the header **21** and to the opposite chamber **29** for recirculation of the cooled water back to the engine, all in accordance with the arrow indications in FIGURE 2.

Referring more particularly to FIGURE 3, a preferred form of mounting the tubes **16**, **17**, **18** and **19** to the headers **20** and **21** is by the use of tube adapters **31** of a cylindrical form open at both ends and fitted with neoprene or other rings **32** into the headers. These tube adapters **31** are provided with outstanding flanges **33** adapted to abut against the ends of the headers at one side and to receive at the other side the abutting ends of the tubing which is affixed to the adapters and/or to the flanges **33** by silver solder **34** or otherwise.

Referring more particularly to FIGURE 4 which shows a cross-section on an enlarged scale through one of the tubes according to a preferred form of the invention, 35 designates longitudinally running circumferentially spaced external projections of the tube wall separated by external spaced grooves 36 opening outwardly.

The tube wall is so fashioned as to provide longitudinally running circumferentially spaced internal projections 37 separated by internal grooves 38 which also run parallel with the axis of the tube. The internal groove diameter is indicated at 39 and the internal projection diameter at 40, from which it will be seen that the internal grooves 38 and the internal projections 37 are arranged in diametric pairs, which pairs are angularly displaced around the circumference of the tube.

The broken circular line 41 indicates the mean circumference of the tube, the external projections 35 and the internal projections 37 extending respectively outside and inside this circumferential line 41 in a configuration resembling a sine curve resulting in a wave-like effect which is probably best described as a fluted tube wall.

Although this preferred form of tube may be of any desired material and produced in any suitable manner, it is recommended that the tubes be seamless, thin-walled, for example of .025 inch thickness of Monel stainless corrosion resistant material. Such material will discourage barnacles and is of great strength. Initially a plain walled cylindrical tube of approximately 1½ inches outside diameter is selected and shaped or formed over a mandrel having an external wave-like pattern by rollers which reduce the diameter to approximately 1⅛ inches outside diameter.

It will be noted that the flutes of the tubing run lengthwise or axially in line to the flow of the cooling water which thus results in an efficient flow of this cooling water over the surface of such tubes.

The form of the tube also cooperates in a novel manner with the mixing baffle 43, shown more particularly in FIGURES 6 to 11.

The baffle may be made from stock stamped out as indicated in FIGURE 6 and cut off into desired lengths to accommodate the selected length of the tubing into which it is to be inserted. This stock strip comprises generally an axial succession of diametric plates in any suitable number designated 44, 44^a, 44^b, 44^c, 44^d, 44^e, 44^f, et cetera, separated by an axial succession of twist joint strips 45, 45^a, 45^b, 45^c, 45^d, 45^e, 45^f, et cetera.

The plates 44, 44^a, et cetera, are flat throughout their length and breadth or height in order to slidably fit into the diametric paths of internal grooves 38 of the tube, the plates being of a width or height approximately that of the length of the diametric line 39 illustrated in FIGURE 4 with suitable tolerance to permit of the plate sliding freely in the diametric pairs of grooves 38 into which it is initially slidably fitted. In this condition the plate is flanked at both diametric opposed edges by internal projections 37 which therefore stabilize the plates against the reaction of the cooling water flowing through the tubes and in general hold the plates to alignment.

As shown in FIGURES 7 and 10, successive plates 44, 44^a, 44^b, 44^c, 44^d and 44^e are displaced angularly from one another about the axis of the tube in the order stated by the angles subtended by the various diametric pairs of internal grooves 38 of the tube. Thus these diametric plates 44, 44^a, et cetera, are progressively stepped angularly around the circumference of the tube, the same being connected together by the twist strips 45, 45^a, 45^b, et cetera, which twist strips are of lesser wall width or have cut away portions 46 to clear the internal projections 37 of the tube at cross-over points to permit the twist strips 45, 45^a, et cetera, to connect adjacent diametric plates 44, 44^a, et cetera, at their rear and forward edges 51 and 52 respectively.

