April 9, 1946. H. L. BARNEBEY ET AL 2,398,279

FLUID HEATER

Filed Jan. 21, 1944 2 Sheets-Sheet 1

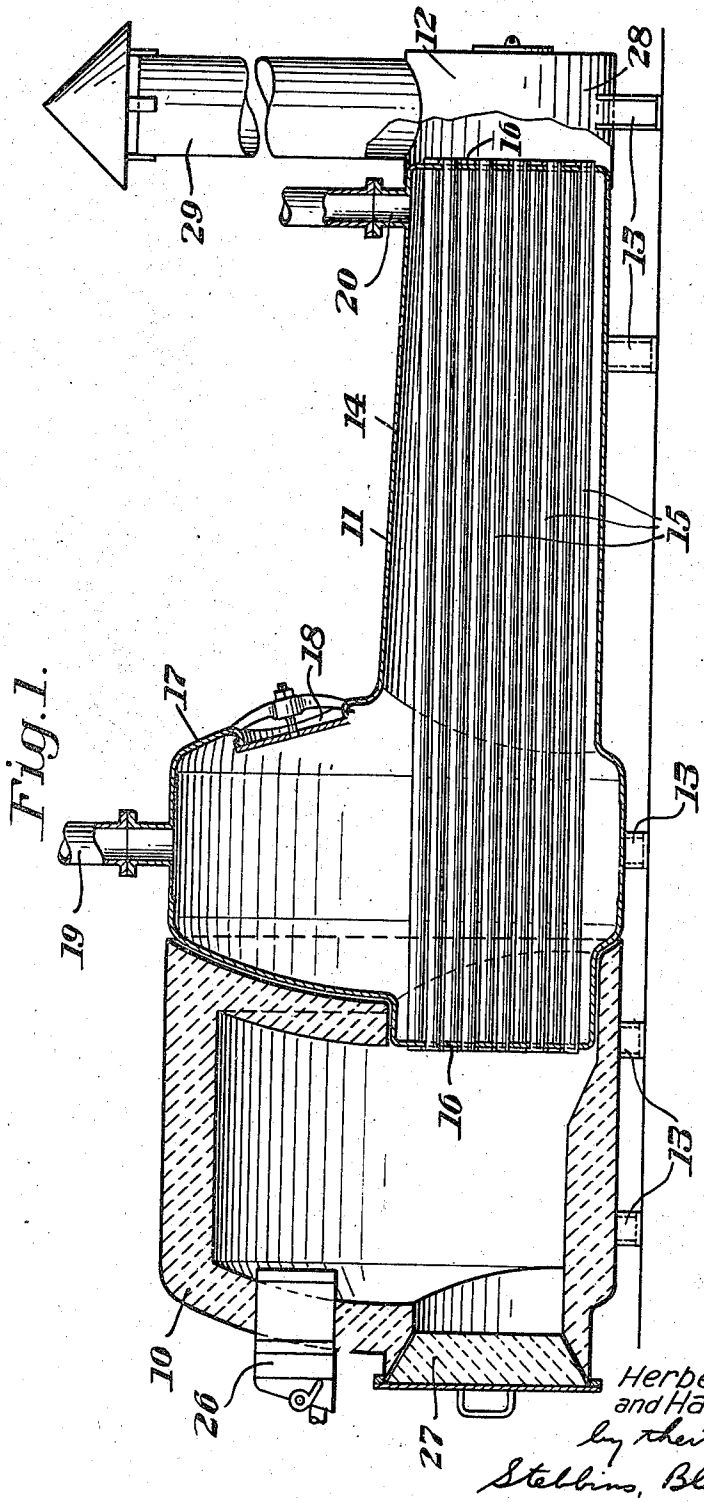


Fig. 1.

INVENTORS
Herbert L. Barnebey
and Harry T. Needham
by their attorneys
Stebbins, Blanks & Webb

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Fig. 2.

