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(54) HEAT EXCHANGER TUBE HAVING INTEGRATED THERMOELECTRIC DEVICES

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(57) ABSTRACT

A heat exchanger for a vehicle is shown, wherein the heat exchanger includes a plurality of tubes having integrated thermoelectric devices disposed thereon to facilitate heat transfer between the tubes and an atmosphere surrounding the tubes.

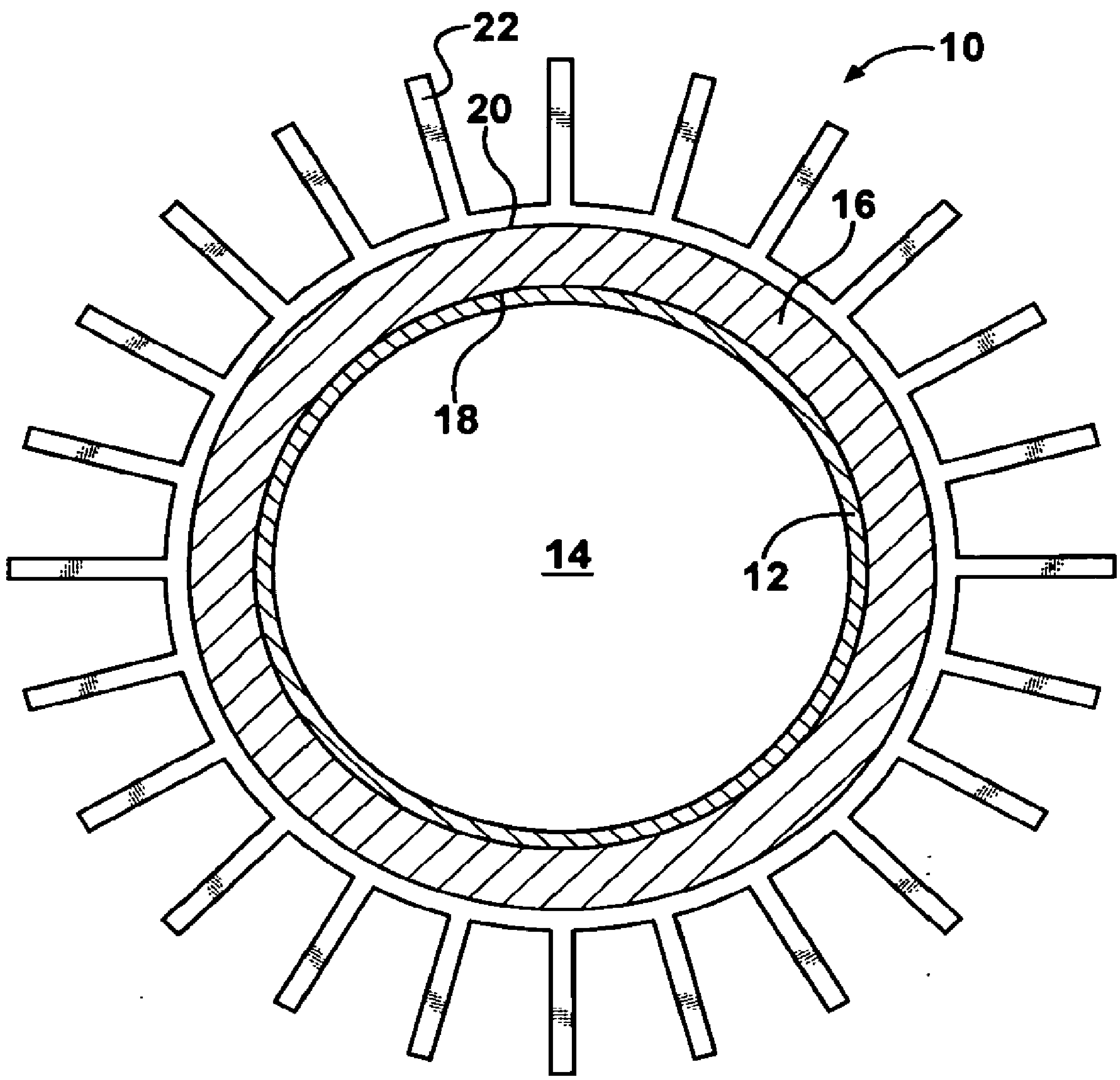
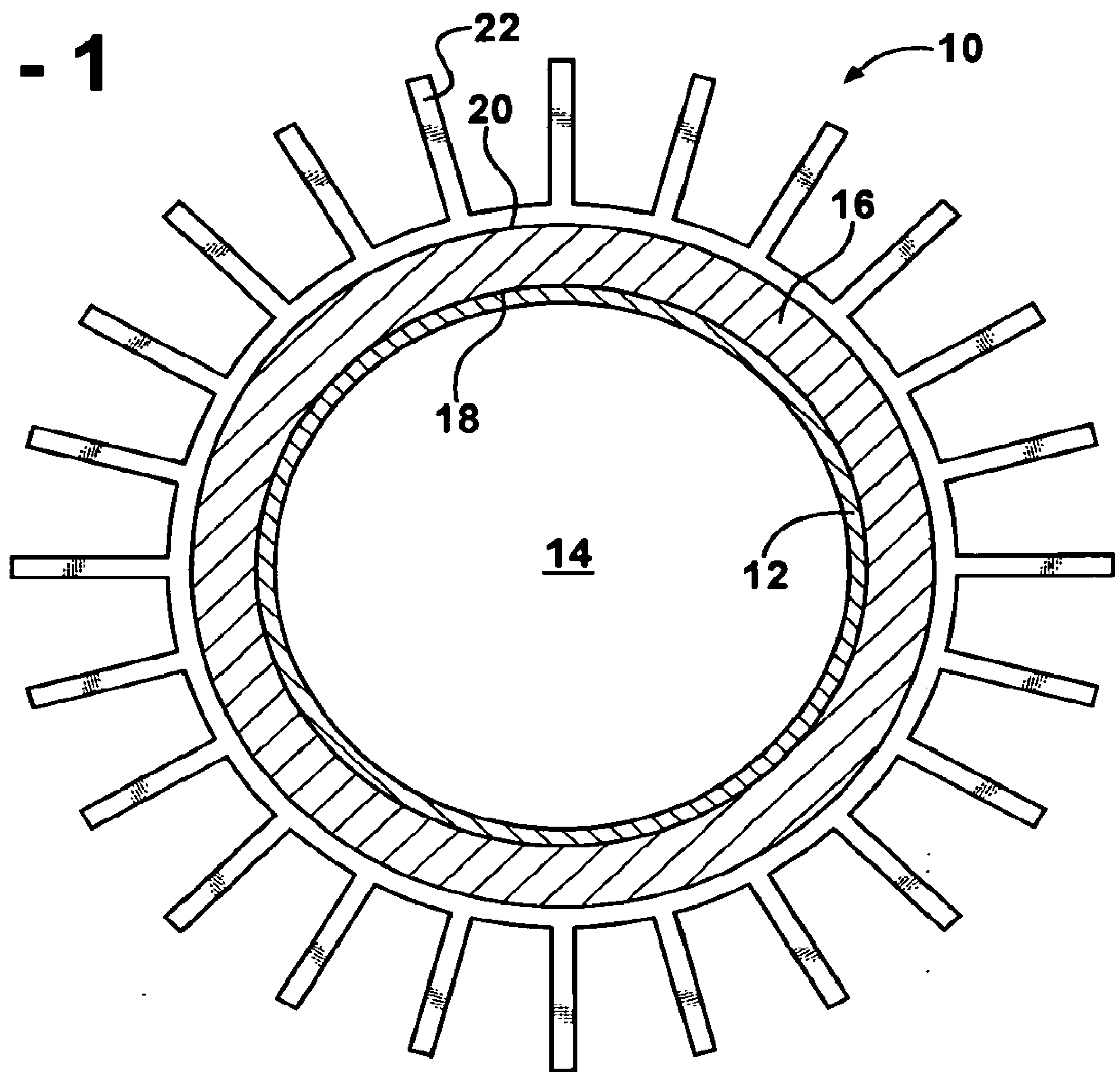


