United States Patent

Widmer

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[54] **WIPED THIN FILM EVAPORATION AND TREATMENT APPARATUS**

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March 21, 1969 Switzerland 4281/69

[52] **U.S. Cl.** ..... **159/6 W,** 159/49

[51] **Int. Cl.** **B01d 1/22**

[58] **Field of Search** ..... 159/6, 6 W, 49; 202/236; 203/89

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[57] **ABSTRACT**

A thin film treatment apparatus, especially for treatment of viscous materials, which is of the type comprising a rotationally symmetrical treatment chamber which is surrounded by a heating- or cooling jacket and which contains a rotor. The rotor is equipped with material conveying means which are inclined with respect to the axis of rotation of the rotor. Further, the rotor is provided with wiper means which extend generally axially and are arranged in offset fashion with respect to the conveying means in the peripheral or circumferential direction. According to an important aspect of the invention, the conveying means are formed of a plurality of vane stubs arranged in at least one axial row, wherein the confronting ends of neighboring vane stubs, viewed in the axial direction, are spaced from one another and, in each instance, form a gap. Further, the wiper means are offset in trailing fashion with respect to the row of vane stubs through an angle less than 90° in the direction of rotation of the rotor and at least partially bridge/or overlie the gap between neighboring vane stubs.

9 Claims, 5 Drawing Figures

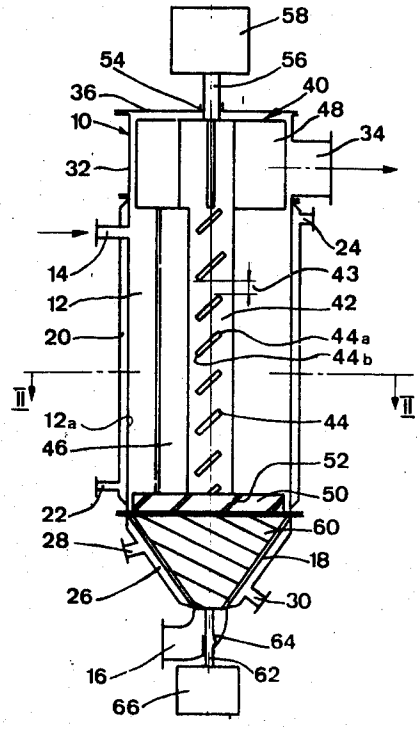


Fig.1

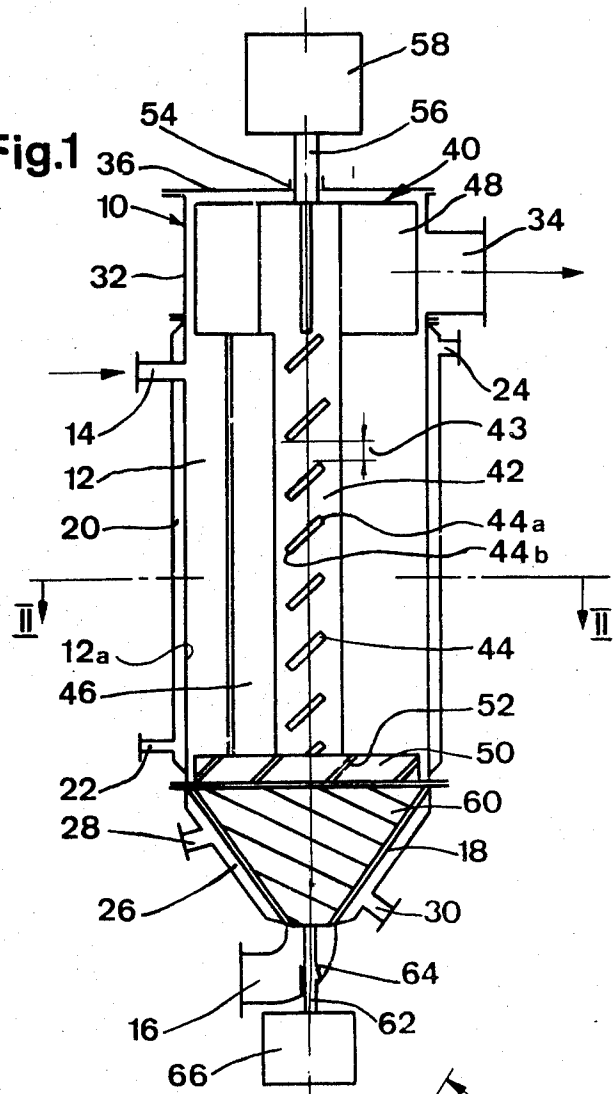
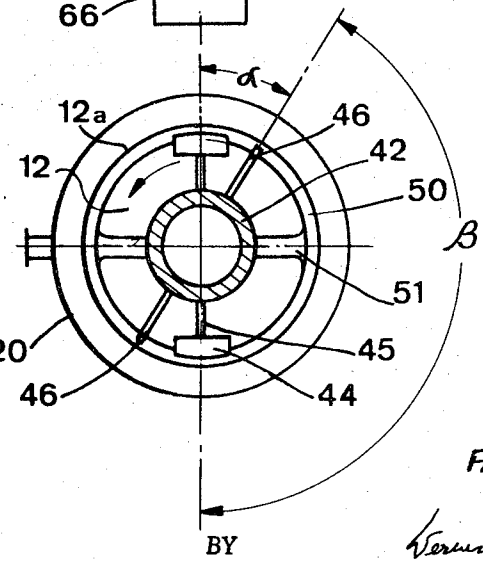


