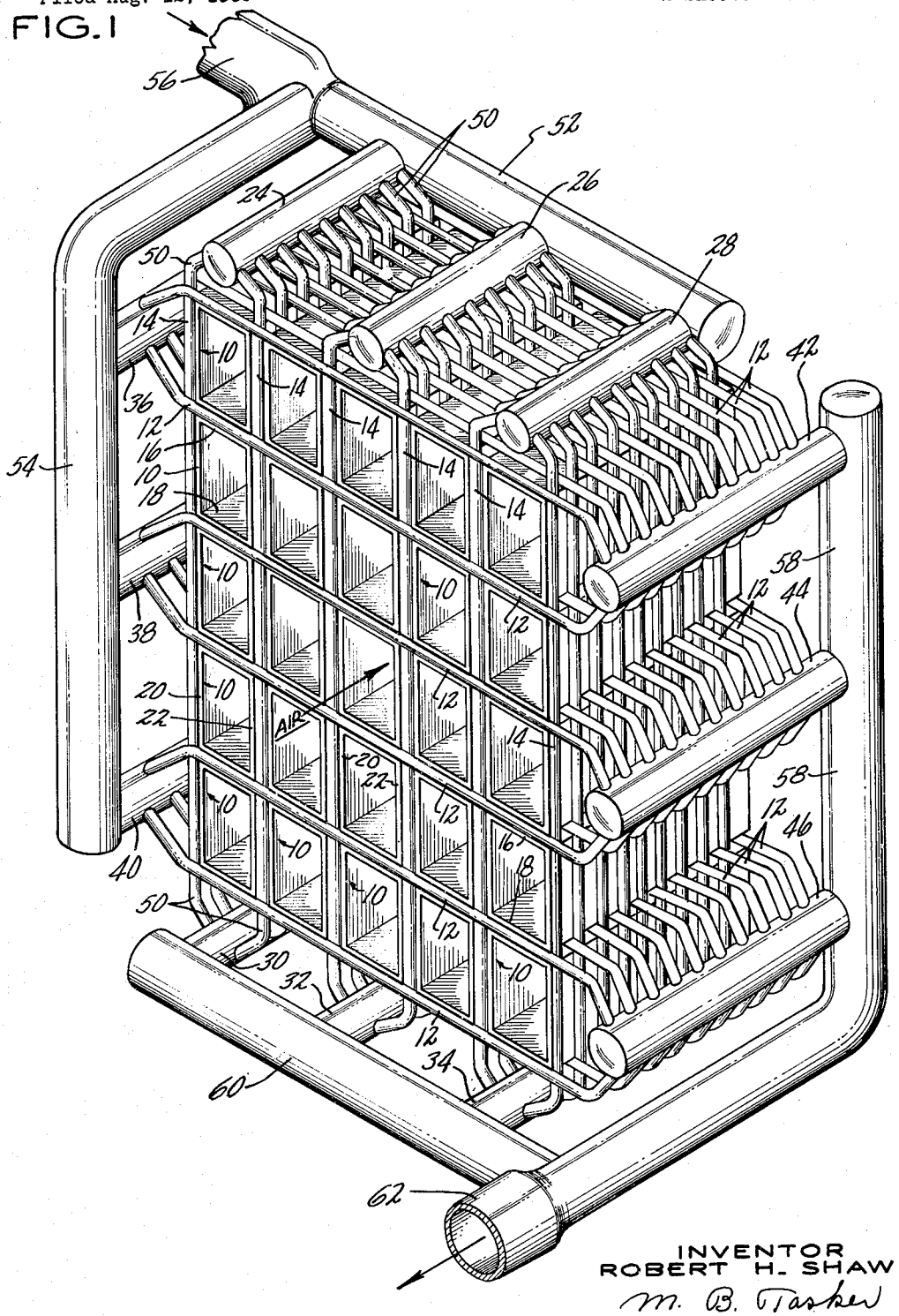
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HEAT EXCHANGER

