June 14, 1966 P. E. BEAM, JR., ET AL 3,255,818

INVOLUTE PLATE HEAT EXCHANGER

Filed March 9, 1964 2 Sheets-Sheet 1

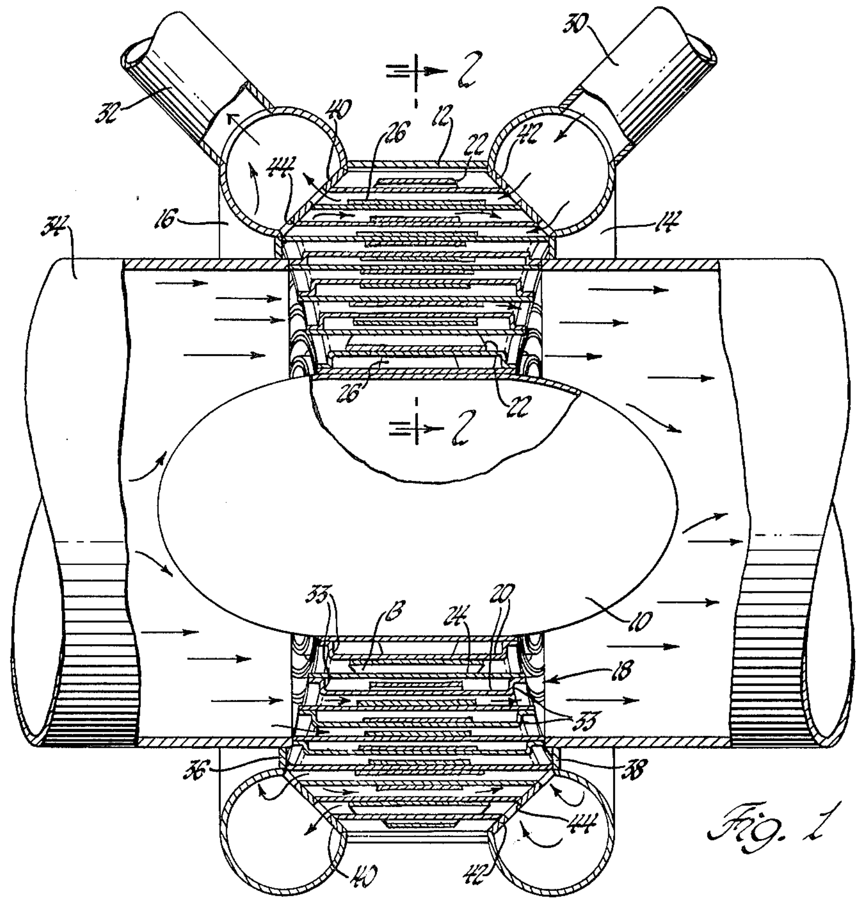

Fig. 1

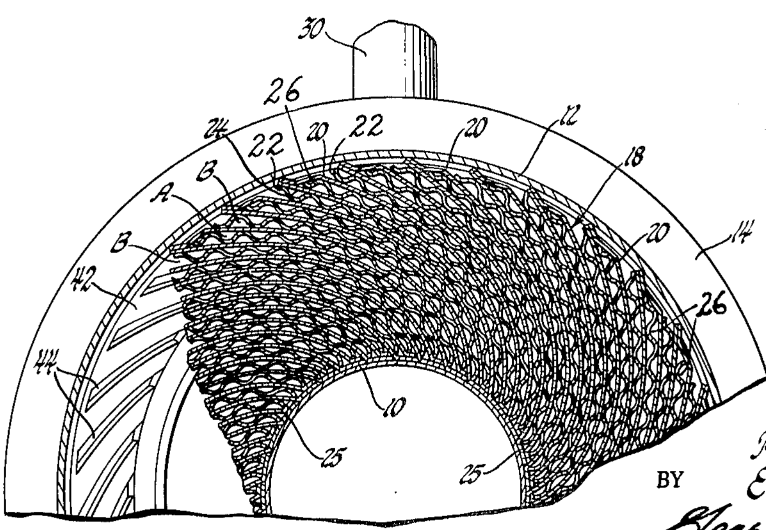

Fig. 2

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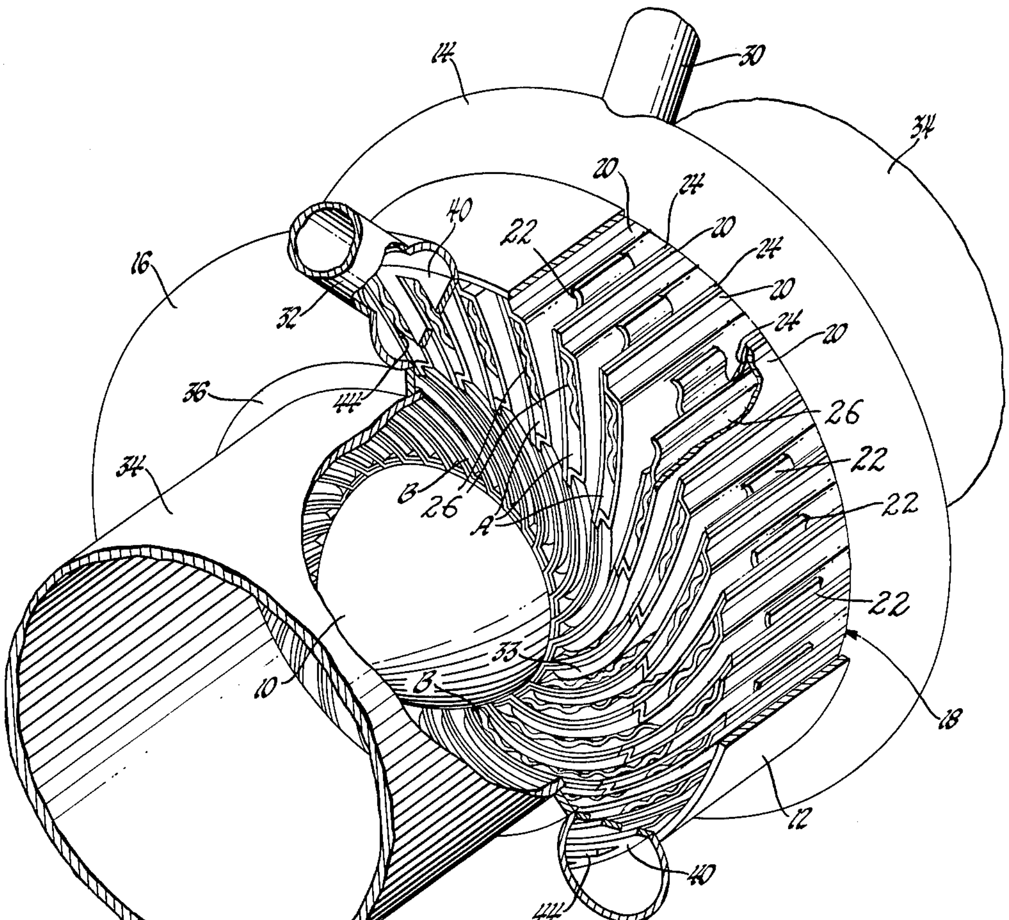

Fig. 3

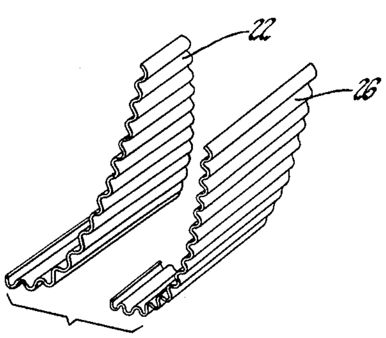

Fig. 4

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INVOLUTE PLATE HEAT EXCHANGER

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This invention relates to heat exchangers and more particularly to toroidal heat exchangers for transferring heat from one fluid to another and especially adapted for heating combustion air for aircraft engine use by extracting heat from engine exhaust gases.

With regard to heat exchangers of the type herein considered, it is particularly advantageous to make each heat exchanger annular in form and when this is done difficulties are encountered in compensating for variations in fluid pressure drop and heat transfer characteristics within the cross sectional area from the inside to the outside diameter of the heat exchanger in achieving efficiency.

An object of the present invention is to provide an improved annular or toroidal heat exchanger of maximum efficiency and of simple plate construction.

A feature of the present invention pertains to a heat exchanger comprising an annular casing and a cylindrical casing joined by an interposed toroidal heat exchange means or core formed with involute plates such that the flow of fluids through the heat exchanger in the general direction of its axis may be at a more uniform rate across the cross sectional area of the core to promote maximum heat exchange efficiency.

These and other important features of the invention will now be described in detail in the specification and then pointed out more particularly in the appended claims.

In the drawings:

FIGURE 1 is an elevation view of a combustion air duct with portions removed and showing, in longitudinal section, a heat exchanger of the present invention installed for cooperation with the duct in extracting heat from engine combustion gases;

FIGURE 2 is a sectional view looking in the direction of the arrows 2—2 in FIGURE 1;

FIGURE 3 is a perspective view of the duct and heat exchanger of FIGURE 1 with parts broken away better to illustrate the construction; and

FIGURE 4 is an exploded view of two adjacent corrugated sections each in involute form and as utilized in the heat exchanger of FIGURES 1 to 3.

