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EVAPORATOR

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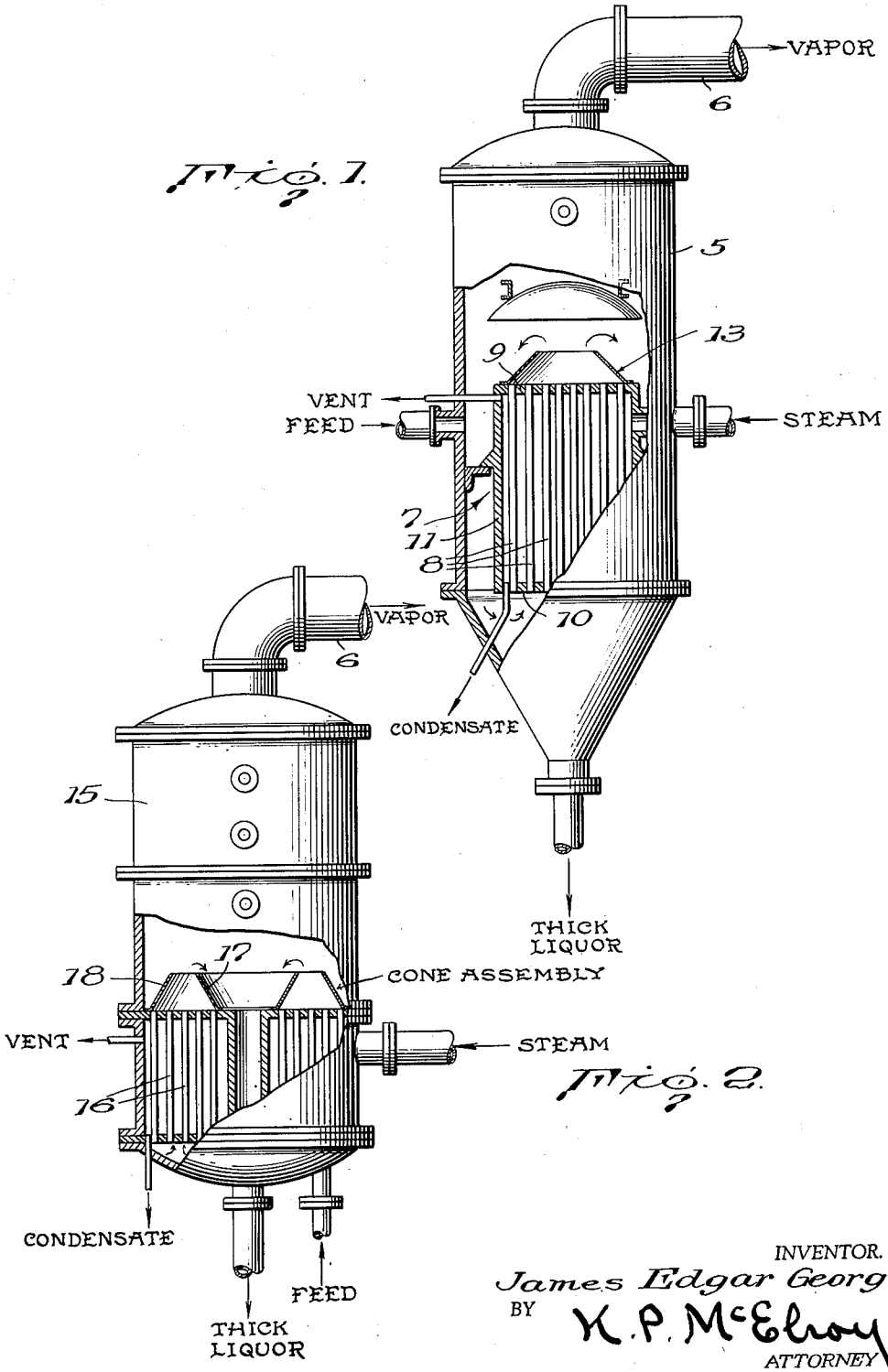


Fig. 1.

Fig. 2.

