

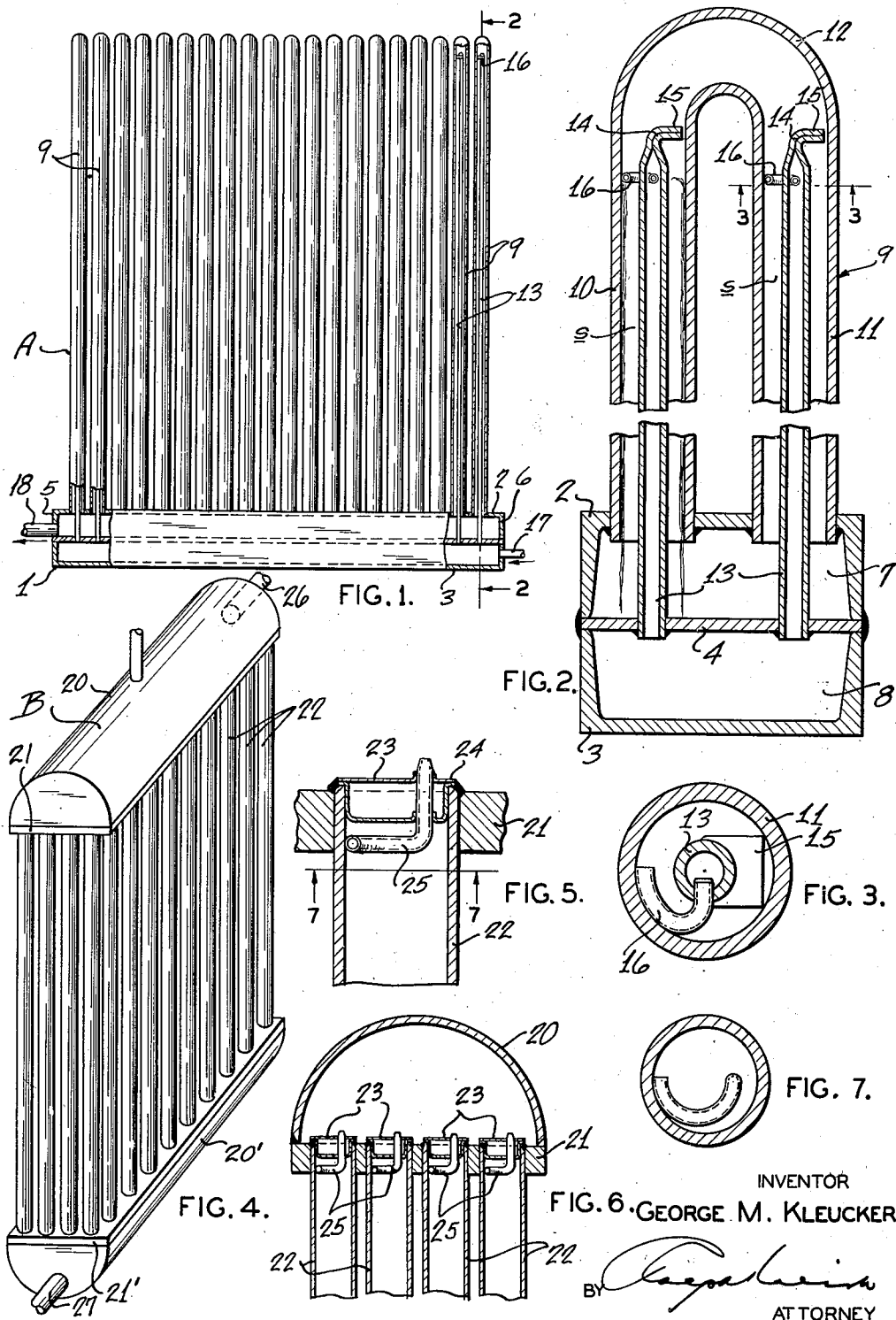
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FLUID COOLING APPARATUS AND METHOD

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FLUID COOLING APPARATUS AND METHOD

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This invention relates to certain new and useful improvements in fluid cooling apparatus and methods.