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FIG. 1



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FIG. 3

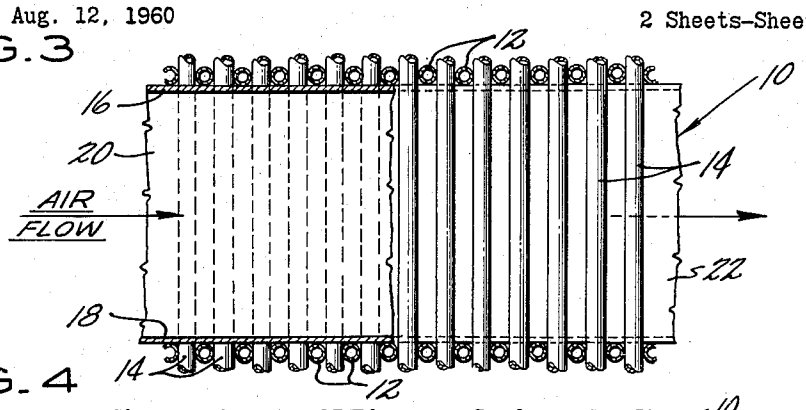


FIG. 4

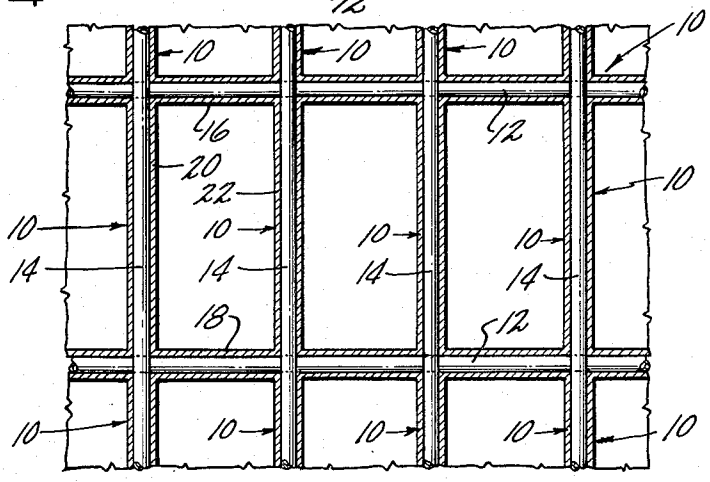
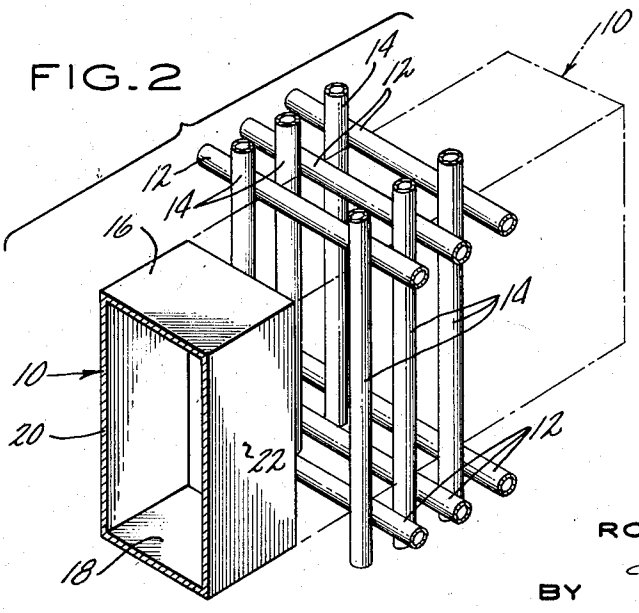


FIG. 2



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3,153,446

HEAT EXCHANGER

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10 Claims. (Cl. 165—164)

This invention relates to heat exchangers of the crossflow type and particularly to a heat exchanger suitable for heating the air discharged from the compressor of an axial-flow gas turbine engine. In such a heat exchanger the source of heat for the crossflow fluid may be a nuclear reactor or some other external source of heat.

It is an object of this invention to provide a heat exchanger which combines the high surface area per unit volume of a finned surface and the high wall temperature of an all-prime surface.

Another object of this invention is to provide an improved heat exchanger unit which can be duplicated to produce a matrix of any desired size or shape.

