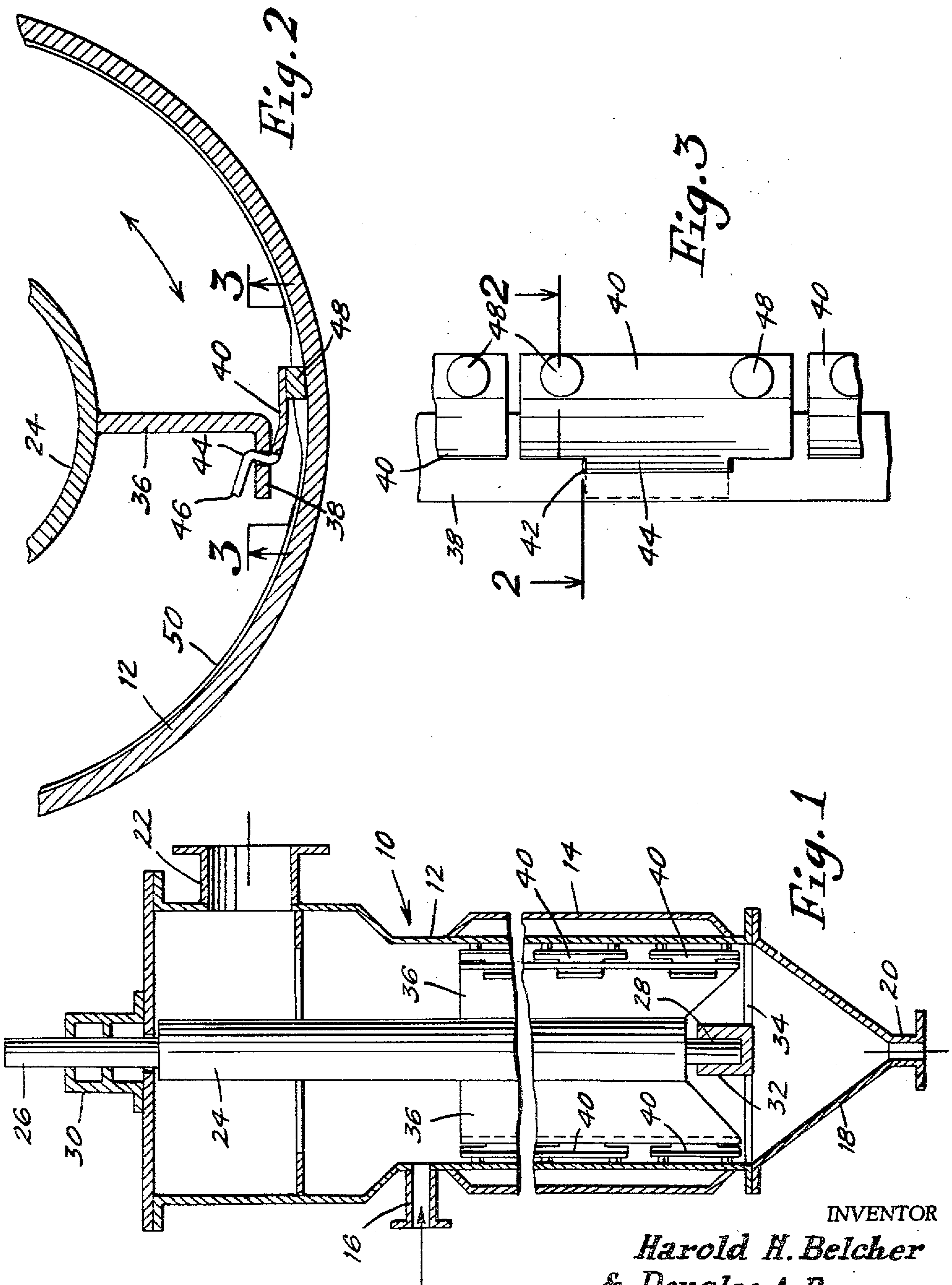
April 27, 1965 H. H. BELCHER ETAL 3,180,399

THIN FILM THERMAL PROCESSOR

Filed Oct. 27, 1961



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United States Patent Office

3,180,399

Patented Apr. 27, 1965

3,180,399

THIN FILM THERMAL PROCESSOR

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Filed Oct. 27, 1961, Ser. No. 148,289

10 Claims. (Cl. 159—6)

This invention relates to thin film thermal processors such as evaporators and the like and more particularly to a novel scraper blade construction for such processors.

