June 27, 1961 E. F. FARRELL 2,990,163

TURBULIZER

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Fig. 2

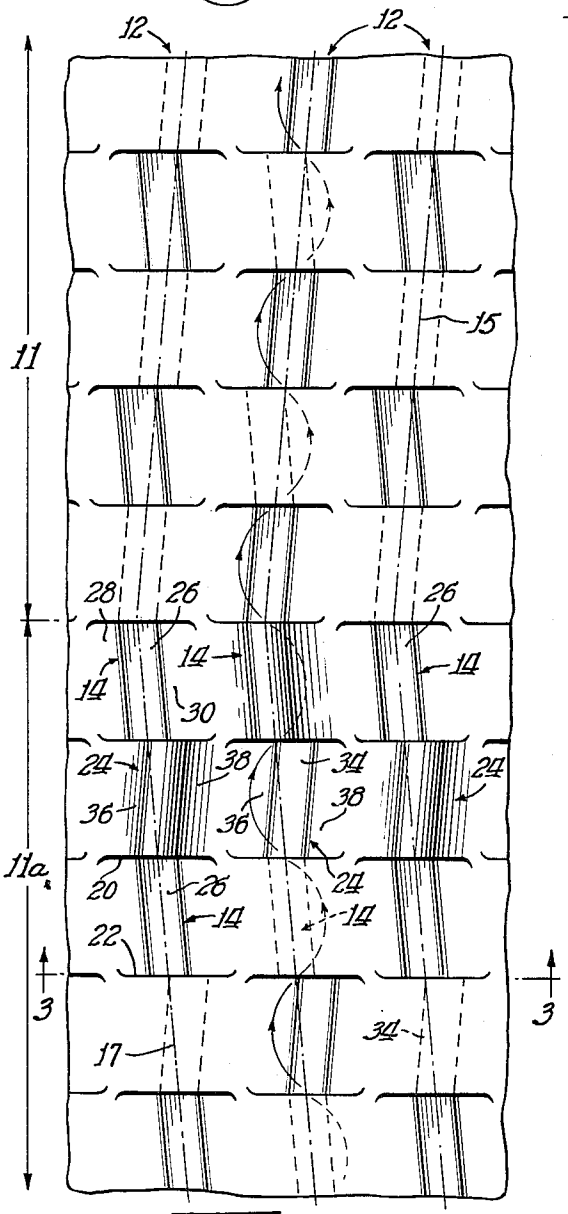


Fig. 1

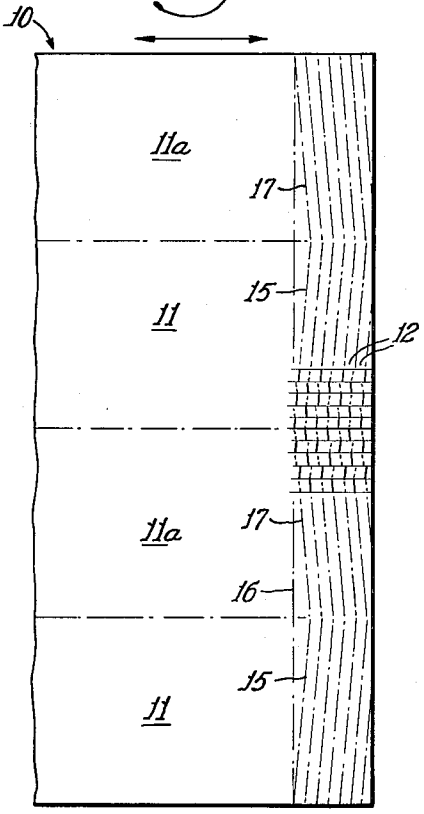


Fig. 4

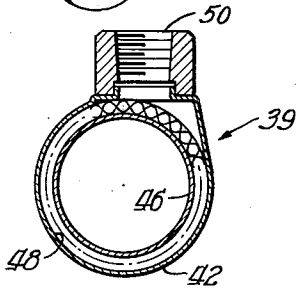
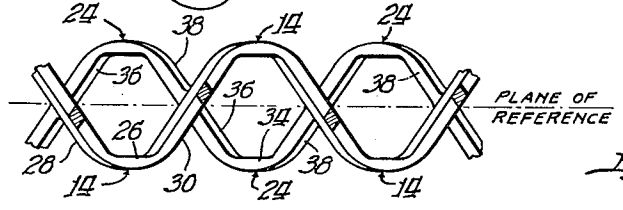


