

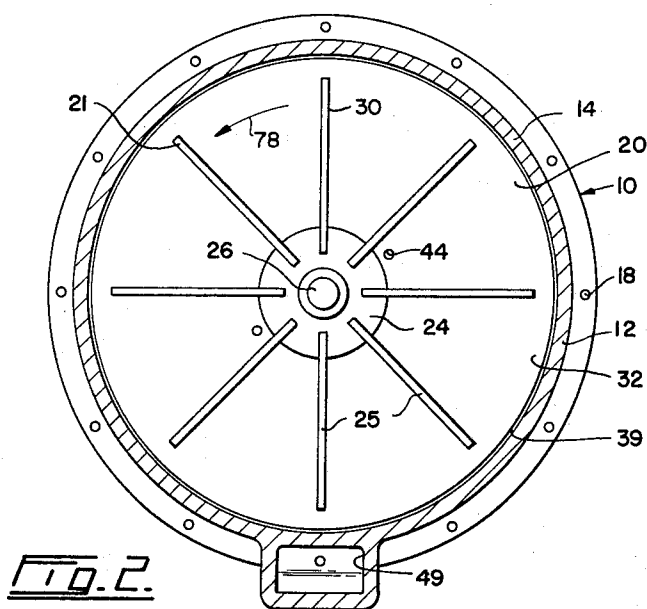
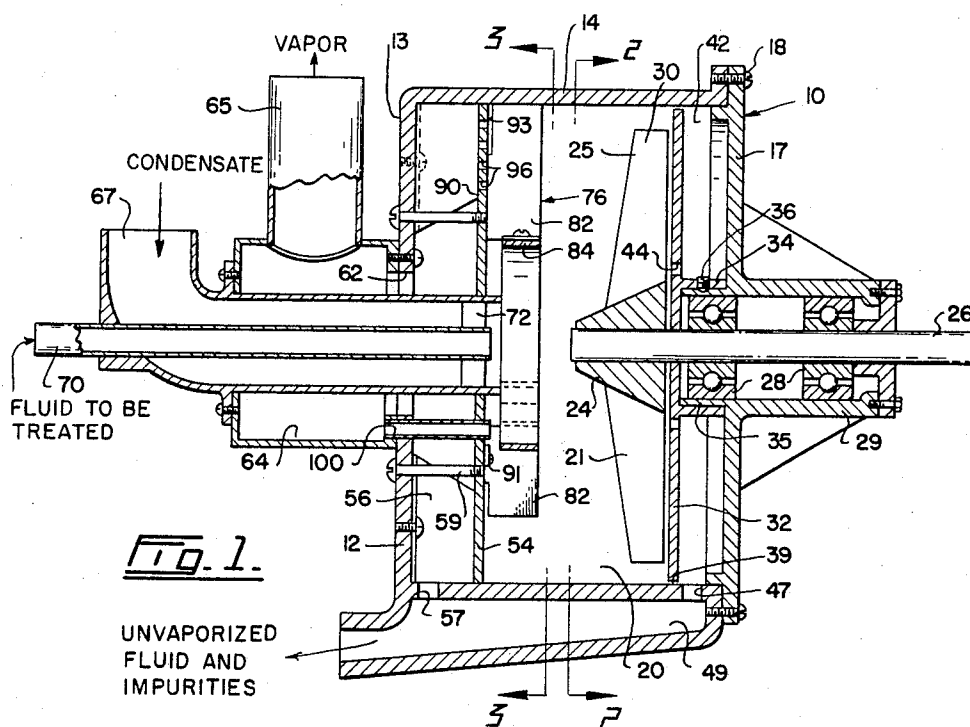
Sept. 20, 1966

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ULTRASONIC FLUID HEATING, VAPORIZING, CLEANING
AND SEPARATING APPARATUS