The present invention relates to thin film thermal processors of the type generally set forth in U.S. Patent No. 2,774,415. Equipment of this type is commonly used in processes of evaporation or distillation, and may be used for a wide variety of other heat or mass transfer processes. In utilization of the equipment, the liquid feed material is introduced at the top of an externally heated hollow cylinder, flows down the inside wall of the cylinder by gravity and is acted upon by a concentric bladed rotor.

Rotors commonly used at present are of two general types. One type utilizes metal blades having a small fixed clearance from the cylinder wall. A second type involves radially movable plastic or carbon blades held in contact with the cylinder wall by either centrifugal force or spring tension or both.

Many materials may be satisfactorily processed in either type of rotor. There are, however, some materials and processes which operate more efficiently and more effectively with a rotor of the second type having blades to scrape the liquid from the wall, mix it to some extent and respread it on the wall. These processes are those which generally require the nearly complete evaporation of one lower boiling component from the mixture. In processes of this type the amount of residue material left near the bottom of the unit may be only a few percent of the feed and highly viscous. For this reason, it is desirable to scrape, mix and respread in order to insure complete removal of the volatile component.

The present invention relates to a centrifugal blade structure of the second type described above for handling a wide variety of materials and is especially suited to processes involving highly viscous materials. The present invention provides improved blade tips for spreading the liquid film evenly over all parts of the heated surface to obtain high rates of heat transfer and uniform treatment of all material by continually mixing and respreading the liquid film.

It is therefore a primary object of the present invention to provide an improved thin film thermal processor.

Another object of the present invention is to provide improved scraper blades for a thin film thermal processor.

Another object of the present invention is to provide a readily cleanable sanitary thermal processor blade construction which is substantially unaffected by moderate departures from exact circular cross-section of the cylinder or exact concentricity of the rotor.

Another object of the present invention is to provide a centrifugal type scraper blade resulting in improved scraping, mixing and respreading of processed material on the wall of the processor.

These and other objects and advantages of the invention will be more apparent upon reference to the following specification, claims and appended drawings wherein:

FIGURE 1 shows an elevational view with parts in cross section of the novel thermal processor of the instant invention;

FIGURE 2 is a partial horizontal cross section through a portion of the thermal processor of FIGURE 1 showing one of the rotor blades; and

FIGURE 3 is an elevational view taken along line 3—3 of FIGURE 2.

Processes for which the scraper blades of the present invention are particularly suited but not limited to require the complete evaporation of one lower boiling point component from a mixture. The desired end product may be the liquid material flowing from the bottom of the machine and quality requirements may dictate a very low content of the more volatile component of the feed mix. On the other hand, the desired end product may be the more volatile component evaporated in the processor and condensed in a separate condensor, and the economy of operation may require a maximum recovery of the more volatile component of the feed mix and minimum amounts left in the residue flowing from the processor.

Four effects complicate such processes. First, the viscosity of the material on the processor wall usually increases as the more volatile component is gradually removed with the remaining residue often rising to very high viscosities. Second, particularly when the volatile component is the desired end product, the amount of residue material left for spreading on the wall near the bottom of the unit may be only a few percent of the feed. Third, when nearly all volatile component has been evaporated, the rate of evaporation of the rest of the volatile component becomes so low that tiny vapor bubbles form within the film of material and do not build up to larger bubbles which can readily escape. As a result, the tiny bubbles are trapped within the viscous residue material. Fourth, at the very low evaporation rate when nearly all the volatile component has been evaporated, very little evaporative cooling effect exists, and the remaining material in contact with the hot wall tends to heat up to the wall temperature increasing the likelihood of charring of the residue and "burn on" of charred dry material on the wall.