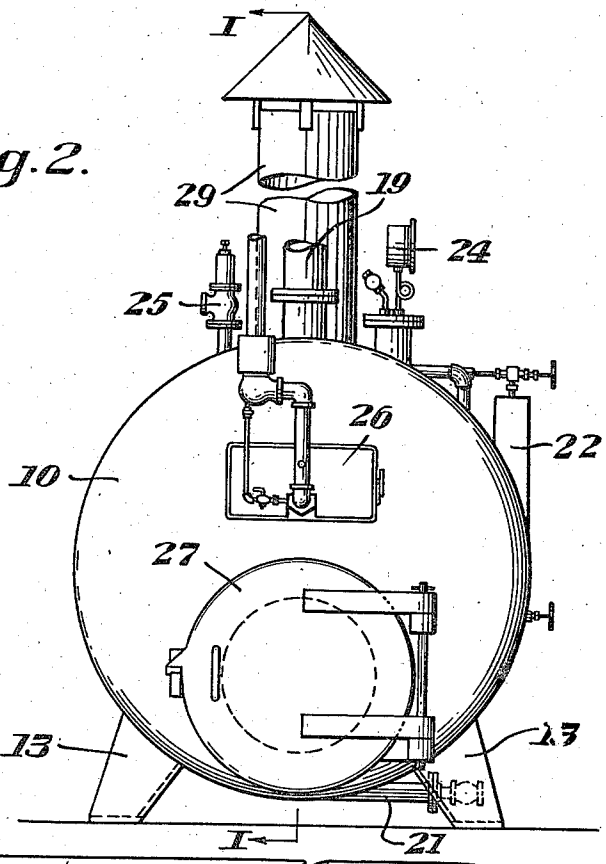
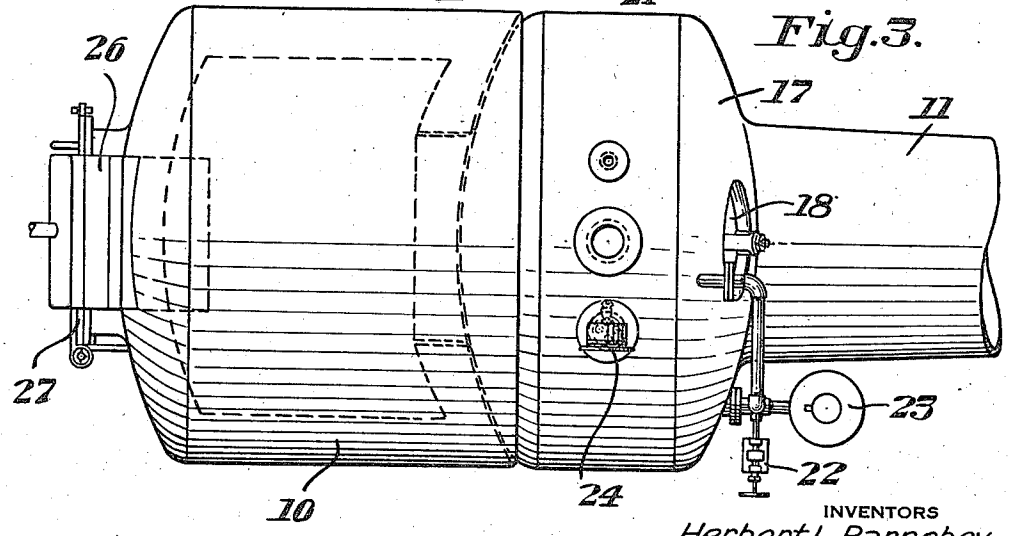


Fig. 3.



