Aug. 6, 1968 E. BECHARD 3,396,088

ROTARY MULTI-COMPARTMENT DISTILLATION DRUM HAVING RADIALLY ADJUSTABLE OUTLET TO VARY THICKNESS OF LIQUID LAYER

Filed April 1, 1964 5 Sheets-Sheet 1

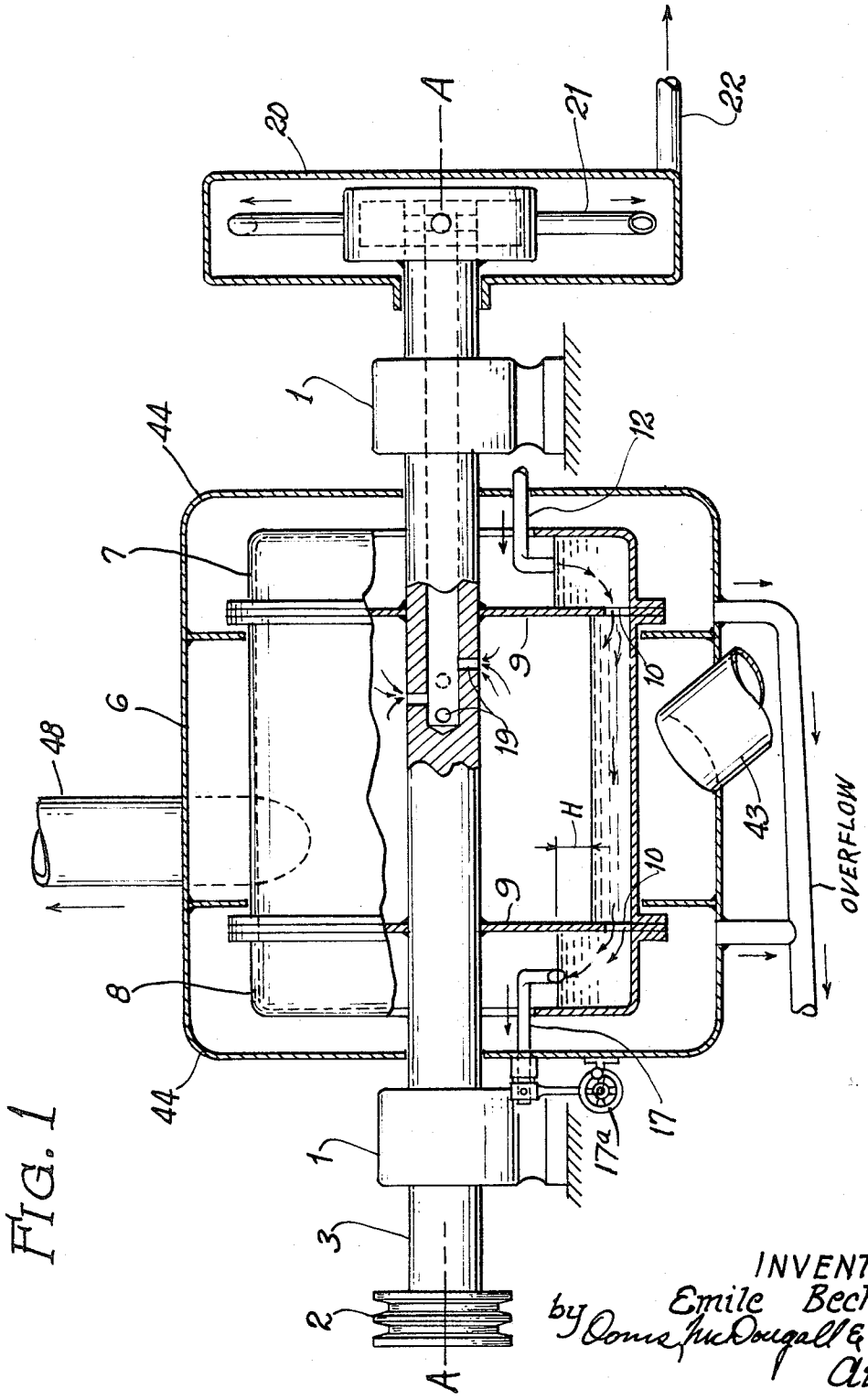


FIG. 1

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FIG. 2