Fig. 3



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TURBULIZER

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Fig. 5

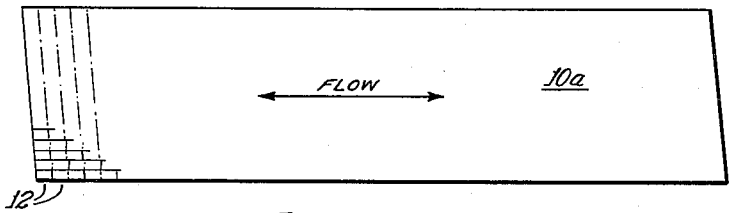


Fig. 6

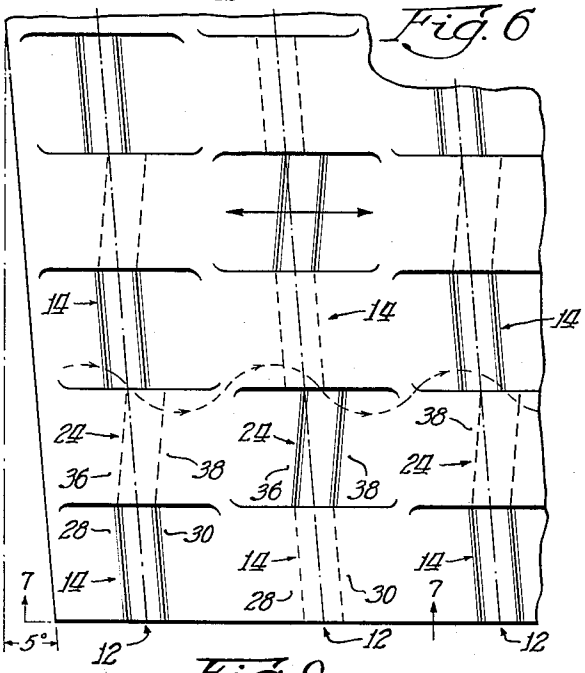


Fig. 7

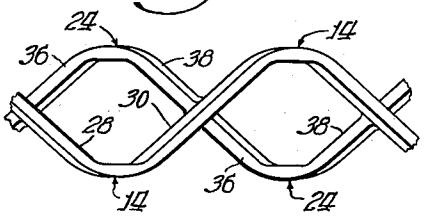


Fig. 8

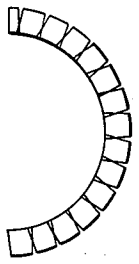
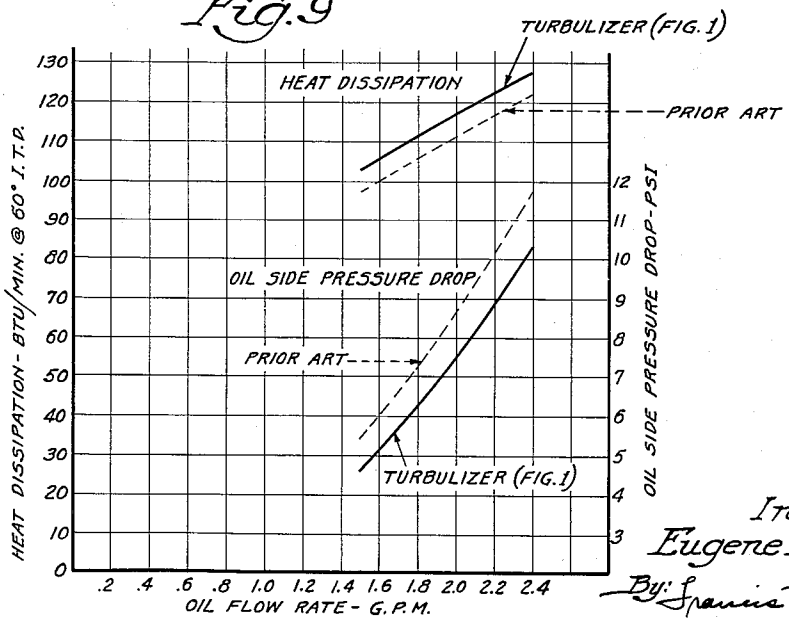


