May 27, 1958 M. M. KOFFLER 2,836,235

VACUUM CONCENTRATOR FOR JUICES OR THE LIKE

Filed Jan. 10, 1956 2 Sheets-Sheet 1

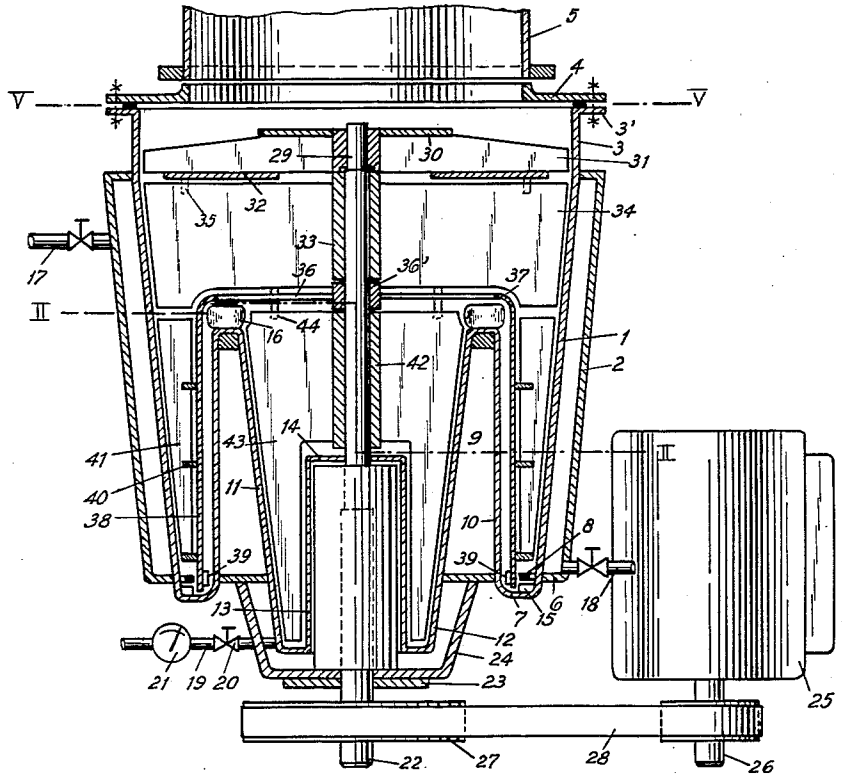

FIG. 1.

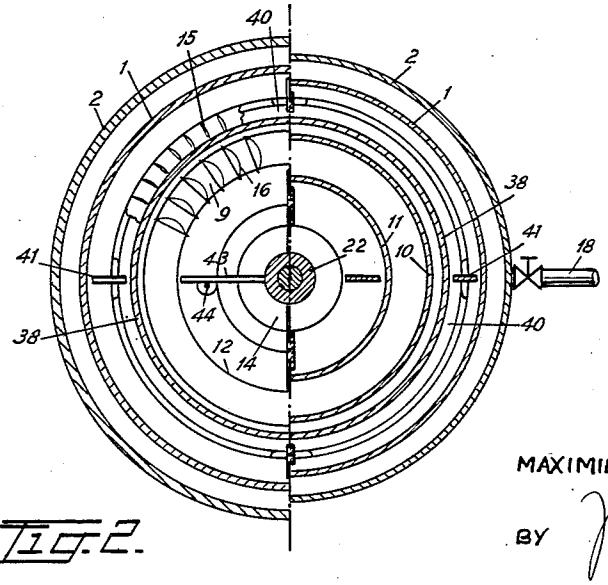

FIG. 2.

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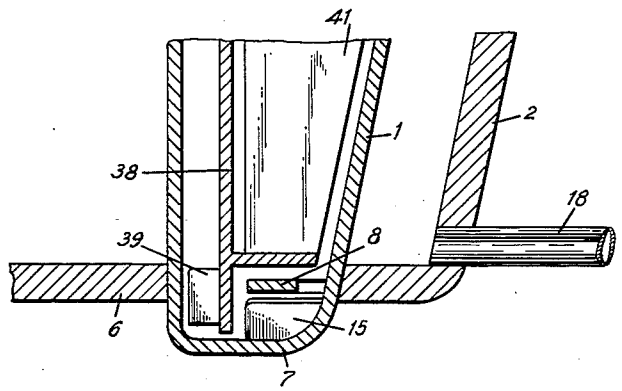

Fig. 3.