FIG - 1



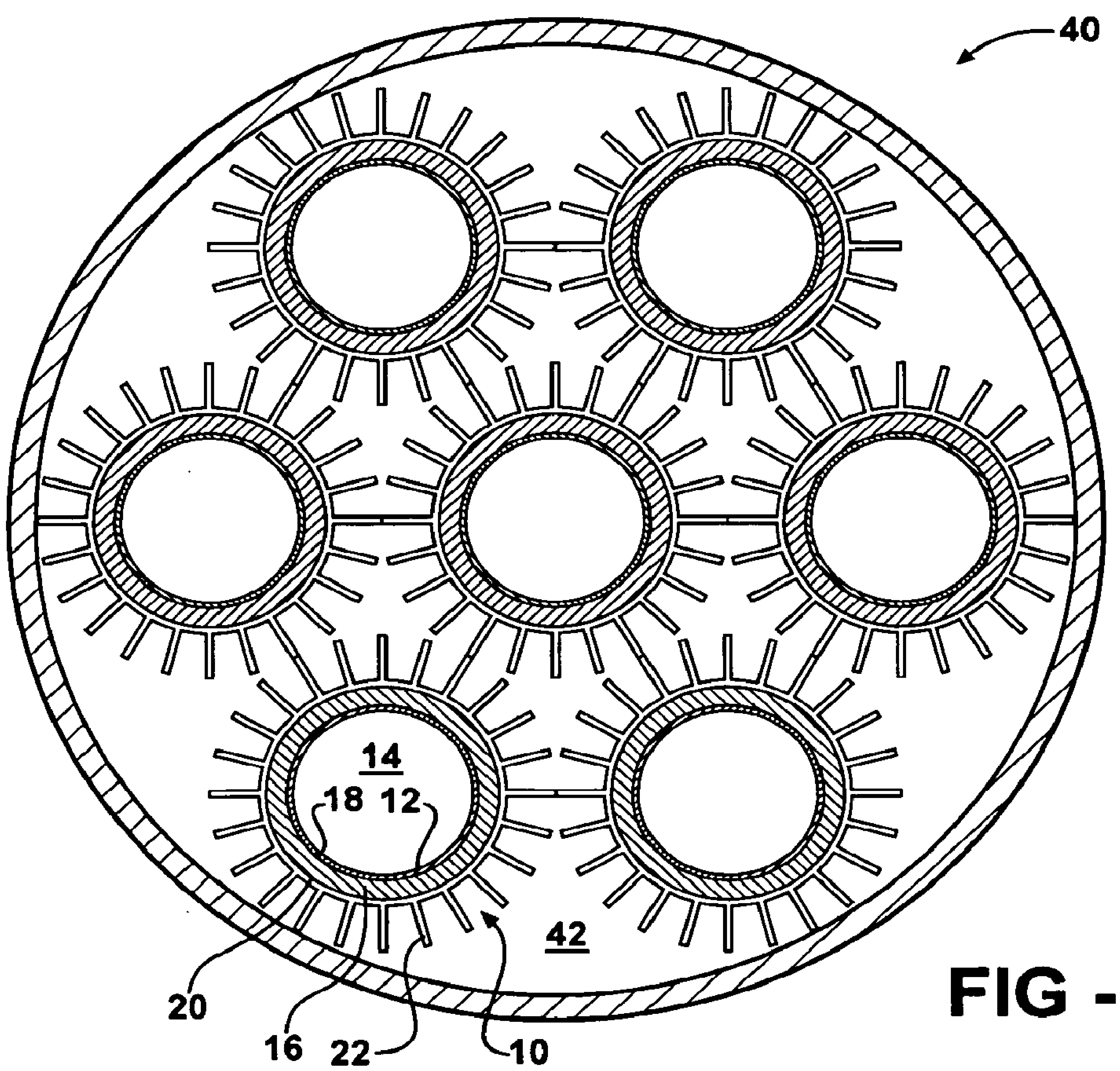


FIG - 2

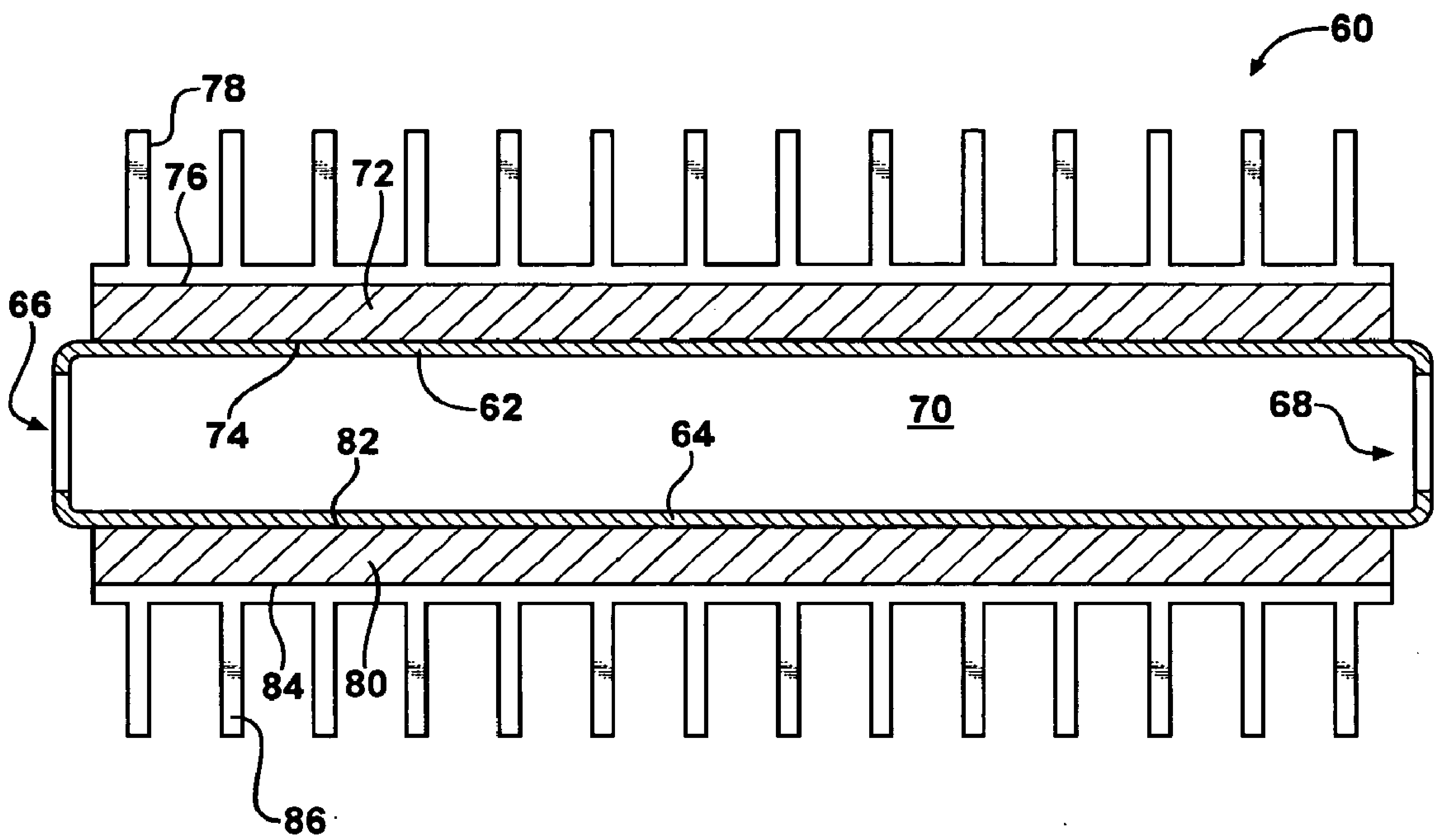
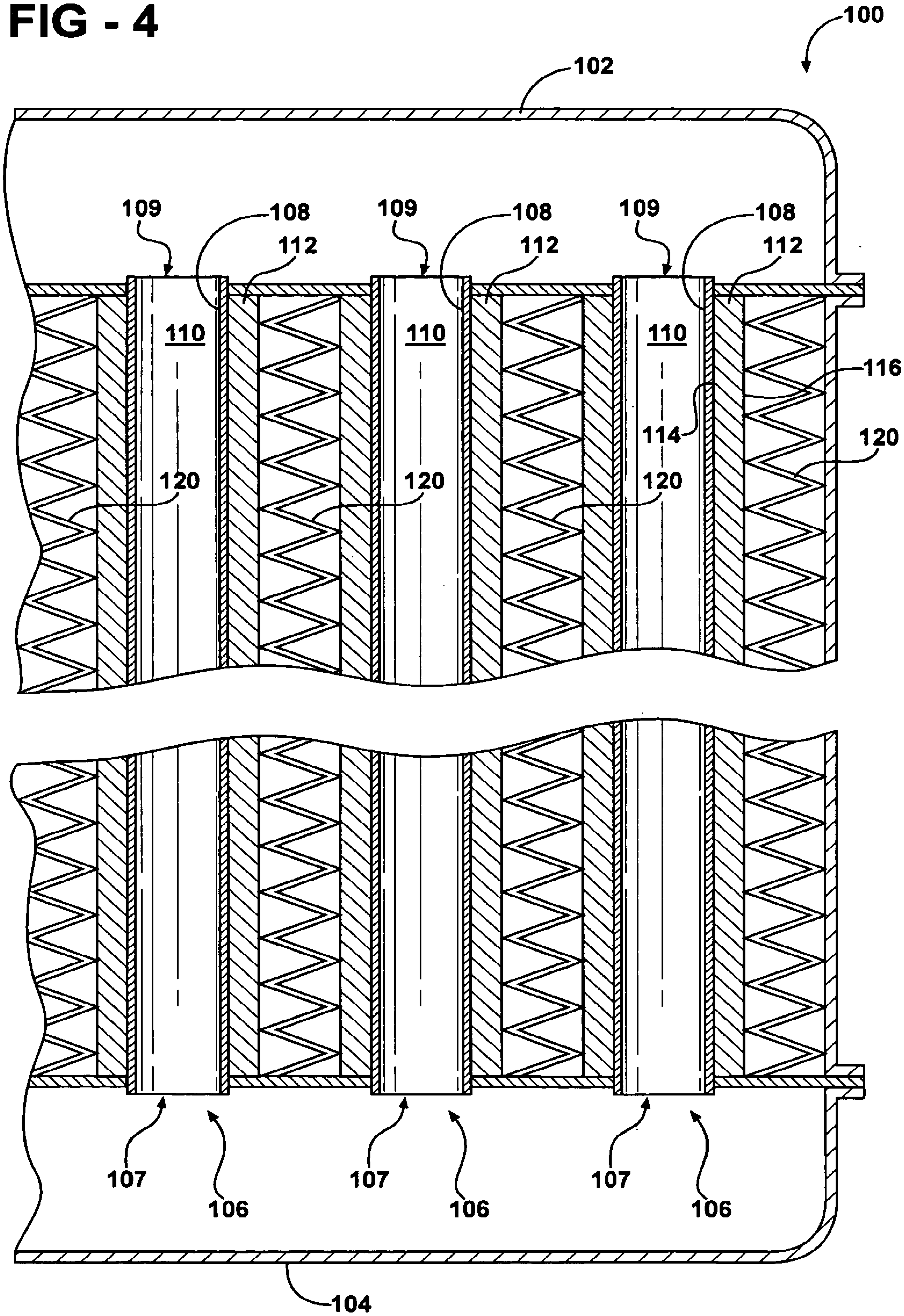


FIG - 3

FIG - 4



HEAT EXCHANGER TUBE HAVING INTEGRATED THERMOELECTRIC DEVICES

RELATED APPLICATIONS

[0001] This application is a continuation of U.S. application Ser. No. 11/497,695, filed Aug. 2, 2006, titled HEAT EXCHANGER TUBE HAVING INTEGRATED THERMOELECTRIC DEVICES, the entire contents of which are incorporated by reference herein and made a part of this specification.

