

June 29, 1965

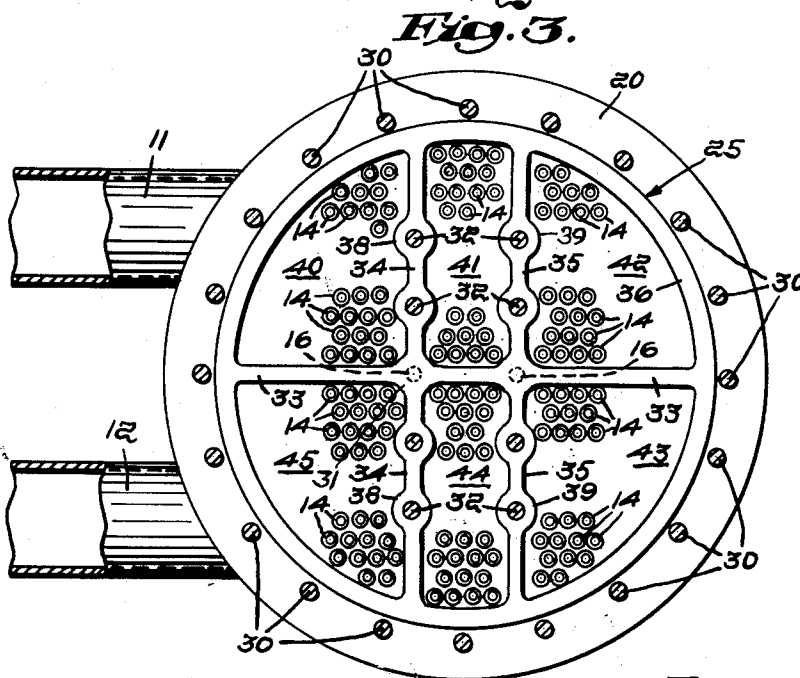
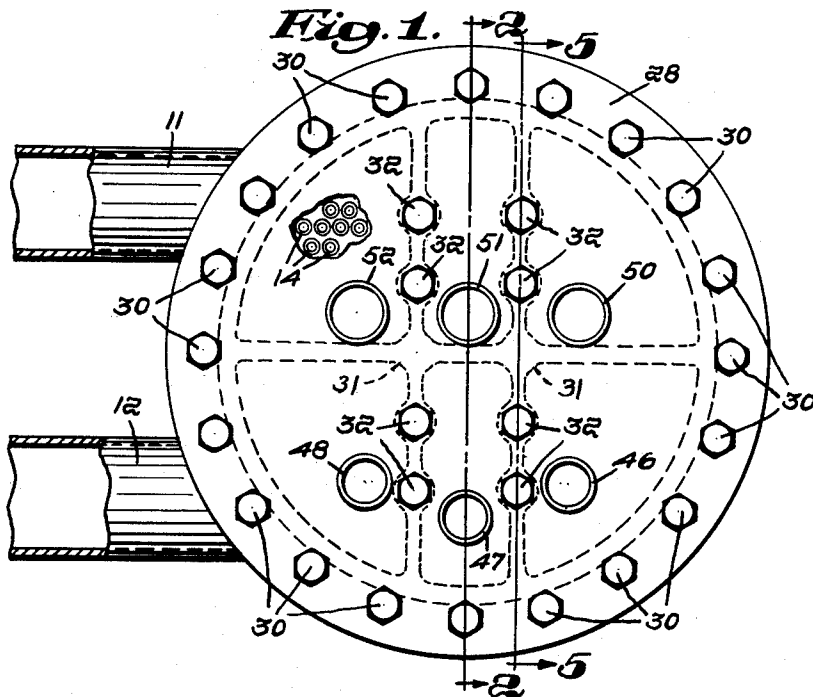
D. K. RICHARDSON