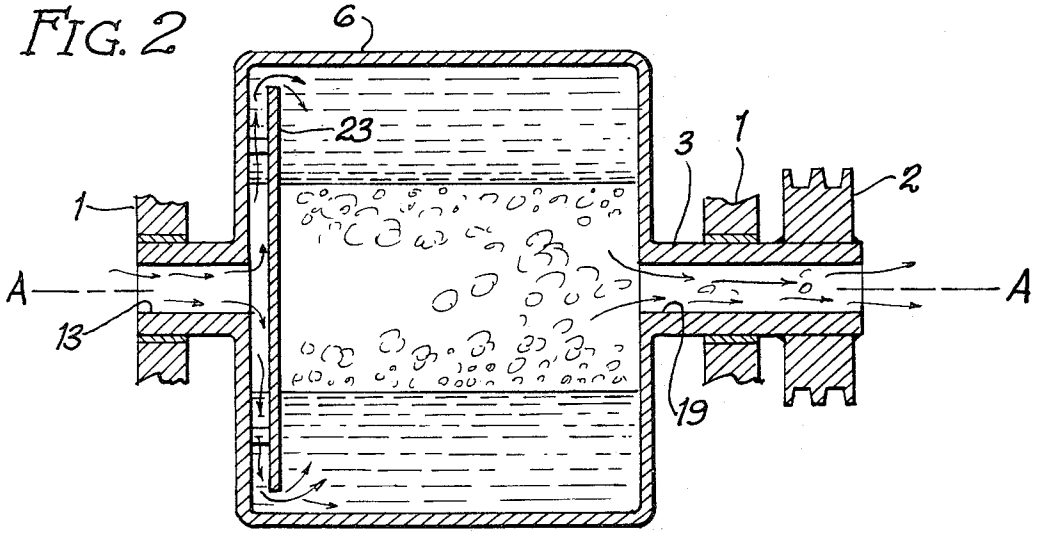


FIG. 3

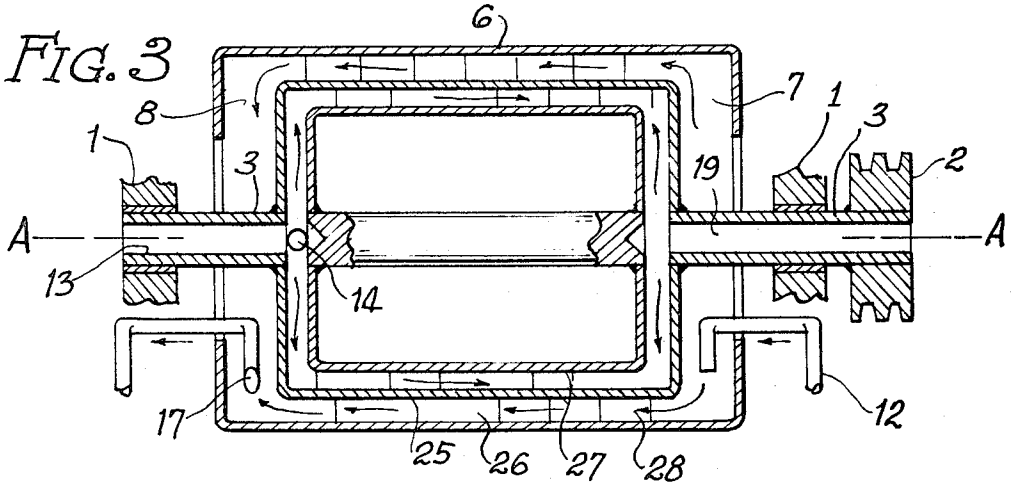


FIG. 4

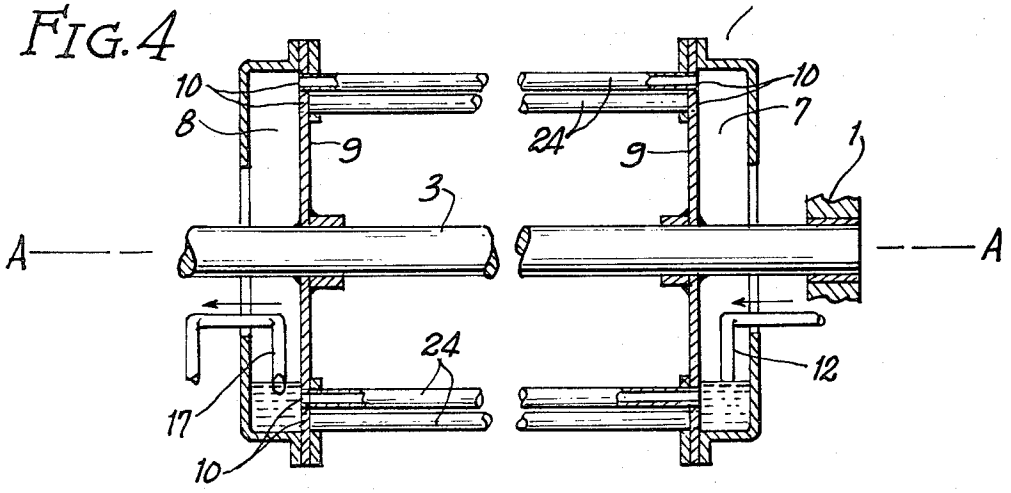


FIG. 5

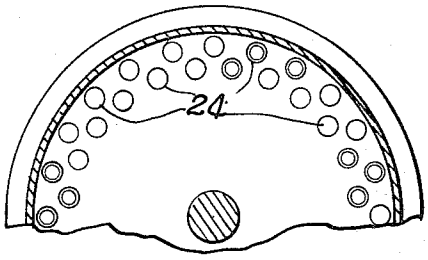


FIG. 6

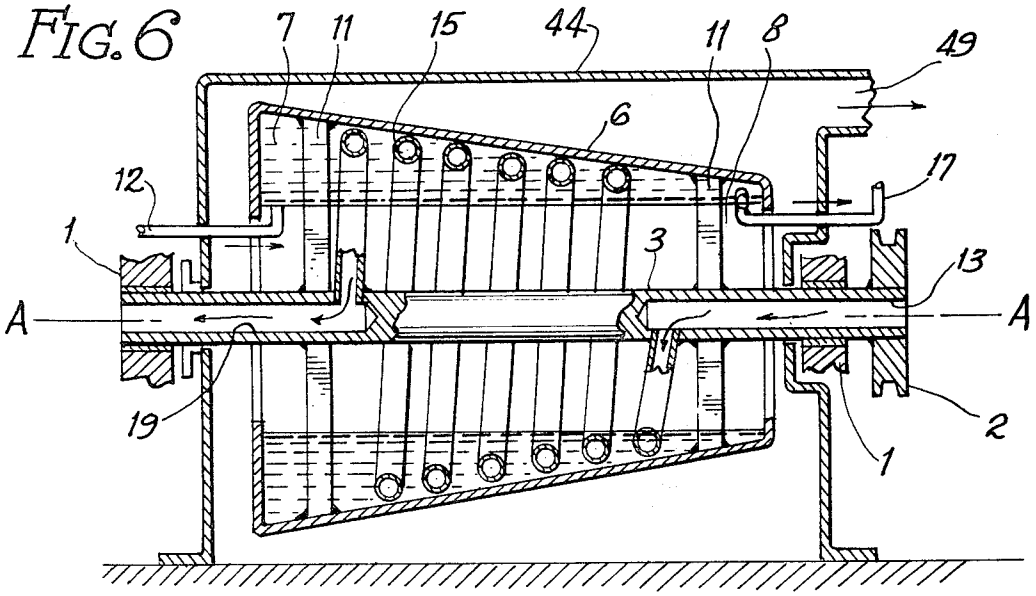
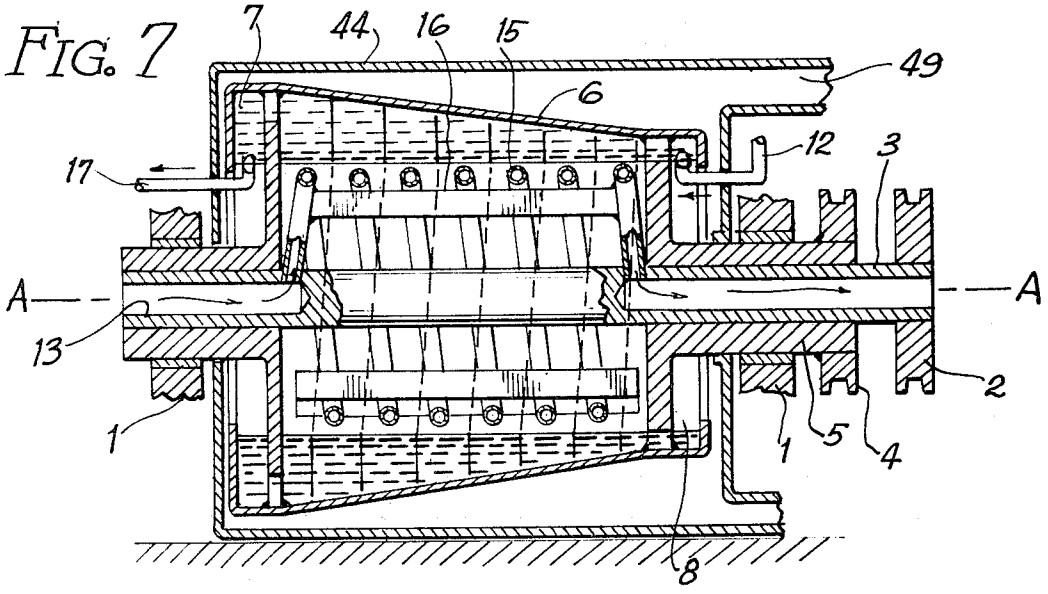


FIG. 7



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ROTARY MULTI-COMPARTMENT DISTILLATION DRUM HAVING RADIALLY ADJUSTABLE OUTLET TO VARY THICKNESS OF LIQUID LAYER

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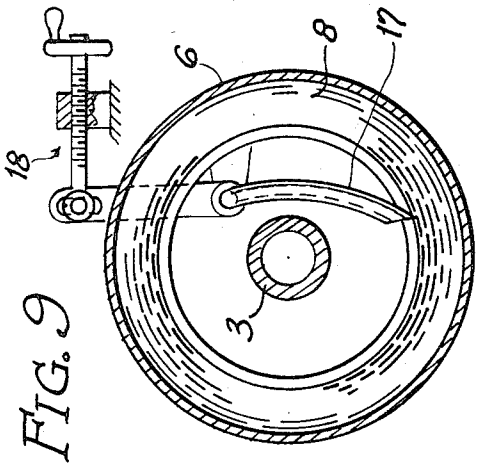


