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HEAT EXCHANGERS EMPLOYING THERMOELECTRIC
ELEMENTS FOR HEAT PUMPING
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FIG. 2

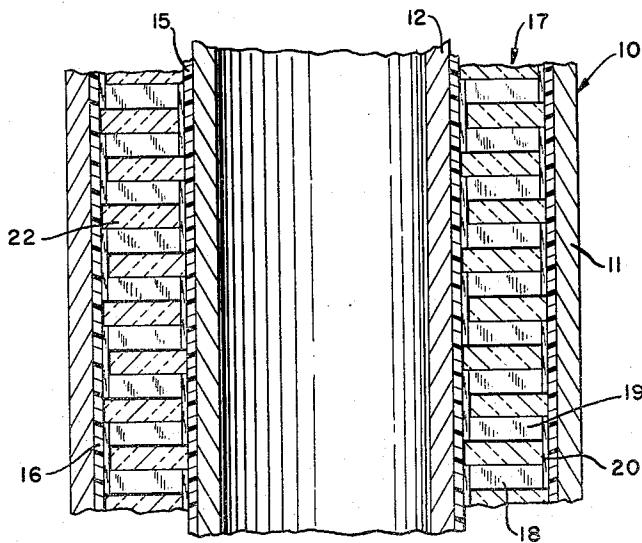
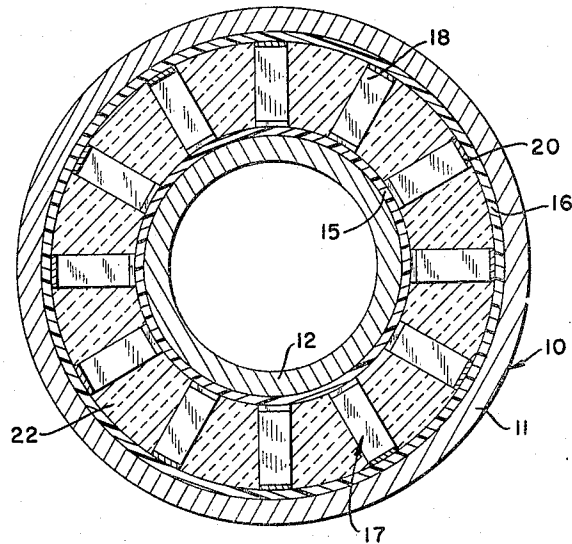


FIG. 1

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HEAT EXCHANGERS EMPLOYING THERMOELECTRIC ELEMENTS FOR HEAT PUMPING

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3 Claims. (Cl. 62—3)

This invention relates to heat exchangers and, more particularly, to a double walled tubular heat exchanger including heat pumping means for transferring heat between the walls.

In effecting fluid to fluid heat exchange, whether this heat exchange is to take place between a gas and a liquid, or a liquid and liquid, highly satisfactory results can be obtained by the utilization of a tubular duct or conduit through which one of the fluids is conducted while the other fluid is passed over the exterior of the duct. The value of tubular fluid conduits becomes particularly important where the fluids between which heat transfer is to be effected are under pressure, in which case maximum structural strength for any given wall thickness is obtained with a tube. Where the heat is to be transferred from a relatively hot to a cold fluid, the natural thermal resistivity of the material of which said tubular conduit is fabricated hampers the effectiveness of heat transfer through the side walls of said conduit.

A primary object of the invention is to provide an improved tubular heat exchanger.

Another object of the invention is to provide a tubular heat exchanger permitting heat transfer through the side walls thereof by means of a heat pumping effect.

It is also an object of the invention to provide means permitting the utilization of thermoelectric couples to implement heat exchange between the interior and exterior of the tube.

These and other objects of the invention which will become apparent in the following disclosure and claims are achieved by providing double walled cylindrical fluid conducting means in the form of a tubular member comprising two concentric axially spaced co-extensive tubes. Heat pumping means comprising thermoelectric couples arranged to operate to produce a Peltier effect are positioned in the spacing between the aforementioned tubes, the junctions of said thermoelectric couples being electrically insulated from the tubes, the hot junctions being in heat exchange relationship with one of the tubes, and the cold junctions being in heat exchange relationship with the other of the tubes.