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EVAPORATOR

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2 Claims. (Cl. 159—28)

This invention relates to evaporators; and it comprises, in a liquid evaporator having a calandria comprising tubes through which liquid flows upwardly, the top of the tubes extending above the normal liquid level in the evaporator, the improvement comprising upwardly-extending inclined annular wall means, above the tops of the tubes, of such height and inclination as to define a discharge opening, for vapor-liquid mixture issuing from the top of the tubes, of area not substantially greater than the combined area of the tube openings; all as more fully hereinafter set forth and as claimed.

One extensively used type of evaporator takes the form of a shell, with vacuum connection at the top, in which shell is disposed a calandria: a set of vertical tubes opening through upper and lower tube sheets and surrounded by a shell. Steam is circulated around the tubes. The calandria is sometimes at the core of the main shell, leaving an outer annular downtake passage, and is sometimes of annular form, leaving a central opening for the downtake. The normal liquid level is below the level of the upper tube sheet. Circulation is upwardly through the tubes in each case. Evaporation takes place within and above the tubes, with formation of vapor bubbles in the rising liquid.

In employing these evaporators with certain saline liquors, considerable trouble is experienced due to incrustations of crystals which form on the upper tube sheet at the point where the ascending liquor emerges from the tubes. This incrustation impairs the heat transfer and restricts the circulation and requires that the evaporators be shut down and washed with water at frequent intervals in order to remove these incrustations and restore the evaporator to its normal operating condition. Shut-downs for washing add materially to the expense of operation, because of increased labor and reduced production.

For example, in the production of caustic soda by the electrolytic process using cells of the diaphragm type, the effluent from the cells (cell liquor) containing from 8 to 12 per cent of NaOH and from 16 to 12 per cent of undecomposed salt (NaCl), is subjected to evaporation in such apparatus, in order to increase the concentration of NaOH and to remove this undecomposed salt for return to the process.

As the concentration of the cell liquor in the evaporator rises due to removal of water, a point is reached where the solution becomes supersaturated as to NaCl and the formation of salt crystals sets in. Most of these salt crystals remain in suspension in the caustic soda solution and suitable means, not here important, are provided for separating them from the circulating liquid undergoing evaporation and removing them from the evaporator. But some of the salt remains as incrustations on the upper tube sheet, as described.

The present invention is based on the discovery that the deposition of salt crystals at the upper tube sheet is due to a tendency for some of the hot rising liquid, as the hydrostatic head thereon drops practically to zero, to flash into steam; a sudden "concentration" of the already saturated liquid which causes immediate local deposition of salt.

I have found that sudden evaporation of water at the upper tube sheet can be greatly reduced or prevented, and the stated source of trouble removed, by imposing a moderate hydrostatic head on the tube sheet; just enough to suppress flash evaporation at this point. This is accomplished most conveniently by mounting above the tube sheet a short tapered discharge conduit, substantially frusto-conical, of particular dimensions as described below, and forming a passage for the liquid-vapor mixture expelled from the tubes. With such a cone, the space into which the ascending column of bubble-containing liquid discharges is more or less restricted depending on the area of the upper opening of the cone. For successful operation this restriction should be sufficient so that the liquid-vapor mixture, rising forcibly through the cone, imposes an additional pressure adjacent the base of the cone, enough to suppress flash evaporation (sudden increase in the vapor phase) until the mixture has emerged from the tubes and is out of contact with the tubes. Flash evaporation occurs within the cone but not to any substantial degree immediately adjacent any metal surface on which the crystals can deposit. The crystals are in fact swept by the flow of the liquid through the upper circle of the cone and flow downward through the downtake space and are ultimately removed from the circulating liquid by means of any of the conventional salt separating devices in common use.

The relation between the discharge area of the conical extension, and the total area of the tube openings in the sheet, is important. On the whole, best results are obtained when the cone exit area is about the same as the combined area of the tubes. It can be slightly greater, or a good deal less, while achieving the stated results.

It should not be too small as this unduly restricts the area exposed for evaporation and the rate of liquid circulation.

