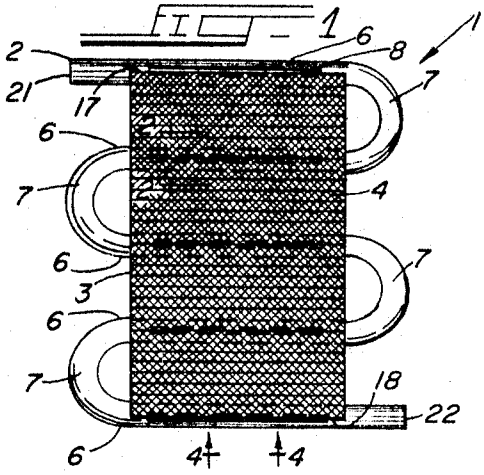
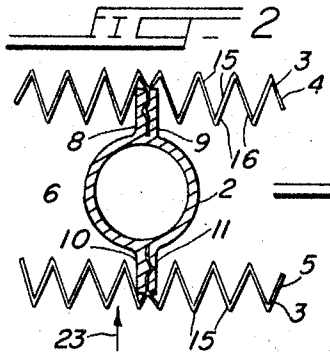
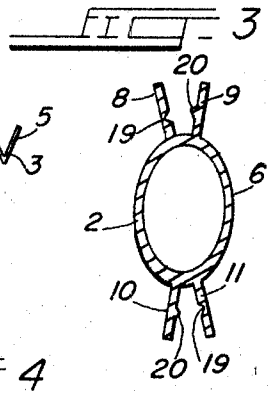
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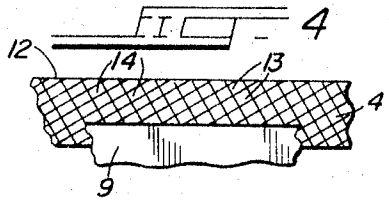
HEAT EXCHANGERS

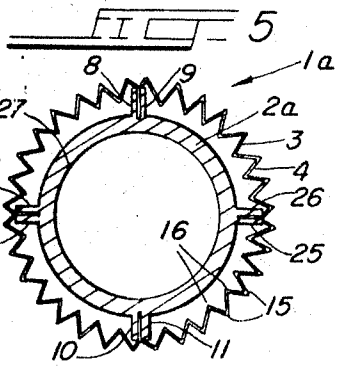
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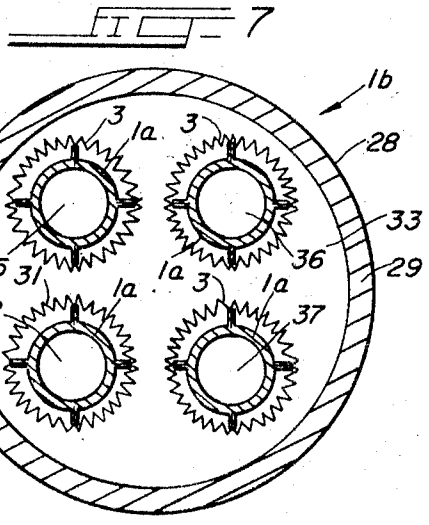


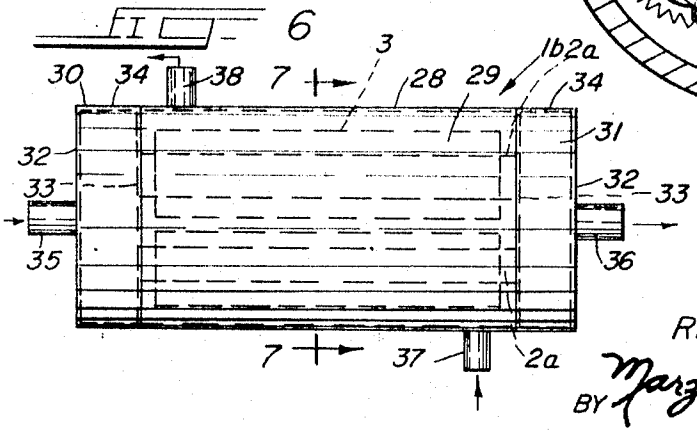












INVENTOR.
RICHARD W. KRITZER
BY Marzall, Johnston, Cook & Root
ATTYS

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HEAT EXCHANGERS

Richard W. Kritzer, Chicago, Ill., assignor to Peerless of America, Incorporated, Chicago, Ill., a corporation of Illinois

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ABSTRACT OF THE DISCLOSURE

A heat exchanger embodying a tubular member for feeding working fluid therethrough, and with a perforated sheet material attached to the tubular member to afford a secondary heat-transfer surface.