3,191,674

SHELL-AND-TUBE TYPE HEAT EXCHANGERS

Filed June 18, 1963

4 Sheets-Sheet 1



Inventor:
Douglas K. Richardson,
by Robert T. Palmer
Attorney

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D. K. RICHARDSON

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Fig. 2

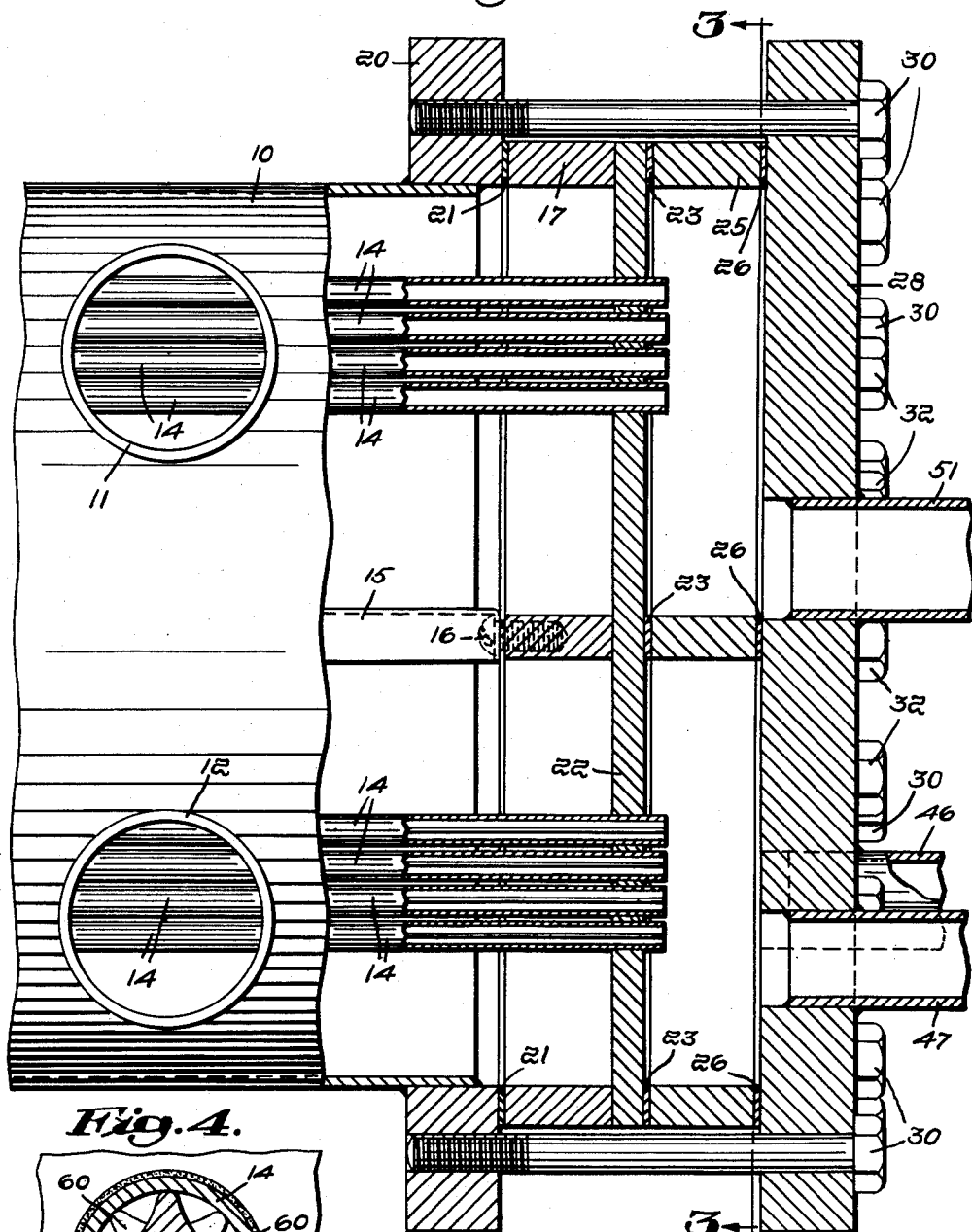
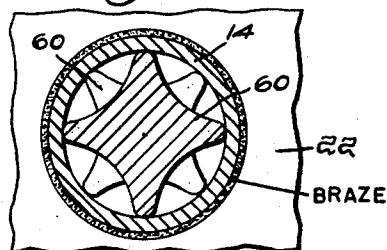


Fig. 4.



