

- [54] **METHOD AND APPARATUS FOR HEAT TREATING LIQUEFORM MATERIALS**
- [75] Inventors: **Elmer S. Davies; Monte R. Edwards,** both of Takoma Park, Md.
- [73] Assignee: **Dasi Industries, Inc.,** Silver Spring, Md.
- [22] Filed: **June 15, 1972**
- [21] Appl. No.: **263,132**
- [52] U.S. Cl. **159/4 A, 159/48 L, 159/DIG. 10, 159/13 C, 261/115**
- [51] Int. Cl. **B01d 1/16, B01d 1/22, F26b 3/12**
- [58] Field of Search..... **159/4 A, 13 R, 13 C, 16 A, 159/16 R, DIG. 10, 48 L, 13 A; 202/236; 261/112, 115; 23/276, 306; 423/322; 126/360 A; 203/49, 100 DC**

[56]

References Cited

UNITED STATES PATENTS

1,054,650	2/1913	Vouga.....	159/13 C
2,640,761	6/1953	Wiseman.....	159/13 R
2,731,081	1/1956	Mayner.....	159/49
2,753,594	7/1956	Buck.....	159/13 C X
2,900,975	8/1959	Northcott.....	159/16 A X
3,088,812	5/1963	Bitterlich et al.....	126/360 A X
3,212,559	10/1965	Williamson.....	159/13 C X
3,300,868	1/1967	Anderwert.....	34/5
3,326,202	6/1967	Sullivan.....	159/13 C X
3,408,168	10/1968	Godwin.....	159/16 A X
3,477,094	11/1969	Maahs et al.....	159/13 A X
3,618,908	11/1971	Stone.....	261/112
3,626,672	12/1971	Burbidge.....	159/13 C
3,713,794	1/1973	Maher et al.....	261/115 X

Primary Examiner—Jack Sofer

Attorney, Agent, or Firm—Clarence A. O'Brien and Harvey B. Jacobson

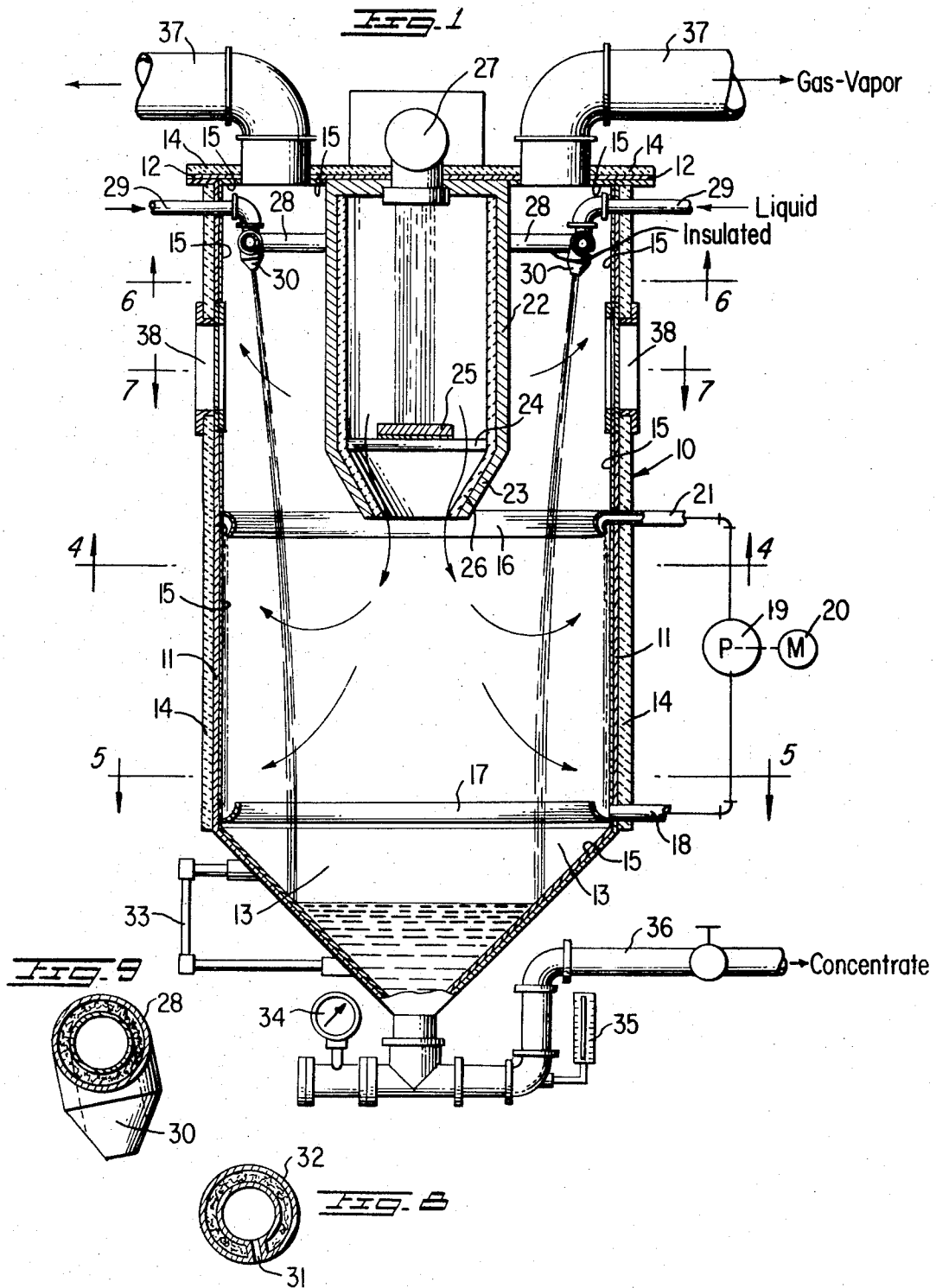
[57]