The invention is applicable to a wide variety of evaporators, of the unsubmerged type. It is shown by way of example, in the accompanying drawing, as applied to two good forms of evaporators. In the drawing

Fig. 1 is a showing partly in vertical section and partly in elevation, of the invention applied to an evaporator of the central calandria type, and

Fig. 2 is a similar showing of the invention applied to an evaporator of the wall calandria type.

Referring to Fig. 1, an evaporator is shown including the usual shell 5 with vacuum connection 6 and a central calandria 7, comprising a set of tubes 8 opening through an upper tube sheet 9 and a lower tube sheet 10 and enclosed by a shell 11 for circulation of heating steam around the tubes. The upper tube sheet is above the normal liquid level in the evaporator. The liquid is not shown.

According to the present invention a conical discharge member is provided above the calandria, as shown at 13, joined with the rim of the tube sheet in any suitable manner. The diameter of the base of this truncated cone is the same as that of the upper tube sheet and the diameter of the top circle varies with that of the bottom. For example, in an evaporator having an upper tube sheet 33 inches in diameter, with tubes in the usual arrangement (about 312 tubes of internal diameter 0.7 inch), of total tube area 120 square inches, the diameter of the upper circle of the truncated cone is best selected between 10 and 14 inches (area 80 and 150 square inches, respectively). The altitude of the truncated cone may be varied in a similar manner. In this example an altitude or vertical rise of 10 inches produces excellent results. In other words, the walls of the cone often slope inwardly at about 45 degrees. The fluid being evaporated spills over the top of the cone as a sort of froth.

The invention is equally well applicable to evaporators of the type having an axial downtake, as shown in Fig. 2. Here the shell 15 contains an annular calandria 16, with a superstructure taking the form of two cones, 17 and 18, mounted on the top of the annular calandria. The tops of the cones define an annular discharge opening of area approximately equal to the sum of the tube openings. The same advantages result.

In evaporators having more than one downtake, the invention can be applied, following the same rules laid down above.

Evaporators that formerly required a shutdown for washing of two hours out of twenty four in order to remove the salt incrustations, were found, after the installation of the improvement of the present invention, to run for over 160 hours before requiring any shut-down for washing. The ratio of operating to non-operating time which is 11 to 1 for the conventional evaporator increases to over 80 to 1 when the evaporator is equipped with the improvement of the present invention.

The cone or cones may be made of sheet metal of any convenient thickness and composition, consistent with the necessary mechanical strength and reasonable durability. Cones made from sheet monel metal or nickel ⅛ inch to $\frac{3}{16}$ inch in thickness give excellent service. However, those made from mild steel or the commercial steels rendered harder by the addition of chromium and nickel are also usable and somewhat less costly than those made from monel metal or nickel.

While the invention has been described mainly in connection with the concentration of caustic soda solutions containing sodium chloride, it is equally applicable to the evaporation of ordinary salt brines for the production of the so-called "evaporated salt" or in fact for the concentration of any solution a component of which tends to form adherent crystal masses during evaporation.

What I claim is:

1. In a liquid evaporator having a calandria comprising heated tubes, through which liquid flows upwardly, disposed in annular arrangement, an annular upper tube sheet through which the tubes open, said tube sheet being above the normal liquid level in the evaporator, and a central tubular downtake passage, the improvement comprising frustoconical shells extending upwardly from the annular tube sheet, inclined toward each other and defining between them an annular liquid discharge opening of area not substantially greater than the combined area of the tube openings in the annular tube sheet.

2. In a liquid evaporator having a calandria comprising heated tubes through which liquid flows upwardly, a discoid upper tube sheet through which the tubes open, said tube sheet being above the normal liquid level in the evaporator, and an annular downtake liquid passage around the calandria, the improvement comprising a frustoconical shell extending upwardly from the upper tube sheet and comprising wall sections inclined inwardly and terminating at an opening of an area substantially smaller than the diameter of the tube sheet and not substantially greater than the combined area of the tube openings in the tube sheet, said opening communicating directly with the evaporator space, so that liquid rises through the shell and flows through the opening.

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