In order to compensate for the above four effects, the present invention provides an effective processing blade system which scrapes over-concentrated, over-viscous material from the hot wall before charring can occur, mixes the material to release fine vapor bubbles and to produce a uniform distribution of the remaining volatile component, and respreads the material uniformly on the wall for further treatment.

Scraper blade systems used for such processes have usually been of comb construction with a multiplicity of scraping elements seperated by comparatively narrow vertical gaps through which the scraped-up material escapes for respreading after passage of the blades. Some systems have employed actual wire or plastic combs or brushes with very small scraping contact areas and very narrow gaps between scraping areas. Devices of this type are subject to rapid wear and more practical devices from the standpoint of blade life have used nonmetallic scraper strips with wider scraping lands and somewhat wider gaps between lands. Most such scraper devices have been held in scraping contact with the processor wall by centrifugal force or spring tension.

The wide land, non-metallic scraper blades have two major disadvantages or limitations. First, they have been shaped as rectangular or trapezoidal scraping surfaces which do a good scraping job but deflect the scraped-up material into the gaps between lands with no action to effect respreading. The material left after passage of the blades is in the form of plowed ridges separated by nearly dry wall areas at the levels of the scraping lands. Respreading must occur by the slumping of these ridges under the influence of gravity. For viscous materials, the slumping action may be quite slow with the result that much of the wall surface remains practically bare reducing the heat transfer efficiency and causing charring and "burn on" of the very thin films left by imperfect action of the scraping lands.

Second, because of the dry wall effect described above, it has usually been necessary to utilize a multiplicity of blades on the rotor with the spacing of lands at each blade tip such as to obtain scraping of the entire wall during the passage of each blade. This has necessitated the sloping or staggering of lands and rather restricted flow passages between lands. When such blades encounter a viscous material on the wall, they scrape up a mass or fillet of material which is pushed ahead of the blade with only a partial flow of material through the gap between scraping lands. The material in this fillet falls by gravity at a faster rate than does the material on the wall being partially held up by viscous drag, so that the final discharged material at the bottom of the unit is a mixture of over-treated and under-treated material. This may prevent the attainment of desired low volatile content in the discharged material, may degrade the product, and poses limitations as to the product viscosity range which may be satisfactorily handled.

The present invention provides a novel scraper blade construction which avoids the above-mentioned difficulties in providing effective scraping, mixing and respreading of the liquid film. Referring to the drawing, FIGURE 1 shows a thin film thermal processor constructed in accordance with the present invention generally indicated at **10** comprising a cylinder **12** surrounded by a heating jacket **14** into which steam or other heating fluid may be supplied. Material to be processed enters cylinder **12** through inlet pipe **16** and flows down the inner wall of vertical cylinder **12** under the influence of gravity to be discharged through conical collector **18** and discharge pipe **20**. Vapors produced from the processed material are discharged from outlet conduit **22**.

A concentric rotor **24** has its top and bottom shafts **26** and **28** respectively carried in suitable bearings **30** and **32**. Lower bearing **32** is supported by a spider **34** secured to the lower end of cylinder **12**. Rotor **24** carries a plurality of blades **36** extending outwardly from the body toward the cylinder **12**.

FIGURE 2 shows a partial section through the processor of FIGURE 1 and FIGURE 3 shows a partial elevation of the blade structure illustrated in FIGURE 2 taken along line 3—3 of FIGURE 2. As seen in FIGURES 2 and 3, blades **36** are welded or otherwise suitably fastened to hollow rotor **24** and extend radially outward to terminate in an angle section **38** approximately parallel to the wall surface of cylinder **12** at the blade location. Blades **36** are fitted with a vertically extending series of relatively short blade tips **40**. The face of angle section **38** is punched with a vertical series of rectangular holes **42** which receive reduced sections or ears **44** of the blade tips. The vertical dimensions of holes **42** are considerably less than the height of the main portion of the blade tips **40** and the vertical spacing between hole centers is the blade tip height plus a small fraction of an inch.