Fig.2



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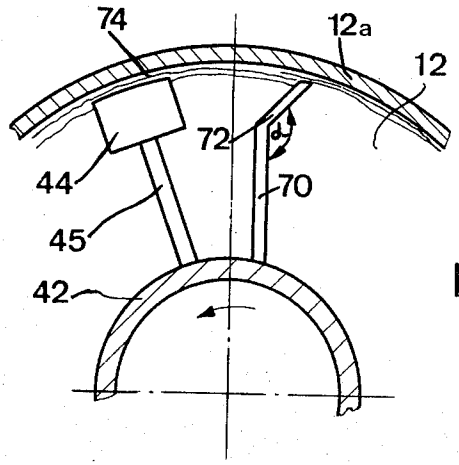


Fig. 3

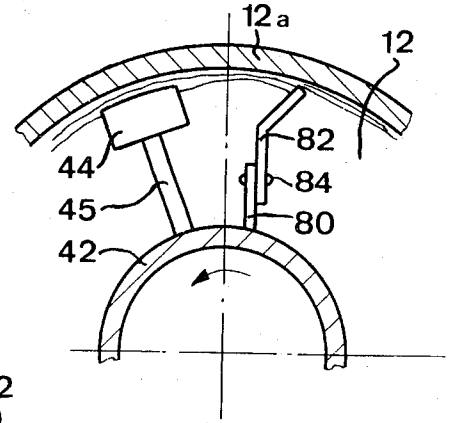


Fig. 4

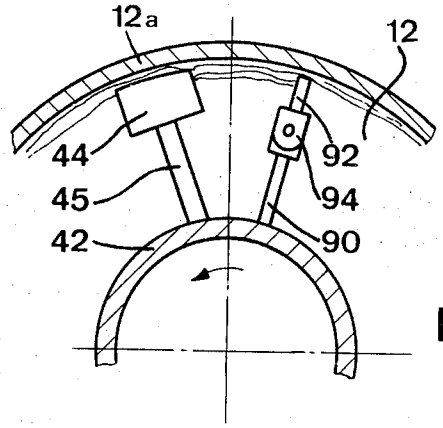


Fig. 5

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WIPED THIN FILM EVAPORATION AND TREATMENT APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to a new and improved thin film treatment apparatus for the treatment or handling of viscous materials.