BACKGROUND

[0002] 1. Field

[0003] The present invention relates to a heat exchanger tube and more particularly to a heat exchanger tube having integrated thermoelectric devices to increase a thermal efficiency of the heat exchanger.

[0004] 2. Description of Related Art

[0005] An air-cooled fin-type heat exchanger is very well known. Heat exchangers are used for changing the temperature of various working fluids, such as an engine coolant, an engine lubricating oil, an air conditioning refrigerant, and an automatic transmission fluid, for example. The heat exchanger typically includes a plurality of spaced apart fluid conduits or tubes connected between an inlet tank and an outlet tank, and a plurality of heat exchanging fins disposed between adjacent conduits. Air is directed across the fins of the heat exchanger by a cooling fan or a motion of a vehicle, for example. As the air flows across the fins, heat in a fluid flowing through the tubes is conducted through the walls of the tubes, into the fins, and transferred into the air.

[0006] One of the primary goals in heat exchanger design is to achieve the highest possible thermal efficiency. Thermal efficiency is measured by dividing the amount of heat that is transferred by the heat exchanger under a given set of conditions (amount of airflow, temperature difference between the air and fluid, and the like) by the theoretical maximum possible heat transfer under those conditions. Thus, an increase in the rate of heat transfer under a given set of conditions results in a higher thermal efficiency.

[0007] Typically, to improve thermal efficiency, the airflow must be improved and/or a pressure drop through the heat exchanger must be reduced. Improved heat exchanger performance can be accomplished by forming the fins and/or louvers on the fins at a predetermined angle in a manner also well known in the art. Pressure drop is associated with the change in airflow direction caused by the louvered fins. A higher air pressure drop can result in a lower heat transfer rate. Various types of fin and louver designs have been disclosed in the prior art with the object of increasing the heat exchanger efficiency by making improvements in the fins, louvers, and airflow pattern.

[0008] Examples of these prior art fin and louver designs include an addition of fin rows in order to increase the amount of air encountered by the heat exchanger. Other designs include louvers formed at an angle to the fin wall, rather than square to the fin wall. Further, the prior art discloses heat exchangers with multiple changes of airflow direction. Air flows through the louvers until a middle transition piece or turnaround rib is reached. The air then changes direction and flows through exit louvers to exit the heat exchanger. Fin design continues to play an important role in increasing heat exchanger efficiency.

[0009] A thermoelectric device can be used to transfer heat between fluids, such as from air flow to a fluid in a fluid conduit, for example. The thermoelectric device includes a hot side and a cold side, wherein one of the hot side and the cold side is in communication with each of the fluids. A heat transfer efficiency of the thermoelectric device decreases as a difference in temperature between the hot side and the cold side thereof increases.

[0010] It would be desirable to produce a tube for a heat exchanger having an integrated thermoelectric device whereby a thermal efficiency of the heat exchanger is maximized.

SUMMARY

[0011] Harmonious with the present invention, a tube for a heat exchanger having an integrated thermoelectric device whereby a thermal efficiency of the heat exchanger is maximized has surprisingly been discovered.

[0012] In one embodiment, a tube for a heat exchanger comprises a hollow conduit having a wall, a first end, and a spaced apart second end; and a thermoelectric device in thermal communication with the wall of the conduit to facilitate heat transfer between a first fluid in the conduit and a second fluid outside of the conduit.

[0013] In another embodiment, a heat exchanger comprises at least one heat exchanger tank; a hollow tube having a wall, a first end, and a spaced apart second end, the tube in fluid communication with the at least one heat exchanger tank; a thermoelectric device in thermal communication with the wall of the tube; and a heat exchanger fin in thermal communication with the thermoelectric device.

[0014] In another embodiment, a heat exchanger comprises at least one heat exchanger tank; a plurality of hollow tubes, each tube having a wall, a first end, and a spaced apart second end, the tubes in fluid communication with the at least one heat exchanger tank and adapted to convey a first fluid; a plurality of heat exchanger fins disposed adjacent the tubes and in thermal communication with a second fluid; and a plurality of thermoelectric devices, at least one thermoelectric device disposed between the tubes and the fins to facilitate heat transfer therebetween.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The above, as well as other objects and advantages of the invention, will become readily apparent to those skilled in the art from reading the following detailed description of a preferred embodiment of the invention when considered in the light of the accompanying drawings in which:

[0016] FIG. **1** is an end sectional view of a tube for a heat exchanger in accordance with an embodiment of the invention;

[0017] FIG. **2** is an end sectional view a heat exchanger using the tube of FIG. **1**;

[0018] FIG. **3** is a side sectional view of a tube for a heat exchanger in accordance with another embodiment of the invention; and

[0019] FIG. **4** is a front sectional view of a heat exchanger in accordance with another embodiment of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0020] The following detailed description and appended drawings describe and illustrate various exemplary embodiments of the invention. The description and drawings serve to enable one skilled in the art to make and use the invention, and are not intended to limit the scope of the invention in any manner.