3,273,631

Filed Jan. 13, 1964

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

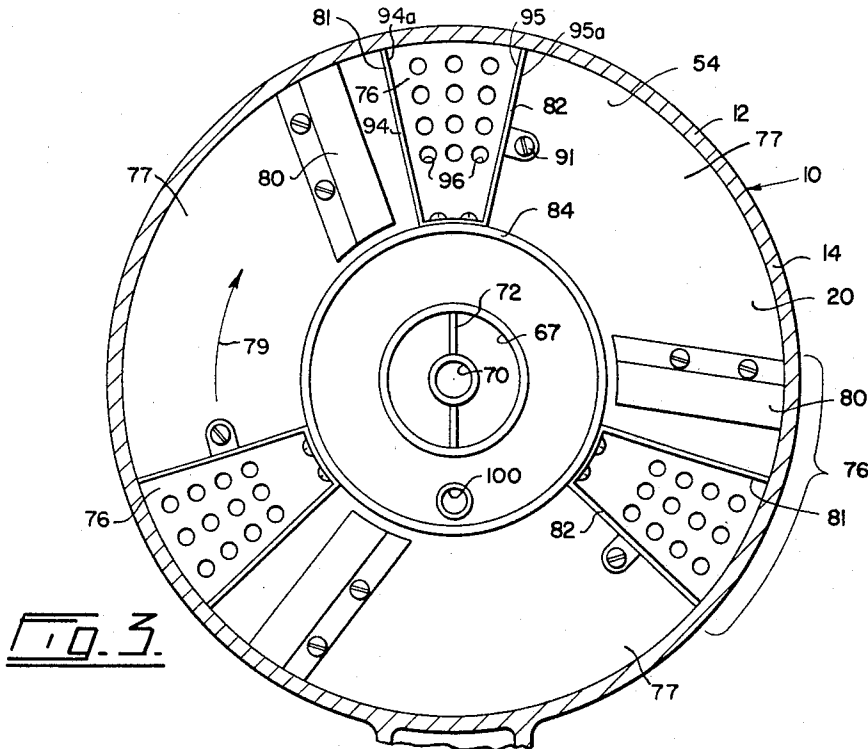


FIG. 3.

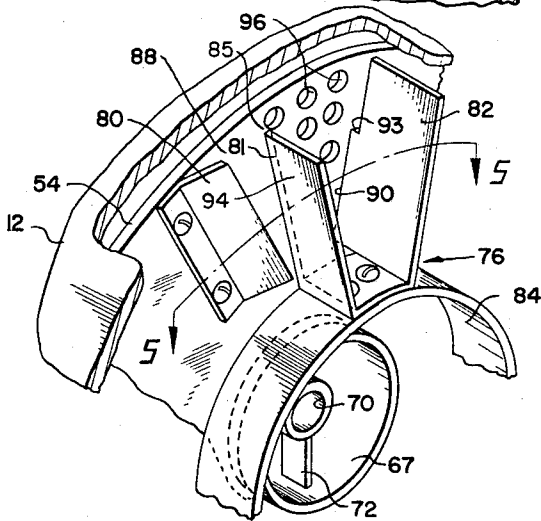


FIG. 4.

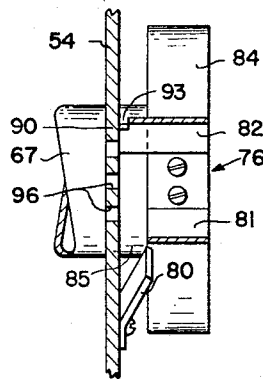


FIG. 5.

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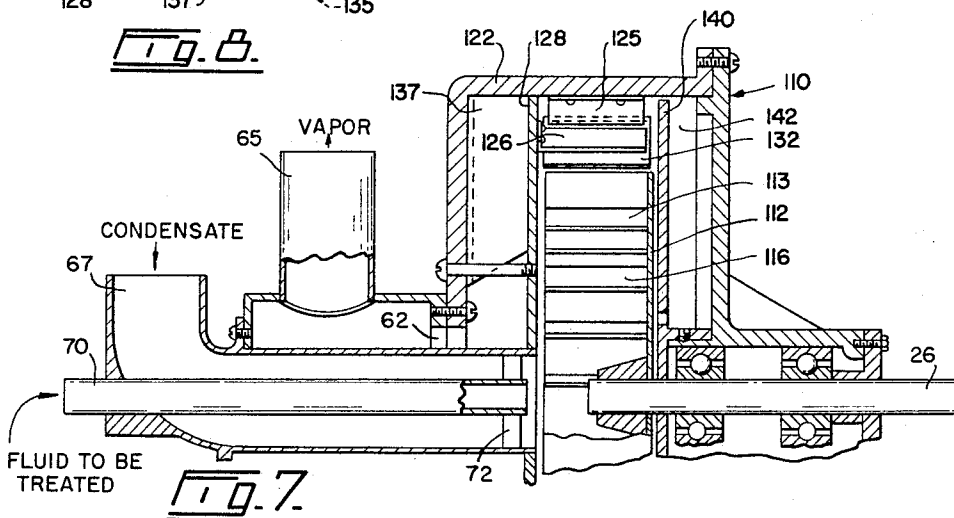
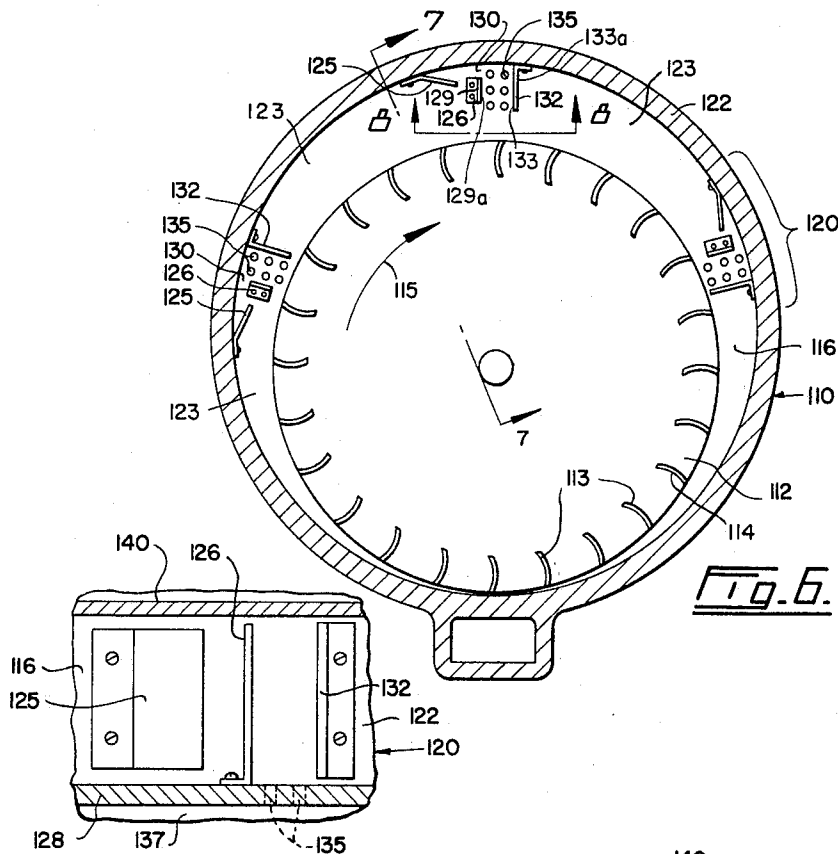
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4 Sheets-Sheet 4