FIG. 9

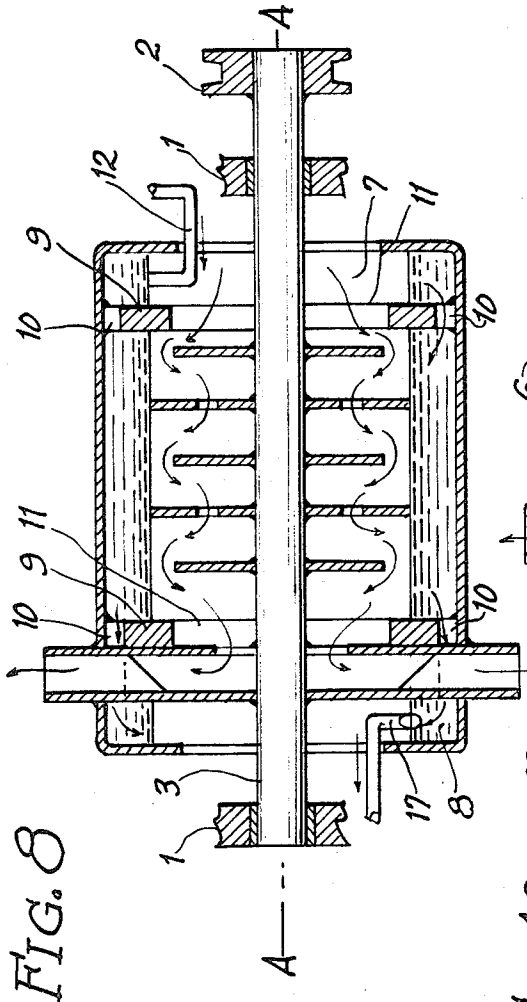


FIG. 8

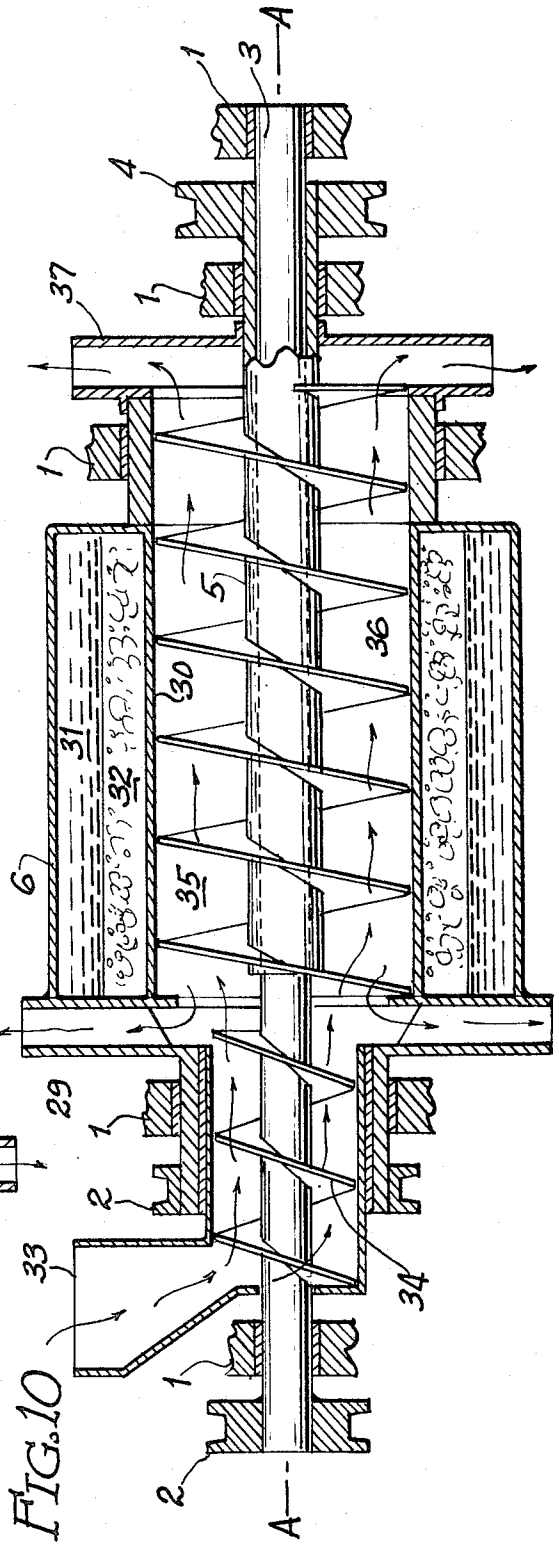
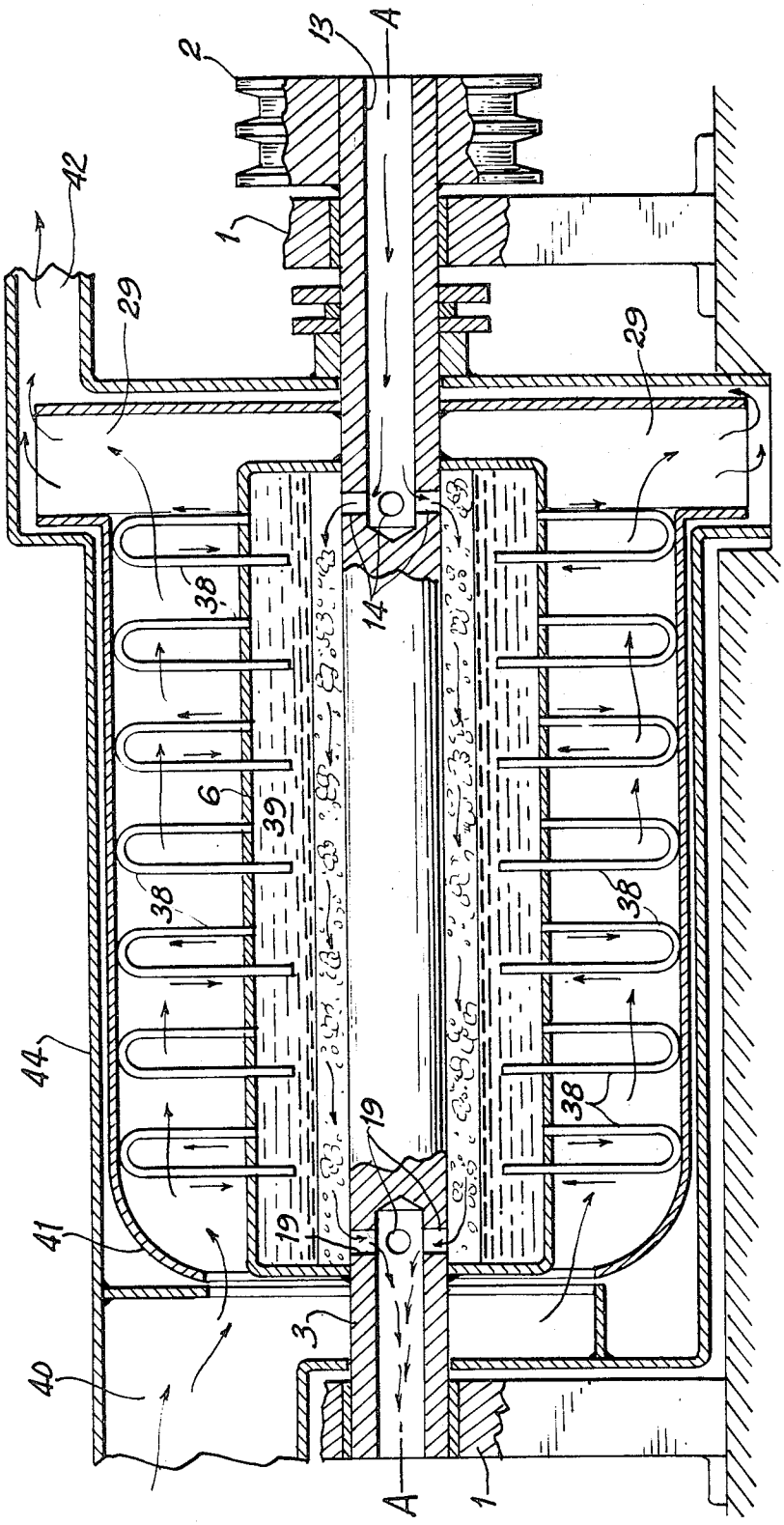