Background of the invention

This invention relates to heat exchangers, and, more particularly, to heat exchangers which are particularly well adapted for use in the refrigeration and air conditioning field.

It is a primary object of the present invention to afford a novel heat exchanger embodying novel secondary heat-transfer surfaces constituted and arranged in a novel and expeditious manner.

Heat exchangers have been heretofore known in the art which embodied secondary heat-transfer surfaces in the form of fins projecting outwardly from tubular members; imperforate plates attached to or extending between such tubular members; or wires extending between adjacent ones of such tubular members in substantially perpendicular relation thereto, and the like. Such heat exchangers as have been heretofore known in the art have had several inherent disadvantages, such as, for example, affording inefficient heat transfer from the working fluid to the air or other fluid to be cooled or heated; being difficult and expensive to manufacture; being difficult to assemble; or not affording or permitting effective fluid flow of air or other material past the tubular portions of the heat exchanger, and the like. It is an important object of the present invention to overcome such disadvantages.

Another object of the present invention is to afford a novel heat exchanger embodying secondary heat transfer surfaces through which air, or the like, to be cooled or heated may pass in a novel and expeditious manner.

Another object is to afford a novel heat exchanger embodying a novel secondary heat transfer surface which breaks up the air, or the like, passing therethrough in a novel and expeditious manner effective to afford intimate contact between the air, or the like, and the secondary surface.

An object ancillary to the foregoing is to afford such a novel heat exchanger wherein the secondary surface is in the form of a perforated screen or mesh.

Yet another object of the present invention is to afford a novel heat exchanger embodying tubular portions for feeding working fluid therethrough and which embodies novel secondary heat transfer portions in the form of perforated sheet material attached to the tubular portions in good heat transfer relation thereto.

A further object is to afford a novel heat exchanger embodying secondary heat transfer portions in the form of screening or mesh material attached to the tubular portions of the heat exchanger in such a manner that the wires, or other structural members, defining the perforations through the screening or mesh material are constituted and arranged in a novel and expeditious manner.

Another object is to enable a novel heat exchanger of the aforementioned type to be produced in a novel and expeditious manner.

A further object of the present invention is to afford a novel heat exchanger of the aforementioned type, which is practical and efficient in operation and which may be readily and economically produced commercially.

Other and further objects of the present invention will be apparent from the following description and claims and are illustrated in the accompanying drawings which, by way of illustration, show the preferred embodiments of the present invention and the principles thereof and what I now consider to be the best mode in which I have contemplated applying these principles. Other embodiments of the invention embodying the same or equivalent principles may be used and structural changes may be made as desired by those skilled in the art without departing from the present invention and the purview of the appended claims.

Description of the drawings

In the drawings:

FIG. 1 is a side elevational view of a heat exchanger embodying the principles of the present invention;

FIG. 2 is an enlarged, fragmentary detail sectional view taken substantially along the line 2—2 in FIG. 1;

FIG. 3 is a detail sectional view through the tubing shown in FIG. 2, showing the tubing at an earlier stage in the production of the heat exchanger shown in FIG. 1;

FIG. 4 is an enlarged, fragmentary elevational view of the heat exchanger shown in FIG. 1, looking in the direction of the arrows 4—4 in FIG. 1;

FIG. 5 is a detail sectional view similar to FIG. 2, but showing a modified form of the present invention;

FIG. 6 is a side elevational view of a heat exchanger embodying a heat exchanger of the type shown in FIG. 5 as a part thereof; and

FIG. 7 is an enlarged detail sectional view taken substantially along the line 7—7 in FIG. 6.