There are already known to the art different thin film treatment apparatus having a rotationally symmetrical treatment chamber and a rotor arranged in such treatment chamber. Means are provided at the rotor of such apparatus which distribute into a thin layer the material to be treated and introduced into the treatment chamber upon the inner wall of such treatment chamber and sumultaneously impart to such material a displacement component directed towards the outlet or discharge connection of the equipment.

According to a known construction of thin film evaporator of this type the rotor possesses essentially a centrally disposed shaft member upon which there is arranged a spiral or helix possessing large pitch. Between the spiral there are mounted upon the shaft member in the direction of rotation, and offset through 180°, vane stubs which mutually overlap in the axial direction and which extend axially. Both the spiral as well as the vane studs extend up to the region of the inner wall of the treatment chamber. During operation of this thin film evaporator, the material introduced into the treatment chamber is contacted by the spiral and spread in the form of a thin layer upon the treatment wall. The vane stud following the spiral only performs a smoothing action upon the surface of the thin film.

This apparatus possesses the primary disadvantage that as soon as the treatment wall is covered with a thin layer of the material to be treated, the surplus material is practically conveyed by the spiral in a single thrust through the treatment chamber. It should be apparent that such excess material is subjected to a shorter treatment time, and therefore, experiences a less intensive heart treatment than that material which has been deposited upon the treatment wall. Hence, the material discharging from the treatment chamber does not possess any uniform properties.

A further considerable drawback of this thin film evaporator resides in the fact that the throughflow velocity of the material engaged by the spiral is directly proportional to the rotational speed of the rotor.

Since the treatment temperature as well as also the duration of treatment is relatively fixed for a predetermined material and, as a general rule, must be maintained within narrow limits, the speed of rotation must be coordinated to this predetermined treatment time. Therefore, it is not possible to accommodate the speed of rotation to other factors, which for instance influence the treatment intensity or the uniformity of the product.

It is known that viscous liquids which exhibit rheological properties, experience a reduction of the viscosity in suitable thin film treatment apparatuses, which is desirable for different reasons. This phenomena results in the presence of shearing stresses which occur upon wiping the viscous liquid between the wall of the treatment chamber and the wiping element, for instance the vane or wiper element. The magnitude of these shearing stresses and, therefore, also the

reduction of the viscosity, among other things, is also dependent upon the speed of rotation of the rotor. Now, if the rotational speed of the rotor is already determined by virtue of other factors, then utilization of these rheological properties cannot occur in optimum fashion.

SUMMARY OF THE INVENTION

Accordingly, it is a primary objective of the present invention to provide a new and improved thin film treatment apparatus which effectively overcomes the aforementioned drawbacks of the known thin film treatment apparatuses.

Another, more specific object of the present invention relates to an improved thin film treatment apparatus which effectively treats the material undergoing processing in an efficient, reliable and satisfactory manner, resulting in a uniform product.

Still another significant object of the present invention relates to an improved thin film treatment apparatus which is relatively simple in construction, extremely reliable in operation, not readily subject to breakdown, and extremely efficient in carrying out proper treatment of a material according to desired processing conditions.

Now, in order to implement these and still further objects of the invention, which will become more readily apparent as the description proceeds, the inventive thin film treatment apparatus possesses material conveying means which are formed from a number of vane stubs which are arranged in at least one axial row, wherein the confronting ends of neighboring vane stubs, viewed in axial direction, are spaced from one another and, in each instance, form a respective gap. Furthermore, the wiper means are offset in trailing fashion in the direction of rotation of the rotor with respect to the row of vane studs through an angle which is less than 90° and at least partially bridge the gaps between neighboring vane stubs.

Due to the fact that the conveying means, instead of being formed as a continuous spiral, now consist of a plurality of vanes, there is prevented that the material to be treated is conveyed through the apparatus without experiencing any residence time upon the treatment chamber walls. Quite to the contrary, the conveying, distribution and treatment of the material occurs stepwise and alternatingly. This results from the fact that the material conveyed by one vane cannot arrive in the operable region of a successive vane in the discharge direction, before this material has been contacted and treated by the wiper means.

