Sept. 16, 1958 R. S. LYNN 2,852,042

TURBULATOR

Filed April 7, 1951

Fig. 1.

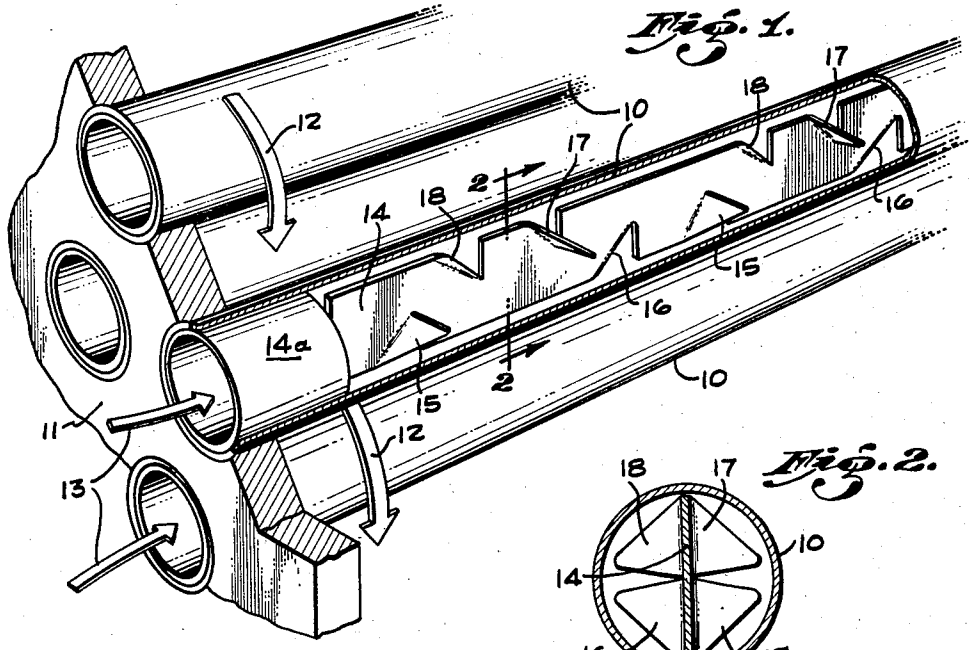


Fig. 2.

Fig. 3.

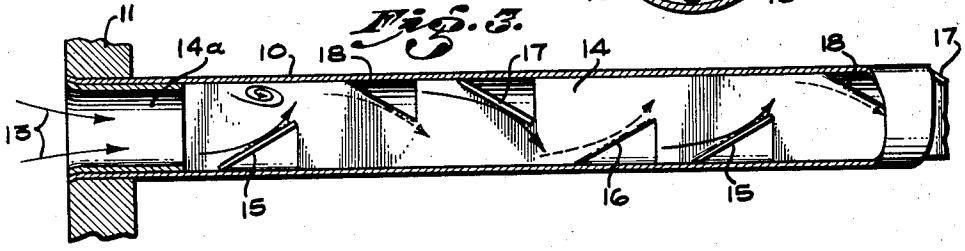
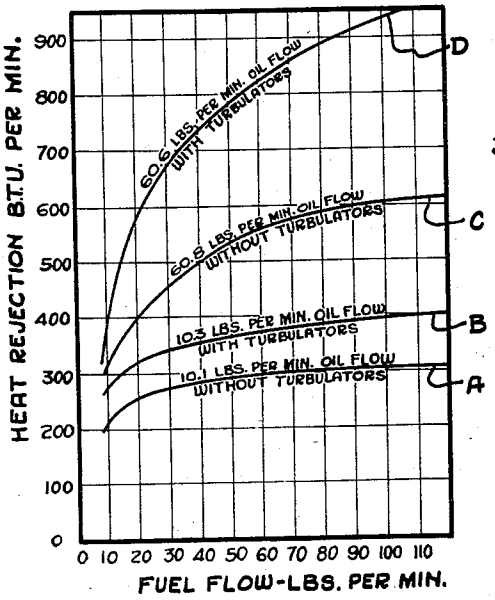


Fig. 4.



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TURBULATOR

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7 Claims. (Cl. 138—38)

This invention pertains to heat transfer mechanisms, and particularly relates to a novel turbulator for increasing the transfer of heat between fluid media flowing in heat exchange relationship in a heat exchange device.

In such heat exchange devices wherein heat transfer occurs through a wall separating non-intermixing fluids, it is desirable that the fluids exchange heat from the hotter to the colder with the greatest facility. The device of the present invention contributes materially to an increase of heat transfer by causing one of the fluids to flow in turbulent fashion along a wall of the exchanger, whereby more of the fluid is caused to come into intimate contact with the walls and thereby to increase the amount of heat transfer over that which would ordinarily occur without such turbulent flow.