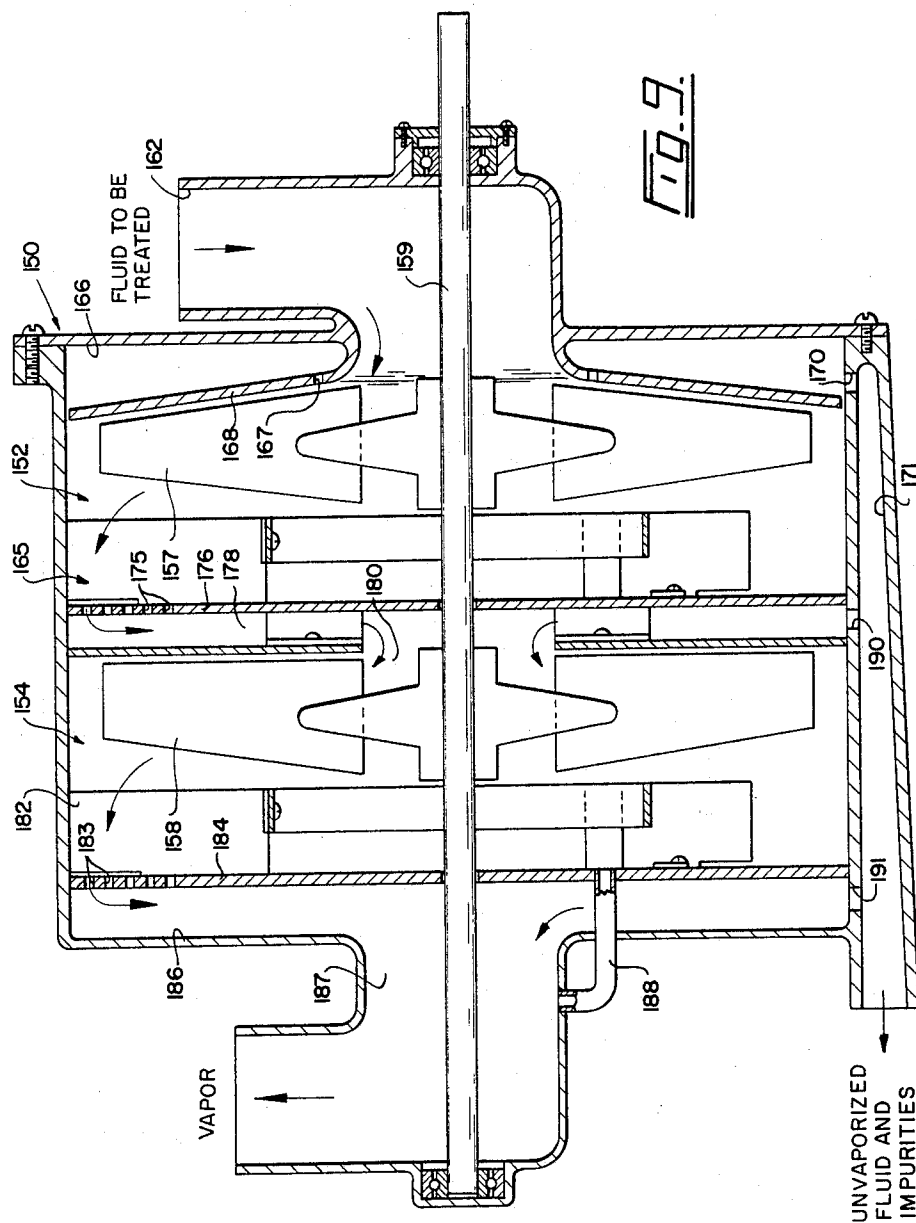


Fig. 9

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ULTRASONIC FLUID HEATING, VAPORIZING, CLEANING AND SEPARATING APPARATUS

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17 Claims. (Cl. 159—6)

This invention relates to apparatus for generating heat, separating fluids and separating particles from fluids by ultrasonic means.

