

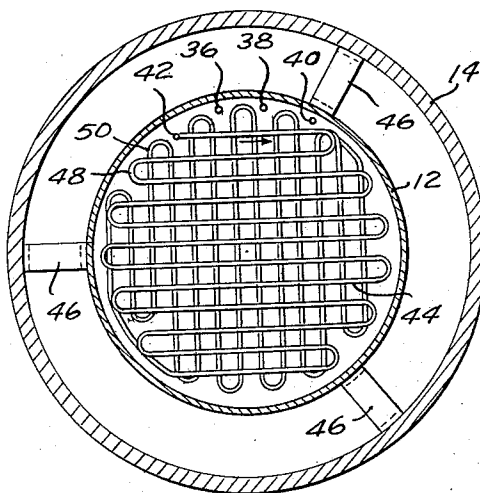
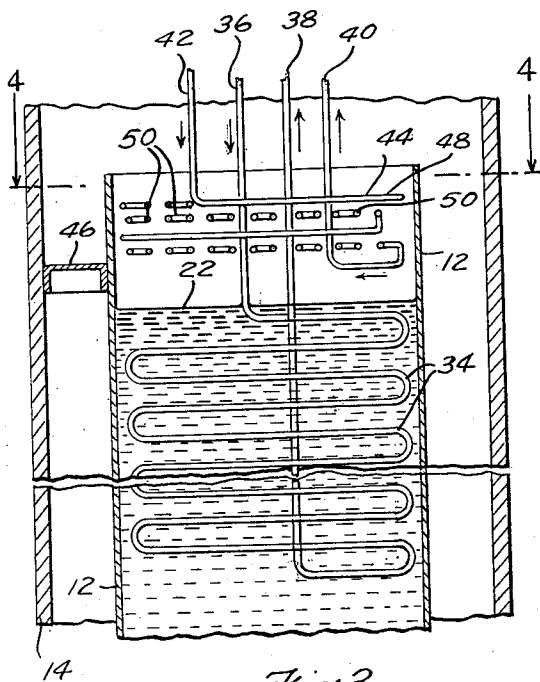
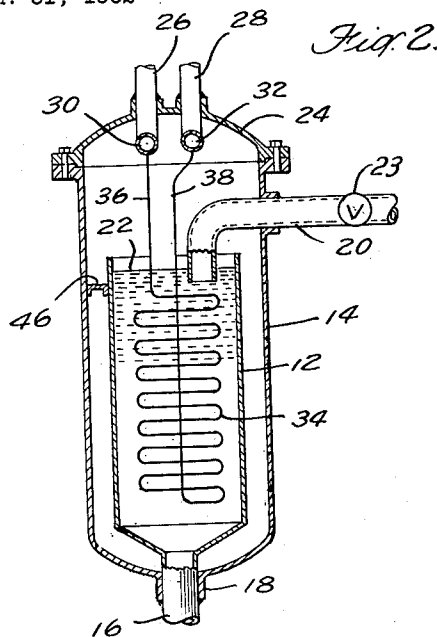
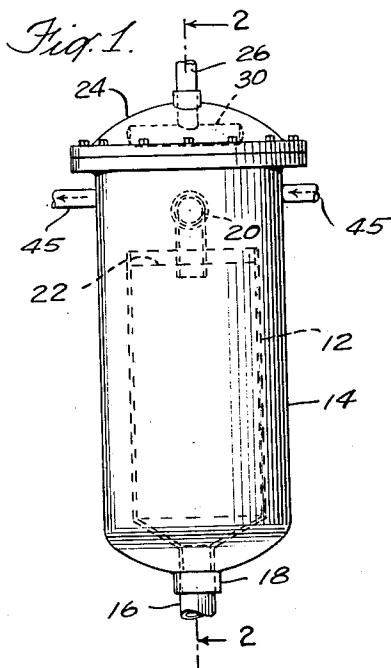
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STEAM GENERATOR

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3,138,199

STEAM GENERATOR

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This invention relates to an indirect heat exchanger, suitable for use as a steam generator or steam heater, in which heat is transferred to water or steam by indirect heat exchange with a liquid metal such as sodium or a sodium/potassium alloy.