While the twist strips may be fashioned in any suitable form so as to join such rear and front edges 51 and 52, of adjacent angularly disposed diametric plates 44, 44^a, et cetera, it is preferred that these twist strips be comprised of leading sections 47, 47^a, 47^b, et cetera, and trailing sections 48, 48^a, 48^b, 48^c, et cetera, in which the sections 47 et cetera and 48 et cetera are approximately triangular in form, being joined together by hypotenuse lines of division 49. The hypotenuse lines 49 are common to the pairs of triangles 47, 48 and 47^a, 48^a, et cetera, so that these triangular sections are in the form of mutual triangles.

These two triangular sections between each pair of diametric plates slope from the hypotenuse line 49 in substantially opposite directions to the edges 51 and 52 of the diametric plates so that the twist strips not only connect adjacent diametric plates which partake of no curvature but they also present to the streams of coolant water in the tube on opposite sides of the mixing baffle offset inclined surfaces diverting and directing the coolant water from the core throughout all strata to and against the internal fluted walls of the tubes thereby bringing all portions of the internally circulating coolant into circulating contact with such walls at which maximum cooling effect takes place.

From FIGURE 10 it appears that six of the diametric plates suffice to comprehend the entire 360 degrees of the circle where twelve pairs of internal grooves 38 are embodied in the tube wall.

In FIGURE 11 three diametric plates 44^1, 44^2 and 44^3 suffice where the diametric plates are successively displaced angularly from one another through angles defined by every second diametric pair of internal grooves 38.

In FIGURE 7 the numeral 50 indicates the free edge of the diametric plate 44, first or last in the order of succession.

In the use of the device the tubes, fabricated as indicated or otherwise, are mounted between the headers and the heat exchanger fixed in place on a boat, being connected to the water cooling system of the engine in a circulation system.

The mixing baffles are of course inserted in the fluted tubes before the latter are mounted in the headers, or at least before the tubes are mounted in one of the headers. Such baffles are introduced into the open ends of the tubes by axial sliding motion in which the leading diametric plate is fitted into selected diametric pairs of internal grooves 38. The baffle is thereupon moved axially inward with the reduced diameter following twist strip entering the tube unimpeded by the internal projections 37 so that the next diametric plate will be correctly alined with the next diametric pair of internal grooves 38, or the next diametric pair of such internal grooves 38 as may be selected to receive the next diametric plate dependent upon the amount of angular twist given the intermediate twist strip, thereupon the lateral edges of this next diametric plate are entered into the diametric pair of internal grooves 38 presented thereto, it being understood that the relative angular positioning of the diametric plates will be such that each successive plate will accurately fit and easily slide in its designated diametric pair of grooves 38 with intermediate twist strips freely clearing the internal projections 37 at cross-over points and between adjacent diametric pairs of internal grooves 38.

With the baffles in place and the tubes connected to both headers, the device is ready to receive streams of water in each tube separated by its baffle with the baffles imposing on the two streams tortuous or serpentine patterns of flow both in the same rotative direction, that is, clockwise or counterclockwise dependent upon whether viewed from one or the other end of the tube.

The heat exchanger is thus reduced in over-all dimensions, the tubes admit of closer grouping and of shorter length while maintaining adequate heat exchange. With the device the pressure drop is less with more heat exchange. The tubing can be reduced, for instance from a length of ten inches to a length of six inches.

The mixing baffle may also be of Monel or other metal.

The twist strips impart the swirl pattern to the two streams on opposite sides of the baffle or partition, while the diametric plates support the twist strips and stabilize such strips in position against the reaction of the water currents. The twist strips may also receive some support and orientation at cross-over points from the internal projections with which they may be in contacting relation.

With reference to FIGURE 8 in comparison with FIGURE 11, it will be noted from FIGURE 11 that the length of the mixing baffle will extend from diametric plate 44^1 to the third plate in order 44^3; although FIGURE 8 shows an additional twist strip 47^b, 48^b and an additional diametric plate 44^4. These last two elements have been added in FIGURE 8 to show that where the tube is longer than from 44^1 to 44^3 the sequence may begin all over with a twist strip 47^b, 48^b leading to the diametric plate 44^4 which corresponds in position and orientation with the initial diametric plate 44^1. The series of course may be added to, as indicated in FIGURE 6, any length desired.