Fig. 9



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2,990,163

TURBULIZER

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10 Claims. (Cl. 257—246)

This invention relates to heat exchangers and more particularly to a heat exchanger having a turbulizer for enhancing the heat transfer between liquid to be cooled and a coolant.

This invention is primarily directed to a heat exchanger of the type utilized to cool automatic transmission fluid and more particularly to a heat exchanger turbulizer constructed and arranged in an annular passage, the walls defining the passage being in heat exchange relation to the coolant in the bottom tank of a radiator of an automotive vehicle.

In prior constructions, turbulizers have been formed from flat ribbon stock and have been characterized by longitudinally aligned groups of U-shaped corrugations offset from the plane of the flat stock and defined by transversely aligned parallel slits. The material between each pair of adjacent slits in a group was positioned at opposite sides of the original plane of the group to form the U-shaped portions. The corrugations of each group were alternately disposed on each side of the plane of the stock with respect to the corrugations of adjacent groups and characterized by crests extending transversely of the stock so that the oil flowing through the cooler impinged against the leading surfaces of the several corrugations, the planes of which extend angularly with respect to a transverse plane and normal to the longitudinal axis and direction of flow. The fluid had a tendency to divide and form an irregular pattern and the resistance to flow through a chamber or passage having a particular cross section and length was constant.

It is an object of the present invention to provide a turbulizer of the stated type wherein the several corrugations extend at an angle to the direction of flow with respect to perpendicular transverse axes so that the oil passes through the annular passage in a predetermined tortuous path.

A further object of the invention is to provide a turbulizer of the mentioned character wherein the corrugations may be disposed in a manner that the oil flows in predetermined tortuous paths in alignment with the axes of formation of the several corrugations.

Another object of the invention is to provide a turbulizer for a heat exchanger of the type utilized to cool automatic transmission fluid in which the flat stock may be bent about one axis for a predetermined pressure drop for a particular dimension of annular passage and may be bent upon a perpendicular axis for a different pressure drop for a particular dimension of passage.

A further object of the invention is to provide a turbulizer in accordance with the preceding objects in which the angularity of the corrugations with respect to the perpendicular axes may be varied to obtain a predetermined pressure drop for a heat exchanger having an annular passage of particular dimensions.

Another object of the invention is to provide a turbulizer of the type described in which the flat stock is bent in a manner that the corrugations are constructed and arranged to afford a flow of oil in streams characterized by a major sinusoidal path and in which the streams assume a minor sinusoidal path with respect to the major sinusoidal path.

A further object of the invention is to provide a turbulizer of the type described in which the flat stock is formed with a plurality of longitudinally disposed groups of corrugations extending in parallel initially at a predetermined angle with respect to the transverse axis of the stock for a predetermined distance, extending oppositely angularly for a predetermined distance, and then extending with respect to the transverse axis at the same angle as initially and wherein each group comprises a first series of corrugations extending out of the plane of the stock in one direction in alignment with the group axis and a second alternate series of corrugations each corrugation of which extends out of the plane of the stock in the opposite direction at a predetermined opposite angle with respect to the adjacent corrugations of the first series.

Another object of the invention is to provide a heat exchanger having a turbulizer formed from flat stock in which the stock is formed with a plurality of transversely disposed corrugation sections including a first series and an alternate series in which the sections of the first series are formed with a plurality of groups of corrugations extending at an angle to the transverse axis of the stock, in which the sections of the alternate series are formed with a plurality of groups of corrugations extending at an equal and opposite angle to the transverse axis of the stock in which each group comprises a first series of corrugations extending outwardly in one direction from a plane of reference and an alternate series of corrugations extending oppositely from the plane of reference and in which the longitudinally disposed corrugations of adjacent groups are alternately on one side and the other of the plane of reference.