Description of the embodiments shown herein

A heat exchanger 1, embodying the principles of the present invention, is shown in FIGS. 1 to 4, inclusive, to illustrate the presently preferred embodiment of the invention.

The heat exchanger 1 shown in the drawings embodies, in general, an elongated tubular member 2 having a secondary heat transfer portion 3 in the form of two pieces of perforated sheet material 4 and 5, FIGS. 1 and 2, secured to the tubular member 2.

The tubular member 2, shown in the drawings, may be made of any suitable material, such as, for example, aluminum or copper tubing, and is bent into a serpentine shape affording a plurality of substantially parallel passes 6, with adjacent ones of the passes 6 connected by return bends 7 disposed alternately at respective opposite ends of the passes 6, FIG. 1. Each of the passes 6 embodies two pairs of outwardly projecting fins 8 and 9, and 10 and 11, respectively, FIG. 2, disposed on diametrically opposed sides thereof. The fins 8–11 preferably extend substantially the full length of the respective passes 6 from which they project, although, as will be appreciated by those skilled in the art, changes in this construction, such as, for example, having the fins 8–11 extend the full

length of the tubular member 2, may be made without departing from the purview of the present invention.

The sheet material affording the secondary heat transfer portion 3 may be of any suitable type of perforated sheet material, but, preferably, comprises a suitable wire screening or wire mesh material, such as, for example, aluminum screening, having a wire thickness of not substantially less than .011 inch and embodying not substantially more than eighteen wires to the linear inch and not substantially less than six wires to the linear inch. As will be appreciated by those skilled in the art, perforated sheet material other than wire screening or wire mesh, and having structural members, other than wire, defining the apertures therethrough, such as, for example, aluminum foil or other suitable sheet material having suitable spaced perforations therein may be substituted for the aforementioned screening or mesh without departing from the purview of the present invention.

In the preferred form of the invention shown in the drawings, the screening 4 and 5 embodies a plurality of substantially parallel wires 12 disposed in criss-cross relation to a plurality of other substantially parallel wires 13, FIG. 4. The criss-crossed wires 12 and 13 define the outer periphery of a plurality of respective apertures 14 through the screening 4 and 5. The apertures 14 afford passages through which air or other fluid to be heated or cooled by the heat exchanger 1 may pass, as will be discussed in greater detail presently.

The secondary heat transfer portion 3 is preferably corrugated in form to afford a plurality of alternately oppositely projecting peaks or ridges 15 and 16, as embodied in the screening 4 and 5 shown in FIG. 2. Such construction affords a series of alternate peaks and valleys on each of the faces of the screening 4 and 5 and substantially increases the surface of each of the faces of the screening 4 and 5 over that which would be afforded if the screening 4 and 5 were in flat form.

In the assembled heat exchanger 1 shown in FIG. 1, the screening 4 and 5 is clamped between the fins 8 and 9 and the fins 10 and 11, respectively, on each of the passes 6 of the tubing 2 to thereby firmly, directly attach the screening 4 and 5 to the tubing 2 with a mechanical bond. Such mechanical bond between the tubing 2 and the secondary heat transfer portion 3 is preferably made by initially forming the tubular member 2 in an oval shape, with the pairs of fins 8–9 and 10–11 projecting outwardly along the longer axis of the oval. With this construction, after the tubular member 2 has been formed into the desired shape, such as, for example, the serpentine pattern shown in FIG. 1, the screening 4 and 5 may be disposed on opposite sides thereof, and portions of the screening 4 and 5 may be inserted between the respective pairs of fins 8–9 and 10-11. Thereafter, the tubular member 2 may be expanded from the oval shape shown in FIG. 3 to the substantially circular shape shown in FIG. 2 by suitable means, such as, by applying internal pressure thereto or applying external pressure thereto, or a combination of both. The expansion of the tubular member 2 from the oval shape shown in FIG. 3 to the substantially circular shape shown in FIG. 2 is effective to close each of the pairs of fins 8–9 and 10–11 and thereby clamp the screening 4 and 5, respectively, between them.