Inventor:
Douglas K. Richardson,
by Robert J. Palmer
Attorney

June 29, 1965

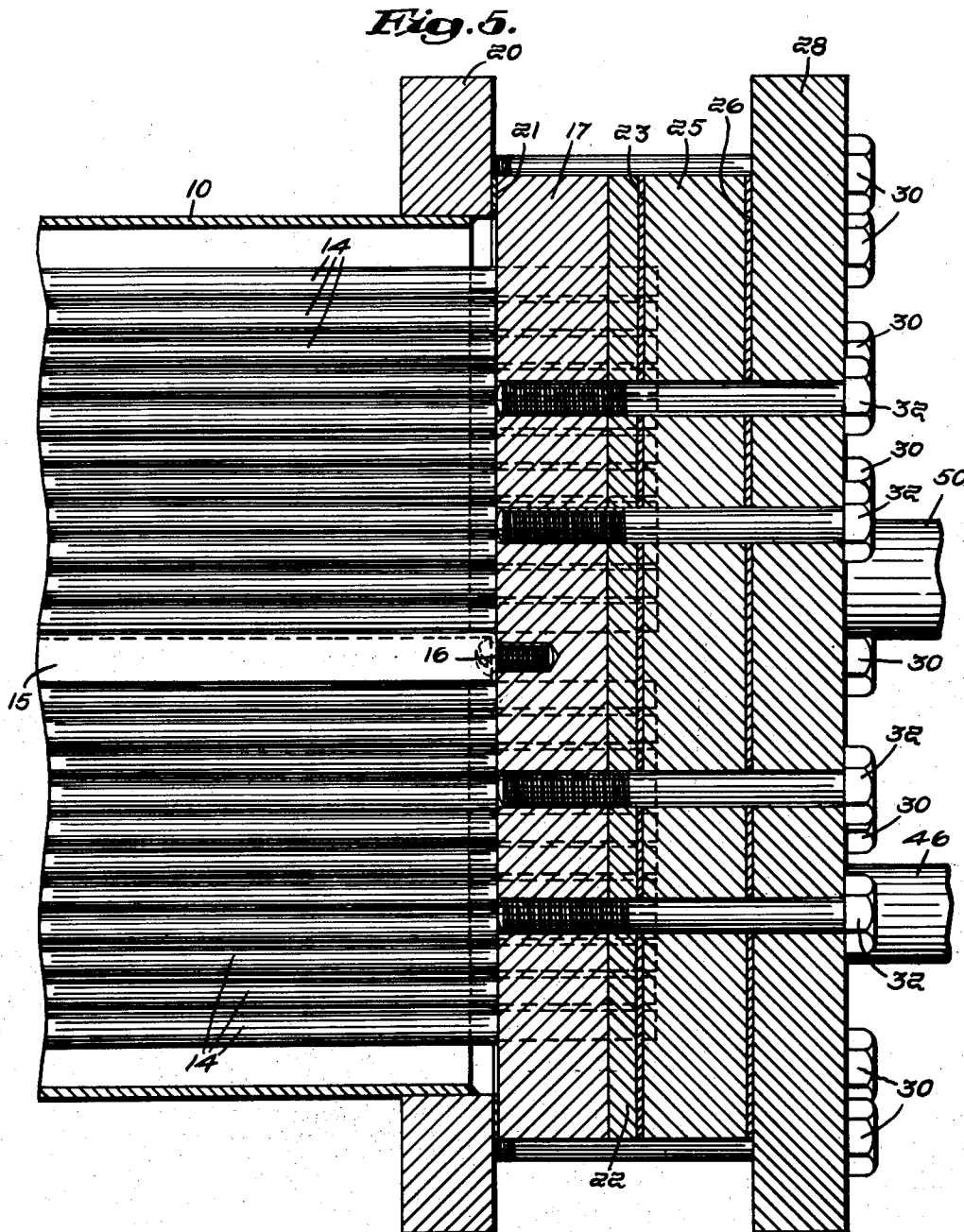
D. K. RICHARDSON

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4 Sheets-Sheet 3



Inventor:
Douglas H. Richardson,
by *Robert J. Palmer*
Attorney

June 29, 1965

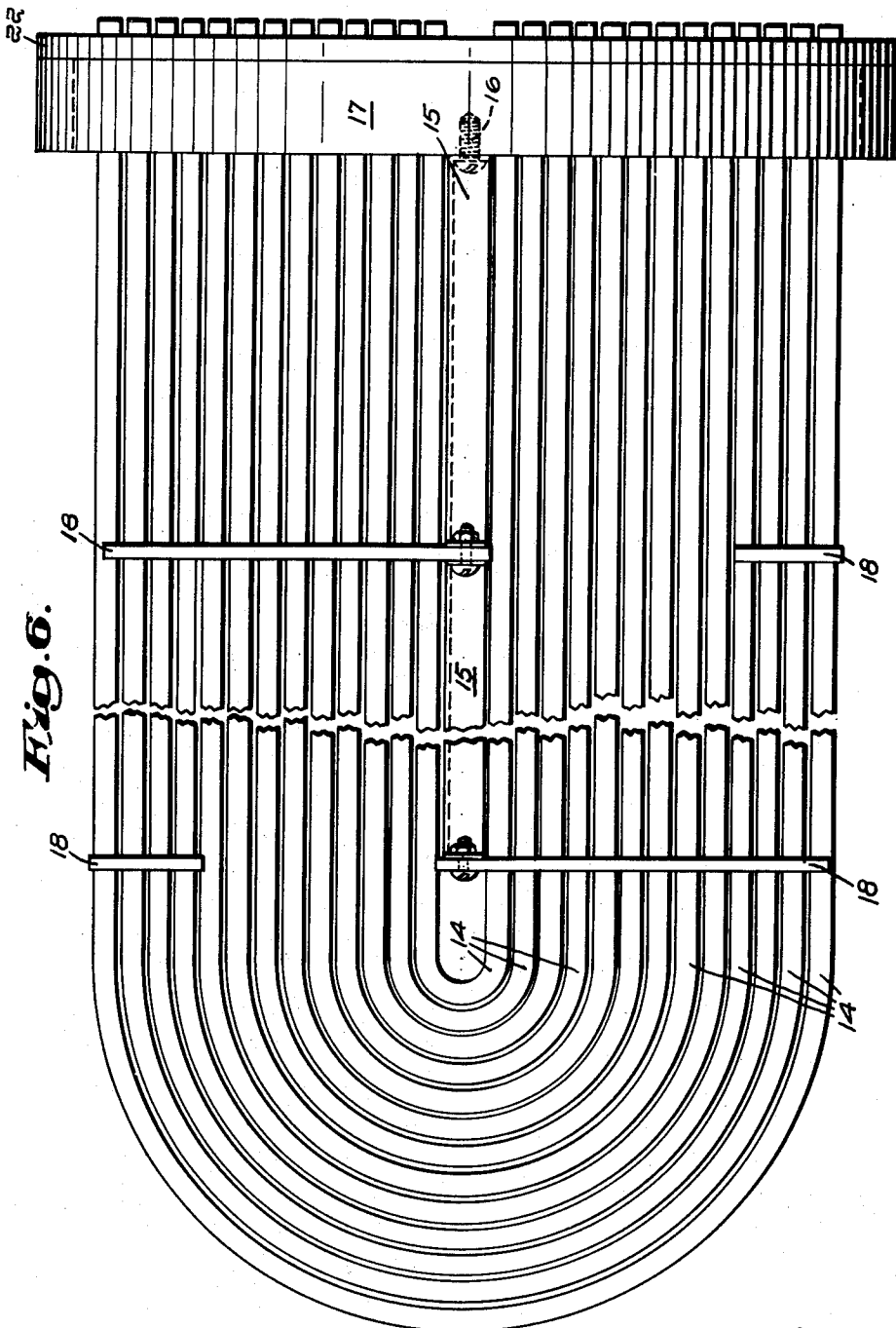
D. K. RICHARDSON

3,191,674

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4 Sheets-Sheet 4



Inventor:
Douglas K. Richardson,
by Robert J. Palmer Attorney

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3,191,674

SHELL-AND-TUBE TYPE HEAT EXCHANGERS

Douglas K. Richardson, Staunton, Va., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