A primary feature of the invention resides in the fact that the structural rigidity provided by relatively thick walled tubular fluid conduits may be obtained in a heat exchanger, with the thermal resistivity of the conduit wall mitigated by the heat pumping effects of the thermoelectric couples.

The specific structural details of the invention, and their mode of fabrication and functioning will be made most manifest and particularly pointed out in clear, concise, and exact terms in conjunction with the accompanying drawings, wherein:

Figure 1 represents a longitudinal cross sectional view through a tubular heat exchanger constructed in accordance with the teachings of this invention; and

Figure 2 is a transverse cross sectional view through the tube of Figure 1.

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Referring now more particularly to the drawings, like numerals in the various figures will be taken to designate like parts.

As seen in the drawing, the heat exchanger structure 10 comprises a double walled conduit comprising an exterior tube 11 and an interior tube 12. Tubes 11 and 12 are concentric and co-extensive in length, but are of a sufficiently different diameter to provide for an annular spacing between said tubes.

An inner sleeve 15 of electrical insulation is provided about the outer surface of inner tube 12. An outer sleeve 16 of electrical insulation is provided along the inner surface of outer tube 11. The insulation 15, and 16 is of a heat conducting type such as a mica filled epoxy resin.

Within the space between inner insulation 15 and outer insulation 16 a heat pump in the form of a battery of thermoelectric couples 17 is arranged. Each thermoelectric couple is formed of two arms 18 and 19 respectively formed of different thermoelectric material and one end of each arm is electrically connected to an end of another arm by means of a jumper 20. The thermoelectric couples are of known form in which each couple contains an arm of P-type material and an arm of N-type material whereby the passage of current through the couple will produce a Peltier effect resulting in one of the junctions being heated while the other junction is cooled. The cold junction is arranged in heat exchange relationship with one of the tubes, and the hot junction is arranged in heat exchange relationship with the other of the tubes.

As will be apparent each battery of thermoelectric couples may be formed of a plurality of couples extending longitudinally of the tube, or of a plurality of couples extending circumferentially of the tube. In the illustrated embodiment of the invention, the couples are arranged longitudinally with the P-type arm of one couple connected by a junction plate to the N-type arm of the adjacent couple. The last arm on each end of the battery has its free end connected to a conductor (not shown) by means of which the thermoelectric battery may be coupled to a source of direct current, either a battery, D.C. generator, or rectifier.

Fabrication of the above described structure may be accomplished in a variety of ways. Some modes of manufacture which have been found satisfactory are here suggested.

In one mode of manufacture, the thermoelectric elements 18, 19 are conjoined by means of jumpers 20 into a battery by assembling the thermoelectric arms 18, 19 in a fixture and then electrically coupling opposite ends of arms 18, 19 by jumper 20. The inner and outer insulation 15 and 16 respectively may be provided in the form of concentric tubes of appropriate diameter or may be more efficiently provided by coating the outer and inner surfaces of inner and outer tubes 12 and 11 respectively; thereafter the thermoelectric elements are slid into position in their assembly fixture within outer tube 11. The assembly fixture is removed, and inner tube 12 is inserted and expanded to hold the parts in assembled relationship. If desired foamed in place insulation 22 may be employed to hold the thermoelectric arms in position.

Fabrication may also be accomplished by splitting outer tube 11, and after assembly of the thermoelectric pile between tubes 11 and 12, applying pressure to outer tube 11 to maintain the components in assembled relationship.

Similarly inner tube 12 might be split to provide an expansion joint. In both cases of splitting of the tubes it is recommended that a tight joint be formed after assembly to prevent leakage of the fluid to the thermoelectric couple.

It is also possible to assemble the thermoelectric arms and their junctions in a cast sleeve of insulating mate-

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rial. The sleeve is thereafter slid in place between the tubes 11 and 12.