FIG. 10

FIG. 11



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3,396,088

ROTARY MULTI-COMPARTMENT DISTILLATION DRUM HAVING RADIALLY ADJUSTABLE OUTLET TO VARY THICKNESS OF LIQUID LAYER

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4 Claims. (Cl. 202—238)

This invention relates to the treatment of water in such processes as concentration, distillation, condensation and refrigeration, and it relates more particularly to methods and equipment for use in the practice of same.

Whether it is a question of heat exchangers or distillation apparatus, such equipment is usually very large, heavy and cumbersome. In the majority of cases, distillation apparatus requires heating, as by steam made available from a boiler.

If the efficiency of each machine is considered, the total efficiency is poor. For example, an efficiency of 0.70 at the boiler and 0.80 at the concentrator, would give a total efficiency of 0.7×0.8, or 0.56.

In accordance with the present invention, all of the elements are grouped as one whereby a higher efficiency can be achieved. The use of centrifugal force to enhance heat transfer allows for considerable output per unit surface area.

The aggregate of these elements allows for the satisfaction of the various requirements with a minimum amount of floor space and with costs reduced to a minimum insofar as investments and exploitation are concerned.

It is an object of this invention to provide an improved method and means for carrying out such water treatment processes and to provide more efficient and better equipment and method for effecting the same.

These and other objects and advantages of this invention will hereinafter appear, and for purposes of illustration, but not of limitation, an embodiment of the invention is shown in the accompanying drawings, in which—

FIG. 1 is a schematic sectional view taken crosswise through the center of apparatus embodying features of this invention showing the operating principles of a centrifugal concentrator, a regulator and control for the filling operation;

FIG. 2 is a schematic sectional view of a portion of the apparatus used for large volumes of liquid and vapor, as needed when substantial supplies thereof are alternately required;

FIG. 3 is a schematic sectional view showing a lamellar exchanger adapted to be heated or cooled by an auxiliary liquid;

FIG. 4 is a schematic sectional view of a portion of the equipment shown in FIG. 1 but in which the annular body is replaced by a group of pipes;

FIG. 5 is a sectional view taken crosswise through a half section of the apparatus shown in FIG. 4;

FIG. 6 is a schematic sectional view showing a heat exchanger with a spiral group of pipes positioned adjacent the inner surface of the apparatus and immersed in the liquid;