Since the wiper means directly trail or follow the vanes during the rotation of the rotor, the wiper means act upon the collected material which forms at the discharge end of each vane, and specifically, before this collection of material has flown away under the influence of the force of gravity. The wiper blade members therefore act extremely intensively upon the material which has accumulated. Therefore, the admixing of the material upon the wall of the treatment chamber is intensified and the distribution of this material upon such wall is improved.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood and objects other than those set forth above, will become apparent when consideration is given to the following detailed description thereof. Such description makes reference to the annexed drawings wherein:

FIG. 1 is a schematic illustration in elevational view of a preferred embodiment of inventive thin film treatment apparatus;

FIG. 2 is a cross-sectional view of the thin film treatment apparatus depicted in FIG. 1, taken substantially along the line II—II thereof;

FIGS. 3–5 inclusive show in enlarged views three further respective constructions of the inventive arrangement of the wiper blade elements.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Describing now the drawings, the exemplary embodiment of thin film treatment apparatus **10** depicted in FIG. 1 will be seen to comprise an essentially vertically arranged, rotationally symmetrical treatment chamber **12**. An inlet connection **14** is provided at the chamber wall **12***a* at the upper end of the treatment chamber **12** and at the lower end thereof, coaxially with respect to such treatment chamber, there is provided the outlet or discharge connection **16**. This outlet connection **16** is operatively connected with the treatment chamber **12** by means of an associated conical member **18**. Continuing, it will be understood that the treatment chamber **12** is encircled or surrounded by a suitable jacket **20** which is provided with an inlet connection **22** and an outlet connection **24** for a suitable heating or cooling medium. In similar fashion, the conical member **18** is encased by a jacket **26** which is equipped with an inlet connection **28** and an outlet connection **30**. Additionally, at the upper end of the treatment chamber **12** there is provided a vapor chamber or compartment **32** which possesses a diameter corresponding to that of the treatment chamber **12**. The upper end of this vapor compartment **32** is closed by a cover member **36**. Finally, at the wall or jacket of the vapor compartment **32** there is provided the vapor discharge connection **34**.

Now, extending coaxially with respect to the treatment chamber **12** and the vapor chamber **32** and arranged therein, there is a rotor member **40** which essentially extends over the entire length of the treatment chamber **12** and the therewith connected vapor chamber **32**. This rotor member **40** embodies a substantially centrally disposed rotor body member or shaft **42** which is connected at its upper end with a shaft stub **56** and, in turn, is rotatably mounted in a bearing **54** arranged in the cover member **36**. The shaft stub **56** is coupled with a suitable drive motor **58**.

The end of the central tubular rotor body **42** which confronts or faces the outlet connection **16** is rotatably mounted at the inner wall **12***a* of the treatment chamber **12** by means of a rim member **50** through the agency of a number of webs **51** (FIG. 2) which are connected with the tubular body member **42** of the rotor. At the outer periphery of the rim member **50** there are provided grooves or ridges **52** which are inclined with respect to the axis of the rotor **40**, and the significance of which will be more fully explained hereinafter.

The section of the tubular rotor body member **42** extending over the length of the treatment chamber **12**, will be seen to be equipped with two radial, axially extending rows of conveyor elements, which are displaced through an angle of 180° with respect to one another, and which are composed of a plurality of vane stubs **44**. More precisely, it will be observed that the vane stubs **44** are secured to the tubular body member **42** by means of the webs or struts **45** (FIG. 2) along an imaginary helical line. Further, the vane stubs **44** are inclined with respect to the axis of the rotor **40** and in the direction of rotation of the rotor. Furthermore, axially extending wiper elements **46** are secured to the tubular rotor body member **42** between the vane elements **44** arranged in axial rows. It is important for the functionality of the apparatus that the wiper elements **46**, in the peripheral or circumferential direction, together with the material conveying element **44**, form an angle α (alpha) which is smaller than 90°. This first material conveyor wiper element combination is followed by a second wiper-material conveyor combination spaced to provide an angle β (beta) between the first wiper **46** and the second material conveyor **44**. Thus, it will be appreciated that the α:β ratio enables the wiped film to remain in contact with heat exchange surface of treatment chamber **12** for a longer time. A plurality of axially extending wipers **48** are arranged at the region of the vapor compartment **32** upon the tubular rotor body member **42**.