The unit length 44^1 to 44^3 is much shorter in FIGURE 8 than the unit length 44 to 44^e in FIGURE 7 due to the fact that the twist strips in FIGURE 8 go through a greater angle of turning because the plates are stepped through angles corresponding to two of the internal grooves 38 of the tube; whereas in FIGURES 7 and 10 the twist strips are turned through the smaller angles between adjacent internal grooves 38.

FIGURE 9 corresponds to FIGURE 7 except that the scale is larger and FIGURE 9 is fragmentary.

The main purpose of my invention is to reduce the length and bulkiness of cooling tubes in an outboard marine engine cooling system. It is of utmost importance to obtain a simple and efficient system as unobtrusive as possible. The average modern motorboat, particularly the pleasure cruiser, is shorter and faster than its predecessor; its engine or engines are more powerful, thus, in order to fresh water cool this engine or engines, the cooling tubes of the outboard cooling systems must be more efficient to fit in a shorter space on the bottom of the boat hull and, at the same time, small enough in diameter to present minimum drag to the speed of the vessel.

Therefore, by folding or fluting, a 1½ inch diameter tube having a surface area of 4.71 square inches for every inch of length, its diameter can be reduced to 1⅛ inches without losing any cooling area, whereas the plain 1⅛ inch diameter tubing has only 3.53 square inches area per inch of length or approximately 75% of the same diameter folded or fluted tube. A marine engine requiring twenty feet of 1⅛ inch cooling tubes for proper heat exchange can thus be effectively cooled with fifteen feet of the same diameter folded or fluted tube. By folding or fluting a 1½ inch diameter tube, as above mentioned, to 1⅛ inch diameter, the cross-sectional area of this fluted tube is then approximately the same as that of the 1⅛ inch diameter plain tube. However, since the length of this folded or fluted tube can be reduced by 25%, namely, from twenty to fifteen feet, the resistance to the flow of the water through this tubing is then also reduced. For instance, to circulate a large amount of cooling water through the engine jackets, then through the keel cooler, a low pressure centrifugal circulating pump is best suited for this purpose. However, such a pump will cavitate an increasing amount of water as the resistance to the

flow of water increases and volume of circulation diminishes. Assuming that the cross-sectional area of the cooling tubes does not restrict the volume of circulation, then the length of cooling tubes is of utmost importance.

A 25% reduction in the length of the cooling tubes will substantially decrease the resistance to the flow of the cooling water through the cooling system and engine water jackets, resulting in a higher volume of cooling water circulation and additional cooling efficiency.

Although I have disclosed herein the best forms of the invention known to me at this time, I reserve the right to all such modifications and changes as may come within the scope of the following claim.

What is claimed is:

A heat exchange unit comprising

(*a*) a tube having

(*b*) a fluted wall with

(*c*) axially running circumferentially spaced external projections forming therebetween

(*d*) external spaced grooves opening outwardly and

(*e*) axially running circumferentially spaced internal projections forming therebetween

(*f*) internal spaced grooves opening inwardly,

(*g*) said external and internal projections being angularly displaced from one another,

(*h*) said external and internal grooves being also angularly displaced from one another,

(*i*) said internal grooves being relatively arranged in diametric pairs,

(*j*) a mixing baffle dividing the tube internally and longitudinally comprising

(*k*) an axial succession of diametric plates having side edge portions received in diametric pairs of the internal grooves and held by adjacent internal projections against angular shifting movements,

(*l*) said diametric pairs relatively displaced about the axis of the tube through successively greater angles, and

(*m*) twist joint strips joining adjacent plates,

(*n*) said strips being of reduced diameter compared to the plates to snugly clear the internal projections at cross-over areas,

(*o*) said strips comprising

(*p*) leading and trailing triangular sections bent in relatively opposite directions along hypotenuse lines,

(*q*) said leading sections connected with the rear edges of the plates and sloped from the planes of the plates laterally of said planes,

(*r*) said trailing sections sloped from the hypotenuse lines to the forward edges of the next successive plates.

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CHARLES SUKALO, *Primary Examiner.*