A further object of the invention is to provide a heat exchanger having a turbulizer in accordance with the preceding objects which is formed from a continuous strip of metal and which may be bent upon either the longitudinal or transverse axis of formation for different pressure drops when used in an annular passage.

Another object of the invention is to provide a turbulizer of the stated type which may be utilized in flat form in a flat type heat exchanger.

This invention consists of the novel constructions, arrangements, and devices to be hereinafter described and claimed for carrying out the above stated objects and such other objects as will be apparent from the following description of preferred forms of the invention, illustrated with reference to the accompanying drawings, wherein:

FIGURE 1 is a plan view of the present turbulizer in flat form showing the manner in which the corrugation sections are arranged to afford the major sinusoidal path;

FIGURE 2 is a greatly enlarged prior view of the present turbulizer in flat form showing the manner in which the minor sinusoidal paths within the major sinusoidal paths are effected;

FIGURE 3 is an elevational sectional view taken substantially on line 3—3 of FIGURE 2;

FIGURE 4 is a vertical sectional view of an oil cooler embodying the turbulizer shown in FIGS. 1, 2, and 3.

FIGURE 5 is a plan view, similar to FIGURE 1, but illustrating the present turbulizer in the flat form it assumes prior to bending about an axis coplanar with the longitudinal axis of the flat sheet for flow of the oil in the manner indicated by the dotted line.

FIGURE 6 is a greatly enlarged plan view of the oil cooler illustrated in FIGURE 5;

FIGURE 7 is a vertical sectional view taken substantially on line 7—7 of FIGURE 6.

FIGURE 8 is an end view illustrating half of a turbulizer, of the type illustrated in FIGURES 5 and 6, in the position it assumes in the oil cooler passage; and

FIGURE 9 is a chart illustrating the efficiency of the turbulizer of FIGURE 1 as compared to a turbulizer made in accordance with the prior art.

Referring to the drawing, and more particularly to

FIGURES 1 and 2, the turbulizer of the present invention is indicated by reference numeral **10** in the flat form it assumes prior to bending about a transverse axis as will be hereafter described. FIGURE 1 shows a portion of the strip stock from which the present heat exchanger is formed, the double arrow indicating the longitudinal axis of the strip stock. The stock is divided laterally into a series of sections **11** and an alternate series of sections **11*a***, each of which has a plurality of groups **12** of corrugations arranged in substantially longitudinal alignment. Each of the groups **12** of the sections **11** includes a first series of corrugations **14** formed on an axis of formation **15** extending at an angle to the transverse axis **16** of the strip **10** while each of the groups **12** of the sections **11*a*** includes a first series of corrugations **14** formed on an axis of formation **17** extending at an equal and opposite angle to the transverse axis **16**. The several successive axes **15** and **17** form a plurality of major sinusoidal paths for the flow of oil, as will be apparent. Each corrugation **14** is defined by a longitudinally extending slit **20** and a similarly extending slit **22** longitudinally offset from its associated slit. Each group **12** further includes an alternate series of corrugations **24** extending at a slight opposite angle to the axis of formation of the corrugations **14** and to the transverse plane **16**. As shown in FIGURE 3 longitudinally successive corrugations **14** and longitudinally successive corrugations **24** are disposed successively on opposite sides of the plane of reference of the strip **10** so that transversely adjacent each depressed corrugation **14** is a raised corrugation **24**. It will be noted that all of the corrugations **14** in the left and right groups illustrate FIGURE 2 below the plane of reference, while in the central group illustrated in FIGURE 2 all of the corrugations **14** are above the plane of reference. So also, all of the corrugations **24** in the end groups illustrated in FIGURE 2 are above the plane of reference while all of the corrugations **24** in the central group illustrated are below that plane. All of the successive corrugations **14**, above and below the plane of reference, are in longitudinal alignment. So also of the corrugations **24**.