An object of the present invention is the provision of apparatus for continuously heating a flow of fluid by means of high frequency vibrations.

Another object is the provision of apparatus for separating impurities from a fluid by means of heat and centrifugal force.

A further object is the provision of apparatus for vaporizing liquids without generating pressure therein.

An important advantage of this invention lies in the fact that any fluid, either liquid or gaseous, can be cleaned, heated and/or vaporizing in a continuous stream without interrupting the flow and without having to shut down for cleaning purposes. Air or other gases may be quickly and continuously heated. Cleaning solvents may be purified for further use.

Cleaning solvents are particularly difficult to clean for reuse. These solvents are expensive, and many efforts have been made to cleanse them. This is done at the present time by distillation. This means that the solvents have to be cleansed in batches, and the cleaning up of the apparatus is time-consuming, difficult and messy.

Apparatus according to this invention includes an impeller rotatably mounted in a chamber, this impeller being rotated at high speeds. The fluid to be heated, vaporized or having impurities to be separated therefrom is directed into the impeller during rotation thereof. The fluid is moved around the chamber and thrown at great speed by the impeller against stationary blades mounted in the chamber to generate ultrasonic vibrations and heat. Centrifugal force throws solid and heavier fluids to a wall around the impeller from whence they are removed. The fluid is heated by high frequency vibrations before it leaves the chamber. If a liquid is directed into the chamber, it is broken down into extremely fine vapor by the high frequency vibrations and heat, and this liberates any solids and/or heavier liquids carried by the original liquids. Moisture can quickly and easily be removed from gases in this apparatus. The apparatus has been used to separate fatty acids, oils and dyes from the dry cleaning fluid as perchlorethylene, and approximately 100% has been removed.

Examples of this invention are illustrated in the accompanying drawings, in which,

FIGURE 1 is a vertical section through a preferred form of fluid heating, vaporizing, cleaning and separating apparatus,

FIGURE 2 is a vertical section taken on the line 2—2 of FIGURE 1,

FIGURE 3 is a vertical section taken on the line 3—3 of FIGURE 1,

FIGURE 4 is a fragmentary perspective view of a portion of the apparatus,

FIGURE 5 is a section taken on the line 5—5 of FIGURE 4,

FIGURE 6 is a cross section through an alternative form of apparatus,

FIGURE 7 is a section taken on the line 7—7 of FIGURE 6,

FIGURE 8 is an enlarged section taken on the line 8—8 of FIGURE 6, and

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FIGURE 9 is a fragmentary view similar to FIGURE 1 illustrating a multiple stage unit.

Referring to FIGURES 1 to 5 of the drawings, 10 is ultrasonic fluid heating, vaporizing, cleaning and separating apparatus comprising a casing 12 having an end wall 13 with an annular wall 14 projecting outwardly therefrom. A wall or cover 17 is removably mounted on the free edge of annular wall 14 by means of screws 18. Annular wall 14 forms a main chamber 20 in which an impeller 21 is rotatably mounted. This impeller includes a hub 24 with blades 25 radiating therefrom, said hub being fixedly mounted on a shaft 26 which extends outwardly from casing 12 through bearings 28 which are carried by a sleeve 29 secured to and projecting outwardly from end wall 17 centrally thereof. This shaft and impeller 21 are rotated at high speed by a motor, not shown, when the apparatus is in operation. Blades 25 have their broad surfaces 30 in planes generally parallel to the axis of rotation of impeller 21.

A partition or wall 32 is mounted behind impeller 21 between the latter and wall 17. This partition has a collar 34 projecting outwardly therefrom centrally thereof and fitting over an extension 35 of sleeve 29 extending inwardly from wall 17. The collar is secured to this extension in any suitable manner, such as by means of a set screw 36. The periphery of partition 32 is preferably spaced slightly from the inner surface of annular wall 14 to form an annular opening 39 therebetween. This opening keeps main chamber 20 in communication radially outwardly of the impeller with a collecting chamber 42 between partition 32 and chamber wall 17. Port means, in the form of a plurality of ports 44, in partition 32 centrally thereof form passages between chambers 20 and 42 near the centre of impeller 21. A discharge outlet 47 is formed in annular wall 14 at the bottom of chamber 42, said outlet opening into a collecting channel 49.

