

[54] **HEAT EXCHANGER LEAKAGE
BAFFLE AND POSITIONING MEANS**

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165/157, 162, 163, 176, 175; 60/39.51 R

[56]

References Cited

UNITED STATES PATENTS

2,047,249	7/1936	Ballard	165/135 X
2,146,352	2/1939	Rohrer	165/180 X
3,064,947	11/1962	McNab	165/150 X

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[57]

ABSTRACT

A heat exchanger comprising serpentine finned tubes disposed in an annular configuration, with means for positioning and supporting the unfinned return bends of the tubing with a porous refractory composition in such a manner as to prevent the external heat transfer fluid from bypassing the finned portions and to prevent leakage of hazardous internal fluid from the tubes, while allowing movement of the tubing in thermal expansion.

6 Claims, 5 Drawing Figures

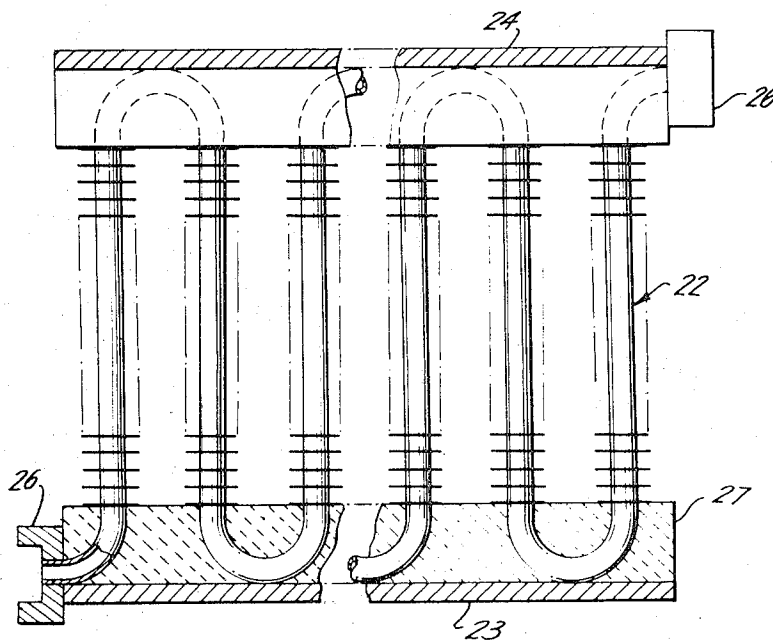


FIG. 1

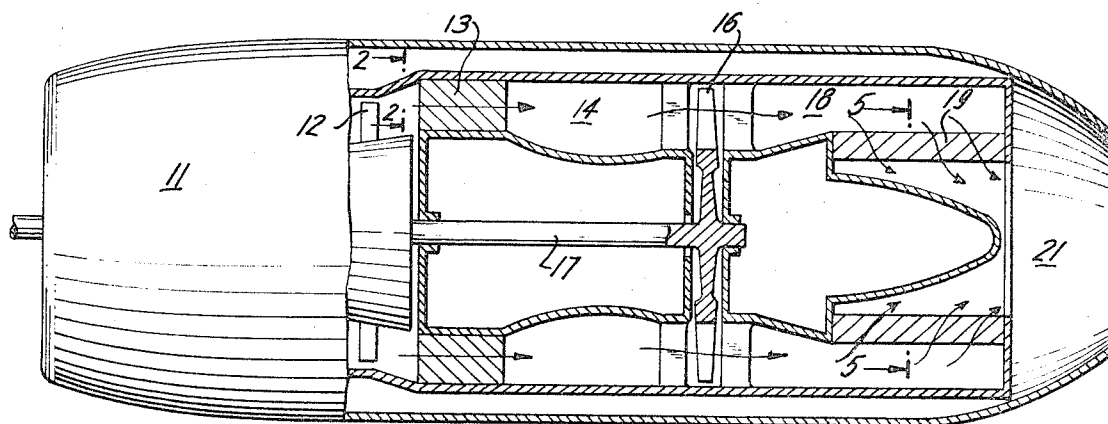
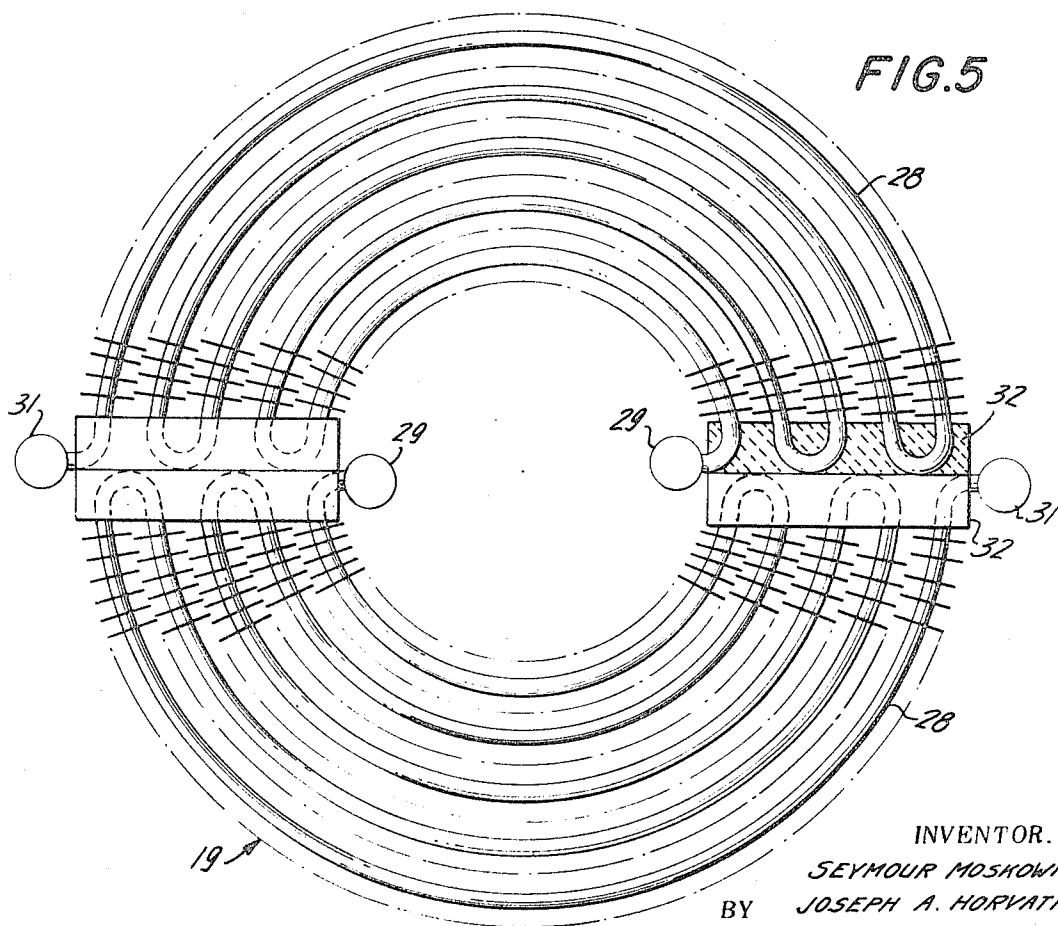