My invention has for a primary object the provision of fluid cooling apparatus which is economical in construction, operation, and maintenance, and capable of extremely high surface and refrigerating efficiency hitherto thought unobtainable.

My invention also has for another object the provision of a method of refrigeration and cooling which makes possible the achievement of heat exchange efficiencies far in excess of anything hitherto thought obtainable, which makes possible material simplification of apparatus and other associated equipment with resultant economies in original investment as well as operation and maintenance, and which is effective and sanitary in the refrigeration and cooling of fluids generally.

And with the above and other objects in view, my invention resides in the novel features of form, construction, arrangement, and combination of parts presently described and pointed out in the claims.

In the accompanying drawing:

Figure 1 is an elevational view, partly broken away and in section, of a fluid cooling apparatus constructed in accordance with and embodying my invention;

Figure 2 is an enlarged vertical sectional view of the apparatus, taken approximately along the line 2—2, Figure 1;

Figure 3 is a transverse sectional view of the apparatus, taken approximately along the line 3—3, Figure 2;

Figure 4 is a perspective view of a modified form of fluid cooling apparatus embodying my invention;

Figures 5 and 6 are enlarged fragmentary sectional views of the modified cooling apparatus; and

Figure 7 is a transverse sectional view of the modified cooling apparatus, taken approximately along the line 7—7, Figure 5.

Referring now in more detail and by reference characters to the drawing, which illustrates practical embodiments of my invention, the apparatus A, which is adapted more particularly for use in cooling gases and most specifically suited for air conditioning systems, comprises an elongated rectilinear shell 1 constructed preferably of two opposed companion channel iron sections 2, 3, separated by a flat horizontal partition 4 and provided preferably integrally with end walls

5, 6, the sections 2, 3, and wall or partition 4 being welded or otherwise secured together in gas-tight manner in the formation of upper and lower chambers 7, 8, as best seen in Figure 2.

Mounted in and extending through the upper horizontal wall of the chamber 7, is a plurality of spaced parallel heat exchange tubes 9, each, as it may be said, being substantially of inverted U-shape and including a pair of parallel legs 10, 11, integrally connected at their upper end by a U-shaped or so-called hairpin bend 12. Extending concentrically through each of the cooler tube legs 10, 11, is a feeder tube or pipe 13 at or adjacent its lower end rigidly mounted in and extending downwardly through the partition 4 for communication with the chamber 8 and at its upper end sealed off, as at 14, and bent over and engaged with the wall of its enclosing tube-leg in the formation of a supporting and spacing member 15, all as best seen in Figure 2.

Fixed in and extending radially through the side wall of each of the feeder tubes 13 adjacent its upper sealed-off extremity, is a so-called tubular "swirler" 16 having communication at its one or inner end with the interior of the feeder pipe 13 and curving outwardly therefrom toward, and at its outer or nozzle-like end being substantially tangent to, the outer wall of the particular tube-leg 10, 11, as the case may be, all as best seen in Figure 3 and for purposes presently more fully appearing.

Mounted in and extending through the shell end wall 6 preferably for communication with the lower chamber 8, is a refrigerant feed line 17, and similarly mounted in and extending through the opposite shell end wall 5 preferably for communication with the upper chamber 7, is a refrigerant return or suction line 18.

In operation, the liquid refrigerant is flooded into the lower chamber 8 through the supply line 17 from any conventional means, rising under pressure through the several feeder pipes 13, and issuing from the bent tubes or swirlers 16 as a liquid jet having high velocity and impinging tangentially against the inner faces of the respective cooler tube-legs 10, 11. As a result of the combined effects of its tangential direction, its high velocity, and the force of gravity, the liquid refrigerant will have a direction and velocity which is the resultant of such component forces, and will move rapidly downward as a cylindrical sheet or film of refrigerant over the inner face of the respective cooler tube-legs 10, 11, leaving an uninterrupted annular free space, as at s, between the inner surface of the refrigerant

film and the outer surface of the respective feeder pipes 13. Due to the velocity and mass of the liquid refrigerant flowing as a rapidly moving sheet, gas bubbles are sheared off at inception and discharged through this liquid refrigerant sheet into the free annular gas space *s*, which is of relatively large volume, and thence into the chamber 7.