Another partition or side wall 54 is mounted within annular wall 14 and spaced outwardly from impeller 21 and between said impeller and chamber wall 13. Partition 54 forms an outlet chamber 56 between said partition and wall 13, said outlet chamber having an outlet 57 in wall 14 at the bottom of the chamber and opening into channel 49. Partition 54 is spaced inwardly from wall 13 in any convenient manner, such as by means of screws 59.

A vapor outlet 62 formed in wall 13 centrally thereof is provided for outlet chamber 56. This vapor outlet opens into a manifold 64 from which an outlet pipe 65 extends. Pipe 65 may extend to a condenser, not shown, in which case condensate which may not have been completely purified can be returned to the apparatus through another pipe 67 which extends through manifold 64, vapor outlet 62 and partition 54, opening into main chamber 20 opposite the centre of impeller 21. Fluid to be treated is directed by a feed pipe 70 into impeller 21 centrally thereof. In apparatus 10, feed pipe 70 extends centrally through pipe 67 and is supported at its inner end by webs 72 extending between this pipe and said pipe 67.

A plurality of groups 76 of stationary blades are mounted in main chamber 20 and circumferentially spaced from each other, there preferably being three of these groups as shown in FIGURE 3. It will be noted that there is a clear space 77 in chamber 20 ahead of each group 76 with reference to the direction of movement of impeller 21, said direction being indicated by arrows 78 and 79 in FIGURES 2 and 3, respectively. Each group 76 includes substantially radiating, stationary blades 80, 81 and 82. Blade 80 preferably mounted on partition 54, extends substantially parallel to blade 81 and is inclined outwardly from partition 54 and towards said blade 81. Blade 81 is mounted on a supporting ring 84 and extends longitudinally of the blade in a substantially radial direction, said blade having an inner edge spaced

outwardly from partition 54, leaving a passage 85 therebetween, as clearly shown in FIGURE 5. Blade 82 is also mounted on supporting ring 84 and extends longitudinally of the blade in a substantially radial direction. Blade 82 has an edge 90 secured to partition 54 in any suitable manner, such as by a lug 91, see FIGURE 3 and, this edge does not extend all the way out to the outer end of blade 82 but is indented to form a passage 93 between the blade and partition 54. It is preferable that the outer ends of blades 80, 81 and 82 extend outwardly to annular wall 14, see FIGURE 3. In addition to this, blades 81 and 82 extend outwardly from partition 54 towards impeller 21. These blades 81 and 82 have their broad transverse surfaces extending generally parallel to the axis of rotation of impeller 21. For example, blade 81 has a broad transverse impinged surface 94 and a leeward surface 94a, while blade 82 has a broad transverse impinged surface 95 and a leeward surface 95a. Stationary blades 81 and 82 lie in planes that either contain the axis rotation of impeller 21 or pass relatively close to said axis and substantially parallel to it.

Outlet means is provided for main chamber 20 in partition 54 adjacent each group or set of blades 76. This outlet means is preferably in the form of a plurality of ports 96 formed in partition 54 between stationary blades 81 and 82, see FIGURES 3 and 4.

When apparatus 10 is in operation, impeller 21 is rotated at high speeds. The fluid to be treated is directed by feed pipe 70 into the impeller centrally thereof. Blades 25 throw the fluid outwardly in a radial direction and towards the groups 76 of stationary blades. Particles and/or heavier liquids or fluids are thrown by centrifugal force against annular wall 14. These have a tendency to move along the wall towards the annular opening 39 around partition 32. This movement is helped by the fact that impeller 21 keeps collecting chamber 42 under a pressure lower than the pressure in main chamber 20 since the impeller draws air and fluid from the collecting chamber through ports 44. The impurities pass through outlet 47 and into outlet channel 49.

The fluid is moved around main chamber 20 and is thrown at great speed by the impeller blades against the stationary blades to generate ultrasonic vibrations and heat. Any desired temperature may be generated in the main chamber by increasing the speed of rotation of the impeller. The temperature may be controlled by controlling the speed of the impeller and/or by controlling the flow of fluid through pipe 70 into the chamber. If the temperature gets too high or too low, the rate of feed of the fluid to the chamber may be increased or decreased, respectively.

The rapid movement of the impeller blades past the stationary blades in the chamber causes the fluid to vibrate in said chamber. Vane 80 of each group 76 lifts the vibrating fluid or gas from partition 54 and directs it against vane 81, said fluid or gas flowing around the inner and outer edges of this vane and against vane 82 which directs it back to the impeller blades. As there is a low pressure area behind each blade 81, this speeds up the flow of fluid, creating a higher vibration frequency than could be created by the impeller itself.