FIG. 7 is a sectional elevational view similar to that of FIG. 6 but showing a modification thereof with spiral pipes mounted tangential to the liquid to be heated or cooled;

FIG. 8 is a schematic sectional view of an exchanger in which one of the fluids is a vapor, air or gas adapted to circulate freely on the surfaces of the liquid to be heated, cooled or evaporated;

FIG. 9 is a schematic sectional view showing the use

of a syphon or ladle to extract the treated or surplus liquids while in motion;

FIG. 10 is a schematic sectional view which, in the upper portion, shows the principle of an exchanger with a padding or thermal insulation to exclude the risks of localized heat, especially in concentrating viscous materials which are sensitive to temperature variations and which, in the lower portion, shows a conical bowl containing a reverse of material to be treated; and

FIG. 11 is a schematic sectional view showing an embodiment of the invention in methodic circulation of the heating and cooling gases and the circulation of the liquids to be heated, vaporized or cooled.

These figures are not restrictive, especially not as to dimensions, and in certain cases they may be combined. For example, one device will produce a fluid, another will use it and a third will make an inverse thermal exchange, by condensing a vapor or by cooling a liquid.

In the same way, all materials, metals or compatible substances, with the pressures, temperatures, the aggressivity of the products or the mechanical resistances, may be used.

Finally, the communicating gear may be any of the known methods, mechanical, thermal or electrical, by belts, chains or grooved pulleys.

Description

To obtain the centrifugal force used to accelerate the thermal exchanges or to localize them, all these embodiments revolve about an axis A—A, supported by ball or roller bearings, or pads **1**.

They are activated by pulleys **2** mounted on the central shafts **3** for the single rotation machines, and by pulleys **4** mounted on the encased shafts **5** for the machines having two concentric rotational elements.

All these machines include a bowl, drum or rotor, generally designated **6**, and which comprise a rotatable sleeve **3** or **5** depending on the process to be used.

This principal element **6** is often supplemented by the annular chamber **7** on the intake side for the product to be treated and a chamber **8** on the outlet side for the products of liquids that have been treated.

The drum or rotor **6**, as illustrated in FIG. 1, comprises annular chambers **7** and **8**, as provided by the discs **9** for integration with the driving shaft. These discs are drilled with holes **10** for the communication between these elements. In certain cases, the discs are replaced by arms **11** as shown in FIG. 6.

The arrival of the liquids to be treated is effected by a pipe **12** when the feed is natural, without pressure. Instead the liquid can be fed through a drilling **13** in the shaft **3** and by the interposition of a stuffing box for the feed of liquids under pressure. These drillings communicate with the intake chamber or thermal exchange chambers by the orifices **14**.

In installations containing one or more coils **15**, these drillings on the shaft communicate with the one or more coils. When such coils are not applied to the inner wall of the bowl, they are supported by squirrel cage bars **16**.

The extraction of the heated, cooled, or concentrated liquid is made by the syphons or ladles **17** fixed or adjustable by screws and steering wheels **17***a* when under pressure **18**, or by the drillings **19** and the interposition of the stuffing box for an outlet under pressure. If there is a need to produce a vapor at a pressure higher than that of the atmosphere, it may be received in a casing **20**, and its outlet may be facilitated by extractor pipes **21**, then directed to other utilizations or treatments by the pipe **22**.

In the exchangers with large volumes of liquids and vapor, so as not to disturb the exchanges in course, the

liquid to be treated is admitted in a circular sheet, formed by the interposition of a disc **23**.

In the embodiments with groups of pipes parallel to the axis, or spiral, these pipes **24** are encased, expanded or set onto the plate **9**. In these embcdiments, the flames or heated gases pass across the group of pipes, thus increasing the exchange surfaces.

In the lamellar embodiments, the arrangement includes an intermediate drum **25** forming a circular space **26** with **6**, in which the heating or cooling liquid circulates. The surplus inside volume is filled by a drum **27** leaving between **25** a sheet of liquid **28** which will rapidly circulate, in any case with the least inertia that could come from a large volume.

The submerged pipes **15** tangential to the drum **6** allow the instantaneous heating of all the volume in the course of treatment, on the other hand, in the arrangements with the pipes tangential to the liquid, supported by the bars **16**, only the inside surface of the top of the liquid is heated, thus bringing no thermal modification to the mass of the liquid in the course of treatment.

In the equipments that use a vapor, a gas or air, these elements, after having fulfilled their functions, being saturated, are extracted by an aspirating device **29**.

To create a thermal padding so as to avoid all local thermal charges, temperature excesses, etc., the liquid ring is contained between the bowl **6** and the bowl **30** on the inside at **6** and between the two is predetermined quantity of liquid of easy evaporation, water for example, which will produce a vapor **32**.

For semi-liquid or viscous products, the inlet will be effected by a funnel **33**. They will be regularly advanced by a screw **34** which will lead them into the treating chamber **35**. In this chamber a screw **36** revolves slowly which advances the products in proportion as the liquid that they contained is vaporized, extracted by **29**, whereas the products are extracted by **37**.