The vertical dimensions of the ears **44** are slightly less than the vertical dimension of the holes **42** and the ears are bent over with an offset **46** to interlock with the holes **42**. With the rotor **24** within cylinder **12** and the blades **36** and blade tips **40** engaged as illustrated in FIGURE 2 the blade tips are maintained in correct vertical spacing. The blade tips can swing in a horizontal plane about one vertical edge of holes **42** but the blade tips cannot be disengaged from the blades **36**. However, when the rotor is removed from the cylinder **12** the blade tips **40** can be swung further out so that offset **46** clears holes **42** and unhooked from the blades for cleaning.

The outer faces of blade tips **40** near the vertical edge opposite ears **44** are fitted with non-metallic scraper buttons **48**. These buttons may be made of plastic or carbon materials. The number of scraper buttons **48** per blade tip **40** may be varied as desired, but two per blade tip is preferred because this arrangement allows the blade tip to rock slightly in its loose pivot construction to maintain scraping contact between all scraper buttons and cylinder **12** in spite of minor irregularities in the cylinder wall surface.

The shape of scraper buttons **48** forming spaced scraping lands is critical for optimum processor performance. As a scraping land of any shape is pushed or drawn through the liquid film **50** on the cylinder wall, the liquid on the wall at the height of the land is necessarily displaced upward or downward or both to an elevation corresponding to the gaps between lands. This displacement involves acceleration of the liquid and vertical momentum in the liquid displaced. Any land shape, such as a square, rectangle, diamond, triangle or trapezoid, which involves a sharp break from the frontal or plowing surfaces to the rearward or trailing surfaces necessarily results in a bare wall surface the full height of the scraping land, with the bulk of displaced liquid thrown out into ridges spaced even wider than the height of the land.

On the other hand, with circular lands of the present invention, the transition from frontal to trailing surfaces of the land is a smooth curve, and vertical acceleration of the liquid gradually falls to zero at the point of minimum gap between lands and the liquid material is therefore held in contact with the side of the button at this point. With this smooth transition continuing to the trailing surfaces of the button, viscous drag between the liquid and the side of the buttons pulls the liquid along the converging back surfaces of the button **48**, respreading it on the wall **12** to at least partially recover the wall area scraped dry by the passage of the land. It has been found that a button with an elongated teardrop shape effectively accomplishes this respreading of the liquid to cover the area scraped dry by the lands, but for the purposes of economy the cylindrical shape of the scraper buttons **48** is preferred, and is very nearly as effective as the teardrop shape.

The vertical spacing of the scraper buttons **48** is not critical, but two conditions should be met. First, the gap between buttons should be comparatively large to permit easy flow of liquid through the gap without build-up of an undesired mass or fillet ahead of the blade. Second, the relationship between the diameter of the scraper buttons **48** and the gap between buttons, the number of blades **36** and the vertical location of each of the blade tips **40** should be such that in one revolution of the rotor every square inch of the inner surface of cylinder **12** will be scraped at least once. In the embodiment shown, four blades **36** are mounted on rotor **24** and the mounting holes **42** in each successive blade are shifted one-quarter of the button spacing vertically to insure that the entire inner surface of the cylinder will be scraped during each complete revolution of the rotor.

As indicated by the double ended arrow in FIGURE 2, the rotor of the present invention may be operated in either direction of rotation. For materials of low viscosity, clockwise rotation in FIGURE 2 is preferred. In this case, frictional forces between the scraper buttons **48** and the wall of cylinder **12** tend to offset part of the centrifugal force effect acting on the blade tips, resulting in a lighter contact pressure between buttons and wall and increased blade life. Reverse rotation in the counterclockwise direction causes friction effects to be added to centrifugal force effects, increasing the contact pressure between buttons and wall and may be used for materials which have a strong tendency to char or "burn on" where a strong scraping action is needed.