FIG. 5



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FIG. 2

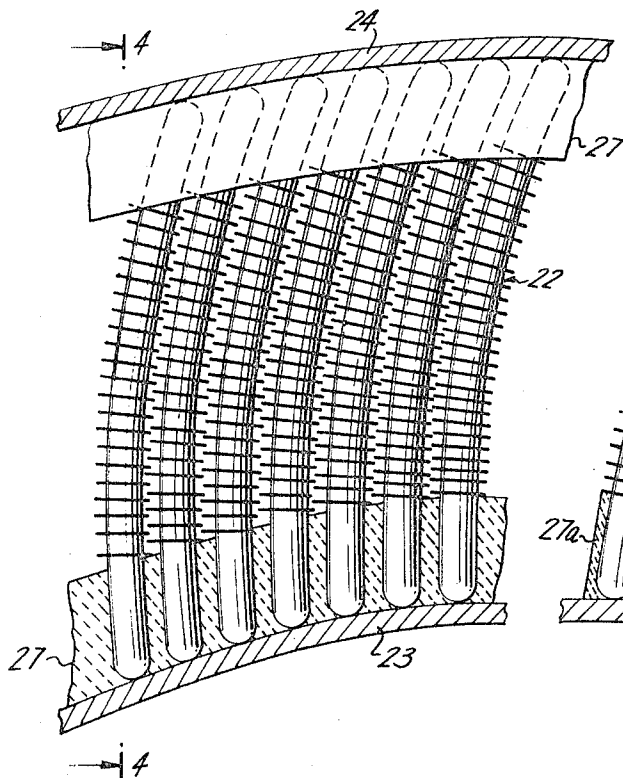


FIG. 3

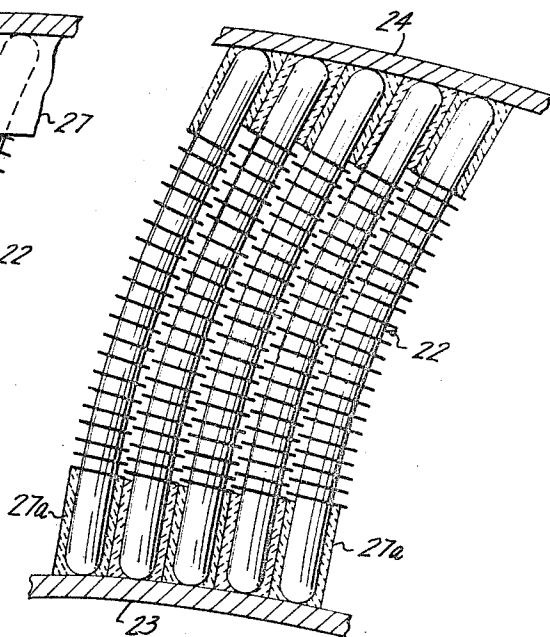
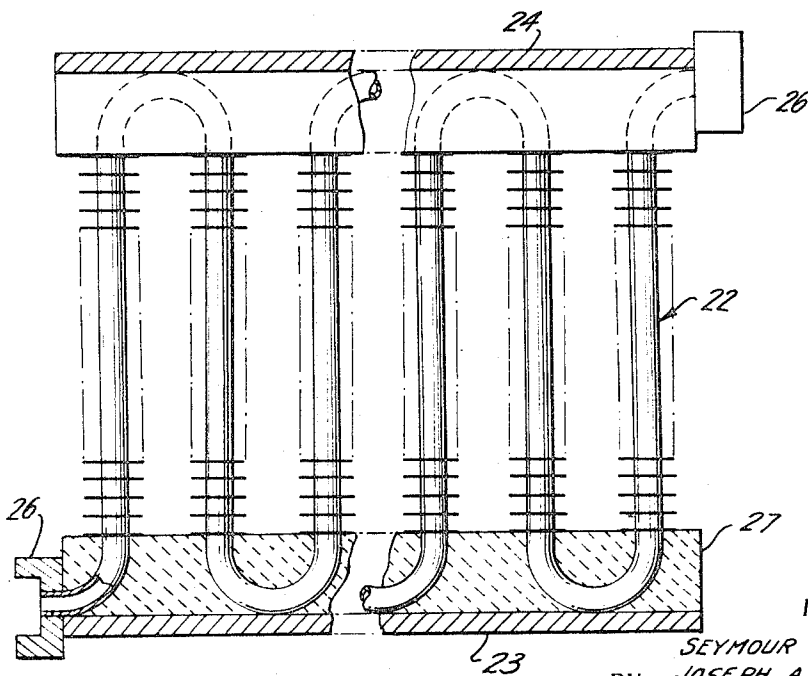