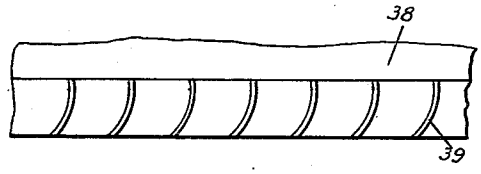

Fig. 4.

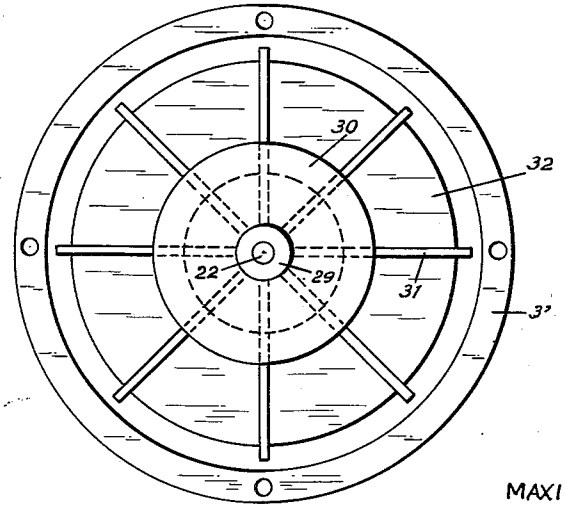

Fig. 5.

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VACUUM CONCENTRATOR FOR JUICES OR THE LIKE

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Application January 10, 1956, Serial No. 558,377

Claims priority, application Israel July 15, 1955

1 Claim. (Cl. 159—6)

This invention relates to a vacuum concentrator for liquids, in particular citrus juices.

The chief drawback of the known concentrators is their low efficiency, as they require relatively large heat exchanging surfaces per unit quantity of the water content removed per unit of time. Because of this fact, the known concentrators are comparatively large, expensive to produce and to install, and inconvenient to handle.

With a view to providing a higher efficiency, the concentrator according to the invention includes an odd number of upright heat exchanging surfaces of circular cross-section disposed coaxially within each other, the first one forming the inner wall of an outermost heat exchanger, the other forming the outer and inner walls, respectively, of coaxial inner heat exchangers, and means for producing the flow of the liquid as a thin film in succession down the first surface, and up and down the outer and inner surfaces of the inner heat exchangers, toward the bottom zone of the inner surface of the innermost heat exchanger.

The inner heating surfaces of the heat exchangers may slope toward their axis so that the downward flow of the liquid is slowed down along these heating surfaces.

It is preferred to provide substantially radial blades revolving about the axis of the concentrator and having their outer edges disposed parallel to the inner heating surfaces of the heat exchangers at a small distance therefrom. These blades serve on the one hand to throw the liquid, fed into the top part of the concentrator, centrifugally towards the inner heating surface of the outer heat exchanger. On the other hand they remove from said heating surfaces the liquid exceeding a certain depth of the layer or film covering the surfaces. In doing so they inpart to the downwards flowing liquid a lateral motion which is preferably rectified by baffles or the like in the transition between the heat exchangers.

While the liquid flows by gravity down the inner heating surfaces of the heat exchangers, its flow up the outer heating surfaces of the inner heat exchangers must be produced positively. By a particular feature of the invention this may be done by means of a rotating sleeve surrounding the inner heat exchanger or one such sleeve for each inner heat exchanger, and dipping with its bottom edge into the liquid collecting at the bottom of the inner surface of the preceding heat exchanger, e. g. in a trough there located. This sleeve is provided on its inner face with vanes imparting to the liquid a spiral upward movement by centrifugal action. The vanes need not extend over the full height of the sleeve but may be confined to the bottom zone thereof.

Of course, other pumping means may be used instead, e. g. piston pumps so disposed as to deliver the liquid in upward direction along the outer surfaces of the inner heat exchanger.