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2 Claims. (Cl. 165—158)

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 tensile 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 steel 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 section 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 10 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 sinuous 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 20 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

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17 at the peripheries of the sheet 22 and the manifold 17. A gasket 23 extends between the outer side of the tube sheet 22 and the inner side of an outer, cast iron manifold 25 which is circular in section, at the peripheries of the sheet 22 and manifold 25. As gasket 26 extends between the outer side of the manifold 25 at its periphery, and the inner side of a steel head 28 which is circular in section.

Bolts 30 extend through the head 28 and around the manifolds 25 and 17 and the tube sheet 22, and are threaded into the annular plate 20. Bolts 32 extend through the head 28, the outer manifold 25 and the tube sheet 22, and are threaded into the inner manifold 17.

The inner and outer manifolds 17 and 25 respectively, are similar except that the manifold 25 has circular holes through which the bolts 32 extend, and the manifold 17 is tapped to receive the threaded inner ends of the bolts 32. Each manifold has an annular rim portion 36, a horizontally extending, diametral rib 33, and vertically extending ribs 34 and 35 which are spaced equal distances from vertical lines extending through the centers of the manifolds. The ribs 34 and 35 have enlargements 38 and 39 respectively, around the bolts 32. The ribs 33, 34 and 35 have enlargements 31 where the rib 33 crosses the ribs 34 and 35, and the threaded ends of the previously described bolts 16 extend into the enlargements 31 of the inner manifold 17. The gasket 26 has portions extending between the outer ends of the ribs of the outer manifold 25 and the adjacent inner surfaces of the head 28. The gasket 23 has portions extending between the inner ends of the ribs of the outer manifold 25 and the adjacent outer surfaces of the tube sheet 22. There is a layer of pipe dope which is not shown, between the outer ends of the ribs of the inner manifold 17 and the adjacent inner surfaces of the tube sheet 22.

Between its rim portion 36, one end portion of its rib 33, and the upper portion of its rib 34, each manifold 17 and 25 has a hollow portion 40. Each manifold has between its rim 36, the portion of the rib 33 between the ribs 34 and 35, and the upper portions of its ribs 34 and 35, a hollow portion 41. Each manifold has between its rim portion 36, the upper portion of its rib 35 and the other end portion of the rib 33, a hollow portion 42. Each manifold has between its rim portion 36, the said other end portion of the rib 33 and the lower rib portion 35, a hollow portion 43. Each manifold has between its rim portion 36, the portion of the rib 33 between the ribs 34 and 35, and the lower portions of the ribs 34 and 35, a hollow portion 44. Each manifold has between its rim portion 36, the lower portion of its rib 34, and the said one end portion of its rib 33, a hollow portion 45. The ends of the tubes 14 extend through the hollow portions 40, 41, 42, 43, 44 and 45 of the inner manifold 17, and through the tube sheet 22 slightly into the corresponding hollow portions 40, 41, 42, 43, 44 and 45 of the outer manifold 25.

Refrigerant liquid inlet tubes 46, 47 and 48 extend into circular openings in the head 28, which connect with the hollow portions 43, 44 and 45 respectively, of the outer manifold 25. Larger, gas outlet tubes 50, 51 and 52 extend into circular holes in the head 28, which connect with the hollow portions 42, 41 and 40 respectively, of the outer manifold 25.

Thus, there are three refrigerant circuits, a first circuit being through the tube 48, the tubes 14 which have their inlet ends connecting with the hollow portion 45, and their outlet ends connecting with the hollow portion 40 of the manifold 25, and the tube 52; a second circuit being through the tube 47, the tubes 14 which have their inlet ends connecting with the hollow portion 44, and their outlet ends connecting with the hollow portion 41 of the manifold 25, and the tube 51, and a third circuit

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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 sinuous.

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

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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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CHARLES SUKALO, *Primary Examiner.*

KENNETH W. SPRAGUE, *Examiner.*