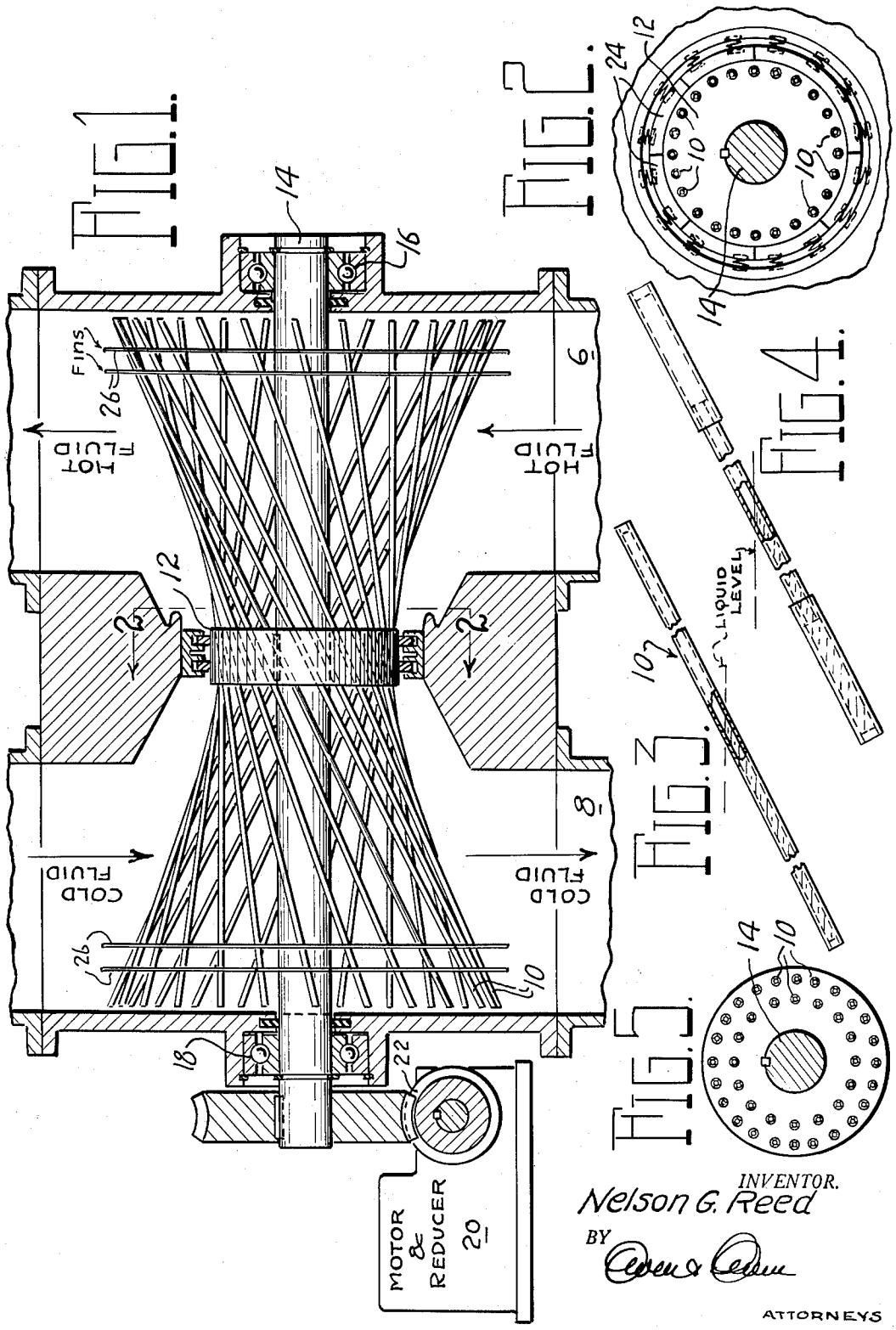
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HEAT EXCHANGER

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HEAT EXCHANGER

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This invention relates to heat exchange devices and has for its primary object to provide a heat exchanger or regenerator of greatly simplified structure and high thermal effectiveness for use with gas turbines, or the like.

