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This invention relates to shell-and-tube type heat exchangers, and relates more particularly to shell-and-tube type water chillers.

In conventional shell-and-tube type water chillers, U-shaped copper tubes are supported within a cylindrical outer shell, with the open ends of the tubes extending through tube sheets into manifolds having passages arranged to route a refrigerant such as Freon, into and out of the tubes in several circuits. Water is flowed through the shell around the tubes, and is chilled by the refrigerant evaporated within the tubes. In such a water chiller, it is difficult to provide a tube sheet at the ends of the copper tubes that will isolate and prevent leaks from the several refrigerant circuits. Rolled joints are difficult to make tight. Copper to steel joints are difficult to braze. Copper to copper tube joints are ideal, but copper tube sheets have previously been considered to have insufficient strength to withstand the additive pressures in the several refrigerant circuits, and have not been used.

This invention uses a copper tube sheet with copper tubes in a shell-and-tube type water chiller, and reinforces the copper sheet by sandwiching it between two cast iron manifolds which are bolted between a steel head and an annular plate attached to the shell. An object of this invention is to provide a shell-and-tube type heat exchanger having copper tubes and a copper tube sheet.

Another object of this invention is to reinforce a copper tube sheet in a shell-and-tube type heat exchanger. This invention will now be described with reference to the annexed drawings, of which:

FIG. 1 is an end view of the head end of a water chiller embodying this invention;
FIG. 2 is an enlarged sectional along the lines 2--2 of FIG. 1;
FIG. 3 is a reduced section along the lines 3--3 of FIG. 2;
FIG. 4 is an enlarged cross-section of one of the copper tubes of the water chiller, near its inlet end;
FIG. 5 is an enlarged section along the lines 5--5 of FIG. 1, and
FIG. 6 is a fragmentary side view of the copper tubes, the water baffles, the inner manifold, and the tube sheet of the water chiller.

A conventional shell has spaced-apart, water inlet and outlet tubes 11 and 12 respectively. Conventional U-shaped copper tubes 14 are supported within the shell 10 around central, horizontally extending, water baffles 15. The outer end of the outer baffle 15 is attached by machine bolts 16 to a cast-iron, inner manifold 17. Notched, vertically extending, water baffles 18 are attached to and spaced apart by the baffles 15. Alternate baffles 18 have their notches at the top, and the other baffles 18 have their notches at the bottom for causing the water circulated through the shell 10 to flow in a sinusuous path.

An annular, steel plate 20 extends around and is welded to the shell 10 at its outer end. A gasket 21 extends between the outer side of the plate 29 and the inner side of the rim of the manifold 17. A circular, copper tube sheet 22 which is solid except where the ends of the tubes 14 and bolts 32 to be described later, extend therethrough, has its inner side in contact through a layer of pipe dope which is not shown, with the outer side of the manifold.
being through the tube 46, the tubes 14 which have their inlet ends connecting with the hollow portion 43, and their outlet ends connecting with the hollow portion 42 of the manifold 25, and the tube 50.

Star-shaped, spirally twisted, aluminum inserts 60 extend within the lower, liquid receiving passes of the tubes 14, those passes below the manifold ribs 33, the straight lengths thereof. The inserts 60 constrict the liquid passages and increase the liquid velocity. The spiral twists in the inserts 60 cause the liquid to spin within the lower passes of the tubes 14, and to scour off the insulating boundary layers of liquid, thereby increasing heat transfer.

Water entering the tube 11 passes over the exteriors of the tubes 14, being chilled by the evaporation of the refrigerant within the tubes 14, and passes out the tube 12, the baffles 18 and 15 causing this flow to be sinusoidal.

The end portions of the copper tubes are tightly sealed to the copper tube sheet by being brazed thereto. The tube sheet is clamped around its rim between the rims of the inner and outer manifolds 17 and 25 respectively, and is further clamped between the ribs 33, 34 and 35 of the manifolds 17 and 25, providing adequate reinforcement of the low tensile strength, copper tube sheet to enable it to withstand the additive pressures within the three refrigerant circuits. This reinforcement is provided at small additional expense.

Fewer or more than the three refrigerant circuits could be provided, the three circuit embodiment being merely illustrative.

What is claimed is:

1. A heat exchanger comprising a shell, circular in section, having an open end, and having water inlet and outlet tubes; a metal inner manifold, circular in section, extending across said open end concentric therewith; a metal outer manifold, circular in section, and having substantially the same diameter as said inner manifold, spaced outwardly from said inner manifold concentric therewith; said manifolds having similar, aligned diametral ribs, having similar annular rims, and each having a plurality of spaced-apart ribs extending perpendicular to its respective diametral rib and extending to its respective rim, corresponding ones of said spaced-apart ribs being aligned, each of said manifolds having an equal number of hollow portions between its respective ribs and rim with one half of its hollow portions being on one side of its respective diametral rib and the other half of its hollow portions being on the other side of its respective diametral rib; a copper tube sheet, circular in section, and having substantially the same diameter as said manifolds extending between said manifolds concentric therewith; a plurality of copper tubes within said shell; said copper tubes having U-shaped bends and extending in straight lengths from said bends with one half of their ends extending through said hollow portions of said inner manifold that are on said one side of its respective diametral rib, through said tube sheet, and into said hollow portions of said outer manifold that are on said one side of its respective diametral rib, and with the other half of their ends extending through said hollow portions of said inner manifold that are on said other side of its respective diametral rib, through said tube sheet, and into said hollow portions of said outer manifold that are on said other side of its respective diametral rib, said ends of said copper tubes being brazed to said tube sheet; a metal head, circular in section, at the outer side of said outer manifold, concentric therewith; means for attaching said head to said shell; means comprising a plurality of bolts extending through said head and said ribs of said outer manifold, and threaded into said ribs of said inner manifold, for clamping said manifolds to said head with said tube sheet clamped between said rims and ribs; refrigerant inlet tubes extending into said head and connecting with said hollow portions of said outer manifold that are on said one side of its respective diametral rib; and refrigerant outlet tubes extending into said head and connecting with said hollow portions of said outer manifold that are on said other side of its respective diametral rib.

2. A heat exchanger as claimed in claim 1 in which said means for attaching said head to said shell comprises an annular metal plate extending around and attached to said shell at said open end, and a plurality of bolts extending through the peripheral portion of said head and threaded into said plate.

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