INVENTORS
Herbert L. Barnebey
and Harry T. Needham
by their attorneys
Stebbins, Blenko & Webb

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FLUID HEATER

Herbert L. Barnebey, Oakmont, and Harry T. Needham, Blawnox, Pa., assignors to Blaw-Knox Company, Blawnox, Pa., a corporation of New Jersey

Application January 21, 1944, Serial No. 519,128

6 Claims. (Cl. 122—51)

This invention relates to heat-exchange apparatus and, in particular, to a boiler capable of delivering vapor for heating to high temperatures jacketed pipes, vessels, tanks and other apparatus used in the process industries.

It is now quite common in the process industry to utilize vaporizable liquid other than water for delivering heat to reactor vessels. Examples of such liquids are diphenyl and diphenyl oxide, tetrahydronaphthalene, and ethylene glycol. It has heretofore been the practice to heat such liquids in boilers constructed in about the same manner as ordinary steam boilers. Serious difficulties have been experienced, however, in the use of such boilers for the purpose indicated. For example, the boilers used heretofore have been subject to fouling as a result of overheating of the tubes in certain portions. They have also exhibited a tendency to develop leaks and have proved to have only a relatively short life. Frequently leakage is due to inadequate provision for thermal expansion, which is considerable, at the high temperatures employed. A further objection is that stay bolts must be used in the portions of tube sheets of fire-tube boilers which are not taken up by the tubes. At the high operating temperatures which are common in the process industry, leaks develop at the connections between the stay bolts and the tube sheets. Finally, conventional boilers have a fairly high liquid level and this usually makes it necessary to pump condensate into the boiler against a substantial liquid head when the boiler is located, as it usually is, on about the same floor level as the reactor vessel. The pumping of hot liquids such as those employed for heating applications is attended with considerable difficulty.

We have invented a novel form of heat-exchange apparatus particularly suited for vaporizing special liquids useful for supplying heat to reactor vessels. Our invention has important advantages such as low head-room requirement, unique provision for thermal expansion, the absence of stay bolts and a simple construction throughout as well as a low liquid level. In a preferred embodiment of the invention, we provide a horizontal boiler composed of an elongated pressure vessel having a bundle of tubes extending therethrough, a fire box removably positioned adjacent one end of the vessel and a smoke box and stack removably positioned adjacent the other end of the vessel. The vessel itself is cruciform or T-shaped in plan and includes a generally cylindrical section which is substantially filled by the tube bundle and a merging chamber adjacent one end providing a vapor space and a large area of liquid surface. Each of the several units, viz., fire box, pressure vessel and smoke box has its own feet and is thereby fully self-supporting whether in cooperative relation to the other parts or separated therefrom. When the several units are properly assembled, they constitute a complete boiler. When the fire box and smoke box are removed from the pressure vessel, the tubes through the latter are fully exposed for inspection or cleaning.

Further details, novel features and advantages of our invention will become apparent during the following complete description and explanation which refer to the accompanying drawings illustrating the preferred embodiment.

In the drawings:

Figure 1 is a longitudinal vertical section through the apparatus of our invention;

Figure 2 is an end view such as would be seen by looking on the structure of Figure 1 from the left; line I—I of Figure 2 indicates the plane on which the section of Figure 1 is taken; and

Figure 3 is a partial plan view.

Referring in detail to the drawings, the apparatus of our invention comprises a fire box 10, a pressure vessel 11, and a smoke box 12. The several units are assembled on a common axis, the fire box being disposed at one end of the vessel 11 and the smoke box at the other. Each of the units has feet 13 whereby it is self-supporting whether disposed together with the other units or apart therefrom. The fire box and smoke box are freely removable from the ends of the vessel.