[0021] FIG. **1** shows a cylindrical tube **10** for a heat exchanger **40** illustrated in FIG. **2**. The tube **10** has an outer wall **12** with a substantially circular cross-sectional shape. Other cross-sectional shapes can be used as desired. The wall **12** is preferably formed from copper or steel; however, other materials may be used to form the wall **12** without departing from the scope and spirit of the invention. The wall **12** forms a hollow interior portion **14**.

[0022] A thermoelectric device (TED) **16** surrounds and is in thermal communication with the wall **12**. The TED **16** includes a first heat transfer surface **18** and a second heat transfer surface **20**. The first heat transfer surface **18** is in thermal communication with the wall **12**. The second heat transfer surface **20** is in thermal communication with a plurality of fins **22** surrounding the TED **16**.

[0023] The TED **16** is in electrical communication with a control system (not shown). The control system controls an electric current sent to the TED **16**. When a current is delivered in one direction, one of the first heat transfer surface **18** and the second heat transfer surface **20** generates thermal energy and the other of the first heat transfer surface **18** and the second heat transfer surface **20** absorbs thermal energy. When the current is reversed, the one of the first heat transfer surface **18** and the second heat transfer surface **20** which was generating thermal energy now absorbs thermal energy, and the other of the first heat transfer surface **18** and the second heat transfer surface **20** now generates thermal energy. When the current is increased, a heating and cooling capacity of the TED **16** is increased. Likewise, when the current is decreased, the heating and cooling capacity of the TED **16** is decreased.

[0024] The TED **16** may be any conventional device such as: those produced by Marlow Industries, Inc. of Dallas, Tex.; the thermoelectric systems described in U.S. Pat. No. 6,539,725 to Bell; a quantum tunneling converter; a Peltier device; a thermo ionic module; a magneto caloric module; an acoustic heating mechanism; a solid state heat pumping device; and the like; for example; or any combination of the devices listed above. Although a single thermoelectric device is shown, it is understood that additional thermoelectric devices can be used, as desired.

[0025] In use, a first fluid (not shown) is caused to flow through the hollow interior portion **14** of the tube **10**. The first fluid can be any conventional fluid such as air or a coolant such as a water-glycol coolant, for example. The first fluid contains thermal energy which is transferred to the wall **12**. Current is supplied to the TED **16**, which causes the first heat transfer surface **18** of the TED **16** to absorb thermal energy from the wall **12**. Simultaneously, the second heat transfer surface **20** of the TED **16** generates thermal energy. The thermal energy generated by the second heat transfer surface **20** of the TED **16** is transferred to the fins **22**. A second fluid (not shown) is caused to flow across and contact the fins **22**. The second fluid can be any conventional fluid such as air, for example. The thermal energy transferred from the second heat transfer surface **20** of the TED **16** to the fins **22** is transferred to the second fluid.

[0026] FIG. **3** shows a tube **60** for a heat exchanger (not shown) having a first wall **62**, a second wall **64**, a fluid inlet **66**, and a fluid outlet **68**. The tube **60** shown is a flat tube for use in a flat tube heat exchanger. However, tubes having other shapes and for use in other types of heat exchangers, such as cross flow heat exchangers, shell and tube heat exchangers, or counter flow heat exchangers, for example, can be used as desired without departing from the scope and spirit of the invention. The walls **62**, **64** are preferably formed from copper or steel. However, other materials may be used to form the walls **62**, **64** as desired. The first wall **62**, the second wall **64**, and a pair of side walls (not shown) cooperate to form a hollow interior portion **70**.

[0027] A first thermoelectric device (TED) **72** is disposed adjacent to and is in thermal communication with the first wall **62**. The first TED **72** includes a first heat transfer surface **74** and a second heat transfer surface **76**. The first heat transfer surface **74** is in thermal communication with the first wall **62**. The second heat transfer surface **76** is in thermal communication with a plurality of fins **78** disposed adjacent to the first TED **72**.

[0028] A second thermoelectric device (TED) **80** is disposed adjacent to and is in thermal communication with the second wall **64**. The second TED **80** includes a first heat transfer surface **82** and a second heat transfer surface **84**. The first heat transfer surface **82** is in thermal communication with the second wall **64**. The second heat transfer surface **84** is in thermal communication with a plurality of fins **86** disposed adjacent to the second TED **80**.

[0029] The TEDs **72**, **80** may be any conventional devices such as: those produced by Marlow Industries, Inc. of Dallas, Tex.; the thermoelectric systems described in U.S. Pat. No. 6,539,725 to Bell; a quantum tunneling converter; a Peltier device; a thermo ionic module; a magneto caloric module; an acoustic heating mechanism; a solid state heat pumping device; and the like; for example; or any combination of the devices listed above. Although two thermoelectric devices are shown, it is understood that a single or additional thermoelectric devices can be used, as desired. Further, it is understood that the side walls of the tube **60** may include additional TEDs if desired. If the side walls of the tube include additional TEDs, a plurality of fins can be disposed adjacent the TEDs as desired.