It is an object of the invention to provide a turbulator which breaks up the laminar flow of a fluid in the tube of a heat exchanger, thereby causing more of said fluid to come into contact with the tube walls, in a scrubbing action which increases the heat exchange effect.

It is another object to provide a device which agitates and breaks up the static boundary layer of a fluid which tends to form on a wall of the exchanger.

It is a further object to provide a turbulator of the type which is adapted to ease of manufacture from strip material and which may be conveniently cut to length and readily assembled in a heat exchanger tube.

It is another object to provide a turbulator of the strip type having turbulating tabs outstanding from the sides of the strip, which tabs are punched, stamped, or otherwise bent outwardly from the strip itself.

It is a further object to provide, in a heat exchanger having a wall dividing fluids between which heat transfer is to take place through the wall, strip means extending along said wall on a side thereof in the direction of flow of one of said fluids, said means being provided with turbulating tab means formed from said strip means and causing laminar flow of said fluid to be interrupted and changed into turbulent flow, and further causing breakup of boundary layer formation at spaced intervals.

A preferred embodiment of a turbulator, incorporating the features of my invention, is shown and described herein without intending to limit the scope of the invention to such embodiment.

Referring to the drawing, wherein like numerals are applied to like parts of the figures,

Fig. 1 is an enlarged partial sectional view of a portion of a heat exchanger, showing a turbulator installed in one of the tubes,

Fig. 2 is an enlarged cross-sectional view of the aforesaid turbulator-equipped tube, taken on line 2—2 of Fig. 1,

Fig. 3 is a longitudinal, partial sectional view of such a tube, taken on line 3—3 of Fig. 2, and

Fig. 4 is a performance curve of a typical heat exchanger, with and without turbulators of the present invention.

Referring to Fig. 1, there is shown a portion of a tubular type heat exchanger having each end of a plurality of tubes **10** secured in a header **11** by brazing, or other preferred means. It will be understood that the other ends of the tubes **10** (not shown) are similarly secured in another header—like that shown at **11**. The heat exchanger may be of the familiar, light-weight tubular type generally associated with aircraft for cooling engine lubricating oil. In some exchangers the oil may flow across the outside of the tubes in heat transfer relation with a coolant fluid flowing through the tubes. In the present embodiment, the coolant flows across the tubes as indicated by the heavy arrows **12** and the oil to be cooled is directed through the tubes as indicated by the arrows **13**. The invention contemplates that any suitable and convenient gaseous or liquid fluid may be utilized as a coolant, and the embodiment depicted utilizes liquid fuel intended for the engine as the coolant fluid.

Disposed within each tube **10** is a turbulator **14** held therein by a ferrule **14***a* which is likewise secured by brazing, or any preferred method in each end of the tube (only one being shown). The turbulator **14** is comprised of a flat strip of material, preferably aluminum, having successive series of outstanding tabs **15**, **16**, **17**, and **18** throughout its length, against which the laminar flow of the oil impinges, there being four tabs in each of the series. As shown, tabs **15** are bent out from one edge of the strip to one side thereof and tabs **16** from the same edge but to the opposite side. Tabs **17** are bent out to the same side as tabs **15** but from the opposite edge of the strip, while tabs **18** are outstanding to the same side as tabs **16** but at the opposite edge.

As viewed in Fig. 2, it is seen that the turbulator strip **14** is of a width to fit snugly within and diametrically of the tube **10**. Each tab is formed by transversely slitting the strip at the desired point for approximately one-half its width, and subsequently bending a corner at the slit approximately 90° to the strip, causing the tips of the tabs so-formed to lie closely adjacent the wall of the tube when the turbulator is inserted. Although the description is for a preferred embodiment, it is apparent that the tabs could be formed by slitting the strip at any preferred angle other than at right angles to the edge of the strip for a distance more or less than half the width thereof. It is also seen that the tabs may be bent up to form any selected angle with the strip other than 90°. It will be noted further that the tabs are bent to alternate sides from each edge of the strip, the purpose being to cause equal and opposite counteracting forces to be applied to the strip by the flow of fluid through the tube, so that any tendency of the strip to turn within the tube is nullified; expressed otherwise, the torque component (counterclockwise) exerted on tabs **16** and **17** is cancelled by the clockwise torque component on tabs **15** and **18**.

Referring again to Fig. 2, it is seen that the turbulator tabs prevent laminar flow throughout the length of the tube, since any series of four successive tabs presents a cross-sectional projection constituting a large majority of the area of the inner cross-section of the tube. The amount of such projected area is dependent to some extent on the lengths of the edges of the tabs and on the angle they make with the strip. As to the remaining area, boundary layer formation is effectively broken up by virtue of the sharp edges of the tabs presented immediately adjacent such layer forming portions of the tubes.

Referring to Fig. 3, the arrows indicate an approximation of the scrubbing action of the oil, although this is mere assumption, since the actual flow pattern is unknown. It can be said however, that the pattern is extremely tur-

bulent at least throughout substantially the length of tubes, as a study of Fig. 4 will prove.