Baffles similar to those provided in the transition between the heat exchangers may also be disposed on the top of the inner heat exchangers in order to right the flow of the liquid before this starts flowing down along the inner surfaces of the inner heat exchangers. Both groups of baffles are suitably disposed in radial positions, or at small angles from the radii of the concentrator.

Where the concentrator according to the invention is used for single-stage operation, it is provided with a conventional hood which is connected to a vacuum duct and which may enclose foam baffles or the like means preventing liquid to be carried off by the escaping vapours. Where the apparatus is used as a second-stage concentrator it may be mounted directly at the bottom end of the first-stage concentrator.

The invention is illustrated, by way of example only, in the accompanying drawings in which:

Fig. 1 is an axial section of a vacuum concentrator according to the invention;

Fig. 2 is a horizontal section thereof on line II—II;

Fig. 3 shows a detail of Fig. 1 in vertical section on a larger scale;

Fig. 4 is a detail in evolution;

Fig. 5 is a horizontal section on line V—V of Fig. 1.

The concentrator here illustrated comprises a heat exchanger 1 of inverted frustoconical shape disposed within a jacket 2 of similar shape. The upper part 3 of the heat exchanger 1 is substantially cylindrical and projects upwards out of the jacket 2. Its flanged upper edge 3' is secured to the bottom flange 4 of a cylindrical body 5 which may be either a hood connected to a vacuum duct, or the bottom part of another concentrator in which a first concentrating stage is performed and to which the concentrator according to the invention is connected in cascade. The connection between the heat exchanger 1 and the hood or other concentrator 5 may be modified in any suitable manner, and in particular the heat exchanger may be hingedly connected to the body 4 so that it can be swung open. The bottom end of the heat exchanger 1 merges through the bottom into an annular trough 7 below the bottom 6 of the concentrator. This bottom 6 in its turn merges into the jacket 2. The trough is covered by an annular lid 8 extending over a part of the width of the trough.

Co-axially disposed within the heat exchanger 1 is a second heat exchanger 9 which is also secured to the bottom 6 of the concentrator. This is an annular body of about trapezoidal cross section whose outer side 10 and inner side 11 both serve as heat exchanging surfaces. The outer side 10 is substantially vertical and merges into the trough 7. The inner side 11 slants downwards into a pit 12. The inner wall of the pit 12 is formed by a cylindrical body 13 whose top wall 14 has a central aperture.

Within the trough 7 there are disposed a number of baffles 15 which may be substantially radial or include relatively small angles with the radii. These serve for rectifying the flow of the liquid which flows down along the inner side of the outer heat exchanger 1 and in doing so is also given a circumferential motion. Similarly, a number of baffles 16 are disposed in radial or near radial positions on the top of the inner heat exchanger 9.

The jacket space surrounding the outer heat exchanger has an inlet 17 and outlet 18 for a heating fluid, e. g. steam under pressure. A similar inlet and outlet (not shown) are provided for the inner heat exchanger 9. The latter may be connected in series with the outer heat exchanger, or it may be supplied with heating fluid independently of the latter.

To the pit 12 an outlet 19 with control valve 20 is connected. A refractometer 21 is provided in the outlet 19. Its indications are a measure of the degree of concentration of the outgoing liquid. If this is not yet sufficiently concentrated it can be recycled into the concentrator.

A shaft **22** is journalled in suitable bearings of which one is disposed in a plate **23** at the bottom of a pit **24** joined to the bottom **6** of the apparatus, while at least one other bearing is disposed at any suitable place above or below the former, e. g. in the top wall **14** of the cylindrical body **13**. The shaft is rotated by a motor **25** whose shaft **26** is connected to a pulley **27** on shaft **22** by a transmission belt **28**.

In the chamber within the cylindrical part **3** of the heat exchanger **1**, a hub **29** is keyed on shaft **22**. This hub carries a distribution plate **30**, a number of radial blades **31**—eight in this example—and an annular distribution plate **32**.

Beneath the hub **29**, another hub **33** is keyed on shaft **22**. This carries a number of radial blades **34**—four in this example—disposed in vertical register with alternating blades **31**, with which they may be connected by means of pins **35** welded to the lower parts of blades **31** and engaging in lateral lugs of blades **34**. The outer edges of blades **34** are parallel and in close proximity to the inner side of the surface **1**, with a gap of, say, 2 mm. or even less.