Additionally, it is to be understood that a suitable material removal device, in this instance in the form of a removal worm member **60** is provided in the conical member **18**. The material removal worm member **60** is rotatably connected via a shaft stub **62** with an appropriate drive mechanism **66**. This shaft stub **62** is rotatably mounted in a bearing **64** arranged at the discharge or outlet connection **16**.

During operation of the heretofore described thin film apparatus **10**, the viscous material to be treated is introduced into the treatment chamber **12**, which is heated and/or cooled by the jacket **20**, via the inlet connection **14** and is engaged by the wiper elements **46** and the vane stubs **44** which are placed into rotation. Whereas the wiper elements **46** spread the engaged material in the form of a thin film upon the inner wall **12***a* of the treatment chamber **12**, the inclined positioned vane stubs **44** impart to the engaged material a displacement component which is directed towards the discharge or outlet connection **16**. As soon as the vane stubs **44** contact the material by means of their inlet or leading edges **44***a*, they displace such material in front of each such vane stub for such length of time until the material has reached the discharge or trailing edge **44***b* of such vane stub **44** and remains in the form of a material bead **74** (FIG. 3) upon the inner wall of the treatment chamber **12** at the region of the gaps **43** between neighboring vane stubs **44**. The next successive or trailing wiper element **46** now contacts the material bead **74**, spreads the material which has been passed through the gap opening upon the inner wall of the treatment chamber **12** and distributes the material excess of the bead **74** upon the entire width of the wiper element **46**. The next successive vane stub **44** as well as the wiper element **46** repeat this treatment for such length of time until the viscous material has reached the lower end of the rotor **40**. By means of the

inclined slots or grooves **52** provided at the supporting ring member **50** the treated material is further conveyed into the discharge or removal worm member **60**. This material removal worm member **60**, in turn, presses the treated material under large pressure through the outlet connection **16** where it can be further processed, for instance discharges such into a suitable container or granulator, which to preserve clarity in illustration has not been shown in the drawing.

The vapors which are formed during the heat treatment of viscous materials ascend in countercurrent with respect to the viscous material undergoing treatment, into the vapor compartment or chamber **32**, where they are contacted by the rotating blades or vanes **48** and separated from any entrained droplets which may be present in known manner. The thus cleaned vapor current now arrives via the vapor discharge connection **34**, for instance, into a suitable non-illustrated condenser.

Due to the inventive arrangement of the wiper element **46** directly behind the associated vane studs **44**, there is achieved a considerably greater utilization of the useful treatment surface in contrast to the known apparatuses for the treatment of viscous materials. This is attributable to the fact that the material collected into a bead by the vane stubs **44** is again completely distributed by the next successive or trailing wiper blades **46** and spread once again in the form of a thin film upon the inner wall of the treatment chamber **12**. In so doing, a portion of the material again comes into the operable region of the higher situated vane stubs **44**, so that for the further conveying of a predetermined quantity of material, on the average a large number of wiping contacts of the inner wall of the treatment chamber **12** by the vane stubs **44** is necessary than such was the case with the previously known apparatuses. This furthermore results in the fact that the residence time of the material to be treated in the treatment chamber is practically no longer dependent upon the number of revolutions or rotational speed of the rotor, rather is dependent upon how intensive the wiper elements **46** tend to spread the material to be treated upon the inner wall of the treatment chamber **12**. In other words, the better that the material is spread the longer becomes the through passage time.

Moreover, it has surprisingly been found that with the use of vane stubs **44** which directly thereat trailing wiper elements **46** the rheological properties of viscous materials can be more extensively utilized. Due to the operation of the apparatus independently of the number of revolutions of the rotor the rotational speed or number of revolutions thereof can be increased in such a way that the thus generated large shear stresses result in a considerable reduction of the viscosity of the material. This could not be predicted since previously the opinion prevailed that when treating viscous materials only such apparatuses could be used which carried out a continuously pronounced conveying action upon the material undergoing treatment. Due to the characteristics of the inventive thin film treatment apparatus it is first possible to successfully treat viscous material, the viscosity of which, under the influence of the described shear stresses, amounts to about 30,000 poise.