The chamber 7 being connected through the pipe 18 to the suction or "low-side" of the refrigerating system, the chamber 7 and the associated cooler tube-legs 10, 11, will be under relatively reduced or so-called back or suction pressure. The bubbles formed at the heat exchange surface will be immediately sheared off by the moving film and discharged into the free space *s* with the production of a highly efficient cooling effect. The gaseous refrigerant thus formed will be continuously exhausted from the free space *s* through the chamber 7 without producing any substantial ebullition or otherwise disturbing the sheet-like continuity, velocity, and direction of movement of the cylindrical refrigerant films. Through the suction line 18, both excess liquid and gas are returned to a conventional collecting vessel (not shown), in which the evaporated refrigerant is taken off at the top to the suction of the compressor and the liquid refrigerant separated out. By means of a conventional float control device (not shown), a predetermined liquid level is maintained in this vessel. Pump circulating means (not shown) continuously circulates liquid refrigerant to the discharge header or chamber 8, so that the unevaporated excess liquid refrigerant returns from the suction header or chamber 7, thus repeating the cycle of recirculation.

Figure 4 illustrates a modified form of cooler of my invention peculiarly suited for use in air conditioning and air cooling systems. Such form of the cooler includes upper and lower parallel headers 20, 20', preferably of elongated hemicylindrical form having horizontal tube sheets 21, 21', and welded at their opposite ends in and extending longitudinally between the tube sheets 21, 21', is a plurality of spaced parallel heat exchange tubes 22, as best seen in Figure 4.

At its upper end, each of the cooler tubes 22 projects a short distance above the tube sheet 21 and is provided in its upper end with a preferably hollow cylindrical sheet metal plug member or closure-forming element 23 having a radial flange 24 along which it is suitably fastened to the upper peripheral margin of the tube 22 with which it is associated. Extending vertically through, and welded or otherwise fixed in, the plug member 23, is a tube or swirler 25 at its upper end projecting somewhat beyond the upper face of the plug 23 and being preferably of slightly reduced diameter and at its lower end extending downwardly beyond the lower face of the plug 23 and being bent at right angles and preferably curved outwardly across the center of the plug 23 and into tangential engagement with the inner wall of the heat exchange tube 22, all as best seen in Figures 5 and 6 and for purposes presently more fully appearing.

The upper header pipe 20 is conventionally provided with a refrigerant supply pipe 26 and the lower header 20 is similarly provided with a combined excess refrigerant return and suction line 27.

Accordingly, liquid refrigerant is flooded into the header 20 under pressure and will flow downwardly through the swirler 25 and issue there-

from in a tangential jet of high velocity, thereby forming a rapidly moving continuous cylindrical film. The interior of the cooler tubes 22 and the lower header 21 being connected through the suction pipe 27 to the "low-side" of the refrigerating system, the film will evaporate into the free space within the cooler tubes 22, with the production of a highly efficient cooling effect in substantially the same manner and under substantially the same conditions as above described.

It will, of course, be evident that both of the heat exchangers A and B may be readily mounted in the conventional type of blower tunnel or duct (not shown) usually employed in air conditioning systems in such a manner that the air to be cooled will be forced to pass between and around the heat exchange tubes.

It should be understood that changes and modifications in the form, construction, arrangement, and combination of the apparatus may be made and substituted for those herein shown and described without departing from the nature and principle of my invention.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. A cooler comprising a shell having an inner partition for dividing the shell into first and second separate compartments, means for supplying liquid refrigerant to the first compartment, a cooler tube operably mounted on the shell for communication with the second compartment, a feeder tube operably mounted in the partition for communication at its one end with the first compartment, said feeder tube being of substantially smaller diameter than, and projecting into, the cooler tube, and means operably mounted on the other end of the feeder tube for tangentially directing liquid refrigerant upon the inner surface of the cooler tube.