As will be appreciated by those skilled in the art, the initial forming of the tubular member 2 into an oval shape and then expanding it to move the pairs of fins 8–9 and 10–11 into closed relation relative to each other is disclosed herein merely by way of illustrating the method I prefer to use, and not by way of limitation, and other methods of forming the tubular member 2 and closing the fins 8–9 and 10–11 may be used without departing from the purview of the present invention. For example, if desired, the tubular member 2 may be initially formed into a substantially circular cross sectional shape, with the fins in each of the pairs of fins 8–9 and 10–11 disposed in separated position relative to each other, and the pairs of fins may subsequently be moved into closed relation to each other by suitable means, such as, for example, wedging them together.

In the preferred form of heat exchanger 1 shown in FIGS. 1–4, the outermost ends 17 and 18 of each of screening 4 and 5 are disposed between the pairs of fins 8–9 and 10–11, respectively, on the respective outermost passes 6. In the heat exchanger 1, the ridges 16 of the pieces of screening 4 and 5 which are most closely adjacent to the pairs of fins 8–9 and 10–11 on the respective intermediate fins 6 when the screening 4 and 5 is disposed in overlying relation to the respective opposite sides of the tubular member 2, are the portions of the screening 4 and 5 which are clamped between the pairs of fins 8–9 and 10–11 thereon. Preferably, each of the fins 8 and 11 embodies an elongated recess or groove 19 extending longitudinally thereof, with the groove opening toward the adjacent fin 9 or 10, respectively. Similarly, each of the fins 9 and 10 preferably has an elongated ridge 20 extending longitudinally thereof and projecting toward the adjacent fin 8 or 11, respectively, in such position that when the pairs of fins are moved into closed relation relative to each other, the ridges 20 on the fins 9 and 10 move into the grooves 19 in the fins 8 and 11, respectively. With this construction, the secondary heat transfer portion 3, when it is clamped by the fins 8–11, is firmly interlocked therewith in a positive manner so as to insure against removal therefrom and, also, so as to insure good heat-transfer contact between the secondary heat transfer portion 3 and the tubular member 2.

In the heat exchanger 1 shown in the drawings, the screening 4 and 5 is so disposed relative to the tubular member 2 that the criss-crossed wires 12 and 13 project from the respective ones of the fins 8–11 to which they are attached at an acute angle, FIG. 4, in such position that both wires 12 and wires 13 disposed between adjacent ones of the passes 6 are connected to each of adjacent passes 6. With this construction, both the wires 12 and 13 afford paths of heat transfer from each adjacent passes 6. This would not be true if the screening 4 and 5 were so disposed on the passes 6 that either of the wires 12 or the wires 13 were disposed perpendicular thereto. Under such circumstances, the other wires 13 or 12, which were not disposed perpendicular to the passes 6, would afford "dead" wires which would be ineffective to transfer heat to or from the passes 6 to which the screening 4 and 5 was connected. Also, it will be seen that by so disposing the screening 4 and 5 on the passes 6 that the wires 12 and 13 thereof are disposed at an acute angle thereto, as shown in FIG. 4, the number of wires extending between each adjacent pair of passes 6, and, therefore, the number of heat paths extending from the passes 6, is substantially increased over the number that would extend therebetween if the screening 4 and 5 were so disposed that either the wires 12 or the wires 13 were disposed perpendicular to the passes 6.

In the operation of the heat exchanger 1, working fluid, such as, for example, a suitable refrigerant may be fed into one end of the tubular member 2, such as, for example, the upper end 21 shown in FIG. 1, from a suitable source thereof, not shown, and the refrigerant may pass downwardly through the tubular member 2 and be discharged from the other end 22 thereof. The air, or other fluid, to be cooled by the refrigerant thus passing through the heat exchanger 1 preferably is fed across the heat exchanger 1 through the screening 4 and 5 in a direction transverse thereto, such as, for example, in the direction of the arrow 23 shown in FIG. 2. Such construction and mode of operation affords several advantages. One of these advantages is that the air, or other fluid, passing through the screening 4 and 5 must pass through the apertures or perforations 14 therein so that it is broken up into many relatively small slivers, with each of the slivers

disposed in intimate contact with the surrounding heat transfer surface afforded by the wires **12** and **13** defining the outer periphery of the perforations.