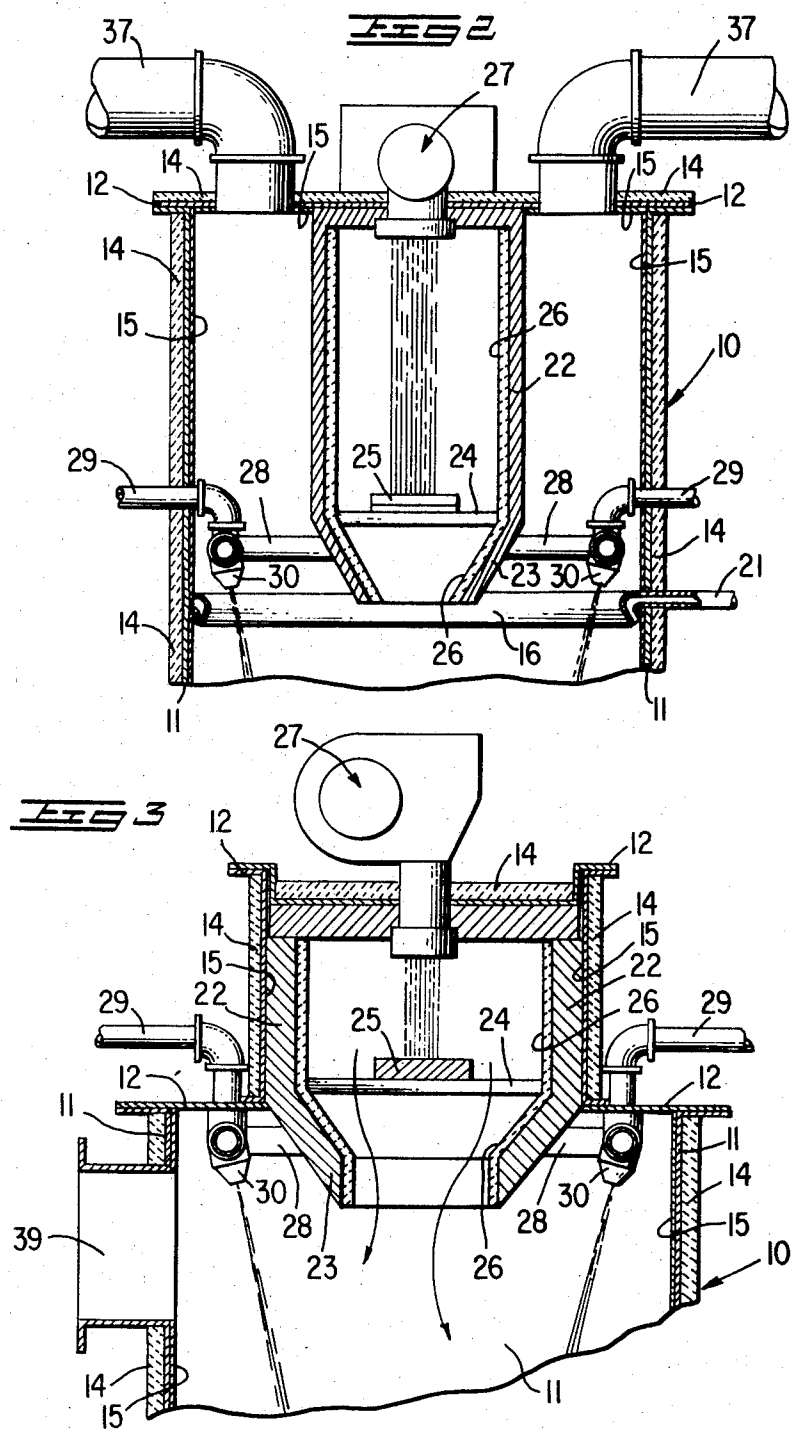
ABSTRACT

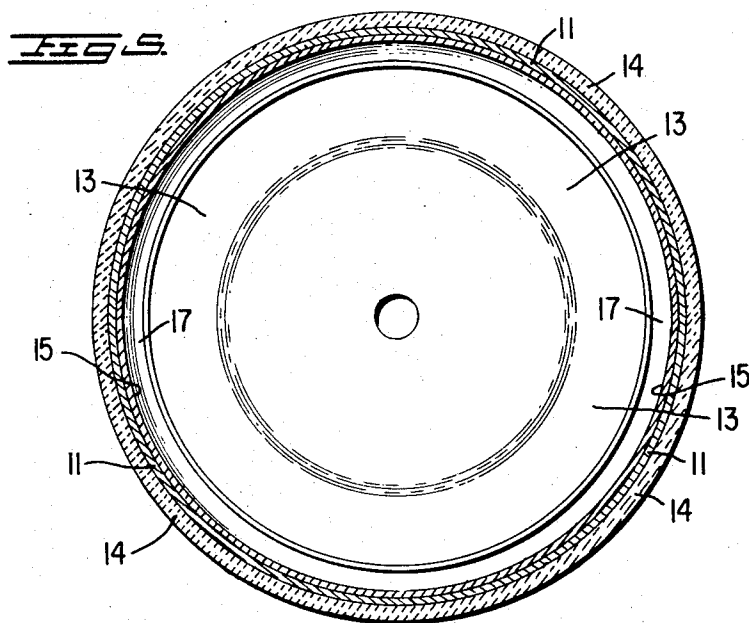
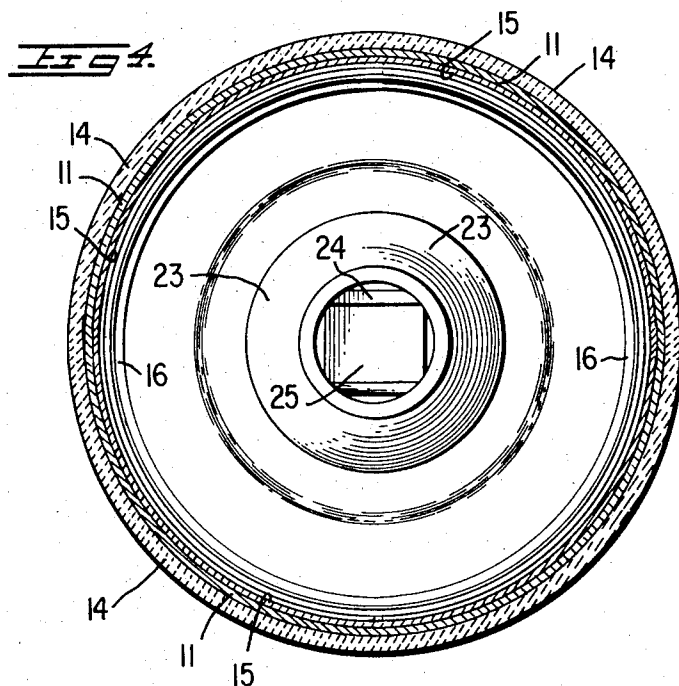
This invention relates to a method and apparatus for heat treating liqueform materials in which a continuous downwardly falling curtain, preferably circular in transverse cross section of the liqueform material to be heat treated, is formed within and is surrounded in spaced relation by a vertically-disposed vessel. A suitable burner is mounted at the upper portion of the vessel and discharges its products of combustion slightly below the upper end of said curtain and downwardly throughout the height of said curtain, at relatively low pressures and at relatively high temperatures, means being provided to prevent the flame from

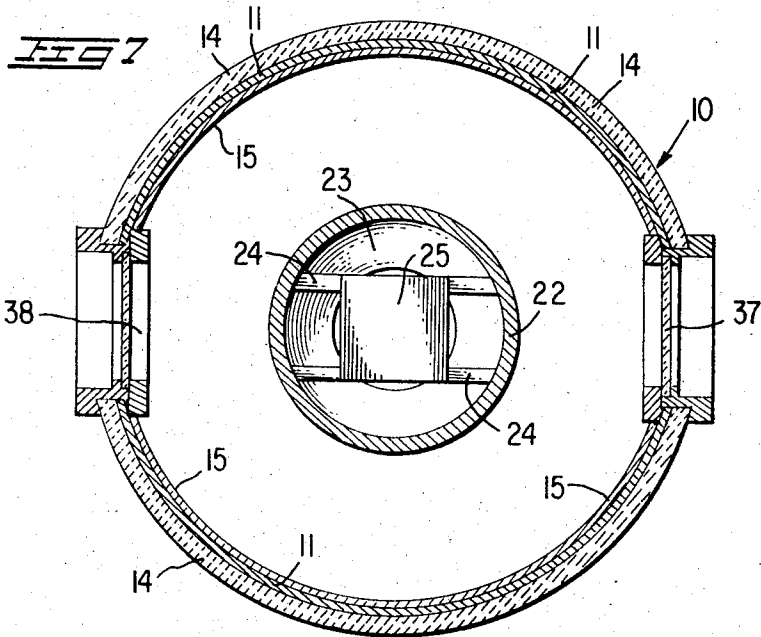
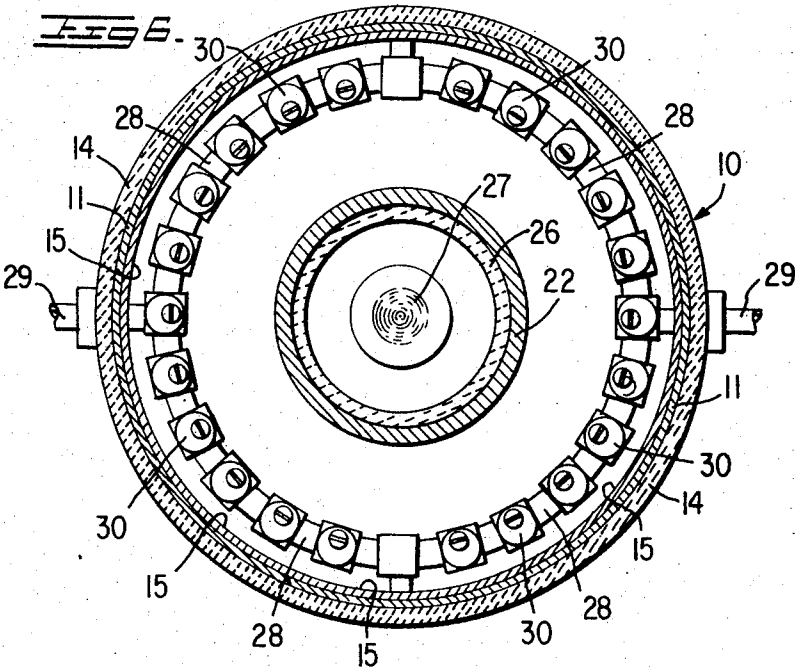
said burner entering the confines of said curtain. The heat of the products of combustion emanating from the burner vaporize the volatile constituents of said curtain which pass upwardly of the vessel through the space existing between the outer surface of said curtain and the inner wall of the surrounding vessel and are discharged through an outlet opening or openings located at or near the closed top of said vessel, the non-volatile constituents of the liqueform material, if any, i.e. the concentrate therefrom, if any, passing to the bottom of the vessel and being discharged through a discharge opening leading from the bottom of said vessel, a relatively small amount of said concentrate, if any, being retained above said discharge opening to form a liquid seal thereabove. Depending upon the particular liqueform material undergoing heat treatment and the use to be made of the volatile constituents driven off from the said curtain and to be made of the non-volatile constituents which are not driven off from the said curtain, said volatile and non-volatile constituents withdrawn from the vessel are available for utilization or may be subjected to further processing to render them suitable for their intended purpose or purposes. The relationship between the height of the surrounding vessel, the height and thickness of the curtain of liqueform material, and the pressure and temperature of the products of combustion passing downwardly throughout the height of said curtain are such that by the time said curtain reaches the bottom of said vessel substantially all of the volatile constituents thereof have been removed therefrom and the pressure and temperature of the products of combustion have been spent, i.e. have performed their intended purpose and have been utilized to their full extent. Suitable means and controls of any desired or preferred construction, either manually or automatically operated, are provided for forming the continuous downwardly falling curtain of the desired thickness; for converting the flame from the burner into its products of combustion and preventing said flame from entering the confines of said curtain; for regulating the relatively low pressure and relatively high temperature of the products of combustion emanating from said burner; and for maintaining a sufficient amount or body of the non-volatile constituents or concentrate, if any, above the discharge outlet at the bottom of the vessel to form a liquid seal above said discharge outlet. Means are also provided for preventing the incrustation of material on the inner wall of the vessel during the heat treating operation.