The heat exchanger of the drawings comprises an inner cylindrical casing or flow divider **10** and an outer annular casing **12** having a common axis. Two toroidal manifolds **14** and **16** are provided each being at one end of the outer annular casing **12** and communicating with a toroidal multi-plate heat exchange means or core generally indicated at **18**. The latter bridges the annular space between the casings **10** and **12** and is formulated of a series of consecutive sets of four involute plates **20**, **22** and **24** and **26**. Each plate **20** cooperates with a plate **24** to enclose a corrugated plate **22** and also cooperates with another plate **24** on its other side to confine a corrugated plate **26**. The outer ends of the plates **20** and **24** of each set are joined at their margins as best illustrated in FIGURE 2 closely to approach the inside wall surface of the outer annular casing **12**. The plates **20** and **24** are smooth surfaced, i.e. not corrugated.

FIGURE 2 also shows how the corrugated and smooth surfaced plates are nested together with inner margins **25** of the plates **24** in close contact with the outer wall of the inner cylindrical casing **10** and margins of the plates **20** resting on the margins **25** of the plates **24**. Variations in the design of these details are possible without departing from the present invention.

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In the disclosure of FIGURE 1, the manifold **14** is served by means of an inlet conduit **30** and the manifold **16** is served by means of an outlet conduit **32**. The nested or annularly stacked plates of the heat exchange means or core **18** are so formed as to define two alternate sets of passages extending parallel with the axis of the heat exchanger. The passages A of one of these sets provide connections or heated fluid communication between the manifolds **14** and **16** but are otherwise closed by wall portions **33** made from the plates **20**. The passages of the other of the sets provide connections through the heat exchanger means **18** for handling cooler fluid flowing through a conduit **34** in paths parallel with the axis of the heat exchanger. The casing **12** includes two end rings **36** and **38** as well as two annular and frustoconical plates **40** and **42**. The end plates **36** and **38** merely serve as convenient connecting plates between the manifolds **16** and **14** and the conduit **34** whereas the plates **40** and **42** are apertured as at **44** properly to connect the manifolds with the alternate passages A of the heat exchange means **18**.

Alternating with the passages A are passages B and these passages B are each defined between adjacent plates **20** and **24** to handle the cooler fluid of the conduit **34**. The passages A each enclose a corrugated plate **26** which progressively narrows in width toward the heat exchanger axis whereas each of the passages B encloses a corrugated plate **22** which progressively increases in width toward that axis, these widths being measured in a direction parallel with the heat exchange axis. A narrow width places less restriction on fluid flow than is done by a greater width and this fact is availed of to achieve uniform flow rates regardless of at which radius each rate is measured for either of both fluids being handled.

A hot gas or fluid entering at **30** and distributed by the manifold **14** will flow through the passages A and will tend to flow along all the grooves of each of the corrugated plates **26** despite the fact that the gas is admitted and discharged near the outer periphery of the heat exchanger core. The air or other fluid to be heated passing countercurrent to the first fluid and along the conduit **34** will flow along all the grooves in each of the corrugated plates **22** although that other fluid is admitted and discharged adjacent the inner periphery of the heat exchanger means or core **18**. The corrugated plates **22** and **26** not only make the flow rate of each gas more uniform throughout the cross-sectional area of the heat exchanger means but also contribute to a more intimate heat transfer relation between the fluids.

We claim:

1. A heat exchanger comprising an inner cylindrical casing and an outer annular casing, said casings having a common axis, two toroidal manifolds, one of said manifolds being positioned at each end of said outer annular casing, toroidal heat exchange means comprising an annular series of involute plates bridging the space between said casings and defining passages with each passage extending radially and outwardly from said inner casing to said outer casing and between said manifolds, alternating passages as defined by said plates connecting said manifolds and conducting one fluid, the remainder of the passages forming paths parallel to said common axis for conducting a second fluid therethrough, a corrugated involute plate in each of said passages having its width measured in the direction of the heat exchanger axis, each corrugated plate in said alternating passages progressively increasing in width from said inner casing to said outer casing and each corrugated plate in the remaining passages progressively decreasing in width from said inner casing to said outer casing so as to effect uniformity of flow rate of the fluid flowing along opposite surfaces of the corrugated involute plates.

2. A heat exchanger as set forth in claim **1** wherein said outer annular casing includes a pair of frusto-conical plates having apertures for communicating said one fluid between said toroidal manifolds and said alternating passages.

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