FIG. 4



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HEAT EXCHANGER LEAKAGE BAFFLE AND POSITIONING MEANS

BACKGROUND OF THE INVENTION

Regenerative heat exchangers in turbine engines are known, in which one heat exchanger containing an internal fluid is disposed to extract heat from the exhaust gases of the turbine, and then transfers its heat exchange medium to another heat exchanger disposed upstream, which gives up the heat to the incoming air. Such heat exchangers are commonly annular in configuration, having a plurality of passes of serpentine tubing disposed within the annulus. When the tubes bear heat-dissipating fins, a problem arises of possible interlocking of the fins of adjacent passes with possible damage to the fins, owing to thermal movements of the tubing. Also, it is not practical to provide fins on the bends where the tubes reverse direction, so that a considerable proportion of the flow of external heat transfer fluid across the tubes may bypass the finned portions and flow across the ends of the bights, where it is less effective in heat transfer. Finally, the fluid contained within the tubing may be hazardous, such as a liquid metal, and leaks may occur in the regions of the bends. These problems are solved by the present invention.

SUMMARY

This invention relates to regenerative heat exchangers for turbine engines, and more particularly to means to prevent loss of effectiveness by flow of the external fluid across unfinned portions of the tubing, to prevent leakage of internal fluid from the bends of the tubes, and for positioning and spacing finned tubing in an annular heat exchanger in such a manner as to allow thermal movement without interlocking and damage to the fins.

This is accomplished by potting the unfinned bends of the tubing in a porous refractory material. The potting material occludes that portion of the annulus which would otherwise present some open area to the flow of external fluid, and thus all external fluid from which or to which heat is being transferred must flow over the finned portions of the tubes. Further, if any leakage of liquid metal should occur in the tube sections enveloped by the potting material, the leakage will take the form of seepage through the porous material. Little air will be present in this zone, which therefore minimizes the hazard of fire. Formation of oxides in the seepage flow will agglomerate and act to plug flow paths of the leakage. As a result, the leak would become sealed, temporarily at least. Finally, the refractory material holds the passes of tubing spaced apart while allowing individual bights to flex under thermal effect.

It is, therefore, an object of this invention to provide baffling means which directs fluid flow across the finned portions of heat exchanger tubing.

Another object is to provide leakage baffling means in a heat exchanger.

A further object is to provide positioning means for finned tubing in an annular heat exchanger.

Still another object is to provide such positioning means, which allows thermal movement of the tubing.

Other objects and advantages will become apparent on reading the following specification with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a semischematic view in cross-section of a turbine engine, showing the general location of the major elements of a regenerative heat exchanger system;

FIG. 2 is a fragmentary view of the forward heat exchanger taken on line 2—2 of FIG. 1;

FIG. 3 is a view similar to FIG. 2 of a modified embodiment;

FIG. 4 is a view taken on line 4—4 of FIG. 2; and

FIG. 5 is a semischematic view of the aft heat exchanger taken on line 5—5 of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1 there is shown a turbine engine 11 having at the forward end an air compressor 12, which delivers air through an annular forward heat exchanger 13 to a combustion chamber 14. The air enters the front end of the heat exchanger and passes therethrough in the longitudinal direction, discharging rearwardly into the combustion chamber, as shown by the arrows.

The air is mixed with fuel in the combustion chamber and burned, the combustion gases driving a turbine 16 mounted on a shaft 17, which in turn drives the compressor. After extraction of work by the turbine, the combustion gases pass into a plenum 18 surrounding an aft heat exchanger 19. The hot combustion gases then pass radially inwardly through the aft heat exchanger 19 where as much as possible of the heat is extracted, and are then discharged through the exhaust section 21.

Both the incoming air from the compressor and the combustion gases from the turbine are external heat exchange fluids in such a system. The forward exchanger 13 and the aft exchanger 19 contain an internal heat exchange fluid, liquid metal in the present case, such as sodium or a mixture of sodium and potassium, or one of the known compositions of metals for heat transfer. The two heat exchangers are connected by appropriate means (not shown), and form a closed system in which the internal heat transfer fluid circulates. The engine may be used as a jet engine for flight, or as a stationary engine from which power may be taken off a protruding portion of the shaft, or by other suitable means. The general arrangement thus far is conventional and known in the art.