Heat exchangers for use with such corrosive and potentially dangerous fluids as sodium and potassium have to incorporate elaborate safety arrangements, the cost of which may largely offset the advantages to be expected from the excellent thermal characteristics of the metals. For instance, surfaces which are normally in contact with the liquid metal cannot be of mild steel which is attacked by the liquid metal. Also, precautions must be taken against rupture of the barrier between the heat exchanging fluids, either by the use of special "leak-proof" tubing and tube plates, or by providing a means to deal with any rupture. Furthermore, there must be no liquid metal surface exposed to air, and it is customary to maintain pressure in the liquid metal circuit by means of a blanket of an inert gas such as argon.

These requirements are met in a novel and relatively inexpensive manner in a heat exchanger, in accordance with the invention, by the use of an open-topped container within a main pressure vessel. A tube bundle can conveniently depend into the container from headers in the upper part of the pressure vessel with inlet and outlet connections for the circulation of water or steam. An inlet connection is provided passing into the pressure vessel arranged for the supply of liquid metal to the inner container, and an outlet connection from the container passes out through the bottom of the pressure vessel. Means are provided for maintaining an inert atmosphere in the pressure vessel above the liquid metal surface.

If the temperature of the liquid metal at its free surface in the container is above the temperature of any part of the pressure vessel, the possibility of condensation of liquid metal on the vessel part or parts can be guarded against by installing and maintaining a comparatively cool surface immediately above the free surface. This cool surface can conveniently take the form of a bank of tubes through which cold water, for example, some or all of the feed to the generator, can be circulated.

In the event of a tube failure in the water or steam circuit, a highly exothermic reaction between the liquid metal and water may occur resulting in a violent shock wave. By the invention, damage from the shock wave will be restricted to the inner container.

There need only be two tubes of the liquid metal circuit passing directly into the pressure vessel so that the risk of leakage of the liquid metal to the atmosphere during normal operation is virtually eliminated.

As the pressure vessel is not normally in contact with the liquid metal and is not subject to its corrosive influence, it can be made of mild steel instead of the much more expensive corrosion resistant alloy steel generally employed. The alloy steel by the invention is required only for the inner container and the water or steam containing tube bundle.

In order that the invention may be better understood, a heat exchanger in accordance with it will be described with reference to the accompanying drawings, in which:

FIGURE 1 is an elevation view of a typical generator according to the invention;

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FIGURE 2 is a section view taken along line 2-2 of FIG. 1;

FIGURE 3 illustrates an enlarged sectional elevation view of a modified form of the invention; and

FIGURE 4 is a sectional view taken along line 4-4 of FIG. 3.

The heat exchanger of the invention illustrated in FIGS. 1 and 2 comprises an inner cylindrical open-topped container 12 of a corrosion resistant alloy steel mounted concentrically within an upright cylindrical pressure vessel 14 of mild steel. A large bore pipe 16 passes out through the bottom of the pressure vessel from the container, and serves as an outlet connection for the inner container for a liquid metal heat exchange medium, for instance, sodium or potassium. The pipe 16 is welded to the sides of an opening 18 in the pressure vessel and serves to locate and support the container within the pressure vessel.

An inlet connection 20 for the liquid metal is welded into the side wall of the pressure vessel above the upper end of the container, with its inner end curving down to a point within the container just below the normal liquid level 22 in the container. Valve 23 in the connection 20 provides a flow-control means for controlling the flow of liquid metal into the container to maintain the liquid level 22.