5 Claims, 9 Drawing Figures









METHOD AND APPARATUS FOR HEAT TREATING LIQUEFORM MATERIALS

FIELD OF THE INVENTION

The present invention relates to a method and apparatus of wide utility, and is applicable to any and all fields of endeavor which involve the heat treatment of liqueform materials to vaporize all or portions of said materials, and/or to separate the volatile constituents from the non-volatile constituents thereof. For example, the method and apparatus may be used for the generation of steam for heating and/or power purposes, for the heat treatment of saline water to provide potable water therefrom, for the heat treatment of waste pickling liquor resulting from processes employed in the steel industry, for the heat treatment of waste sulphite liquor resulting from processes employed in the paper making industry, for the heat treatment of various liquid foods and beverages, for the heat treatment of various liquid pharmaceutical and chemical solutions, for the separation of non-objectionable volatile constituents from the objectionable non-volatile constituents of garbage, sewage and the like liqueform materials when dealing with the problem of anti-pollution, etc. The wide utility and efficiency of the method and apparatus of the present invention will be readily apparent to anyone reasonably skilled in the art to which the present invention pertains.

DESCRIPTION OF THE PRIOR ART

The prior art in the various fields of endeavor to which the method and apparatus of the present invention relates, has provided various methods and apparatus for effecting the heat treatment of liqueform materials which contain volatile as well as non-volatile constituents, and which methods and apparatus involve the formation of various types of sprays and streams and, in a few instances, involve the formation of downwardly falling continuous curtains, and the like, which are subjected to heat treatment from various sources of heat, but as far as applicants are aware they know of no prior art which discloses or even suggests a method and apparatus possessing the features and advantages provided by their present invention. Extensive searches have been made by competent attorneys prior to the preparation and filing of the present application, and the closest and most pertinent prior patented art located and of which applicants have knowledge is the patent to Williamson U.S. Pat. No. 3,212,559 of Oct. 19, 1965 entitled "Method of Concentrating Liquid-Containing Mixtures".

The aforesaid Williamson patent discloses the formation of a vertically-disposed liquid blanket or curtain formed within and surrounded in spaced relation by, a vertically-disposed vessel, with a combustion chamber containing therein a burner and depending from the top of said vessel, which combustion chamber is surrounded by an annular passageway which serves as a conduit for the liquid containing mixture to be evaporated or concentrated, the lowermost end of said combustion chamber discharging slightly below the upper end of said downwardly falling liquid curtain. In this Williamson patent, the purpose of the vertically-disposed and downwardly falling annular curtain is to enclose and confine therein the discharged gas stream and flame from the burner so as to force the said gas

stream and flame at relatively high velocity and pressure onto the upper surface of the liquid contained in a reservoir at the bottom of the surrounding vessel and beneath the burner and combustion chamber, through said upper surface and around said curtain. Hence it will be seen that Williamson vaporizes the liquid contained in a reservoir located in the lower portion of the surrounding vessel by projecting the flue gas and flame at relatively high velocity and pressure onto the surface of the liquid in the said reservoir which liquid, as clearly shown in the drawing of the Williamson patent, tends to take the form of fine bubbles of volatile material which apparently break and the volatile constituents thereof pass upwardly through the space between the outer surface of the curtain and the inner wall of the surrounding vessel to and through an outlet opening at the top of the vessel. The flue gases and flame emanating from the burner of the Williamson patent would of necessity be projected at high velocity and pressure in order to penetrate the upper surface of the liquid material in the reservoir, and obviously the annular curtain of this patent would have to be relatively thick in order to confine the high velocity and pressure flue gases and flame and not to be destroyed by the same. Williamson is not concerned with the removal of volatile constituents from a continuous downward falling curtain of the material undergoing heat treatment but is concerned with the vaporization of the volatile components of the surface of the material in a reservoir of the liquid contained in the lower portion of the vessel. Applicants' present invention involves no such procedure.