A further object of this invention is to provide a heat exchanger having a novel combination of tubes and fins structurally intercocnnected to provide a strong and rigid structure producing a minimum of obstruction to the flow of fluid in contact with the heat exchanger surfaces and particularly the axial flow of air from an engine compressor.

A yet further object of the invention is to provide a matrix unit for a heat exchanger which can be multiplied to produce any desired shape and size of heat exchanger at a very low cost both of material and labor.

It is another object of this invention to provide a particularly simple structure for a crossflow heat exchanger in which one fluid flows axially into the matrix and the other fluid flows in straight lines transversely of the axis of the matrix in two directions at right angles to each other.

It is a further object of this invention to generally improve the construction and performance of heat exchangers.

These and other objects and advantages of the present invention will be pointed out in connection with the following detailed description of a preferred embodiment of the invention shown in the accompanying drawings. In these drawings:

FIG. 1 is an isometric view of a heat exchanger embodying this invention;

FIG. 2 is an isometric view illustrating a basic unit of the heat exchanger;

FIG. 3 is a side view of the basic unit partly in section; and

FIG. 4 is a front view showing several adjacent units.

The basic heat exchange unit shown in FIG. 2 includes an elongated duct 10 rectangular in cross section. The duct 10 conducts one of the fluids through the heat exchanger. The other fluid flows through horizontal pipes 12 and vertical pipes 14 which are disposed at right angles to the axis of the duct and frame the duct; thus, the horizontal pipes 12 lie in contact with the top and bottom walls 16 and 18 of the duct, while the vertical pipes 14 lie in contact with the side walls 20 and 22 of the duct. It will be noted from FIG. 2 that the vertical pipes 14 are spaced apart by the horizontal pipes 12 and that the horizontal pipes 12 are similarly spaced apart by the vertical pipes 14. The vertical pipes 14 which are in contact with the side walls 20 and 22 of the duct are secured thereto either by brazing or welding, and the horizontal pipes 12 which are in contact with the top and bottom walls 16 and 18, respectively, are secured thereto by welding or brazing.

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Also, pipes 12 and 14, where they engage each other, are also secured together by welding or brazing, so that the pipes and the duct are in good heat-conducting relation throughout.

It will be evident from FIGS. 3 and 4 that a matrix for a heat exchanger can be built up from a number of units, a duct 10 being provided for each rectangular opening formed by the horizontal and vertical pipes 12 and 14 spaced as shown in FIG. 2. Such a heat exchanger is shown in FIG. 1. In this figure, a matrix is shown consisting of five horizontal units and five vertical units. Each unit includes a duct 10 having vertical pipes 14 running along and in contact with the side walls 20 and 22, and horizontal pipes 12 running along and in contact with its top wall 16 and its bottom wall 18. Each unit of the twenty-five units shown in FIG. 1 is identical with that illustrated in FIG. 2. Also, it will be noted that the alternate arrangement of the vertical and horizontal pipes continues along the ducts throughout the full length of the ducts. These ducts may be as long as desired. Herein, nine sets of vertical pipes and ten sets of horizontal pipes have been shown, but it will be understood that the number of pipes and the number of ducts is a matter of design.

Fluid flow through the multiple ducts 10 is an axial flow, as indicated by the arrow in FIG. 1. The crossflow is through the pipes 12 and 14. This is accomplished by providing a plurality of longitudinal headers at the top and bottom of the matrix and on each side thereof; thus, longitudinal headers 24, 26 and 28 are provided at the top of the matrix; longitudinal headers 30, 32 and 34 are provided at the bottom of the matrix; headers 36, 38 and 40 are provided at the left; and headers 42, 44 and 46 are provided at the right of the matrix.

It will be noted that the matrix is made up of an odd number of ducts in both the horizontal and vertical rows thereof. Beginning at the left-hand side of the matrix in FIG. 1, it will be evident that all of the vertical pipes 14 on opposite sides of the first vertical row of ducts 10 are connected to longitudinal headers 24 and 30 at the top and bottom, respectively, of the row. This is accomplished by bending the vertical pipes 14 on opposite sides of the row toward the header to provide oblique portions 50 which are connected to the header by welding. The vertical pipes 14 on opposite sides of the middle row of ducts 10 are similarly connected at their upper and lower ends to headers 26 and 32, respectively. Finally, the vertical pipes 14 on opposite sides of the last vertical row of ducts 10 are similarly connected to longitudinal headers 28 and 34 respectively.