The fluid is broken up, heated and vaporized in main chamber 20, and passes out through ports 96 into outlet chamber 56. Any heavy or unvaporized fluid drops to the bottom of this chamber and passes out through outlet 57. The remainder of the fluid in vapor form travels through outlet 62 into manifold 64. If the apparatus is used for vaporizing and cleaning liquids, pipe 65 directs the vapor to a condenser. Part or all of the condensed liquid may be returned for further treatment through pipe 67. If any liquid gets into manifold 64, it is directed back to the main chamber through a return pipe 100, see FIGURE 1.

Although the fluid in chamber 20 is subjected to great battering against the stationary blades, it still moves fairly

freely around the chamber so that there is little if any back pressure generated in the system. Vanes 80 direct the moving fluid against stationary vanes 81, and the fluid that passes around the latter vanes enters the space between vanes 81 and 82, some of it passing out through ports 96, some striking vane 82 and being directed back to the impeller blades, and some passing through passages 93 at said blades. The groups 76 of stationary blades tend to slow down the movement of the fluid in chamber 20, but the clear spaces 77 therein enable the impeller to keep the fluid moving at high speeds.

FIGURES 6 to 8 illustrate ultrasonic heating, vaporizing, cleaning and separating apparatus 110 which has the main, collecting and outlet chambers the same as those of apparatus 10. The main difference is that instead of impeller 21, apparatus 110 has a squirrel cage type rotor 112 having radiating blades 113 around the periphery thereof. The broad surfaces 114 of blades 113 extend generally parallel to the axis of rotation of rotor 112, said direction being indicated by arrow 115 in FIGURE 6. This impeller or rotor may be mounted concentrically in main chamber 116, or it may be eccentrically mounted therein, as shown in FIGURE 6. A plurality of groups 120 of stationary blades are arranged around the annular wall 122 of the main chamber with clear spaces 123 therebetween. Each group includes a blade 125 mounted on wall 122 and inclined towards a blade 126 (similar to blade 81) which is mounted on chamber wall or partition 128 spaced radially inwardly a little from the annular wall to form a passage 130 therebetween. The broad or impinged transverse surface 129 of blade 126 extends generally parallel to the axis of rotation of impeller 112, said blade also having a leeward surface 129a. Another blade 132 (similar to blade 82) is spaced from and parallel to blade 126 and projects radially inwardly from annular wall 122 upon which it is mounted. Blade 132 has broad impinged and leeward transverse surfaces 133 and 133a on opposite sides thereof. A plurality of ports 135 are formed in partition 128 and communicate with the outlet chamber 137 of this apparatus. Another partition or wall 140 behind impeller or rotor 112 forms the collecting chamber 142.

Apparatus 110 is just a variation of apparatus 10 and functions in substantially the same manner.

FIGURE 9 illustrates a multiple stage ultrasonic fluid heating, vaporizing, cleaning and separating apparatus. This unit is substantially two units 10 arranged in tandem. The main difference is that the fluid to be treated is directed into each stage of the apparatus at the back of the impeller instead of at the front thereof, as in FIGURE 1.

The apparatus 150 of FIGURE 9 illustrates a first heating, vaporizing, cleaning and separating apparatus 152 and a second heating, vaporizing, cleaning and separating apparatus 154 combined into a single unit. These devices are arranged in tandem, and respectively include impellers 157 and 158 secured to a common shaft 159. The fluid to be treated is directed by a pipe 162 to the central part of impeller 157 of unit 152, said impeller directing the fluid against a plurality of groups 165 of stationary blades which are similar to the groups 76 of apparatus 10. A collecting chamber 166 is located behind impeller 157, and ports 167 are formed in partition 168 near the centre of the impeller. Chamber 166 drains through discharge outlet 170 into a collecting channel 171.

The fluid after treatment in unit 152 passes through ports 175 in partition 176 into a collecting chamber 178 of unit 154, said collecting chamber acting as an outlet chamber for unit 152. The fluid is directed through an inlet 180 to the centre of impeller 158. Chamber 178 opens into inlet 180 around shaft 159. Impeller 158 directs the fluid against a plurality of groups 182 of stationary blades, which are similar to the groups 76 of unit 10, and this fluid passes out through ports 183 in partition 184 into an outlet chamber 186. The fluid leaves chamber 186 through a central outlet 187. If any liquids or

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solids reach outlet 187, they pass through return pipe 188 back into the main chamber of unit 152 in which impeller 158 is located. Chambers 178 and 186 communicate with collecting channel 171 through ports 190 and 191, respectively.

The operation of unit 150 is the same as the previously-described units, but the treated fluid leaving unit 152 travels into unit 154 for further treatment.

As stated above, this apparatus can be used to treat any fluid in either gaseous or liquid form. If liquid with or without impurities in solid or liquid form is directed into the impeller of the apparatus, said impeller immediately breaks it into a fine spray, and the generated heat transfers it into a vapor. The breaking up of the liquid and the heating thereof helps to separate the impurities from said liquid. Gas with or without impurities or gas and liquid with or without impurities can be treated, thus, the term "fluid" as used herein and in the claims is intended to include liquid and/or gas with and without particulate solids therein.