2. A cooler comprising a shell having an inner partition for dividing the shell into first and second separate compartments, means for supplying liquid refrigerant to the first compartment, a cooler tube operably mounted on the shell for communication with the second compartment, a feeder tube operably mounted in the partition for communication at its one end with the first compartment, said feeder tube being of substantially smaller diameter than, and projecting into, the cooler tube, and a bent tube mounted in the feeder tube for communication at its one end with the interior of the feeder tube and extending outwardly therefrom into abutment with the inner surface of the cooler tube for applying liquid refrigerant to the inner surface of the cooler tube in the form of a tangential jet.

3. A cooler comprising an upper header, a lower header, means for supplying and maintaining a vaporizable refrigerant under substantial pressure to the header, a cooler tube operably mounted at its ends in and extending longitudinally between said headers for communication at its one end with one of said headers and at its other end being provided with an imperforate plug, and a bent tube operably mounted in and extending through said plug for communication at its one end with the other header, said tube at its other end being bent substantially into abutment along its outer face with the inner face of the cooler tube and having a relatively small opening in the provision of an inlet jet adapted to cover the interior of the cooler tube with a substantially continuous swirling film of refrigerant and impart to such film in the formation

thereof a swirling velocity resulting from the jet energy of the refrigerant.

4. A cooler comprising a first header, a second header, means for supplying and maintaining a vaporizable refrigerant under substantial pressure to the header, a heat exchanger tube mounted at its opposite ends in and extending longitudinally between said headers, said tube at its one end communicating with the second header and at its other end being provided with a closure-element, means for introducing liquid refrigerant into the first header, and a bent tube mounted in said closure-element and having a hook-like jet-forming nozzle portion for conducting liquid refrigerant from the first header through said closure-element and having an opening disposed in a plane approximately radial to the surface of the heat exchanger tube for impinging said liquid refrigerant tangentially upon the inner surface of the heat exchanger tube in the provision of an inlet jet adapted to cover the interior of the cooler tube with a substantially continuous swirling film of refrigerant and impart to such film in the formation thereof a swirling velocity resulting from the jet energy of the refrigerant.

5. A cooler comprising an elongated shell having an inner partition dividing said shell into two separate compartments, a plurality of heat exchange tubes having the shape of an inverted "U" operably mounted on the shell for communication with one of said compartments, a feeder tube mounted axially in each leg of each of said heat exchange tubes for communication with the other compartment, and means operably associated with the feeder tube for introducing liquid refrigerant upon the inner surface of the tube-leg with which it is associated.

6. A cooler comprising an elongated shell having an inner partition dividing said shell into two separate compartments, a plurality of heat exchange tubes having the shape of an inverted "U" operably mounted on the shell for communication with one of said compartments, a feeder

operably mounted in the partition for communication at its one end with the other compartment, each of said feeders being of substantially smaller diameter than, and projecting into, the heat exchange tubes, and means operably mounted on the other end of each feeder for directing liquid refrigerant upon the inner surface of each heat exchange tube.

7. A cooler comprising an elongated shell having an inner partition dividing said shell into two separate compartments, a plurality of heat exchange tubes of an inverted "U" shape and having two legs connected by a reverse bend, said tubes being operably mounted on the shell for communication with one of said compartments, a feeder tube operably mounted in the partition and extending into each of said tube-legs for communication at its one end with the other compartment, each of said feeder tubes being of substantially smaller diameter than the heat exchange tubes, and a bent tube mounted in each feeder tube for communication at its one end with the interior of the feeder tube and extending outwardly therefrom into abutment with the inner surface of the corresponding tube leg for applying liquid refrigerant to the inner surface thereof in the form of a tangential jet.

8. A cooler comprising an upper hemicylindrical header, a lower hemicylindrical header, a plurality of spaced parallel heat exchange tubes operably mounted at the ends in and extending longitudinally between said headers for communication at one end with one of said headers and each at its other end being provided with a closure-element, and a bent tube operably mounted in and extending through each of said closure-elements for communication at its one end with the other header, each of said bent tubes at its other end being disposed in substantial abutment with the inner face of its associated heat exchange tube and communicating at said end with the interior of such heat exchange tube.

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