Considering first the vessel 11, it is composed of a substantially cylindrical portion 14 substantially filled with a bundle of tubes 15 extending between tube sheets 16 at the ends of the vessel, the tube ends being exposed on the exterior of the tube sheets. The vessel also includes a generally cylindrical enlargement 17 near one end merging into the portion 14. As shown in Figures 1 and 3, the enlargement 17 extends upwardly and laterally from the cylindrical portion 14, so as to provide a large area in horizontal planes at the top of the tube bundle and for a desirable distance thereabove, the bottoms of the two parts of the vessel being nearly at the same level. The bottom of portion 17 is made preferably somewhat lower than the bottom of portion 14, sufficient to allow a continuous curvature of the merging surfaces at the transition with suitable radii. This construction also provides for relative expansion of the tubes and shell. The actual

amount by which the bottom of portion 17 is lower than the bottom of portion 14 would be small, from three to eight inches, for example; and it would vary somewhat with the size of the vessel. While the portion 14 has been referred to as substantially cylindrical, it is preferably somewhat frusto-conical as shown in the drawings, the diameter thereof adjacent the enlargement 17 being slightly greater than the diameter adjacent the smoke box. The wall of the portion 14 thus slopes upwardly toward the enlargement 17. This facilitates the travel of vapor from the smoke-box end of the vessel to the enlargement 17 thereof which constitutes a vapor space.

A manway 18 is formed in the side of the enlargement 17 remote from the fire-box end of the vessel 11. A vapor outlet connection 19 is formed on the upper side of the enlargement 17. A liquid inlet 20 is formed adjacent the smoke-box end of the vessel. A liquid outlet or drain connection 21 extends laterally from the bottom of the enlargement 17. The foregoing functions ascribed to connections 19, 20 and 21 are illustrative of typical cases only, it being understood, of course, that these and other connections may be provided and selected as inlets or outlets for fluids when desired in a particular case. Other connections extend from the enlargement 17 to a liquid-level gauge 22, a liquid-level alarm or control device 23, a vapor-pressure gauge 24 and safety valve 25.

When the boiler has been filled with cold liquid sufficient to cover the tubes, the surface lies in the region of portion 17 having a relatively large horizontal area; and as the cold liquid is heated and expands volumetrically, a small change in level will accommodate a relatively large change in volume. This is important particularly in maintaining low liquid level. A mixture of diphenyl and diphenyl oxide, for example, having a volume of 178 gallons at 70° F., expands to a total volume of 252 gallons at 700° F., a commonly used temperature. This is a volumetric expansion of about 40%, yet in the boiler of our invention it is accommodated with a change in level of only a few inches.

The fire box 10 is simply a combustion chamber composed of a refractory lining laid up within a sheathing of metal plate. As shown in Figures 1 and 3, the outer end of the fire box is provided with a burner 26. While a fluid-fuel type of burner is shown, any suitable means for burning solid or fluid fuels may be used. A clean-out or inspection door 27 is mounted below the burner. The other end of the fire box is shaped to fit closely around the adjacent end of the vessel 11 and its enlargement 17, having an opening adapted to receive the extreme end of the vessel whereby the flame and hot gases produced in the fire box by combustion of fuel supplied through pipe connections to the burner 26, pass through the tubes 15 to heat the liquid contained in the vessel 11.

The smoke box 12 comprises simply a cylindrical drum 28 of suitable metal plate open at one side, having a stack 29 projecting upwardly therefrom. As shown, the drum 12, like the fire box 10, is disposed in overlapping relation with the adjacent end of the vessel 11 whereby the combustion gases, after traversing the tubes 15, collect within the drum 12 and then pass upwardly through the stack to the atmosphere.

It will immediately be apparent that when the fire box and smoke box are withdrawn from the positions in which they are illustrated, the tubes 15 are exposed at both ends of the vessel 11 for convenient inspection or cleaning. It will also be apparent from the drawings that all parts of the apparatus are of exceedingly simple construction, thus minimizing both the first cost and maintenance expense.