It has heretofore been proposed to make liquid-coupled indirect-transfer regenerators for gas turbine engines in the form of a heat collecting device exposed to the hot gases issuing from the turbine and to recover the energy by dissipating it in the air streams supplied to the engine combustor. In each instance the heat transfer unit comprised a conventional finned-tube heat exchanger. Coupling liquid, such as known alloys of sodium and potassium were pumped from one unit to the other, to absorb heat in one unit and to dissipate it in the other. Regenerators of this kind, while efficient, are subject to all of the difficulties encountered in the manufacture of finned-tube heat exchangers and, in addition, to the difficulties encountered in pumping the molten metal.

It has also been proposed to make rotary matrix heat exchangers for gas turbine engines in the form of a honeycombed metal rotor heated in one sector of its circumference by hot gas and dissipating the heat in another sector of its circumference to cold air. In the existing rotary matrix types the seals and duct work are complicated. Also some cold air trapped in the matrix is carried over and lost to the gas turbine by mixing with the hot gas.

The present invention provides a completely different approach to the problem and includes an apparatus in which no pump is required, eliminates the carry-over loss of cold air, simplifies the seal and ducting problems, and preserves advantages existing in both the liquid-coupled and rotary matrix types.

Fig. 1 shows a somewhat diagrammatic disclosure of a preferred form of the invention;

Fig. 2 is a section on the line 2—2 of Fig. 1;

Fig. 3 is a fragmentary cross sectional view of a single tube of the form shown in Fig. 1;

Fig. 4 is a fragmentary cross sectional view of a modified form of tube; and

Fig. 5 is a diagrammatic side view of a hub carrying a plurality of tube bundles.

Briefly stated, the present invention comprises the provision of a volume, such as a metal tube, containing a heat transfer material that is molten at its minimum operating temperature, the volume extending into chambers at high and low temperature so that heat may be taken up in one chamber and given off in the other, with provision for so moving the volume bodily that the heat transfer material fills alternately the portions of the volume in the high temperature and in the low temperature chambers. In the preferred form, one or more bundles of tubes comprise the volume above mentioned, and the tubes are so related to their mounting means as to tip from end to end during movement.

Referring to the specific form of the invention shown

in the drawings, there is indicated a duct 6 in which heated fluid is assumed to be flowing, and a spaced but related duct 8 in which cold fluid is flowing. Whether the fluid flow is in the same direction or in different directions is relatively immaterial.

The heat exchanger of the present invention is shown in a simple embodiment comprising a multiplicity of tubes 10 hereinafter referred to as a tube bundle. Each tube is closed at each end and is filled about half full with a material that is liquid at the normal minimum working temperature of the tube. For example, in installations where the minimum working temperature is about 210° F. metallic sodium can be used. The filling material is selected not only on the basis of its melting point but also on the basis of its thermal conductivity and specific heat. The material must be and remain liquid throughout its operating range and should have as high thermal conductivity and as high specific heat as possible. Certain alloys of sodium and potassium melting below 100° F. are suited to the purpose.

In the form shown in Fig. 1 each tube 10 is mounted to extend substantially equi-distantly into the hot fluid duct 6 and the cold fluid duct 8 through a rotatable separating wall member or hub 12. The axis of the tube, at least that portion on each side of the hub 12, is skewed or angularly disposed with relation to the axis of the hub. Thus as the hub is rotated the ends of the tube are alternately elevated one with respect to the other, and the liquid contents flow by gravity first to one end of the tube and then the other.

During the period that the liquid contents of a given tube 10 are in that portion of the tube that is in the hot duct, heat will be transferred to the contents from the wall of the tube. It will be apparent that for 180° of the rotation of the hub this transfer will continue. When the tube assumes a position such that the end in the hot duct is higher than the end in the cold duct, the liquid contents will flow by gravity into the cold end of the tube. The heat absorbed by the liquid will be given up to the cold walls of the tube and thence to the stream of cold fluid passing therearound. Obviously, when the elevation of the end of the tube in the cold duct again exceeds the elevation of the end of the same tube in the hot duct the liquid contents will flow from the cold chamber into the hot chamber again to take up their increment of heat from the hot fluid.