SUMMARY OF THE PRESENT INVENTION

It is an object of the present invention to provide a highly practical and efficient method and apparatus for heat treating liqueform materials to vaporize therefrom the volatile constituents thereof, or to vaporize and separate the volatile constituents from the non-volatile constituents thereof and to use the liberated volatile constituents and the non-volatile constituents or concentrate for any desired or intended purpose or purposes, either by direct utilization or by subjecting the same to subsequent processing or treatment.

It is a further object of the present invention to provide a method and apparatus for the heat treatment of liqueform materials in which the material undergoing treatment is formed into a continuous, relatively thin curtain preferably of circular transverse cross section, and to project the curtain thus formed downwardly within a surrounding vessel having its inner wall spaced from the outer surface of said curtain to provide a space therebetween, and to provide a burner near the top of said vessel and within a downwardly-extending combustion chamber having its discharge end located below the upper end of said curtain and provided with means therein to prevent the flame from the burner from passing out of said discharge end, whereby the products of combustion without the flame are projected at relatively low pressure and relatively high temperature into and through the confines of said curtain, whereby the heat from said products of combustion vaporize the volatile constituents of the liqueform material undergoing heat treatment, and the non-volatile constituents, if any, of said material are discharged from the bottom of said vessel.

It is a further object of the present invention to provide a method and apparatus of the type referred to above in which a relatively small amount of the non-volatile constituents, if any, or concentrate resulting from the heat treatment of the said curtain, is maintained slightly above the discharge outlet at the bottom of the vessel to form a liquid seal overlying said discharge outlet, and wherein the relationship between the height of the surrounding vessel, the height of "fall" and the thickness of the continuously-falling curtain, and the relatively low pressure and the relatively high temperature of the products of combustion emanating from the discharge end of the combustion chamber are such that when the products of combustion reach the surface of the liquid or concentrate seal in the bottom of the vessel, i.e. the relatively small amount of liquid or concentrate forming the liquid seal, the pressure and temperature of said products of combustion are spent and their intended purpose or function has been completely accomplished.

It is a further object of the present invention to provide a method and apparatus of the type and for the various purposes set forth above, which include a continuous supply of flushing liquid flowing downwardly along and covering that portion of the inner surface of the surrounding vessel below the discharge end of the combustion chamber to prevent the incrustation of material on the inner surface of said portion.

It is a still further object of the present invention to provide a method and apparatus of the type and for the various purposes set forth above that are relatively simple in construction and operation, that are relatively easy to operate and maintain, and that are highly practical and efficient for the accomplishment of their intended purposes.

THE DRAWINGS

In the accompanying drawings wherein for the purpose of illustration there are shown several preferred embodiments of the present invention and wherein like numerals are employed to designate like parts throughout the several views:

FIG. 1 is a vertical sectional view illustrating the details of construction of one form of the present invention and showing the liqueform material distributing pipe which forms the continuously downwardly flowing curtain of the material to be subjected to heat treatment located within and adjacent the upper portion of the surrounding vessel and near the upper end of the combustion chamber, and with the burner mounted on the top of the vessel and with the combustion chamber secured to and depending from said top and terminating well below said fluid distributing pipe;

FIG. 2 is a fragmentary vertical sectional view of the upper portion of the apparatus shown in FIG. 1 but differing from the showing of FIG. 1 in that the annular liqueform material distributing pipe is located adjacent but slightly above the lower discharge end of the combustion chamber;

FIG. 3 is a fragmentary vertical sectional view of the apparatus shown in FIG. 1 but differing from the showing of FIG. 1 in that the burner, the combustion chamber and the annular liqueform material distributing pipe are all mounted on the top closure of the vessel with the major portion of the combustion chamber positioned above said top closure and with the lower or discharge end of the combustion chamber terminating

below said top closure and slightly below said fluid distributing pipe;

FIGS. 4, 5, 6 and 7 are transverse sectional views taken on the lines 4—4, 5—5, 6—6, and 7—7, respectively of FIG. 1;

FIG. 8 is an enlarged transverse sectional view of a form of annular liqueform material distributing pipe provided with a continuous open slot extending along the lower portion thereof; and

FIG. 9 is an enlarged transverse sectional view of the form of annular liqueform material distributing pipe provided with a plurality of circumferentially spaced discharge nozzles of the form shown in FIGS. 1, 2, 3 and 6 of the accompanying drawing.

DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE PRESENT INVENTION

Referring more in detail to the accompanying drawings, and with particular reference to FIG. 1 thereof, the reference numeral 10 designates broadly the main body portion or vessel of the heat exchange apparatus of the present invention, which body portion or vessel may comprise a cylindrical, vertically-disposed body portion 11 of suitable material such, for example, stainless steel, which vessel 10 is closed at its upper end by a metallic top closure 12 and which terminates at its lower end in a downwardly directed conical portion 13. The outer surfaces of the cylindrical body portion 11 and of the top closure 12 are preferably covered with suitable heat insulating material 14, and the entire inner surface of the said cylindrical portion 11, of the top closure member 12, and of the lower conical portion 13 are preferably lined with an impervious material 15 which is immune to the action of acid or other chemicals in liquid or gaseous form and which is not affected by relatively high temperatures.