It will be noted that the apparatus has a low overall height and a low liquid level. In fact, the bottom of the pressure vessel is almost at floor level. This is of particular advantage when the apparatus is used to supply heat to processing reactors. In such cases it is not possible to mount the reactor at a height much above the floor level and it is not convenient to mount the heating apparatus on the floor below the reactor since accepted practice requires in a majority of cases a separate heating apparatus for each reactor to provide flexibility of control, and it is desirable to have the heating apparatus near the reactor, there usually being a fireproof partition between them. The low liquid level characteristic of our apparatus permits the return of condensate by gravity flow and without pumping. We thus avoid in many instances the difficulties involved in pumping hot liquids.

The construction of our apparatus also has several structural and mechanical advantages. Stay bolts are not necessary. The curvature at the merging of small and large sections of the shell provides adequately for thermal expansion of the shell and tubes. A multiplicity of inspection hand holes and manways are obviated, furthermore, since the single manway provided opens into the enlargement which is of sufficient size to permit entry of an inspector.

Our apparatus has numerous applications in addition to the production of heated vapor. It may be used to deliver hot liquid or for the concentration of dilute solutions. In the former case, the vapor outlet 19 may be blanked off and the hot liquid may be delivered from the outlet 21, which in that case would be somewhat larger than illustrated, preferably about the same size as the liquid inlet 20. When the apparatus is used for concentration, the dilute solution is introduced through the inlet 20, the vapor driven off is removed through outlet 19 and the concentrated solution delivered from outlet 21.

Although we have illustrated and described but a preferred embodiment, it will be recognized that changes in the construction and arrangement of the parts may be made without deviating from the principle of the invention or the scope of the appended claims.

We claim:

1. In a heat-exchange apparatus: a pressure vessel adapted to be fired, said vessel comprising spaced tube sheets forming the ends of the vessel; a generally cylindrical shell joined to said sheets, horizontal tubes extending between said sheets and substantially filling said shell, said shell having a generally cylindrical enlargement adjacent one end of the shell, and a fire box removably positioned at the end of the shell at which said enlargement is located, said fire box comprising a generally cylindrical chamber of substantially the same diameter as said enlargement and being disposed coaxially therewith.

2. A vapor generator comprising an elongated cylinder having a tube sheet at each end and a bundle of tubes extending between said sheets and substantially filling said cylinder, said cylinder merging gradually into a generally cylindrical enlargement adjacent one end, the axis of said enlargement being substantially parallel to the axis of the cylinder and located substantially

at the level of the top of said cylinder, whereby the liquid surface in the enlargement is a maximum at liquid levels which cover the tubes.

3. The apparatus defined by claim 2 characterized by the bottom of said enlargement being at substantially the same level as the bottom of said cylinder.

4. A vapor generator comprising an elongated cylinder having a tube sheet at each end and a bundle of tubes extending between said sheets and substantially filling said cylinder, said cylinder merging gradually into a generally cylindrical enlargement adjacent one end, the axis of said enlargement being substantially parallel to the axis of the cylinder and located substantially at the level of the top of said cylinder, whereby the liquid surface in the enlargement is a maximum at liquid levels which cover the tubes, a fire-box at the end of the cylinder adjacent which said enlargement is located, the fire-box having its top and bottom substantially at the levels of the top and bottom of the enlargement, respectively.

5. A vapor generator comprising spaced tube sheets, an elongated cylinder joined to said sheets, horizontal tubes extending between said sheets and substantially filling said shell, and a generally cylindrical enlargement near one end of the shell, the axis of the enlargement being parallel to that of the cylinder but located substantially at the level of the top of the cylinder so that horizontal sections through the enlargement have maximum area substantially at liquid levels submerging said tubes.

6. A horizontal boiler comprising two intersecting and merging cylinders of different lengths and diameters disposed with their axes parallel, the longer cylinder having the smaller diameter and being filled with heat-exchange tubes, the shorter cylinder being disposed adjacent one end of the longer cylinder with its axis at substantially the level of the top of the longer cylinder, whereby said tubes are submerged when said shorter cylinder is approximately half-full of liquid.

HERBERT L. BARNEBEY.
HARRY T. NEEDHAM.