Another advantage of such construction and mode of operation is that the embodiment of the screening **4** and **5** in the heat exchanger **1** increases the secondary heat transfer surface substantially over that to be afforded by bare tubing or tubing embodying fins such as the fins **8–11**.

Also, it will be seen that by forming the secondary heat transfer portion **3** with corrugations, such as the corrugated screening **4** and **5** shown in FIG. 2, the heat transfer surface afforded by each face of the secondary heat transfer portion **3** is considerably increased over that which would be afforded if the secondary heat transfer portion **3** were merely flat. Preferably, the screening **4** and **5** is so corrugated that this increase in face surface is in the nature of 25%.

In addition to increasing the face surface, as mentioned above, the corrugating of the screening **4** increases the number of apertures **14** in any given area thereof over the number of apertures which would be afforded if the screening **4** and **5** were flat, so that the air passing therethrough is broken up into a greater number of the aforementioned slivers, to thereby increase the intimacy of contact between the air and the secondary heat transfer surfaces afforded by the screening **4** and **5**.

It will be appreciated by those skilled in the art that although in the preferred operation of the heat exchanger **1**, the flow of air, or other fluid, to be heated or cooled thereby is in the aforementioned transverse direction shown by the arrow **23**, the present invention is not limited thereto, and, if desired, the flow can be in any other direction without departing from the purview of the present invention.

In FIG. 5 a modified form of the present invention is shown, and parts thereof which are the same as parts shown in FIGS. 1–4 are indicated by the same reference numerals, and parts which have been substituted for parts shown in FIGS. 1–4 are indicated with the same reference numbers with the suffix *a* added thereto.

The heat exchanger **1***a* shown in FIG. 5 embodies, in general, an elongated tubular member **2***a* having diametrically opposed, outwardly projecting pairs of fins **8** and **9**, and **10** and **11**, projecting upwardly and downwardly as viewed in FIG. 5, and having similar pairs of fins **23** and **24**, and **25** and **26**, projecting horizontally outwardly, in opposite directions, midway between the pairs of fins **8–9** and **10–11**.

A perforated secondary heat transfer portion **3** made of suitable material, such as the aforementioned screening or mesh **4**, is mounted in each of the pairs of fins **8–11** and **23–26** and is held thereby in outwardly spaced, surrounding relation to the body portion **27** of the tubular member **2***a*. In mounting the screening **4** on the tubular member **2***a*, one end of the screening **4** may be disposed between one of the pairs of fins, such as, for example, the pair of fins **8-9** and the screening **4** may be extended around the tubular member **2***a* with respective ridges **16** disposed between each of the pairs of fins **25–26**, **10–11**, and **23–24**, and the other end of the sheet material **3** may then be disposed between the pair of fins **8–9**. Thereafter, the respective pairs of fins **8–9**, **25–26**, **10–11** and **23–24** may be moved into closed relation to each other by suitable means such as wedging them together, to thereby clamp the sheet material **3** firmly to the tubular member **2***a* in outwardly spaced relation to the body portion **27** thereof. With this construction, the heat exchanger **1***a* embodies an extensive secondary heat transfer portion **3** which is disposed in good heat-transfer relation to the tubing **2***a*; the secondary heat transfer portion **3** affords a casing-type of structure around the tubing **2***a* which is of assistance in directing fluid flow longitudinally along the outside of the tubing **2***a*; and the air, or other fluid, to be heated or cooled can flow transversely through the secondary heat transfer portion **3**.

As will be appreciated by those skilled in the art, the tubular member **2***a* with the sheet material **3** disposed thereon in the aforementioned manner can be formed into any suitable shape, such as, for example, the serpentine shape shown in FIG. 1. However, it is particularly well adapted for use in heat exchangers wherein the tubular members thereof are substantially straight, such as, for example, the heat exchanger **1***b* shown in FIGS. 6 and 7 of the drawings.