As an effective and efficient means for preventing the incrustation of material on the inner wall of the lower portion of cylindrical portion 11, i.e. on the impervious material 15 lining such portion, means are provided for supplying along said lower portion, a continuous downwardly flowing liquid chemical composition which is immune to reaction with the fluent material undergoing heat treatment in the apparatus and which is not affected by acids or other chemicals in liquid or gaseous form or by the high temperatures existing within the vessel 10, and which liquid chemical constitutes a flushing liquid for said lower portion of cylindrical portion 11, all as clearly shown in FIG. 1 of the accompanying drawings. To accomplish this flushing action, there is provided an annular supply pipe 16 mounted within and extending transversely of the cylindrical portion 11 of vessel 10 and discharging through a continuous annular slot extending along the lower portion of said supply pipe and discharging slightly below the discharge end of the combustion chamber of the apparatus as clearly shown in FIGS. 1 and 2 of the accompanying drawings. The flushing liquid supplied through the slot of annular pipe 16 flows downwardly along the entire inner surface of the lower portion of cylindrical portion 11 and collects in an open topped annular trough 17 from which said flushing liquid is withdrawn through a discharge pipe 18 which is connected to the intake side of a liquid pressure pump 19 driven by a motor 20 from which pump the flushing liquid is returned to annular, slotted supply pipe 16 by a pipe 21 leading from the outlet side of pump 19, it being under-

5

stood that said pump 19 is continuously driven by motor 20 during the entire heat treating operation.

In the form of the invention shown in FIGS. 1 and 2 of the accompanying drawings, an elongated, vertically-disposed combustion chamber 22 closed at its upper end, depends from the central portion of top closure member 12 and terminates at its lower end in a conical open ended portion 23. A pair of spaced, parallel and horizontally extending rods or bars 24 extend transversely across the interior of combustion chamber 22 slightly above the conical portion 23 of said combustion chamber 22, and support thereon a flat, substantially square refractory baffle 25 upon which the flame from the burner impinges for a purpose to be hereinafter described. The entire inner surface of combustion chamber 22 including the lower conical portion 23, is lined with refractory brick or other refractory flame and heat resisting material 26 to prevent direct contact between the flame from the burner and the inner surface of said combustion chamber, and to prevent radiation of heat from the walls of combustion chamber 22 and its conical lower portion 23 into the space surrounding said combustion chamber 22 and said conical portion 23.

A suitable burner 27 of any preferred construction is provided with controls for regulating the pressure and temperature of the flame projecting therefrom, which burner 27 is mounted on and secured to the central portion of top closure member 12 and projects its flame downwardly into direct contact with a refractory baffle 25 which breaks up the flame into its products of combustion and effectively prevents the flame from projecting into the confines of the continuously downwardly falling curtain of the liqueform material undergoing heat treatment, where the presence of the flame would be objectionable when heat treating certain liqueform materials, with the resulting production of undesirable aldehydes, for example. The burner 27 is supplied with natural gas or other liquid fuel such as methane, propane, or other light carbon liquid or gaseous fuel, natural gas being the preferred fuel for said burner when carrying out the method of the present invention. The temperature of the products of combustion emitted from the lower discharge end 23 of combustion chamber 22 is controlled manually or automatically and is generally relatively high depending upon the vaporization temperature of the related constituents of the material undergoing heat treatment, while the velocity and pressure of the said products of combustion is relatively low and is just sufficient to force the products of combustion downwardly from the discharge end 23 of combustion chamber 22 to the bottom of the continuous downwardly falling curtain so that by the time said products of combustion reach the bottom of the apparatus the pressure and temperature of said products of combustion have been spent, it being obvious that the relatively low pressure does not in any way tend to destroy the continuity of said curtain. Having determined the vaporization temperature of the volatile constituents of the liqueform material to be heat treated in carrying out applicants' method in the apparatus disclosed herein, the desired and effective temperature of the products of combustion emanating from the combustion chamber can be readily determined and controlled. Depending upon the height or "fall" of the curtain, the pressure of the products of combustion can also be readily determined and con-

6

trolled, such pressure being relatively low and only sufficient to cause said products of combustion to traverse the entire height or "fall" of said curtain before said pressure is exhausted.

In that form of the invention shown in FIGS. 1, 2, 3 and 6 of the accompanying drawings, the liqueform material to be heat treated is supplied through an insulated circular fluid supply pipe 28 which preferably consists of two semi-circular portions to which the liqueform material to be heat treated is supplied through pipes 29 which lead from a suitable source of said liqueform material at the desired controlled pressure and temperature and is discharged through each of a plurality of closely adjacent nozzles 30 which are disposed in circumferentially spaced positions throughout the length of the annular pipe 28, or through the continuous annular slot 31 in an annular pipe 32 of the form shown in FIG. 8 of the accompanying drawings. In the showing of FIGS. 1, 2 and 3 there are only shown two nozzles 30 but as clearly shown in FIG. 6 there are a plurality of these nozzles 30 circumferentially spaced throughout the length of the annular pipe 28.

The lower conical portion 13 of vessel 10 constitutes a collection chamber for the liquid non-volatile constituents or concentrate if any resulting from the heat treatment of the liqueform material constituting the continuous downwardly falling curtain. A relatively small amount or portion of said liquid non-volatile constituents or concentrate, if any, is retained in the lower portion of said conical portion 13 and above the discharge opening at the bottom thereof to form a liquid seal to prevent the escape of the products of combustion and other gases from within the vessel 10. A liquid level sight gauge 33 is provided to visually indicate the level of the liquid which forms the liquid seal, and a pressure gauge 34 is also provided to visually indicate the pressure existing within the apparatus. A thermometer 35 is connected to a valve controlled discharge pipe 36 leading from the discharge outlet at the bottom of conical portion 13, said discharge pipe 36 extending upwardly a suitable distance above said outlet to insure that there is contained within conical portion 13 a sufficient amount of concentrate to constitute the liquid seal for said outlet.