Beginning at the top of the matrix as shown in FIG. 1, the first two sets of horizontal pipes 12 on opposite sides of the first horizontal row of ducts are similarly connected to longitudinal headers 36 and 42 on the left- and right-hand sides, respectively, of the matrix. The middle pairs of horizontal pipes 12 are connected to longitudinal headers 38 and 44 at the left- and right-hand sides, respectively, of the matrix and the lower-most pair of horizontal pipes 12 are connected to longitudinal headers 40 and 46 at the left- and right-hand sides, respectively, of the matrix.

Longitudinal headers 24, 26 and 28 at the top of the matrix, and headers 36, 38 and 40 at the left-hand side of the matrix, are inlet headers. Headers 24, 26 and 28 are connected at their rear ends by a manifold 52, and headers 36, 38 and 40 are connected by manifold 54. Both manifolds 52 and 54 are connected to a common inlet pipe 56. Similarly, headers 42, 44 and 46 at the right of the matrix, and headers 30, 32 and 34 at the

bottom of the matrix, are outlet headers. Headers 42, 44 and 46 are connected by a manifold 58, while headers 30, 32 and 34 are connected by a manifold 60. Both manifolds 58 and 60 are connected to an outlet pipe 62.

The operation of the heat exchanger will be evident from the above description. Air from the engine compressor flows through the longitudinal ducts 10, as indicated by the arrow in FIG. 1. The crossflow fluid, which may be liquid metal, enters the heat exchanger through pipe 56, manifolds 52 and 54, inlet headers 24, 26 and 28, and 36, 38 and 40. After passing through the sets of horizontal and vertical crossflow pipes, crossflow fluid is collected in longitudinal headers 30, 32 and 34 at the bottom of the matrix and headers 42, 44 and 46 at the right-hand side of the matrix. From these headers the fluid flows through manifolds 58 and 60 into the outlet pipe 62.

It will be evident that a heat exchanger has been provided which has a very low resistance to the fluid flowing both in the axial and in the crossflow directions. It will also be evident that by brazing the pipes directly to the ducts 10 which comprise the extended surfaces, a very efficient transfer of heat has been provided. The arrangement described combines the high surface area per unit volume of a finned surface and the high wall temperature of an all-prime surface. In fact, the surface, for practical purposes, may be considered one-hundred percent effective in this arrangement.

When the difficulties in making the usual finned surfaces are considered, it will be evident that the present invention provides a very simple and cheap construction in which the side walls of the ducts 10 comprise the finned or extended surfaces of the tubes.

It will be understood that the entire heat exchanger may be enclosed in the usual outer casing which has been omitted in the drawing to facilitate illustration.

While only one embodiment of the invention has been shown herein, it will be understood that various changes may be made in the construction and arrangement of the parts without departing from the scope of the appended claims.

I claim:

1. A heat exchanger cell comprising a longitudinal duct of substantial size and rectangular in cross section having four planar sides and through which air is adapted to be passed, and a plurality of crossflow pipes to each of which a second fluid is separately supplied extending transversely of the axis of said duct external of said duct along and past each of its sides, each of said pipes extending across one side only of said duct, said pipes being in contact with the outer sides of said duct and brazed thereto, the pipes on each side of the duct being spaced apart along the length of the duct by the pipes on the adjoining sides of said duct.

2. A heat exchanger cell comprising an air duct rectangular in cross section and of substantial length, said duct having flat side walls, horizontal rows of crossflow pipes extended across and in contact with the upper and lower external flat surfaces of said duct, said pipes being perpendicular to the longitudinal axis of said duct and being spaced from one another along the length of said duct, rows of like pipes extended vertically in contact with the opposed external flat side surfaces of said duct and through the spaces between the pipes in said horizontal rows of pipes, the pipes of said horizontal and vertical rows each extending along one side wall of and past said duct and crossing each other and where they cross being in contact with each other, said pipes being brazed to said external duct surfaces and also being brazed to each other at their points of contact with each other, and means for supplying a second fluid separately to each of said crossflow pipes in said horizontal and vertical rows.