It will be understood by those skilled in the art that air films are eliminated by the use of silicone oils or other heat transfer fluids in the assembly of the structure.

The aforescribed structure fabricated as disclosed may be readily employed to effect heat exchange between two fluids, either a liquid and gas, liquid and liquid, or gas and gas. This is done by directing the two fluids into heat exchange relationship with an interior and exterior wall respectively of the heat exchanger 10. Since a maximum coefficient of performance of the thermoelectric couples is attained with a minimum heat gradient between opposite faces of the couples, it is recommended that the fluids be directed in counterflow to each other. Thus the novel heat exchanger will be so positioned in the flow paths of the fluids between which the heat exchange is to be effected so as to attain this minimum temperature gradient across the couple and the highest temperature fluid externally of the structure will flow adjacent the highest temperature fluid internally.

The primary advantage provided by the herein described novel heat exchanger structure centers about the fact that heat exchange may be effected between fluids of relatively high pressure. This is so since the rigidity provided by a tubular member is made available for use in conjunction with the heat pumping effects of a thermoelectric couple. The thermoelectric couple serving to permit the pumping of heat from a fluid and to mitigate the thermal resistivity of the tubular wall where heat transfer is to be effected from a relatively hot to a cold fluid. Thus without necessitating intermediate heat exchange fluids, and without requiring complex refrigeration systems, by the use of a relatively simple rigid tubular structure constructed in accordance with the teachings of this invention, it is possible to employ the heat pumping effects of a thermoelectric couple to implement heat exchange between fluids.

As will be apparent to those skilled in the art the novel structure may be employed so that the thermoelectric heat pump aids in the transfer of heat through the walls of the exchanger from a warm fluid to a relatively cooler fluid or it may, by reversing the flow of electricity be employed to effect heat pumping from a cool fluid to a relatively warmer fluid. It will be understood that when the warmer fluid flows through the interior or inner tube 11 and the cooler fluid over the outer or exterior tube 12, and it is desired to transfer heat from the warmer fluid in the inner tube to the cooler fluid, the thermoelectric battery operates in aid of the normal heat flow, while if the reverse is true and it is desired to remove heat from the cooler fluid, the battery may be employed to pump this heat.

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The above disclosure has been given by way of illustration and elucidation, and not by way of limitation, and it is desired to protect all embodiments of the herein disclosed inventive concept within the scope of the appended claims.

We claim:

1. A thermoelectric heat exchanger comprising a continuous inner tubular member, an outer tubular member surrounding said inner member and spaced therefrom, a first sleeve of electrical insulation adjacent the exterior of said inner tubular member, a second sleeve of electrical insulation adjacent the interior of said outer tubular member, a plurality of thermoelectric elements disposed between said first sleeve and said second sleeve, said thermoelectric elements having dissimilar thermoelectric properties, a plurality of jumpers of electrically conducting material positioned adjacent and in heat exchange relation with said inner tubular member and spaced therefrom by said first sleeve, a plurality of jumpers of electrically conducting material positioned adjacent and in heat exchange relation with said outer tubular member and spaced therefrom by said second sleeve, said jumpers electrically joining pairs of thermoelectric elements having dissimilar thermoelectric properties in a predetermined series order to form thermoelectric junctions adjacent said tubular members such that heat energy may be transferred from one of said tubular members to the other of said tubular members by the passage of an electric current through said thermoelectric elements.

2. A thermoelectric heat exchanger as defined in claim 1 wherein said thermoelectric elements are spaced from each other and wherein a mass of foam insulation substantially fills the space between said first and said second sleeves of electrical insulation and surrounds said thermoelectric elements to inhibit heat transfer between said inner and said outer tubular members.

3. A thermoelectric heat exchanger as defined in claim 1 wherein said thermoelectric elements are arranged in a plurality of series connected rows each of said rows of thermoelectric elements comprising a plurality of thermoelectric junctions extending axially along said continuous inner and outer tubular members and each of said rows of thermoelectric elements being positioned about the exterior of said inner tubular member and spaced therefrom by said first sleeve.

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