The top closure 12 has extending therethrough one or more discharge openings communicating with discharge pipes 37 through which the gases or vapors driven off from the continuous, downwardly falling curtain during the heat treatment operation pass for utilization or subsequent processing, each of which discharge pipes 37 may be provided with a manual or automatic valve to control the passage of said gases or vapors through said pipes. Preferably the body portion 11 is provided with one or more glass covered sight openings 38 through which the operation being performed therein may be readily observed. These sight openings may be constructed as to also function as hand openings through which access may be had to the interior of the vessel 10.

As a modified form of the invention shown in FIGS. 1 and 2, there is shown in FIG. 3 a construction in which the burner 27, combustion chamber 22, and pipe 28, are all mounted on and removable with the top closure member 12, the major portion of the combustion chamber 22 extending upwardly and above said top closure member 12 with the lower conical portion 23 of said combustion chamber 22 extending downwardly

and terminating below said top closure member 12 and slightly below the annular series of discharge nozzles 30. One or more discharge openings 39 extend outwardly from the upper portion of vessel 10 for the discharge of the gases or vapors driven off from the continuously downwardly falling curtain during the heat treatment operation, which gases or vapors pass upwardly in the span existing between the outer surface of said curtain and the inner wall of vessel 10, suitable pipes (not shown) being connected to said openings 39 for conveying the said gases or vapors to places of utilization or for subsequent processing or treatment.

DESCRIPTION OF PREFERRED METHODS OF THE INVENTION

Having thus described the construction of several preferred forms of the apparatus of the present invention, reference will now be made to applicants' method of heat treating liqueform materials to vaporize therefrom the volatile constituents or portions of such constituents therefrom, or to vaporize therefrom the volatile constituents to separate the same from the nonvolatile constituents of the selected liqueform material undergoing heat treatment in said apparatus. If the apparatus is to be used for the generation of steam for heating, power, sterilizing or other purposes, water is supplied to pipes 32 or 28 of the forms shown in FIGS. 8 and 9, respectively, to form the downwardly falling curtain. The temperature of the products of combustion emitted from the combustion chamber 22 is controlled to exceed the vaporization temperature of the water, and the pressure of said products of combustion is so regulated as to be relatively low and only sufficient to cause said products of combustion to traverse the vertical distance between the discharge opening of conical portion 23 of combustion chamber 22 and the surface of the liquid seal in the lower conical portion 13 of the heat treating apparatus before the temperature and pressure are spent and have successfully performed their intended purpose. The water discharged from the bottom of the apparatus and drawn off through pipe 36 has been heated by the products of combustion and may be used whenever hot water is required, or may have added thereto additional water and be recirculated through the apparatus to produce additional steam, which recirculation is continued until the desired amount of steam has been produced. The steam driven off from the downwardly falling curtain passes out of the top discharge pipes 37 and is conveyed to its desired point of use for heating, power, sterilizing, or other purposes.

The apparatus and method of the present invention has particular utility in the production of potable water from saline water, a problem of considerable importance at the present time. When it is desired to accomplish this result, saline water is supplied to fluid distributing pipes 32 and 28 of the forms shown in FIGS. 8 and 9, respectively, to form the downwardly falling curtain. The temperature of the products of combustion emitted from the combustion chamber 22 is controlled to exceed the vaporization temperature of the water, and the pressure of said products of combustion is so regulated as to be relatively low and only sufficient to cause said products of combustion to traverse the vertical distance between the discharge opening of conical portion 23 of combustion chamber 22 and the surface of the liquid seal in the lower conical portion 13 of the

apparatus before the temperature and pressure are spent and have successfully performed their intended purpose. The steam driven off from the downwardly falling curtain as the result of this heat-treating method passes out of the top discharge pipes 37 and is condensed in suitable condensing apparatus to provide the desired potable water, while the non-volatile constituents of the saline water are drawn off at the bottom of the apparatus.

The apparatus and method of the present invention are particularly useful in the treatment of waste sulphite liquors resulting from conventional paper making procedures or in connection with the treatment of pickling liquids employed in the steel industry. When employing the apparatus and method of the present invention in cases where the material to be heat treated and which forms the downwardly falling curtain, the temperature of the products of combustion is so regulated and controlled as to have a temperature sufficiently high to vaporize the volatile constituents of the sulphite liquor, and the pressure of said products of combustion is relatively low and only sufficient to traverse the distance between the discharge opening from the combustion chamber and the surface of the liquid in the bottom of the apparatus which forms the liquid seal in conical portion 13. By this method, the volatile constituents of the sulphite liquor are separated from the non-volatile constituents thereof, and pass out of the apparatus through discharge pipes 37 for utilization or for subsequent processing or treatment, while the non-volatile constituents of the sulphite liquor are drawn off at the bottom of the apparatus and pass through discharge pipe 36 for utilization and re-use of the sulphuric acid contents thereof or for subsequent processing or treatment thereof.

In the preceding paragraphs, there has been disclosed but a few of the many fields of endeavor in which the apparatus and method of the present invention find utility, but the availability and efficiency of said apparatus and method are by no means restricted to the several examples. Such examples, however, are considered to be quite sufficient to convey to anyone reasonably skilled in the art to which the present invention relates, as to the manner in which said apparatus and method may be used and carried out in connection with the heat treatment of various liqueform materials, such as various liquid foods and beverages, various liquid pharmaceutical and chemical solutions, for treatment of liqueform garbage, sewage and the like fluent materials.