FIG. **3** illustrates a modified version of wiper element. The marginal portion **72** of the therein illustrated wiper element **70** and which confronts the inner wall **12***a* of the treatment chamber **12** is flexed or bent in a direction opposite to the direction of rotation of the rotor. This radially extending wiper element **70** encloses together with the bent marginal portion **72** an angle α between 100° and 170°, advantageously between 130° and 150°. Due to the flexed marginal portion **72** of the wiper element **70** there is achieved that the material collected in front of the wiper element **70** is subjected to a wedge action, so that this material is pressed through between the edge of the flexed marginal portion **72** and the inner wall **12***a* of the treatment chamber **12**. This form of wiper element **70** enhances the processing of highly viscous materials without the danger of clogging the treatment chamber **12**.

FIG. **4** illustrates a further embodiment of wiper element. Instead of the wiper element **46** of the type shown in FIG. **2**, in this arrangement a blade stub **80** is secured to the tubular rotor body member **42**. Furthermore, a blade or leaf spring **82** which is bent or flexed opposite the direction of rotation of the rotor **40** is secured to this blade stub **80** by means of the attachment wiping element **84**. This blade spring **82** wipes in idleness, during rotation of the rotor **40**, along the inner wall of the treatment chamber **12**. However, as soon as the material to be treated arrives at the operable region of the blade spring **82**, such blade spring is lightly raised by virtue of the wedge action of the material, so that the material to be treated is pressed through between the blade spring **82** and the inner wall of the treatment chamber **12**. By means of this arrangement there can be spread an especially thin layer of material upon the inner wall **12***a* of the treatment chamber **12**.

Finally, in FIG. **5** there is shown a further modification of the wiper element. Here, it will be seen that hinge elements **94** are provided at the blade stubs **90** secured to the tubular rotor body member **42**. These hinge elements **94** hingedly connect a wiper member or element **92** with the blade stub **90**. The spacing between the center of the tubular rotor body member **42** and the hinge axis of the hinge joint or member **94** is adjustable in such a way that the gap between the wiper element **92** and the inner wall **12***a* of the treatment chamber **12** can be exactly adjusted. The use of the wiper element **92** has proven particularly advantageous when the material to be treated at the beginning of the treatment processes a low viscosity. By virtue of the gap between the wiper element **92** and the inner wall of the treatment chamber **12**, which gap can be controlled in size, it is possible to also contact materials of low viscosity and to effectively spread such in the form of a thin layer upon the inner wall **12***a* of the treatment chamber **12**.

The wiper elements **46** depicted in FIGS. **1** and **2** need not of necessity be constructed to be continuous throughout the entire length of the treatment chamber **12**. In fact, each such wiper element **46** can also be formed of a plurality of axially extending partial or component elements, not shown in the drawing. What is important is only that the individual partial elements which face the discharge or outlet connection **16**, protrude at both sides in axial direction past the radi-

ally extending edges of the vane stubs **44**. If the properties of the material to be treated require a particularly long residence time in the thin film treatment apparatus, then, it is even possible to secure the individual partial elements in an arrangement which is inclined opposite the direction of rotation of the rotor **40**, so that the treated material is subjected to a displacement component which is directed towards the inlet connection by virtue of the action of the partial elements of the wiper members **46**.

Due to the conveying action of the rotator **40** in the inventive thin film treatment apparatus, it is possible to operate such in any random desired position. Thus, in case the necessity exists, it is possible to have the treatment chamber **12** assume an inclined or horizontal position. It is even possible to introduce the material at the lower end of a vertically extending treatment chamber and to convey such by means of the rotor **40** towards the upper end of the treatment chamber **12**, where it is removed by an appropriate mechanism out of the chamber **12**.