The heat exchanger **1***b* embodies a housing **28** having a substantially cylindrical shaped tubular body portion **29**, on the opposite ends of which are mounted two headers **30** and **31**, respectively. Each of the headers **30** and **31** includes a substantially flat, circular shaped outer end wall **32** disposed in parallel spaced relation to an inner substantially flat, circular shaped end wall **33**, a side wall **34** extending between the respective end walls **32** and **33** and closing the outer peripheries of the headers **30** and **31**

Each of the end walls **33** has four openings **35, 36, 37** and **38** extending therethrough, FIG. 7, disposed in axial alignment with the corresponding openings **35–38** formed in the other of the end walls **33**.

Four heat exchangers **1***a*, of the type shown in FIG. 5, are mounted in the housing **28**, the tubular members **2***a* of each of the four heat exchangers **1***a* being disposed in and extending between the aligned pairs of the openings **35–38**, respectively. The tubular members **2***a* are mounted in the end walls **33** of each of the headers **34** by any suitable means, such as, for example, welding, so as to afford a sealed connection between the outer periphery of the tubular members **2***a* and the end walls **33**. Preferably, the ribs **8–11** and **23–26**, and the screening **4** on each of the heat exchangers **1***a* terminate at their outer ends in inwardly spaced relation to the adjacent walls **33** of the respective headers **30** and **31**, FIG. 6.

A suitable inlet, such as a nipple **35**, is mounted in the outer end wall **32** of the header **30** for feeding working fluid, such as a refrigerant, into the header **30** for passage therefrom longitudinally through the tubes **2***a* into the header **31**. A suitable outlet, such as a nipple **36**, is mounted in the outer end wall **32** of the header **31** for discharging the refrigerant thus fed into the header **31** through the tubes **2***a* from the housing **28**.

Another inlet nipple **37** is mounted in the outer side wall of the body portion **29** of the housing **28** inwardly of the header **31**, and another outlet nipple **38** is mounted in the outer side wall of the body portion **29** of the housing **28** inwardly of the header **30**, on the side of the body portion **29** remote from the inlet nipple **37**, FIG. 6. With this construction, a fluid to be cooled or heated, such as, for example, water, air, or the like, may be fed into the housing **28** through the inlet nipple **37** exteriorly of the tubular members **2***a* and may pass longitudinally and transversely through the body portion **29** and be discharged therefrom outwardly through the outlet nipple **38**.

In the operation of the heat exchanger **1***b* the working fluid entering through the inlet nipple **35** and being discharged from the outlet nipple **36**, and the fluid to be heated or cooled entering through the inlet nipple **37** and being discharged from the outlet nipple **38** pass longitudinally through the body portion **29** of the housing **28** in opposite directions so as to insure the greatest temperature differential between the fluids within and outside of the tubular members **2***a* throughout the length of the body portion **29**. With the heat exchangers **1***a* disposed in the aforementioned position in the housing **28**, the screening **4** affords tubular members through which the fluid to be heated or cooled may pass longitudinally in good heat transferring contact with the respective tubular members **2***a* and the screening **4**. In addition, the liquid passing through the housing **28** exteriorly of the tubular members **2***a* is free to flow transversely through the perforated secondary heat transfer portion **3** during passage of the fluid from the inlet **37** to the outlet **38**.

It will be seen that the heat exchanger **1***b* shown in

FIGS. 6 and 7 is particularly well adapted for use in installations wherein it is desired to closely confine the flow of the liquid to be heated or cooled, such as, for example, in certain types of air blowers, or in water coolers, and the like, the housing **28** being effective to so confine the fluid.

Also, the heat exchanger **1***b* is particularly well adapted for use in installations wherein the fluid to be heated or cooled is intermittently fed, such as, for example, in soda fountains, water coolers, and the like, the body portion **29** affording a reservoir which is effective both to store such a fluid and to effect a heat transfer between the fluid and the heat exchangers **1***a*.

Also, it will be seen that in constructing a heat exchanger in the manner of the heat exchanger **1***b*, a heat exchanger is afforded which embodies a novel, extensive, highly practical and effective secondary heat transfer portion.

From the foregoing it will be seen that the present invention affords a novel and practical heat exchanger construction which embodies a novel and highly effective secondary heat transfer portion.

Also, it will be seen that the present invention affords a novel heat exchanger which is practical and efficient in operation and which may be readily and economically produced commercially.