Referring again to FIGURE 3, each corrugation **14** has a base **26** and angularly extending walls **28** and **30**. Each corrugation **24** has a base **34** and angularly extending walls **36** and **38**. The included angularity of the walls **28** and **30**, and of the walls **36** and **38**, in the preferred form of the invention is approximately 64°.

Fluid to be cooled flows through the preferred form of turbulizer in the manner illustrated by the dotted line in FIGURE 2. During the course of passage, it flows in a major sinusoidal path through the several changes of direction of the axes of formation **15** and **17** of the series of sections **11** and **11*a*** respectively and while traversing that path it flows in a secondary sinusoidal path with respect to the major sinusoidal path. It will be noted that the secondary sinusoidal path is of greater frequency than the major sinusoidal path and that the fluid flows in parallel streams and in each section **11*a***, impinges against a wall **30** of each corrugation **14**, a wall **36** of each corrugation **24** of the alternate series of corrugations of a group and thence into engagement with the wall **30** of the next corrugation and so on. In each section **11**, on the other hand, the oil flows against the wall **28** of each corrugation **14** and thence against the wall **38** of each corrugation **24**, and so on. The angular relation of the several corrugations **14** and **24**, according to the present invention, effects an angular disposition of the leading walls of the corrugations with respect to both axes perpendicular to the direction of flow.

In FIGURE 4 is illustrated a heat exchanger **39** made in accordance with the present invention and including an outer tubular casing **42** and a tubular conduit **46** in spaced relation to the casing **42** and defining therebetween a substantially annular passage **48** for the oil to be cooled. The heat exchanger **39** may be arranged in the

bottom tank of the radiator of an automotive vehicle or in a tubular conduit such as a hose connection between the vehicle engine and the radiator. The passage **48** may be closed at each end by any suitable means and oil may be introduced through an inlet **50** and discharged through a suitable outlet (not shown). It will be understood that the present heat exchanger is characterized by compactness and that the axial extent of the passage **48** is limited. Thus, it is important to retard the rate of flow of the oil and bring the oil into intimate contact with the surfaces of the conduit **46** and the casing **42** so that maximum heat transfer may be effected. It will be apparent that the flow rate is a function of the angularity of the corrugations **14** with respect to the transverse axes of the strip and the angularity of the corrugations **24** with respect to the corrugations **14**. Thus, the pressure drop may be varied to some extent, at least, by varying the angular relation of the corrugations.

In forming a turbulizer in accordance with the preferred form of the invention the preform illustrated in FIGURES 1 and 2 may be bent on a suitable mandrel about the transverse axis of the strip **10** so that the turbulizer assumes the position shown in FIGURE 4, completely filling the annular passage **48**. In that position, the bases **26** and **34** of the corrugations **14** and **24** respectively are alternately in intimate heat conductive relation with the conduit **46** and the casing **42**.

In FIGURE 9 is illustrated the substantial difference between the heat dissipation rate of a turbulizer made in accordance with the preferred form of the present invention as contrasted with the heat dissipation rate of a turbulizer constructed in accordance with the prior art. This chart also compares the oil side pressure drop in pounds per square inch with the oil flow rate in gallons per minute of the present turbulizer as compared to the oil side pressure drop of a turbulizer of known type. It will be apparent that the present turbulizer exhibits important advantages over prior art turbulizers.

In FIGURES 5 and 6 is illustrated a modified form of the present invention which is identical to that of the preferred form of the invention with the exception that the included angle between the walls of a corrugation is approximately 90° as compared to approximately 64° in the preferred form of the invention and only one section is employed. In other words the several groups extend angularly in but one direction. Moreover, in this form of the invention a blank **10*a*** is bent on a suitable mandrel about an axis parallel to the longitudinal axis of the strip to form a hollow semi-cylindrical section such as is indicated in FIGURE 8. It will be appreciated that two of these sections are required to fill the passage **48**. In this form of the invention, assuming a flow to the right as viewed in FIG. 6, the oil flows generally in parallel with the corrugations and impinges against the wall **28** of depressed corrugation **14**, angularly into contact with the wall **38** of the adjacent raised corrugation **24** against the wall **28** of the adjacent raised corrugation **14**, into engagement with the wall **38** of the adjacent depressed corrugation **24**, into contact with the wall **28** of the next succeeding depressed corrugation **14** and so on in the manner illustrated by the dotted line in FIGURE 6. It will be appreciated that this flow is effected by the angularity of the walls of the corrugations **14** and **24**. The flow illustrated is idealized, it being understood that thorough intermixing of the streams of fluid is effected with the result that a high degree of heat exchange is afforded. Assuming a flow of oil in a direction opposite to that indicated by the arrows in FIG. 6, the oil will flow against the wall **30** of each corrugation **14** and into contact with wall **36** of each corrugation **24**, as will be understood.