The forward annular heat exchanger 13, shown in FIGS. 2-4, is formed of a plurality of passes of serpentine tubing with each pass 22 longitudinally disposed in the annulus between a pair of inner and outer cylindrical walls 23 and 24, with the bights of the serpentine extending back and forth across the diametral dimension of the annulus, with appropriate headers at the upstream and downstream ends thereof. If each pass 22 of serpentine were positioned in the annulus in a plane strictly radial to the longitudinal axis, the annulus would be less than completely filled with tubing, owing to the greater circumference of the outer cylindrical wall. Therefore, although the passes are in the generally radial plane, they are curved therefrom with their outer ends circumferentially displaced from the radial position like curved spokes in a wheel, so that the passes are arcuately nested around the annulus. The actual curve is that of an involute of a cylinder of smaller

diameter than the diameter of the inner cylindrical wall.

As shown in FIG. 4, each pass 22 of tubing extends from one end to the other of the forward heat exchanger 13, with the ends of the tubing united to a header connection 26 at each end of the exchanger. The end of the tubing is positioned within a mating bore in the header connection as appears in the lower portion of FIG. 4, and the tube is welded to the header connection. The welding is done by an electron beam directed longitudinally at the end of the tubing wall as it rests within the bore, the beam then being circularly traversed around the circumference of the tubing.

Although the diameter of the electron beam is very minute and the path of traversal as accurate as possible, nevertheless it may occur that a portion of the beam spreads beyond the portion it is intended to weld, particularly to the inside of the tubing. When this occurs the beam impinges on the interior of the tube at the bend, thereby producing an imperfection or weak spot in the wall of the tube at that point, or even a minute hole. Further, the 180° bends of successive bights of tubing within a given pass are longitudinally aligned, and therefore are in the path of a leaking electron beam if the beam should pierce the tubing wall at the first bend, and are also subject to damage. Although it is unlikely that any tubing beyond the first bend from the weld area would thus be affected, the process of bending produces certain strains and discontinuities in the material of the tubing, as by the stretching of the outermost wall and the compression of the innermost wall.

Thus the bends between bights of tubing are zones of potential weakness, and since the pressure of the internal fluid increases markedly with an increase of turbine temperature it is desirable to protect these zones from leaks. This is particularly true when the internal fluid is a liquid metal.

For this reason the unfinned bends are potted or packed in a porous ceramic composition 27. Materials suitable for such packing are fibrous ceramics capable of withstanding high temperature and thermal shock, and chemically stable and corrosion resistant. Such materials as are used for insulating fill in furnaces and muffles are generally satisfactory. A particularly suitable material is that sold under the name Fiberfrax (registered trademark of The Carborundum Company). This substance is in the form of fibers having lengths from shorts to 1-1/2 inches and diameters from submicron to 10 microns, with a mean of 2 microns, and a specific gravity of 2.73. Its approximate chemical composition in weight percent is as follows:

Al ₂ O ₃	50.9%
SiO ₂	46.8
B ₂ O ₃	1.2
Na ₂ O	0.8
Trace Inorganics	0.3-0.5

The portion of tubes to be encased is first liberally coated with a heat resistant paint, which may be either sprayed on or applied with a brush, and acts as a binder between the metal and the packing. The loose fibrous potting material is then packed into the space around and between the individual tubes. It may be packed to a density greater than 6 pounds per cubic foot, but a lower density is preferable, between 3 and 6 pounds per cubic foot, in order to preserve a certain degree of porosity. The packed material is then given at least one coat of the heat resistant paint, and preferably two or

three coats. This surface treatment increases the hardness and erosion resistance of the fibrous material, enabling it to be handled without fragmentation.

Suitable paint for the purpose is one of the aluminum-silicone varieties, which withstands a skin temperature up to 1000°F. The paint may be dried in air, but drying time may be shortened by curing under a heat lamp. Although the heat exchanger in a turbine environment will be exposed to higher temperatures than that recommended for the paint, once the packing has been set in its final form it retains its shape and hardness.