Rotation of the hub 12 and thus of the entire tube bundle may be accomplished in any suitable manner as by a shaft 14 journaled at 16 and 18 and driven by a motor 20 through an appropriate speed reducing drive 22. Rotation of the hub 12 may be intermittent, constant speed or variable speed, and may be under any suitable control.

Any suitable seal may be used to prevent leakage axially at the periphery of the hub from one duct to the other and the resiliently backed sealing shoes 24 indicated in Fig. 2 are only illustrative.

To increase the rigidity of the tube bundle as well as to increase the heat transfer into and out of the tubes, one or more fins 26 may be employed. The fins may take the form of disks perforated to receive the tubes and fasten thereto as by welding, or may take any other suitable form depending on the desired heat capacity of the unit.

While in the form shown in Fig. 1 of the drawings a single layer of uniform diameter tubes has been employed, under some circumstances a plurality of layers of tubes providing concentric tube bundles will be preferred since in this way the capacity of the heat exchanger can be increased. Such a modification is indicated in Fig. 5. Also, the diameter of each tube may be varied, for example as shown in Fig. 4. The vari-

ation in diameter can be used at both ends, if desired, to increase the surface area and weight of content material without increasing the size of the hub. However, a shorter, thicker section can be used at one end than at the other in those cases where the ducts cannot be made of substantially equal size, because of optimum fluid velocities and minimum pressure losses as dictated by the design considerations of the engine with which the heat exchanger is used.

It will also be seen that the problem of sealing between the ducts is greatly simplified over known rotary-type heat exchangers since the surface to be sealed is only a cylinder of relatively small diameter.

There being so circulation pump required, all problems involved in pumping molten metal are eliminated from the known types of liquid coupled indirect transfer regenerators.

While the invention has been shown in conjunction with a specific form and disposition of the parts and minor modifications have been suggested, it will be appreciated that other modifications and changes may be made therein without departing from the scope of the appended claims.

What I claim is:

1. A heat exchanger for use with a chamber containing fluid at high temperature and a chamber containing fluid at low temperature, comprising supporting means disposed between said two chambers, closed hollow means carried by said supporting means and having a hollow portion extending into each of said chambers and tending to assume the temperature thereof, a volume of high heat conductivity material, liquid at its normal working temperature, disposed within and partially filling said hollow means, and means to move said supporting means in a manner such that said liquid enters the portions of said hollow means alternately in said high and low temperature chambers.

2. A heat exchanger for use with a chamber containing fluid at high temperature and a chamber containing fluid at low temperature, comprising supporting means disposed between said two chambers, closed hollow means carried by said supporting means and having a hollow portion extending into each of said chambers and tending to assume the temperature thereof, a volume of high heat conductivity material, liquid at its normal working temperature, disposed within and partially filling said hollow means, and means to alternately elevate and depress the ends of said closed hollow means whereby said liquid enters the portions of said hollow means alternately in said high and low temperature chambers.

3. A heat exchanger for use with a chamber containing fluid at high temperature and a chamber containing fluid at low temperature, comprising a rotatable supporting means disposed between said two chambers, closed end tubular means carried by said supporting means and having a hollow portion extending into each of said chambers and tending to assume the temperature thereof, the axis of said tubular means being spaced from and angularly disposed with relation to the axis of said supporting means, a volume of high heat conductivity metallic material, liquid at its normal working temperature, disposed within and partially filling said tubular means, and means to rotate said hub whereby said liquid material enters the portions of said tubular means alternately in said high and low temperature chambers.

4. A heat exchanger for use with a chamber containing fluid at high temperature and a chamber containing fluid at low temperature, comprising a rotatable supporting means disposed between said two chambers, a plurality of closed end tubes carried by said supporting means and each having a hollow portion extending into each of said chambers, and tending to assume the temperature thereof, the axis of each of said tubes being spaced from and angularly disposed with relation to the axis of said supporting means, a volume of high heat conductivity metallic material, liquid at its normal working temperature, disposed within and filling substantially half of each of said tubes, and means to rotate said hub whereby said liquid material enters the respective portions of each of said tubes alternately in said high and low temperature chambers.

5. The combination of elements defined in claim 4 and fin means connected to each of said tubes adjacent the ends thereof to maintain the spatial relationship of said tubes with each other and to increase the heat flow into and out of said tubes.

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