The resistance to flow is also influenced considerably by the included angle of the corrugations. For instance, increasing the angle from sixty-four degrees to ninety

degrees reduces the number of corrugations which, in turn, reduces the pressure drop.

The formation of the corrugations 14 and 24 is preferably accomplished by the use of suitable dies in which the male die has projections dimensioned to correspond to the full extent of certain of the corrugations, and recesses similarly dimensioned. The female die is correspondingly formed. The present turbulizer may be used, in flat form, in a heat exchanger of the flat type, if desired.

While I have described my invention in connection with certain specific constructions and arrangements it is to be understood that this is by way of illustration and not by way of limitation and the scope of my invention is defined solely by the appended claims which should be construed as broadly as the prior art will permit.

I claim:

1. A heat exchanger comprising a tubular casing, a coaxially disposed tubular conduit arranged within said casing to define an annular passage therebetween for flow of fluid to be cooled, a turbulizer arranged in said passage in heat conductive relation to said casing and said conduit, said turbulizer having a plurality of circumferentially extending corrugations, said corrugations being arranged in axially disposed sections each of which is provided with a plurality of groups of corrugations extending angularly with respect to the axis of said conduit, the angularity of the groups of certain of said sections being opposite with respect to the angularity of the groups of others of said sections, each of said groups including a first series of corrugations having crests in alignment with the axis of formation of the group and an alternate series of corrugations having crests extending at an opposite angle to the adjacent corrugations of said first series, whereby a plurality of major tortuous paths are formed for flow of fluid through said passage and a plurality of secondary tortuous paths are formed with respect to the major tortuous paths.

2. A heat exchanger for oil coolers comprising radially spaced tubes defining an annular passage therebetween, a hollow cylindrical turbulizer arranged in said passage in heat exchange relation to said tubes and formed with a plurality of circumferentially extending corrugations, said corrugations being arranged in axially aligned sections, each of said sections having a plurality of groups each of said groups including a first series of corrugations extending radially in one direction extending axially of the tubes in angular relation to the tube axis, the groups of alternate sections extending angularly oppositely, each group further including an alternate series of corrugations disposed angularly with respect to the corrugations of said first series, whereby a plurality of major sinusoidal paths are formed along the axes of formation of the first series of corrugations of each group of successive sections and a plurality of secondary sinusoidal paths are formed through successive corrugations of each group.

3. A heat exchanger comprising a tubular casing, a coaxially disposed tubular conduit arranged within said casing to define an annular passage therebetween for flow of fluid to be cooled, a turbulizer arranged in said passage in heat conductive relation to said casing and said conduit said corrugations being arranged in a series of sections having a plurality of groups of corrugations extending at an angle to the axis of said casing and an alternate series of sections having a plurality of groups of corrugations extending at an opposite angle to the axis of said casing, each of said groups including a first series of corrugations in alignment with the axis of formation of the group and extending in one direction from a plane of reference and an alternate series of corrugations disposed at an angle to the axis of the group, and extending in the opposite direction from a plane of reference, the corrugations of successive groups being alternately disposed on one side and on the other of the plane of reference, all of said corrugations having walls extending angularly with respect to the direction of flow of the fluid so that the fluid flows in a plurality of streams impinging against the angular walls of the corrugations of successive groups.