This last figure shows the actual performance of a heat exchanger having 85 tubes, each being approximately 14 inches long, .210 inch in outside diameter, and about .010 inch in wall thickness. The figure plots fuel (coolant) flow against heat rejection in B. t. u. per min., the coolant having an inlet temperature of 130° F. and the hot oil an inlet temperature of 272.2° F., at flows of hot oil of 10.1 pounds per minute for curve A (without turbulators), 10.3 pounds per minute for curve B (with turbulators), 60.8 pounds per minute for curve V (without turbulators), and 60.6 pounds per minute for curve D (with turbulators). All four curves show a sharp rise of heat rejection as the coolant flow is increased. Curves A, B, and C show considerable leveling-off at the higher coolant flow rates, whereas curve D is still rising rather steeply at the test limit. The turbulator strips in the tubes each had 52 tabs spaced approximately ¼ inch apart.

A glance at the curves reveals an unanticipatedly large increase in heat rejection with the use of turbulators patterned after the present invention. For oil flows of 10.1–10.3 pounds per minute, the heat rejection was increased approximately 30% by the use of turbulators. In the case of oil flows of 60.8–60.6 pounds per minute, the increase in heat rejection varied from about 45% at 10 pounds per minute coolant flow to over 53% at 100 pounds per minute flow of coolant. The improvement is startling, considering the apparent simplicity of the device.

It has also been found that substantially the same quantitative improvement is obtained if the coolant is caused to flow through the tubes and the hot oil over the outside thereof. Furthermore, it was discovered that within the range of possible test error, there is no difference in the figures if the fluid flowing through the tubes is reversed from the direction indicated by the arrows 13 of Figs. 1 and 3.

I claim:

1. An agitator for tubular heat exchangers comprising, a spine section formed of comparatively rigid material and having lobes struck out transversely therefrom substantially at right angles to the longitudinal plane of the spine section and with the plane of each lobe disposed at an angle to a transverse radial plane normal to the opposite longitudinal edges of the spine section and with the planes of alternate lobes oppositely disposed with respect to the respective radial plane.

2. An agitator for tubular heat exchangers comprising a spine section having lobes struck out transversely therefrom on opposite sides substantially at right angles to the longitudinal plane of the spine section with the planes of the respective lobes on one side of the spine section disposed at a common angle inclined to a transverse radial plane normal to the opposite edges of the spine section and with the planes of the respective lobes on the other side of the spine section also disposed at a common angle inclined to a transverse radial plane normal to the opposite edges of the spine section the common angle of the second lobes being opposite to the common angle of the first lobes.

3. A turbulator to be positioned interiorly of a heat exchanger tube to create turbulent flow of fluid passing through such tube comprising, a planar strip having spaced uni-directional slits formed to extend inwardly of each edge of said strip and terminating short of the strip width, a triangular tab bent outwardly from the plane of said strip at each slit along a line extending diagonally from the inner end of the slit to a point on the edge of said strip, the points being spaced longitudinally toward the same end of said strip relative to the slit from which the corresponding tab is bent, successive tabs along the length of said strip being bent to extend outwardly from opposite sides of said strip with the tips of said tabs being disposed closely adjacent to a circumference embracing the opposite edges of the strip.

4. A turbulator as recited in claim 3 wherein said unidirectional slits extend inwardly perpendicular to the edges of said strip.

5. A turbulator as recited in claim 3 wherein said tabs are bent to extend ninety degrees from the plane of said strip.

6. A turbulator to be positioned interiorly of a heat exchanger tube to create turbulent flow of fluid passing through such tube comprising, a planar strip having pairs of spaced slits formed to extend inwardly of each edge of said strip and terminating short of the strip width, the pairs of slits on one edge of said strip being alternated along the length of said strip with the pairs of slits on the other edge of said strip, a tab bent outwardly from the plane of said strip at each slit along a line extending from the inner end of the slit to a point on the edge of said strip, the points being spaced longitudinally toward the same end of said strip relative to the slit from which the corresponding tab is bent, the tabs at each pair of slits being bent to extend outwardly from opposite sides of said strip.

7. A turbulator to be positioned interiorly of a heat exchanger tube to create turbulent flow of fluid passing through such tube comprising, a planar strip having pairs of spaced slits formed to extend generally perpendicularly inwardly of each edge of said strip and terminating substantially midway of the width of said strip, the pairs of slits on one edge of said strip being alternated along the length of said strip with the pairs of slits on the other edge of said strip, a tab bent outwardly from the plane of said strip at each slit along a line extending from the inner end of the slit to a point on the edge of said strip, the points being spaced longitudinally toward the same end of said strip relative to the slit from which the corresponding tab is bent, the tabs at each pair of slits being bent to extend outwardly from opposite sides of said strip.

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