To achieve rigorously methodic thermal exchange, that is to say, counter current, in which the heated fluid circulates in the opposite direction to the cold fluid, so as to maintain constant the maximum divergence between them, on the collector, rotor, bowl or drum, pipes are mounted, called hairpin pipes **38**.

The arm on the inlet side of the liquid does not pass beyond the interior of the thickness of the collector **6**. The other arm, that on the outlet side of the heated fluid, on the other hand, continues through to the interior of the liquid layer **39**. The heated liquid or formed vapor will escape by means of the passages **19**, to be directed to its use, passing through the fixed piping by means of a conventional stuffing box.

As far as the flames or the heated gas are concerned, which are admitted at **40**, they go through to the revolving chamber **41**, which revolves with the rotor **6** and the pipes **38** avoids whirls. Thus the gasses circulate freely to leave at **42**, aspirated by the ventilator **32**.

This invention can use all known types of heating, solid (wood or coal) in a fire set under the bowl, rotor or drum, by gas or liquid fuels **43** from which the flames are directly projected onto the revolving sections, which run no risk of burning, on account of the continual movement in front of the flame.

To retain the hot gases around the exchange elements, the latter is enclosed in a casing or housing **44**.

In the cases when electrical heating is being used, the electrical resistance **45** is submerged in the liquid to be heated, or supported by the squirrel cage bars when the heating should be made on the inside layer of the liquid **46**.

If heating by infra-red rays is used, the lamps **47** are mounted in segments or rings around the elements to be heated, which revolves in the center.

The residual heating gases, the saturated air or vapors are ejected into the open air through the chimney **48**.

When it is a question of recuperating distillation gases

and eventually condensing them, they leave by the tube **49** which can be connected to an apparatus "in vacuo" or a condenser.

The ribs with their developed surfaces, have the advantage, under an equal volume, of being able to increase the exchange surfaces between the metal and the gases or liquids.

The ribs parallel to the axis, or in appropriately oriented spirals, have the advantage of being able to facilitate a progessive advance in the direction of the methodic exchanges; the radial ribs, on the other hand, circular in shape, on the inside or the outside, would stabilize between each circle, forming as many circular rings, which in certain cases would be deterimental to the circulation of the liquids or gases, but which in other cases allows a selection of the produced vapor.

In nearly all these embodiments having the same aim, to concentrate, to distill, to condense or to cool, the most important part is in maintaining a constant level in the bowl, rotor or drum while assuring the distribution of the evaporated liquids, that is to say, assuring a supply as a function of the liquid given off in the form of vapors.

Operation

It is known and has been demonstrated that the density of a liquid, vapor or gas, varies with the temperature because of the increase or dilation of a given weight, or because of its contraction or reduction in volume.

If D is equal to the density of a liquid at rest, water for instance at 10 C. or D equals 0.99907, and *d* the density at 110 C=0.951, the density has diminished from D to *d*—0.99907 to 0.951=0.4807.

If water at 10 C. is placed in a rotor with a diameter of 0.5 meter, turning at 1,000 revolutions per minute, it will be subject to an acceleration of which the vapor B is given by the simplified formula

$$B-12\times 0.5\times(1{,}000/100)^2$$

that is 56, thus a weight of one kilogram on balance will effect a pull of 56 kilograms at its center of gravity, if it turns at a speed of 1000 revolutions per minute, on a radius of 0.50 meter, that is at a distance of 0.5 meter from the axis.

By applying this coefficient 56 to the differences in density, they successively become $0.99907\times 56=55.94792$, and $0.951\times 56=53.256$, that is a difference of

$$55.94792-53.256=2.69192$$

It is easily understood and admitted, and experience has shown it to be so, that with a difference of centrifugal density of 2.69192, the water will separate itself in function of its density, the hottest at the center, and the coldest at the inside circumference of the rotor, bowl or drum.

If he heat does not act on the bowl, rotor or drum, the liquid has no relative radial movement between the inside layer and the inside of the casing.

If, on the other hand, the casing **6** is heated, whatever the source of heat, the water for example that is in contact with the outside casing will become lighter proportionally to the heat received, its density will diminish; this diminution multiplied by the coefficient *B*—56 in the above example will cause such a lightening that it will come rapidly nearer to the center, giving place to colder water, whence an accelerated convection. This accelerated convection allows the obtaining of very considerable thermal exchanges per surface unit.

Another phenomenon improves the production, the suppression of the film, called the contact which disturbs the exchanges, the liquids being bad conductors.

In the present invention the elements **6**, **7** and **8** form an aggregate of three compartments revolving together, separated by the partitions **9** but communicating between themselves by the orifices **10** placed as near as possible to the outside.

The water taken into **12** will be distributed in the rim (crown) if the aggregate revolves until the level is

limited by the syphon or ladle **17**. From that moment the level will be stable, regulated by the shoe **52** and the surplus extracted by **17**.

As long as the heating does not intervene, there will be no change of movement in the liquid.

The lighting of the burner **43** will cause a rise in temperature of the water contained in the central body **6**. The rise in temperature will cause a formation of vapor, which before escaping at **19** will be transformed by an elevation of pressure in the body **6**; this pressure will be balanced by the centrifugal force, acting on the water contained in the bodies **7** and **8**, which stay at atmospheric pressure.