3. A heat exchanger cell comprising an air duct rectangular in cross section and of substantial length, said duct having flat side walls, horizontal rows of crossflow

pipes extended across and in a straight line beyond the upper and lower external surfaces of said duct, said pipes being perpendicular to the longitudinal axis of said duct and the rows being spaced apart from each other along the length of said duct by a distance equal to the pipe diameter, rows of like pipes extended in a straight line vertically along and in a straight line beyond the opposite external side surfaces of said duct and beyond said horizontal pipes, said horizontal and vertical rows of pipes being alternately arranged along the length of said duct and having a brazed connection both with each other and with the flat walls of said duct, and means for supplying a second fluid separately to each of said crossflow pipes in said horizontal and vertical rows.

4. In a heat exchanger, a plurality of parallel rectangular ducts arranged in horizontal and vertical rows, said ducts having flat side walls, fluid-conducting pipes extending vertically between the vertical rows of ducts and spacing said vertical rows apart horizontally by the diameter of said pipes, fluid-conducting pipes extending horizontally between the horizontal rows of ducts and spacing said horizontal rows of ducts apart vertically by the diameter of said pipes, said vertically extending and horizontally extending pipes being welded to the contacting flat walls of said ducts, said vertically extending pipes being spaced apart by said horizontally extending pipes and said horizontally extending pipes being spaced apart by said vertically extending pipes, said pipes being welded to each other at their points of contact.

5. In a heat exchanger, a plurality of rectangular ducts arranged in horizontal and vertical rows in spaced relation, and a plurality of crossflow pipes extending transversely of the axes of said ducts between each of said rows, each of said pipes being welded to the sides of the ducts proximate thereto, the pipes extending between horizontal rows of ducts forming spacers for the pipes extending between vertical rows of ducts, and said horizontally and vertically extending pipes being welded at their points of contact.

6. In a heat exchanger, a plurality of parallel ducts rectangular in cross section arranged in horizontal and vertical rows, a plurality of fluid-conducting pipes extending vertically between the vertical rows of ducts in spaced relation along the length thereof, a plurality of fluid-conducting pipes extending horizontally between the horizontal rows of ducts in spaced relation along the length thereof, said vertically extending pipes being spaced along said ducts by said horizontally extending pipes and said horizontally extending pipes being spaced along said ducts by said vertically extending pipes.

7. A heat exchanger as defined in claim 6 in which headers are provided for the ends of the pipes at the top and bottom of the heat exchanger and at both sides thereof, an inlet manifold connects the headers at the top of said exchanger and at one side thereof, and an outlet manifold connects the headers at the bottom and at the other side of said heat exchanger.

8. In a heat exchanger, a plurality of parallel ducts rectangular in cross section arranged in horizontal and vertical rows, each vertical and horizontal row comprising an odd number of ducts, a plurality of fluid-conducting pipes extending vertically along both sides of each vertical row of ducts along the length thereof, a plurality of fluid-conducting pipes extending horizontally along both sides of each horizontal row of ducts along the length thereof, said vertically extending pipes spacing said horizontally extending pipes along the length of said ducts and said horizontally extending pipes spacing said vertically extending pipes along the length of said ducts, said vertically extending pipes being welded to the side walls of said ducts, said horizontally extending pipes being welded to the top and bottom walls of said ducts, and said vertically and horizontally extending pipes being welded where they cross each other.

9. A heat exchanger as defined in claim 8 in which horizontal headers are provided at the top and bottom

and two sides of the heat exchanger and the pipes extending along on opposite sides of the horizontal and vertical rows of ducts are connected at their ends thereto, an intake manifold is provided for supplying the headers at the top and one adjacent side, and an outlet manifold is provided for discharging fluid from the headers at the bottom and the other side of the heat exchanger.

10. A heat exchanger as defined in claim 9 in which a header is provided at the top, bottom and sides of the heat exchanger for each alternate row of ducts and the pipes extending along said alternate ducts are connected to opposite sides of the respective headers.

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