[0030] The first TED **72** and the second TED **80** are in electrical communication with a control system (not shown). The control system controls an electric current sent to the TEDs **72**, **80**. When a current is delivered in one direction, one of the first heat transfer surfaces **74**, **82** and the second heat transfer surfaces **76**, **84** generates thermal energy and the other of the first heat transfer surfaces **74**, **82** and the second heat transfer surfaces **76**, **84** absorbs thermal energy. When the current is reversed, the one of the first heat transfer surfaces **74**, **82** and the second heat transfer surfaces **76**, **84** which was generating thermal energy now absorbs thermal energy, and the other of the first heat transfer surfaces **74**, **82** and the second heat transfer surfaces **76**, **84** now generates thermal energy. When the current is increased, a heating and cooling capacity of the TEDs **72**, **80** is increased. Likewise, when the current is decreased, the heating and cooling capacity of the TEDs **72**, **80** is decreased.

[0031] In use, a first fluid (not shown) is caused to flow through the hollow interior portion **70** of the tube **60**. The first fluid can be any conventional fluid such as air or a coolant such as a water-glycol coolant, for example. The first fluid contains thermal energy which is transferred to the first wall **62** and the second wall **64**. Current is supplied to the TEDs **72**, **80**, which causes the first heat transfer surfaces **74**, **82** of the TEDs **72**, **80** to absorb thermal energy from the first wall **62**

and the second wall **64**. Simultaneously, the second heat transfer surfaces **76**, **84** of the TEDs **72**, **80** generate thermal energy. The thermal energy generated by the second heat transfer surfaces **76**, **84** of the TEDs **72**, **80** is transferred to the fins **78**, **86**. A second fluid (not shown) is caused to flow across and contact the fins **78**, **86**. The second fluid can be any conventional fluid such as air, for example. The thermal energy transferred from the second heat transfer surfaces **76**, **84** of the TEDs **72**, **80** to the fins **78**, **86** is transferred to the second fluid.

[0032] FIG. **4** shows a heat exchanger **100** in accordance with another embodiment of the invention. The heat exchanger **100** includes a first header **102** and a spaced apart second header **104**. A plurality of cylindrical tubes **106** are disposed between the first header **102** and the second header **104**. The tubes have walls **108** with a substantially circular cross-sectional shape. Other cross-sectional shapes can be used as desired. The walls **108** are preferably formed from copper or steel. However, other materials may be used to form the walls **108** without departing from the scope and spirit of the invention. The walls **108** form hollow interior portions **110** and include a fluid inlet **107** and a fluid outlet **109**.

[0033] A thermoelectric device (TED) **112** surrounds and is in thermal communication with each of the walls **108**. Each TED **112** includes a first heat transfer surface **114** and a second heat transfer surface **116**. The first heat transfer surface **114** is in thermal communication with the wall **108** of the corresponding tube **106**. The second heat transfer surface **116** is in thermal communication with a plurality of fins **120** disposed between each adjacent tube **106**.

[0034] Each TED **112** is in electrical communication with a control system (not shown). The control system controls an electric current sent to the TED **112**. When a current is delivered in one direction, one of the first heat transfer surface **114** and the second heat transfer surface **116** generates thermal energy and the other of the first heat transfer surface **114** and the second heat transfer surface **116** absorbs thermal energy. When the current is reversed, the one of the first heat transfer surface **114** and the second heat transfer surface **116** which was generating thermal energy now absorbs thermal energy and the other of the first heat transfer surface **114** and the second heat transfer surface **116** now generates thermal energy. Additionally, when the current is increased, a heating and cooling capacity of the TED **112** is increased. Likewise, when the current is decreased, the heating and cooling capacity of the TED **112** is decreased.

[0035] The TEDs **112** may be any conventional devices such as: those produced by Marlow Industries, Inc. of Dallas, Tex.; the thermoelectric systems described in U.S. Pat. No. 6,539,725 to Bell; a quantum tunneling converter; a Peltier device; a thermo ionic module; a magneto caloric module; an acoustic heating mechanism; a solid state heat pumping device; and the like; for example; or any combination of the devices listed above. Although a single thermoelectric device is shown disposed adjacent each of the tubes **106**, it is understood that additional thermoelectric devices can be used, as desired.

[0036] In use, a first fluid (not shown) is caused to flow from the second header **104** through the fluid inlets **107** into the hollow interior portions **110** of the tubes **106**. The first fluid can be any conventional fluid such as air or a coolant such as a water-glycol coolant, for example. The first fluid contains thermal energy which is transferred to the walls **108**. Current is supplied to each TED **112**, which causes the first heat transfer surface **114** of each TED **112** to absorb thermal energy from the wall **108** of the corresponding tube **106**. Simultaneously, the second heat transfer surface **116** of each TED **112** generates thermal energy. The thermal energy generated by the second heat transfer surface **116** of each TED **112** is transferred to the fins **120**. A second fluid (not shown) is caused to flow across and contact the fins **120**. The second fluid can be any conventional fluid such as air, for example. The thermal energy transferred from the second heat transfer surface **116** of each TED **112** to the fins **120** is transferred to the second fluid. The first fluid flows out of the fluid outlets **109** and into the first header **102**.