4. A turbulizer for a heat exchanger having spaced walls in heat exchange relation with the fluid comprising a metallic strip formed with a series of corrugation sections, each of said sections including a plurality of successive groups of corrugations extending at a predetermined angle to the transverse axis of said strip, an alternate series of corrugation sections having a plurality of successive groups extending at a predetermined opposite angle to the transverse axis of said strip, each of said groups including a first series of corrugations extending in one direction from said strip and an alternate series of corrugations extending in the opposite direction from said strip, whereby a plurality of tortuous paths are formed for the flow of fluid between said walls.

5. In a heat exchanger having a casing, a conduit concentrically disposed within said casing and forming therebetween an annular passage, the improvement comprising a turbulizer for effecting turbulization of fluid received in said passage and for affording heat exchange between the fluid, said conduit, and said casing comprising a metallic strip shaped to conform to said annular passage, said strip having a plurality of groups of successive corrugations extending angularly with respect to the axis of said strip, each of said groups including a first series of corrugations extending in one direction from the plane of said strip and an alternate series of corrugations extending in the opposite direction of the plane of said strip, whereby a plurality of tortuous paths through said passage are formed.

6. A turbulizer in accordance with claim 5 wherein the corrugations of said alternate series are disposed at an angle to the corrugation of said first series.

7. A turbulizer for a heat exchanger having spaced walls in heat exchange relation with a fluid comprising a metallic strip having a longitudinal axis and a transverse axis and having a plurality of longitudinally extending slits, successive slits being progressively offset longitudinally, the metal between adjacent slits being bent from the original plane of the strip to form a first series of corrugations formed on an axis extending at an angle to the transverse axis and an alternate series of corrugations, each corrugation of said alternate series extending at an angle to an adjacent corrugation of said first-named series, whereby a plurality of angularly extending surfaces are presented for directing fluid to be cooled in a tortuous path.

8. In a heat exchanger having a pair of spaced walls in heat exchange relation with a fluid, a turbulizer for effecting turbulence in fluid flowing between said walls comprising a metallic strip having a longitudinal axis and a transverse axis, a plurality of groups of corrugations extending angularly with respect to said transverse axis, each of said groups comprising a first group of corrugations in alignment with the axis of formation of the group and an alternate series of corrugations extending angularly with respect to adjacent corrugations of said first series, said turbulizer being adapted to be arranged between said walls in heat exchange relation therewith and being adapted to be disposed in such a manner that either the transverse or the longitudinal axis is parallel to the direction of flow of fluid between said walls.

9. A heat exchanger comprising a tubular casing, a concentrically disposed conduit arranged within said casing to define an annular passage therebetween for flow of fluid, a turbulizer arranged in said passage in heat conductive relation to said casing and conduit, said turbulizer being formed from a strip of metal having a longitudinal axis and a transverse axis, said strip being formed with a plurality of adjacent groups of corrugations extending at an angle to the transverse axis and being bent about the transverse axis to assume a substantially cylindrical configuration, each of said groups including a first series of corrugations in alignment with the group axis,

and an alternate series of corrugations extending at an opposite angle to adjacent corrugations of said first series so that a plurality of sinusoidal paths are formed for flow of fluid through said passage.

10. A heat exchanger comprising a tubular casing, a concentrically disposed conduit arranged within said casing to define an annular passage therebetween for flow of fluid, a turbulizer arranged in said passage in heat conductive relation to said casing and conduit, said turbulizer being formed from a strip of metal having a longitudinal axis and a transverse axis, said strip being bent upon the longitudinal axis to conform to the configuration of said passage and being provided with a plurality of groups of corrugations extending at an angle to the original transverse axis, each of said groups including a first series of corrugations in alignment with the group axis and extending outwardly from the original plane of the strip in one direction, and an alternate series of corrugations extending at an angle to the adjacent corrugations of said first series and outwardly from the original plane of the strip in the opposite direction, successive corrugations of adjacent groups being disposed alternately on opposite sides of the original plane of the strip, whereby fluid in said passage is directed in a plurality of sinusoidal paths substantially parallel to the longitudinal axis of the strip.

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