What I claim as my invention is:

1. Ultrasonic apparatus for heating, vaporizing, cleaning and separating flowing fluids, comprising a closed chamber, an impeller having radially-extending blades mounted for rotation in the chamber and adapted to be rotated at high speeds, said blades having broad surfaces in planes generally parallel to the axis of rotation of the impeller, means for directing fluid into the impeller blades during rotation of the impeller, said fluid being moved at high speed along a circular path around the axis of the impeller in the chamber by the impeller blades, at least one stationary blade extending longitudinally thereof in a substantially radial direction and mounted in the chamber across said circular path near the impeller and forming an obstruction to the movement of the fluid around the chamber, said stationary blade having a front impinged broad surface extending transversely of said blade and generally parallel to said axis of rotation and against which the fluid is directed and a back leeward surface where a low pressure area is formed, said chamber having a clear space on the impinged surface side of said stationary blade in which said movement of the fluid is unobstructed before impinging against said surface, said fluid flowing around an edge of the stationary blade between the latter and at edges of the impeller blades, and outlet means for the chamber adjacent the stationary blade through which fluid exits from the chamber, whereby the impeller blades moving past the stationary blade generate ultrasonic vibrations in the fluid in the chamber.

2. Apparatus as claimed in claim 1 including a second stationary blade mounted in the chamber near the impeller on the leeward surface side of the first-mentioned stationary blade, said second stationary blade extending longitudinally thereof in a substantially radial direction and being positioned to direct fluid having flowed around said first-mentioned stationary blade into the blades of the impeller.

3. Ultrasonic apparatus for heating, vaporizing, cleaning and separating fluids, comprising a closed chamber having spaced end walls and a peripheral wall, an impeller having radially-extending blades mounted for rotation in the chamber and adapted to be rotated at high speeds, said blades having broad surfaces in planes generally parallel to the axis of rotation of the impeller, means for directing fluid into the impeller blades during rotation of the impeller, said fluid being moved at high speed around the chamber by the impeller blades, a group of stationary blades extending longitudinally in a substantially radial direction and mounted on at least one of said walls in the chamber near the impeller and in the path of the fluid moved around the chamber; said group including a first blade having a front impinged broad surface extending transversely of said blade and generally parallel to said axis of rotation and against which the fluid is directed and a back leeward surface where a low

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pressure area is formed, and a second blade spaced from the leeward surface of and substantially parallel with the first blade; said chamber having a clear space on the impinged surface side of the first stationary blade and in which said movement of the fluid is unobstructed before impinging against said surface, said fluid flowing around the first blade and being directed by the second blade towards the impeller, and outlet means in the chamber at said group of blades through which fluid exits from the chamber, whereby the impeller blades moving past the stationary blades generate ultrasonic vibrations in the fluid in the chamber.

4. Apparatus as claimed in claim 3 including at least one other group of stationary radial blades in the chamber circumferentially spaced from and the same as said first-mentioned group of blades.

5. Apparatus as claimed in claim 4 in which the first blade of each group has radially-extending side edges and is positioned so that fluid can flow around said side edges.

6. Ultrasonic apparatus for heating, vaporizing, cleaning and separating fluids, comprising spaced first and second end walls and an interconnecting peripheral wall, a partition substantially parallel with and between said end walls and dividing the space therebetween into a closed main chamber and a collecting chamber, an impeller having radially-extending blades mounted for rotation in the main chamber and adapted to be rotated at high speeds, said blades having broad surfaces in planes generally parallel to the axis of rotation of the impeller, opening means in said partition at the peripheral wall and radially outwardly from the impeller maintaining the collecting chamber in communication with the main chamber along said peripheral wall, a discharge outlet in the collecting chamber through which liquids can run, means for directing fluid into the impeller blades during rotation of the impeller, said fluid being moved at high speed around the chamber by the impeller blades, a group of stationary blades extending longitudinally in a substantially radial direction and mounted on at least one of said walls in the main chamber near the impeller and in the path of the fluid moved around the chamber; said group including a first blade having a front impinged broad surface extending transversely of said blade and generally parallel to said axis of rotation and against which the fluid is directed and a back leeward surface where a low pressure area is formed, and a second blade spaced from the leeward surface of and substantially parallel with the first blade; said chamber having a clear space on the impinged surface side of the first stationary blade and in which said movement of the fluid is unobstructed before impinging against said surface, said fluid flowing around the first blade and being directed by the second blade towards the impeller and outlet means in the chamber at said group of blades through which fluid exits from the chamber, whereby the impeller blades moving past the stationary blades generate ultrasonic vibrations in the fluid in the chamber, and any heavy materials in the fluid being separated therefrom and thrown against the peripheral wall to move therealong through said opening means into the collecting chamber.

7. Apparatus as claimed in claim 6 including at least one other group of stationary radial blades in the chamber circumferentially spaced from and the same as said first-mentioned group of blades.