It is apparent from the above that the present invention provides a novel thin film thermal processor blade construction particularly suited for use in processes where it is desirable to scrape, mix and respread the processed material. The construction is free of cracks, crevices or close clearances where bacterial action may occur and is readily removable and cleanable to meet sanitary standards particularly when operating upon food and medicinal products. The combination of wide spacing between the scraping surfaces and a smooth curved contour connecting leading and trailing surfaces of the scraping lands results in a construction useable over a wide range of liquid viscosity conditions and a construction leaving a minimum of dry wall after passage of the scrapers. Since the blade tips are free to swing under the influence of centrifugal and hydrodynamic forces it is apparent that minor deviations from true circular cross section of the cylinder or minor eccentricity of the rotor and cylinder alignment have a negligible effect on the operation of the device.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. A scraper blade assembly for thermal processors comprising a rotor having at least one outwardly extending blade, and a plurality of longitudinally spaced blade tips pivotally secured to said blade, each of said blade tips including at least one scraping right circular cylindrical button including a land formed with curved leading edges for engagement with the inner surface of a thermal processor.

2. A scraper blade assembly for thermal processors comprising a rotor having a plurality of outwardly extending blades, a plurality of longitudinally spaced plates each having a pair of longitudinal edges pivotally secured adjacent one longitudinal edge to the free edge of each of said blades, said plates having flat surfaces forming their other longitudinal edges approximately parallel with the inner surface of a processor and a pair of longitudinally spaced right circular cylindrical buttons on each of said flat surfaces for engaging the inner surface of a thermal processor.

3. A scraper blade assembly for thermal processors comprising a rotor having a longitudinal axis, a plurality of radially extending rigid blades carried by said rotor, each of said blades having a plurality of longitudinally spaced and longitudinally aligned rectangular apertures, a plurality of longitudinally spaced blade tips, each of said blade tips having an offset portion pivotally received in said apertures whereby the trailing edge of said blade tip is free to swing outwardly under the action of centrifugal force when said rotor is rotated and a plurality of buttons on said blade tip adjacent said trailing edges for engagement with the inner surface of a thermal processor.

4. An assembly according to claim 3 wherein said buttons include lands which are formed with leading edges smoothly curved over at least 180° of the land periphery facing into the direction of rotation.

5. An assembly according to claim 4 wherein said buttons have a teardrop shaped cross section.

6. An assembly according to claim 4 wherein said buttons have a circular shaped cross section.

7. An assembly according to claim 6 wherein there are at least two longitudinally spaced buttons on each blade tip.

8. An assembly according to claim 7 wherein the lands on adjacent blades are staggered vertically to insure land contact with the entire inner surface of a processor during each complete revolution of said rotor.

9. An assembly according to claim 8 wherein said rotor is provided with four blades, said buttons are spaced four button diameters apart, and the apertures in said blades are longitudinally shifted in each successive blade by one-quarter of the longitudinal center to center distance between lands.

10. A thin film thermal processor comprising a cylindrical chamber, means for heating at least a portion of said chamber, product inlet and outlet means coupled to said chamber, a rotor concentrically mounted in said chamber, a plurality of radially extending rigid longitudinal blades secured to said rotor, each of said blades having a plurality of longitudinally spaced and longitudinally aligned rectangular apertures, a plurality of longitudinally spaced blade tips, each of said blade tips having an offset portion pivotally received in said apertures whereby the trailing edge of each of said blade tips is free to swing outwardly under the action of centrifugal force when said rotor is rotated, and a plurality of circular cross-sectioned non-metallic buttons adjacent the trailing edge on each of said blade tips for scraping the inner surface of said chamber.

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