Furthermore, it can be advantageous if the material removal worm member **60**, instead of being driven by an independent drive member **66**, as explained above, is directly coupled with the rotor member **40**. If this be the case, then, the rotor drive mechanism **58** must be appropriately designed to possess a greater driving capacity.

It is, of course, also conceivable to use the inventive thin film treatment apparatus for carrying out reaction processes. In such instance the materials to be reacted are advantageously admixed prior to introduction into the treatment chamber **12**. When carrying out reactions under exothermic conditions, it is furthermore conceivable to use the jacket **20** for cooling the reacting material. In such case, it is necessary to deliver via the inlet connections **22** or **24**, respectively, a medium to the jacket **20** which possesses a temperature below the reaction temperature.

While there is shown and described present preferred embodiments of the invention, it is to be distinctly understood that the invention is not limited thereto but may be otherwise variously embodied and practiced within the scope of the following claims. ACCORDINGLY,

What is claimed is:

1. A wiped thin film treatment apparatus, especially for treating viscous materials, comprising means defining a rotationally symmetrical treatment chamber, heating or cooling jacket means encircling said treatment chamber, rotor means within said treatment chamber, said rotor means comprising a rotor shaft, material conveying means and wiper means, said material conveying means comprising a plurality of vane stubs arranged in at least one row extending in axial direction along said rotor shaft and being supported thereby, each vane stub having a conveying surface inclined with respect to the axis of rotation of said rotor shaft at an angle of less than 90° with respect to said axis, each vane stub further having a leading edge and a trailing edge, each trailing edge of one vane stub of said row being spaced from the leading of the succeeding vane stub of said row as viewed in the axial direction to form a respective axial gap between adjacent vane stubs in said row, which is not swept by any vane stubs in said row, said wiper means comprising at least one wiper member extending substantially over the length of the treatment chamber said wiper member being angularly retarded in immediate trailing fashion with respect to said row of vane stubs, said vane stubs forming ridged circumferential arcs of the material being treated on the chamber inner surface of substantially shortened circumferential extent relative to the circumferential extent and width of the continuously wiped film formed by said wiper member, said ridged arcs being sheared and spread upwardly and downwardly substantially immediately by said wiper member after being formed, thereby minimizing the gravitational effects on said ridged arcs and increasing the wiped film residence time with the heat exchange surface contacted.

2. A thin film treatment apparatus as defined in claim **1**, wherein said wiper means at least partially bridges said respective axial gap between neighboring vane stubs.

3. A thin film treatment apparatus as defined in claim **1**, wherein said rotor means possesses a discharge end, a removal mechanism disposed at said discharge end coaxially with respect to said rotor means and adapted to be driven independent of said rotor means.

4. A thin film treatment apparatus as defined in claim **3**, further including drive means for driving said removal mechanism independently of said rotor means.

5. A thin film treatment apparatus as defined in claim **1**, wherein said rotor means possesses a discharge end, a ring member rigidly connected with said discharge end of said rotor means for mounting said discharge end of said rotor means upon the inner wall of said treatment chamber.

6. A thin film treatment apparatus as defined in claim **1**, wherein said wiper means comprises at least one wiper blade member having a marginal portion which neighbors the inner wall of said treatment chamber and is rearwardly flexed with respect to the direction of rotation of said rotor means.

7. A thin film treatment apparatus as defined in claim **1**, wherein said wiper means comprises at least one wiper blade member incorporating a blade stub element and a wiper element, said blade stub element being secured to said rotor means, and means for pivotally connecting said wiper element with said blade stub element.

8. A thin film treatment apparatus as defined in claim **1**, wherein said wiper means comprises at least one wiper blade member incorporating a blade stub element and a wiper element, said wiper element being a blade spring member secured to said blade stub element, each such blade spring member having a wiper edge which contacts the inner wall of said treatment chamber.

9. A thin film treatment apparatus as defined in claim **1**, wherein said wiper member is constituted by a radially and axially extending linear wiper blade.

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