8. Ultrasonic apparatus for heating, vaporizing, cleaning and separating fluids, comprising a closed casing having an annular wall, a partition in and dividing the casing into a main chamber and a collecting chamber, said main chamber having a partition wall spaced from and opposed and substantially parallel to said partition, an impeller having radially-extending blades mounted for rotation in the main chamber and adapted to be rotated at high speeds, said blades having broad surfaces

in planes generally parallel to the axis of rotation of the impeller, opening means in said partition at the annular wall and radially outwardly from the impeller maintaining the collecting chamber in communication with the main chamber along said annular wall, a discharge outlet in the collecting chamber through which liquids can run, stationary blades extending longitudinally in a substantially radial direction and mounted in the chamber and axially displaced from and facing the impeller blades and having broad impinged and leeward transverse surfaces generally parallel to said axis of rotation, means for directing fluid into the impeller blades during rotation of the impeller, said fluid being moved around the main chamber by the impeller blades, said main chamber having a clear space on the impinged surface side of at least some stationary blades, said fluid being thrown at great speed by the impeller blades against the stationary blades to generate ultrasonic vibrations and heat, said fluid being thus subjected to vibrations, heat and centrifugal force in the main chamber, any heavy materials in the fluid being separated therefrom and thrown against the annular wall to move therealong through said opening means into the collecting chamber and discharge outlet, and outlet means in said side wall and at the stationary blades through which fluid passes from the main chamber.

9. Apparatus as claimed in claim 8 including port means in said partition near the centre of rotation of the impeller and maintaining the collecting chamber in communication with the main chamber, whereby said impeller draws fluid through said port means from said collecting chamber to keep a lower pressure therein than in the main chamber.

10. Ultrasonic apparatus for heating, vaporizing, cleaning and separating fluids, comprising a closed chamber having spaced first and second end walls with a connecting annular wall extending therebetween and forming a main chamber, a high speed impeller mounted for rotation in the main chamber near the second wall and having blades radiating from the centre thereof, said blades having broad surfaces in planes generally parallel to the axis of rotation of the impeller, a partition in the chamber spaced from the first wall and substantially parallel with and spaced from the impeller and lying between the impeller and the first wall a plurality of stationary blades extending longitudinally in a substantially radial direction and mounted near the partition and the annular wall and on the same side of the partition as the impeller, said stationary blades being axially opposed to and axially displaced from the impeller blades near outer ends of the latter blades and having broad impinged and leeward transverse surfaces generally parallel to said axis of rotation, opening means for the main chamber at the annular wall and radially outwardly from the impeller, means for directing fluid into the chamber and into the impeller blades near the centre of the impeller, said fluid being moved around the chamber by the impeller blades, said main chamber having a clear space on the impinged surface side of at least some stationary blades, said fluid being thrown at great speed by the impeller blades against the stationary blades to generate ultrasonic vibrations and heat, said fluid being thus subjected to vibrations, heat and centrifugal force in the main chamber, any heavy materials in the fluid being separated therefrom and thrown against the annular wall to move therealong through said opening means from the main chamber, and

outlet means in the partition near the stationary blades through which fluid passes from the chamber.

11. Apparatus as claimed in claim 10 including an outlet chamber in the main chamber between the first wall thereof and the partition, fluid from the main chamber passing through the outlet means in the partition being received in said outlet chamber, a fluid outlet from said outlet chamber in said first wall medially thereof, and a drain opening out from the bottom of the outlet chamber through which liquids can flow.

12. Apparatus as claimed in claim 10 including a second partition between the impeller and said second wall and spaced from the latter to form a collecting chamber, said opening means of the main chamber being in said second partition at the annular wall and maintaining the collecting chamber in communication with the main chamber, any heavy materials in the fluid being thrown by the impeller against the annular wall to move therealong through said opening means into the collecting chamber, and a bottom discharge outlet in the collecting chamber through which liquids can run.

13. Apparatus as claimed in claim 12 including port means in the second partition near the centre of the impeller maintaining the collecting chamber in communication with the main chamber whereby said impeller draws fluid through said port means from said collecting chamber to keep a lower pressure therein than in the main chamber.

14. Apparatus as claimed in claim 10 in which the stationary blades are arranged in circumferentially spaced groups of three circumferentially spaced blades arranged around the axis of the impeller and casing.

15. Apparatus as claimed in claim 14 in which each group of stationary blades comprises a first blade, a second blade on the leeward surface side of the first blade, said first and second blades projecting from the partition towards said impeller, and a third blade on the impinged surface side of said first blade, said third blade extending generally parallel to the first blade and projecting from the partition and being transversely inclined towards said first blade.

16. Apparatus as claimed in claim 15 in which said first stationary blade is spaced outwardly from said partition towards the impeller.

17. Apparatus as claimed in claim 16 in which said outlet means is located between the first and second blades of each group, and part of said second stationary blade is spaced outwardly from the first partition towards the impeller.

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