Having thus disclosed and described herein several preferred forms of our present method and apparatus, we claim:

1. A method of heat treating liqueform materials to vaporize therefrom volatile constituents thereof which includes the steps of

a. forming without preheating a relatively thin, annular downwardly flowing curtain or predetermined height of said liqueform material within and surrounded by a vertically-positioned vessel having its inner wall spaced outwardly from the outer surface of said curtain to provide a space therebetween, and providing said vessel with a discharge opening at the upper portion thereof in communication with said space, and with a discharge opening at the bottom of said vessel;

b. projecting downwardly within the confines of the lower portion of said curtain and laterally through said curtain throughout the height thereof, the products of combustion from a burner and combustion chamber assembly mounted in the upper portion of said vessel coextensive with the upper portion of said curtain, and discharging the combustion products downwardly below the upper end of the curtain and substantially above the lower end thereof, at a relatively high temperature sufficient to vaporize the volatile constituents of said curtain and at a relatively low pressure just sufficient to cause said products of combustion to traverse the height of said curtain but not to impinge with any substantial velocity upon non-volatile constituents in the bottom of the vessel;

c. discharging the vapors formed from the volatile constituents of said curtain from the space surrounding said curtain and through the discharge opening at the upper portion of said vessel and discharging the non-vaporized remainder of said curtain of said liqueform material through the discharge opening at the bottom of said vessel;

d. retaining a relatively small amount of the unvaporized remainder of said liqueform material in the bottom portion of said vessel above said bottom discharge opening to form a liquid seal above said bottom discharge opening; and

e. insulating the burner and combustion chamber and concentrically spacing the burner and combustion chamber from the curtain to prevent preheating of the liqueform material before it is formed into a curtain.

2. A method as defined in claim 1 including the steps of discharging a flame from the burner at the upper portion of said vessel downwardly into a combustion chamber which depends from the upper portion of said vessel and is provided with a lower discharge opening which terminates below and within the upper portion of the downwardly flowing curtain of liqueform material, and impinging the flame onto a refractory baffle within the lower portion of said combustion chamber extending transversely across a part of the interior of said combustion chamber and above said lower discharge opening thereof to break up said flame into its products of combustion and prevent said flame from projecting into said downwardly flowing curtain of liqueform material.

3. A method as defined in claim 2 including the step of covering the surface of the inner wall of said vessel with a lining material which is immune to the action of acids or other chemicals in liquid or gaseous form and which is not affected by the relatively high temperatures employed in carrying out the vaporization within said vessel of the volatile constituents of the fluent material undergoing heat treatment within said vessel, and supplying along the surface of the lining material on said lower portion of the inner wall of said vessel a downwardly flowing liquid chemical composition which is immune to reaction with the liqueform material undergoing heat treatment within said vessel and which is not affected by acid or other chemicals in liquid or gaseous form or by the high temperatures employed in carrying out the vaporization of the volatile constituents of the liqueform material undergoing heat treatment within said vessel, said downwardly flowing

liquid chemical composition preventing encrustation of solids on the surface covered by the same.

4. An apparatus for heat treating liqueform materials to vaporize volatile constituents therefrom which comprises

- a. a vertically-disposed outer vessel of a predetermined height having a top closure and a bottom closure, said vessel having a gas vapor discharge opening in the upper portion thereof and the bottom closure having a concentrate discharge opening therein;
- b. means in the upper portion of said vessel for forming a downwardly flowing annular curtain of said liqueform material of a predetermined height with the outer surface of said curtain spaced inwardly from the inner wall of said vessel to provide a space therebetween;
- c. a burner centrally spaced from said curtain and mounted on the top closure of said vessel and projecting its products of combustion downwardly within the confines of the lower portion of said curtain of liqueform material and laterally throughout the height thereof to vaporize the volatile constituents of said curtain and force the vapors resulting from said vaporization into the space between the outer surface of said curtain and the inner wall of said vessel to be discharged through the discharge opening at the upper portion of said vessel, the remainder of said curtain consisting of the material not vaporized during the travel of said downwardly flowing curtain from the top portion of the vessel to the bottom thereof, accumulating in the lower portion of said vessel and all but a small portion thereof passing through said discharge opening in the bottom closure of said vessel, the small portion of said unvaporized liqueform material being retained in the lower portion of said vessel and above said discharge opening in the bottom closure of said vessel to form a liquid seal above said discharge opening in said bottom closure, a combustion chamber containing said burner depending from the central portion of the top closure of said vessel, said combustion chamber having a discharge opening at the bottom thereof substantially below the top of said downwardly flowing curtain, and said combustion chamber including a wall surrounding the flame from said burner guiding the products of combustion from said flame downwardly through the discharge opening of said combustion chamber and laterally into and throughout the height of the downwardly flowing curtain of liqueform material, the wall defining said combustion chamber being provided with heat insulating material to prevent the radiation of heat from said burner and combustion chamber into the upper portion of the vessel surrounding said combustion chamber thereby preventing preheating of the liqueform material before it is formed into a curtain.

5. An apparatus as defined in claim 4 in which said combustion chamber has a refractory baffle disposed transversely across a portion thereof and above the discharge opening at the lower end of said combustion chamber upon which baffle the flame from said burner impinges to break up said flame into its products of combustion and to prevent passage of said flame into said downwardly flowing curtain of fluent material,

11

means lining the lower portion of the vessel and means covering the lining on the inner wall of said vessel below the top of said downwardly flowing curtain of liqueform material with an impervious liquid to prevent encrustation of solids on said inner wall, said liquid not being affected by the high temperature employed in

12

carrying out the vaporization of the volatile constituents of the liqueform material undergoing heat treatment within said vessel and being immune to reaction with said fluent material and which is not affected by acids or other chemicals in liquid or gaseous form.

* * * * *

10

15

20

25

30

35

40

45

50

55

60

65