Another satisfactory binder for the packing material is Nicrobraz Cement, a liquid plastic manufactured by Wall Colmonoy Corporation. It holds the packing in place, and volatilizes completely between 500° and 600°F.

If there should be any undetected minute perforations of the tubing in the bends, or if such perforations should develop in service, leakage of the liquid metal from the tubes will seep only very gradually into the porosities of the packing, where it will oxidize and plug the capillary pores. On the other hand, there is not enough air contained in the capillaries for any danger of fire.

Individual bights of the tubing can flex under thermal action, but potting the bends fixes the position of the ends of the bights at a predetermined spacing, so that they cannot drift out of position with danger of interlocking and damaging the fins. An additional advantage of such potting is that the external heat transfer fluid has no path across the bends of tubing and must pass across the finned portions, so that maximum effectiveness in heat exchange is achieved.

In FIG. 3 there is shown a modified embodiment of the forward heat exchanger wherein it may be desirable for each pass 22 of tubing to have the capability of some independent longitudinal movement from thermal effects. In this case each pass is potted 27a with an individual packing in the longitudinal direction. Thus the passes are not united to each other by the packing material and are able to perform slight independent longitudinal movements.

FIG. 5 shows a semischematic view of the aft heat exchanger 19, looking in the axial direction. This generally annular exchanger is intended for generally radial flow of the external heat transfer fluid, from the plenum 18 surrounding the exchanger to the inner diameter from which it is subsequently exhausted. The external fluid in this case comprises the combustion gases from the turbine, from which heat is extracted by the internal fluid which is then transferred to the forward heat exchanger.

The aft heat exchanger 19 shown in FIG. 5 is formed by two semicylindrical halves, each half comprising a plurality of generally semicircular passes 28 of finned tubing. Each pass is formed of a plurality of semicircular bights of tubing having 180° return bends at the meeting plane of the two halves, and each pass of tubing is connected at one end to a header 29 at the internal circumference and at its other end to a header 31 at the external circumference. Connections to the header are made by electron beam welding as previously described, and since the tubing bends are again in line the same considerations apply.

The bends of the tubes are potted 32 in the manner previously described, either with a unitary packing for

all the passes, or with each pass potted individually to allow independent movement. Either type of packing has the advantages of sealing possible leakage, spacing and positioning the tubing, and compelling the external fluid to flow over the finned portion of the tubing.

What is claimed is:

1. In a turbine engine, a regenerative heat exchanger using a liquid metal heat transfer medium, said regenerative heat exchanger comprising an annular heat exchanger having finned tubing disposed in an annular configuration, the tubing containing internal heat transfer fluid and comprising a plurality of individual passes of tubing for flow of external heat transfer fluid thereover, each pass being serpentine into a plurality of bights and having a plurality of mutually aligned unfinned return bends, the tube of each pass being connected at each end to a header and the serpentine bights being freestanding, the unfinned bends being potted in a porous fibrous ceramic material to occlude the external fluid from flowing over the unfinned portions of tubing and to position and space the passes while allowing thermal movement to individual bights, the porous ceramic material also serving to absorb internal heat transfer fluid in the event of leakage from

the tubing bends.

2. The combination recited in claim 1, wherein the porous potting material is formed of ceramic fibers having the approximate chemical composition of 50.9 percent Al_2O_3 , 46.8 percent SiO_2 , 1.2 percent B_2O_3 , and 0.8 percent Na_2O .

3. The combination recited in claim 2, wherein the tubing bends of a plurality of passes are potted in a unitary packing.

4. The combination recited in claim 2, wherein each pass of tubing is potted separately, allowing thermal movement between passes.

5. The combination recited in claim 2, wherein each pass of tubing is serpentine in the longitudinal direction into a plurality of bights extending in a generally radial direction.

6. The combination recited in claim 2, wherein each pass of tubing is serpentine into a plurality of semicircular bights extending in the circumferential direction to form an annular heat exchanger separable on a diametral plane, with the potted return bends of the tubing positioned at the meeting plane.

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