Thus, while I have illustrated and described the preferred embodiments of my invention, it is to be understood that these are capable of variation and modification, and I therefore do not wish to be limited to the precise details set forth, but desire to avail myself of such changes and alterations as fall within the purview of the following claims.

I claim:

1. A heat exchanger comprising
(a) an elongated tubular member for passing working fluid therethrough, said tubular member having longitudinally extending outer portions, and
(b) sheet material having perforations therethrough for feeding fluid transversely through said sheet material,
(c) said sheet material being clamped and interposed in at least one of said portions of said tubular member for transferring heat between said tubular member and such last mentioned fluid passing through said perforations.

2. A heat exchanger as defined in claim **1** and in which
(a) said tubular member has an outwardly opening recess, and
(b) said sheet material has a portion disposed in said recess and clampingly retained therein by said tubular member.

3. A heat exchanger as defined in claim **1** and in which
(a) said tubular member includes a pair of outwardly projecting fins, and
(b) said sheet material is clamped by said fins to said tubular member.

4. A heat exchanger as defined in claim **1** and in which
(a) said tubular member includes
(1) a body portion, and
(2) a plurality of elongated, outwardly projecting pairs of fins extending longitudinally of said body portion, and
(b) said sheet material
(1) is clamped by said pairs of fins and
(2) extends from one pair of fins to the other outwardly of said body portion.

5. A heat exchanger as defined in claim **4** and
(a) which includes
(1) a housing having
(a') an elongated body portion and
(b') two headers mounted on respective opposite ends of said last mentioned body portion, and
(b) in which
(1) said tubular member
(a') is mounted in said body portion of said housing and
(b') extends between and is operatively connected to said headers for feeding such working fluid through said housing body portion from one to the other of said headers, and
(2) said screening is disposed in said housing body portion, and
(c) which includes
(1) means for feeding working fluid into said one header,
(2) means for feeding working fluid out of said other header,
(3) means for feeding said second mentioned fluid into said end of said housing body portion to which said other header is attached exteriorly of said tubular member, and
(4) means for feeding said second mentioned fluid out of said end of said housing body portion to which said one header is attached.

6. A heat exchanger as defined in claim **1** and in which
(a) said tubular member includes a pair of elongated, outwardly projecting fins extending longitudinally thereof,
(b) said sheet material comprises screening having elongated criss-crossed wires defining the outer peripheries of said perforations,
(c) a portion of said screening is disposed between and clamped by said fins substantially throughout the length of the latter in such a manner that criss-crossed ones of said wires are disposed in engagement with said fins, and
(d) another portion of said screening projects outwardly away from said fins.

7. A heat exchanger as defined in claim **1** and in which
(a) said tubular member is disposed in a serpentine path affording a plurality of side-by-side passes interconnected by bends, and
(b) said sheet material extends between and is clamped to said passes substantially throughout the length of the latter.

8. A heat exchanger as defined in claim **7** and in which
(a) said sheet material comprises screening having elongated criss-crossed wires defining the outer peripheries of said perforations, and
(b) said screening is so connected to said passes that criss-crossed ones of said wires are directly clamped to both passes of adjacent ones of said passes.

9. A heat exchanger as defined in claim **7** and in which
(a) said sheet material comprises screening having elongated criss-crossed wires defining the outer peripheries of said perforations, and
(b) said screening is corrugated to afford a cross-sectional shape having alternate ridges and valleys.

10. A heat exchanger as defined in claim **7** and in which
(a) said sheet material comprises screening having elongated criss-crossed wires defining the outer peripheries of said perforations,
(b) said passes have respective pairs of outwardly projecting fins thereon, and
(c) said screening is clamped by and between said fins in said pairs.

11. A heat exchanger as defined in claim **7** and in which
(a) said sheet material comprises screening having elongated criss-cross wires defining the outer peripheries of said perforations, and
(b) said wires are not substantially less than .011 inch in thickness and are not disposed substantially closer together than 18 wires to the linear inch.

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ROBERT A. O'LEARY, Primary Examiner

THEOPHIL W. STREULE, Assistant Examiner

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