The pressure of the vapor will cause a difference of level H in centrifugal value, that is under pressure $B \times H \times R \times d$, this being per square centimeter, the center of gravity of this column being H/a, the distance R being the radius of rotation of this liquid column, the density being expressed in kilograms per cubic centimeter.

This contribution of heat which will make the liquid lighter on contact with the heated wall, will force it closer to the center with a speed increased by the acceleration B, a colder liquid will take its place, whence the accelerated convection.

The effects of centrifugal force on the thermal exchanges may be strictly and rigorously controlled locally by the use of pipes **15** or concentric drums **60**, **25**, **27**, which bring liquids to different temperatures causing the exchanges.

The terminal compartments **7** and **8** being in relation with the atmospheric pressure, this type of exchanger is strictly explosion-proof. In fact a sudden or abnormal excess of pressure in compartment **6** will force the liquids from compartments **7** and **8**, thanks to the free passages **10**.

In the case of the slowing down of the speed of rotation, the centrifugal force diminishes and at the same time so does the pressure in compartment **6**.

In the case of the machine stopping, at least half of the passages **10** are immediately in contact with the atmosphere.

In the case of stoppage of the supply of the liquid to be heated or evaporated, the pressure diminishes at the same time as the thickness of the liquid rim (crown) to be eliminated when the passages **10** are opened.

Heating without a liquid presents no danger on account of the rotation which assures distribution by avoiding burnouts

When the principle is used to concentrate, to distill or to dry liquids containing solid elements, that may be centifuged, it is necessary to remove and to extract these elements before they can form a layer or crust struck to the inside of the bowl **6**, isolating and risking burnouts; this removal is assured by the screws **34** and **35**, to be evacuated, concentrated or dried by the centrifugal extractor **37** when the evaporated liquid is extracted by the ventilator **29**.

For products that are fragile and sensitive to heat, the liquid padding **31** is used, whose vapor **32** heats the cylinder **30**.

As the vapor **32** cools, giving up its heat, it becomes heavier, even condenses and returns to a liquid state **31**, thus forming a cycle having a great regularity, hence the slight temperature variations.

It will be understood that changes may be made in the details of construction, arrangement and operation without departing from the spirit of the invention, especially as defined in the following claims.

I claim:

1. A device for the treatment of a liquid comprising a drum mounted for rotational movement about a horizontal axis, means for rapidly rotating the drum about its axis at a rate sufficient to generate centrifugal force greater than that of gravity, a pair of axially spaced radially extending partitioning members secured for rotation with said drum and subdividing the drum into a central compartment and outer compartments on each side of the central compartment and openings in the partitioning members adjacent the peripheral surfaces of the drum whereby the central compartment communicates with each of the outer compartments, a stationary inlet extending into one of the outer compartments for introduction of liquid to be treated, a stationary outlet extending into the other of the outer compartments with means for radial adjustment of the outlet for adjusting the thickness of the layer of liquid retained on the peripheral surfaces of the compartments during rotational movement of the drum, vapor outlet conduit means in communication with the interior of the central compartment inwardly of the liquid level during rotational movement of the drum and extending axially within the compartments for drawing off vapors given off by the liquid in the drum, and means for heating the peripheral surface of the central compartment whereby, during rotational movement of the drum, the layer of the liquid on the peripheral surface of the drum having a thickness at least as great as the radial height of the openings communicating the drums will separate in response to gravity with the heavier and colder liquid adjacent the outer peripheral surfaces of the drum and the lighter and hotter liquid at the interior surfaces of the liquid layer for release of vapors at the interior of the drum to be taken off through said outlet means.

2. A device as claimed in claim **1** in which the vapor outlet means comprises a hollow axial shaft, openings in the shaft communicating the interior of the drum with the interior of the shaft and means communicating with an end portion of the shaft beyond the drum for removal of vapors from the shaft.

3. A device as claimed in claim **1** which includes a stationary casing enclosing the drum for the circulation of heat exchange gases and fluids therethrough in heat exchange relationship with the periphery of the drum.

4. A device as claimed in claim **1** which includes baffles in the form of disc members axially spaced apart within the central compartment, alternating disc members being dimensioned to have a radius greater than the others with the disc members of larger radius extending into the wall of liquid with the disc members of shorter radius terminating short of the wall of liquid, and openings in the disc members of larger radius short of the wall of liquid whereby vapor directed axially through the interior of the drum passes therethrough in a sinuous path about the ends of the smaller disc members and through the openings in the larger disc members.

References Cited

UNITED STATES PATENTS

2,220,171	11/1940	Noaillon	202—238
2,493,220	1/1950	Bibby	202—236
2,894,879	7/1959	Hickman	202—236 X
2,999,796	9/1961	Bromley	202—236
3,136,707	6/1964	Hickman	202—236
3,163,587	12/1964	Champeo	202—236 X
3,200,051	8/1965	Silvern	202—236
1,501,515	7/1924	Testrup	202—236 X
1,748,178	2/1930	Hume	159—11 X
1,795,495	3/1931	Lavett	159—11 X

FOREIGN PATENTS

940,896	12/1948	France.
72,838	7/1953	Netherlands.

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