Immediately below the hub **33**, radial arms or spikes **36** are secured to a hub **36'** keyed to the shaft **22**. To their ends there is fixed the upper, inwards rimmed edge **37** of a sleeve **38** which surrounds the inner heat exchanger **9**. The bottom edge of the sleeve **38** dips into the trough **7** past the lid **8** of the latter and carries on its inner face a plurality of vanes **39**. These vanes are slightly curved, as shown in Fig. 4. The sleeve **38** serves as a centrifugal pump which, by means of the vanes **39**, takes up the liquid collecting in the trough **7** and delivers it upwards along the outer face **10** of the heat exchanger **9** and past the top of the latter. The sleeve **38** is structurally reinforced by outer annular ribs or flanges **40** which also serve for the support of radial blades **41**. The latter are in vertical register with the outer parts of blades **34**, and their outer edges are continuations of those of blades **34**.

Below the arms **36** another hub **42** is keyed on the shaft **22**. This carries radial blades **43** in vertical register with the inner parts of blades **34** to which they may be secured by means of pins **44** welded to the lower part of blades **34** and engaging in lateral lugs of blades **43**.

The concentration of liquids by means of this apparatus proceeds as follows:

While shaft **22** is rotating with a relative high speed, say 250 R. P. M., fresh or pre-concentrated liquid is delivered onto the plate **30**. It is disintegrated into a fine spray which is centrifugally thrown towards the surface **3**. The part of the liquid which does not reach the wall **3** drops onto the plate **32** and is delivered to the surface **3** by the revolving plate **32** in cooperation of the blades **31**.

The liquid flows down along the surfaces **3** and **1** and is heated indirectly by the heating fluid streaming through the jacket space **2**. As the liquid flows down it is reduced to a thin film by the blades **34** and **41** which act both as fans and as scrapers. The blades impart to the liquid a lateral motion. When the liquid reaches the trough **7**, the sideward component of its movement is suppressed by the baffles **15**.

From the trough **7**, the liquid is taken up by the vanes **39** of sleeve **38** and, with a spiral movement, is thrown upwards along the outer surface **10** of the inner heat exchanger **9**. On reaching the top it is directed inwards by the rim **37** of the sleeve **38**, and its flow is straightened by the baffles **16**. Thereafter it descends in a straight and quiet flow along the inner surface **11** of the inner heat exchanger, in order finally to collect in the pit **12** whence it is drained off through the conduit **19**.

Where a higher number of heat exchangers is provided, say three, with altogether five heat exchanging surfaces, the general design of the blades and rotary sleeves may be analogous with still higher numbers of heat exchangers, the mechanical difficulties become so great as to outweigh the advantages.

The concentrator according to the invention has been found to allow of great compactness with a large output, with a high evaporating efficiency. Its extremely simple design makes its manufacture inexpensive and its cleaning and maintenance simple.

I claim:

A vacuum concentrator for liquids, comprising in combination: three upright coaxial heat exchanging surfaces of circular cross-section, of which the outermost and innermost ones are inverted-conical, the outermost one forms the inner wall of an outer heat exchanger, the two others form the outer and inner wall, respectively, of an inner heat exchanger; means for substantially uniformly distributing liquid to be concentrated over the top zone of the outermost heat exchanging surface; an annular trough in the bottom region between the two heat exchangers for collecting the liquid flowing off the outermost heat exchanging surface, a trough for collecting the concentrate flowing off the innermost heat exchanging surface, and means for withdrawing the concentrate from this collecting trough; substantially radial blades mounted on a rotary shaft disposed in the axis of the heat exchangers with their outer edges parallel to the inner surfaces of both heat exchangers, respectively, at a small distance therefrom, and being adapted to move peripherally and to reduce to a thin film the liquid layer flowing down along these surfaces; a cylindrical sleeve secured to said shaft, said sleeve being rimmed inwards and open at its top and surrounding the inner heat exchanger at a small distance therefrom and having on its inner surface, within said annular trough, vanes adapted to take up the liquid from the trough and to deliver it upwards on to the top of the inner heat exchanger; and baffles in the annular trough the heat exchangers and on top of the inner heat exchanger for rectifying the flow of the liquid and suppressing peripheral movement thereof.

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