The pressure vessel 14 has a removable top 24 in the form of a flanged dome. Two tubes 26 and 28 pass side by side through this dome and each carries a transverse header, the headers being designated by the numerals 30 and 32. A tube bundle 34 depends from the two headers into the container vessel. This bundle comprises a nest of flat vertical sinuous tubes with relatively straight connections 36 and 38 from the top and bottom ends of the bundle to the headers.

Two additional connections 40 and 42 may be provided in the dome if there is to be a cooling tube bundle 44, FIG. 3, positioned over the free surface 22 of the liquid metal in the container; as so positioned, the bundle 44 acts as a condenser for vaporized metal emerging from the body of liquid metal.

The pressure vessel will have inlet and outlet connections 45 for the admission of an inert gas to the free space therein, as well as the usual monitoring, liquid level gauges and other conventional connections.

The advantages of the invention mentioned above should be apparent, the principal ones being the elimination of expensive safety features and avoidance of extensive use of high alloy metals. A further advantage of the arrangement described is that there is no need to make special provision for differential expansion between the pressure vessel, the inner container, and the tubes as each of these items is only connected to one of the others and at a single point. For instance, the inner container is supported in the pressure vessel by the connection between pipe 16 and opening 18. Spacers 46 near the top of the container may be provided to hold the container in alignment with the vessel, but preferably, there is no connection at this point.

FIG. 4 illustrates the manner in which a tube bundle may be arranged to provide a condensing surface. As shown alternate layers 48 and 50 of the tubes extend at right angles to each other to provide a crisscross pattern.

Many modifications will be apparent to those skilled in the art, and the invention is to be limited only as defined in the following claims.

What is claimed is:

1. A vapor generator for indirect heat exchange between a liquid and a liquid metal, such as sodium or potassium, comprising a pressure vessel, an open-topped container, means to support the container within and encompassed by the pressure vessel, liquid metal within

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the container, inlet and outlet connections for the liquid metal extending through said pressure vessel to the container arranged for the flow of liquid metal into and out of the container, means for maintaining the liquid metal in the container at a predetermined normal liquid level below the open top of the container and out of contact with said pressure vessel, means for maintaining a gas under pressure in the vessel, a tube bundle depending from the vessel into said container and immersed in said liquid metal, and inlet and outlet connections for said tube bundle.

2. A vapor generator according to claim 1 wherein said container outlet connection extends through the bottom of said pressure vessel, means affixing said outlet connection to said pressure vessel, said container being supported within said pressure vessel by the affixing of said connection to said pressure vessel.

3. A vapor generator according to claim 1 wherein said pressure vessel is constructed of mild steel, said container being constructed of a corrosion resistant alloy.

4. A vapor generator according to claim 1 and further including a bank of tubes disposed above the free surface of said liquid metal and arranged to condense vapor emitting from said liquid metal free surface, said bank of tubes depending from and being supported by said pressure vessel.

5. A vapor generator for an indirect heat exchange between a liquid and a liquid metal, such as sodium or potassium, comprising a pressure vessel constructed of a mild steel, an open-topped high alloy corrosion resistant container, the container being within and encompassed

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by the vessel, liquid metal within the container, inlet and outlet connections for the liquid metal, the outlet connection extending through the bottom of the pressure vessel from the bottom of the container and being affixed to the vessel wall by which the container is supported within the vessel, means aligning the container within the vessel to maintain the open top of the container in an up position, said means permitting the expansion of the container relative the vessel, the inlet connection extending through the wall of the vessel having an open end which depends into the container, means for maintaining the liquid metal in the container at a predetermined normal liquid level below the open top thereof and out of contact with the pressure vessel, the inlet connection open end depending into the container to a point below said normal liquid level, means for maintaining an inert gas under pressure in the vessel, a tube bundle supported by and depending from said pressure vessel into said container and immersed in said liquid metal, inlet and outlet connections for passing a heat exchange fluid through said bundle, a further bank of tubes disposed above the free surface, said bank of tubes depending from and being supported by said pressure vessel.

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