[0037] From the foregoing description, one ordinarily skilled in the art can easily ascertain the essential characteristics of this invention and, without departing from the spirit and scope thereof, can make various changes and modifications to the invention to adapt it to various usages and conditions.

What is claimed is:

1. A heat exchanger comprising:
at least one fluid channel;
a plurality of hollow tubes, each of the plurality of tubes having a wall, a first end, and a spaced apart second end, wherein a hollow interior portion of each of the plurality of tubes is in fluid communication with the at least one fluid channel;
a plurality of thermoelectric devices, each of the plurality of thermoelectric devices comprising a first heat transfer surface and a second heat transfer surface, wherein the first heat transfer surface of each of the plurality of thermoelectric devices is in thermal communication with at least a portion of the wall of at least one of the plurality of tubes; and
a plurality of heat exchanger fins, each of the plurality of heat exchanger fins in thermal communication with the second heat transfer surface of at least one of the plurality of thermoelectric devices, wherein the plurality of heat exchanger fins are configured to substantially increase a surface area of thermal communication between the plurality of thermoelectric devices and a working fluid flowing outside the plurality of hollow tubes beyond the surface area of thermal communication of the heat exchanger without the plurality of heat exchanger fins.

2. The heat exchanger of claim **1**, further comprising a control system in electrical communication with the plurality of thermoelectric devices, the control system configured to control a direction of electric current delivered to the plurality of thermoelectric devices.

3. The heat exchanger of claim **2**, wherein the control system is configured to control a variable electric current delivered to the plurality of thermoelectric devices.

4. The heat exchanger of claim **1**, wherein at least one of the plurality of thermoelectric devices is disposed around the wall of at least one of the tubes.

5. The heat exchanger of claim **1**, wherein the hollow interior portion of the plurality of tubes is configured to convey a first fluid, and the heat exchanger is configured to convey a second fluid outside the plurality of tubes.

6. The heat exchanger of claim **5**, wherein the first fluid is a liquid, and the second fluid is a gas.

7. The heat exchanger of claim **1**, wherein the heat exchanger is a flat tube heat exchanger.

8. The heat exchanger of claim **1**, wherein the heat exchanger is a cross flow heat exchanger.

9. The heat exchanger of claim **1**, wherein the heat exchanger is a shell and tube heat exchanger.

10. The heat exchanger of claim **1**, wherein the heat exchanger is a counter flow heat exchanger.

11. The heat exchanger of claim **1**, wherein the control system is configured to control the direction of the electric current delivered to the plurality of thermoelectric devices in order to select between a first mode, in which thermal energy is transferred from the wall to the plurality of heat exchanger fins, and a second mode, in which thermal energy is transferred from the plurality of heat exchanger fins to the wall.

12. A method of manufacturing a heat exchanger, the method comprising:

providing a plurality of hollow tubes, each of the plurality of tubes having a wall, a first end, and a spaced apart second end, wherein a hollow interior portion of each of the plurality of tubes is in fluid communication with the at least one fluid channel;

providing a plurality of thermoelectric devices, each of the plurality of thermoelectric devices comprising a first heat transfer surface and a second heat transfer surface;

placing the first heat transfer surface of each of the plurality of thermoelectric devices is in thermal communication with at least a portion of the wall of at least one of the plurality of tubes; and

providing a plurality of heat exchanger fins;

placing each of the plurality of heat exchanger fins in thermal communication with the second heat transfer surface of at least one of the plurality of thermoelectric devices, wherein the plurality of heat exchanger fins are configured to substantially increase a surface area of thermal communication between the plurality of thermoelectric devices and a working fluid flowing outside the plurality of hollow tubes beyond the surface area of thermal communication of the heat exchanger without the plurality of heat exchanger fins.

13. The method of claim **12**, further comprising operatively connecting a control system to the plurality of thermoelectric devices, the control system configured to control a direction of electric current delivered to the plurality of thermoelectric devices.

14. The method of claim **13**, wherein the control system is configured to control a variable electric current delivered to the plurality of thermoelectric devices.

15. The method of claim **12**, wherein at least one of the plurality of thermoelectric devices is disposed around the walls of the tubes.

16. The method of claim **12**, wherein the plurality of heat exchanger fins extend radially outwardly from outer surfaces of the thermoelectric devices.

17. The method of claim **12**, wherein the hollow interior portion of the plurality of tubes is configured to convey a first fluid, and the heat exchanger is configured to convey a second fluid outside the plurality of tubes.

18. The method of claim **17**, wherein the first fluid is a liquid, and the second fluid is a gas.

19. The method of claim **12**, wherein the heat exchanger is one of a flat tube heat exchanger, a cross flow heat exchanger, a shell and tube heat exchanger, and a counter flow heat exchanger.

20. The method of claim **12**, wherein the control system is configured to control the magnitude of the electric current delivered to the at least one thermoelectric device in order to select a heating and cooling capacity of the at least one thermoelectric device.

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